



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of Economic Affairs, Education and Research
EAER

Swiss Science Council SSC

Impact Assessment of National Promotion Initiative Nano-Tera.ch

Report and recommendations of the Swiss Science Council SSC commissioned by the State Secretariat for Education, Research and Innovation SERI

Final report approved at the plenary session on 4–5 June 2018.

Swiss Science Council SSC
Einsteinstrasse 2, 3003 Bern
Tél. +41 58 463 00 48, Fax +41 58 463 95 47
praesidium@swr.admin.ch
www.wissenschaftsrat.ch

Table

Résumé.....	3
Zusammenfassung.....	4
Executive summary.....	6
A. Recommendations of the Swiss Science Council	7
B. Swiss Science Council report	8
1. Introduction.....	8
1.1 Mandate	8
1.2 Procedure.....	8
1.3 Structure.....	9
2. The Nano-Tera.ch initiative: an overview.....	10
2.1 Scientific and institutional context.....	10
2.2 Legal bases, funding and general organisation	11
2.3 Objectives and selection procedure.....	12
3. SSC analysis	16
3.1 Scientific impact	16
3.1.1 Analysis	16
3.1.2 Conclusions	18
3.2 Educational impact.....	18
3.2.1 Analysis	19
3.2.2 Conclusions	19
3.3 Economic impact.....	20
3.3.1 Analysis	20
3.3.2 Conclusions	22
3.4 Societal impact.....	22
3.4.1 Analysis	23
3.4.2 Conclusions	23
3.5 Institutional impact	24
3.5.1 Analysis	24
3.5.2 Conclusions	25
3.6 Broader impact.....	26
3.6.1 Broader impact of Nano-Tera.ch: what added value for the ERI system?.....	26
3.6.2 Reflections on the implementation of Nano-Tera.ch.....	27
Abbreviations.....	29
References	30
Annexes.....	32

Résumé

En septembre 2016, le Secrétariat d'Etat à la formation, à la recherche et à l'innovation (SEFRI) a confié au Conseil suisse de la science (CSS) le mandat d'apprécier les effets de Nano-Tera.ch, programme de recherche soutenu de 2008 à 2016 par un financement fédéral à hauteur de 120 Mio CHF. Le mandat comportait également un volet consacré à l'appréciation des effets du programme SystemsX.ch, traité séparément par le CSS. Conformément au mandat, l'appréciation porte sur les impacts scientifique, éducationnel, économique, sociétal et institutionnel. A quoi s'ajoute la mise en perspective de Nano-Tera.ch dans le système de la formation, de la recherche, et de l'innovation (FRI). L'appréciation du CSS se fonde sur un rapport d'auto-évaluation établi par le consortium de Nano-Tera.ch, sur une appréciation indépendante par un panel d'experts internationaux, sur une étude externe du transfert de savoir et de technologies (TST) dans Nano-Tera.ch, sur une série d'entretiens du CSS avec les acteurs-clé, ainsi que sur la documentation reçue et disponible.

Il ressort de l'analyse menée par le CSS que Nano-Tera.ch a produit une recherche d'excellente qualité. La communauté de recherche en sciences de l'ingénieur, principalement issue des écoles polytechniques fédérales, a été orientée vers davantage de collaborations interdisciplinaire et interinstitutionnelle, et vers l'application. La formation de plus de 360 doctorants dans des domaines-clé pour la recherche scientifique et pour l'économie témoigne de l'impact éducationnel. Au niveau économique, Nano-Tera.ch a créé plusieurs start-ups prometteuses ou déjà confirmées, ainsi que des démonstrateurs et prototypes. Ces résultats sont dus à la qualité intrinsèque des projets soutenus, à la dotation financière globale importante, et au rôle du panel du Fonds national suisse pour l'encouragement de la recherche scientifique (FNS) dans la sélection des projets et dans leur suivi, en particulier lors du passage de la phase I (2008-2012) à la phase II (2013-2016).

L'initiative Nano-Tera.ch a rencontré différentes difficultés dans la formulation des objectifs stratégiques et dans leur mise en œuvre, marquée par la prise plutôt tardive de mesures d'encouragement ciblé. Par exemple, le TST n'a pas fait l'objet d'une définition explicite et était laissé à l'appréciation des chercheurs. Le programme de soutien au TST (Gateway) n'a été lancé qu'en 2015, de même que le soutien ciblé à la formation doctorale (NextSteps). Dans les deux cas, l'introduction tardive et la dotation financière réduite ont limité le potentiel d'efficacité. Les impacts sociétal et institutionnel ne comptaient pas parmi les objectifs stratégiques initiaux de Nano-Tera.ch, ce qui explique l'absence de mesures spécifiques prises dans ces dimensions. Des impacts indirects sont constatés, sans qu'un lien de causalité ne puisse être démontré. Par exemple, Nano-Tera.ch a contribué à la formulation du programme «Bridge», lequel se fonde aussi sur d'autres expériences nationales et internationales.

Suite aux prises de position de différents acteurs du domaine FRI, la base légale pour de telles initiatives se situe depuis 2014 dans la Loi sur l'encouragement de la recherche et de l'innovation (LERI). Compte tenu de ce changement législatif et suite à l'appréciation de Nano-Tera.ch, le CSS recommande au SEFRI d'examiner dans quelle mesure les dispositions légales actuelles (art. 41, al. 5 et 6 LERI) garantissent le respect de principes clairs quant à la formulation, au choix et à l'organisation interne des initiatives financées à ce titre. Considérant que Nano-Tera.ch est marqué par une forte orientation vers l'application socio-économique, le CSS recommande en outre, dans la mise en œuvre de telle initiatives, de veiller à :

- Encourager l'ensemble de la chaîne de création de valeur de manière à créer une valeur ajoutée par rapport aux dispositifs d'encouragement existants;
- Formuler les objectifs stratégiques en accord avec les parties prenantes, le cas échéant en associant le secteur privé et/ou des utilisateurs finaux à la sélection des projets et au suivi de la mise en œuvre;
- Etablir dès le début de l'initiative des concepts de mesures opérationnelles en accord avec les objectifs, en particulier sous l'angle scientifique, éducationnel, socio-économique, institutionnel et international;
- Disposer d'une gouvernance, d'un pilotage et de règles de monitoring en accord avec les parties prenantes et correspondant aux standards en vigueur;
- Prévoir un dispositif de nature structurelle pour s'assurer que la valeur ajoutée de l'initiative se perpétue au sein des partenaires institutionnels et disciplinaires après la fin du financement fédéral

Zusammenfassung

Im September 2016 hat das Staatssekretariat für Bildung, Forschung und Innovation (SBFI) dem Schweizerischen Wissenschaftsrat (SWR) den Auftrag erteilt, die Auswirkungen des Forschungsprojekts Nano-Tera.ch zu beurteilen. Dieses Projekt wurde von 2008 bis 2016 mit einem Bundesbeitrag in der Höhe von 120 Mio. CHF unterstützt. Teil des Auftrags war es auch, die Auswirkungen des vom SWR separat behandelten Programms SystemsX.ch zu untersuchen. Evaluiert werden sollten gemäss dem Auftrag die wissenschaftlichen, pädagogischen, wirtschaftlichen, gesellschaftlichen und institutionellen Auswirkungen. Ausserdem ging es darum, Nano-Tera.ch in das Bildungs-, Forschungs- und Innovationssystem (BFI-System) einzuordnen. Die Beurteilung des SWR stützt sich auf einen Selbstbeurteilungsbericht des Konsortiums von Nano-Tera.ch, eine unabhängige Evaluation eines internationalen Expertenpanels, eine externe Studie zum Wissens- und Technologietransfer (WTT) im Rahmen von Nano-Tera.ch, eine Reihe von Gesprächen des SWR mit den Hauptakteuren sowie die erhaltene und verfügbare Dokumentation.

Die Analyse des SWR zeigt, dass die Forschung von Nano-Tera.ch qualitativ hervorragend ist. Die Forschungsgemeinschaft der Ingenieurwissenschaften, die hauptsächlich aus den Eidgenössischen Technischen Hochschulen stammt, wurde dadurch stärker auf die interdisziplinäre und interinstitutionelle Zusammenarbeit und auf die Anwendung ausgerichtet. Die Ausbildung von mehr als 360 Doktorandinnen und Doktoranden in Bereichen, die für die wissenschaftliche Forschung und die Wirtschaft von zentraler Bedeutung sind, verdeutlicht die pädagogische Wirkung des Projekts. Auf wirtschaftlicher Ebene hat Nano-Tera.ch mehrere vielversprechende oder mittlerweile etablierte Start-ups sowie Demonstratoren und Prototypen hervorgebracht. Zu verdanken sind diese Ergebnisse der Qualität der unterstützten Projekte an sich, der grosszügigen Mittelausstattung und der Rolle des Panels des Schweizerischen Nationalfonds (SNF) bei der Auswahl und Begleitung der Projekte, insbesondere beim Übergang von der Phase I (2008–2012) zur Phase II (2013–2016).

Bei der Formulierung der strategischen Ziele und deren Umsetzung bekundete die Initiative Nano-Tera.ch verschiedene Schwierigkeiten, wobei eher spät gezielte Unterstützungsmassnahmen getroffen wurden. So wurde der WTT beispielsweise nicht explizit definiert und vielmehr der Einschätzung der Forschenden überlassen. Das Programm zur Unterstützung des WTT (Gateway) wurde erst 2015 lanciert, ebenso die gezielte Unterstützung der Doktoratsausbildung (NextSteps). In beiden Fällen schränkten die späte Einführung und die begrenzten finanziellen Mittel das Effizienzpotenzial ein. Die gesellschaftlichen und institutionellen Auswirkungen gehörten ursprünglich nicht zu den strategischen Zielen von Nano-Tera.ch, weshalb in diesen Bereichen keine spezifischen Massnahmen getroffen wurden. Es gab indirekte Auswirkungen, ohne dass sich jedoch eine kausale Beziehung aufzeigen liess. So trug Nano-Tera.ch beispielsweise zur Erarbeitung des Programms «Bridge» bei, das auch auf anderen nationalen und internationalen Erfahrungen beruht.

Aufgrund der Stellungnahmen von verschiedenen Akteure des BFI-Bereichs ist die gesetzliche Grundlage für solche Initiativen seit 2014 im Forschungs- und Innovationsförderungsgesetz (FIGG) zu finden. Angesichts dieser rechtlichen Änderung und nach der Evaluation von Nano-Tera.ch empfiehlt der SWR dem SBFI zu prüfen, inwieweit die aktuellen Gesetzesbestimmungen (Art. 41 Abs. 5 und 6 FIGG) die Einhaltung klarer Grundsätze betreffend Formulierung, Wahl und interne Organisation der zu diesem Zweck finanzierten Initiativen sicherstellt. Zumal Nano-Tera.ch stark auf die sozioökonomische Anwendung ausgerichtet ist, empfiehlt der SWR überdies, bei der Umsetzung solcher Initiativen auf folgende Punkte zu achten:

- Unterstützung der gesamten Wertschöpfungskette, um gegenüber den bestehenden Förderinstrumenten einen Mehrwert zu schaffen;
- Formulierung der strategischen Ziele im Einklang mit den beteiligten Akteuren, gegebenenfalls unter Einbezug des Privatsektors und/oder der Endnutzerinnen und -nutzer in die Auswahl der Projekte und die Begleitung der Umsetzung;
- Erarbeiten von Konzepten für operative Massnahmen ab Beginn der Initiative, im Einklang mit den Zielen, insbesondere in wissenschaftlicher, pädagogischer, sozioökonomischer, institutioneller und internationaler Hinsicht;

- Festlegen einer Governance-Struktur, von Steuerung und Monitoring im Einvernehmen mit den beteiligten Akteuren und entsprechend den geltenden Standards;
- Einführen von strukturellen Vorkehrungen, um sicherzustellen, dass der Mehrwert der Initiative bei den institutionellen und disziplinären Partnern nach dem Auslaufen der Bundesfinanzierung weiterbesteht.

Executive summary

In September 2016, the State Secretariat for Education, Research and Innovation (SERI) commissioned the Swiss Science Council (SSC) to assess the impact of Nano-Tera.ch, a research programme that received CHF 120 million in federal funding between 2008 and 2016. The SSC was also commissioned to assess the impact of the research programme SystemsX.ch; the SSC managed this mandate separately. The impact assessment of Nano-Tera.ch was to focus on the scientific, educational, economic, societal and institutional impacts of Nano-Tera.ch and on its position within the education, research and innovation (ERI) system. The SSC's analysis is based on a self-assessment report carried out by the Nano-Tera.ch consortium, an independent assessment by an international panel of experts, an external review of knowledge and technology transfer (KTT) at Nano-Tera.ch, a series of interviews conducted by the SSC with key actors, as well as a range of other documentation.

The SSC's analysis reveals that Nano-Tera.ch produced research of excellent quality. It encouraged the engineering sciences research community, mainly from the Swiss federal institutes of technology, to take part in more interdisciplinary and inter-institutional collaborations and to consider the practical application of research to a greater extent. The educational impact of the programme is evident: more than 360 PhD students were trained in key areas for scientific research and the economy. In terms of economic impact, Nano-Tera.ch created a number of promising or already established start-ups, as well as demonstrators and prototypes. These results were achieved thanks to the intrinsic quality of the projects supported, the significant amount of funding dedicated to the programme, and the role of the Swiss National Science Foundation (SNSF) panel in selecting and monitoring projects, in particular during the transition from phase I (2008–2012) to phase II (2013–2016).

The Nano-Tera.ch initiative encountered various difficulties in formulating and implementing its strategic objectives, emphasised by the somewhat late implementation of targeted funding measures. For example, KTT was not explicitly defined and was left to the discretion of researchers. The KTT support programme (Gateway) and the support programme targeted at PhD students (NextSteps) were not launched until 2015. The potential effectiveness of both of these programmes was limited by their late introduction and the fact that funding was restricted. Societal and institutional impacts were not included in the initial strategic objectives of Nano-Tera.ch, which explains why no specific measures were taken in these areas. Indirect impacts were observed, but no causal link could be established: for example, Nano-Tera.ch contributed to set up the Bridge programme, which was also derived from other national and international experiences..

As a result of the positions taken by various actors in the ERI sector, since 2014 the legal basis for such initiatives has been the Research and Innovation Promotion Act (RIPA). Considering this legislative change and following the Nano-Tera.ch assessment, the SSC recommends that SERI examine the extent to which current legal provisions (Art. 41 paras 5 and 6 RIPA) ensure that clear principles are followed with regard to the formulation, selection and internal organisation of initiatives funded on this basis. Bearing in mind that Nano-Tera.ch focuses strongly on socioeconomic application, when such initiatives are implemented the SSC also recommends that:

- the entire value chain is supported in such a way as to generate added value in relation to existing funding schemes;
- strategic objectives are formulated in agreement with stakeholders, if necessary involving the private sector and/or end users in project selection and implementation monitoring;
- concepts are developed from the outset for operational measures that are in line with the objectives, in particular from a scientific, educational, socioeconomic, institutional and international perspective;
- governance, steering and monitoring rules are defined in agreement with stakeholders and in accordance with current standards;
- structural measures are introduced to ensure that institutional and disciplinary partners preserve the added value of the initiative once federal funding has ended.

A. Recommendations of the Swiss Science Council

1. Guarantee efficient implementation of Art. 41 paras 5 and 6 RIPA

Initiatives planned and coordinated by the Federal Council under Art. 41 paras 5 and 6 RIPA have particular financial and organisational consequences and cannot be implemented within the standard promotion activities of the research funding institutions, so should therefore form an exception. Nevertheless, they should also be based on clear principles, in particular with regard to the formulation and selection of such initiatives, and in terms of the rules of internal organisation, particularly the procedure for selecting projects for funding. The SSC recommends that SERI examine the effectiveness of the current legal provisions (Art. 41 paras 5 and 6 RIPA) to ensure such implementation.

2. Promote the entire value chain

Initiatives with socioeconomic application and funded under Art. 41 para. 5 RIPA should involve a clear vision of promotion along the whole value chain, from research and development to market sales. Synergies should be encouraged between the selection criteria for projects supported under the initiative and the targeted measures (e.g. KTT, PhD students, encouraging interdisciplinarity, structural measures) in order to create added value compared to existing funding schemes.

3. Formulate strategic objectives in agreement with stakeholders

The strategic objectives, implementation concept, organisation and procedure for selecting projects to be supported under the initiative should be based on a consensus between stakeholders as defined in the RIPA (Art. 41 para. 6), in other words the research bodies, the Swiss Conference of Higher Education Institutions (SCHEI) and the ETH Board. In cases in which the orientation is predominantly applied and/or societal, the private sector and/or end users should be involved in defining strategic objectives, selecting projects to support, and monitoring implementation, for example by integrating a scientific and economic advisory board.

4. Establish concepts for operational measures in line with objectives

For initiatives with socioeconomic application, the programme initiators should define operational measures in line with the corresponding objectives. These measures may be at scientific, socioeconomic or structural level, or concern international positioning, promotion of PhD students or KTT. The supported projects should have an explicit KTT concept, and include industrial partners and/or end users where necessary. The involvement of industrial mentors for all PhD students and post-docs, including principal investigators (PIs) and co-principal investigators (co-PIs), should be considered, as should specific measures to promote interdisciplinarity during implementation of the programme and at publication.

5. Governance, steering and monitoring

Governance, steering and monitoring should reflect the prior consensus between stakeholders and comply with current standards, including regarding conflicts of interest. The targeted measures, in particular in the areas of doctoral training and KTT (for initiatives with socioeconomic application), should have a sufficient budgetary allocation to facilitate action from the beginning of the initiative. Monitoring should be used for strategic steering of the initiative; if necessary, it may be based on specific indicators. The quality of monitoring not only influences programme implementation, but also ex-post assessment.

6. Foster sustainability of medium- to long-term impact

Owing to the exceptional character of the initiatives funded under Art. 41 paras 5 and 6 RIPA, there should be a sustainability requirement regarding their medium- to long-term impact. The initiative should include structural measures to ensure that the institutional and disciplinary partners preserve the added value of the initiative after federal funding has ended.

B. Swiss Science Council report

1. Introduction

1.1 Mandate

In September 2016, the State Secretariat for Education, Research and Innovation (SERI) commissioned the Swiss Science Council (SSC) to assess the impact of Nano-Tera.ch,¹ the “Swiss initiative for engineering sciences and information technology”.² This nationwide research programme received CHF 120 million in federal funding between 2008 and 2016. The SERI mandate also included an element dedicated to assessing the effects of the SystemsX.ch programme.³ The general procedure is the same for both programmes under review, but the schedule and elements to be assessed are different for each.

The implementation framework of the SERI mandate⁴ establishes the evaluation procedure, consisting of a self-assessment report drawn up by the constituent consortium of Nano-Tera.ch followed by an external assessment led by the SSC. This is an independent assessment by an international expert panel (hereinafter: SSC expert panel) which looks at five impact dimensions: scientific, educational, economic, societal and institutional. The assessment also provides a broader view, which the SSC measured by placing the overall assessment of Nano-Tera.ch within the context of the ERI system.

1.2 Procedure

The SSC analysis was carried out by a working group comprising Prof. Fariba Moghaddam and Jean-Marc Triscone, both SCC members. The secretariat assisted them in their work. In line with the SERI mandate, in April 2017 the SSC established the SSC expert panel according to a selection process run in consultation with Nano-Tera.ch and the Swiss National Science Foundation (SNSF).⁵ The members of the SSC expert panel are:

- Prof. Jeremy Baumberg, Director of the Nanophotonics Centre, University of Cambridge;
- Prof. Rudy Lauwereins, Vice President of IMEC;
- Prof. Mark Lundstrom, Professor of Electrical and Computer Engineering, Purdue University.

Following submission of the self-assessment report on Nano-Tera.ch at the end of October 2017,⁶ the SSC organised a site visit to Bern on 13–14 November 2017 attended by the SSC working group, the SSC expert panel, a delegation from Nano-Tera.ch and a delegation from the SNSF.⁷ The meeting was an opportunity for the SSC expert panel to interact directly with the representatives of Nano-Tera.ch and the SNSF and to ask questions based on the SERI mandate.⁸ It should be noted that the SNSF is not subject to the SSC assessment of Nano-Tera.ch, but was represented on the SSC expert panel owing to its involvement in implementation of the initiative. The final report by the SSC expert panel is based on discussions held, the self-assessment report on Nano-Tera.ch and various additional documents;⁹ the SNSF and Nano-Tera.ch both commented on the SSC expert panel’s report.¹⁰

*All the internet links were checked on 21 August 2018.

¹ Annex A.

² Wording used by the Board of the Swiss Federal Institutes of Technology (ETH Board) in 2007: ETH Board, Briefing from the ETH Board meeting, Bern, 3 October 2007. Cf. https://www.ethrat.ch/sites/default/files/F-Informations_de_la_se-ance_du_CEPF_02031007.pdf. Between 2008 and 2016, Nano-Tera.ch was variously described as an initiative and a national cooperation project. Since 2014, the legal basis of such projects is Art. 41 paras 5 and 6 of the Federal Act of 14 December 2012 on the Promotion of Innovation and Research (RIPA) SR 420.1, <https://www.admin.ch/opc/en/classified-compilation/20091419/index.html>, and the designation varies, depending on the national language, between ‘initiative’ and ‘project’. In order to facilitate reading, Nano-Tera.ch is referred to in this report as an initiative or a programme, without these formulations having any normative value.

³ The SCC’s final report on SystemsX.ch (SSC 2018) has been submitted to SERI.

⁴ Annex A.

⁵ The members of the SSC expert panel have all acknowledged the Terms of reference listed in Annex C1.

⁶ Annex B.

⁷ Annex G.

⁸ Annex C2.

⁹ Annex C3.

¹⁰ Annexes C31 and C32.

The SSC used the various documents and exchanges for its own analysis. In addition, an external study was conducted on behalf of the SSC by the research and consultancy firm Interface in Lucerne¹¹ to further assess the implementation and impact of Nano-Tera.ch in terms of knowledge and technology transfer (KTT). This study was conducted before the self-assessment report was submitted by Nano-Tera.ch. The SSC conducted 15 semi-structured interviews to assess Nano-Tera.ch from a broader perspective and according to the various dimensions under review.¹² Finally, the SSC also based its analysis on an extensive body of confidential documents supplied by the staff of the ETH Board, by Nano-Tera.ch and by the SNSF.

The SSC working group regularly updated the Council on the progress of this work. Coordination was organised with the working group in charge of assessing SystemsX.ch and with the secretariat. In April 2018, the SSC discussed the results of the Nano-Tera.ch analysis. This report and the recommendations it contains were accepted by the SSC at its plenary session on 4–5 June 2018.

Although the analysis comprises an impact assessment of Nano-Tera.ch as requested in the SERI mandate, this report by the SSC does not set out to establish a causal link between the programme and its anticipated outcomes/impact. Existing methodologies, particularly in economic and social sciences,¹³ which can isolate the effects of publicly funded projects by quantitative methods are not applicable in the case of a large-scale programme such as Nano-Tera.ch. Indeed, Nano-Tera.ch consists of several scientific communities and levels of state engagement, which constitute a complex system of interrelationships of which the programme is just one determinant. Equally, the available monitoring data are not sufficiently detailed or precise to provide information about all the processes at work.¹⁴ Finally, the exceptional character of Nano-Tera.ch¹⁵ limits the use of comparison or of a control group. The principal benchmark for Nano-Tera.ch is therefore its initial objectives and the expectations which led to its creation. Information from other research programmes and research funding instruments or schemes in Switzerland gives an idea of orders of magnitude. Furthermore, the SSC considers the specific objectives of SystemsX.ch and Nano-Tera.ch to be too different to justify a comparison of the two programmes. Using qualitative analysis from various sources and by triangulating the information used, the SSC helps identify and assess the programme results with regard to its objectives and implementation in order to stimulate reflection and debate among beneficiaries of the programme and policy makers.

1.3 Structure

Chapter 2 presents an introductory overview of the Nano-Tera.ch initiative. It is mainly based on freely accessible documentation and on the confidential documentation received. In chapter 3, after mentioning the key statements relating to each dimension in the SERI mandate, the analysis sums up the SSC's principal observations and conclusions on each dimension under review. The sources are mainly based on documents produced for this report, and on the SSC's own analysis.

¹¹ Meyer and Rieder 2017 (Annex D).

¹² Annex F.

¹³ See Givord 2010, Link et al. 2013.

¹⁴ See SSC analysis, chapter 3.

¹⁵ See chapter 2.

2. The Nano-Tera.ch initiative: an overview

This chapter provides some introductory remarks on the general context, setup and principal objectives and processes of Nano-Tera.ch. It is based on freely accessible documents, on the documentation received from the ETH Board, from Nano-Tera.ch and from the SNSF, on the in-depth discussions conducted during the site visit in November 2017, and on the interviews conducted by the SSC.

2.1 Scientific and institutional context

Nano-Tera.ch operates in an environment that has been shaped since the 1990s by a convergence of disciplines,¹⁶ particularly in micro- and nanoelectromechanical systems (MEMS and NEMS); a strategic positioning of academic institutions in these fields; and a range of public funding opportunities. The federal government has long promoted nanosciences/nanotechnologies and microsystems/microelectronics, often in partnership with private industry.¹⁷ For example, during the 1990s, there were at least three SNSF National Research Programmes (NRPs)¹⁸ and four Priority Research Programmes (PRPs)¹⁹ run by the ETH Board in this field. Other instruments, such as the microelectronics action programme *Microswiss*, run by the Commission for Technology and Innovation (CTI) from 1992 to 1997, focused on the future Universities of Applied Sciences (UAS) and on support for small and medium-sized enterprises (SMEs). From 2004 onwards, at the end of the joint CTI-ETH Board programme *Top-Nano 21* (2001–2003), the CTI incorporated its support for nanotechnologies and microsystems under its ‘New Technologies’ umbrella. From 2001, the National Centre of Competence in Research (NCCR) *Nanoscale Science – Impact on Life Sciences, Sustainability, Information and Communication Technologies*, hosted by the University of Basel (UniBAS), supported the creation of a Swiss nanoscience institute in Aargau (2005) and introduced new interdisciplinary courses in Basel. Other NCCRs covered neighbouring fields.²⁰ From 2004, the Swiss University Conference (SUC) backed extending the UniBAS courses to the University of Neuchâtel (UniNE), and encouraged a partnership between the Swiss Federal Institute of Technology Lausanne (EPFL) and UniNE’s Institute of Microtechnology (IMT), which was cemented in 2009 when the IMT was integrated into the EPFL.²¹ Throughout this period, the field of nanosciences/microsystems was a strategic priority for several institutions, particularly UniBAS, the Swiss federal institutes of technology in Zurich (ETHZ) and Lausanne (EPFL), UniNE, the Università della Svizzera italiana (USI) and the Swiss Centre for Microelectronics and Microtechnology (CSEM). Almost all these programmes or projects were based on matching funds, sometimes with private participation. The stated goals were inter-institutional and interdisciplinary cooperation, and the creation of competence centres, training and KTT.

The formal establishment of Nano-Tera.ch is linked to that of SystemsX.ch.²² It should be noted that SystemsX was initially funded by the SUC and the ETH Board from 2005 to 2007 in order to support joint projects in systems biology at the UniBAS, the ETHZ and the University of Zurich. When, in 2006, the State Secretariat for Education and Research (SER) received a funding request from the SystemsX project, it stipulated the requirement that SystemsX, which focused on the Basel-Zurich area, be extended to the national research community – with the ‘.ch’ extension symbolising a national partnership. In summer 2006, the ETH Board learned that the EPFL was preparing an initiative entitled ‘Nano-Giga’. In all likelihood, this project stemmed from the advances made thanks to previous developments in microtechnology and nanosciences in the partnership between Basel and Lausanne. Citing the example

¹⁶ Cf. the notion of ‘technological convergence’ disseminated by Mihail C. Roco in the United States: Roco 2002, Roco and Bainbridge 2003. For a critical approach, see Vinck and Robles 2012.

¹⁷ For more on the development of research into micro- and nanosciences/technologies in Switzerland, see Harayama et al. 2004, Biniok 2013 and Merz 2015.

¹⁸ NRP 13 Microelectronics and optoelectronics, 1980–1991; NRP 24 Chemistry and physics on surfaces, 1987–1995; NRP 36 Nanosciences, 1996–2000.

¹⁹ PRP Power electronics, computer systems technology (LESIT, 1992–1995); PRP Optics I (1993–1995) and Optics II (1996–1999); PRP Micro and nanosystems technology (MINAST, 1996–1999).

²⁰ In particular: NCCR MICS – Mobile information and communication systems (host institution: EPFL); NCCR Quantum photonics (EPFL); NCCR CO-ME – Computer-aided and image-guided medical interventions (ETHZ); NCCR IM2 – Interactive multimodal information management (IDIAP).

²¹ Cf. cooperation and innovation project ‘Studies in nanosciences’, funded by project contributions. Cooperation and innovation project ‘Inter-university centre for research in microsystems and nanotechnology, CIMENT’. cf. CUS 2005. After supporting the creation of a faculty of computer sciences at USI (2000–2003), the SUC continued to encourage the development in 2004–2007, notably with the introduction of a Master of Science in embedded systems design.

²² For details on the origin of SystemsX.ch, see SSC 2018.

of the partnership in microtechnology between the UniNE, the CSEM and the EPFL, in 2006 National Councillor D. Burkhalter called on the Federal Council to make the field one of the strategic priorities in the upcoming Dispatch on Education, Research and Innovation (ERI) for the period 2008–2011.²³ The Federal Council accepted the proposal in September, stipulating that the SUC and the ETH Domain should be responsible for implementing and financing a potential project in this field.

In December 2006, two projects were discussed at the ETH Board's session: one from the EPFL led by G. De Micheli entitled 'Nano-giga systems'; the other from the ETHZ led by R. Vahldieck entitled 'Quantum tera-scale systems information technology for the 21st century: National network programme'. Both projects were in the technological convergence between research in engineering sciences at the nano or micro level and applications in the field of information and communication technologies, characterised by the processing of large datasets (giga scale/tera scale).²⁴ The ETH Board took the view that the first of these projects was geared towards applied research and the second towards basic research. It decided to merge the two approaches into a national project modelled on SystemsX.ch. The proposal had to be submitted to SER by 21 January 2007;²⁵ the deadline was extremely tight as SER was already finalising the ERI Dispatch for the period 2008–2011, which was adopted by the Federal Council on 24 January 2007.²⁶ In this document, the Federal Council requested Parliament to approve a budget for project funding in a number of initiatives, including SystemsX.ch and a new national cooperation project called Nano-Tera.ch.²⁷ The formal aspects of Nano-Tera.ch were thus modelled on SystemsX.ch, particularly in terms of SER's willingness to entrust the SNSF with the scientific evaluation of research projects supported by Nano-Tera.ch.²⁸ The first call for proposals was published in late January 2008 and Nano-Tera.ch officially launched at the beginning of February.

2.2 Legal bases, funding and general organisation

Nano-Tera.ch was funded on the basis of the applicable legislation, in particular the project contributions instrument.²⁹ This instrument was the only one available at the time, although it was not designed to fund large-scale research projects. During the consultation on the revision of the Federal Act on the Promotion of Research and Innovation (RIPA) in 2010, the SUC, the ETH Board and the SNSF called for the principle of financing large-scale research projects such as SystemsX.ch and Nano-Tera.ch to be enshrined in the new RIPA, rather than in the future Federal Act on the Funding and Coordination of the Higher Education Sector (HEdA) in the form of project contributions.³⁰ These bodies wanted such initiatives to be subject to a coordination process explicitly regulated in the RIPA. The new RIPA, which entered into force in 2014, had been amended accordingly, with the addition of a new article (Art. 41 paras 5 and 6).³¹

²³ 06.3263, Postulate Didier Burkhalter. Microtechnology and nanosciences. Strategic project in the national interest, submitted on 13.06.2006, <https://www.parlament.ch/fr/ratsbetrieb/suche-curia-vista/geschaefte?AffairId=20063263>.

²⁴ For a more detailed description, see: 'ETH debate: national projects. Major engineering project at the EPFL and ETHZ'. *ETH-Life*, 18.12.2006, http://www.ethlife.ethz.ch/archive_articles/061218-debattevahldieck/index.html.

²⁵ 154th EPFL Assembly, 09.01.2007, <https://ae.epfl.ch/page-28438-fr.html#4>.

²⁶ Federal Council, Dispatch on the Promotion of Education, Research and Innovation for the period 2008 to 2011 of 24 January 2007, Federal Gazette 2007 1149, <https://www.admin.ch/opc/fr/federal-gazette/2007/1149.pdf>.

²⁷ Idem. The Dispatch was adopted by the Federal Assembly on 5 October 2007.

²⁸ However, the SNSF had planned to transfer this responsibility to the CTI, given the strongly applied nature of the initiative. It should be remembered that in 2007 the CTI was part of the Federal Office for Professional Education and Technology (OPET), which was attached to the Federal Department of Economic Affairs (FDEA). Its legal bases were reviewed in 2011 in order to give it a new status in the Federal Act on Research. It was not until September 2013 that the CTI was entrusted with implementation of research programmes on behalf of the Federal Council.

²⁹ Federal Act on University Funding and Cooperation in the field of University Education (University Funding Act, UFundA) of 8 October 1999 (version dated 1 January 2008), Arts 20–21, SR 414.20.

³⁰ "[...] the SUC, the ETH Board and the SNSF commented on the legal framework of major projects such as SystemsX.ch and NanoTera.ch. Rather than considering them as cooperation projects in accordance with Art. 59 of the draft HEdA, they should be placed under the RIPA regime". Federal Department of Home Affairs (FDHA), total revision of the Federal Act on the Promotion of Research and Innovation (RIPA). Report on the results of the consultation. Bern, 1 September 2010, p. 14. <https://www.admin.ch/ch/f/gg/pc/documents/1764/Ergebnis.pdf>

³¹ "The Federal Council shall coordinate the planning and implementation of national promotion initiatives in the field of research and innovation which, due to their organisational and financial consequences, cannot be implemented within the standard promotion activities of the research funding institutions and the CTI."

³² "In doing so, it shall ensure that the research bodies, the Swiss University Conference and the ETH Board are involved in the planning. It shall draft proposals to the Federal Assembly regarding promotional measures under paragraph 5, including decisions on financing and implementation, in agreement with the Swiss University Conference." Federal Act on the Promotion of Research and Innovation (RIPA), Art. 41 paras 5 and 6, SR 420.1.

Following the example of SystemsX.ch, Nano-Tera.ch was set up as a simple partnership.³² The consortium of founding partner institutions was made up of the Swiss Federal Institute of Technology Lausanne EPFL (host institution), the ETHZ, the UniBAS, the Unine, the USI and the CSEM.³³ Researchers affiliated with universities of applied sciences could participate in Nano-Tera.ch projects, but not as principal investigators (PIs).³⁴ The steering committee was formed from the management boards of the partner institutions. The executive committee (ExCom) is responsible for operational management, particularly the scientific and strategic planning of Nano-Tera.ch. It is chaired by G. De Micheli (EPFL), brings together researchers from various partner institutions and covers the disciplines of Nano-Tera.ch. It is assisted by an international scientific advisory board. Each member of the ExCom can submit requests for funding from Nano-Tera.ch.³⁵ General administration is carried out by the EPFL-based management office. Finally, there is a special panel set up by the SNSF dedicated to the scientific evaluation of specific projects (SNSF panel).

The two development phases of Nano-Tera.ch (2008–2011 (2012); 2013–2016³⁶) were financed by the federal government, partner institutions (matching funds) and by third party funds. Federal funding amounted to CHF 120 million, provided through SUC project contributions and participation of the ETH Board in projects of national importance.³⁷ Over all, Nano-Tera.ch received global funding of close to CHF 260 million.³⁸

The main Nano-Tera.ch funding instruments are Research, Technology and Development (RTD) projects, Nano-Tera.ch Focused (NTF), and Education and Dissemination (ED).³⁹ The goals, conditions, procedures and criteria relating to acceptance of funding requests under these three instruments were specified in the calls for proposals published from 2008 and formulated by Nano-Tera.ch with the support of the SNSF for aspects relating to RTD.⁴⁰ RTD projects are the main type of funding offered by Nano-Tera.ch, accounting for around 80% of sums awarded, and are the only type of project subject to evaluation by the SNSF panel; budget management is the responsibility of the SNSF.⁴¹ Most of these formal characteristics were derived from those developed for SystemsX.ch.

2.3 Objectives and selection procedure

According to the 2008–2011 ERI Dispatch, Nano-Tera.ch involves “developing key technologies that use micro- or nano-components with the aim of implementing a data network in the fields of security, the environment, medicine and health.”⁴² This formulation corresponds to the prevailing vision in the funding request addressed to the SUC in June 2007 and in the business plan of November 2007,⁴³ although no part of these documents was specifically dedicated to the initiative objectives. An analysis conducted in 2007 by the SNSF and based on four reports by independent experts, two of whom were from industry, considered the overall vision of Nano-Tera.ch to be sound, but stated that it was not

³² Nano-Tera.ch. Ordinary Partnership Contract, January 2008. The annual scientific reports of Nano-Tera.ch provide information on the detailed composition of the different bodies.

³³ In 2010, the University of Geneva joined the consortium following acceptance of a project led by a PI affiliated with that institution. See Nano-Tera.ch Scientific Report 2010, 1 December 2010.

³⁴ Nano-Tera.ch. Ordinary Partnership Contract, January 2008, Art. 4.

³⁵ Nano-Tera.ch. Ordinary Partnership Contract, January 2008, Art. 20 para. 1: “In case an issue is discussed in which an Executive Committee member has conflict of interests, she/he may be asked to leave. In any case, if attending, she/he will not take part in the discussion and decisions.” Tighter rules aiming to limit the amounts allocated to members of the ExCom who were PIs of RTD projects were implemented from phase II.

³⁶ Phase II formally ended on 30 June 2018.

³⁷ 2008–2011: CHF 20m SUC + CHF 40m ETH Board; 2012: CHF 5m SUC + CHF 10m ETH Board; 2013–2016: CHF 15.5m SUC + CHF 32m ETH Board. The ETH Board contribution comprises funding from the OPET to support participation of the UAS totalling CHF 1.8m (phase I) and CHF 2m (phase II).

³⁸ See Annex B.

³⁹ Annex B provides a comprehensive overview of the various funding instruments and their financial allocation.

⁴⁰ Cf. http://www.nano-tera.ch/news/textes/nano-tera_call_for_proposals2008.pdf

⁴¹ See below, section 2.3.

⁴² Federal Council, Dispatch of January 2007 on the Promotion of Education, Research and Innovation for the period 2008 to 2011, Federal Gazette 2007 1203. <https://www.admin.ch/opc/fr/federal-gazette/2007/1149.pdf>

⁴³ SUC, Proposal for a cooperation and innovation project or programme, project contributions 2008–2011, project title: “Nano-Tera.ch”, June 2007. Nano-Tera.ch. The Swiss Initiative Engineering and information technology for health and security of the human being, and the environment. Business Plan, 19 November 2007.

sufficiently well defined in terms of its implementation and operationalisation strategy for it to be possible to make a comprehensive assessment and to guarantee the initiative's success. In discussions with SER, the SNSF suggested setting up a working group to formulate specific strategic objectives. While reiterating the principle that projects funded by Nano-Tera.ch should still be scientifically evaluated by the SNSF following the SystemsX.ch model, SER encouraged the SNSF and Nano-Tera.ch to work together more closely. In a first instance, the project evaluation procedure set out in the request to the SUC was revised in the business plan.⁴⁴ The SNSF and Nano-Tera.ch then drew up the first call for proposals.⁴⁵ This document, which was published at the end of January 2008,⁴⁶ set out the programme's overall objectives, namely:⁴⁷

- to improve quality of life and security of people across different levels of education, wealth and age and to create innovative products, technologies and manufacturing methods, thus resulting in job and revenue creation;
- to bridge traditional disciplines, including but not limited to electrical engineering, micro/nano-mechanical systems engineering, biomedical sciences and computer/communication sciences, with the objective of (i) deepening the understanding of enabling technologies and reducing scientific concepts to practice, and (ii) mastering the novel challenges of engineering tera-scale complex systems.

The specific objectives were:

- to pursue excellence in collaborative scientific research in the aforementioned disciplines;
- to create and expand educational programmes;
- to construct demonstrators of the technologies being studied and transfer the results to Swiss industry.

The strategic research focuses covered by Nano-Tera.ch were:

- Research and development of advanced technologies, such as i) microelectromechanical and nanoelectromechanical systems (MEMS/NEMS) and manufacturing processes; ii) (bio)-sensors, actuators and their system-level integration; iii) information and communication sciences as well as systems and software engineering.
- Integration of these technologies into application fields, such as wearable systems (e.g. for monitoring of patients, sportsmen and the elderly), ambient systems (e.g. for environmental intelligence, building monitoring and virtual world) and remote systems (e.g. space applications such as pico-satellites, remote sensing).

The following characteristics distinguished Nano-Tera.ch from other available funding schemes:

- Engineering of complex (tera) systems out of small (nano/micro) components, by leveraging scientific and technological discoveries, with the objective of developing technology demonstrators that can be transformed into products in the medium term;
- Synergy of various disciplines through well-coordinated research efforts, to explore topics at the boundary of traditional scientific domains;
- Collaborative nature and significant funding size of average research projects (and specifically RTD projects) which would not be otherwise available through usual channels (e.g. SNSF projects);
- Social relevance, in terms of projected benefits to health, security and the environment.

⁴⁴ In the request submitted to the SUC (June 2007), the SNSF's role was limited to conducting an international technical review, whereas the ExCom was responsible for scientific and strategic evaluation. In the business plan (November 2007), the procedure was realigned towards the SNSF's forthcoming decision in March 2008 (see below, footnote 55).

⁴⁵ This collaboration required further interventions from SER to remind the leaders of Nano-Tera.ch to respect the framework conditions established on the basis of the SystemsX.ch model. For example, in December 2007, SER explained in a letter that the call for proposals could not be restricted *ex ante* to principal investigators affiliated with the founding institutions of Nano-Tera.ch. Besides the absence of a legal basis, a restriction of this sort would go against the national and open aspect of Nano-Tera.ch. In the same letter, SER underscored the lack of operationalised strategic objectives serving as evaluation criteria for requests submitted under the Nano-Tera.ch programme as a serious shortcoming, which is why SER supported the SNSF's proposal to review and supplement the call.

⁴⁶ Nano-Tera.ch. The Swiss Initiative in Engineering and information technology for health and security of the human being, and the environment. Call for Proposals [28.01.2008]. http://www.nano-tera.ch/news/textes/nano-tera_call_for_proposals2008.pdf

⁴⁷ These objectives are summarised in Annex B, pp. 20–21.

In addition, the institutional partners that were members of the Nano-Tera.ch consortium also had specific objectives, which were set out in the Ordinary Partnership Contract concluded in January 2008:⁴⁸

- a) Coordinate the national and international collaboration of partners in the field of health-security-environment systems engineering;
- b) Carry out scientific and complex multidisciplinary engineering projects establishing highly specialised development and technology platforms with demonstrators in the field of health-security-environment systems engineering;
- c) Coordinate financial contributions for research projects in the field of health-security-environment systems engineering;
- d) Coordinate the presentation of the partnership under the name Nano-Tera.ch and establish this name as a mark of quality in the field of health-security-environment systems engineering;
- e) Develop and implement common training programmes targeted at young researchers in the field of Health-security-environment systems engineering;
- f) Coordinate and intensify cooperation with the private sector;
- g) Promote a dialogue in and with the public on health-security-environment systems engineering;
- h) Secure additional external funding.

The objectives of Nano-Tera.ch remained largely unchanged, with the exception of a few details. From 2009, the call for proposals specified that, in order to be eligible for funding, RTD projects had to comply with the strategic funding objectives of Nano-Tera.ch.⁴⁹ From the 2011 call onwards,⁵⁰ Nano-Tera.ch covered the field of energy in addition to health, security and the environment.⁵¹ From 2012 onwards,⁵² every RTD project had to integrate end users and no longer just an industrial partner, as had been the case during phase I.⁵³

The SNSF's role in the implementation of Nano-Tera.ch was outlined in 2007 in an implementation scheme. The guiding principles and general procedure of the scientific evaluation by the SNSF were formulated in the Ordinary Partnership Contract signed in January 2008.⁵⁴ This document specified that the SNSF could state its opinion on the initiative in general and on the scientific quality of RTD projects, while the ExCom adjudicated on their compliance with strategic goals. The final funding decision rested with the SNSF's National Research Council. Following a meeting held in January 2008 between Nano-Tera.ch and the SNSF, the decision was made not to specify in the call for proposals being drafted which party was responsible for which scientific or strategic criteria, on the grounds that assessment of such criteria was de facto interdependent.

In March 2008, the National Research Council approved the official regulation governing evaluation of RTD Nano-Tera.ch projects by the SNSF.⁵⁵ This document, which is available on the Nano-Tera.ch website, details the principles, procedures and criteria. In particular, the SNSF panel was responsible for the scientific evaluation of RTD applications. Nano-Tera.ch was required to inform the SNSF panel in writing in advance of the evaluation whether or not it considered an application to be compliant with the general programme (Art. 4). If there were divergent opinions, the final decision rested with the SNSF panel (Art. 6 para. 2). Finally, the SNSF panel received Nano-Tera.ch's scientific annual reports and

⁴⁸ Nano-Tera.ch. Ordinary Partnership Contract, January 2008, Art. 1 let. 2.

⁴⁹ Nano-Tera.ch. The Swiss Initiative in Engineering and information technology for health and security of the human being, and the environment. Call for proposals 2009. http://www.nano-tera.ch/news/textes/nano-tera_call_for_proposals_2009.pdf

⁵⁰ Nano-Tera.ch. The Swiss Initiative in Engineering and information technology for health and security of the human being, and the environment. Call for proposals 2011. http://www.nano-tera.ch/pdf/Nano-TeraCall_2011.pdf.

⁵¹ This decision followed a recommendation by the SNSF panel. A previous version of the call for proposals 2011, which was issued unilaterally by Nano-Tera.ch, did not include this dimension.

⁵² Nano-Tera.ch. The Swiss Initiative in Engineering and information technology for health and security of the human being, energy and the environment. Call for proposals 2012, http://www.nano-tera.ch/pdf/NT_Call_2012Final.pdf

⁵³ Besides the introduction of end users, the SNSF panel also suggested implementing a specific instrument for KTT within RTD projects.

⁵⁴ Nano-Tera.ch. Ordinary Partnership Contract, January 2008.

⁵⁵ SNSF. Regulation of Nano-Tera.ch applications (Approved by the Swiss National Research Council on 12 March 2008), http://www.nano-tera.ch/news/textes/nano_tera_regulation.pdf

could judge the progress of the overall programme (Art. 15 para. 2). The SNSF panel's recommendations concerning all projects and reports were taken into account by SER for decisions regarding the continuation of the programme (Art. 15 para. 3).

Most of the changes that appeared in the various Nano-Tera.ch calls for proposals were the result of recommendations by the SNSF panel. Their implementation sometimes required clarification, such as when the management of Nano-Tera.ch was required to take account of the SNSF panel's recommendations on phase I when drafting a funding request to the SUC for phase II. These collaboration difficulties appeared to be resolved from phase II, and the SNSF panel remarked that the scientific results were excellent. In May 2012, the SNSF confirmed in a letter to the SUC that collaboration with Nano-Tera.ch was progressing smoothly. However, the Presiding Board of the Swiss National Research Council observed that, where appropriate, the design of such research initiatives should be fundamentally re-examined.

3. SSC analysis

3.1 Scientific impact

Key statements⁵⁶

- *Nano-Tera.ch has promoted excellence in research in various domains of engineering sciences.*
- *Nano-Tera.ch has fostered strongly collaborative research.*
- *Nano-Tera.ch has fostered strongly interdisciplinary research.*
- *Nano-Tera.ch has triggered inter-institutional collaborations among very diverse players at the national level.*
- *Nano-Tera.ch has fostered strongly applications-oriented research in various domains of engineering sciences.*
- *Nano-Tera.ch has funded ambitious projects.*
- *Nano-Tera.ch has an almost exhaustive coverage of the Swiss scientific community in the programme's fields.*

3.1.1 Analysis

The scientific results of Nano-Tera.ch were excellent overall. The SNSF panel noted this from the end of phase I, highlighting the extent to which the interdisciplinary and inter-institutional collaboration encouraged researchers to focus on application. Although Nano-Tera.ch operated in a context in which large amounts of public funding were available,⁵⁷ the financial scope, duration and the interdisciplinary and inter-institutional nature of projects helped make the initiative a unique opportunity to develop the field of engineering sciences. The self-assessment report presents these aspects in detail.⁵⁸ That said, the lack of comparable programmes in the same scientific field which can be used as benchmarks makes it difficult to assess the results,⁵⁹ even though the number of publications and conferences in absolute terms illustrates the quality and intensity of the research produced.

The overall scientific quality of Nano-Tera.ch is also noted in the SSC expert panel's report, in particular from the point of view of inter-institutional collaboration.⁶⁰ However, the international experts found that the demonstration of interdisciplinarity in the self-assessment report and during the site visit was not entirely convincing.⁶¹ Just under one third of Nano-Tera.ch publications are by two authors partnering on the same project (PI and co-PI); the vast majority (over 70%) remain the work of a single PI or co-PI.⁶² This result is in sharp contrast with the collaborative spirit during project implementation, when an average of 2.4 partners (PIs or co-PIs) were in charge of the same research focus.⁶³ Equally, the self-assessment report notes an overall average of 2.73 different disciplines per RTD project.⁶⁴ Measuring the performance of interdisciplinary research is complex, as the publication of an article is based on a strategy involving reputational criteria linked to academic careers (reward system), and interdisciplinary reviews are sometimes lacking.⁶⁵ However, this asymmetry between the research implementation phase and the results publication phase suggests that more attention could have been paid to interdisciplinarity.

The SSC expert panel considers that the scale and duration of RTD funding helped Nano-Tera.ch to reach a critical threshold necessary to match the ambition of the projects and objectives. Nano-Tera.ch appears to distinguish itself less by the originality of its projects than by the consolidation and orientation towards scientific excellence and application of an engineering sciences research community, for the main part from the Swiss federal institutes of technology. According to the SSC analysis, some 80% of PIs on the 44 RTD projects were affiliated with the ETH Domain, either the EPFL (22 PIs) or the ETHZ

⁵⁶ All Key statements are quotations from the SERI mandate, Annex A.

⁵⁷ Cf. section 2.1.

⁵⁸ Annex B, pp. 49-60. Note in particular (p. 56) the overall average for the 44 RTD projects of 2.7 institutions of different types (i.e.: ETH Domain, cantonal university, university of applied sciences, university hospital, public or private research institute, etc.).

⁵⁹ SystemsX.ch cannot be used as a benchmark due to the significant differences in the objectives.

⁶⁰ Annex C3.

⁶¹ Annex C3, p. 3, question I/2.

⁶² Annex B, p. 53, chart 'Number of joint publications'.

⁶³ Annex B, pp. 52-53, chart 'Number of Research Group per Research Task'.

⁶⁴ Annex B, p. 55. The method and criteria used to define the disciplines considered are not specified, however.

⁶⁵ This problem is not unique to Nano-Tera.ch: "ID [interdisciplinary research] tends to struggle to get published in high impact factor journals. More broadly, limitations of research metrics for ID work have been well-documented, so funders are more likely to retreat from metrics use in this domain." Kolarz 2017, p. 34.

(13 PIs). The rest were split between the CSEM (3 PIs, approx. 7%) and cantonal universities (6 PIs, approx. 14%), i.e. three at the UniBAS and one each at the University of Geneva (UniGE), the University of Lausanne (UniL) and the University of Bern (UniBE). The Nano-Tera.ch research community largely originates from the NCCRs, with which it shares several PIs and co-PIs. For example, 23 Nano-Tera.ch PIs were from the first series of NCCRs.⁶⁶ Subsequently, several PIs from Nano-Tera.ch joined other NCCRs in the third and fourth series.⁶⁷

Researchers funded by Nano-Tera.ch as PIs or co-PIs also benefited from SNSF support for other applications made during the same period. According to an internal SNSF analysis submitted to the SSC, Nano-Tera.ch PIs and co-PIs received more than 1,077 SNSF grants, worth a total of CHF 401.7 million. See the table below for details:⁶⁸

SNSF funding category	# Grants	MCHF	% total SNSF funding
Project funding	728	225.5	7.4
Programmes ⁶⁹	179	133.3	13.7
Infrastructure	122	31.5	10.7
Science communication	33	1.2	2.7
Careers	15	10.3	0.9

This result is testament to the success of researchers supported by Nano-Tera.ch in securing funding. It also suggests that Nano-Tera.ch was not the only funding opportunity for the researchers concerned. On the other hand, the average financial allocation per RTD project (CHF 2.1 million)⁷⁰ was much greater in Nano-Tera.ch than the average granted by the SNSF per independent research project (approx. CHF 310,000),⁷¹ even though the number of beneficiaries was smaller (44 RTD projects). The funding from Nano-Tera.ch therefore complements that of the SNSF.⁷²

The SSC expert panel laments Nano-Tera.ch's lack of international strategy.⁷³ It also notes that the various international measures with strategic scientific goals taken by the ExCom were not based on an initial in-depth analysis. For example, the reference centres abroad cited in the 2007 business plan were located in the United States, the Netherlands, Belgium and Japan,⁷⁴ yet the ExCom used its strategic funds to fund Nano-Tera.ch's participation in a scientific cooperation programme between Switzerland and China from 2011 to 2013,⁷⁵ then in the Switzerland-Korea Joint Workshops held at the EPFL in May 2013. As part of an International Exchange Programme, Nano-Tera.ch organised four international symposia between 2013 and 2017. Only three individual speakers were invited to attend the whole programme.⁷⁶

The SNSF panel played a crucial role in the overall quality of Nano-Tera.ch. For example, its recommendations to PIs following the mid-term evaluation meetings regularly mentioned the issue of transferability of results, illustrating the panel's focus on application. In its assessment submitted in 2011, before the transition to phase II, the SNSF panel highlighted the overall excellence of Nano-Tera.ch, in partic-

⁶⁶ NCCR MICS, Quantum Photonics, Nanoscale Science, CO-ME, Neuro, Molecular Oncology, MaNEP, Structural Biology, IM2.

⁶⁷ NCCR 3rd series: Robotics; QSIT; MUST; chembio; TransCure. NCCR 4th series: MSE, MARVEL.

⁶⁸ Source: Annex E.

⁶⁹ Excluding the NCCRs.

⁷⁰ Annex B, p. 14, Table 'Funded projects'.

⁷¹ CHF 225.5 million / 728 = approx. CHF 310,000.

⁷² As a reminder, one of the characteristics of Nano-Tera.ch announced in the first call for proposals in 2008 is: "Collaborative nature and significant funding size of the average research projects (and specifically RTD projects) which would not be otherwise available through usual channels (e.g. SNSF projects)." Nano-Tera.ch. The Swiss Initiative in Engineering and information technology for health and security of the human being, and the environment. Call for proposals [28.01.2008]. http://www.nano-tera.ch/news/textes/nano-tera_call_for_proposals2008.pdf

⁷³ Annex C3, pp. 7–8.

⁷⁴ Namely: in the United States: Wireless Research Center (BWRC) (University of California, Berkeley), High Performance Wireless Research and Education Network (HPWREN) (University of California, San Diego); in the Netherlands: Holst Centre (Human++ research programme); in Belgium: IMEC; in Japan: Ambient SoC Center of Excellence (University of Waseda).

⁷⁵ Six projects funded with approximately CHF 530,000 (Annex B, p. 13), as part of the Sino-Swiss Science and Technology Cooperation (SSSTC) programme, launched in 2008 following a pilot phase (2004–2007).

⁷⁶ Annex B, pp. 51, 89–92.

ular as a funding scheme for application-oriented research in engineering sciences. It strongly recommended continuing the programme. However, it also considered it necessary to strengthen the programme's application potential. It therefore suggested introducing a specific programme to foster the transfer of results to industry (KTT). The SNSF panel also recommended that all RTD projects in phase II should be required to integrate practitioners from the field in question, such as potential end users (e.g. doctors in public health projects). By doing this as soon as the research goals were formulated, the results could be more readily applied to practice. The request was implemented in the 2012 call for proposals with the addition of a criterion on end users for RTD project applications.⁷⁷

These recommendations reflect the SNSF panel's concern to take measures to ensure the implementation of Nano-Tera.ch's strategic objectives. In 2016, the panel considered that "the programme is on the path to success. Several projects are already able to show both significant innovations as well as very good scientific output. They have already produced a demonstrator or will have demonstrators ready by the end of the grant duration. They show significant potential to have a real impact on innovation in their respective domains. The collaboration between the research groups of different institutions, backgrounds and disciplines seems to work quite well for most projects. In the panel's opinion, the Nano-Tera.ch programme therefore showed the usefulness of a new and complementary type of funding scheme in Switzerland promoting application-driven projects, where interactions between scientific, engineering, and innovation-based activities are enabled."⁷⁸

3.1.2 Conclusions

- Generally speaking, Nano-Tera.ch produced research of excellent quality, guiding the engineering sciences research community towards interdisciplinary and inter-institutional collaboration and application. These results appear to relate more to the intrinsic quality of Nano-Tera.ch researchers and to the criteria used for the allocation of RTD projects than to implementation of the programme by the ExCom.
- The SNSF panel was in large part responsible for ensuring the application-based approach of the RTD projects, both during the annual evaluations and after phase I. The criticism that the SNSF panel made a strictly scientific selection ("SNSF-only selection") therefore seems unjustified.⁷⁹ However, certain strategic decisions made by the ExCom, particularly at international level, appear to bear little relation to the initial objectives, or were simply not subject to an in-depth initial analysis. Measures to complement the selection criteria for RTD projects, for example to strengthen interdisciplinarity, do not appear to have been implemented.
- The SNSF and Nano-Tera.ch position statements on the SSC expert panel's report⁸⁰ reflect the divergences of opinion encountered in the running of the programme, in particular regarding the selection process for RTD projects.⁸¹ The lack of concrete strategic scientific objectives hampered the implementation of specific measures to ensure the effectiveness of the initiative. For example, the Gateway programme to support KTT was only introduced in 2015 and was limited to eight projects.⁸²

3.2 Educational impact

Key statements

- *Nano-Tera.ch has substantially contributed to the training of next generation researchers (PhD students, Post Docs).*

⁷⁷ See Nano-Tera.ch. The Swiss Initiative in Engineering and information technology for health and security of the human being, energy and the environment. Call for proposals 2012. http://www.nano-tera.ch/pdf/NT_Call_2012Final.pdf. The first call for proposals in phase II, launched in the autumn of 2011, did not yet include the SNSF panel's request regarding end users (cf. Nano-Tera.ch. The Swiss Initiative in Engineering and information technology for health and security of the human being, and the environment. Call for proposals 2011. http://www.nano-tera.ch/pdf/Nano-TeraCall_2011.pdf). Implementation of the KTT programme occurred in 2015 with the launch of the Gateway programme. See section 3.3.

⁷⁸ SNSF, RC Presiding Board, 502th meeting, 12 July 2016, agenda item 7.1 (Nano-Tera.ch: Mid-term evaluation).

⁷⁹ Contrary to the analysis by the SSC expert panel, cf. Annex C3, p. 5.

⁸⁰ Annexes C31 and C32.

⁸¹ See chapter 2.

⁸² See section 3.3.

- *Nano-Tera.ch has encouraged stronger collaborative spirit in the community of PhD students involved in the program and increased their autonomy by giving them the opportunity to submit their own collaborative research proposals.*
- *Nano-Tera.ch has encouraged stronger entrepreneurial spirit in the community of PhD students involved in the program.*

3.2.1 Analysis

The main educational outcome of Nano-Tera.ch was the training of 366 PhD students over the course of the programme. The Nano-Tera.ch PhD students benefited from the interdisciplinary focus and the holistic approach specific to the “Nano”-“Tera” dimensions of the initiative, which reinforced their added value in both scientific and economic terms.⁸³ A survey conducted among PhD students receiving funding from Nano-Tera.ch between 2009 and 2013 (308 responses) revealed that 208 had found a job: 39% in academia (57% in Switzerland), and 61% in industry (75% in Switzerland).⁸⁴

Support for PhD students and post-docs within Nano-Tera.ch was mainly provided through RTD projects, which attracted around 80% of financial resources. Another source of funding, albeit much smaller,⁸⁵ was Education and Dissemination (ED) project funding, which was managed and allocated solely by the ExCom.⁸⁶ In a total of sixty-one ED actions (total funding of CHF 1.4 million), PhD students received one-time funding to cover short courses, workshops, mini conferences, etc.⁸⁷

From phase II, a number of more targeted measures were introduced, such as a meeting of PhD students held the day before Nano-Tera.ch’s annual meeting in 2014 which included an information session on the exploitation of their results, particularly at industrial level.⁸⁸ However, the main support for PhD students outside of RTD projects remained the NextSteps programme, launched with its own coordinator in 2015. This programme, which is based on the results of the survey conducted among PhD students who received funding between 2009 and 2013, aims to reinforce interdisciplinary collaboration among PhD students (track 1: Scientific collaboration), promote their entry into the labour market (track 2: Entrepreneurship) and strengthen their communication skills (track 3: ‘My Thesis in 180 Seconds’).

The SCC shares the opinion of its expert panel⁸⁹ that the NextSteps programme meets the standards of targeted support for PhD students in a programme on this scale.⁹⁰ However, its late introduction meant that participation was low (seven projects for track 1 and four for track 2),⁹¹ and its potential impact reduced. Similarly, NextSteps was financed within the framework of ED projects, so the financial allocation was somewhat reduced.⁹² In addition, as highlighted by the SSC expert panel,⁹³ Nano-Tera.ch did not implement any specific measures directed at post-docs, particularly PIs and co-PIs, although such measures could have increased the latter’s focus on application and translation.

3.2.2 Conclusions

- The main impact of Nano-Tera.ch in educational terms lies in the training of 366 PhD students. The quality of doctoral training is clear, both in terms of the needs of academia and of industry.

⁸³ This point was confirmed by the interviews conducted by the SSC.

⁸⁴ Source: Annex B, p. 72. The date of the survey is not precise, but in all likelihood it took place in 2014–2015. Of the 100 people not in employment, 93 had not completed their PhDs and 7 were unemployed. The rate of 39% (academia) and 61% (industry) thus refers to a total of 208 PhD students, and not the 366 PhD students supported over phases I and II. See also section 3.3.

⁸⁵ 1.2% of the total budget, according to Annex B, p. 13. The category ‘PhD Projects’ (CHF 1.3 million) is not clearly defined in the self-assessment report.

⁸⁶ According to the Ordinary Partnership Contract, these projects were supposed to take the form of e.g. short courses, workshops and mini conferences and aimed to develop the new teaching syllabuses in fields not covered by partner universities. Cf. Nano-Tera.ch. Ordinary Partnership Contract, January 2008, Art. 32.

⁸⁷ The self-assessment report (Annex B) does not present these activities in detail. There do not seem to have been any special measures to promote the participation of women (77 PhD students: 21%).

⁸⁸ Nano-Tera.ch, Scientific Report 2014, 1 June 2013 – 31 May 2014, pp. 22–23.

⁸⁹ Annex C3, p. 5.

⁹⁰ This assessment applies to tracks 1 and 2. The competition ‘My Thesis in 180 Seconds’ (track 3) is a rework for the Nano-Tera.ch community of a competition first introduced in Switzerland by the EPFL in 2015 and based on an idea (2008) from the University of Queensland in Australia, cf. <https://mediacom.epfl.ch/mt180-en> and <https://threeminutethesis.uq.edu.au/about>.

⁹¹ Annex B does not specify the total number of persons supported under NextSteps.

⁹² Annex B does not specify the exact amount of funding for NextSteps.

⁹³ Annex C3, p. 5.

- The bulk of Nano-Tera.ch support to PhD students and post-docs was in the form of regular funding for RTD projects. There was no strategic concept for doctoral training on the part of the programme's management, and one-off support (ED projects) constituted a minimal share of the allocated budget. The ED measures do not appear to have led to the creation of new syllabuses at partner institutions.⁹⁴ No specific measures to encourage the participation of women on doctoral programmes or to support post-docs appear to have been implemented.
- NextSteps (tracks 1 and 2) was a convincing but delayed realisation of a transversal concept in this area, yet concentrated on PhD students only and was limited to a restricted number of projects, most of which were successful, as illustrated by the creation of three start-ups at the end of track 2. The rework of track 3 of NextSteps (My Thesis in 180 Seconds) was not specifically adapted to Nano-Tera.ch.
- There is no mention of the educational measures such as NextSteps being continued in partner institutions after the conclusion of Nano-Tera.ch.
- Monitoring of the educational impact lacks detail.

3.3 Economic impact

Key statements

- *Nano-Tera.ch has fostered research with high economic potential.*
- *Nano-Tera.ch has deployed a novel pilot funding instrument (the Gateway programme) efficiently combining support for research and innovation and integrating an appropriate monitoring mechanism.*
- *Nano-Tera.ch has fostered user-centric research with an early involvement of field practitioners through field tests, clinical studies, etc.*
- *Nano-Tera.ch has contributed to the dissemination of the scientific results achieved to the Swiss industry.*

3.3.1 Analysis

The economic impact of Nano-Tera.ch shows significant potential. Besides programmes for PhD students that are adapted to the needs of industrial players, most projects in both phases resulted in the production of demonstrators, platforms or prototypes, start-ups and other standard indicators of potential success in terms of economic impact (patents, licences, CTI funding, etc.).⁹⁵ The majority of these results were obtained by RTD projects, mobilising a broad range of instruments for transfer to the economy and society.⁹⁶ The financial contribution of industrial partners/end users to RTD projects did not exceed 20% of total RTD funding,⁹⁷ yet the number of industrial partners/end users (103 for 44 RTD projects) benefited the dissemination of results from Nano-Tera.ch.

An external study commissioned by the SSC examined the design and implementation of KTT in Nano-Tera.ch.⁹⁸ Based on an in-depth document analysis, 15 interviews and three case studies, it appears that the design of KTT in Nano-Tera.ch is based on a reflective model.⁹⁹ KTT in Nano-Tera.ch involved collaboration in research, the participation of third-party partners from the public and private sectors, and training of highly qualified staff.¹⁰⁰ However, KTT is not explicitly defined in terms of its design and implementation in projects;¹⁰¹ it is implicitly derived from the overall goals of Nano-Tera.ch.¹⁰² The extent

⁹⁴ This point was not covered in the self-assessment report (Annex B), although for example the Advanced Learning and Research Institute (ALaRI) at the l'Università della Svizzera italiana (USI) opened a Master Program on Cyber-Physical and Embedded Systems in 2017, in which several PIs from Nano-Tera.ch are involved, cf. <http://www.alari.ch/education/master-science>.

⁹⁵ As shown in Annex B (p. 71), ten start-ups emerged from projects supported by Nano-Tera.ch (six set up, four in the process of being set up). In addition to this, three start-ups were set up based on work carried out by PhD students supported by NextSteps (Annex B, p. 69). During the site visit of 13–14 November 2017, the Nano-Tera.ch representatives mentioned forty start-ups rather than ten. A list was sent to the SSC secretariat. This difference in numbers reflects the difficulty in establishing a causal link between a research programme and the creation of a start-up, but also demonstrates the inadequacy of the monitoring process.

⁹⁶ See the external study commissioned by the SSC, Annex D, p. 29.

⁹⁷ The financial contribution from private third-party funds and industrial partners totalled CHF 18 million (cf. Annex B, p. 72), or around 19% of total RTD funding allocated (CHF 95 million: Annex B, p. 13).

⁹⁸ See Annex D.

⁹⁹ For a definition of the KTT models, see Annex D, pp. 21 ff.

¹⁰⁰ Annex D, p. 25.

¹⁰¹ Annex D, pp. 8–9.

¹⁰² In particular from the 2007 business plan, cf. Annex D, pp. 24–25.

to which KTT was implemented therefore depends on how important it is deemed in each project. Furthermore, not all RTD projects involve the same understanding of KTT, which depends on several factors, such as disciplinary cultures, the goals of the research project and the ability of partners to collaborate. Several RTD projects are more geared towards basic research than applied research, so KTT is also marked by a more conventional linear approach.¹⁰³ In this sense, Nano-Tera.ch is not fundamentally different from other contemporary research programmes, such as the first series of NCCRs (launched in 2001).¹⁰⁴ However, this scattergun approach to KTT was criticised by the SSC expert panel, and by the external study commissioned by the SSC. A study of good practices could have been carried out in Europe and beyond at the beginning of the programme in order to establish effective KTT. Finally, it should be noted that since 2011, the SNSF has asked every NCCR to draw up a strategic document concerning KTT. This change was introduced in the third series of NCCRs in 2010. Since the fourth series (2014), a detailed action plan has been required.¹⁰⁵

The approach to KTT has evolved over the course of the Nano-Tera.ch initiative. During phase I, RTD projects were required to have an industrial partner. This obligation was modified in 2012 (phase II): an industrial partner was still recommended but no longer compulsory, and the obligation to involve an end user was introduced. This change was made following a consideration of the ways in which the economic impact of projects could be reinforced and results better focused on the initiative's strategic goals. Stemming from recommendations made by the SNSF panel at the end of phase I,¹⁰⁶ the need to consider these elements gained ground following an internal study at Nano-Tera.ch, conducted among 15 of the 19 RTD projects funded during phase I.¹⁰⁷ The change in requirement from industrial partner to end user between phases I and II therefore changed the selection criteria for RTD projects. This modification was a necessary improvement in the funding scheme, and undoubtedly the most effective given the concentration of funding on RTD projects. The other measures taken by the Nano-Tera.ch management, which did not relate to the RTD budget, were unable to achieve a comparable effect. In 2014, a collaboration was thus launched with the EPFL's tech transfer office, in the form of an Industrial Valorisation Fund (IVF), which enabled four initiatives originating from RTD projects to find lasting private partners.¹⁰⁸ In 2015, one of the components of the NextSteps programme was launched (track 2: Entrepreneurship), as well as the Gateway programme.

Following an initial pilot phase in November 2015 (four projects), the Gateway programme was officially launched in November 2016 (also four projects). The principal role of the programme coordinator was to provide coaching to the supported projects. The design and internal organisation of the programme did not elicit any particular remarks, and the SSC considered that it met quality standards, in particular concerning the selection process and project monitoring. By providing an interface with industry and by improving the Technology Readiness Level (TRL) of supported projects, Gateway reinforced the economic impact of Nano-Tera.ch results. The programme was a welcome addition to the introduction of end users during phase II, whose integration in projects was sometimes complex.¹⁰⁹ According to the SSC expert panel, Gateway is an excellent measure but the funding it received (CHF 1.6 million) was too modest and it was introduced too late to be effective.¹¹⁰ Above all, the experts emphasise the greater advisory role that the industrial partners could have played, both in Gateway and in RTD projects, if an industrial advisory board had been set up at management level and in each RTD project, for example with industrial mentors for PhD students.

¹⁰³ See the case studies presented in Annex D, chapter 4.

¹⁰⁴ Annex D, pp. 41 ff.

¹⁰⁵ SSIC 2015, p. 75 and p. 96. In 2016, an assessment of the first phase of Swiss Competence Centres for Energy Research (SCCERs) highlighted the lack of strategic objectives and the absence of tools to allow effective monitoring. The CTI then asked the SCCERs to draw up a Top Innovation Chart to implement the objectives. See Hammer and Iten 2016 (summary), Ott et al. 2016, Ess et al. 2016, Buser et al. 2016, Good and Ohler 2016, and CTI 2016 (CTI position statement).

¹⁰⁶ Cf. section 3.1.2.

¹⁰⁷ Cf. Annex D, pp. 23–25.

¹⁰⁸ Annex B, p. 74.

¹⁰⁹ Annex D, p. 9.

¹¹⁰ Annex C3, pp. 6–8.

The implicit reflective KTT model, coupled with the measures implemented during phase II, contributed to achievement of Nano-Tera.ch's ambitious economic objectives.¹¹¹ The diversity of concepts allowed research groups to adapt the implementation of KTT to their needs, i.e. their schedules and ways of working, in an autonomous way. This is reflected in the diversity of KTT channels employed by different projects.¹¹² Moreover, collaboration with an industrial partner is only worthwhile from a certain development threshold, and this may vary by discipline. Conversely, integrating end users at the stage when research objectives are formulated encourages project leaders to consider the applicability of the anticipated results. All of this results in overall high quality of KTT, at least in the case studies conducted for the external analysis.¹¹³

This implicit model has its limits, however. The lack of a clear KTT concept at strategic level made KTT more dependent on individual researchers' tendency to prioritise scientific objectives over the economic. While changing the selection criteria for RTD projects in phase II encouraged the transferability of results, it did not entail a fundamental change in of the way KTT was implemented in RTD projects. Certainly, unlike in Gateway, there was too little formal monitoring of KTT in RTD projects.¹¹⁴ This despite the fact that the Nano-Tera.ch managers had announced in the 2007 business plan¹¹⁵ that they intended to develop a systematic monitoring system modelled on the Microelectronics Advanced Research Corporation (MARCO), which managed the US Focus Center Research Program from 1997 to 2013.¹¹⁶

3.3.2 Conclusions

- In general, Nano-Tera.ch showed great economic potential as it trained qualified staff in a key field of industry, created promising start-ups and promoted established ones, and produced demonstrators and prototypes. The RTD projects made use of a broad range of KTT methods, reflecting the broad span of Nano-Tera.ch from basic to applied research. However, the fact that these results originate less from clear implementation strategy design than from improvement measures implemented during the course of the programme considerably limited the potential economic impact.
- The introduction of end users as a selection criterion for RTD projects in phase II reflects the concerted effort of the Nano-Tera.ch management and of the SNSF panel to find ways of improving KTT in projects. The original funding scheme needed to be modified in this way in order to better align the selection criteria with Nano-Tera.ch's strategic objectives. In the second half of phase II, the Nano-Tera.ch management introduced some complementary measures, in particular the Gateway programme; however, the effectiveness of these measures was limited due to their modest funding and delayed introduction.
- The concept of KTT in RTD projects was based on an implicit reflective model. The implicit dimension of this concept encouraged autonomous implementation of KTT according to the specific needs and capacities of each project. However, this very flexibility limited the strategic management of KTT throughout the initiative, as there was insufficient monitoring and no explicit concept developed by the Nano-Tera.ch management. The advisory role of industrial players at the programme management level and within projects seems to have been insufficiently considered. Finally, private financial contributions remained very low for an initiative explicitly geared towards application.

3.4 Societal impact

Key statements

- *Nano-Tera.ch has contributed to steering the research funded toward current social needs (health, environment, energy, etc.).*
- *Nano-Tera.ch has contributed to disseminating the results achieved within and beyond the Nano-Tera.ch community.*

¹¹¹ Annex D, pp. 38–39.

¹¹² Annex D, p. 37, Table D 4.3.

¹¹³ Annex D. In the three case studies reviewed, all collaborations with the public or private sector appear to continue after funding from Nano-Tera.ch has ended.

¹¹⁴ Annex D, p. 10, 40.

¹¹⁵ Nano-Tera.ch. The Swiss Initiative Engineering and information technology for health and security of the human being, and the environment. Business Plan, 19 November 2007, pp. 32–33.

¹¹⁶ See NRC 2003 and <https://www.src.org/program/fcrp/>

- *Nano-Tera.ch has implemented efficient pilot actions to promote the activities of the programs in high school and towards younger children.*

3.4.1 Analysis

Formulating societal objectives and measuring the societal impact of a research programme is a complex challenge, where the choice of methods and the quality of data are crucial.¹¹⁷ In the case of Nano-Tera.ch, the societal impact was not a priority of the strategic objectives.¹¹⁸ The contribution of Nano-Tera.ch to society was seen more as an indirect effect, aimed at raising awareness of the potential societal impact of engineering sciences.

The results presented by Nano-Tera.ch in its self-assessment report show a convergence between the fields covered by the scientific projects in Nano-Tera.ch and the concerns of the public and of policy-makers.¹¹⁹ However, this is not strictly speaking a societal impact linked to the activity of Nano-Tera.ch during the period from 2008 to 2016. Neither the SSC expert panel nor the SSC believe that the method used to present the societal impact of the Nano-Tera.ch programme was particularly convincing. Specific measures targeted at young people were implemented in 2015 and 2016, with the results of some projects being presented in EPFL activities.¹²⁰ But for the most part, the societal dimension seems to have been projected via more conventional institutional communication channels, such as the website, publications for the general public, and numerous interviews given in the Swiss media.¹²¹

In the view of the SSC expert panel, these various measures, and in particular the presence in the Swiss media, reinforced the potential impact of funded projects.¹²² For the SNSF panel, Nano-Tera.ch primarily managed to raise awareness among researchers of the need for interdisciplinary collaboration to address societal challenges.¹²³ End-user participation in RTD projects in phase II also strengthened the societal impact of RTD projects.¹²⁴ For example, thanks to collaboration with end users in Zurich and Lausanne, the detectors and individual mobile sensors developed in the OpenSense I and II projects helped to improve air pollution monitoring in urban areas.¹²⁵ The Institute of Social and Preventive Medicine, Lausanne is currently looking into how to process these new data while respecting the privacy of sensor carriers.¹²⁶

3.4.2 Conclusions

- Nano-Tera.ch helped promote a vision of engineering sciences geared towards the needs of society. A specific societal impact of the funded projects lies in an awareness among research groups of the importance of addressing these issues via interdisciplinary collaboration involving end users.
- Societal impact was not a strategic priority of Nano-Tera.ch. The specific measures developed mainly involved raising the profile of Nano-Tera.ch with the general public (general communication) and with young people (in 2015 and 2016). However, the presented results are not sufficiently backed up to establish a causal link between the measures taken by Nano-Tera.ch and the effects observed.
- With the exception of the programme's annual meeting, most of the measures cited under societal impact were occasional, limited to the EPFL or introduced in phase II.

¹¹⁷ For an overview, see in particular: Bornmann 2012, Bornmann & Marx 2014, de Jong et al. 2014.

¹¹⁸ This dimension is virtually absent in initial documents: it is not mentioned at all in the 2007 business plan; only the summary of the request to SUC refers to it (SUC, Proposal for a cooperation or innovation project or programme, project contributions 2008-2011, project title: Nano-Tera.ch, June 2007, p. 36): "The scientific outcome is expected to (...) promote a vision of engineering with social objectives." There is also a reference to the societal dimension in the 2008 call for proposals, which emphasises that the programme is distinguished by its "social relevance, in terms of projected benefits to health, security and the environment." Nano-Tera.ch. The Swiss Initiative in Engineering and information technology for health and security of the human being, and the environment. Call for proposals [28.01.2008]. http://www.nano-tera.ch/news/textes/nano-tera_call_for_proposals2008.pdf

¹¹⁹ Annex B, pp. 80-84.

¹²⁰ Annex B, p. 93.

¹²¹ 1 to 2 interviews per month on Nano-Tera.ch from 2008 to 2016. Annex B, p. 86.

¹²² Annex C3, p. 8.

¹²³ This aspect was confirmed in the SSC interviews.

¹²⁴ This aspect was confirmed in the SSC interviews.

¹²⁵ See Annex B, pp. 30 and 38 as well as <http://www.opensense.ethz.ch/> and http://opensense.epfl.ch/wiki/index.php/OpenSense_2.html

¹²⁶ SSC interview.

3.5 Institutional impact

Key statements

- *Nano-Tera.ch has substantially contributed to the setting up of the joint SNSF-CTI programme Bridge, a novel funding instrument aiming at better exploiting the economic and societal potential of scientific research by promoting the transfer from scientific knowledge to innovation.*
- *The operational procedures deployed and tested during the Nano-Tera.ch programme are an interesting example of innovative mechanisms for financing and monitoring research with high economic potential.*

3.5.1 Analysis

The key statements from the SERI mandate focus on the Bridge programme,¹²⁷ one of the Federal Council's measures to strengthen the value chain promotion system. It was presented to the Federal Assembly in the ERI Dispatch 2017–2020.¹²⁸ Its total financial allocation is CHF 70 million, with the annual funding amount increasing between 2017 and 2020.¹²⁹ The Bridge programme is a special federal government mandate jointly managed by the SNSF and Innosuisse. It was launched in December 2016 and is still in its pilot phase.¹³⁰ An initial review of its introduction is scheduled for 2019.¹³¹

As for all the dimensions under review, the SSC assessed the institutional impact of Nano-Tera.ch by taking into account the original strategic objectives of the initiative in the first instance.¹³² From this perspective, the Bridge programme cannot be considered a direct institutional impact of Nano-Tera.ch as the implementation of structural measures was not one of the original strategic objectives of the programme.¹³³ This point is emphasised by the Nano-Tera.ch management in its position statement on the SSC expert panel's report.¹³⁴ One might ask, however, given the financial magnitude of Nano-Tera.ch and the scope of its ambitions, whether a structural dimension should not have been included in the initial objectives.

This does not exclude the fact that Nano-Tera.ch may have had a structural impact, in particular at partner institution level. But a degree of caution is advisable when assessing this aspect. For example, the inter-institutional dimension of every RTD project facilitated access to the ETH Domain, albeit modest, by institutions such as the CSEM, the cantonal universities, the universities of applied sciences and university hospitals, both in terms of funding and of the way in which research is organised.¹³⁵ One positive outcome is the fact that a number of inter-institutional and interdisciplinary collaborations continued after the Nano-Tera.ch funding had finished.¹³⁶ Certain strategic initiatives taken by members of the consortium demonstrate a proximity to Nano-Tera.ch. One example is the ETH Domain's Advanced Manufacturing strategic focus area (CHF 20 million, 2016–2020),¹³⁷ in which several beneficiaries and supervisors are former PIs or co-PIs from Nano-Tera.ch.¹³⁸ The Nano-Tera.ch self-assessment report

¹²⁷ <http://bridge.ch/fr/>

¹²⁸ Federal Council (2016), Dispatch of 24 February 2016 on the Promotion of Education, Research and Innovation for the period from 2017 to 2020, Federal Gazette 2016 2917-3178. Besides the Bridge programme, the Federal Council mentions the reform of the CTI to become Innosuisse, and announces that the selection of the next series of NCCRs envisages (p. 2971) "retaining the centres promising basic research of very high quality combined with significant potential for application to innovation that can be achieved in the medium to long term".

¹²⁹ Idem, figure 19 p. 3020 and figure 21 p. 3036. The principle of shared management by two institutions responsible for promoting research (namely Innosuisse and the SNSF) was enshrined in the RIPA (new wording of Art. 7 para. 3).

¹³⁰ Federal Council (2016), Dispatch of 24 February 2016 on the Promotion of Education, Research and Innovation for the period from 2017 to 2020, Federal Gazette 2016, p. 3,016.

¹³¹ 2017–2020 service agreement [between SERI and the SNSF], 31.05.2017. Annex, pp. 4–5. http://www.snf.ch/SiteCollection-Documents/Convention_de_prestations_FNS_2017-2020_F_incl_annexe.pdf

¹³² Cf. section 1.2.

¹³³ Except for the creation of new course programmes as part of ED projects, cf. Nano-Tera.ch. Ordinary Partnership Contract, January 2008.

¹³⁴ Cf. Annex C32, p. 2: "The specific legal status of Nano-Tera.ch ("National Joint Action") did not provide for any potential legacy of the program. In particular, it did not require from the involved institutions any commitment in terms of long-term structural investment (such as the creation of permanent chairs, or institutionalized entities), while this is the case for other funding instruments such as the SNSF's NCCRs."

¹³⁵ SSC interviews.

¹³⁶ According to Annex B, pp. 28–41 and SSC interviews.

¹³⁷ ETH Board (2014), Strategic plan 2017–2020 for the ETH Domain. p. 52 ff.

¹³⁸ Especially: Christofer Hierold, Christian Enz (members of the Steering Committee); Jürgen Brugger (PI project Ceramic X.0), Kristina Shea (PI project SD4D), etc., cf. <https://www.sfa-am.ch/research-projects.html>.

does not provide any information on these aspects, or on the potential continuation at partner institutions of measures taken under Nano-Tera.ch, such as the NextSteps programme.

Between late 2013 and early 2014, the Nano-Tera.ch management was involved in developing a proposal for a new joint funding instrument between the CTI and SNSF in the field of engineering sciences. Drawing on the experience of Nano-Tera.ch and the SNSF programme precoR,¹³⁹ this new instrument aimed to foster the translation of basic research in engineering sciences to application, with the involvement of industry.¹⁴⁰ The instrument had to be separate from the internal organisation of Nano-Tera.ch, which could not be applied; the funding had to come from the regular budgets of the CTI and SNSF.¹⁴¹ In its multi-year programme in 2015, the SNSF announced the launch of the Bridge programme as a joint measure with the CTI to strengthen the transfer of knowledge and innovation.¹⁴² The SNSF justified the setting up of Bridge besides Nano-Tera.ch and precoR by citing its collaboration with the CTI on certain NRPs and experiences from abroad.

Nano-Tera's contribution to the setting up of Bridge is thus proven, and the SSC believes that Bridge includes various aspects which were previously unique to Nano-Tera.ch in the field of engineering sciences, in particular interdisciplinarity, inter-institutional collaboration and targeted support for young researchers. Although the design of Bridge was linked to the experience of implementing Nano-Tera.ch as a programme, and in particular the measures implemented during phase II to reinforce KTT (Gateway programme and NextSteps), it does not seem appropriate to carry out a systematic comparison of these two programmes, especially as Bridge is still in the implementation phase. Without giving an opinion on the criticisms levelled at Bridge with regard to its limited budget or relatively low success rate,¹⁴³ the SSC considers that the Bridge programme clarifies the role of stakeholders in implementation, organisation and the selection procedure, and defines expectations with regard to KTT.¹⁴⁴ In this sense, Bridge can be deemed an indirect impact of Nano-Tera.ch, both on an institutional and organisational level.

3.5.2 Conclusions

- Considering that the institutional impact was not one of the initial strategic objectives of Nano-Tera.ch, it makes sense that no specific measures were taken in this regard by the programme management. This point is not covered as such in Nano-Tera.ch's self-assessment report.¹⁴⁵ This absence is all the more regrettable given that Nano-Tera.ch had considerable financial resources at its disposal and the realisation of its ambitious vision would probably not have been hampered by the introduction of structural objectives.
- The Bridge programme is an indirect institutional impact of Nano-Tera.ch. The Nano-Tera.ch management was involved in the design of the Bridge programme, which is also based on other national and international experiences. Bridge has adopted many positive aspects of Nano-Tera.ch, and its internal organisation also shows that lessons have been learned in terms of governance from the experience of Nano-Tera.ch.
- Nano-Tera.ch highlighted the difficulties linked to the promotion of basic to applied research in engineering sciences. The introduction of the NextStep and Gateway programmes during phase II made it possible to test targeted promotion schemes to improve the translation of results to industry and collaboration with the private sector, including at doctoral programme level (promoting entrepreneurship). However, it is not documented whether these measures were continued within partner institutions.

¹³⁹ Initiative for funding precompetitive research (2014), cf. <http://www.snf.ch/en/funding/programmes/precor/Pages/default.aspx>.

¹⁴⁰ An SSC interview confirmed the need for a greater incentive for collaboration in Bridge than was the case in Nano-Tera.ch.

¹⁴¹ These two points were confirmed in the SSC interviews.

¹⁴² SNSF (2015), Multi-year programme 2017–2020. Planning document for the federal authorities, SNSF, Bern p. 16.

¹⁴³ SSC interviews.

¹⁴⁴ See the various documents on the Bridge website, in particular the Terms of Reference, available at: http://www.snf.ch/SiteCollectionDocuments/Bridge_Terms_of_Reference.pdf

¹⁴⁵ Annex B.

3.6 Broader impact

This section seeks to put in perspective two fundamental aspects of Nano-Tera.ch that emerge from the assessment of the various dimensions in the SERI mandate. These are, on one hand, the added value of the promotion activities carried out by Nano-Tera.ch for the ERI system, and, on the other hand, the main lessons one can take away from the experience of implementing Nano-Tera.ch.

3.6.1 Broader impact of Nano-Tera.ch: what added value for the ERI system?

The research projects supported by Nano-Tera.ch (RTDs) are characterised as follows:

- Interdisciplinary and inter-institutional research groups, with a community mostly from engineering sciences and the ETH Domain, but also integrating other disciplines and resources from the universities, universities of applied sciences, technology competence centres working with higher education institutions, university hospitals and the private sector;
- More funding per project than SNSF independent research projects, and an average duration of four years;
- A socioeconomic orientation, with participation of an industrial partner/end user in each project;
- An implicit KTT model that is more reflective than linear,¹⁴⁶ the production of several demonstrators or prototypes and the creation of start-ups.

During the course of Nano-Tera.ch (2008–2017), various research and education funding schemes and instruments contributed to interdisciplinarity, inter-institutional collaboration, KTT and the orientation of results towards societal goals, according to the varying organisational arrangements and levels of funding.¹⁴⁷ This allowed the whole spectrum of promotion of research, higher education and innovation to be covered, in order to achieve the Federal Council's strategic objectives in the ERI sector. In addition, the priority given to bottom-up approaches was compatible with the federalist structure and the principle of subsidiarity in federal funding.

However, throughout the period from 2008 to 2016, only Nano-Tera.ch (and SystemsX.ch) appeared to combine all these attributes in a single scheme and within the same scientific project. Consequently, the main added value of Nano-Tera.ch is to be found less in its novelty than in the concentration of promotion methods within the same research initiative. Mobilising these methods, covering both basic and applied research, was essential to the attempt to fulfil the programme's highly ambitious initial vision.

By deploying a range of funding opportunities covering the whole value chain, the Nano-Tera.ch initiative responded to the challenges of translating basic research to applied research in engineering sciences. The introduction of the Gateway and NextSteps programmes reinforced this movement, but these targeted measures only concerned a small proportion of projects/PhD students.¹⁴⁸ The added value of Nano-Tera.ch is positive on the whole, but it should be noted that it concentrated on engineering sciences and the ETH Domain, which accounts for almost 80% of PIs.¹⁴⁹ The participation of other disciplines and other institutions was significant, but was shaped by this reality. Finally, Nano-Tera.ch did not have any structural or institutional objectives, which limited its medium- to long-term impact.¹⁵⁰

The experience of Nano-Tera.ch highlighted the need to complement research funding along the entire value chain, in particular in terms of pre-competitive research. The introduction of end users as a selection criterion for RTD projects in phase II demonstrates a welcome capacity for reflection. It was not necessary to wait until the end of Nano-Tera.ch to see certain aspects of the programme's funding system included in the regular funding of the ERI system, first and foremost the Bridge programme.¹⁵¹ In terms of scientific orientation, the emergence of new NCCRs in neighbouring fields,¹⁵² and the launch

¹⁴⁶ For the definition of KTT models, see Annex D, pp. 21 ff.

¹⁴⁷ This particularly concerns the following schemes: the Sinergia funding scheme, the NCCRs and NRPs; CTI funding (supporting innovation, creation of start-ups and national thematic networks); the Swiss Competence Centres for Energy Research (SCCER) launched in 2013; the SUC "project contributions" instrument.

¹⁴⁸ See section 3.3.

¹⁴⁹ See section 3.1.

¹⁵⁰ See section 3.5.

¹⁵¹ See section 3.5.

¹⁵² In particular the NCCRs Robotics, QSIT, MUST chembio, TransCure (3rd series); MSE, MARVEL (4th series).

of the ETH Domain's Advanced Manufacturing strategic focus area were part of a similar momentum. However, in the SSC's view it is too soon to carry out a comparative analysis of these programmes and Nano-Tera.ch. It would be advisable to wait at least until the end of the Bridge programme's pilot phase (2020). Furthermore, such a study should take account of the new RIPA, which entered into force in 2014, and integrate the Swiss Competence Centres for Energy Research (SCCERs),¹⁵³ which continue until 2020.

3.6.2 Reflections on the implementation of Nano-Tera.ch

Nano-Tera.ch came into being thanks to the window of opportunity created by the transition from SystemsX (2004–2007) to SystemsX.ch (2008–2016). The two initiatives were presented to Parliament in the same 2008–2011 ERI Dispatch. The support of the Federal Council and Federal Assembly for SystemsX.ch and Nano-Tera.ch legitimised their inclusion in the funding landscape of the ERI sector. It could therefore appear logical for lawmakers to develop the implementation scheme for Nano-Tera.ch according to the same principles as the one developed for SystemsX.ch. But while SystemsX.ch was built on a previous three-year cooperation between the universities of Basel and Zurich and the ETHZ, the Nano-Tera.ch scientific project came into being in less than six months and the programme was formalised in less than a year.¹⁵⁴

Such rapidity in designing and setting up a programme on this scale is a spectacular achievement. But this design and formalisation phase also saw significant differences of opinion between stakeholders, illustrating a lack of joint vision of objectives, roles and competences.¹⁵⁵ Two central points are worthy of note. On the one hand, the lack of clear strategic objectives to operationalise the initial scientific vision was highlighted by the SNSF as early as 2007, even before Nano-Tera.ch officially launched. This shortcoming impacted the selection process for RTD projects, the formulation of calls for proposals,¹⁵⁶ and the overall implementation of the initiative. On the other hand, concentrating the bulk of financial resources on RTD projects, which were subject to selection by the SNSF panel, was interpreted by the ExCom as a limitation of its room for manoeuvre in implementing Nano-Tera.ch.¹⁵⁷ The SSC analysis suggested that certain assessments were unjustified, for example the claim that the SNSF panel did not take adequate account of industrial aspects when selecting RTD projects.¹⁵⁸ While certain targeted measures initiated by the ExCom reinforced the potential impact of Nano-Tera.ch, such as the Gateway and NextSteps programmes, their effect was reduced due to restricted funding and late introduction in the second half of phase II. Finally, it should be borne in mind that the overall weakness of monitoring, picked up on in particular by the external study commissioned by the SSC,¹⁵⁹ makes it difficult to provide an overall assessment of the results.

The lessons of Nano-Tera.ch for the ERI system have already partially been learned. Two years after the launch of Nano-Tera.ch, the position statements of the SUC, the Rectors' Conference of the Swiss Universities (CRUS), the ETH Board and the SNSF during the total revision of the RIPA were based directly on the experience of Nano-Tera.ch and SystemsX.ch, and called for initiatives of this type "to

¹⁵³ The Swiss competence centers for energy research (SCCERs) were launched in 2013 as part of the "Swiss Coordinated Energy Research" action plan. They are monitored and funded by Innosuisse, in collaboration with the SNSF and the Swiss Federal Office of Energy (SFOE) Cf. <https://www.innosuisse.ch/inno/en/home/thematische-programme/foerderprogramm-energie.html>. See also: Dispatch on the "Swiss Coordinated Energy Research" action plan – measures for the period from 2013 to 2016, dated 17 October 2012, Federal Gazette 2012 8331.

¹⁵⁴ From the decision by the ETH Board to merge the two proposals from the EPFL and the ETHZ (December 2006) to submission of the programme proposal to the SUC (June 2007), and then the creation of Nano-Tera.ch as a simple partnership and the publication of the first call for proposals (January 2008), cf. chapter 2.

¹⁵⁵ Nano-Tera.ch's position statement on the international experts' report commissioned by the SSC demonstrates the persistence of these differences, cf. Annex C32.

¹⁵⁶ See chapter 2.

¹⁵⁷ This point is particularly evident from the perspective of implementation of KTT: "The nature and extent of Nano-Tera's KTT-related measures have been strongly constrained by the imposition to work under SNSF's umbrella, while typically projects involving industry are run by CTI/KTI which was not involved in Nano-Tera.ch," cf. Annex C32, p. 1.

¹⁵⁸ See sections 3.1 Scientific impact and 3.3 Economic impact.

¹⁵⁹ See Annex D, as well as the variations in the number of start-ups created thanks to Nano-Tera.ch (between 10 and 40), cf. section 3.3.1.

be subject to a coordination and decision-making process explicitly regulated in the RIPA".¹⁶⁰ Article 41 paragraphs 5 and 6 of the new RIPA, which entered into force in 2014,¹⁶¹ stipulate that the Federal Council is responsible for planning and coordinating initiatives of this type, in conjunction with actors from the ERI sector, in particular the Swiss Conference of Higher Education Institutions (SCHEI). This modification should help to clarify how to define the strategic objectives of such programmes which are exceptional in scope and organisation. However, greater attention should also be paid to a number of points that the experience of Nano-Tera.ch highlighted:

- An initiative's scientific and socioeconomic objectives should be clearly defined, along with its expected structural effects. Its added value, in particular in terms of organisation and the expected effects, should be set out in an initial document;
- The strategic objectives, implementation concept and selection procedure for projects supported under the initiative should be based on a consensus between stakeholders and should be documented in detail;
- Internal organisation and governance should be compatible with the strategic objectives; they should reflect a prior consensus between stakeholders and should be in keeping with applicable standards, in particular with respect to managing conflicts of interest and monitoring;
- Where the main focus is applied research, the private sector should be involved in defining strategic objectives and implementation, for example by setting up a scientific and economic advisory board;
- The current legal provisions should be examined to verify their effectiveness regarding the formulation of such initiatives, the procedure for selecting projects for funding and the rules of internal organisation.

¹⁶⁰ Dispatch on the total revision of the Federal Act of 9 November 2011 on the Promotion of Research and Innovation, Federal Gazette 2011, p. 8124. Cf. <https://www.admin.ch/opc/fr/federal-gazette/2011/8089.pdf>. See also: FDHA, Total revision of the Federal Act on the Promotion of Research and Innovation (RIPA). Report on the results of the consultation, Bern, 1 September 2010, p. 14. <https://www.admin.ch/ch/f/gg/pc/documents/1764/Ergebnis.pdf>

¹⁶¹ Federal Act of 14 December 2012 on the Promotion of Research and Innovation (RIPA) (version dated 1 January 2018), SR 420.1. <https://www.admin.ch/opc/fr/classified-compilation/20091419/index.html>

Abbreviations

Co-PI	Co-Principal investigator
CRUS	Rectors' Conference of the Swiss Universities
CSEM	Swiss Centre for Electronics and Microtechnology
CTI	Commission for Technology and Innovation
EAER	Federal Department of Economic Affairs, Education and Research
ED	Education and Dissemination
EPFL	Swiss Federal Institute of Technology Lausanne
ERI	Education, research and innovation
ETH Board	Board of the Swiss Federal Institutes of Technology
ETHZ	Swiss Federal Institute of Technology Zurich
ETHZ and EPFL	Swiss Federal Institutes of Technology
ExCom	Executive committee (Nano-Tera.ch)
FDHA	Federal Department of Home Affairs
HEdA	Federal Act on the Funding and Coordination of the Higher Education Sector
IMT	Institute of Microengineering
Innosuisse	Swiss Innovation Agency
IVF	Industrial Valorisation Fund
KTT	Knowledge and technology transfer
m	millions
MEMS	Microelectromechanical systems
NCCR	National Centre of Competence in Research
NEMS	Nanoelectromechanical systems
NRC	National Research Council
NRP	National Research Programmes
NTF	Nano-Tera.ch Focused
O-RIPA-EAER	EAER Ordinance of 9 December 2013 to the Research and Innovation Promotion Ordinance
PI	Principal investigator
precoR	Initiative for funding precompetitive research
PRP	Priority research programmes
RIPA	Federal Act on the Promotion of Research and Innovation
RIPO	Ordinance of 29 November 2013 on the Promotion of Research and Innovation
RTD	Research, technology and development
SCCER	Swiss Competence Centre for Energy Research
SCHEI	Swiss Conference of Higher Education Institutions
SER	State Secretariat for Education and Research
SME	Small and medium-sized enterprises
NSF	Swiss National Science Foundation
SR	Classified Compilation of Federal Legislation
SSC	Swiss Science Council
SSIC	Swiss Science and Innovation Council
SSSTC	Sino-Swiss Science and Technology Cooperation programme
SUC	Swiss University Conference
swissuniversities	Swiss Conference of Rectors of Higher Education Institutions
TRL	Technology Readiness Level
UAS	University of applied sciences
UniBAS	University of Basel
UniGE	University of Geneva
UniL	University of Lausanne
UniNE	University of Neuchâtel
UniZH	University of Zurich
USI	Università della Svizzera italiana

References

- Biniok, P. (2013). *Wissenschaft als Bricolage: die soziale Konstruktion der Schweizer Nanowissenschaften* Bielefeld Transcript-Verlag.
- Bornmann, L. (2012). What is societal impact of research and how can it be assessed? a literature survey. *Journal of the American society for information science and technology*, 64(2), 217–233.
- Bornmann, L. and Marx, W. (2014). How should the societal impact of research be generated and measured? A proposal for a simple and practicable approach to allow interdisciplinary comparisons. *Scientometrics*, 98(1), 211-219.
- Buser, B. et al. (2016). Commission for Technology and Innovation CTI. SCCER Accompanying Research – Module 3: Contacts with Enterprises. Final report of module 3, Ernst Basler + Partner AG, Zurich, Université de Neuchâtel (IRENE), Neuchâtel.
- CSSI Conseil suisse de la science et de l'innovation (2015). Examen systématique des effets de l'instrument Pôles de recherche nationaux PRN (série 1, 2001 – 2013). Rapport et recommandations du Conseil suisse de la science et de l'innovation CSSI, sur mandat du Secrétariat d'Etat à la formation, à la recherche et à l'innovation SEFRI. Rapport final. Document CSSI 7/2015: CSSI.
- CTI Commission for Technology and Innovation (2016). Stellungnahme des SCCER Steuerungskomitees zu den Empfehlungen der Begleitforschung der ersten Förderperiode 2013-2016, 21. September 2016.
- CUS Conférence universitaire suisse (2005), Rapport annuel 2004, CUS, Bern.
- De Jong, S. et al. (2014). Understanding societal impact through productive interactions: ICT research as a case. *Research Evaluation*, 23(2), 89-102.
- Ess, F. et al. (prognos) (2016). SCCER Accompanying Research Module 2: Interdisciplinary collaboration. Commissioned by the Commission for Technology and Innovation CTI, Basel, prognos.
- FNS Fonds national suisse pour l'encouragement de la recherche scientifique (2006). Programme pluriannuel 2008-2011. Défis pour l'encouragement de la recherche et réponses du FNS, FNS, Berne.
- FNS Fonds national suisse pour l'encouragement de la recherche scientifique (2015). Programme pluriannuel 2017–2020. Planification à l'attention des autorités fédérales, FNS, Berne.
- Givord, P. (2010). *Méthodes économétriques pour l'évaluation de politiques publiques*. Paris: Institut National de la Statistique et des Etudes Economiques, DESE, Documents de Travail de la DESE / G 2010-08.
- Good, B. and Ohler, F. (technopolis) (2016). Module 4 - International positioning. SCCER Accompanying research, Technopolis [group], Vienna.
- Hammer, S. and Iten, R. (2016). SCCER Accompanying Research. Synthesis (Commissioner: Commission for Technology and Innovation CTI), Zurich, Infrac.
- Harayama, Y. et al. (2004). *Dynamique de la création de connaissances : microsystèmes en Suisse romande*, Bern [etc.] Peter Lang.
- Kolarz, P. et al. (2017). Use-inspired basic research at Swiss National Science Foundation SNSF. Final report: technopolis group.
- Link, A. N. et al. (ed.) (2013). *Handbook On The Theory And Practice Of Program Evaluation*, Cheltenham: Edward Elgar Publishing.
- Merz, M. (2015). Dynamique locale des nanosciences au croisement de disciplines établies. In A. Gorga & J.-P. Leresche (Eds.), *Disciplines académiques en transformation. Entre innovation et résistance* (pp. 105-118). Paris: Editions des archives contemporaines.
- Meyer, L. and Rieder, S. (Interface) (2017). Wissens- und Technologietransfer von Nano-Tera.ch. Schlussbericht zuhanden der Geschäftsstelle des Schweizerischen Wissenschafts- und Innovationsrates (SWIR), 3. Oktober 2017, Luzern, Interface-Politikstudien. [Annexe D]

- NRC National Research Council (US) (2003). Securing the Future: Regional and National Programs to Support the Semiconductor Industry: National Academies Press.
- Ott, W. et al. (econcept) (2016). Commission for Technology and Innovation (CTI), SCCER Accompanying Research. Module 1: Thematic, Institutional and Knowledge Value Chain Related Shortcomings. Final Report, March 30, 2016, econcept ag, Zurich.
- Roco, M. C. (2002). Coherence and divergence of megatrends in science and engineering. *Journal of Nanoparticle Research*, 4, 9-19.
- Roco, M. C. and Bainbridge, W. S. (Eds.). (2003 (2002)). *Converging Technologies for Improving Human Performance. Nanotechnology, Biotechnology, Information Technology and Cognitive Science.* NSF/DOC-sponsored report. Dordrecht, The Netherlands: Kluwer Academic Publishers.
- SWR Schweizerischer Wissenschaftsrat (2018). Wirkungsprüfung des nationalen Förderprogramms SystemsX.ch. Bericht und Empfehlungen des Schweizerischen Wissenschaftsrates SWR im Auftrag des Staatssekretariats für Bildung, Forschung und Innovation SBFI. Vom SWR verabschiedet am 05. Februar 2018 (rev. 3. September 2018), Bern, SWR.
- Vinck, D. and Robles Belmont, E. (2012). Convergence dans les nanosciences et nanotechnologies. Le cas des micro et nanosystèmes. In B. Miège & D. Vinck (Eds.), *Les masques de la convergence. Enquêtes sur sciences, industries et aménagements* (pp. 43-65). Paris: Éditions des Archives Contemporaines.

Annexes

- A. *SERI mandate and concept, September 2016***
- B. *Self-assessment report on Nano-Tera.ch, October 2017***
- C. *SSC expert panel report and position statements, 2017–2018***
 - C1. *Terms of reference of external experts (TOR)***
 - C2. *SSC questions to the expert panel***
 - C3. *SSC expert panel report***
 - C31. *SNSF position statement on the SSC expert panel report***
 - C32. *Nano-Tera.ch position statement on the SSC expert panel report***
- D. *Knowledge and technology transfer in Nano-Tera.ch, October 2017***

Meyer, L., Rieder, S. (Interface) (2017). Wissens- und Technologietransfer von Nano-Tera.ch. Schlussbericht zuhanden der Geschäftsstelle des Schweizerischen Wissenschafts- und Innovationsrates (SWIR), 3. Oktober 2017, Luzern, Interface-Politikstudien.
- E. *Nano-Tera.ch: related grants awarded by the SNSF, April 2017***
- F. *SSC interviews: list of interviewees and interview guides, 2017-2018***
- G. *Programme and participant list for site visit meeting, November 2017***

Annex A –SERI mandate and concept, September 2016



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement für
Wirtschaft, Bildung und Forschung WBF

**Staatssekretariat für Bildung,
Forschung und Innovation SBFi**
Abteilung Nationale Forschung und Innovation

MANDAT

(Verwaltungsinterne Vereinbarung)

des

Eidgenössischen Departements für

Wirtschaft, Bildung und Forschung (WBF)

vertreten durch das

Staatssekretariat für Bildung, Forschung und Innovation (SBFI)

an den

Schweizerischen Wissenschafts- und Innovationsrat (SWIR)

**Wirkungsprüfung
der beiden nationalen Förderprogramme
Nano-Tera.ch sowie SystemsX.ch**

Vertragsnummer: 2016.0009

I. Ausgangslage

Unter dem Titel "NanoTera.ch" und "SystemsX.ch" wurden mit den Entscheiden zur BFI-Botschaft 2008-2011 zwei nationale Förderinitiativen lanciert. Angesichts des Profils dieser beiden Initiativen als "nationale Verbundaufgaben" wurde für jede eine spezifische *Aufbauorganisation* (Konsortium - verantwortlich u.a. namentlich für die strategische Führung) geschaffen. Mit einer Laufzeit von nunmehr insgesamt 9 Jahren werden beide Förderprogramme auf Ende 2016 beendet. Dabei hat der Bund über die gesamte Laufdauer insgesamt rund 340 Mio. CHF Fördermittel zur Verfügung gestellt.

In Absprache mit den involvierten Stellen hat das zuständige SBFI entschieden, beide Förderinitiativen vor ihrem Abschluss einer umfassenden Wirkungsprüfung zu unterziehen. Gestützt auf Artikel 44 Absatz 3 und Artikel 54 Absatz 2 FIGG sowie in Abstimmung mit seinem Legislaturprogramm 2016-2019 wird der SWIR mit der Wirkungsprüfung der beiden nationalen Förderprogramme "Nano-Tera.ch" sowie "SystemsX.ch" beauftragt.

II. Auftrag/Ziele – Gegenstand

Das SBFI beauftragt den SWIR mit der Durchführung einer Wirkungsprüfung beider Programme. Deren übergeordnetes Ziel besteht darin, unter programmspezifisch relevanten Aspekten die Wirkungen umfassend festzustellen und aus übergeordneter Sicht zu bewerten. Ziel und Gegenstand der Wirkungsprüfung sind in den beiden Konzeptsdokumenten "Framework of the impact evaluation for the National Funding Program *NanoTera.ch*" sowie "Framework of the impact evaluation for the National Funding Program *SystemsX.ch*" detailliert dargestellt (fortan: *Konzeptunterlagen*).

III. Zeitplan

Die Arbeit des SWIR richtet sich nach Zeitplan gemäss Konzeptunterlagen. Danach ergeben sich folgende Meilensteine:

	NanoTera.ch (Abschluss)	SystemsX.ch (Abschluss)
Bericht der zuständigen Konsortien ("Selbstevaluation")	10/2017	03/2017
Bericht der externen Fachpanels ("Panelberichte")	3/2018	12/2017
Stellungnahmen zum "Panelbericht" (Konsortien; SNF)	tbd	tbd
SWIR Abschlussbericht (zuhanden SBFI)	06/2018	02/2018

IV. Weitere Bestimmungen

Methodisches Vorgehen

Der SWIR ist in der Wahl seiner Methoden frei.

Betreffend Nominierung der externen Fachpanels durch den SWIR gelten die in den Konzeptunterlagen gesetzten Rahmenbedingungen.

- Aktenzugang: Die Konsortien sind gegenüber dem SWIR auskunftspflichtig. Sie stellen ihm auf Nachfrage namentlich sämtliche offiziellen Strategie- und Entscheidungsdokumente in ihrem Zuständigkeitsbereich zur Verfügung.
- Weitere Vorgaben hinsichtlich Berichte der Konsortien, der externen Fachpanels sowie zu den übergeordneten Abschlussberichten des SWIR sind in den Konzeptunterlagen dargelegt.

Publikation

Über die Publikation seiner Abschlussberichte entscheidet der SWIR.

- Form: Die Publikation umfasst pro Abschlussbericht neben den übergeordneten Befunden / Bewertungen und allfälligen Empfehlungen des SWIR auch den Bericht des Konsortiums (Selbstevaluation), den externen Panelbericht, die formelle Stellungnahme des Konsortiums und des SNF zum Panelbericht sowie allfällige weitere Begleitmaterialien oder ergänzende Untersuchungen des SWIR.
- Fristen: Die Publikation der Abschlussberichte erfolgt frühestens nach Zustellung derselben an das SBFI.

Bestandteile: Konzeptunterlagen

Die beiliegenden Konzeptunterlagen "Framework of the impact evaluation for the National Funding Program *NanoTera.ch*" (datiert vom 29.08.2016) sowie "Framework of the impact evaluation for the National Funding Program *SystemsX.ch*" (datiert vom 30.08.2016) bilden einen integrierenden Bestandteil dieser Vereinbarung.

V. Finanzierung und Auszahlung

Finanzierung und Auszahlung

Das Staatssekretariat für Bildung, Forschung und Innovation SBFI beteiligt sich mit höchstens CHF 30'000 (inkl. MWST) an den Kosten, die dem SWIR durch die Erfüllung dieses Mandats entstehen (Kostendach).

Darin eingeschlossen sind namentlich die Aufwendungen für die vom SWIR mandatierten externen Fachpanels sowie für logistische Kosten der Expertisierung durch die Fachpanels.

Dieser Beitrag gilt als Obergrenze und darf ohne Abänderung dieser Vereinbarung im beiderseitigen Einvernehmen nicht überschritten werden. (Allfällige, dieses Kostendach übersteigende Aufwendungen des SWIR sind im Prinzip durch sein allgemeines Funktionsbudget zu decken wie unter Punkt 5 in den Konzeptunterlagen vermerkt.)

Die Auszahlung bzw. Freigabe der Mittel erfolgt gestützt auf eine entsprechende Rechnungsstellung des SWIR zuhanden SBFI (Ressort Nationale Forschung) unter Angabe der Vertragsnummer (siehe Deckblatt) an folgende Adresse

Staatssekretariat für Bildung, Forschung und Innovation SBFI
c/o. DLZ FI EFD
Effingerstrasse 27
3003 Bern

Eine erste Rechnung (1/3 des Gesamtbetrages) kann nach Unterzeichnung des Vertrages bis spätestens Ende November 2016 eingereicht werden. Weitere Teilrechnungen (zu einem Maximalbetrag von 10'000 CHF im Rechnungsjahr 2017 bzw. im

Rechnungsjahr 2018) können entweder nach effektiv anfallendem Aufwand *oder* tran-
chenweise (maximal je 1/3 des Gesamtbetrages) nach Abschluss der Hauptphasen
(Abschluss Konsortialberichte - Abschluss Panelberichte - Abschlussbericht SWIR)
eingereicht werden. Mit der letzten Teilrechnung muss auch eine Gesamtrechnung
(Projektgesamtaufwand) vorgelegt werden. Die verrechneten Positionen werden in
den Rechnungen detailliert ausgewiesen (Honorare, Spesen, etc.). Es gelten die Ho-
noraransätze des SBFI bzw. die (Reise-)Spesenregelungen des Bundes.

Fehlerhafte Rechnungen werden zur Korrektur an den Absender zurückgeschickt.

VI. Schlussbestimmung

Inkrafttreten, Beendigung

Die Vereinbarung beginnt am 30.09.2016 und dauert bis 30.06.2018. Sie tritt nach
beiderseitiger Unterzeichnung in Kraft. Sie ist mit der Erfüllung der vereinbarten Ver-
pflichtung beendet, spätestens am 30.06.2018. Die vorzeitige Beendigung bleibt vor-
behalten.

Kontaktperson

Für Fachkontakte zum Mandat und während der Durchführung der Wirkungsprüfung
gemäss Mandat sowie für allfällige Anpassungen der vorliegenden Vereinbarung ist
seitens des SBFI Dr. G. Haefliger, Vizedirektor und Leitung Abteilung Nationale For-
schung & Innovation zuständig.

**Staatssekretariat für Bildung, Forschung
und Innovation SBFI**

Dr. Mauro Dell'Ambrogio

Staatssekretär

Bern, der September 2016

Schweizerischer Wissenschafts- und Innovationsrat (SWIR)

Prof. Gerd Folkers

Präsident SWIR

Bern, der 29. September 2016

Beilagen:

- FRAMEWORK OF THE IMPACT EVALUATION for the NATIONAL FUNDING PROGRAM "SystemsX.ch" (SBFI, 30.08.2016)
- FRAMEWORK OF THE IMPACT EVALUATION for the NATIONAL FUNDING PROGRAM "Nano-Tera.ch" (SBFI, 29.08.2016)



CH-3003 Bern, NFI/SBFI/hae

FRAMEWORK OF THE IMPACT EVALUATION for the NATIONAL FUNDING PROGRAM "Nano-Tera.ch"

1. Background

Based on the decisions announced in the SERI message of 2008-2011¹, a national funding program named "Nano-Tera.ch" has been launched in accordance with Article 41, paragraph 5 of the Federal Act on the Promotion of Research and Innovation (RIPA).²

The main goal was the development of key technologies involving micro- and nano-scale components in the framework of an interdisciplinary national network with the scientific challenge of developing basic technologies in electronics, information and communication sciences as well as materials science, to create blocks at the micro- and nano-scale able to generate large amounts of useful data and to be used in various engineering applications. In the foreseeable future, the program should lead to a significant strengthening in the domain of Knowledge and Technology Transfer and to an increased collaboration with the interested players from the private sector.

As the program has been created in the form of a "national joint task", it has been implemented with a specific organizational structure (the Nano-Tera.ch Consortium, responsible in particular for the strategic management). In addition, a scientific evaluation mechanism independent from the Consortium has been institutionalized by the Swiss National Science Foundation in the form of a special commission (the SNSF Evaluation Panel). A specific reporting mechanism has also been established as part of the procedures associated to "project-linked contributions" (cooperative projects).

Already at its launch in 2008, the perspective of approximately 10 years of financial support has been envisioned for the program. With a one-year extension in 2012 (SERI message of 2012) and a 4-year extension based on the decisions announced in the SERI message of 2013-2016, the Nano-Tera.ch program is terminating at the end of 2016 and will thus have been running for a total of 9 years. Altogether, the Swiss Confederation has provided a total funding of about 120 million CHF over the lifetime of the program.

In agreement with the involved parties, the SERI, as competent authority, decided that the "Nano-Tera.ch" program should undergo an impact evaluation before its formal conclusion³.

¹ BBI 2007 1223 ; see in particular chapter 2.2.2, project-linked contributions.

² The current legal basis is ruled by the fully revised law of Dec. 14 2012 (AS 420.1). For the legal basis at the time concerning project-linked contributions, see SERI message of 2008-2011.

³ The *formal* conclusion (including all final reports, audits and the dissolution of the associated legal entity) should take place by June 2018 at the latest.

2. Nano-Tera.ch objectives

The activities proposed by Nano-Tera.ch to the Swiss government were articulated in a Proposal (for a cooperative project) and in a Business plan both presented in 2007. The **overall vision** can be articulated as follows.

The program aims at bringing Switzerland to the forefront of a new technological revolution driving engineering and information technology for health and security of humans and the environment in the 21st century. This revolution is rooted in advances in engineering nano-scale materials and their exploitation in a variety of systems, requiring extreme integration and coordinated control of diverse micro- and nano-scale components.

In this perspective, the mission of the program can be summarized as the *research, design and engineering of complex (tera-scale) systems and networks* to monitor and connect humans and/or the environment. Beyond straightforward integration, the program aims at identifying and fostering the potential synergies between micro- and nano-scale component technology and large-scale system design technologies (ranging from hardware to software and networking).

Strategic objectives

Nano-Tera.ch's original strategic objectives (described in the 2007 Proposal and Business plan) call for the collaboration of the main scientific institutions in Switzerland to create *interdisciplinary* and *inter-institutional* teams of researchers. Namely:

The program is a collaborative engineering program that fosters the research and crossbreeding of hardware and software technologies in the areas of wearable, ambient and space systems. The program is mainly expected to:

- be instrumental in keeping Switzerland in the lead in the high-tech industrial sector, in particular by fostering innovation through collaboration between researchers and industrial partners with large research projects
- develop advanced technologies, such as micro/nano-electronics, sensors, micro/nano-electromechanical systems (MEMS/NEMS), systems and software, information and communication
- integrate these technologies to better the quality of health, security and environment systems in Switzerland, thus promoting a vision of engineering with social objectives
- embody the research outcomes into prototypes, acting both as demonstrators and technology drivers to strengthen technology transfer to the Swiss industry
- train junior scientists through interdisciplinary graduate/doctoral education programs and workshops in the domains covered by the program.

Operational plan

In 2008, the governing bodies of Nano-Tera.ch (Steering and executive committees) in consonance with the Swiss National Foundation plan set up operational procedures, taking into account realistic constraints related to budget and priorities. Specifically, the Swiss National Foundation requested excellence in research as a primary objective, and the Nano-Tera.ch boards requested a fair distribution of the Nano-Tera.ch activities through the various institutions and over the various scientific topics. As a result, Nano-Tera.ch focused on supporting and nurturing *pinnacles of excellence* within the broad area of research proposed in the original vision.

3. Impact Evaluation

3.1 Goal / Main issues for the Impact Evaluation

In addition to providing an overall synthesis of the Nano-Tera.ch program (see below 3.3), the main objective of the evaluation is to assess the **impact** of the program in several key dimensions and based on various **objective metrics** described in the appendix.

The impact dimensions expected to be relevant are:

- The scientific impact
- The educational impact
- The economic impact
- The societal impact
- The institutional impact.

For each of the impact dimensions indicated, there **is a set of the key statements** to be assessed, along with related factual data and metrics to be used (see appendix).

For each of the key statements, the goal is to evaluate to what extent it has been fulfilled and to what extent the Nano-Tera.ch framework has been efficient. The evolution of the evaluation results from Phase 1 (2008-2012) to Phase 2 (2013-2016) may also be considered as an interesting aspect to analyze the impact of the program.

Dimension I	Scientific impact
-------------	-------------------

- *Key statement 1:* "Nano-Tera.ch has promoted **excellence** in research in various domains of engineering sciences."
- *Key statement 2:* "Nano-Tera.ch has fostered strongly **collaborative** research."
- *Key statement 3:* "Nano-Tera.ch has fostered strongly **interdisciplinary** research."
- *Key statement 4:* "Nano-Tera.ch has triggered **inter-institutional** collaborations among very diverse players at the national level."
- *Key statement 5:* "Nano-Tera.ch has fostered strongly **applications-oriented research** in various domains of engineering sciences."
- *Key statement 6:* "Nano-Tera.ch has funded **ambitious projects**."
- *Key statement 7:* "Nano-Tera.ch has an **almost exhaustive coverage** of the Swiss scientific community in the program's fields."

Dimension II	Educational impact
--------------	--------------------

- *Key statement 8:* "Nano-Tera.ch has substantially contributed to the **training of next generation researchers** (PhD students, Post Docs)."

- *Key statement 9:* "Nano-Tera.ch has encouraged stronger **collaborative spirit** in the community of PhD students involved in the program and increased their autonomy by giving them the opportunity to submit their own collaborative research proposals."
- *Key statement 10:* "Nano-Tera.ch has encouraged stronger **entrepreneurial spirit** in the community of PhD students involved in the program."

Dimension III	Economic impact
----------------------	------------------------

- *Key statement 11:* "Nano-Tera.ch has fostered research with **high economic potential**."
- *Key statement 12:* "Nano-Tera.ch has deployed a novel pilot funding instrument (the "Gateway" program) **efficiently combining support for research and innovation** and integrating an appropriate **monitoring mechanism**."
- *Key statement 13:* "Nano-Tera.ch has fostered **user-centric research** with an early involvement of field practitioners through field tests, clinical studies, etc."
- *Key statement 14:* "Nano-Tera.ch has contributed to the **dissemination of the scientific results achieved** to the Swiss industry."

Dimension IV	Societal impact
---------------------	------------------------

- *Key statement 15:* "Nano-Tera.ch has contributed to steering the research funded toward **current social needs** (health, environment, energy, etc.)."
- *Key statement 16:* "Nano-Tera.ch has contributed to **disseminating the results** achieved within and beyond the Nano-Tera.ch community."
- *Key statement 17:* "Nano-Tera.ch has implemented efficient **pilot actions** to promote the activities of the programs in high school and towards younger children."

Dimension V	Institutional impact
--------------------	-----------------------------

- *Key statement 18:* "Nano-Tera.ch has substantially contributed to the setup of the **joint SNSF-CTI program "Bridge"**, a novel funding instrument aiming at better exploiting the economic and societal potential of scientific research by promoting the transfer from scientific knowledge to innovation."
- *Key statement 19:* "The **operational procedures** deployed and tested during the Nano-Tera.ch program represent an interesting example of innovative mechanisms for financing and monitoring research with high economic potential."

3.2 Procedure and responsibilities

The impact evaluation is carried out in the two following steps:

- *An internal* impact evaluation under the responsibility of the Nano-Tera.ch Consortium.
The result is an analysis report (hereinafter: the Consortium report; language: English) to the attention of the SSIC.
- *An external* impact evaluation under the responsibility of the SSIC.
The result is a final report (hereafter: the SSIC final report; language: German / French) to the attention of the SERI.

3.3 Requirements / conditions for the internal impact analysis

Consortium report structure

Part I: Overview (Organization / Finances)	- Description of the organizational structure and of the main decision procedures (including SNSF) - Financial Overview (whole period)	<i>Sources:</i> activity and financial reports
Part II: Objectives	- Original set of goals (presentation) - Presentation/justification of possible goal adjustments during the course of the program	<i>Sources:</i> relevant strategy documents and implementation measures
Part III: Overview of the outputs of the program	Overall synthesis of the Nano-Tera.ch program, in the form of a report compiling the main facts and statistics (at a high level of aggregation and limited to the most important areas)	
Part IV: Impact Analysis (main part)	Data analysis and assessment/justification of the key statements (1 to 19) identified for the impact analysis	<i>Sources:</i> Data / Outputs from the Consortium's Monitoring procedure; Metrics in accordance with the Appendix
Part V: Conclusion	Overall Conclusion: Lessons learned	

Methodology

The impact analysis (Part IV) is essentially carried out on the basis of the data and information identified in the established monitoring procedure (no additional extensive surveys).

A factual selection of the adequate data/information should be made for the assessment/justification of the key statements used for the analysis (in part IV). For the different areas or domains, a multi-methodological approach may be used to show evolution over the duration of the program.

3.4 Requirements / conditions for the external impact evaluation

Expert Panel

For the external impact evaluation, the SSIC appoints an expert panel, consisting of national and international experts. For this task, the SSIC consults the Nano-Tera.ch Consortium, and, if necessary, the SNSF. While only the SSIC is accountable and responsible for the final expert nomination, *the Nano-Tera.ch Consortium is given both a proposition and a veto right.*

The nomination and formal appointment of the panel experts is the SSIC's responsibility. The only associated condition is that the SSIC ensures the evaluation panel produces an independent evaluation report (hereinafter: the Panel report) according to the mandate specifications. Based notably on the Consortium report and further on the additional findings resulting from complementary measures agreed with the SSIC such as a site visit, discussions with the Consortium, etc., this report should present the panel's position/assessment about/of the key statements used for the Impact Evaluation (see 3.1 above).

SSIC Final Report

The SSIC produces an independent final report to the attention of the SERI. In this report, the SSIC takes a broader view to provide an overall evaluation in addition to their own position about the assessment of the key statements used for the Impact Evaluation (see 3.1 above). For this, the SSIC should take into account the Consortium report, the panel report, the Consortium and SNSF position about the panel report, as well as the SSIC's own findings.

3.5 Coordination

The coordination between internal and external impact evaluations (agreements on temporal and content related issues, specification and implementation) is exclusively the SSIC's responsibility. The required interactions and contacts with the Nano-Tera.ch Consortium and governing bodies are to take place under the direct authority and responsibility of the SSIC.

4. Timeline

Milestones (draft schedule) as follows:

09/2016	Mandate finalization	SERI (with SSIC and Consortium)
11/2016	Coordination & Implementation scheduling	SSIC (with Consortium)
12/2016 - 10/2017	Internal Impact Analysis; Consortium Report	- January to June 2017 (Data acquisition; Metric Production) - July to October 2017: Production of the report and approval by the Consortium Consortium transmits their report to SSIC by the end of October 2017.
04/2017	External Impact Evaluation: Expert Panel Nomination	SSIC
11/2017 - 3/2018	External Impact Evaluation: Panel Report	SSIC / Expert Panel
6/2018	Final Report	SSIC transmits their report to SERI by the end of June 2018

5. Funding

The cost of the internal impact analysis, including all costs related to the production of the Consortium report as well as the contribution to the external Impact Evaluation according to the SSIC's specifications will be covered by the Nano-Tera.ch Consortium.

The cost of the external Impact Evaluation, including all organizational costs related to the production of the panel report and final report will be covered by the SSIC's operational budget. Any additional cost incurred by SERI will be settled in the framework of the SSIC's Global Mandate (Impact Evaluation of the "SystemsX.ch" & "Nano-Tera.ch" funding programs).

SERI, 29/08/2016

Dr. G. Haefliger, Vice-director

Appendix: Nano-Tera.ch Consortium: objective metrics for the key statements.

Appendix

Nano-Tera.ch Consortium: objective metrics for the key statements

Dimension I	Scientific impact
	<ul style="list-style-type: none">• Key statement 1: "Nano-Tera.ch has promoted excellence in research in various domains of engineering sciences." <i>Factual data:</i> The complete database of publications and presentations reported by the project consortia during the lifetime of the program; history of various scientific awards (lifetime achievements, best papers, fellowships, etc.) received by Nano-Tera.ch researchers; list of the events organized in the framework of the Nano-Tera.ch International exchange program. <i>Metrics to be used:</i> Various measures of bibliometric performance (number of citations, H-index); various absolute and normalized counts; ability of Nano-Tera.ch to attract the participation of the most renowned international experts in the field.• Key statement 2: "Nano-Tera.ch has fostered strongly collaborative research." <i>Factual data:</i> The publication database; collaborative tasks reported in the scientific reports provided by the consortia; the list of the collaboration grants awarded in the framework of the Sino-Swiss Science and Technology Cooperation. <i>Metrics to be used:</i> Average number of institutions per project; average number of research groups per research task; amount of joint publications between partners; level of funding granted.• Key statement 3: "Nano-Tera.ch has fostered strongly interdisciplinary research." <i>Factual data:</i> List of main fields of research for all co-investigators in the projects; list of conferences where Nano-Tera.ch researchers have made a contribution. <i>Metrics to be used:</i> Average number of research fields covered by the project consortia; diversity of the conference fields.• Key statement 4: "Nano-Tera.ch has triggered inter-institutional collaborations among very diverse players at the national level." <i>Factual data:</i> List of the institutions involved in each Nano-Tera.ch project. <i>Metrics to be used:</i> Diversity of the profiles of the institutions involved (ETH Board, universities, universities of applied sciences, industrial partners, hospitals, etc.)• Key statement 5: "Nano-Tera.ch has fostered strongly applications-oriented research in various domains of engineering sciences." <i>Factual data:</i> List of the demonstrators obtained; produced videos describing Nano-Tera.ch's concrete achievements; photos from the exhibition areas organized at the occasion of the various Annual meetings of the program. <i>Metrics to be used:</i> Number of the demonstrators obtained; distribution of demonstrators over the engineering sciences domains covered.• Key statement 6: "Nano-Tera.ch has funded ambitious projects." <i>Factual data:</i> Budgets allocated to the projects; list of staff members involved in each project; duration of the projects; profiles of the researchers involved. <i>Metrics to be used:</i> Level of funding; average number of researchers involved; amount of achievements; reputation of the researchers involved.• Key statement 7: "Nano-Tera.ch has an almost exhaustive coverage of the Swiss scientific community in the program's fields." <i>Factual data:</i> List of the funded projects; overall budget available; localization of the involved research teams.

Metrics to be used: Territorial coverage of the involved research teams and institutions; distribution of the number of involved researchers over the covered research topics; level of funding compared with other funding instruments.

Dimension II Educational impact

- **Key statement 8:** "Nano-Tera.ch has substantially contributed to the **training of next generation researchers** (PhD students, Post Docs)."

Factual data: List of PhD students involved; analysis of their activities after their PhD thesis defense; list of Nano-Tera activities (coaching, training, information, MT180 contest) specifically tailored for PhD students.

Metrics to be used: Number of PhD students funded/impacted/trained in the framework of the program; invested budget; activity level (number of days).

- **Key statement 9:** "Nano-Tera.ch has encouraged stronger **collaborative spirit** in the community of PhD students involved in the program and increased their autonomy by giving them the opportunity to submit their own collaborative research proposals."

Factual data: Detail on the various actions set up by Nano-Tera.ch in this perspective (NextStep collaborative research program with specific ED calls).

Metrics to be used: Attendance of the PhD students to these programs; resulting achievements and satisfaction.

- **Key statement 10:** "Nano-Tera.ch has encouraged stronger **entrepreneurial spirit** in the community of PhD students involved in the program."

Factual data: Detail on the various actions set up by Nano-Tera.ch in this perspective (NextStep entrepreneurship program, support for participation to high impact events).

Metrics to be used: Attendance of the PhD students to these programs; resulting achievements and satisfaction.

Dimension III Economic impact

- **Key statement 11:** "Nano-Tera.ch has fostered research with **high economic potential**."

Factual data: List of patents filed; CTI projects originating from the program; startups and spinoffs created; industrial collaborations resulting from the program; interviews with RTD projects principal investigators; results of the Nano-Tera.ch Industrial Valorization Fund.

Metrics to be used: Standard performance metrics based on absolute or normalized counts; multi-dimensional analysis (radar plots) of the industrial potential of the scientific results achieved.

- **Key statement 12:** "Nano-Tera.ch has deployed a novel pilot funding instrument (the "Gateway" program) **efficiently combining support for research and innovation** and integrating an appropriate **monitoring mechanism**."

Factual data: Results of the quarterly Gateway progress meetings; description of the industrial prototypes achieved; feedback from the industrial partners.

Metrics to be used: Success rate in producing well-accepted industrial prototypes; satisfaction level of industrial players.

- **Key statement 13:** "Nano-Tera.ch has fostered **user-centric research** with an early involvement of field practitioners through field tests, clinical studies, etc."

Factual data: List of various non-academic partners involved in Nano-Tera.ch projects (hospitals, private institutions); list of field experiments (field tests, clinical studies) carried out and corresponding budgets.

Metrics to be used: Level of involvement (matching funds) of various non-academic end-users; funding level dedicated to field experiments.

- **Key statement 14:** "Nano-Tera.ch has contributed to the **dissemination of the scientific results achieved** to the Swiss industry."

Factual data: Details regarding the Information Days organized for Swiss industrial players.

Metrics to be used: Attendance to the organized events and feedback from participants.

Dimension IV Societal impact

- **Key statement 15:** "Nano-Tera.ch has contributed to steering the research funded toward **current social needs** (health, environment, energy, etc.)."

Factual data: List of the calls published by the program; description of the projects selected; strategic actions launched.

Metrics to be used: Level of overlap with identified social trends (e.g. Google trends) and future priority programs.

- **Key statement 16:** "Nano-Tera.ch has contributed to **disseminating the results** achieved within and beyond the Nano-Tera.ch community."

Factual data: List of all communication, documents and videos produced and disseminated; details and statistics regarding the Nano-Tera.ch website; list of mentions of the program in the media; information regarding the Nano-Tera.ch Annual Meetings and other public events; contacts with the Swiss Science journalists; description of the various dissemination channels set-up in social networks (Facebook, Twitter).

Metrics to be used: Google Analytics of the Nano-Tera.ch website; various standard audience measures for disseminated documents; results of satisfaction evaluations for organized events; measure of the impact in the media.

- **Key statement 17:** "Nano-Tera.ch has implemented efficient **pilot actions** to promote the activities of the programs in high school and towards younger children."

Factual data: Detail of the Nano-Tera.ch action in high school and in the framework of the EPFL Scientastic festival; List of participants; Photos produced.

Metrics to be used: Level of involvement and feedback of the high school students; perceived level of motivation and satisfaction

Dimension V Institutional impact

- **Key statement 18:** "Nano-Tera.ch has substantially contributed to the setup of the **joint SNSF-CTI program "Bridge"**, a novel funding instrument aiming at better exploiting the economic and societal potential of scientific research by promoting the transfer from scientific knowledge to innovation."

Factual data: Various internal documents produced by Nano-Tera.ch during the setup of the Bridge program.

Metrics to be used: Overlap of the Nano-Tera.ch suggestions with the final Bridge program framework.

- **Key statement 19:** "The **operational procedures** deployed and tested during the Nano-Tera.ch program represent an interesting example of innovative mechanisms for financing and monitoring research with high economic potential."

Factual data: Description of the Nano-Tera.ch operational mechanisms in comparison with the other existing funding instruments.

Metrics to be used: Identification of important differences and similarities.

Annex B – Self-assessment report on Nano-Tera.ch, October 2017

Swiss Research Program Nano-Tera .ch

Engineering Multi-Scale
Systems for Health, Security,
Energy and the Environment

Impact Analysis Report 2017

Nano-Tera.ch is an unprecedented nation-wide program that has contributed to positioning Switzerland at the forefront of research on multi-scale engineering of complex systems and networks. It has been operational for almost 10 years, was supported by public funds of more than CHF 120 million, and has had a strong impact on the Swiss Engineering Sciences landscape. It has led to numerous scientific and technological breakthroughs exploiting synergies between various disciplines, and explored topics at the boundary of traditional scientific domains to generate highly exploitable demonstrators with socially relevant applications in the areas of health, energy, and the environment.

At the scientific level, Nano-Tera.ch strongly promoted ambitious cutting-edge research. It strengthened inter-institutional collaboration at the boundary of traditional disciplines, by heavily supporting large, long-lasting, collaborative research projects. In particular, it specifically contributed to synergies between micro/nanocomponent technology and large-scale system design to achieve scientific and technological breakthroughs. These synergies have produced, amongst other examples, miniaturized X-ray sources with exceptional tomographic imaging capabilities; highly robust sensor networks deployed in the Alps to monitor rock falls; super-paramagnetic particles used for the detection and treatment of cancer; and perovskite-based tandem solar cells with world-leading performance.

Nano-Tera.ch significantly impacted Swiss research in Engineering Sciences. This was demonstrated by nearly 1,600 peer-reviewed publications and more than 2,000 presentations at conferences and workshops. Annual evaluations conducted by the Swiss National Science Foundation and the Nano-Tera.ch Scientific Advisory Board have consistently pinpointed scientific excellence during the entire course of the program.

Most of the scientific impact is due to 44 large research projects, each benefitting from CHF 2,000,000 of public funding on average over four years, matched by an equivalent contribution provided by the project partners. These projects established truly collaborative and interdisciplinary research, with an average per project of six research teams combining expertise from three different disciplines.

Furthermore, Nano-Tera.ch increased its scientific impact by spearheading an International Exchange program. The program organized symposia on emerging trends in fields it was covering, and invited world-leading scientists to interact with the Nano-Tera.ch community through discussions and talks.

At the educational level, Nano-Tera.ch focused on training the next generation of scientific talents by funding more than 360 PhD students. Furthermore, a specific NextStep program has been created to help these PhD students increase their autonomy, collaborative spirit, entrepreneurial mindset, and communication abilities. About 40% of the doctoral graduates decided to pursue a career in academia (of which 57% stayed in Switzerland) and 60% in industry (75% in Switzerland). This shows that Nano-Tera.ch has provided Swiss academic institutions and industry with a substantial number of highly skilled researchers and engineers with the potential to efficiently develop their research and innovation.

The NextStep program has been implemented along three complementary tracks: (1) a Collaborative Research track offering Nano-Tera.ch PhD students the opportunity to autonomously apply for collaborative research projects; (2) an Entrepreneurship track providing Nano-Tera.ch PhD students with the opportunity to interact with entrepreneurship coaches to help them examine the economic potential of their scientific skills and results; and (3) an MT180 track in which Nano-Tera.ch organized the “My Thesis in 180 Seconds” contests to train Nano-Tera.ch PhD students to present their research to a larger audience outside their field.

In addition, the program also strengthened its general educational impact by funding 61 educational actions, such as specialized courses, summer/winter schools, and workshops.

At the economic level, the program has contributed to the strengthening of the economic potential of research results. This was achieved by focusing on establishing the proper conditions for economic value creation. Major projects were required to deliver research prototypes, acting both as demonstrators and technology drivers. They were also required to bring on board industrial or industry-oriented partners and end users (e.g., hospitals), respectively representing 31% and 10% of the project consortia (the rest being research partners). As a result, the program has achieved a strong impact in terms of *knowledge transfer*. Indeed, the project consortia were able to satisfy the absorptive capacity of the involved industrial partners by giving them access to experts in areas they consider to be strategic for their development and competitiveness.

In addition, Nano-Tera.ch has also strongly contributed to Knowledge and Technology Transfer by funding a large number of PhD students who transferred to industry after graduation. These students made a substantial contribution to industry by bringing with them fresh ideas and the substantial knowledge of new technologies they acquired during their research. Some of the funded PhD graduates and Postdocs directly contributed to the creation of 10 start-up/spin-off companies, such as IRsweep, a spin-off bringing a novel optical frequency comb laser spectroscopy to the market, or Zaphiro Technologies, a start-up developing real-time monitoring systems for the smart grid.

Furthermore, Nano-Tera.ch used strategic funds to launch the Gateway program, which translated research results into industrial-grade prototypes. Within this program, Nano-Tera.ch launched eight projects specifically positioned at the interface between research and innovation. This enabled the involved industrial partners to quickly take on highly exploitable demonstrators, such as smart wound pads exploiting fluorescent dyes for non-invasive wound monitoring. The Gateway program also provided the opportunity to validate a novel project monitoring mechanism specially designed for projects focusing on innovation stemming from forefront research.

At the societal level, the primary objective of Nano-Tera.ch was to promote a vision of engineering with true social objectives. This goal has been achieved by strategically supporting research at the intersection of industrially relevant, cutting-edge, technologies and three socially relevant application areas: health, environment, and energy. The social relevance of the selected areas was confirmed by an *a posteriori* analysis of their match with the topics covered by the mainstream media, parliamentary proceedings, and Federal investments over the lifetime of the program.

Encouraging the funded research to aim to produce concrete prototypes also substantially helped the industrial partners and end-users involved in the program to envision and suggest concrete applications linked to actual needs and potentially benefitting the whole of society. These included high-performance tandem solar cells, advanced monitoring systems for neonates, and urban air quality monitoring sensor networks.

At the institutional level, Nano-Tera.ch triggered intense nationwide collaboration between various Swiss research institutions involved in Engineering Sciences, such as the two Federal Institutes of Technology (EPF Lausanne and ETH Zurich), several universities and universities of applied sciences, as well as industry-oriented research and technology institutions (CSEM and Empa).

With more than 91% of its budget invested in 127 research projects (including the 44 large ones mentioned above) and 61 educational actions, the Nano-Tera.ch has managed to create a community of around 1,600 members from more than 40 different research institutions, representing a very substantial proportion of the Swiss scientific community in the fields covered by the program.

Nano-Tera.ch further increased its institutional impact by implementing various dissemination tools designed to showcase the results achieved within the program (e.g. the Nano-Tera.ch website and the Nano-Tera.ch presentation videos), or to nurture the Nano-Tera.ch research community (e.g. the Nano-Tera.ch Annual Meetings). The Nano-Tera.ch website has attracted about 160,000 unique visitors accessing 7–8 pages per session. The seven annual meetings organized by the program allowed the Nano-Tera.ch community to meet and share results, and attracted a steadily increasing audience, growing from 200 to 350 participants.

Finally, the specific organizational framework put in place for the program strongly contributed to the strengthening of its overall achievements. In particular, Nano-Tera.ch's lean, autonomous management structure gave it the required flexibility to rapidly implement novel instruments, such as the NextStep and Gateway programs when this was deemed necessary. Similarly, splitting responsibility for evaluation between the Nano-Tera.ch Executive Committee, in charge of the strategic monitoring of the program, and the Swiss National Science Foundation, responsible for the scientific evaluation of the submitted proposals and the annual review of the large research projects, further reinforced the impact of the program by strengthening its links with the Swiss authorities in charge of science at the federal level.

Lausanne, October 31st, 2017

Prof. Giovanni De Micheli
Chair of the Scientific Executive Committee
EPFL INF 341 Station 14
CH-1015 Lausanne
Tel: +41 21 693 09 11
giovanni.demicheli@epfl.ch



NANO-TERA.CH: FUNDING RESEARCH IN SYSTEMS ENGINEERING



Prof. Giovanni De Micheli
Nano-Tera.ch Program Leader,
Executive Committee Chair

Nano-Tera.ch is a national funding program supporting research in engineering of complex (tera-scale) systems for health and the environment using nanotechnologies. Energy and security issues are also investigated as crucial transversal themes for system design.

Nano-Tera.ch funding is open to all Swiss research institutions according to the corresponding legislation and its mission includes research, development and technology transfer, as well as education and dissemination. In particular, Nano-Tera.ch puts a special focus on PhD students by providing them with a specific training, the Nano-Tera.ch NextStep program, targeting collaborative research and the economic exploitation of scientific results.

Moreover, Nano-Tera.ch fosters collaboration among researchers and industries that are partners or supporters of the research projects. In this perspective, Nano-Tera.ch strongly contributed to the design of BRIDGE, a new concept for jointly funding research and pre-competitive technological innovation that has been deployed by the Swiss National Science Foundation (SNSF) and the Swiss Commission for Technology and Innovation (CTI) in the form of a novel common funding instrument for the period 2017-2020.

The Swiss National Science Foundation (SNSF) also contributes to the Nano-Tera.ch program by evaluating and monitoring the large research projects through an international panel of experts, thus ensuring the high scientific quality of the program.

Nano-Tera.ch strives to enable mechanisms that can map the high productivity of research ideas, publications and patents of the Swiss community into a significant momentum in terms of industrial growth as well as job and enterprise creation. To further strengthen its contribution to this goal, Nano-Tera.ch has joined efforts with CSEM and Empa, and created a specific funding instrument, the Gateway program, intrinsically positioned at the frontier between research and innovation. Gateway aims at the translation of research results obtained within Nano-Tera.ch projects into industrial demonstrators directly exploitable by the industrial partners involved in the Gateway projects.

NANO-TERA.CH: SWISS EXCELLENCE IN RESEARCH



Prof. Heinrich Meyr
Nano-Tera.ch
Scientific Advisory Board Chair

The Scientific Advisory Board has been reviewing the Nano-Tera.ch program as a whole and providing criticisms and suggestions for its growth. The Board regards the Nano-Tera.ch program as a unique blend of technology exploration and system design. The scientific and industrial challenges studied in the program were related to exploiting micro and nano components within complex systems whose added value is much larger than the sum of their parts. A notable example is networked sensors for medical and environmental applications. Networking boosts the intrinsic power of local measurements, and allows to reach new standards in health and environment management, with positive fallout on security of individuals and communities.

Smart and diversified energy generation, such as harvesting and low-power system design are of the utmost importance to society and the economy. Truly innovative approaches are needed, that can only be found by massively investing in engineering research. Thus the Board lauded the extension of the Nano-Tera.ch scope to include energy as an application area.

The upcoming scientific and engineering challenges are too heterogeneous and complex to be solved within a single scientific domain. They require a truly collaborative and cross-disciplinary approach. In this perspective, the Nano-Tera.ch program brought together excellent researchers in various fields from many Swiss institutions with outstanding reputation.

The program was not only of high scientific value but also of eminent economic importance for the industrial sector of Switzerland. The program served as the seed for truly innovative products and industries. It also fostered the education of highly-qualified engineers and researchers who are the most valuable and indispensable resource of this country.

TABLE OF CONTENTS

Part I Overview.....	7
I.1 General Overview of the Program.....	8
I.2 Terms and Figures	9
I.3 Organizational Structure.....	15
Part II Objectives	19
II.1 Original Objectives	20
II.2 Goal Adjustments.....	22
Part III Program Outputs	27
III.1 Main Scientific Achievements, Phase I	28
III.2 Main Scientific Achievements, Phase II.....	32
Part IV Impact Analysis.....	43
IV.1 Synthesis	44
IV.2 Key Statements Related to Scientific Impact	49
IV.3 Key Statements Related to Educational Impact	61
IV.4 Key Statements Related to Economic Impact	71
IV.5 Key Statements Related to Societal Impact	80
IV.6 Key Statements Related to Institutional Impact.....	94
Part V Conclusion	99
Appendices.....	103
A. Timeline of Main Projects	104
B. Technology Readiness Levels	106

PART I

OVERVIEW

I.1 GENERAL OVERVIEW OF THE PROGRAM

Nano-Tera.ch is a Swiss national program supporting research in multi-scale system engineering for health, energy and the environment using nano-technologies. Launched in 2008, the program focused on excellence in collaborative research in engineering disciplines, the design of applied demonstrators, targeted educational programs, and the transfer of acquired research results to Swiss industry. It was jointly funded by the Swiss ETH-Board (ETH) and Swissuniversities (formerly CUS/SUK), under the general responsibility of the State Secretariat for Education, Research, and Innovation (SERI).

Nano-Tera.ch is one of the largest federal programs funding research in engineering sciences. It supported 188 projects with a total budget of about CHF 110 million of public funds (representing 91% of the overall budget of the program), complemented by about CHF 150 million of matching funds provided by the project partners. The funded projects range from large, 3-4 year research projects (RTD projects), carried out by consortia of 3 to 10 research groups from various Swiss institutions (Federal Institutes of Technology, Universities, Universities of Applied Sciences, etc.) to smaller research projects (NTF projects) focused on technologies, as well as various educational actions (ED projects).

The Nano-Tera.ch research community represents a network of more than 40 Swiss research institutions and involves about 1,600 members, covering a substantial fraction of the Swiss scientific community in the relevant fields.

The funded research resulted in nearly 1,600 peer-reviewed publications (44% of which were in established journals) and more than 2,000 presentations at conferences and workshops worldwide. A total of 77 awards have been received by Nano-Tera.ch researchers during the course of the program.

The scientific results were showcased each year at the Nano-Tera.ch Annual Meetings. Numerous prototypes and demonstrators were presented during those meetings, showing that the program focused on concrete collaborative research leading to potentially exploitable results. The scientific excellence of the funded projects was acknowledged by the annual evaluations carried out by a Panel of international experts under the responsibility of Swiss National Science Foundation and by the Nano-Tera.ch Scientific Advisory Board, who also continuously stressed the strong contribution the Nano-Tera.ch program made to the multidisciplinary development of Swiss engineering sciences.

The funded research was exploring various key thematic areas related to health and the environment. During the Phase 1 of the program (2008-2013), the research projects focused on topics such as enabling technologies for nano-systems (e.g. sensors, 3-dimensional integration), or various Health-Energy-Environment applications (e.g., environmental sensing of air quality and alpine movements, metabolic and biological cell monitoring, circuit design and cryptography). In the Phase 2 of the program (2013-2017), the research projects were exploring various topics combining engineering with life sciences, medicine and energy. For example, projects on smart prosthetics and body repair covered topics ranging from image-guided micro surgery for hearing aid implantation to tactile prosthetics for amputees or spinal cord neuro-prosthesis for restoration of locomotion. Health monitoring projects addressed the use of smart textiles for monitoring long-term obesity, smart bandages, newborn care, and personalized therapeutic drug monitoring. Projects on innovative medical platforms include flexible MRI detectors, cancer diagnostic using cantilever sensors, or high-performance portable 3D ultrasound platforms. In addition to these health-related challenges, Nano-Tera.ch was also tackling important issues in environmental monitoring, with technologies such as distributed sensor networks for air quality monitoring or natural hazard detection, multi-color lasers analyzing greenhouse gases or aquatic robots tracking water pollutants. Finally, Nano-Tera.ch was focusing on the crucial theme of smart energy, with projects addressing ultra-high performance photovoltaic solar cells, economically viable renewable energy production through solar-hydrogen generators, or smart power grid monitoring and management.

To further strengthen the impact of the research carried out in the program, the Nano-Tera.ch Executive Committee launched six strategic projects on topics such as the setup of industrial test-beds for research on smart energy systems, the promotion of user involvement in the domain of pervasive health systems, and the detailed analysis of the reliability/usability of sensor generated data.

At the international level, Nano-Tera.ch has contributed to several symposia, courses and seminars in collaboration with worldwide partners, and provided visibility for its research by taking booths at large conferences. In 2011 the program launched a strategic initiative aimed at encouraging Sino-Swiss research collaborations within Nano-Tera.ch thematic areas. This initiative benefitted from the existing agreement between the Chinese Academy of Sciences and the Sino-Swiss Science and Technology Cooperation program (SSSTC) supported by the SERI, and took the form of a competitive call for collaborative Sino-Swiss projects that led to the approval of 6 joint projects. Furthermore, Nano-Tera.ch launched an International Exchange Program inviting several prominent scientists to deliver a series of talks in various institutions involved in the program.


At the educational level, Nano-Tera.ch set up a specific NextStep program, designed to help PhD students explore different ways of increasing their potential as highly skilled staff for Swiss research and the Swiss economy. In particular, Nano-Tera.ch has provided coaching to PhD students to encourage them to consider economic applications for their scientific results. It provided research grants to fund collaborative research exclusively involving PhD students, and organized “My Thesis in 180 Seconds” contests to train PhD students to present their research to a larger audience outside their field.

From an industrial perspective, most of the RTD projects received support from industrial partners and/or hospitals: in total, industrial partners/hospitals have been involved in about 60% of the Nano-Tera.ch research projects, for a total of more than CHF 19.7 million of matching funds. Furthermore, 67 patent applications have been filed since the beginning of the program.

The impact on Swiss industry has been further strengthened by the Gateway pilot program, whose purpose was to transfer research results to Swiss industry. Concretely, eight projects were launched with a total public funding of around CHF 1.66 million, involving laboratories, institutions specialized in technology transfer (Empa and CSEM), as well as industrial partners. The goal of these projects was to convert the laboratory prototypes resulting from Nano-Tera.ch research projects into industrial demonstrators with high economic potential, directly exploitable by the industrial partners involved in the projects.

The Nano-Tera.ch results have raised public awareness of the program's achievements, with reports broadcast on national TV and Radio networks (SFR and RTS), articles published in the national press (the "Neue Zürcher Zeitung" and "Le Temps" newspapers) and international news networks (e.g. CNN).

Detailed information about Nano-Tera.ch can be found on the Nano-Tera website (www.nano-tera.ch), which is one of the main dissemination channels for the program. It typically attracts around 100,000 page views per year from more than 140 countries.

Nano-Tera.ch: Key figures				
Lifetime	2008-2017 (~10 years)			
Budget	273,779,298 CHF	Nano-Tera Funding	120,198,800 CHF	
		Own Contributions	153,580,498 CHF	
Projects	188	Large collaborative research projects (RTD)	44	
		Focused research projects (NTF)	24	
		RTD extensions (add-on, Gateway, PhD)	47	
		International research collaboration (SSSTC)	6	
		Strategic projects (STRAT)	6	
		Education and Dissemination activities (ED)	61	
Institutions	44	ETH-Domain	EPFL • ETHZ • Empa • Eawag • PSI	
		Universities	UniBas • UniBE • UniFR • UniGE • UNIL • UniNE • UniSG • USI • UZH	
		Uni. Appl. Scn.	BFH • FHNW • FHO • HESSO • SUPSI	
		Translational	CSEM • Empa	
		Hospitals	CHUV • Insel • HRC • HUG • Spitäler SH • Kinderspital ZH • KSW • USB • USZ	
		Others	15	
Industrial partners	69			
Personnel	~1,600	294	Project partners	
		366	PhD students involved in research projects and actions	
Publications	~1,600			
Awards	77			
Patents	67			

I.2 TERMS AND FIGURES

The purpose of this section is to define the key terms used in this evaluation report, and to summarize the main figures (duration, budgets, numbers of projects funded, etc.) providing a quantitative description of the overall operation of the Nano-Tera.ch program.

PROGRAM DURATION AND PHASES

The program has been organized in two main parts:

Phase 1: 2008 – 2012 (including the 2012 transition year)

Phase 2: 2013 – 2017

Ramping down Phase: January 2018 – June 2018

FUNDING INSTRUMENTS

To meet its strategic objectives, Nano-Tera.ch has deployed three main types of projects/actions:

- **Research, Technology and Development (RTD)** projects, representing about 80% of the Nano-Tera.ch budget, are large research projects involving a collaboration between several research groups from different disciplines, preferably from different institutions. Within an RTD project, the involved research groups contribute to a coordinated research efforts and exploit the synergies between their disciplines to explore topics at the boundary of traditional scientific domains. As the focus is on research projects with size, budget, and duration that could not be otherwise achieved through usual funding channels, RTD projects are ambitious research projects, with an expected duration of 3 or 4 years, and allocated budgets in the range of CHF 550,000/year, aiming at research on multi-scale system engineering, as well as at the training of doctoral students. An RTD project typically focuses, either on the in-depth study of a particular vertical technology or on the development and implementation in a specific horizontal application area. In addition to novel scientific and technological results, the RTD projects must also produce a system demonstrator showing how the achieved results can be used to seed a prototype/product development with tangible benefits to health, energy and the environment. An RTD project consortium should include one (or more) end-user(s) for the technology being developed, and the participation of industrial partners providing in-kind or in-cash contributions was strongly encouraged.
- **Nano-Tera Focused (NTF)** projects are small-scale research projects addressing specific scientific/technical issues and needs. Examples include, but are not limited to, activities collateral to RTDs, activities that are in-between the scope of two RTDs (glue projects) and activities that promote technology transfer. A limited percentage of the grant could be used for lab materials and supplies. Typical NTF duration range from one to two years, with an allocated funding of around CHF 110'000/year.
- **Education and Dissemination (ED)** actions correspond to activities aiming at supporting short courses, workshops, mini-conferences, and developing new curricula in domains covered by Nano-Tera.ch that are not provided by Swiss Universities or Polytechnic Institutes. ED actions may address the in-depth study of a technology or interdisciplinary horizontal activities, and their typical funding level is in the range of CHF 15-30,000.

Furthermore, additional types of projects have been supported to meet specific needs during the course of the program:

- **RTD Add-on projects** aimed at further consolidating the strategic vision of the program towards synergy between “Nano“ and “Tera“, strengthening and expanding presently established network of expertise and increasing industrial participation. RTD Add-on applications were restricted to Principal Investigators (PIs) from already existing Nano-Tera.ch, but each proposal could involve partners from other RTDs and/or totally new partners. Typical duration ranged from 6 months and beyond, but the any RTD Add-on had to terminate at the latest at the same time as the correlated RTD project. The total budget invested over the two phases by Nano-Tera.ch in RTD Add-ons was slightly above CHF 2.5 million.
- **SSSTC projects:** Under the umbrella of the Sino Swiss Science and Technology Cooperation (SSSTC), a Swiss national program for the promotion of bilateral science and technology cooperation with China., the SSSTC projects aimed at creating synergy and encouraging Swiss-Chinese research collaboration within the Nano-Tera.ch thematic areas. Project duration is at most 1 year, with a maximum funding per project of CHF 100'000.
- **Gateway projects:** Within the framework of the Gateway program (described in detail in Key Statement 12), the Gateway projects aimed at supporting the translation of research results obtained within Nano-Tera.ch RTD or NTF projects into operational industrial demonstrators, directly exploitable by the involved industrial partners. The total budget invested by Nano-Tera.ch in such projects was slightly above CHF 1.6 million.
- **Strategic projects:** To further strengthen the impact of the research carried out in the program, the Nano-Tera.ch Executive Committee has launched six strategic projects, focusing on topics such as the setup of industrial test-beds for research on smart energy systems, the promotion of user involvement in the domain of pervasive health systems or the detailed analysis of the reliability/usability of sensor generated data; for a total budget of about CHF 1.6 million.

CALL MECHANISMS

RTD and RTD Add-on projects were subject to specific calls and submission deadlines. Their competitive selection was operated under the supervision and evaluation of SNSF. NTFs and EDs resulted from a periodic call mechanism, with deadlines at the end of each quarter. The evaluation of the EDs was under the direct responsibility of the Executive Committee. For the NTF projects, a specific evaluation panel consisting of seven international experts external to Nano-Tera.ch has been put in place (see “The Nano-Tera.ch NTF Evaluation Panel” in section “I.3 Organizational Structure”). The responsibility of this panel was to evaluate the received NTF proposals, and to provide their recommendations in the form of a ranked list to the Executive Committee, who then took the final funding decisions. Strategic and Gateway projects were subject to specific calls launched under the responsibility of the Executive Committee. For the Gateway projects, an evaluation mechanism relying on a specific external evaluation panel, similar to the one put in place for NTF projects, has been used (see Key Statement 12 in “Part IV: Impact Analysis” for more detail).

The strategic positioning of the Nano-Tera.ch program has been translated into eligibility conditions imposed in the program calls, and which gave specific characteristics to the Nano-Tera.ch projects and consortia. In particular, for the RTD projects, Nano-Tera.ch imposed the following criteria:

- A clear positioning of the targeted research objectives in a "technology by applications" matrix, with vertical technologies intersecting horizontal application areas. This made it possible (1) to concentrate the research on three application areas (health, environment, energy), thus avoiding to scatter the available funds on too many topics, while contributing to a socially relevant scientific progress with a strong potential for the whole society; and (2) to focus on research in the engineering of integrated technological systems and platforms requiring a substantial collaboration between several scientific disciplines, and thus defining new areas of interdisciplinary research;
- The participation of industrial partners and end-users (typically hospitals);
- The required development of technology demonstrators, which encouraged integrative approaches involving industrial partners and end-users, and increased the potential for a transfer of the results to the Swiss industry.

Matching funds

As requested by the existing legislation, the budget of any project funded by Nano-Tera.ch had to include matching funds provided by the involved partners. To guarantee a matching fund ratio of 50% for the whole budget received by Nano-Tera.ch, including the management budget, the imposed level of matching fund for the funded projects was 53% of the total project cost in Phase 1 and 55% in Phase 2.

Eligible Applicants

Applications for Nano-Tera.ch projects were open to faculty members and senior scientists of both Polytechnic Institutes and other institutions of the ETH-Domain, of Swiss Universities and Universities of applied sciences, as well as of public and private research institutions outside of academia. In the case of private research institutions, eligibility for Nano-Tera.ch funding was regulated by the applicable legislation.

LAUNCHED CALLS

From 2008 to 2017, Nano-Tera.ch has launched 10 calls for proposals:

Year	Call	Launch Date
2008	1st Call for RTD, NTF, and ED projects	28.01.2008
2009	2st Call for RTD, NTF, and ED projects	11.12.2009
2010	Call for RTD-ADD-ON projects	16.09.2010
2011	Call for SSSTC, and ED projects, and for RTD PhD extensions	11.10.2011
2012	3rd Call for RTD, NTF, and ED projects	23.05.2012
2012	Call for Phase 1 Strategic projects	12.10.2012
2013	4th Call for RTD, NTF, and ED projects	14.02.2013
2015	Pilot call for Gateway projects	01.07.2015
2015	Call for Phase 2 Strategic projects	01.07.2015
2015	Call for Gateway projects and RTD PhD extensions	19.07.2016

Table 1. Calls for proposals.

The distribution of accepted proposals by project type and the year of the corresponding call is provided below.

Project Type	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
RTD	10	9			18	7				44
RTD-ADD-ON			8							8
GTW								4	4	8
PHD				18					13	31
SSSTC				6						6
STRAT					3			3		6

Table 2. Projects by call year.

For the two funding instruments that were implemented in the form of periodic calls, the distribution by starting year is given in the table below.

Project Type	2008	2009	2010	2011	2012	2013	2014	2015	2016	2016	Total
NTF	1	1	12	1		9					24
ED	1	2	4	12	5	8	9	12	5	3	61

Table 3. NTF projects and ED activities by starting year.

The competitive nature of the Nano-Tera call is illustrated by the table below, summarizing the acceptance rates achieved for RTD and NTF calls:

RTD projects	call	submitted proposals	accepted proposals	acceptance rate
Phase 1	2008	54	10	19%
	2009	15	9	60%
	Total	69	19	28%
Phase 2	2011	20	6	30%
	2012	31	12	39%
	2013	27	7	26%
	Total	78	25	32%
TOTAL		147	44	30%

NTF projects	submitted proposals	accepted proposals	acceptance rate
Phase 1	31	15	48%
Phase 2	37	9	24%
TOTAL	68	24	35%

Table 4. Acceptance rate.

PROJECT PARTNERS, THIRD PARTIES AND STAFF MEMBERS

Any of the accepted Nano-Tera.ch RTD project proposals was led by one of the applicants, called the Principal Investigator, or PI. The PI managed the project and ensured that it was carried to completion in all its aspects including reporting. The other applicants were called the project Co-PIs, and, collectively with the PI, the project partners. All partners of an accepted project signed a contractual agreement with Nano-Tera.ch (the “project guidelines”) defining their rights and obligations.

Each partner could use their allocated budget to fund full-time or part-time positions for staff to be involved in the project. Staff funded by other sources than Nano-Tera.ch could also be involved in accepted projects and their costs then became eligible as matching funds (also called “own contributions”).

Furthermore, any partner could also be associated with one or more additional teams that provided expertise and matching funds to the project. These additional teams were called project 3rd parties, and, contractually, each partner was responsible for the 3rd parties they have brought to their project.

Each project partner and 3rd party was attached to an institution/company, and institutions/companies involved in Nano-Tera.ch projects have been further categorized into a small set of types: research institutions, translational institutions, industry and end-users., where “translational” institutions are the ones, CSEM and Empa, specifically concerned with the transfer of research results to the industry, and “end-users” the ones, University hospitals for example, bringing real end-users to the project consortia, as well as concrete applicative contexts for the resulting prototypes/demonstrators.

The 188 projects and actions funded by Nano-Tera.ch involved a total of 346 partners and 3rd parties, stemming from 111 institutions/companies. The distribution of all partners and 3rd parties involved in Nano-Tera.ch projects by institution type is displayed in the chart below.

Type	Partners	3rd Parties	Total
Research	166	7	173
Translational	51	1	52
Industry	18	62	80
End user	33	8	41
Total	268	78	346

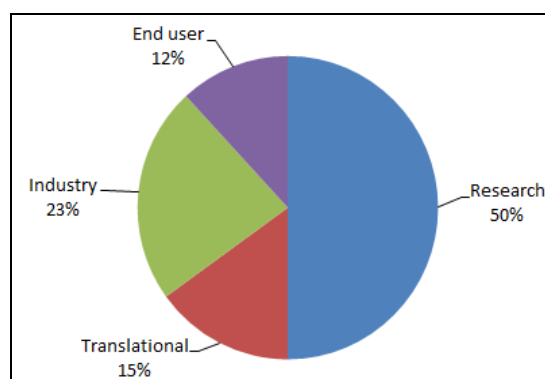


Figure 1. Number of partners and third parties by institution type.

FINANCIAL DATA

The Nano-Tera.ch program benefitted from a total budget of 120'198'800 CHF, provided at two-thirds by the ETH-Board and at one-third by the Board of the Swiss Universities, under the supervision of the Swiss National Science Foundation (SNSF). The original distribution of this budget over the Phases and the budget types was defined in the SERI decrees related to the Nano-Tera.ch, and is given in the table below:

Budget type	Phase 1 (2008-11)	Transition year (2012)	Phase 2 (2013-17)	Total	%
Management budget	3'200'000	800'000	3'200'000	7'200'000	6%
Strategic budget	2'000'000	600'000	2'000'000	4'600'000	4%
NTF projects	3'000'000	90'000	2'400'000	5'490'000	5%
ED projects	1'500'000	375'000	600'000	2'475'000	2%
RTD projects(*)	48'942'800	12'935'000	38'556'000	100'433'800	83%
Total	58'642'800	14'800'000	46'756'000	120'198'800	

(*) The 48 942 800 CHF budget planned for Phase 1 RTD projects includes the Federal cut imposed in 2010 by the Swiss government on all research programs. In the case of Nano-Tera.ch, this cut amounted to 557'200 CHF.

Table 5. Original budget overview.

The final budget distribution resulting from the balancing between the program phases and budget types required by the call results and operational constraints of the program is given in the table below:

Budget	Phase1	Phase2	Total	%
Management	3'483'730	4'339'354	7'823'084	6.5%
Strategic	954'564	1'448'111	2'402'675	2.0%
STRAT projects	890'787	780'000	1'670'787	1.4%
NTF projects	2'823'746	2'466'894	5'290'640	4.4%
ED projects	825'044	600'000	1'425'044	1.2%
RTD projects	44'348'595	51'215'184	95'563'779	79.5%
PHD projects	876'747	418'119	1'294'866	1.1%
RTD-ADD-ON projects	2'530'425	0	2'530'425	2.1%
SSSTC projects	530'526	0	530'526	0.4%
GTW projects	0	1'666'975	1'666'975	1.4%
Total	57'264'163	62'934'637	120'198'800	

Table 6. Actual budget distribution.

In addition, the charts below are displaying the distribution of the project allocated budgets (left), and associated matching funds (right).

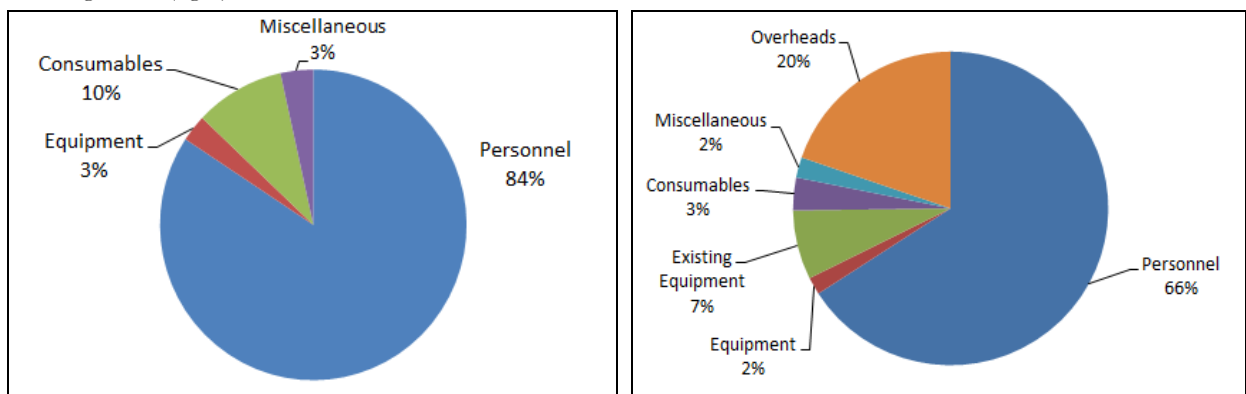


Figure 2. Left: Distribution of Nano-Tera budget by cost categories. Right: Distribution of matching funds provided by project partners.

A more detailed analysis of the Nano-Tera.ch budget invested in personnel in RTD projects further provided the budget distribution by personnel categories given in the figure below. In particular, this distribution indicates that more than 69% of the RTD personnel budget has been invested in junior researchers (PhD students and Postdocs).

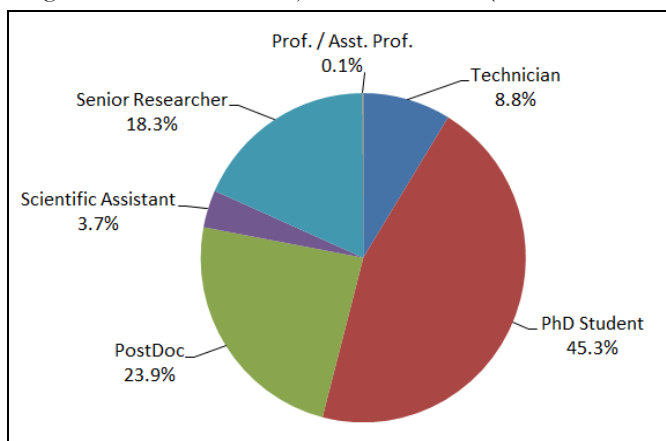


Figure 3. Distribution of budget invested in personnel by personnel categories (RTD projects).

Finally, the chart below provides the distribution of the allocated budgets by institution type.

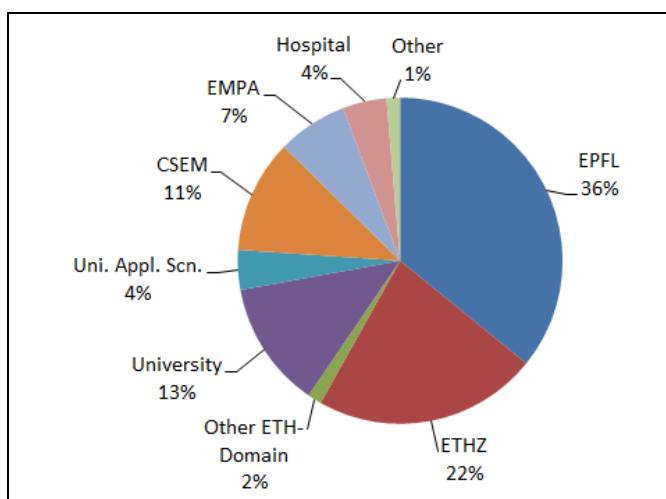


Figure 4. Distribution of allocated budget by institution type.

FUNDED PROJECTS

The distribution by project type of the 188 projects funded by Nano-Tera.ch during each of its two phases is provided in the table below, along with the average duration, number of partners and third parties, and average budget.

Project Type	Phase 1	Phase 2	Total	Avg. duration (months)	Avg. Nb. Partners & 3 rd parties	Avg. Budget (CHF)	% from Research	% from Translational	% from Industry	% from End Users
RTD	19	25	44	48	7	2'171'904	58%	12%	19%	12%
RTD-ADD-ON	8	0	8	28	5	316'303	63%	11%	21%	5%
GTW	0	8	8	16	3	208'372	7%	37%	56%	0%
PHD	18	13	31	7	1	41'770	97%	3%	0%	0%
SSSTC	6	0	6	13	2	88'421	83%	17%	0%	0%
STRAT	3	3	6	23	3	278'465	81%	6%	6%	6%
NTF	15	9	24	25	2	220'443	56%	20%	11%	13%
ED	29	32	61	6	2	23'173	85%	14%	0%	1%
Total	98	90	188							

Table 7. Statistics showing the number of projects by phase, the average duration, number of partners and budget.

I.3 ORGANIZATIONAL STRUCTURE

The Nano-Tera.ch program built on the experience acquired in several Swiss initiatives, such as NCCRs, the National Competence Centers for Research launched by the ETH-Board, and received a strong support from the Swiss National Science Foundation (SNSF), who has been in charge of the evaluation of the proposals received for the RTD calls, and for the annual review of the accepted RTD projects. As a result, the State Secretariat for Education, Research, and Innovation (SERI) has set up Nano-Tera.ch as a consortium (the “Nano-Tera.ch Consortium”) of seven member institutions: the two Federal Institutes of Technology (EPF-Lausanne and ETH-Zurich), the Centre Suisse d’Electronique et de Microtechnique (CSEM), and four universities (the University of Basel, of Neuchâtel, of Geneva, and of Svizzera Italiana). The consortium took the legal form of an Ordinary Partnership (“société simple” or “Einfache Gesellschaft”), relying on four governing bodies: the Nano-Tera.ch Steering Committee, the Nano-Tera.ch Executive Committee, the Nano-Tera.ch Scientific Advisory Board, and the SNSF Evaluation Panel. An additional evaluation panel, the Nano-Tera.ch NTF evaluation panel, has been set up by Nano-Tera.ch specifically for the evaluation of the NTF calls. The operational management of the program is carried by a specific management structure, the Nano-Tera.ch Management Office, hosted at EPFL.

NANO-TERA.CH STEERING COMMITTEE

The Nano-Tera.ch Steering committee is responsible for the overall monitoring and responsibility of the program. It is composed of the Rectors, Presidents, and CEOs of the partner institutions, and chaired by the President of EPFL. The Steering Committee makes all high-level decisions and conducts actions requiring statutory authority.

These attributions include, notably:

- government and institutional relations;
- decisions that directly impact the structure of the partnership (e.g., new partners, legal form of the partnership);
- appointment of the members of the Executive committee and of the Scientific Advisory Board;
- approval of the global strategy of the program, and of its annual budget and annual report.

Institutions with the statute of partner in Nano-Tera.ch have up to one representative in the Steering committee. The Steering committee may also invite non-voting members, from other institutions or from companies that have close collaborations with Nano-Tera.ch.

Voting members each have one vote, the Chair having a casting vote in a case of tie. The Steering committee typically meets once a year. Generally, the Chair of the Executive committee participates to the meetings as a non-voting invited member. If needed, the committee decides on measures to be implemented, that take into account some suggestions provided by the Nano-Tera.ch Executive Committee.



Prof. Patrick Aebischer
Chairman and President
of EPFL



Prof. Philippe Gillet
Alternate to the Chair and
Vice-President for
Academic Affairs, EPFL



Dr. Mario El-Khoury
CEO
CSEM



Prof. Yves Flückiger
Rector
UniGE



Prof. Detlef Günther
Vice-President
ETHZ



Prof. Piero Martinoli
President
USI



Prof. Martine Rahier
President
UniNE



Prof. Andrea Schenker-Wicki
Rector
UniBas

As the composition of the Nano-Tera.ch Steering Committee changed over the lifetime of the program, the above mentioned list of current members is complemented below by the list of all former members:

Prof. Jean-Pierre Derendinger	UniNE	Until 07.2008
Prof. Ralph Eichler	ETHZ	Until 01.2015
Dr. Thomas Hinderling	CSEM	Until 10.2009
Prof. Antonio Loprieno	UniBas	Until 07.2015
Prof. Jean-Dominique Vassalli	UniGE	Until 07.2015

In addition, as Vice-President for Academic Affairs of the hosting institution, Prof. Giorgio Margaritondo also played a central role in the setup of the initial Steering Committee and was responsible for the overall supervision of the program as substitute of the Steering Committee president.

NANO-TERA.CH EXECUTIVE COMMITTEE

The Nano-Tera.ch Executive committee (ExCom) is the scientific executive body of Nano-Tera.ch. It consists of a group of nine representatives from partner institutions, and is chaired by the spokesperson of the program. The ExCom coordinates and fosters collaborations between the research groups that participate to Nano-Tera.ch. As the overarching scientific body of Nano-Tera.ch, it provides the scientific guidance for the program. Members of the ExCom cover collectively all strategic orientations and thematic foci of Nano-Tera.ch. Their candidacy is put forward by their respective institutions and they are appointed (or dismissed) by the Steering committee.

By delegation of the Steering committee, the ExCom has all competences not otherwise attributed.

In particular, the ExCom:

- defines and implements the scientific and academic strategy;
- plans, announces and coordinates the calls for proposals;
- proposes cross-disciplinary projects with other major initiatives;
- plans and implements educational initiatives in the framework of Nano-Tera.ch;
- designs and coordinates outreach initiatives (e.g. continuing education and training);
- defines and ensures communication, both among the researchers of Nano-Tera.ch and in Switzerland, and with similar institutions or Centers outside Switzerland;
- finalizes the financial planning and annual budget;
- decides the funding of tactically important projects, according to predefined rules and attributions decided by the Steering committee and the competent federal agencies.
- plans and coordinates the scientific reviews and corresponding reporting;
- ensures the necessary monitoring and follow-up, both scientific and financial;
- proposes the names of international specialists to be appointed by the Steering Committee for the Scientific Advisory Board.

The ExCom meets six to twelve times a year. The Executive director of Nano-Tera.ch generally participates to the meeting as a non-voting member. The general practices and organization of the ExCom are detailed in the founding agreement for Nano-Tera.ch.



Prof. Giovanni De Micheli
Chair, EPFL



Prof. Nico de Rooij
EPFL



Dr. Michel Despont
CSEM



Dr. Alex Dommann
EMPA



Prof. Boi Faltings
EPFL



Prof. Christofer Hierold
ETHZ



Prof. Qiuting Huang
ETHZ



Prof. Mirosław Malek
USI



Prof. Hugo Zbinden
UniGE

As the composition of the Nano-Tera.ch Executive Committee changed over the lifetime of the program, the above mentioned list of current members is complemented below by the list of all former members:

Prof. Mehdi Jazayeri	USI	Until 03.2013
Prof. Christian Schönenberger	UniBas	Until 01.2010
Prof. Lothar Thiele	ETHZ	Until 03.2014

Note that Prof. Lothar Thiele is now serving as President of the BRIDGE Steering Committee.

NANO-TERA.CH SCIENTIFIC ADVISORY BOARD

The role of the Nano-Tera.ch Scientific Advisory Board is to provide the necessary input on performance and overall quality of the entire program. The board consists of industry representatives and academics from institutions other than institutions participating in Nano-Tera.ch. In 2017, the Nano-Tera.ch Scientific Advisory Board was composed of the following eight members:

Prof. Heinrich Meyr, Chair	TU Dresden
Dr. Andreas Cuomo	STMicro
Prof. Satoshi Goto	Waseda University
Prof. Enrico Macii	Politecnico di Torino
Prof. Khalil Najafi	University of Michigan
Prof. Calton Pu	Georgia Tech
Prof. Lina Sarro	Technical University Delft
Prof. Göran Stemme	Royal Inst. of Technology Stockholm

As the composition of the Nano-Tera.ch Scientific Advisory Board changed over the lifetime of the program, the above mentioned list of current members is complemented below by the list of all former members:

Prof. Nick Jennings	University of Southampton	Until 05.2011
Prof. Teresa Meng	Stanford University	Until 2015

SNSF EVALUATION PANEL

To fulfil their evaluation and review responsibility in Nano-Tera.ch, the SNSF appointed a specific panel to evaluate the proposals and activities developed within Nano-Tera.ch that are not of the exclusive responsibility of the Nano-Tera.ch ExCom. The panel comprises international and Swiss experts in the fields of engineering relevant to Nano-Tera.ch. The recommendations of the panel are transmitted to the SNSF National Research Council that takes the final decisions. The latest SNSF Evaluation Panel was composed of the following 17 members:

Prof. Paul Leiderer, Chair	SNSF
Dr. Amara Amara	ISEP
Prof. Manfred Bayer	TU Dortmund
Dr. David Bishop	Boston University
Prof. Chris Boesch	University of Bern
Prof. Harald Brune	SNSF
Prof. Frederica Darema	NSF (USA)
Dr. Urs Dürig	SNSF
Prof. Georges Gielen	Leuven University
Prof. Chih-Ming Ho	UCLA
Dr. Patrick Hunziker	UniBas
Prof. Mary Jane Irwin	Penn State University
Dr. Karl Knop	SATW
Prof. Leila Parsa	Rensselaer Polytechnic Institute
Prof. Jan Rabaey	University Berkeley
Prof. Albert van den Berg	University Twente
Prof. Hubert van den Bergh	SNSF

As the composition of the SNSF Evaluation Panel changed over the lifetime of the program, the above mentioned list of current members is complemented below by the list of all former members:

Prof. Patrick Dewilde	TU München	Until 2010
Prof. Rolf Ernst	TU Braunschweig	Until 2013
Prof. Jeff Maggee	Imperial College	Until 2009
Prof. Jürg Osterwalder	SNSF	Until 2009
Prof. Christopher Rose	Brown University	Until 2009
Prof. Rodney Ruoff	University of Texas at Austin	Until 2009
Dr. Marco Wieland	SNSF	Until 2013
Prof. Hiroto Yasuura	Kyushu University	Until 2013

NANO-TERA.CH NTF EVALUATION PANEL

The NTF Evaluation Panel consists of international experts, responsible for the evaluation of the NTF proposals.

The current members of the Nano-Tera.ch NTF Evaluation Panel are:

Dr. Thomas Burg	Max Planck Inst. for Biophys. Chemistry
Dr. Thomas Ernst	CEA-LETI
Dr. Victor Erokhin	Università degli studi di Parma
Prof. Luca Fanucci	Università di Pisa
Dr. Ahmed Jerraya	CEA-LETI
Prof. Jan Madsen	Technical University of Denmark
Dr. Firat Yazicioglu	GlaxoSmithKline

NANO-TERA.CH MANAGEMENT OFFICE

The operational administration and management of Nano-Tera.ch are ensured by a specific structure, the Nano-Tera.ch Management Office, supervised by the Chair of the ExCom and hosted by EPFL. The Management Office is headed by the Nano-Tera.ch Executive Director, whose tasks and competences are proposed by the Chair of the ExCom and approved by the ExCom.

In particular, the Nano-Tera.ch Executive Director is responsible to:

- implement the strategy, vision and plan proposed by ExCom;
- be the point of contact between the ExCom and the research teams involved in Nano-Tera.ch;
- be the contact point between the ExCom, the Steering Committee, the CUS, the ETH Board and the SERI;
- serve as the secretary of the Steering committee and ExCom; this includes preparing the agenda and possible decision protocols, organizing the meetings and recording their corresponding minutes and decisions;
- elaborate the financial planning and annual budget;
- set-up and run the administrative structure of the program;
- ensure management, accounting and reporting of all resources transiting through or contributed to Nano-Tera.ch;
- coordinate the implementation of education and outreach initiatives, evaluation procedures and overall monitoring of the program;
- prepare and coordinate meetings and timely reporting;
- provide the necessary support and assistance for issues pertaining to intellectual property, industrial liaison, research contracts and interface with other similar initiatives, in Switzerland and abroad.
- organize scientific events (meetings, workshops, etc.) and contribute to the international visibility of nano-tera.ch through adequate communication (e.g. web site, newsletters, etc.)

PART II

OBJECTIVES

II.1 ORIGINAL OBJECTIVES

BACKGROUND

Based on the decisions announced in the SERI message of 2008-2011, the national funding program Nano-Tera.ch was launched in accordance with Article 41, paragraph 5 of the Federal Act on the Promotion of Research and Innovation (RIPA).

The main goal of this program was the development of key technologies involving micro- and nano-scale components in the framework of an interdisciplinary national network, with the scientific challenge of developing basic technologies in electronics, information and communication sciences, as well as material sciences, to create blocks at the micro- and nano-scale, able to generate large amounts of useful data and to be used in various engineering applications. In the foreseeable future, the program should lead to a significant strengthening in the domain of Knowledge and Technology Transfer and to an increased collaboration with the interested players from the private sector.

As the program has been created in the form of a *national joint task*, it has been implemented with a specific organizational structure (the Nano-Tera.ch Consortium, responsible in particular for the strategic management). In addition, a scientific evaluation mechanism independent from the Consortium has been institutionalized by the Swiss National Science Foundation in the form of a special commission (the SNSF Evaluation Panel). A specific reporting mechanism has also been established as part of the procedures associated to *project-linked contributions* (cooperative projects).

Already at its launch in 2008, the perspective of a relatively long-term financial support had been envisioned for the program. With a one-year extension in 2012 (SERI message of 2012) and a 4-year extension based on the decisions announced in the SERI message of 2013-2016, the Nano-Tera.ch program is terminating at the end of 2017 and will thus have been running for a total of 9 years. Altogether, the Swiss Confederation has provided a total funding of about CHF 120 million CHF over the whole lifetime of the program.

In agreement with the involved parties, the SERI, as competent authority, decided that the Nano-Tera.ch program should undergo an impact evaluation before its formal conclusion.

VISION

The activities proposed by Nano-Tera.ch to the Swiss government were articulated in a Proposal (for a cooperative project) and in a Business plan, both presented in 2007. The overall vision can be articulated as follows.

The program aims at bringing Switzerland to the forefront of a new technological revolution driving engineering and information technology for health and security of humans and the environment in the 21st century. This revolution is rooted in advances in engineering nano-scale materials and their exploitation in a variety of systems, requiring extreme integration and coordinated control of diverse micro/nano-scale components.

In this perspective, the mission of the program can be summarized as the research, design and engineering of complex (tera-scale) systems and networks to monitor and connect humans and/or the environment. Beyond straightforward integration, the program aims at identifying and fostering the potential synergies between micro/nanocomponent technology and large-scale system design technologies (ranging from hardware to software and networking).

STRATEGIC OBJECTIVES

Nano-Tera.ch's original strategic objectives (described in the 2007 proposal and business plan) call for the collaboration of the main scientific institutions in Switzerland to create interdisciplinary and inter-institutional teams of researchers.

Namely, the Nano-Tera.CH program should be a collaborative engineering program that fosters the research and crossbreeding of hardware and software technologies in the areas of wearable, ambient and networked systems. The program is mainly expected to:

- be instrumental in keeping Switzerland in the lead in the high-tech industrial sector, in particular by fostering innovation through collaboration between researchers and industrial partners within large research projects;
- develop advanced technologies, such as micro/nano-electronics, sensors, micro/nano-electromechanical systems (MEMS/NEMS), as well as systems and software for information processing and communication;
- integrate these technologies to better the quality and security of health and environment systems in Switzerland, thus promoting a vision of engineering with social objectives;
- embody the research outcomes into prototypes, acting both as demonstrators and technology drivers, to strengthen technology transfer to the Swiss industry;
- train junior scientists through interdisciplinary graduate/doctoral education programs and workshops in the domains covered by the program.

TARGETED RESEARCH

Advanced research for health, energy and the environment requires the meaningful and efficient acquisition, processing, transmission, and integration of data coming from a very large number of heterogeneous sources. Thus, the scientific unifying theme of this program is to design and demonstrate tera-scale networks that combine information coming from different sources, such as biomedical information, physical quantities, audio-visual-sensorial information, etc. Whereas the design of large-scale networks proved to be feasible and successful in many domains (e.g., the Internet revolution), Nano-Tera.ch aims at raising current network capabilities in two directions: (1) the heterogeneity of sources and applications; and (2) adaptation to the scale and complexity human and environmental landscape.

To achieve its scientific objectives, Nano-Tera.ch covers two major dimensions:

- Research and development of advanced technologies, such as (1) micro/nano-electronics, electromechanical systems (MEMS/NEMS) and manufacturing processes; (2) (bio)-sensors, actuators and their system-level integration; (3) information and communication sciences, as well as systems and software engineering.
- Integration of these technologies into application fields, such as wearable systems (e.g., for monitoring of patients, sportsmen, and the elderly), ambient systems (e.g., for environmental intelligence, building monitoring and virtual world) and networked systems (e.g., sensor networks operating in various environments, ranging from rock movement monitoring networks deployed in the very adverse conditions of high altitude mountains to city scale air pollution monitoring networks operating with mobile sensors on buses or trams).

The program has been organized in a matrix-like structure, intersecting targeted cross-disciplinary research with three socially relevant areas: health, energy and the environment.

The underlying enabling technology is relying on micro/nano-technologies and their applications to the design of distributed, networked, embedded systems. Thus, Nano-Tera.ch is built around a technology kernel that supports embedded system applications. Beyond the mere straightforward integration, the program aims at identifying and fostering the potential synergies between micro/nanocomponent technology and large-scale system design technologies, ranging from hardware to software and networking. Indeed, the availability of sensing, computing and communication technologies enables and constrains the design of embedded systems. Conversely, the stringent requirements of embedded systems on size, weight, power dissipation and communication range demand major innovation in micro/nano-technologies. While the existence of such synergy opportunities is widely recognized, an ambitious large-scale holistic approach such as the one proposed by the Nano-Tera.ch initiative was still unheard of at the inception of the program.

II.2 GOAL ADJUSTMENTS

INITIAL ADJUSTMENTS: RESHAPING THE RESEARCH SPACE

In 2008, the governing bodies of Nano-Tera.ch (Steering and executive committees) and the Swiss National Science Foundation set up operational procedures for the program, taking into account realistic constraints related to budget and priorities. Specifically, the Swiss National Foundation requested excellence in research as a primary objective, and the Nano-Tera.ch boards requested a fair distribution of the Nano-Tera.ch activities through the various institutions and over the various scientific topics. As a result, Nano-Tera.ch focused on supporting and nurturing pinnacles of excellence within the broad area of research proposed in the original vision.

The original matrix-like structure of the program has been modified in order to match the program objectives with the current most adequate research topics.

In the first call for proposals (2008), the reference matrix was the following:

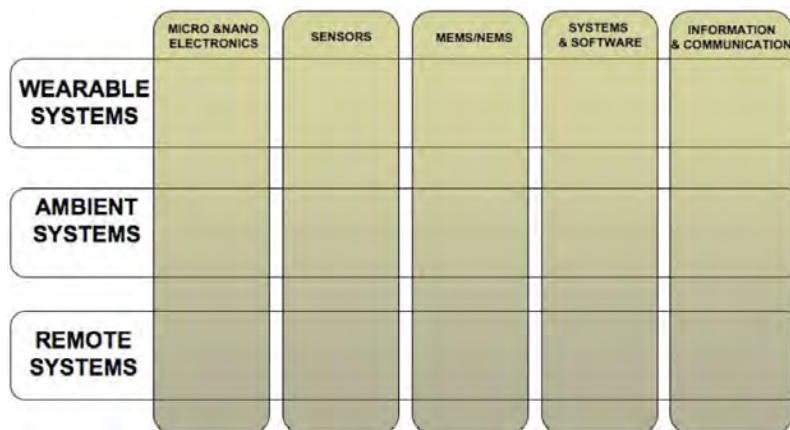


Figure 5. Original matrix structure.

In the 2011 call for proposals, the matrix was altered to include the theme of energy and the domains have been consolidated to take into account the distribution of the past proposal submissions and of the research activities in Switzerland. It took the shape displayed in the figure below and was no longer modified.

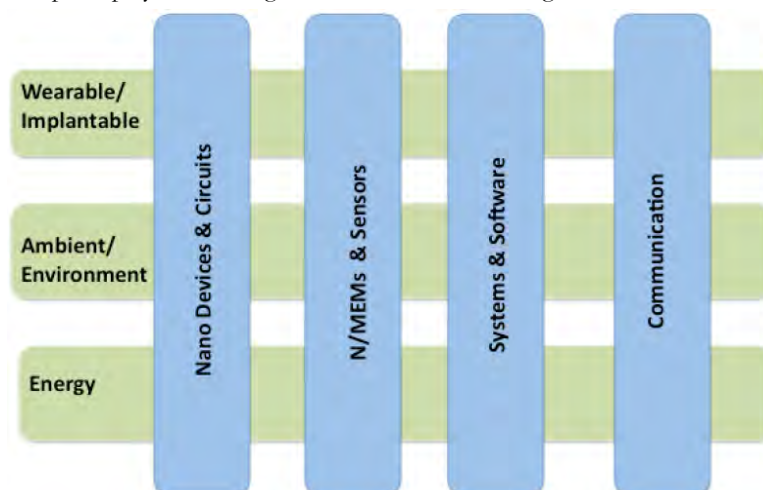


Figure 6. New matrix structure, call 2011.

SPECIFIC ADJUSTMENTS: ANALYZING TECHNOLOGY TRANSFER

Tech Transfer Maps

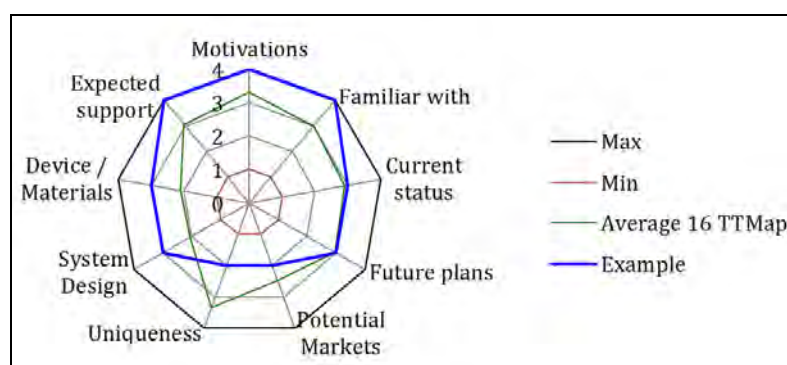
At the end of Phase1, Nano-Tera.ch hired an external consultant to conduct a survey of the Knowledge and Technology Transfer activities performed within the RTD projects. The survey took the form of a questionnaire sent to the PIs of the 19 RTD projects, and exploring the following 9 Technology Transfer related dimensions:

- | | |
|---------------------|--|
| - Motivation | Motivations within the RTD project for Technology Transfer |
| - Familiar with | How familiar are the RTD partners with Technology Transfer? |
| - Current status | What is the current status in terms of Technology Transfer? |
| - Future plans | What are the future plans? |
| - Potential markets | What are the potential markets for the generated research results? |
| - Uniqueness | How unique is the expertise developed in the RTD project? |
| - System Design | What is the level of integration of the generated prototype(s)? |
| - Device/Materials | Where is the key differentiator (in devices or in materials)? |
| - Expected Support | Do you expect to receive support from Nano-Tera.ch for Technology Transfer issues? |

In total, the questionnaire consisted of more than 100 questions, and 15 of the 19 contacted PIs accepted to participate to the survey. The provided answers were used to produce, for each of the surveyed RTD projects, a global rating for each of the 9 dimensions considered, ranging from 0 (the dimension has not really been taken into account in the RTD project) to 4 (the dimension has strongly been taken into account in the RTD project).

Finally, the ratings of each of the 15 projects analyzed have been displayed in the form of a “radar plot”, hereafter called the “Tech Transfer Map” of the project (or TTMap). All the maps have been validated by the involved PIs.

The chart below displays the aggregated results of the survey in the form of the min, max and average radar plots.



The survey resulted in the following specific conclusions, corresponding to the dimensions associated with higher or lower overall scores.

Five dimensions have been associated with higher score:

- “Motivation” (scored 3.3/4): The PIs are understanding the importance of Technology Transfer, even if they do not plan to lead an specific action related to it;
- “Uniqueness” (scored 3.3/4): The PIs have a very clear understanding of the scientific positioning of their research, and a good knowledge of their scientific competitors (i.e. other laboratories worldwide carrying out similar research);
- “Expected support” (score 3.1/4): The PIs demand for Nano-Tera.ch support related to Technology Transfer is high, but not very specific due to the lack of precision of the associated future plans (see “Future plans” below);
- “Familiar with” (scored 3.0/4): The PIs are quite familiar with various approaches to Technology Transfer, in particular the creation of start-ups;
- “Future plans” (scored 3.0/4): Many PIs can imagine a future in terms of Technology Transfer, but few of them can be very specific in describing such plans.

Four dimensions have been associated with a lower scores, in particular:

- “Potential markets” (scored 2.5/4): Exploring potential markets is not a central concern for the PIs, and the RTD project thus remain quite far from market considerations;
- “System design” (scored 2.1/4): Targeting an integrated demonstrator requires a lot of effort and time, and it is therefore truly challenging to develop a “unique blend of technology exploration and system design”.

Furthermore, the survey led to the following general conclusions:

- Scientific inter-disciplinarity is seen as a necessity, as it represents a true differentiator, but it also substantially adds to the complexity of possible go-to-market strategies;
- The “system engineering” approach is considered as essential and complements the scientific inter-disciplinarity; it is a key element for the production of socially relevant results, but it also strongly adds to the complexity of the possible “go-to-market” strategies.

Tech Transfer Positioning Tables (Phase 1)

The answers to the survey have also been used to derive a “Tech Transfer Positioning Table” (or TTPositioning Tables) in which each of the analyzed RTD projects has been positioned along two dimensions: (1) Fundamental research vs. pre-competitive research; and (2) Short vs Long Time to market.

On the “Fundamental research vs. pre-competitive research” dimension, the positioning of the projects has been derived from the analysis of the answers provided to the survey, and resulted in the clustering of the project results (i.e. demonstrators and prototypes) in 3 distinct clusters:

- Cluster 1 (prototype in an industrially relevant environment, i.e. at Technology Readiness Level 6+, or TRL6+, for a precise definition of the various TRLs, see Appendix B): There is a prototype that demonstrates the feasibility and the usefulness and the integration in the “value chain”, and researchers *with* users *and* companies are able to answer the questions: What is the problem solved? How to produce it at a reasonable cost in the market?
- Cluster 2 (prototype in simulated operational environment, i.e. at Technology Readiness Level 5, or TRL5): There is a prototype, demonstrating viability and usefulness of the technology, able to convince industrial partners to consider its exploitation, and researchers *with* users are able to answer the questions: What is the problem solved? What's the point?
- Cluster 3 (prototype in laboratory environment, i.e. at Technology Readiness Level 4, or TRL4): The prototype is not yet mature enough to convince industrial partners to exploit it; researchers mainly target a proof-of-concept and were so far the only ones considering the question: What is the problem solved?

On the “Short vs Long Time to market» dimension three time horizons have been considered:

- Short term, i.e. 2013 – 2016;
- Mid-term, i.e. 2016 – 2019;
- Long term, i.e. beyond 2019.

The resulting Tech Transfer Positioning Table obtained for the 15 analyzed Phase 1 RTD projects is provided in the figure below:

Technology Readiness Level (TRL)			
industrial relevant environment (TRL6+) simulated operational environment (TRL5) laboratory environment (TRL4)			X-Sense OpenSense CMOSAIC QCrypt
	ISyPeM PATLiSci i-IronIC Nutrichip SimOS	IrSens NexRay	
	MIXSEL CabTuRes SelfSys LiveSense		
	Long-term (>2019)	Mid-term (2016-2019)	Short-term (2013-2016)
	Potential Time-to-Market		

Figure 7: Tech Transfer Positioning Table (Phase 1 RTD projects).

In this figure, the 6 projects highlighted in green have been extended with follow-ups to Phase 2.

The major conclusion to be derived from the resulting Phase 1 TTPositioning Table is that 31.5% of the RTD projects were able to produce industrially exploitable (or nearly exploitable) prototypes (i.e. prototypes at TRL5 or higher with an expected mid- or short-term Time-to-Market).

The combined analysis of Phase 1 TTMaps and TTPositioning Tables led to the following overall conclusion related to the Knowledge and Technology Transfer aspects in Nano-Tera.ch: while the Knowledge Transfer resulting from the set-up of long-lasting research consortia (the ones of the RTD projects) mixing research partners and industrial partners has been operating very efficiently, the impact in terms of Technology Transfer needed to be further strengthened to increase the fraction of RTD projects producing industrially exploitable (or nearly exploitable) prototypes. In this perspective, the following corrective measures have been implemented:

- Modifying the eligibility conditions of the Phase 2 RTD calls Phase 2 by making the presence of end-users mandatory: the goal is to increase the applicative relevance of the produced prototype, thus making them easier to consider for exploitation by the involved industrial partners;
- Launching a specific program, the NextStep program, aiming at helping the PhD students involved in Nano-Tera.ch increase their entrepreneurial mindset and consider the economic exploitation of the results of their research, e.g. by the creation of start-ups (see Key Statement 10);
- Launching a specific program, the Gateway program, aiming at strengthening the conversion of forefront research results into industrially exploitable prototypes (see Key Statement 12).

In March 2017, the oral presentations made by all the Phase 2 RTD project PIs about the intermediate results obtained in their projects, as well as the Impact Sheets produced by Nano-Tera.ch for each of these projects, have been analyzed to produce a "Tech Transfer Positioning Table" for the 25 Phase 2 RTD projects. This table, built according to the same principle as the one produced for Phase 1 RTD projects, is provided below.

Figure 8: Tech Transfer Positioning Table (Phase 2 RTD projects).

The major conclusion derived from this table is that 56% of the Phase 2 RTD projects were able to produce industrially exploitable (or nearly exploitable) prototypes, while this ratio was of 31.5% for the Phase 1 RTD projects. This substantial increase clearly illustrates the positive impact of the corrective measure taken at the end of Nano-Tera.ch Phase 1.

PART III

PROGRAM OUTPUTS

III.1 MAIN SCIENTIFIC ACHIEVEMENTS, PHASE I

HEALTH MANAGEMENT

Future health management systems require an increasingly large presence of automation, information extraction and elaboration, as well as control of the medical procedures. In this perspective, three major innovation areas have been addressed in the first phase of the Nano-Tera program: biosensing, advanced diagnosis tools, and medical care support.

BIOSENSING

Although some biosensors are already available on the market, there is a strong potential for improvement of the techniques used to perform bio-measurements, for example by exploring novel sensing mechanisms, by using advanced electronic devices and materials, or by tightly coupling electronic sensing to data acquisition chains.

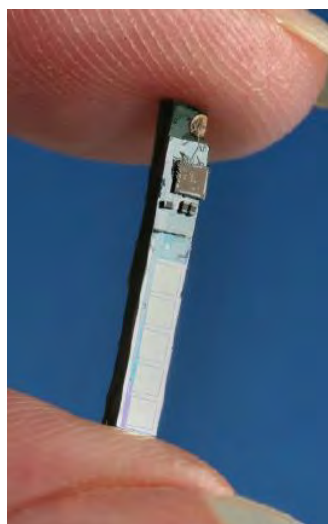
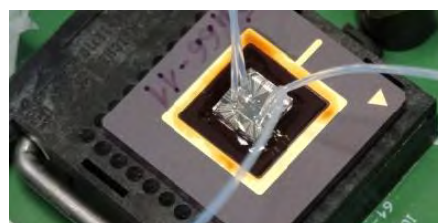
In this perspective, Nano-Tera.ch projects have been exploring different avenues:



Building sensing platforms based on optical near and mid-infrared range spectroscopy that exploit optical absorption properties of the analytes. In such platforms, the sensors probe the vibrational frequencies of molecules present in fluids and gases. A typical example of such an approach is the **IrSens** project that has led to the industrialization of a hydrogen fluoride sensor, a compact instrument measuring CO₂ isotopes with record precision, as

well as the first detection of cocaine in saliva using mid-infrared sensing techniques.

Developing modular sensor platforms using silicon nanowire (SiNW) field-effect transistors, interfaced to electronics and microfluidic channels for liquid handling. As illustrated in the **NanowireSensor** project, one of the important advantages of such platforms is that the sensors have the potential to be mass manufactured at reasonable costs, allowing their integration as the active sensor part in electronic point-of-care diagnostic devices.

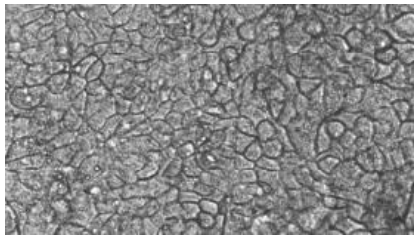


Health monitoring systems combining networked databases with on-line (i.e. real-time) wearable/implantable monitoring devices represent a true potential for better therapy and increased autonomy of the patients. However, noting that few systems involving on-line biosensing capabilities were available – and often limited to either wearable devices for human telemetry that do not measure any molecular metabolites, or glucose monitoring systems for diabetic patients – it was important to design accurate and affordable biosensing devices able to provide fast response and secure interaction with on/in body electronics, and to detect and quantify multiple compounds in parallel several times a day. This challenge has been tackled by the **i-IronIC** project, which designed an on-line implant for real-time monitoring of various human metabolites (such as lactate, cholesterol, ATP, glutamate, or glucose). The prototype includes a sensor array, a CMOS mixed signal chip and a tridimensional integrated coil for receiving inductive power and transmitting data via backscattering. The sensor array is realized with an innovative technology, where carbon nanotube (CNT)-nanostructured electrodes enable the measurement of metabolites with increased sensitivity and lower detection limits as compared to the state of the art. The results have generated intense international coverage in dozens of media outlets worldwide.

ADVANCED DIAGNOSIS TOOLS

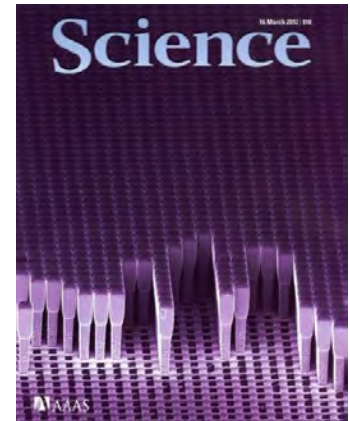
Advanced diagnosis requires the design of new methods for probing the human body, as well as the design of miniaturized (thus portable) diagnosis tools that can be made easily available at points of care. In this perspective, Nano-Tera.ch projects have been focusing on the following challenges:

Designing novel techniques for the diagnosis of human tissues based on micro-mechanical sensing, similar to atomic force microscopy scanning. Indeed, the measurement of nano-mechanical properties of cells and cell-cell interactions as a function of milieu parameters offers unprecedented insights into the tissue structure and is of particular interest in cancer research, where it has been recently shown that stiffness of cancer cells affects the way they spread in the body. The **PATLiSci** project is an example of a Nano-Tera.ch research in this direction: nanomechanical cantilever array sensors have been applied to detect a mutant gene, making it possible to apply personalized therapies for the cure of melanoma.



Building integrated lab-on-a-chip platforms able to monitor and investigate various metabolic functions of the human body. In particular, the **NutriChip** project focused on food digestion with the design of a prototype of an artificial and miniaturized gastrointestinal tract using a minimal set of biomarkers identified through in vivo and in vitro studies. Such a prototype offers novel perspectives for probing the impact on health of dairy food samples, and was tested for the screening and selection of dairy products with specific health-promoting properties.

Developing miniaturized X-ray sources based on multi-walled carbon nanotube (MWCNT) cold-electron emitters. When combined with novel image processing techniques exploiting X-ray time-of-flight measurements (to probe the depth inside objects), as well as the specific pixel structures of both the X-ray source and the X-ray detector, such approaches open very interesting possibilities for the design of portable X-ray systems with fully unprecedented tomographic imaging capabilities. The **Nexray** project is an illustration of such a research track in the Nano-Tera.ch program: the consortium produced pocket X-ray sources with a size of about 0.1 cm^3 , producing X-rays of about 3 keV, as well as detectors involving monolithically integrated Ge absorption layers on a CMOS chip. The main scientific achievement is a breakthrough in epitaxy thick layers of Ge on Si, which made it on the cover page of Science journal and generated ample scientific press coverage.

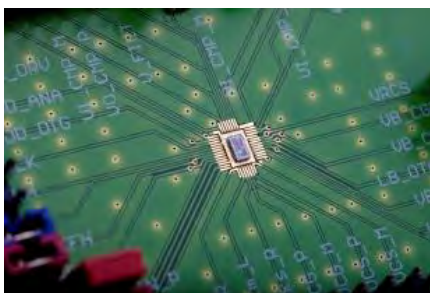


MEDICAL CARE SUPPORT

The general area of monitoring systems for medical care support represents an extremely rich research domain with multiple research directions:

Electronic textiles relying on advanced (electrical/optical) fibers incorporating sensors, signal transmitters and other active nanocomponents. They provide very interesting possibilities for implementing body area networks where both sensing and communication are integrated in the same medium. In this domain, the Nano-Tera.ch **TecInTex** project developed such a technology demonstrator, embodied in an electronic underwear for paraplegic people able to prevent pressure ulcers (which typically occur twice a year for these patients), thus entailing an important reduction of pain and associated health care costs for such patients. Sensorized fabrics were tested on body and on wound model and the components and technology for the near-infrared spectroscopy demonstrator have been approved for the textile integration and clinical testing.

Smart prostheses integrating innovative micro-devices to measure in vivo crucial bio-mechanical parameters of joint prostheses, orthopedic implants, bones and ligaments. For example, the Nano-Tera.ch **SimOS** project designed an implant module including sensors to measure forces, interface frictions, stem micro-motion and impacts to help surgeons with prosthesis alignment and positioning during surgery, detect early migration during rehabilitation, thus potentially avoiding failure due to excessive wear or micro-motion information, and evaluate in vivo joint functions. Such capabilities represent a potentially huge progress in the domain of hip and knee prostheses, since over a million prostheses are currently implanted each year in the EU and the US, with a premature failure rate of about 20% (for people less than 50 years old) translating into a substantial amount of complex and traumatic revision surgeries.



system and it indeed released a set of technologies addressing drug monitoring and automated administration.

Smart drug delivery based on drug response monitoring through the in vivo measurement of drug concentrations and relevant biomarkers. Indeed, while medical progress is increasingly improving the survival rate and life quality of patients affected by long-lasting diseases (HIV infection, cancers, vital organ failure, etc.), these achievements significantly rely on drug regimens and therapeutic protocols that require long-term daily administration of highly active drugs, for which the huge individual response variability raises severe problems in efficient treatment definition. In this perspective, the Nano-Tera.ch **ISyPeM** project sought to provide advanced technologies for seamless drug monitoring and delivery by an ultra-low power integrated

ENVIRONMENTAL MONITORING

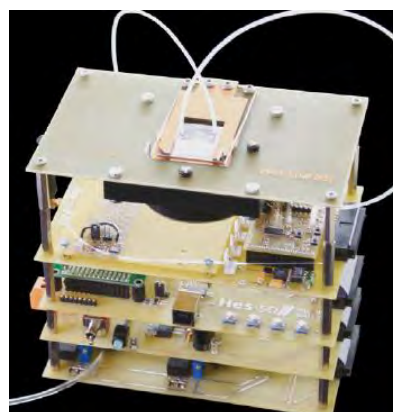
Within Nano-Tera's first phase (and continuing into its Phase II, see below), the objectives of the research on environmental monitoring included monitoring the quality of air and water, by measuring pollution in terms of biological and/or inorganic compounds; and instrumenting the environment to detect movements that can lead to catastrophes, such as rockslides, avalanches, floods or to the instability of constructions such as buildings and bridges.

MONITORING WATER POLLUTION

The quality of water is crucial for both developed and developing countries, as it directly affects health and quality of living. The design of efficient, reliable and affordable technologies to measure levels of pollution in fresh waters is therefore an important problem.

In this perspective, Nano-Tera.ch research has been focusing on **environmental sensing based on living cells**. Indeed, living cells are the most natural biosensors, since they integrate the biological effects of the pollutants and respond by metabolic or phenotypic changes that are relevant to potential effects in the human body. More precisely, the general idea behind living cell-based sensors is that cellular responses are measured in real time by secondary probes or sensors integrating optical, chemical or electrical microsensors.

For example, the Nano-Tera.ch **LiveSense** project designed a cell-based sensing platform taking the form of an autonomous, wireless, hand-held system for fluid monitoring. The modular prototype includes a fully functional bioreactor based on genetically modified E. coli cells (HepG2/C3A hepatocytes) and cells derived from human epithelial colorectal adenocarcinoma (C2BBel cells), for which storage and culture protocols have been established and sensitivity to various target analytes characterized, as well as various secondary sensors for fluorescence, impedance, and mechanical/trans-epithelial resistance. The prototype (which can be remote controlled with a smart phone) has been validated by characterizing the relation between measured fluorescence intensity and the concentration of arsenic in the analyzed water sample. In addition, label-free techniques to distinguish healthy, sick and dead cells have been designed, making it possible to detect cellular changes long before cellular death, thus offering a high sensitivity in comparison with conventional viability assays.



MONITORING AIR POLLUTION

Wireless sensor networks publishing sensor data on the Internet bear the potential to substantially increase public awareness as well as involvement in environmental sustainability. Air pollution monitoring in urban areas is a prime example of such an application, as air pollutants have a direct effect on human health.



The Nano-Tera.ch **OpenSense** project is an example of research on air pollution monitoring. It focused on the design of a network of mobile air pollution sensors with intermittent GPRS connectivity, deployed on top of public buses in the city of Lausanne and on top of trams in the city of Zurich (where ten sensor boxes on trams have been deployed, monitoring a wide range of pollutants on an area of 100 km²). The prototype sensor network is operational and provides valuable insights on sensor capabilities and behaviors in realistic environments. The generated network and air pollution data have been used for the various modeling tasks (mobility, air pollution, etc) and the resulting models in turn serve for generating numerical input that can be used for efficient signal processing and machine learning. Different modeling methods were used to produce high quality

and fine-grained pollution maps. In addition, a collaboration with the Nokia Research Center in Lausanne led to the setup of user studies that clearly demonstrated both the public interest for air pollution data and the commercial potential of the developed technology. The dimension of crowdsourcing is being addressed in a project follow-up (see below).

MONITORING ROCK AND GLACIER MOVEMENTS

Global climate change dramatically influences the visual appearance of mountain areas like the European Alps, and may trigger or intensify destructive geological processes that impact the stability of slopes, thus posing a threat to local communities.

In this perspective, research in Nano-Tera.ch has been focusing on the development of wireless sensing technologies for environmental sensing under extreme environmental conditions (temperature, humidity, mechanical forces, snow coverage, etc). In particular, in the Nano-Tera.ch **X-Sense** project, various rugged electronic chips have been built to install more than 50 sensors in the Mattertal area of Switzerland. The corresponding prototype of wireless sensor network and GPS data processing framework has been deployed with improved system reliability and data quality derived from model-based design principles. The full pipeline from GPS and image sensors to the data-base servers has been established and thoroughly tested. New algorithms have been developed and applied that lead to high precision sensing, high data quality by means of network tomography and highly robust processing and communication in extreme environments. The installation has been in operation for over 4 years: this continuous operation period as well as the corresponding data quality is unique. As a result, many new scientific results in the area of geoscience have been made possible. They help us understand the complex geophysical processes in permafrost regions and the destructive processes due to global warming. Currently, hardware and software are built and transferred to the Federal Office for the Environment for early warning purposes. Further field sites are envisioned for the next year. It was therefore shown that wireless sensor network technology makes it possible to quantify mountain phenomena, and can be used for safety critical applications in a hostile environment.



ENABLING TECHNOLOGIES

In some cases, research and development may impact several areas in the health and environment domains, and some of the Nano-Tera.ch projects have therefore been focusing on generic enabling technologies.

For example, the Nano-Tera.ch **MIXSEL** project has been investigating the use of laser sources to create short pulses that can support microscopy and optical tomography. Similarly, the **CabTuRes** project studied new materials, such as carbon nanotubes (CNTs), using them as resonators for electronics applications as well as mass balances for sensing.

Heat management in high-performance multi-processing systems, realized as 3-Dimensional Integrated Circuits is another generic track of research, and, in this domain, the Nano-Tera.ch **CMOSAIC** project combined competencies in thermodynamics, mechanics of materials, and dynamic power management to design liquid cooling techniques specifically tailored for 3D chips.

On the other side of the spectrum, research in Nano-Tera.ch also concentrates on low-power electronic systems, and specifically autonomous systems, that are crucial for both health and environment applications. In this perspective, the Nano-Tera.ch **PlaCITUS** project focused on the design of a generic technology platform that can be used to deploy biomedical wireless sensor networks. Such a platform typically consists of many sensors and actuators connected together and to the outside world, through a short range wireless network, and interfaced with micro-power data acquisition and driver circuits supplied either by battery or by inductively coupled remote power.

Another critical issue is the manufacturing of integrated nano-systems consisting of large numbers of connected nano-devices. The Nano-Tera.ch **SelfSys** project studied fluid-mediated self-assembly techniques to lower manufacturing costs and enable the assembly of structures with unprecedented complexity.

In the security domain, the Nano-Tera.ch **QCrypt** project improved secret key distribution and message encryption based on the fundamental properties of quantum physics (Quantum Key Distribution). The team has built a complete, working prototype with unprecedented real time hardware key distillation, finite key security analyses and fully automated operation over a single fibre using wavelength division multiplexing. On the encryption side, error-free data encryption at 40 Gbit/s with 100% throughput was demonstrated. In addition, the QCrypt project is a good example of the industrial impact resulting from a Nano-Tera.ch research project. Indeed, this project not only led to a follow-up CTI project, but also made it possible for the involved ID Quantique company to market more than one hundred crypting devices using the technology developed within the project and generate about 30 new jobs.

Finally, in the energy domain, the **GreenPower** project developed cost-effective membranes for H₂-O₂ fuel cells suitable for mobility applications based on the conversion of solar energy into hydrogen and oxygen. A demonstrator of a self-sensing composite vessel for high pressure storage was produced. Belenos car and boat demonstrators accomplished one year test under real drive and navigation conditions.

III.2 MAIN SCIENTIFIC ACHIEVEMENTS, PHASE II

Nano-Tera.ch Phase II supported 25 collaborative 3- and 4-year RTD projects, uniting teams right across the country. Health-related themes feature strongly among the research subjects selected, with strong participation from university hospitals and doctors. The themes related to environmental monitoring and energy are also taking pride of place. As with previous calls for proposals, the key domains of Nano-Tera.ch (Bioengineering and Electronics) are well represented in this selection. What is new compared to the earlier phase of the program is the arrival of research topics combining engineering with life sciences, medicine and energy.

A STRONG FOCUS ON HEALTH APPLICATIONS

The university hospitals and the specialists that thrive there, such as specialized surgeons, neurologists and cardiologists, represent about a fifth of all co-investigators involved. The CHUV, the InselSpital of Bern, the University Children's Hospital in Zurich, the University Hospitals of Basel and Zurich and the Hospitals of Schaffhausen are all bringing their knowledge and expertise to the research of the Nano-Tera program. Research with health-related applications can be loosely arranged in three distinct thematic clusters:

SMART PROSTHETICS AND BODY REPAIR

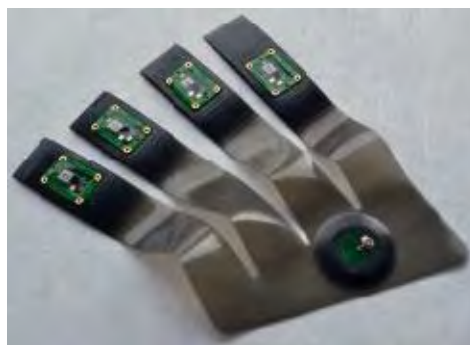
Smart prosthetics and body repair is an integral part of the program, with projects addressing tactile prosthetics and other sensorimotor functions (in particular after spinal cord injury), as well as micro surgery.



An integrated spinal neuroprosthesis to restore leg motor control after spinal cord injury. People who sustain a Spinal Cord Injury often do not recover the ability to stand or walk again. **SpineRepair** advances implantable neurotechnologies to re-establish control of the leg locomotor movements after such injuries. The multidisciplinary team first unravelled the mechanisms and neural structures through which electrical stimulation of the spinal cord facilitates motor control. They next exploited this knowledge to engineer technologies for soft implantable electrodes based on nanowire-elastomer composites and thin metal films. The project thus conceived a soft, electrochemical spinal implant, termed electronic dura mater or e-dura, capable of delivering both biochemical and electrical stimulation of the spinal cord, while demonstrating unprecedented biointegration over extended durations. Using e-dura implants, the team developed conceptually new

stimulation protocols termed spatiotemporal neuromodulation therapies, whereby electrical stimulation is delivered through spatially selective spinal electrodes with an appropriate temporal structure in order to reproduce natural spinal circuit dynamics. In parallel, they designed a customized low-power CMOS chip capable of advanced stimulation pattern programming and interfaced it with miniaturized telemetry and powering hardware to fit a compact system. Using medical grade implantable technologies from Medtronic, the team also conceived a wireless brain-spine interface, decoding motor cortical activity to adjust spatiotemporal neuromodulation of the spinal cord and producing intended leg movements in a non-human primate model of spinal cord injury. Also note that the technologies developed in SpineRepair are often versatile and can be applied to a wide range of applications. For example, the nanowire based stretchable conductors or biphasic Gallium based thin films are suitable interconnect technologies for stretchable multilayered printed circuit boards.

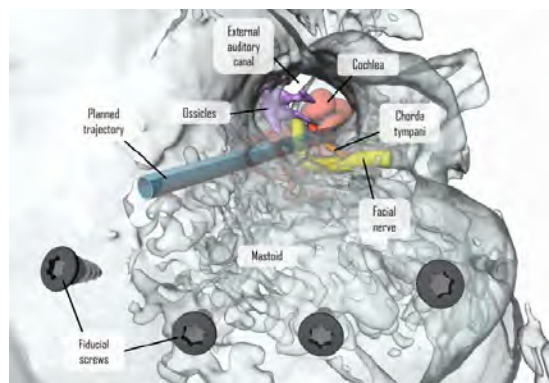
Wise skin for tactile prosthetics. Amputation of a hand or limb is a catastrophic event resulting in significant disability with major consequences for daily activities and quality of life. A sense of tactility is needed for providing feedback for control of prosthetic limbs and to perceive the prosthesis as a real part of the body, inducing a sense of “body ownership” and a natural sensation of touch. The **WiseSkin** project has developed a non-invasive solution for the restoration of natural sense of touch to persons who have lost limbs. The solution leverages the phantom limb effect, but may also be applied where the persons lack a phantom map. Miniature wireless tactility sensors are embedded in a flexible, stretchable “skin” that provides for powering, RF waveguide and shielding against interference. Sensory feedback is provided via a tactile



display (amputation stump) of miniature actuators. The sensor modules are integrated into a silicone elastomer scaffold and encapsulated on both sides with soft metallization layers. Dedicated wireless technologies were developed. The solution is scalable to many sensor devices in a high density network and offers low latency sensory feedback. Multiple tactile feedback devices were developed and tested with amputees and healthy subjects. A prosthetic hand integrated with tactility sensors and tactile feedback actuators was evaluated on an amputee with a hand phantom map. WiseSkin pushed the forefront in miniature, ultra-low power sensor and communication devices, materials and sensory feedback systems. Beyond prosthetics, the sensory skin developed in WiseSkin has potential application in the domains of rehabilitation (e.g. stroke), safety (robots working alongside people) and haptic interfaces (e.g. virtual reality, games, the haptic Internet).

Image-guided micro surgery for hearing aid implantation.

The project **HearRestore** has developed novel technologies to drastically reduce the invasiveness and improve the outcome of cochlear implant surgery. HearRestore has demonstrated the potential of robotic surgery in microsurgical interventions, with its robotic surgical intervention platform for use with a robotic microsurgery treatment-model. It encompasses computer-assisted surgery planning and modelling, precision stereotactic image-guidance, in-situ assessment of tissue properties and multipolar neuromonitoring, robotic access-drilling, computer-assisted electrode selection and keyhole electrode-placement. Preclinical work included, ex-vivo and animal research trials to validate a heat-minimized robotic drilling process in which safety supervision involved a multipolarelectromyographic neuromonitoring approach. The developed models are expandable to integrate additional robotic functionalities such as cochlear access and electrode insertion. The results obtained show the applicability, feasibility and suitability of robotic technology for microsurgery on the lateral skull-base. The robotic treatment approach opens up opportunities for significant benefit in other microsurgical domains for which there is no task-oriented, robotic technology available at present. In addition to these technology outcomes, HearRestore also resulted in the successful translation of the robotic microsurgical technology into a clinical application. The project has proudly reported the first successful stereotactically-guided robotic cochlear implantation in man worldwide. To the team's knowledge, no other group in the world other than theirs has produced sufficiently safe and accurate robotic microsurgery technology to enable microsurgical interventions at this scale and in a patient clinical trial. Real-term economic impact has been created through the licensing of the technology to a consortium of industrial manufacturers of surgical robotic and navigation technology (CAScination AG, Bern) and cochlear implants (Med-El GmbH, Innsbruck). Both CE marking and commercial launch of the technology are expected in 2017.



In the associated Gateway project **HearRestoreGate**, the scientists have been working with the company Atracsys, whose main business is to sell medical-grade tracking systems all around the world. What limits their expansion is the price and the cumbersomeness of their systems. A development strategy is to propose innovative products in that direction, which require the use of new technologies. The HearRestore tracking system is the technological next step. It is miniaturized, lens-less and uses off-the-shelf components, thus rendering it cost effective. The team has the smallest surgical tracking device compared to the state-of-the-art. The current maturity of development (TRL4-6) of the HearRestore tracking system enables the exploration of these new opportunities and defines the starting point of a medical industrialization which might be realized through a CTI project between CSEM and Atracsys. Detailed market analysis, resulting from potential customer interaction, demonstrates that by 2020, the expected revenues will be improved from a forecast of slightly higher than 2.5 million CHF to slightly higher than 4.5 million, meaning an approximate revenue increase of 40%. This could result in a conservative estimation to the creation of 4-5 sustainable jobs.

Use of superparamagnetic nanoparticles for the detection and treatment of cancer. Indeed, such particles are used as contrast agent for MRI, especially for the liver, and as heat sources for the treatment of tumors (magnetic hyperthermia). **MagnetoTheranostics** has been developing a nanomedical system utilizing nanoparticles for the detection and therapy of lymph node metastasis by applying iron oxide nanoparticles as contrast agents for metastatic lymph nodes and at the same time as a heat source for thermotherapy (Hyperthermia). Iron oxide particles were developed and the manufacturing process is so far developed, that a transfer to GMP production is possible. To achieve specific targeting, the team successfully developed a selection of coatings and targeting molecules as well as the corresponding coating technologies. In vitro tests were successful, in vivo tests are ongoing and look promising. The team was able to functionalize the particles with FDA accepted processes and materials, and a transfer to clinical tests should be feasible. Provided that the size of the particles, their performance as a magnetic resonance imaging agent, and their suitability for thermal therapy are strongly correlated, the project successfully developed novel MRI sequences and magnetic field generators as well as software which allows the medical doctors targeted planning and treatment safety/efficacy assessment. Overall, the consortium was able to develop at preclinical level a diagnostic and therapeutic tool for the detection and treatment of primary and metastatic (Lymph node) tumors.

Cutting-edge technology for the next-generation of artificial muscles. **SmartSphincter** studied smart muscles for incontinence treatment and involves hundreds of thousands of low-voltage, dielectric, electrically activated nanometer-thick polymer layers. The researchers have found two promising alternatives to conventional stiff metal electrodes for the polymer actuators and shown that they are able to power them for 10 days without recharge from available lithium ion cells. The team has also successfully applied to their local ethical committee for a full pilot study involving 10 male and 10 female participants. By summer 2015, several participants had signed up for the study from which seven male subjects have been assessed. The analysis of the data has proven the conclusion drawn based on the pre-pilot study.

HEALTH MONITORING

Nano-Tera focuses on personalized health management through the use of implanted devices, smart textiles and intelligent drug monitoring systems. Application targets are in the fields of monitoring of obesity and neonatology, among others. Like in the initial phase of Nano-Tera, the area of health monitoring and personalized health management is well covered, with several projects addressing different research avenues, such as:

Newborn monitoring based on multiple vision sensors. The increasing number of parameters being monitored in preterm infants in neonatal intensive care units, and the sensitivity of these sensors to body movement (especially the limbs) are responsible for the unacceptable high rate of false alarms, which in turn generates discomfort, stress and cardiorespiratory instability. In **NewbornCare**, a real-time system using computer vision non-invasive techniques has been developed to estimate and monitor the heart and respiratory rates of neonates, with an accuracy and robustness that is on par with dedicated contact sensors. By tracking and monitoring the neonate constantly and remotely, the system does not suffer loss of signals due to motions and therefore limits the amount of false alarms. First prototypes of sensors that measure brain tissue oxygenation are being taken into operation at the University Hospital of Zurich. The sensor translates the intensity of travelled-through-tissue, near-infrared light to create and visualize information on the brain tissue oxygenation in real time. It is attached to the head of a newborn by a proprietary headband, which exists in different sizes. The results of preliminary measurements with the oxygen saturation on phantoms with optically well-defined properties are encouraging. Moreover a clinical trial “Exploratory study on ability of dedicated novel sensor technologies to reduce false alarms in vital sign monitoring of the neonates” has been approved by SwissMedic. Databases of signals have been collected on voluntary healthy patients for testing and calibration purposes. A full system has been developed to encapsulate the data acquisition and monitoring in order to facilitate clinical trials. The NewbornCare demonstrator consists of a system connecting the vision sensors and a dedicated head-band housing the oxygen saturation sensors into a real-time remote monitoring application, which can also communicate alarms if necessary. Signal readouts, baselines and alarms are displayed for inspection. The vision sensors are placed on the intensive care unit crib, operating contactless, while the headband housing the other sensors, and specifically designed for clinical usage, is fitted on the neonate.

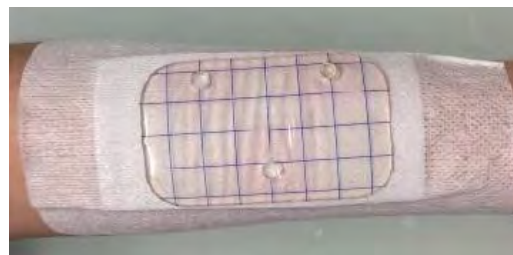


Monitoring the consequences of obesity. Obesity is an increasing problem in high-income countries and emerging markets, because it leads to serious health issues. Obesity imposes a challenge on several modalities to assess physiology correctly, due to the thick superficial layer of fat. **ObeSense** provided an ideal collaboration platform to overcome limitations and develop novel algorithms and calibration methods to handle fat layers. Several demonstrators were built with some even being close to regulatory approval and being ready for translation to clinical practice. One of the most important scientific results obtained during ObeSense concerns the validation of cardiac output and pulmonary artery pressure estimates based on electrical impedance tomography principle. Moreover, a novel near-infrared spectrometry oximeter was developed, built, and validated. The oximeter showed superior precision and

robustness in vitro compared to the common state-of-the-art commercial instruments. ObeSense partners have developed a touch-based ultra-low power device for real-time impedance cardiogram and ECG signal acquisition, and hemodynamic parameters estimates. A detection of obstructive sleep apnea by non-intrusive wearable system is also achieved. In many cardiovascular monitoring settings, the main physiological activities of interest are the heart rate variability, the respiration rate, and the influence of the latter on the former (respiration sinus arrhythmia). Wearable technologies present significant challenges in this context, as the electrocardiogram from which the heart rate variability is extracted is often of poor quality, and respiration may even be not recorded. In ObeSense, the team has developed real-time (which existing approaches are not) robust algorithms with a low computation cost to extract these parameters from the electrocardiogram only.

As a consequence of the development of many innovative demonstrators and their corresponding clinical validation, ObeSense partners have established serious discussion about possible technology transfers towards industrial partners, among them Edwards Lifesciences Corporation, Actelion, Iffremont, and Dräger Medical about EIT solutions and Vexatec, Bodyconnect, and Decathlon about the single-lead monitoring system. Moreover, the development of the single-lead monitoring system platform has led to a new Gateway project, the **ObesenseGate** project, in partnership with FieldWiz which consists in the technological transfer of the electrocardiogram front and embedded algorithms into FieldWiz actual product.

Monitoring of the healing of chronic wounds. The treatment of large and open wounds is a major challenge in medicine, especially after trauma or in immune-compromised patients. In particular, when wounds are associated with chronic infections, a significant threat is presented to the patient that can result in death. To date, the monitoring of the wound healing process is difficult, which is solely based on the qualitative judgment of the clinician. An accurate system that investigates the local environment at the wound site and detects the early changes before any clinical symptoms occur is highly desirable. **FlusiTex** has developed a textile-based sensing system to monitor the wound healing process. Within this Nano-Tera project, the team has combined fluorescence-based chemical and biochemical recognition methods with advanced optical readout methods. Sensing techniques are based on fluorescent dyes immobilized on hydrogels, and enzymatic methods.

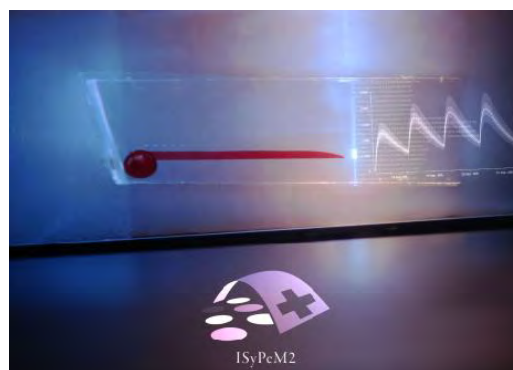


In the associated Gateway project **FlusiGate**, the outcome is a functional prototype able to sense and indicate the pH of the wound via fluorescent measurements. Such a sensor is suited for a range of users/applications: at-home use for self-evaluation by the patient, or clinical use by a clinician for a precise measurement of pH evolution of chronic wounds. In particular, the team has developed a sensing patch consisting in a modified commercial wound-pad containing the fluorescent molecules: spots of either textile fibers or hydrogel containing the fluorescent molecules are incorporated into the commercial pad. The fluorescence intensity of the spots changes according to the pH of the underlying skin model. The genericity of the technologies developed in FlusiTex has been further demonstrated by another associated Gateway project, the **FlusiSafe** project, aiming at the exploitation of fluorescence lifetime imaging (FLIM) for anti-counterfeiting and brand protection, with lifetime-encoded security tags and associated 1D or 2D lifetime readers.

A system on a chip to make medical devices wearable. For both in- and outpatient applications, the electronic interface to typical sensors and electrodes still has a size and weight that prevents it from being used in the convenient and flexible way. Integration of the plethora of functionalities required in a wearable medical monitor, including the management of wireless connectivity, holds the key to the breakthrough required for clinical and user acceptance. This is why **WearMeSoC** has been developing a chip that will enable very small wearable medical monitors with wireless connectivity to small phones and tablets. A modular and multi-functional hardware prototype has been evaluated successfully and a miniaturization of the multi-functional device has been targeted. A first prototype of a medical monitoring SoC based on a parallel ultra-low power (PULP) multi-core processor has been developed. Finally, a first prototype of a battery-operated biomedical implant device including a wireless link with the dimensions below 1cm³ has been realized.

Therapeutic drug monitoring for personalized medicine.

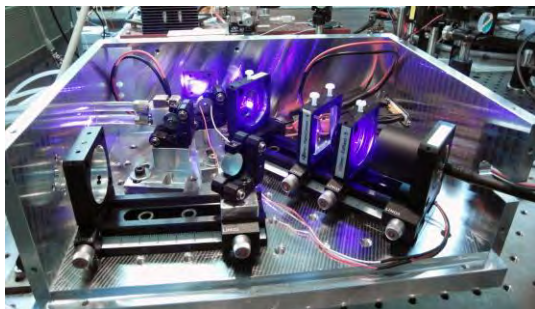
Modern therapeutics must benefit from the development and large-scale implementation of convenient, user-friendly, miniaturized, integrated instruments enabling drug concentration monitoring and seamless pharmacokinetically-guided dosage individualization. A portable system able to perform drug concentration measurement in patients receiving critical treatments should be offered at affordable costs to specialized clinics, and progressively to general practices or even to the patients themselves (as it is already the case, for instance, for blood glucose determination). **ISyPeM II** proposes a comprehensive integrated approach to Therapeutic Drug Monitoring that combines innovative point-of-care compatible assays, prescription decision support and interoperability in a complex data-sharing scenario. The consortium achieved important results in the field, all along the pipeline of this individualized therapy approach.



The design of their point-of-care system is addressed to respond to two main objectives. The first one is to perform the measurement of drug concentration in blood samples by an automated and compact analytical setup; the demonstrator performs fluorescence polarization immunoassay analytics in an ultra-compact format integrating sample preparation based on capillary separation from whole blood. The assay biochemistry is addressed to tobramycin and tacrolimus as case studies. The second main objective is to provide the medical doctor with information on the behavior of the patient within the population and accordingly suggest dosage adjustment and collect drug usage and measurement data into a remote database, enabling further refinements in dosage adjustment procedures. The consortium developed an intuitive and flexible software intended to assist clinicians in therapeutic drug monitoring interpretation that integrated innovative pharmacokinetic models. The software, which is currently in use at the CHUV Hospital in Lausanne and is connected with the internal database, is undergoing the validation process as a Class 1 medical device.

MEDICAL PLATFORMS

In this new phase, Nano-Tera.ch is developing several medical platforms, notably a next-generation, high-quality, mobile ultrasound imaging device and elastic, lightweight MRI detectors that patients can wear like a piece of clothing. The research covers several fields of medicine, such as oncology.



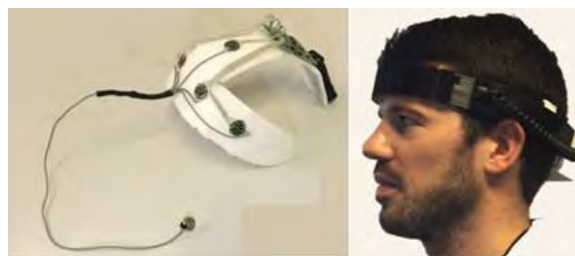
Novel semiconductor disk lasers for biomedical and metrology applications. In a follow-up to the original MIXSEL project, **MIXSEL II** is consolidating its high-power ultrafast semiconductor laser technology. Lasers generating short pulses – referred to as ultrafast lasers – enable many applications in science and technology. Numerous laboratory experiments have confirmed that ultrafast lasers can significantly increase telecommunication data rates, improve computer interconnects, and optically clock microprocessors. Some applications are better enabled with shorter femtosecond pulses, while they so far had to rely on bulky and complex ultrafast solid-state lasers. In comparison optically pumped

semiconductor disk lasers such as the modelocked integrated external cavity surface emitting lasers (MIXSEL) are ideally suited for mass production and widespread applications, because they are based on a wafer-scale technology with reduced packaging requirements and a high level of integration.

The MIXSEL II project enabled world-record achievements in the development of femtosecond semiconductor disk lasers and their applications in frequency metrology and biomedical microscopy. Four laser prototypes were built for application demonstrations in different labs. A new unplanned invention and discovery was the dual-comb modelocked MIXSEL with which dual-comb spectroscopy on water vapor was demonstrated for the first time. The fast sampling rate and the single laser cavity approach supported such measurements even for a free-running laser without any additional stabilization – a paradigm shift in frequency metrology. The team has successfully demonstrated in-vivo imaging in drosophila larvae and in mouse brains using these prototype lasers in multiphoton microscopy. Compared to conventional bulky lasers, the same image quality was obtained, but suffered from less bleaching because of the higher gigahertz pulse repetition rate. Patents have been filed, efforts started for a new spin-off company with some of the graduate students.

Wearable ICT for zero power medical applications.

Keep your friends close, but keep your medical sensors closer: such could be the motto of the **BodyPoweredSenSE** project, which aims to demonstrate that smart medical diagnostics can be performed using ergonomic, efficient, energy harvesting based sensors. The project has significantly contributed to the medical community understanding of the human brain and how brain rhythms and other biomarkers change as a function of ageing. Also, the ability to record or process multi-parametric medical data simultaneously from any organ (foot, heart, brain) over long periods in a comfortable manner, without power interruption or recharge, opens a new era of medical diagnostic and recovery monitoring research and application. The demonstrators of this project are extremely low-cost devices that can be manufactured as mass consumer products, thus accessible to the elderly and young for medical monitoring. These devices will offer early warning of diseases thereby improving the immediacy and efficacy of treatment, and assessment of recovery, while all focusing in the pharmacological intervention; these outcomes are important contributions to wearable medical informatics and advanced ICT in health. One spin off company has emerged and a NextStep project aims towards a second spin off. Further opportunities exist for commercial exploitation backed by strong support from the clinical partners. The interaction of so many multidisciplinary PhD students as key research personnel in this project has underpinned both the strong collaboration between the involved institutions, as well as a deepening and broadening of the knowledge base of all involved across the multiple levels of technology and medical science. Overall, this project has demonstrated, using electroencephalogram-based functional connectivity and alpha rhythm in healthy adults and mild cognitive impairment that Alzheimer's disease patients show interhemispheric functional connectivity declines with age-related diseases, and alpha rhythm loses its polyrhythmic structure forming biomarkers for monitoring age-related neurodegenerative processes in the brain.

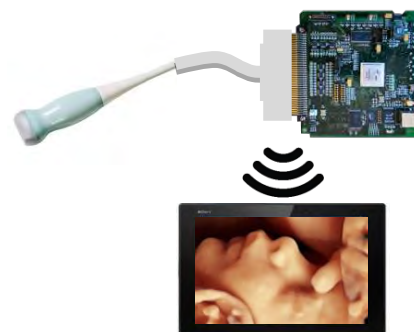


Rapid sensing of cancer. Cancer is among the most frequently-occurring diseases and causes huge treatment costs. Our easy-to-use and automated quantitative diagnostic tool will lead to improved therapies to the benefit of the whole society. Swiss industry has a longstanding tradition in high precision mechanics. The techniques developed in **PATLiSci II** introduces nanotechnology to medical diagnostics. In particular, PATLiSci II targets fast detection of cancer in human patient's biopsy samples suffering from breast or skin cancer. A measurement module has been developed based on a commercial scanning force microscope FlexAFM head from the Swiss company NanoSurf AG, allowing rapid integration of our technology into a future commercial product. The measurement principle is based on force spectroscopy, extended here from a single cantilever to a custom-developed array of cantilevers, reducing diagnosis times drastically.



cantilever sensing demonstrated reliably detection of HER2 overexpression relevant in breast cancer diagnosis.

High performance portable 3D ultrasound platform. While ultrasound imaging is ubiquitous in medicine due to its low cost compared to other imaging techniques such as MRI – whose own challenges are addressed below – its image quality is usually poorer, and the high-quality devices that exist are expensive and aimed at hospital operation only. This is the reason why **UltraSoundToGo** devised hardware and software techniques to make 3D ultrasound imaging possible with off-the-shelf components in a package that can be portable and battery-operated. The objective is to decouple the acquisition of ultrasound scans and their diagnosis, both of which currently must be performed in hospitals by specialists. The team envisions that the acquisition could instead be performed locally by minimally-trained operators, like nurses or family doctors, and the scans uploaded wirelessly (telesonography) to the remote hospital. The platform to do so could be deployed in medical cabinets, in rural and developing areas, in ships, ambulances, and helicopters. The result would be drastically more ubiquitous access to diagnostic services, reduced delays, and improved healthcare costs and efficiency. Nearing its completion, **UltraSoundToGo** has delivered a comprehensive set of developments to unlock this vision. At one end, research on the ultrasound matrix probe itself resulted in a novel device that provides its outputs directly in digital form, enabling more compact and more robust systems. This probe can be connected to an imaging unit fully designed within the project consortium, which adopts various processing optimizations to reconstruct high-quality volumetric scans in 5W of power budget, enabling battery-powered operation. To minimize the bandwidth (and therefore cabling) in between the two, novel compressed sensing algorithms have been developed, and demonstrated to reduce the signal bandwidth. Finally, advanced software mapping toolchains have been created to efficiently deploy image processing software on the latest multi-core chips, while guaranteeing safety of operation as required by medical standards.



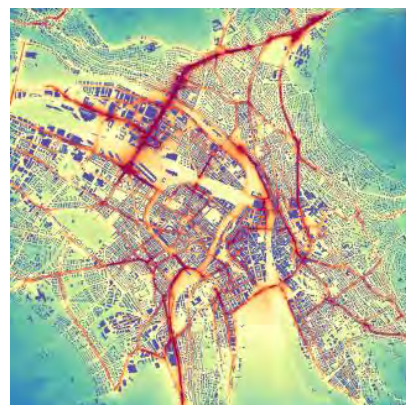
Wearable MRI detector and sensor arrays. Magnetic resonance imaging (MRI) is another widely used imaging technique in medical diagnostics and basic research. The final outcome of the **WearableMRI** project is the introduction of wearable detection to MRI and thus to one of the most widely used medical imaging modalities. For MRI, the advent of wearable detection marks a pivotal transition away from its current paradigm of rigid, bulky detector arrays, which limit the technology in several ways. Large numbers of RF cables next to the patient are a safety issue in MR systems, which expose the body to high-power RF transmission. One-fits-all rigid detector cages lose intrinsic sensitivity by conforming badly to individual anatomies. Moreover, they are intimidating, contribute to claustrophobia, and preclude imaging in varying states of motion or flexion. The wearable paradigm alters this situation fundamentally by the transition to flexible, lightweight detectors that patients wear like pieces of clothing, improving both intrinsic sensitivity and ergonomics. On-body digitization and optical conversion remove safety and handling limits on the channel count. The advent and demonstration of this concept challenge the MRI industry and hold potential for product implementations at the systems and accessories levels. The successful introduction of integrated RF reception to the harsh electromagnetic environment inside MR systems also paves the way for expansion into a full-blown system-on-a-chip, including a local controller, optical conversion, and power management circuits. One core component of the new system is the world's very first fully integrated RF CMOS receiver for MRI. An excellent noise figure below 1dB for the entire receive chain is achieved by adaptable input noise match and noise cancellation circuitry. The receiver also features a transmit mode to track the tuning and matching of wearable MR detector coils. Integrated with optical conversion and mounted directly on a pair of receiver coils each, the receiver chip forms a first-of-its-kind wearable MRI detector module. The new system has been successfully used for actual MR imaging of test objects and humans. The demonstrator is a wearable four-channel detector array for MRI of the human knee at 3 Tesla, consisting of four flexible detector coil front-ends connected to two receiver units each comprising an integrated two-channel receiver and optical conversion for signal transmission out of the MR system. The wearable assembly will be of size suitable to be worn around a human knee for imaging, with each of the electronics units being 2 cm x 3 cm in size. The demonstrator system also includes a specifically developed out-of-field FPGA receiver that takes in and pre-processes the optical data streams before routing them to higher-level processing or storage. Demonstration amounts to actual imaging of a human knee, using regular clinical scanning procedures.

A NEW LOOK AT ENVIRONMENTAL MONITORING WITH FURTHER CHALLENGES

Given the importance of environmental monitoring, several projects from Nano-Tera's initial phase are extended into the second phase with new directions. Projects address both air and water pollution monitoring, as well as environmental sensing in mountainous areas, as detailed below:

Crowdsourcing high-resolution air quality sensing. Air pollution represents the number one environmental health risk, with millions of people dying every year because of poor air quality. The urban landscape leads to highly heterogeneous pollutant concentrations, which cannot be directly captured by traditional sparse static monitoring stations. The solution proposed by **OpenSense II** is innovative not only because of its extended sensing coverage but also because the measurements happen in situ, essentially sampling the very same air volume citizens breathe. In OpenSense II, the researchers took a holistic approach in demonstrating the viability of mobile sensor networks to enable the high-resolution air quality monitoring needed for studying the effect of exposure to air pollution.

Leveraging mobile networks anchored to public transportation vehicles and deployed in the cities of Zurich and Lausanne, the project has produced highly original research on high-resolution urban air quality mapping. The two deployments were continuously improved over the project duration and they currently represent the longest-running testbeds of their type with the probably largest accumulated urban air quality dataset in the world. These are the first results on a number of essential topics for ensuring the data quality of this novel type of mobile monitoring systems including mitigation of mobility-induced measurement distortion, automatic sensor calibration, and measurement-driven air quality modeling, producing the first high-resolution maps (for both Zurich and Lausanne). Furthermore, in the sustained effort to ensure data quality through cross-validation, the team implemented a highly innovative dispersion multi-level modeling framework which was applied to both cities, producing a collection of modeled air quality maps over a large temporal span. Subsequently, such highly resolved air quality maps were for the first time used in a study concerned with the inflammatory effect of prolonged human exposure to PM10. Finally, to enable the inclusion of crowd-sourced measurements, OpenSense II developed two novel algorithms: a rewarding mechanism for incentivizing good-quality measurements and an algorithm for characterizing sensor accuracies, while minimizing sampling cost and maximizing data utility. The list of potential stakeholders goes beyond research institutions targeting human exposure and our work has opened the door to a wide array of novel applications for urban planning and eHealth. For instance, some of the project outputs have already been recommended or adopted by authorities in the city of Zurich, and several of the technologies developed in OpenSense II have been further exploited in the associated **CarboSense** Gateway project aiming at the deployment of a unprecedented, dense, low power sensor network providing near-real time information based on 300 nodes equipped with battery-powered CO₂ sensors distributed over all of Switzerland at Swisscom radio transmitter locations.



An aquatic robot which can “smell” polluting substances in water. The global outcome of the **Envirobot** project is an integrated system that combines novel sensors to an autonomous robot in an aquatic setting, and that allows both sensor data recording/transmission to a remote observer during predefined missions, as well as a form of self-guidance based on real-time sensory input. The self-guiding aquatic robot can integrate physical, chemical and biological measurements of water quality parameters. The robot consists of a 1.0-m segmented snake/eel with anguilliform movement, which causes less turbulence to the sample measurement. The latest self-localization systems

permitted the Envirobot to follow a 1 km remote-programmed track to within 2 m accuracy at cruise speed of 0.42 m/s in the lake. Adapted temperature and conductivity sensors were produced and installed in the robot segments, which can record data and transmit them remotely. These two sensors will be used to demonstrate robot self-guidance and continuous measurements in a river mouth. Prototypes of other sensor systems were fabricated (e.g., miniaturized pH and oxygen measurement), ready to be connected to the robot. Developed biological sensor modules for the robot include general toxicity measurements by *Daphnia* and fish cell lines, as well as light-emitting bacteria reactive to specific toxicants (e.g., mercury). Further for the biological sensors specific robot sampling segments were fabricated that include passive water samplers. The Envirobot system is the first self-guiding aquatic robot capable of performing water quality measurements during short sampling missions. The individual particular robot that was constructed is certainly impressive and will have impact by itself. However, the knowledge and experience gained from the combined engineering/robotic efforts is even more important. The combined efforts for this project have led to many novel spin-off ideas in sensor and tool development. This includes in software development, tracking algorithms, sensor miniaturizations, new sensor concepts and proof-of-principles. Many of those will continue to live on and become improved after the project's life-time, or will be starting points for spin-off activities. This includes, for example, the novel carbon nanotube printed sensors and the fish-cell line toxicity sensors.

MEMS acoustic detectors for natural hazard warning systems. Understanding, controlling and minimizing the risk associated with changes in our natural environment is of major societal interest, and there is an increasing need for risk-reduction methods and technology. Based on the predecessor project, **X-Sense II** contributes to close the growing gap by technological development and scientific advance. It investigates a complete data chain from custom designed sensor technology over networking, data storage and processing towards new discoveries in environmental sciences and new, more effective technologies for early warning from natural hazards.



The interdisciplinary team of X-Sense achieved major breakthroughs on several axes. The team investigated MEMS technology allowing for the partial relocation of signal processing and decision-making from the computing domain to the sensor itself. With this approach, for the first time, close to zero standby-power is possible, which is a prerequisite for long-term, unattended monitoring of spurious events. Integrated in a new class of event-driven wireless sensing systems and in combination with other sensing modalities unprecedented level of detail about the underlying processes leading to natural hazards is revealed.

The monitoring-system produced by the project provides data on slope movements and environmental conditions in mountain permafrost that is worldwide unique with respect to temporal resolution, coverage and observation duration. The recent addition of continuous micro-seismic/acoustic emissions allows the investigation of precursor signals of failure events in (frozen) bedrock and thereby contributes towards the further development of early warning systems. X-Sense developed, operates and maintains several field-sites in the Alps, i.e., at Matterhorn, Dirruhorn/Grabengufer, Saastal and Randa. In addition, 10 long-term monitoring sites are operated in collaboration with Permafrost Monitoring Switzerland. Sensor data are locally collected and transferred to datacenter in Zurich where processing and interpretation takes place. The long-term, autonomous and dependable operation of sensor networks in harsh environment mountain areas is unparalleled in the scientific community. The numbers are impressive: 8 years operation with multi-modal monitoring (thermal sensors, crackmeters, GPS, Meteo-stations, high resolution cameras, seismic sensors and radar) and last but not least really big amounts of data that are under constant investigation, showing the applicability of the scientific results obtained, providing us with new scientific challenges, used to gather important input for novel geophysical discoveries and providing a showcase for early warning



An all-in-one detection platform for air pollutants and greenhouse gases.

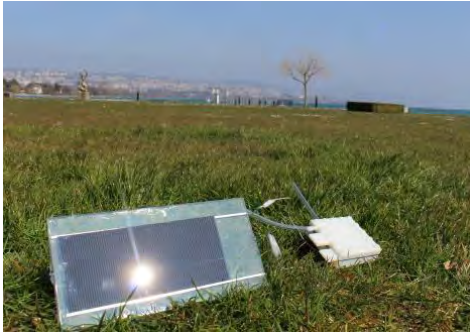
The environmental dimension can also be a new direction added to a past project. While IrSens developed a sensing platform for liquid and gases using near and mid-infrared spectroscopy to measure cocaine concentration in saliva and CO₂ isotope ratios in air, **IrSens II** is going several steps further by realizing new tools for gas monitoring, specifically analyzing nitrogen dioxide as well as major air pollutants and greenhouse gases. The final gas spectroscopy setup allows us to simultaneously measure the concentration of ten highly relevant greenhouse gases (CO₂, H₂O, CH₄, N₂O) and pollutants (NO, NO₂, NH₃, SO₂, O₃, CO) with ultrafast data acquisition. The setup reaches a precision comparable to state-of-the-art instrumentation, while reducing the footprint thanks to the use of dual-wavelength laser sources. The spectrometer produced

can replace many power consuming and expensive conventional environmental gas sensors in air pollution monitoring and research stations. Moreover, the compact and portable gas detection is selective, fast, autonomous, and can be maintained via remote access. This is particularly valuable for obtaining temporally and spatially resolved data needed for future (urban) climate modelling and health studies. In general, the project has made significant contributions towards establishing laser spectroscopy as a method of choice for mid-infrared gas sensing: multi-wavelength quantum cascade lasers were developed allowing for compact and versatile instruments detecting several gases. Additionally, the researchers have developed new driving schemes and electronics for quantum cascade lasers, which allow for continuous data streaming and therefore better signal to noise ratio. Furthermore, the cylindrical multi-pass cell with the patented absorption mask is by now commercially available and will be used in many gas-sensing applications. Finally, IrSens has led to the foundation of the highly successful spin-off IRSweep AG.

A first demonstrator for nitrogen dioxide detection was installed and operated on top of a tramway in Zurich, yielding hitherto unreached precision, selectivity and time resolution. City-wide air pollution maps were simulated using 1000 hours of unique spatially and temporally resolved data.

A CRUCIAL MATTER: THE MANAGEMENT OF ENERGY

The theme of energy has taken on a whole new dimension in this phase of Nano-Tera.ch. In the past, the research being funded related mostly to ultra-low power microchip or systems. Energy is a central theme that affects system design, society and the economy, and now takes center stage: Nano-Tera.ch addresses various high relevance application areas such as low-power trustable electronics, smart grids, green data centers and environmentally friendly energy harvesting systems:



Cost-effective and integrated solar-hydrogen generator. The development of economically viable technologies to produce fuels such as hydrogen, solely based on sunlight and water is one of many potential solutions, on a global scale, to transition from a fossil fuel economy to a renewable energy economy. **SHINE**'s goal is to develop the design principles and experimentally demonstrate a continuously-operating solar-hydrogen generation system with an optimal working point in terms of fuel production cost. The most important short-term outcome of the project is the demonstrated 14.2% solar to hydrogen conversion efficiency based on commercially available, abundant and affordable components. The 40% increase of hydrogen production over previous results not only decreases the cost per kg but also decreases the area

necessary to collect light. Such efficient systems can be scaled with available materials by following careful system design rules. In the long term, the innovative designs for the electrolyzer, fuel cell, and self-tracking concentrators reported in this project can potentially lead a new class of electrochemical reactors and solar concentrators which are less expensive, long lasting, and more efficient. These devices have also triggered a new research line in the relevant communities as can be inferred from several recent papers reporting on similar concepts. Detailed life cycle and techno-economic analysis together with multiphysics simulations of solar water splitting with concentrated photovoltaics have also provided design guidelines for development of reactors based on efficient GaAs panels under large concentration factors.

Green servers and datacenters. Energy-efficient datacenters are strategic for Switzerland, as 75% of the Swiss economy is service-based and depends on the datacenter infrastructure cost. Moreover, 3-4% of the Swiss energy is devoted to datacenters, and grows by 20% annually. In **YINS**, energy consumption was reduced by introducing specific server nodes and new cooling technologies, as well as improving system performance by accelerating inter-server communication. Overall, YINS enabled datacenter providers, like BrainServe, to improve their energy efficiency by 30% on average, while guaranteeing reliable operation. In addition, Eaton benefitted from our virtual machines thermal-aware allocation and server power management approaches to develop intelligent power distribution units that reduce total energy consumption and carbon footprint. Finally, 29 GWh were consumed by Credit Suisse's datacenters when YINS started. Today, the newly developed energy-aware virtual machines consolidation technique in active racks enables 11 GWh of energy savings (35% on average) in daily operation. Moreover, the new thermosyphon cooling technology enables an additional 40% energy reduction. Overall, YINS enabled a total energy reduction of 75% on average in Credit Suisse data centers. Furthermore, larger energy reduction figures are expected in other businesses in Switzerland, where datacenter operations are less constrained than in the banking industry.



Thermal storage control. The project **HeatReserves** deals with the use of thermal loads as additional means for electricity grid ancillary services to account for the expected increase in renewable energy sources. The team has developed an integrated framework to enable the introduction of reserves from two types of thermal loads: Heating, Ventilation, and Air Conditioning (HVAC) systems of an aggregation of several office buildings, and a very large number of small household appliances. For the first category, a novel methodological framework was developed for estimating the amount of building reserves that can be robustly extracted; this required the development of a completely novel control algorithm involving the optimization of uncertain sets. During the last year of the project, the team plans to experimentally test this method on the NEST building on the Empa campus. For the second category, estimation and control methods were developed to allow the coordination of the energy consumption of large collections of small devices (in particular, air conditioning units, refrigerators, and water heaters) by macroscopic signals. The economic and marketing case for both types of thermal loads was also investigated; in particular, thermal deviations acceptable by users and incentive schemes for enticing users to participate in demand response schemes were determined.



Systems for ultra-high performance photovoltaic energy harvesting.

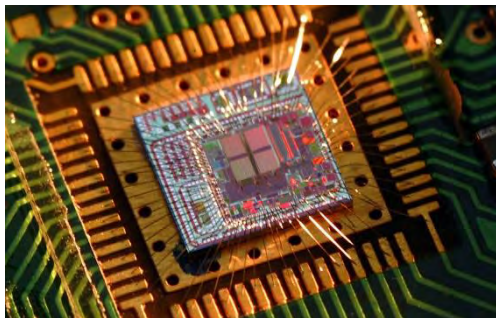
The cost of photovoltaic (PV) modules recently dropped drastically, such that the overall PV system costs are dominated by non-module costs. Improving the efficiency of the modules at only moderate additional costs therefore is the most straightforward pathway towards lower PV electricity prices. However, many established PV technologies reached efficiencies close to their practical limits. A promising, disruptive approach is to combine an established PV technology, such as a crystalline silicon or CIGS cell, with emerging technologies, including III-V nanowire and perovskite cells, to form a tandem device with the potential for ultra-high performance. The project **Synergy** led to the demonstration of infrared-transparent perovskite cells with high efficiency, to the realization of mechanically-stacked and monolithically-integrated tandem cells and to several efficiency world records in that research domain. These results show that even state-of-the-art high performance single-junction solar cells can further be improved by this tandem approach. In addition, with the realization of a 5x5 cm² perovskite mini-module, it was demonstrated that the emerging perovskite PV technology can be up-scaled. Finally, together with the industrial partners, an assessment of the potential applications and markets for each of the developed tandem configurations was made.



The companion Gateway **SynergyGate** project has focused on bringing perovskite/silicon and perovskite/CIGS tandems closer towards commercialization by up-scaling from the typical laboratory size of <1 cm² to 5 x 5 cm² substrates, by using lightweight, flexible substrates, as well as by developing metallization, interconnection and encapsulation schemes that are compatible with industrial processes.

Real time monitoring and management of smart grids.

The project **SmartGrid** seeks to optimize the power grid through a hierarchical vision, from the individually monitored power consumption of electrical appliances, across the mid-scale “Microgrid” that optimizes small pools of consumers and at high level with high speed electronics for power system dynamic emulation. The team has developed and validated thanks to the electrical grids of EPFL an online monitoring infrastructure for distribution systems. This infrastructure is the foundation of the modern Distribution Management Systems with reference to the smart-grid concept. The consortium demonstrated the feasibility of supporting phasor measurement unit deployments with standard TCP/IP technology while being secure and real-time. This paves the way to an online control and monitoring for intelligent and renewable energy systems. The Nano-Tera.ch infrastructures have been used for the monitoring, control and protection of new smart-grids funding from the CTI and the Canton de Vaud. In addition, the capabilities and features of the intelligent building as a service provider for the smart-grid was demonstrated. The socio-economic and technical barriers to this technology introduction were identified and solutions for several of those were provided. The study of the smart-building as a system beyond domotics and Internet of Things technologies (IoT) paves the path for sustainable smart cities and smart grid. Based on the outcome of the smart-building research, a new startup company is created and awarded by the EPFL innograts.



Inexact sub-near-threshold systems for ultra-low power devices.

Ultra-low power near-sensor processing is a key requirement for many applications such as watch ICs, radio frequency identification tags, sensor interfaces and near-sensor processing in devices targeting emerging IoT applications. Unfortunately, the design of corresponding hardware becomes increasingly difficult, since low power consumption is often achieved by operating at low voltages, which leads to a loss in performance and to reliability issues, especially in modern process technologies. The main outcome of the **IcySoC** project is a toolset with a wide range of techniques and a platform that facilitate the design of such systems and alleviate the issue associated with low-voltage operation. As such, the technologies and building blocks developed in the project solve key problems in the design of a variety of different devices for different process nodes ranging from 180 nm down to 28 nm. It is therefore expected that many applications can benefit from the know-how and the IP generated by the project. Some of this IP (namely the PULP platform that underlies the project) is also available as Opensource hardware and therefore provides immediate benefit to industry and other research organizations that wish to develop custom circuits for their specific applications.

PART IV

IMPACT ANALYSIS

IV.1 SYNTHESIS

This section provides an overall synthesis of the **impact** of the Nano-Tera.ch program, which has been assessed for several key topics, based on various **objective metrics**.

The various topics that have been considered have been categorized into the five following impact dimensions:

- The scientific impact
- The educational impact
- The economic impact
- The societal impact
- The institutional impact

The synthesis presented below covers each of the considered five dimensions, and is substantiated in the next sections by a set of **key statements**, along with associated factual data and metrics used. For each of the key statements, the goal is to evaluate to what extent and how efficiently Nano-Tera.ch has fulfilled its objectives.

Throughout the synthesis, details about the cited impacts can be found in the associated Key Statements that are indicated in brackets for reference (with the following format: [KS1], [KS2], etc.).

SCIENTIFIC IMPACT

The nearly 1,600 publications generated with Nano-Tera.ch indicate that the research carried out in Nano-Tera.ch projects has been widely recognized by the relevant scientific communities. Moreover, 44% of the publications have been published in journals with an average Impact Factor (resp. CiteScore) of 5.3 (resp. 4.9), indicating the high scientific impact of the research carried out in the Nano-Tera.ch program. [KS1]

The attractiveness of Nano-Tera.ch has also been illustrated by the program's almost exhaustive coverage of the scientific communities related to its topical domains, as well as by the visit of several world-leading scientists who came to interact with various Nano-Tera teams as part of Nano-Tera's International Exchange Program. [KS1,7]

The broad objective of the Nano-Tera.ch program was to improve the quality of life and safety of people in three application areas: Health, Energy and Environment. Such societal issues are inherently complex. To produce significant advances, it is essential to mobilize diverse high level scientific knowledge, to leverage a broad basket of technologies that are often interrelated, and to involve industrial partners and end-users in large projects over several years, with a shared objective. The fact that the Nano-Tera.ch program funded research projects with specific characteristics was a key component, which strongly contributed to the scientific impact achieved by the program. In this respect, the crucial characteristics of the funded projects have been the following:

- **Ambitious** – The funded projects were carried out by large consortia and benefited from substantial funding (about CHF 2 million per project) over a long period of time (4 years on average). [KS6]
- **Strongly collaborative** – On average over 6 partners from 4 different institutions were involved in the RTD projects, with about 2.4 partners collaborating on any given project task during Phase 1. The strong collaboration between project partners also resulted in multiple joint publications with several Nano-Tera.ch partners as co-authors. [KS2]
- **Strongly interdisciplinary and inter-institutional** – On average, the researchers involved in RTD projects originated from about 2.7 different types of institution (ETH, universities, applied universities, hospitals, industry...) and brought expertise from about 2.7 different disciplines. [KS3,4]
- **Applications-oriented** – The RTD projects consortia involved complementary types of participants, with slightly over half (57%) being researchers as expected, but also translational partners (Empa, CSEM; 12%), end-users (typically hospitals; 12%), as well as industrial partners (19%). This type of mixed consortia represented a very favorable setup for application-oriented research, as non-academic partners tend to drive the research results towards their applicative needs. [KS5]

These projects have led to a number of breakthroughs. Examples include, but are not limited to:

- The HearRestore project resulted in the successful translation of the robotic microsurgical technology into a clinical application. The project has reported the first successful stereo-tactilely guided robotic cochlear implantation in man worldwide. To the project team's knowledge, no other group in the world has produced sufficiently safe and accurate robotic microsurgery technology to enable microsurgical interventions at this scale and on a patient in a true clinical set-up. This breakthrough would not have been possible without the collaboration in a single project of multiple partners with competencies in several disciplines (robotics, surgery, etc.) and a substantial level of funding.
- The SHINE project resulted in a proven 14.2% solar to hydrogen conversion efficiency, based on commercially available, abundant and affordable components. The 40% increase in hydrogen production over previous results not only decreased the cost per kg, but also decreased the area necessary to collect light. In the long term, the achieved innovative design for the electrolyzer fuel cell and self-tracking concentrators can potentially lead to a new class of electrochemical reactors and solar concentrators, which will be less expensive, long lasting, and more efficient.

- The IrSens II project has used near and mid-infrared spectroscopy to realize new tools for gas monitoring, specifically analyzing nitrogen dioxide as well as major air pollutants and greenhouse gases. The cylindrical multi-pass cell is now commercially available and will be used in many gas-sensing applications. IrSens has led to the foundation of the highly successful spin-off IRSweep AG. A first demonstrator for nitrogen dioxide detection was installed and operated on top of a tramway in Zurich, yielding hitherto unreached precision, selectivity and time resolution. City-wide air pollution maps were simulated using 1000 hours of unique spatially and temporally resolved data.

EDUCATIONAL IMPACT

Nano-Tera.ch has contributed to the training of the next generation of researchers, with a total of 366 PhD students involved in the program's projects (192 in Phase 1 projects and 202 in Phase 2 projects, some of which took part to both phases of the program). These students have been about equally distributed among the thematic clusters of Nano-Tera. [KS8]

	Phase 1	Phase 2	Overall
Number of PhD students	192	202	366

To further strengthen the importance of the PhD students within the program, Nano-Tera set up a specific program, the **NextStep program**. This program, decomposed in three distinct tracks, was specifically designed to help PhD students explore possible ways to exploit the scientific skills that they were gaining during their PhD.

More precisely:

The Track 1 of the NextStep program has encouraged stronger collaborative spirit in the community of the PhD students involved in Nano-Tera.ch, and increased their autonomy by giving them the opportunity to submit their own collaborative research proposals. The goal was to give the PhD student the opportunity to learn the full procedure of submitting proposals to get funding: building a consortium, identifying research challenges, writing a scientific proposal, and putting together a reasonable budget. Several students expressed interest in this opportunity, and 7 projects were submitted and accepted for funding. [KS9]

Through Track 2 of the NextStep program, Nano-Tera.ch has encouraged stronger entrepreneurial spirit in the community of PhD students. To this end, it has allowed them to interact with experts and coaches in entrepreneurship and helped them learn how to describe the skills they have acquired in an effective way for potential future industrial contacts. It has also helped them develop ideas on how to economically exploit their thesis results and skills for the purposes of licensing or startup creation. For example, they were given the opportunity to do a dry run for a pitch, and to win a trip to a high impact event such as CeBit or CES. [KS10]

In the Track 3 of the NextStep program, Nano-Tera organized MT180 ("My Thesis in 180 Seconds") contests to encourage PhD students to learn how to communicate their work and results in a clear and appealing way, easily understandable outside their field of specialization. In such contests, the PhD students had 3 minutes to present the content of their research to a wide audience, with the support of only one static slide. [KS8]

Finally, the 61 Education and Dissemination activities (ED activities) funded by Nano-Tera.ch for a total budget of more than CHF 1.4 million have also strongly contributed to the educational impact of the program. More than half of the activities consisted of conferences, symposia and workshops. About a quarter have been courses and winter or summer schools. [KS8]

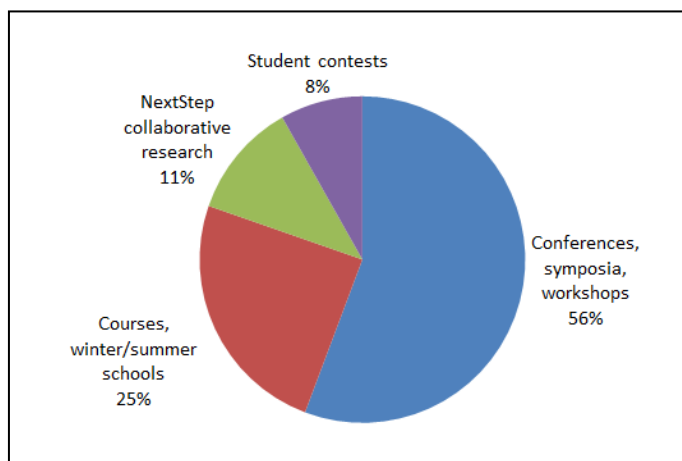


Figure 9. ED activities by type.

ECONOMIC IMPACT

Within Nano-Tera.ch, by the end of 2016, 67 patents had been filed based on results stemming from Nano-Tera.ch projects, 10 start-ups had been created or were in the process of being created, and 9 CTI follow-up projects had been approved. [KS11]

However, in the specific case of a research program such as Nano-Tera.ch, such standard indicators provide a very incomplete view due to the inherent delay between the time a scientific result is produced, and the time it potentially produces economic value (e.g. a product or a service). Indeed, as there is no follow-up reporting obligation after the end of a project, the program structurally lacks effective ways to provide reliable values for many of the standard indicators. As a result, most of this sub-section focuses on the evaluation of the "Economic potential" of the program, i.e. its ability to set-up the right conditions for economic value to be created.

INVOLVEMENT OF INDUSTRIAL PARTNERS AND END-USERS

Nano-Tera.ch exploited its pro-active role in the definition of the eligibility conditions associated with the calls for proposals launched by the program to substantially strengthen the economic potential of the funded research projects.

In particular the presence of industrial partners and end-users (e.g. hospitals) was strongly recommended in all Nano-Tera.ch RTD calls and made mandatory ("must meet" criterion) for all Nano-Tera.ch Phase 2 RTD projects. This led to the set-up of RTD project consortia consisting of an average of 57% of research partners, 31% of industrial and translational partners, and 12% end-users. Such a proportion of non-research partners in Nano-Tera.ch RTD projects, combined with their long duration, created an important economic potential for the program, as the RTD projects strongly contributed to Knowledge Transfer by playing the role of information exchange platforms, with various project consortium level meetings and events leading to numerous formal and informal contacts between partners. It is worth noting that this type of Knowledge Transfer (formal and informal information exchange) has been identified as the preferred transfer channel by more than 60% of Swiss Industry active in KTT (as shown in the KOF Knowledge and Technology Transfer Survey¹). [KS11]

EDUCATION OF PHD GRADUATES FOR THE INDUSTRY

An important economic impact of the Nano-Tera.ch program resulted from the training of a substantial number of PhD students who chose to pursue their activity in industry (about 60% of the more than 360 PhD students trained in the program). This caters to strong demand from Swiss companies, who consider the lack of qualified staff as a deficiency (see KOF Knowledge and Technology Transfer Survey 2011 mentioned above). The recruitment of Nano-Tera.ch PhD graduate by Swiss companies (75% of the ones who transferred to industry) also has the advantage of increasing the ability of companies to interact with researchers and thus to utilize research results. [KS11]

Furthermore, the coaching provided in the Entrepreneurship Track of the NextStep program helped several Nano-Tera.ch PhD students develop an early-stage entrepreneurial mindset by making them explore how to generate economic value from research results, how to identify market opportunities, and how transform ideas into business propositions. As a result, four business ideas have been presented at an Impact Event and three startups were created (end of 2016). [KS10]

THE NANO-TERA.CH INDUSTRIAL VALORIZATION FUND

In 2014, Nano-Tera.ch decided to set up a funding framework, the Nano-tera.ch Industrial Valorization Fund (IVF), specifically dedicated to technology transfer with the objectives to strengthen industrial valorization. With this fund, first jointly managed by Nano-Tera.ch and the EPFL Technology Transfer Office, and later extended to all the institutions involved in Nano-Tera.ch of EPFL, Nano-Tera.ch has supported several industrial valorization actions with promising Knowledge and Technology Transfer aspects. [KS11]

THE NANO-TERA.CH GATEWAY PROGRAM

While all the 25 Phase 2 RTD project produced research prototypes, 56% of these projects led to demonstrators and platforms with a high potential to rapidly result in products (estimated time to market in 2017-2023).

To further strengthen the impact of these results on Swiss industry, Nano-Tera.ch used about CHF 1.66 million of its strategic funds to launch the Gateway pilot program. Within this program, Nano-Tera.ch launched eight Gateway projects specifically targeting the conversion of research prototypes with high economic potential into industrial demonstrators directly exploitable by the industrial partners involved in the projects (see also "Institutional impact" below). [KS12, 18]

¹ Knowledge and Technology Transfer between Universities and Private Enterprises in Switzerland 2011, S. Arvanitis, M. C. Ley, M. Wörter, KOF Studies, Vol. 37, KOF Zurich, 2012

SOCIETAL IMPACT

At the societal level, the primary objective of Nano-Tera.ch was to promote a vision of engineering with true social objectives. In this perspective, the social relevance of Nano-Tera.ch's research has been confirmed by an *a posteriori* analysis of the match of the results of the program in the health, environment, and energy application areas with the topics covered by the mainstream media, parliamentary proceedings, and Federal investments. [KS15]

More precisely,

- The **media** – which often mirror the population's interests and concerns – have consistently published, throughout the 2008-2016 period, numerous articles related to specific themes addressed by the program in health, energy and environment. During this period, the presence of such themes in the media was high, with about 5% of all articles devoted to themes corresponding to some selected Nano-Tera-related keywords. In particular, the proportion of articles related to specific health-related issues considered within Nano-Tera has almost tripled. For example, the concept of wearables was virtually unheard of until 2011, picking up considerably in the past few years. Likewise the articles relating to intelligent sensors were more than 5 times more frequent in 2016 than in 2008. Most themes related to energy also attracted considerable interest during the period, with a peak in 2011, which may probably be related to the Fukushima disaster.

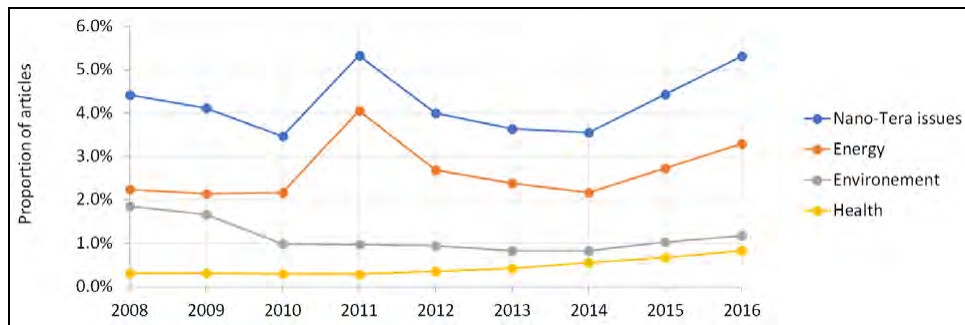


Figure 10. Proportion of all articles in the selected media addressing certain topics.

Furthermore, the research funded by Nano-Tera.ch also matched current social concerns and needs:

- In an annual nationwide **“Worry Barometer”** survey which has been gathering information about the concerns of the Swiss population since 1976, themes related to health or energy issues have consistently rated high – typically in the top third – among a list of themes of interest.
- The **parliamentary proceedings** offer a complementary legislative perspective on society's priorities in terms of needs. A search in the parliamentary proceedings for keywords related to Nano-Tera.ch's research (e.g. “sensors”, “cancer treatment”) shows a constant interest by Parliament in health, environment and energy matters. From 2008 to 2016, the total numbers of proceedings related to health, energy and environmental issues represented almost 20% of all proceedings.

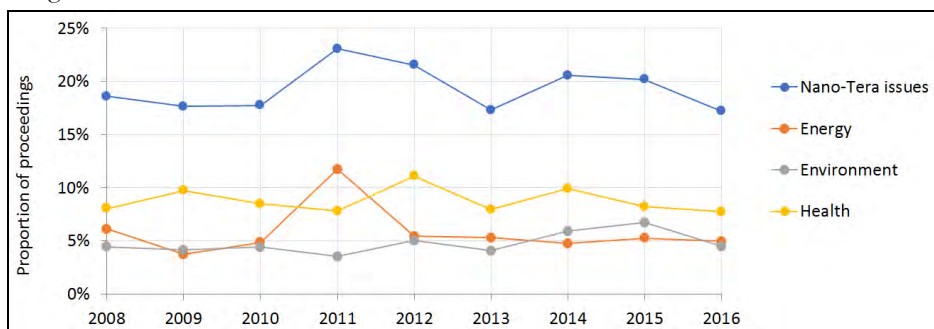


Figure 11. Proportion of parliamentary proceedings addressing certain topics.

- Finally, an analysis of **Federal spending** in specific departments (“Offices”) related to health, energy and environment issues (the Federal Office of Public Health, the Office of Energy, and the Office for the Environment) provides crucial information about the measures taken by the authorities to tackle various problems. It shows in particular that several issues covered by Nano-Tera.ch's research benefited from substantial fundings by these three departments, and that these funding have strongly increased (by 65% overall) in the considered period.

Nano-Tera.ch has contributed to its societal impact by **disseminating** the results achieved within and beyond its community. Various communication and dissemination activities were aimed at developing the program's profile in the media, keeping governing bodies informed about the program's progress, federating the PI and PhD students, exchanging information around the results, as well as presenting the program's results to the global scientific community. This was achieved through numerous printed documents (activity reports, brochures, etc.), organization of events (including Nano-Tera Annual Meetings), participation in external events through oral presentations and conference exhibitions, creation of videos covering Nano-Tera research, as well as through the website and other media channels. [KS16]

Finally, Nano-Tera.ch implemented various pilot projects to promote the program **in high school and with younger children**. This included the set-up of a booth presenting the Nano-Tera.ch SHINE project at the Scientastic Sciences Festival 2016, an EPFL event aiming at making scientific knowledge accessible to a wide audience and generating enthusiasm for scientific and technological research. Moreover, Nano-Tera organized a dissemination event where 40 high school students had the opportunity to meet and interact with Nano-Tera PhD students and researchers, and to brainstorm about potential applications for the various technologies developed within several of the Nano-Tera.ch projects. [KS17]

INSTITUTIONAL IMPACT

In 2015, based on the analysis of the results achieved by the program during Phase 1 and the first half of Phase 2, Nano-Tera.ch decided to embody several of the core conclusions resulting from the analysis into a specific pilot program, the **Gateway program**, intrinsically positioned at the frontier between research and innovation, and aiming to incorporate research results obtained within Nano-Tera.ch projects into industrial demonstrators directly exploitable by the industrial partners involved in the program. [KS12]

To implement this novel program, Nano-Tera.ch first joined forces with CSEM and Empa to analyze the running RTD projects and select the ones who could benefit most from a Gateway extension. As a result, four pilot Gateway projects (associated with the Synergy, HearRestore, and Flusitex RTD projects, and with the ParaTex NTF project) were launched in November 2015, with operation planned until March 2017. [KS12]

Based on the experience gained within this first pilot experiment, an official Gateway call was launched in July 2016 which led to the selection of four additional Gateway projects (associated with the IrSensII, ObeSense, and FlusiTex RTD projects, and with the Nambp NTF project). The selected projects were launched in November 2016, with operation planned until October 2017. [KS12]

Furthermore, Nano-Tera.ch has provided its expertise to contribute (through meetings, preparatory discussions and positioning documents) to the setup of the joint SNSF-CTI program **BRIDGE**, a novel funding instrument deployed at the Federal level for the budgetary period 2017-2020. The BRIDGE program aims at better exploiting the economic and societal potential of scientific research by promoting transfer from scientific knowledge to innovation. BRIDGE was designed as a new concept for jointly funding research and pre-competitive innovation in Switzerland in the field of Engineering Sciences. It aims to help turn publicly-funded research results into pre-competitive innovation. In order to achieve its goals, it plans to better connect academic and industrial players through ambitious research projects, thus creating suitable platforms for collaborative knowledge and technology transfer based on cross-exposure and inter-connection of personnel, with a special focus on junior researchers/engineers. [KS18]

IV.2 KEY STATEMENTS RELATED TO SCIENTIFIC IMPACT

Key statement 1

Nano-Tera.ch has promoted **excellence in research** in various domains of engineering sciences.

EVALUATIONS PERFORMED DURING THE LIFETIME OF THE PROGRAM

The annual evaluation of the running RTD projects performed independently from Nano-Tera.ch by a panel of international experts appointed by the SNSF (the SNSF Evaluation Panel) consistently acknowledged the scientific excellence of the funded projects, while the Nano-Tera.ch Scientific Advisory Board stressed the strong contribution of the Nano-Tera.ch program to the multidisciplinary development of Swiss engineering sciences.

NUMBER OF PUBLICATIONS

In terms of scientific dissemination, the research funded by Nano-Tera has generated almost **1,600 publications** (758 during its first phase, and 818 in the second phase).

About **44%** of these publications were articles in journal and books, the rest consisting of conference proceedings (in the conference proceedings, short abstract-style contributions have not been taken into account).

The distribution of the publications by publication type (journals or conference proceedings) is given below.

	Phase 1	Phase 2	Total
Publications in journals and books	344	354	698
Publications in conference proceedings	414	464	878
Total	758	818	1,576

PUBLICATION IMPACT

The impact of the publications published in journals can be measured by several metrics: The new journal metric launched by Elsevier in December 2016, the CiteScore, now competes with the Impact Factor, produced by Clarivate Analytics (formerly part of Thomson Reuters.) The two companies also maintain competing bibliographical citation databases, with Scopus for Elsevier and the Web of Science for Clarivate. Despite being a widely used measure of journal quality for over 40 years, the Impact Factor has suffered from a lot of criticism because of some of its limitations, namely²

- Since the Impact Factor is derived from journals indexed in the Web of Science, no other journals can have an Impact Factor.
- Since the Impact Factor only looks at citations in the current year to articles in the previous two years, it only works well for disciplines in which rapid citation is the standard.
- The Impact Factor does not take into account disciplinary differences in expected numbers of citations.
- There is no Journal Citation Report (JCR) for arts and humanities, therefore no Impact Factor for journals in these disciplines.

Other attempts have been made to offer alternatives to the Impact Factor, such as the Eigenfactor Score, which uses the same journal source list as the JCR, the Scimago Journal Rankings, and the SNIP (Source Normalized Impact per Paper), which uses the Scopus journal source list. However, the CiteScore represents the most credible competitor to the Impact Factor because of the following aspects:

- It is free to access on the Scopus Journal Metrics website (while the JCR requires a paid subscription).
- It is derived from the Scopus journal source list, which is much larger than the Web of Science list and includes more social sciences and humanities journals.
- It provides a 3-year citation window, rather than the 2-year window used for the Impact Factor.

The Nano-Tera publications that appeared in journals with a known Impact Factor (Web of Science) or CiteScore (Scopus) lead to the following Impact Factor and CiteScore distributions.

² For more detail, see <https://library.osu.edu/researchcommons/2017/06/12/citescore-vs-impact-factor>

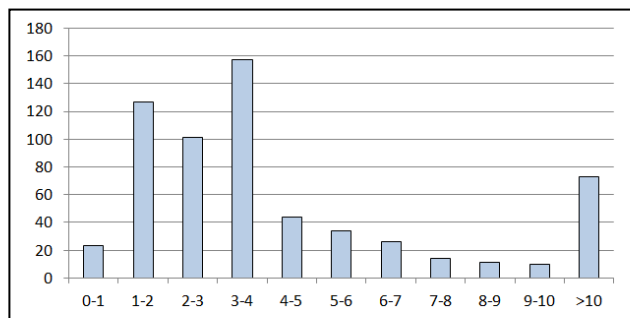


Figure 12. Distribution of Impact Factors.

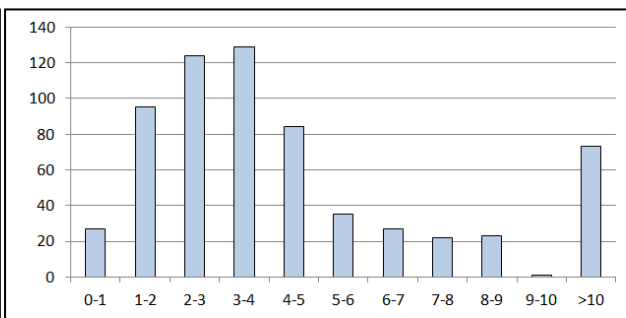


Figure 13. Distribution of CiteScore.

The corresponding average Impact Factor and CiteScore for Nano-Tera publications are given in the table below.

	Phase 1	Phase 2	Overall
Average Impact Factor	3.96	6.72	5.34
Average CiteScore	3.88	5.95	4.92

CONFERENCES AND WORKSHOPS

In the first phase of Nano-Tera, more than **1,200 presentations** at conferences and workshops have been given, in addition to almost **900 presentations** which have been reported so far for the second phase (about 40% of which were invited oral presentations, the rest being other oral presentations or posters). Furthermore, the projects have led to several presentations in the media (television, radio, press).

This brings the overall number of Nano-Tera presentations in various conferences to over **2'000** since the beginning of the program.

	Phase 1	Phase 2	Total
Conferences	1'265	882*	2'147

* As of 2015.

AWARDS

Numerous awards have been received by Nano-Tera researchers, 19 of which being awarded for personal achievements of prominent researchers for their lifetime contributions to their field, and 59 awards for best presentations, papers, presentations, demonstrator, etc.

	Phase 1	Phase 2	Total
Awards for personal achievements	12	7	19
Best poster/paper/pres. awards	25	33	58
Total	37	40	77

PROMINENT RESEARCHERS

Below are the publication and citation statistics of some prominent Nano-Tera researchers (i.e. all Phase 2 PIs or Co-PIs with an H-index of at least 50, listed in alphabetical order). The provided statistics are taken from Google Scholar as of August 2017.

	Publications since 2012	Citations since 2012	H-index
Luca Benini, ETHZ	377	15'157	89
Giovanni De Micheli, EPFL	321	11'959	93
Nico De Rooij, EPFL	182	7'535	78
Jérôme Faist, ETHZ	171	11'235	87
Hubert Girault, EPFL	81	8'042	75
Michael Grätzel, EPFL	483	133'136	218
Ursula Keller, ETHZ	278	12'357	94
Ernst Meyer, Uni Basel	122	6'247	71
Demetri Psaltis, EPFL	131	7'438	85
Philippe Renaud, EPFL	166	6'636	64
Joseph Sifakis, EPFL	33	4'612	58
Lothar Thiele, ETHZ	167	20'107	73

INTERNATIONAL EXCHANGE PROGRAM

Nano-Tera has attracted the attention of world-leading scientists through its International Exchange Program. In this framework, Nano-Tera.ch has invited three prominent internationally renowned researchers to make a series of talks in various institutions involved in Nano-Tera:

- Prof. Krishna Palem (Rice University), widely recognized for his pioneering contributions to the foundations of embedded computing, interacted with several Nano-Tera scientists at EPFL in a form of stimulating exchanges of ideas and perspectives.
He visited Nano-Tera in July 2013.



- Prof. Rahul Sarpeshkar, currently professor at the Thayer School of Engineering at Dartmouth and former award-winning professor at MIT, presented his pioneering contributions in the area of ultra energy efficient systems in biology, engineering and medicine in a widely followed series of talks at EPFL, CSEM and ETHZ.
He visited Nano-Tera in October 2013.



- Prof. Massimiliano Di Ventra, professor at the Department of Physics at the University of California in San Diego, presented his research on the theory of electronic and transport properties of nanoscale systems, non-equilibrium statistical mechanics, DNA sequencing/polymer dynamics in nano-pores, and memory effects in nanostructures for applications in unconventional computing and biophysics.
He visited Nano-Tera in May 2014.



Key statement 2

Nano-Tera.ch has fostered strongly **collaborative** research.

NUMBER OF PARTNERS PER PROJECT

A central measure of the level of collaboration within a given project is the number of partners working in that project. We therefore computed how many partners (PI and Co-PIs) are officially participating in each of the Nano-Tera.ch RTD projects.

The results of this analysis show that the RTD projects have had between 3 and 10 different partners, with an overall average of 6.11 (5.8 for the first phase of the program, and an average of 6.3 for the second phase).

	Phase 1	Phase 2	Overall
Average number of partners (RTD)	5.84	6.32	6.11

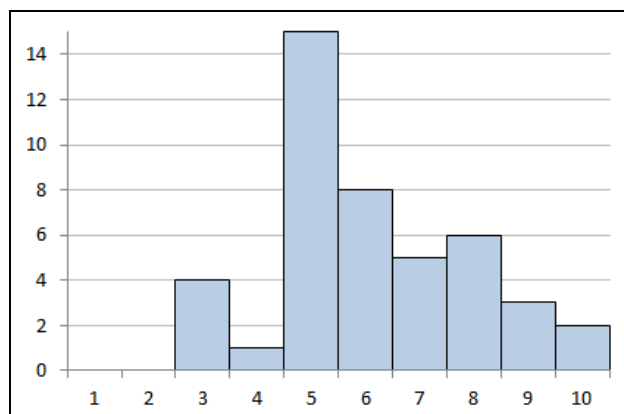


Figure 14. Distribution of the number of partners (RTD projects).

NUMBER OF INSTITUTIONS PER PROJECT

The above metric does not consider the potential diversity of the institutions involved in a project, as several consortium members may originate from the same institution or even the same unit within a given institution. A complementary way of evaluating the level of collaboration within a project is therefore to measure the number of different institutions represented by the project partners (PIs and Co-PIs) within each of the Nano-Tera.ch RTD projects.

The results of this analysis show that the RTD projects of both phases have had up to 7 different institutions involved, with an average of almost 4.

	Phase 1	Phase 2	Overall
Average number of institutions (RTD)	3.89	3.88	3.89

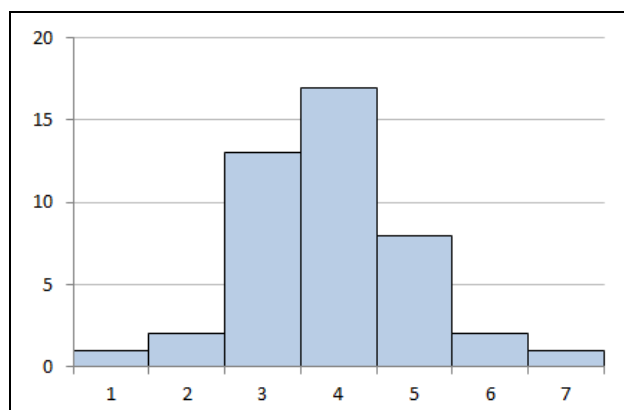


Figure 15. Distribution of the number of institutions in RTD projects.

NUMBER OF RESEARCH GROUPS PER RESEARCH TASK

A more detailed way of assessing the collaborative nature of the research carried out within the Nano-Tera program is to analyze the number of research groups involved in the same research task.

Because of the very heavy workload it represents, this type of analysis has been only performed for Phase 1 RTD projects.

The results of the analysis show that, on average, 2.4 partners (PI or Co-PIs) were involved in a given task in Phase 1 RTD projects. In fact, almost two thirds of all subtasks identified in these projects are carried out by several partners, as illustrated by the distribution below.

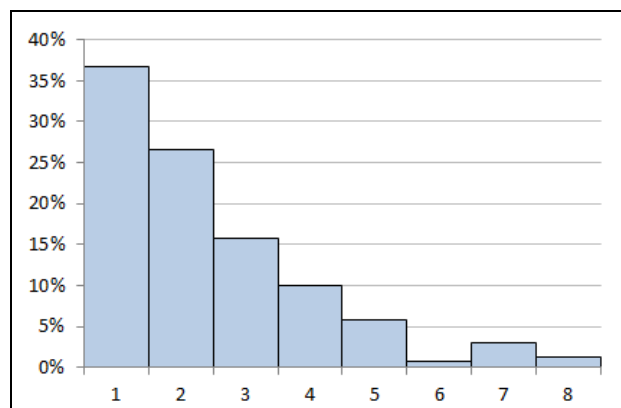


Figure 16. Number of partners in a task (RTD projects Phase 1).

AMOUNT OF JOINT PUBLICATIONS

To further quantify the amount of collaboration taking place in the Nano-Tera.ch projects, we have also analyzed all the publications stemming from the RTD projects, and identified how many project partners (PIs and Co-PIs) they involve. The results show that nearly 28% of the publications are co-authored by at least two project partners, the detailed distribution being provided in the figure below.

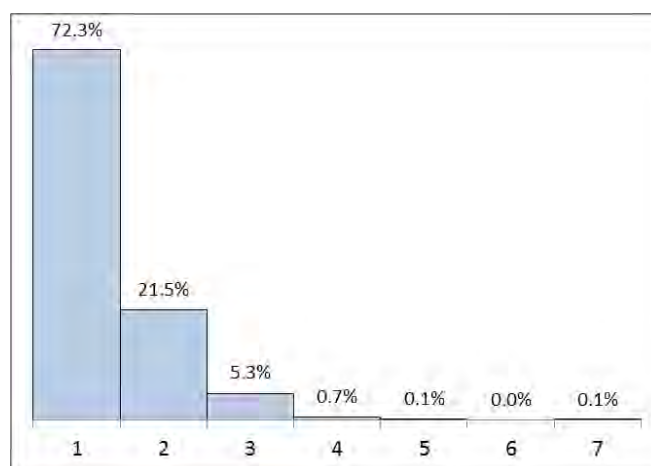


Figure 17. Distribution of the RTD project publications by number of co-author partners.

NANO-TERA – SSSTC PILOT GRANTS

In 2011, Nano-Tera launched an initiative aiming at creating synergies to encourage Swiss-Chinese research collaborations within Nano-Tera.ch thematic areas.

An important first step took place in November 2010, when, recognizing the importance of bilateral relations, Nano-Tera.ch took part to an official visit to various Chinese institutions in order to initiate a dialog on possible future collaborations.

The collaboration of Nano-Tera with the Chinese Academy of Science (CAS) benefitted from the existing agreement between CAS and the Sino-Swiss Science and Technology Cooperation (SSSTC) program, hosted by the ETHZ and supported by the State Secretariat for Education, Research, and Innovation (SERI) in the framework of the promotion of bilateral science and technology cooperation with China. Following this first exploratory phase, and combining the strengths of Nano-Tera.ch and SSSTC, a joint call for Sino-Swiss Pilot Grants was launched in Spring 2011.

The same funding rules as the ones defined for standard Nano-Tera.ch Phase 1 projects have been imposed for this collaboration: total own contributions had to be at least 53% of the total budget. In addition, it was highly recommended that Chinese matching funds amounted to at least 33% of the total budget. In order to support the initiative and increase Nano-Tera.ch visibility in China, a booth presenting Nano-Tera.ch activities and promoting the SSSTC call was set up at the large Transducers conference held in Beijing in early June 2011, and benefitted from the presence of several Nano-Tera investigators, thus initiating discussions between Swiss and Chinese scientists.

The initiative coincided with the visit to China of Federal Councilor Didier Burkhalter, and his discussions with the ministers of science and technology, education and health aiming at reinforcing common programs in sectors such as health, environment, and energy, to cite those directly correlated to the strategic objectives of Nano-Tera.



Figure 18. Location of Chinese partners.

The Nano-Tera.ch SSSTC call resulted in the selection of the following SSSTC projects:

i-Needle	Intelligent Needles with Wireless Connection to Internet for Biophysical Bases of Acupuncture	Dr. S. Carrara EPFL
M3WSN	Mobile Multi-Media Wireless Sensor Networks	Prof. T. Braun UniBE
NaNiBo	Nano-Confinement of Nitrogen and Boron based Hydrides	Prof. A. Züttel EMPA
NetCam	Real Time Computation & Optimization for Networked Camera Surveillance	Prof. J. Lygeros ETHZ
SiC-nanomembranes	SiC Nanomembranes for MEMS Biofuel Cell	Prof. J. Brugger EPFL
3DOptoChemImage	Optofluidic 3D Chemical Imaging Cytometry based on inline Digital Coherent anti-Stoke Raman Scattering Holography	Prof. D. Psaltis EPFL

Key statement 3

Nano-Tera.ch has fostered strongly **interdisciplinary** research.

NUMBER OF DISCIPLINES PER PROJECT

To analyze the inter-disciplinarity of the research carried out within Nano-Tera.ch RTD projects, the following list of disciplines has been considered to categorize the researchers involved in the projects:

- Bioengineering & Life Sciences
- Information & Communication Systems
- Electrical Engineering
- Electronic & Optical Systems
- Medicine
- Micro-engineering
- Energy
- Environment
- Fundamental Sciences

The results of the analysis show that most projects indeed include specialists from different disciplines, with the project consortia covering on average almost 3 different disciplines:

	Phase 1	Phase 2	Overall
Average number of disciplines (RTD)	2.74	2.72	2.73

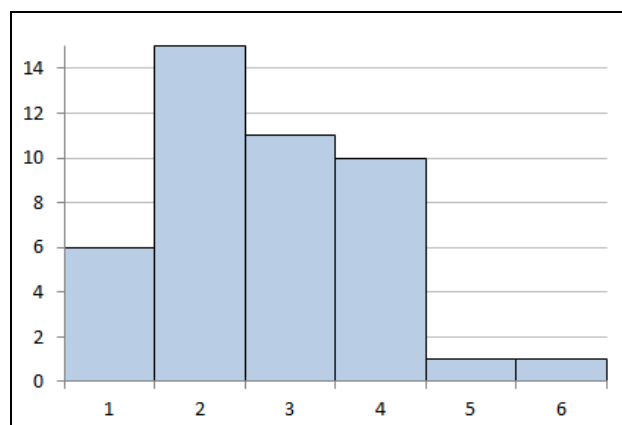


Figure 19. Distribution of the number of disciplines brought by project partners to RTD projects.

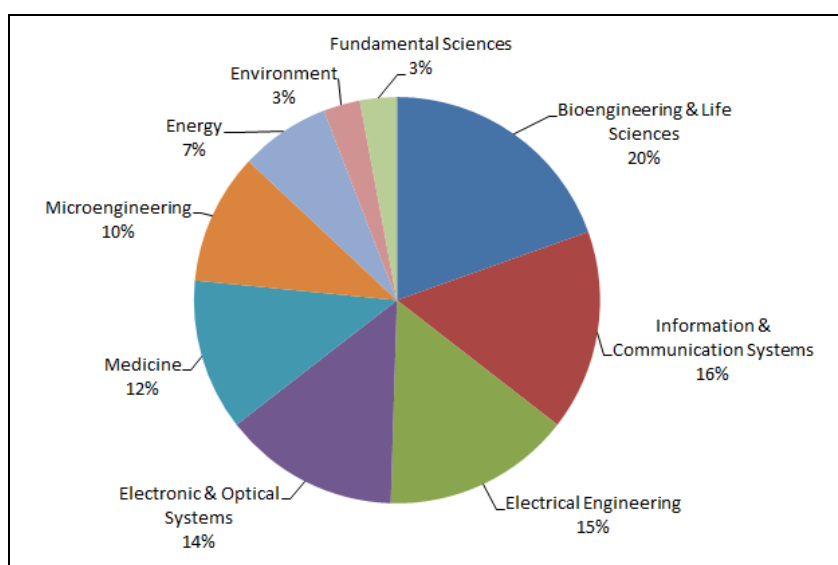


Figure 20. Distributions of disciplines among project partners (RTD projects).

Key statement 4

Nano-Tera.ch has triggered **inter-institutional** collaborations among very diverse players at the national level.

NUMBER OF DIFFERENT TYPES OF INSTITUTIONS PER PROJECT

For the inter-institutional nature of the consortia of the Nano-Tera.ch RTD projects, the following five institution types have been considered:

- ETH-Domain institutions (EPFL, ETHZ, Empa, Eawag, etc.)
- Universities
- Universities of applied sciences
- Hospitals
- Others (private institutions, etc.)

Overall, 9 of the 44 main RTD projects have had 4 types of institutions represented, with the following averages and distribution:

	Phase 1	Phase 2	Overall
Average number of inst. types (RTD)	2.63	2.80	2.73

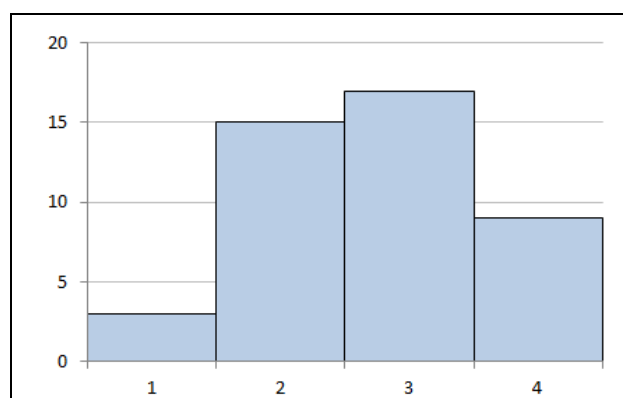


Figure 21. Distribution of the number of institution types in RTD projects.

In addition, an analysis of the distribution in the RTD projects of project partners (PIs & Co-PIs) by institution type has been carried out with a finer grained set of institution type distinguishing the two Federal Institutes of Technology from the other ETH-Domain institutions. The results of this analysis are shown below.

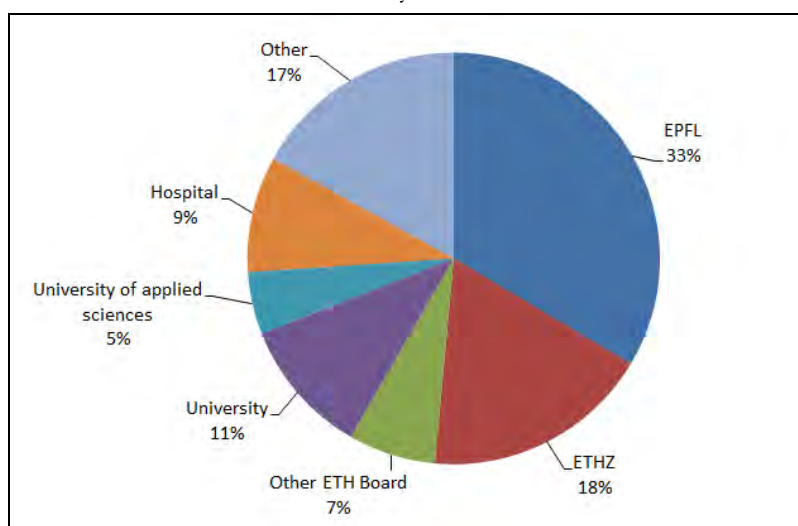


Figure 22. Distribution of the project partners by institution type (RTD projects).

IMPROVEMENT OF THE RELATIONS BETWEEN FEDERAL INSTITUTIONS

As a result of the true inter-institutional nature of the Nano-Tera.ch projects, one of the important impacts of the program has been to substantially strengthen the relations between the involved institutions, and especially between the two Federal Institutes of Technology (EPFL and ETHZ).

Key statement 5

Nano-Tera.ch has fostered strongly **applications-oriented research** in various domains of engineering sciences.

To some extent, fundamental research and application-oriented research can be considered as the two faces of the same coin, as they can be carried out by the same researchers. However, they strongly differ in the nature of the expected results. On one hand, when working on fundamental research issues, researchers are usually operating in a very exploratory mode, faced with highly evolving conditions, dealing with a high level of uncertainty, and ready to react to unexpected findings by rapidly adapting the original research objectives. On the other hand, when working on application-oriented research issues, researchers have to deal with very different concerns, typically resulting from their interaction with partners focusing on the exploitation of the research results for non-scientific purposes (typically applicative or economic). This thus requires from the researchers to take time to discover the expectations of the non-research partners, to concretize the research results into exploitable prototypes, and to stick to a more stable set of shared goals, expressed in terms of broadly understandable applicative objectives.

In consequence, to strengthen its application-oriented, Nano-Tera had to

- translate its scientific vision into more specific applicative goals associated with the broad application areas defined for the program: health, energy and the environment,
- foster the synergies between partners with scientific and non-scientific profiles,
- encourage the production of technology demonstrators potentially exploitable for the development of products in the medium term.

STRENGTHENING THE PARTICIPATION OF INDUSTRIAL PARTNERS AND END-USERS

Nano-Tera.ch mainly achieved this objective by exploiting the eligibility conditions imposed on the consortia of the RTD projects. Concretely, the presence of industrial partners and end-users (e.g. hospitals) has been strongly recommended in all Nano-Tera.ch RTD calls, and made mandatory for Nano-Tera.ch Phase 2 RTD and Gateway projects. Indeed, building research consortia with industrial partners eager to benefit from the research results for economic exploitation, and with end-users seeking solutions to specific problems contributed to turn the RTD projects into very early stage incubators. This type of approach can therefore be considered as an effective way to foster application-oriented research.

As a result, 80 industrial partners and third parties as well as 41 end users (partners and third parties) were involved in the Nano-Tera.ch program..

Moreover, the RTD projects consortia involved complementary types of partners, with a bit more than half (57%) being researchers as expected, but also translational partners (CSEM and Empa, 12%), end-users (mainly hospitals, 12%), as well as industrial partners (19%). This type of mixed consortia represented a very favorable setup for application-oriented research, as the non-academic partners contributed to channel the research towards results that matched their applicative needs.

ENCOURAGING THE PRODUCTION OF CONCRETE DEMONSTRATORS

The outputs of the Phase 1 and Phase 2 RTD projects have been analyzed (see Key Statement 11 and 12 for more detail on the performed analysis) to identify the number and nature of demonstrators and platforms produced. These demonstrators and platforms have been further characterized in terms of marketability (e.g., expected time to market – TTM – where lower TTM corresponds to higher marketability) and exploitability (e.g., technology readiness levels – TRL – where higher TRL identify results closer to industrialization, see Appendix B for details).

In particular, the results of the analysis showed that 31.5% of the 19 Phase 1 RTD projects and 56% of the 25 Phase 2 RTD projects led to demonstrators and technology platforms with a high potential to rapidly convert into products, which clearly indicates that Nano-Tera.ch managed to deploy the proper measures for strengthening the application-oriented nature of the research carried out in in the program.

Key statement 6

Nano-Tera.ch has funded **ambitious projects**.

One of the important goals of the Nano-Tera.ch program was to provide a funding structure able to support large, ambitious research projects that could not be otherwise funded through the existing funding instruments.

LEVEL OF FUNDING

The RTD projects have benefitted from an ambitious funding, as shown below.

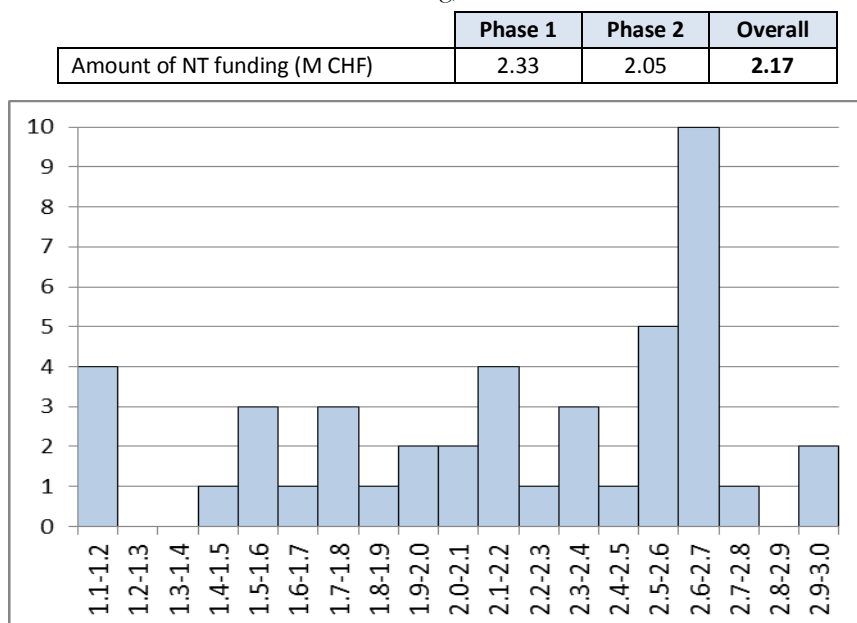


Figure 23. Distribution of the level of Nano-Tera.ch Funding per RTD project.

NUMBER OF RESEARCHERS IN EACH PROJECT.

In order to address ambitious projects, a substantial team is needed. Nano-Tera.ch has provided the opportunity to build large consortia, which was much harder with other funding instruments.

On average, the RTD projects have included 36 (possibly part-time) members (Co-PIs, senior scientists, postdocs, PhD students, etc.), with the distribution of the consortium sizes provided below. Note that all types of projects members are considered in this analysis: both full-time and part-time members, either funded by the allocated budgets or by the matching funds provided by the project partners.

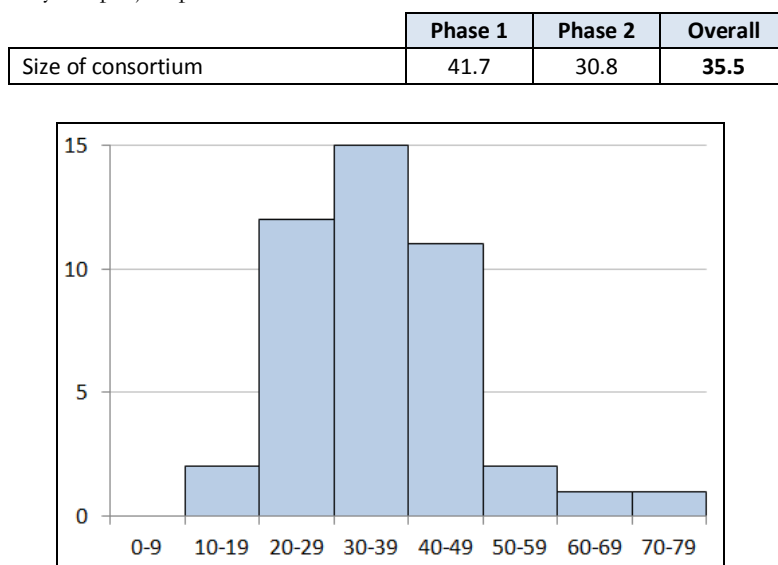


Figure 24. Distribution of the number of researchers in RTD projects.

PROJECTS DURATION

The RTD projects have extended over a significant period of time, spanning at least 3 years, and sometimes more than 4.5 years. Note that we consider the effective duration of projects, potentially different from the originally planned one, because many projects have been extended with no additional funding.

On average, RTD projects of Phase 1 have spanned over 46.3 months and Phase 2 projects over 49.2 months, thus leading to an overall average of almost exactly 4 years.

	Phase 1	Phase 2	Overall
Average project duration (in months)	46.3	49.2	47.9

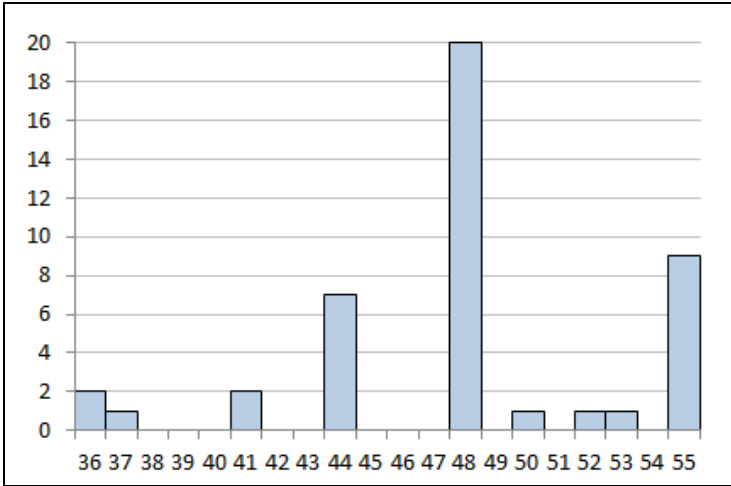


Figure 25. Duration of the RTD projects (in months).

Key statement 7

Nano-Tera.ch has an **almost exhaustive coverage** of the Swiss scientific community in the program's fields.

A DENSE GEOGRAPHICAL COVERAGE

The maps below show, for each phase of the program, the geographical coverage of the partners present in all the projects. The size of the displayed circles is proportional to the number of involved research partners in the corresponding site and institution. The thickness of the displayed links indicates the number of projects that a given pair of institutions is involved in. Over both phases of the program, about **1,600 different researchers** have been involved in Nano-Tera projects, and, when taking into account the fact that a researcher can be involved in several projects, the total amounts to almost 2,300 persons.project.

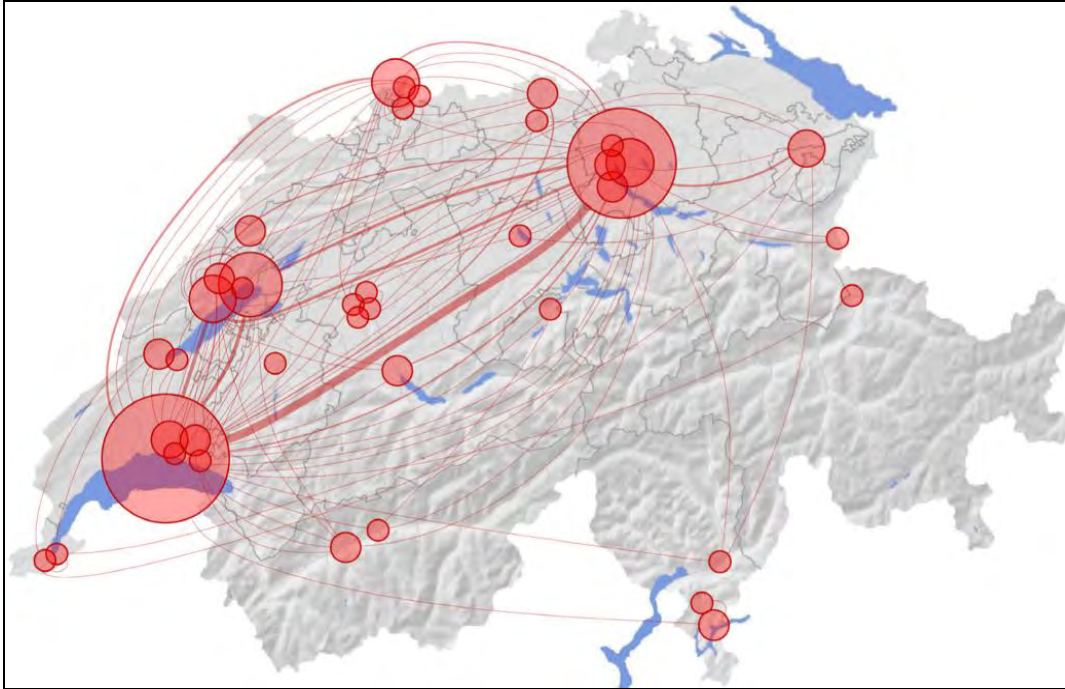


Figure 26. Geographical coverage of the partners present in all projects (Phase 1).

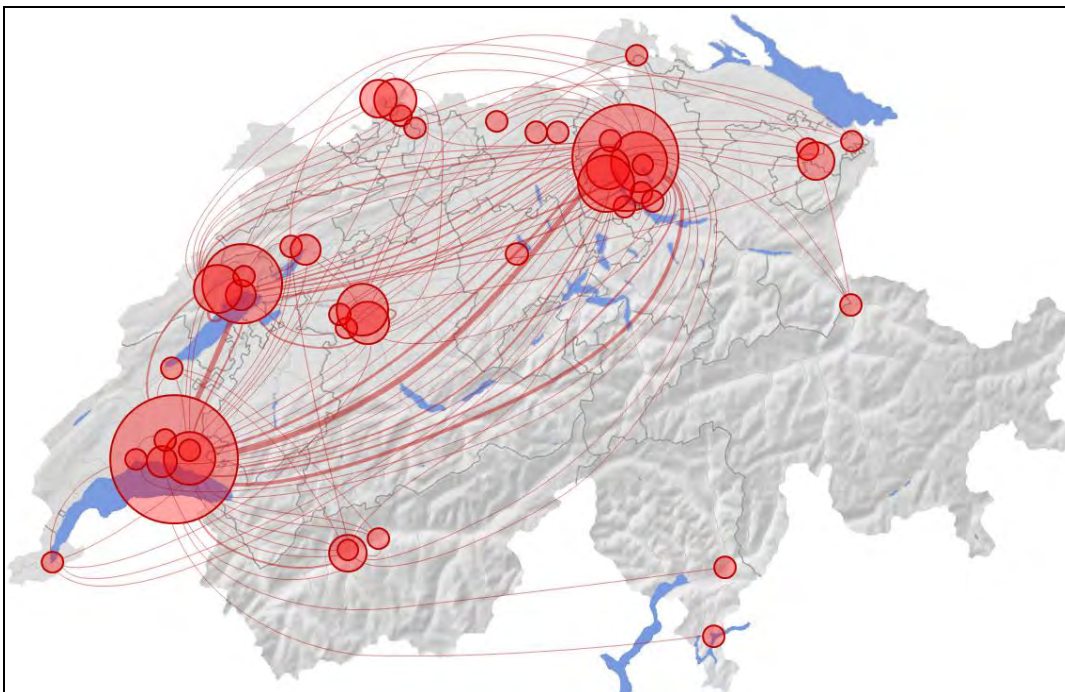


Figure 27. Geographical coverage of the partners present in all projects (Phase 2).

IV.3 KEY STATEMENTS RELATED TO EDUCATIONAL IMPACT

Key statement 8

Nano-Tera.ch has substantially contributed to the **training of next generation researchers** (PhD students, Post Docs).

A LARGE NUMBER OF PHD STUDENTS

Nano-Tera.ch has contributed to the training of the next generation of researchers, with a total of 366 PhD students involved in the program's projects, 192 in Phase 1 projects and 202 in Phase 2 projects (some of which took part to both phases of the program).

	Phase 1	Phase 2	Overall
Number of PhD students	192	202	366

DISTRIBUTION OF PHD STUDENTS BY INSTITUTION

About 77% of all PhD students are affiliated with EPFL, ETHZ or another ETH-Domain institution, as shown in the graph below. About 15% study in a university or a university of applied sciences. The rest are affiliated with hospitals or other institutions.

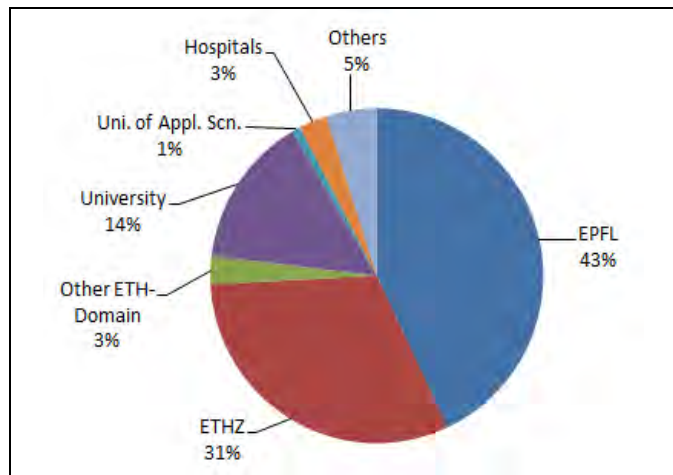


Figure 28. Distribution of PhD students by institution.

DISTRIBUTION OF PHD STUDENTS BY THEMATIC CLUSTER, PHASE II

Based on the thematic clusters defined for Phase II projects, the distribution of PhD students by topic is shown below. There are 31 PhD students are involved in a project related to environmental monitoring, and 57 are involved in smart energy. The three health-related clusters (health monitoring, smart prosthetics & body repair, medical platforms) have 49, 29 and 36 PhD students respectively.

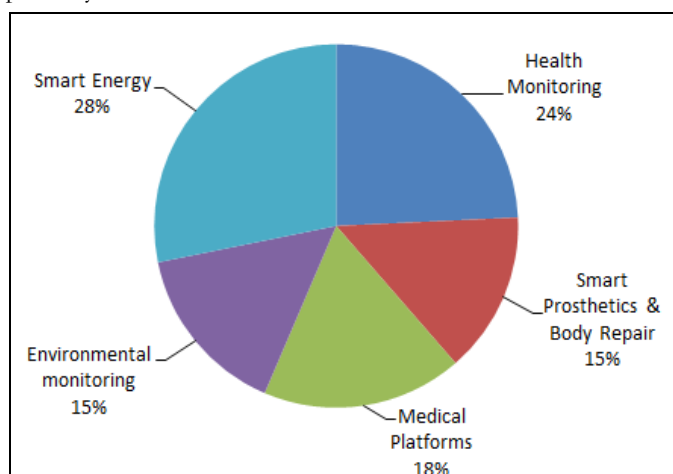


Figure 29. Distribution of PhD students by thematic cluster (Phase 2).

DISTRIBUTION OF PhD STUDENTS BY GENDER

There are 77 female PhD students, representing about 21% of the total.

PROFILE DIRECTORY OF PhD STUDENTS

A special page devoted to PhD students has been created on the Nano-Tera website. It consists of a complete directory of students, which can be sorted and filtered by project, by institution and several other criteria: www.nano-tera.ch/phd

<div> <div>SEARCH </div> <div>Results: 19</div> <div>Clear filters</div> <div>Page: < 1 ></div> </div>					
Adrien Besson EPFL Lausanne <i>UltrasoundToGo</i> Jean-Philippe Thiran 01.01.2015 - 31.12.2018	Marco Capogrosso EPFL Lausanne <i>SpineRepair</i> Silvestro Micera 01.11.2009 - 31.10.2013	Fan Fu EMPA Zurich <i>Synergy</i> Ayodhya Tiwari 01.02.2014 - 31.01.2017	Peter Fuchs EMPA Zurich <i>Synergy</i> Ayodhya Tiwari 01.09.2013 - 31.08.2016	Jérôme Gandar EPFL Lausanne <i>SpineRepair</i> Grégoire Courtine 15.04.2014 - 15.10.2018	Pascal Alexander Hager ETHZ Zurich <i>UltrasoundToGo</i> Luca Benini 01.08.2014 - 31.07.2017
Arthur Hirsch EPFL Lausanne <i>SpineRepair</i> Stéphanie Lacour 15.08.2013 - 15.08.2017	Aya Ibrahim EPFL Lausanne <i>UltrasoundToGo</i> Giovanni De Micheli 01.10.2014 - 30.09.2017	Federico Matteini EPFL Lausanne <i>Synergy</i> Anna Fontcuberta i Morral 01.04.2012 - 31.03.2016	Dmitry Mikulik EPFL Lausanne <i>Synergy</i> Anna Fontcuberta i Morral 01.10.2014 - 30.09.2018	Eduardo Martin Moraud EPFL Lausanne <i>SpineRepair</i> Silvestro Micera 15.10.2010 - 03.10.2014	Henri Saab EPFL Lausanne <i>UltrasoundToGo</i> Jean-Philippe Thiran 15.03.2014 - ..quit 30.06.2014

TIMELINE

Based on the starting dates and expected end dates of the PhD students, the graph below indicates how many PhD students have been active at any given time.

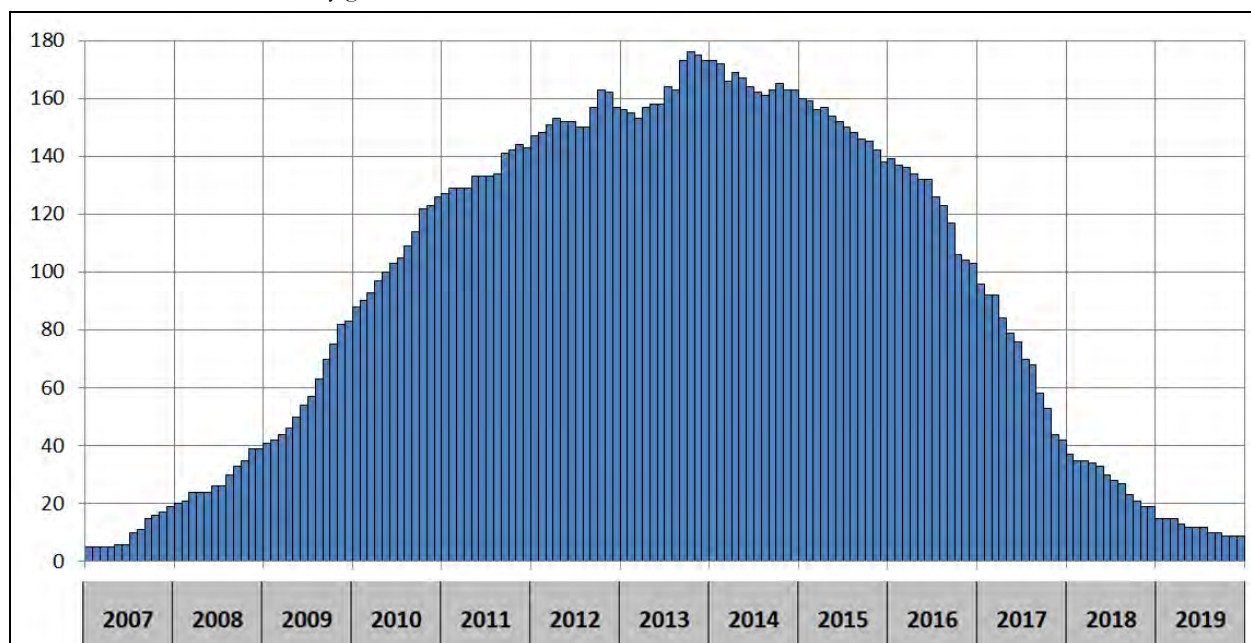


Figure 30. Time evolution of the number of PhD students that have been active in the Nano-Tera program.

THE NEXTSTEP PROGRAM FOR PHD STUDENTS

To strengthen the importance of PhD students within the program, Nano-Tera has set up the NextStep program, specifically for PhD students. This program has been designed to help the PhD students explore possible ways to exploit the scientific skills they had acquired during their PhD. In particular, NextStep was promoting the possibility for them:

- to apply for specific research grants to fund collaborative research involving several PhD students. (Track 1, **described in Key statement 9**)
- to be exposed to different ways of considering economic exploitation of the scientific skills and results obtained during their PhD work. (Track 2, **described in Key statement 10**)
- to present their research to a larger audience outside their field (Track MT180, see below).

NEXTSTEP TRACK MT180: MY THESIS IN 180 SECONDS CONTESTS

In addition to carrying out excellent science, it was important for PhD students to be able to communicate their work and results, in a clear and appealing way, easily understandable outside their field of specialization.

As it is now done in many higher education institutions to help their junior researchers acquire the required communication skills, Nano-Tera has organized MT180 (“My Thesis in 180 Seconds”) contests, where PhD students had 3 minutes to present the content of their research to a wide audience, with the support of only one static slide.

A first contest, open to all Nano-Tera PhD students, ended up giving six of the participants the opportunity to benefit from personal coaching under the supervision of Swiss journalists specialized in science and technology. Furthermore, three PhD students have been selected by a jury involving journalists and researchers to make their MT180 presentation in front of the whole Nano-Tera community at the Nano-Tera Annual Meeting 2016.

Concretely, interested participants first had to submit their draft MT180 presentation in the form of a video contribution of at most 3 minutes, involving the presentation of one static slide. The contributions have been evaluated by a jury composed of six researchers and six scientific journalists. The jury selected the six most promising contributions, and each of the selected PhD students benefitted from a personalized coaching by one of the scientific journalists in the jury, to help them improve the content of their presentation.

After their coaching, the six selected PhD students participated to a “semi-final” in the form of a live presentation in front of the jury. The three best participants faced off in the final at the Nano-Tera Annual Meeting 2016, with Débora Bonvin declared the winner by the audience.



Figure 31. Débora Bonvin (EPFL), Romain Jacob (ETHZ) and Leila Mirmohamadsadeghi (EPFL), 3 finalists.

Following the success of this Nano-Tera contest, **an international contest** has been organized in early 2017, involving parallel competitions in Brazil and in Switzerland. The more than 20 students who participated to the event were evaluated by a local jury as well as by a jury in the other country and the students from the other country.

Two Swiss and two Brazilian students have been declared winners and received a grant to give their 3-minute presentation along with a more extensive talk to host institutions of their choice, with Swiss students traveling to Brazil and vice versa.



THE EDUCATION AND DISSEMINATION ACTIVITIES

Nano-Tera Education and Dissemination (ED) activities are actions aiming at supporting short courses, workshops, mini-conferences, and developing new curricula in domains covered by Nano-Tera.ch that are not provided by Swiss Universities or Polytechnics. ED activities may address the in-depth study of a technology or interdisciplinary horizontal activities.

Nano-Tera.ch funded 61 ED actions for a total budget of more than CHF 1.4 million. More than half of the activities funded consisted of conferences, symposia and workshops. About a quarter have been courses and winter or summer schools.

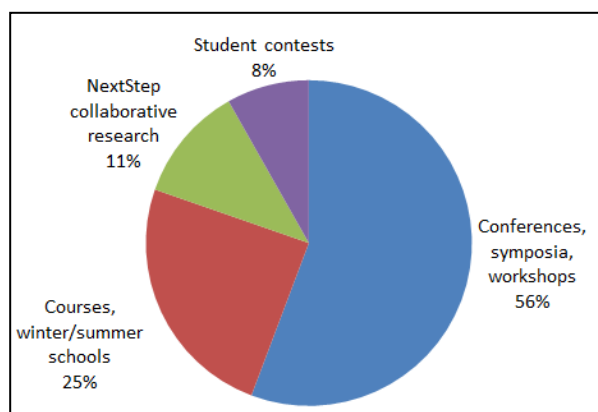


Figure 32. ED activities by type.

iCAN student contests

Nano-Tera has supported several years the Swiss selection for the international student contest in micro/nanodevice applications. Swiss student teams were competing to develop new applications using commercial sensor devices, donated by the industry.

In the iCAN 2016 selection for example, after a preparation phase of 3-4 months, the Swiss selection took place with a jury composed of industry professionals. The Swiss selection was open to all Swiss higher education systems. As a result of the Swiss selection day, two Swiss winning teams were sponsored to travel to Paris to participate to the international iCAN contest. The two Swiss teams performed very well in the finals, receiving a 1st and 2nd place award. It was deemed an excellent project involving young, ambitious students to work as a team on a tightly scheduled project.



Figure 33. Adrian Sarbach (EPFL), Pius Theiler (ETHZ), Ricarda Nebling (ETHZ) winners of the first prize (left) and Arthur Gay and Thibaut Paschal (EPFL), winners of the second prize (right)

Artist School 2013

In the continuation of the Artist Summer School series of events (2003, 2005, 2007–2012), the program of the Nano-Tera/Artist International Summer School 2013 was tailored to compensate for the lack of curricula in European universities introducing a rigorous approach to system design, providing the attendees with an overview of the state-of-the-art research in the relevant domains.

The topics usually addressed at the school include, among others, Modelling and Validation, Compilers and Timing Analysis, Control for Embedded Systems, Execution Platforms and MPSoC, Temperature- and Energy-Aware Design of Systems and Sensor Networks. Thus, the topics of the Artist Summer School are highly relevant to the application areas and basic engineering technologies composing the Nano-Tera research space, and particularly Software and Systems, Communications, Wearable and implantable and Energy systems.

A total of 67 participants, including 56 students for 15 countries attended the summer school. The students involved with Nano-Tera projects were registered free of charge.



Training and Education Activities

This ED activity consisted of a package of training activities spanning two years. The activity included the following three main activities:

- Internal workshops for NanoTera scientists:
The Nano-Tera.CH program gathers scientists from different backgrounds working on common projects in different fields. This leads to a large demand for cross-disciplinary education among the scientists, which was addressed by the internal workshops program where experienced scientists presented the most relevant enabling technologies to the NanoTera researchers. The aim of the workshops was to exchange experience and know-how and to create a real NanoTera community. This resulted in the organization of four workshops for Nano-Tera researchers (duration 1-2 days each), gathering a total of 119 participants.
- Training courses for professionals in the field of micro/nano
In order to ensure the success of the industrialization stage, there is a need for transfer of knowledge from the research institutions to the industry. This was addressed by a large Nano-Tera.ch continuous education program for professionals. This resulted in the organization of 16 short training courses for industrial and academic participants (duration 1-2 days each)
- A Summer school for academic education
Nano-Tera.CH pursues scientific excellence in many technologies and in their integration into systems. For students and researchers at Swiss and foreign universities and especially for young researchers from the Nano-Tera community, a condensed summer school on specific topics has been organized.

Key statement 9

Nano-Tera.ch has encouraged stronger **collaborative spirit** in the community of PhD students involved in the program and increased their autonomy by giving them the opportunity to submit their own collaborative research proposals.

NEXTSTEP PROGRAM FOR PHD STUDENTS: TRACK 1 – SCIENTIFIC COLLABORATION

GOAL

The lone scientist in his laboratory is an idealized image far from reality. As the multidisciplinary nature of Nano-Tera projects illustrates, it is becoming more and more crucial to be able to conduct research in a collaborative manner. The objective of Track 1 of the NextStep action is therefore to give students the opportunity to consider the development of a collaborative work, within the framework of their thesis. This can be done via a joint validation of their results, for example by building a common prototype.

In general, the goal is to expose the PhD student to new concepts and approaches, thus strengthening the educational impact of the NextStep program within a multidisciplinary framework.

Concretely, Track 1 of the NextStep program gives them the opportunity to learn the full procedure of submitting proposals to get concrete funding: from building a consortium, picking the research challenges, writing the scientific proposal, and building a reasonable budget.

TIMELINE

The program consisted of 4 modules, with a first one taking place in March 2015: the scientific collaboration track gathered all interested students for a day in order to start sharing their preliminary ideas of potential collaborations.

The second module took place during the 2015 Nano-Tera Annual Meeting, giving participants the possibility to present their collaborative research ideas to a panel of experts. Based on this first interaction, the ideas have become more mature and more precise: in a third stage of the Track 1 program, participants have submitted proposals, all of which have been accepted for funding.

Finally, the last module took place at the Nano-Tera Annual Meeting 2016, where some first results of the approved collaborative projects were presented.



Figure 34. Nano-Tera.ch annual meeting 2016, Lausanne.

PROJECTS

The funded projects are summarized below:

Name	NT Project	Acronym	Title
T. Brusa, UniBE <i>PI: P. Büchler</i>	SmartSphincter	BAFIARS	Assessment of anatomic, physiologic & bio-mechanical characteristics of the anal canal & pelvic floor: an observational study in patients
M. Thielen, ETHZ <i>PI: C. Hierold</i>	BodyPoweredSenSE	BioFlex	Soft dry Biopotential Electrodes for Long-Term EEG recording
T. Wyss, UniBE <i>PI: P. Büchler</i>	HearRestore	BonePro	HearRestore: Bone Impedance modelling
P. Hager, ETHZ <i>PI: L. Benini</i>	UltraSoundToGo	LightProbe	Digital UltraSound Head
J. Ansó, UniBE <i>PI: S. Weber</i>	HearRestore	NerveSafe	Facial nerve monitoring during robotic cochlear implantation
D. Mikulik, EPFL <i>PI: A. Fontcuberta</i>	Synergy	SolCelMeas	Analyzing optical and electrical measurements of GaAs nanowire solar cells
H. Huang, BFH <i>PI: V. Koch</i>	WiseSkin	MultiHaptic	Human study: info transfer analysis & early evaluation of multi-modality haptic displays for sensory feedback

- BAFIARS, the first project, was a clinical study on the anatomy and morphology of the anal canal, anatomical and functional parameters were studied in order to prepare a guideline for artificial sphincter implant. The study already presented a surprising fact; pressure measurements showed that the anorectal sphincter pressure among men could amount to 156mmHg when squeezed versus 77mmHg for women. This recently discovered fact is of great importance for the production of future implants.
- Moritz Thielen (pictured) presented his BioFlex project, which addresses a new generation of electrodes that do not need conductive gels to work properly. New conductive nanostructures in flexible substrates compare with standard wet electrodes for electrocardiography as supported by tests in laboratory.



- BonePro focused on a mathematical model of the electrical properties of the mastoid, the bony structure behind the ear, for the creation of a new and safe surgical procedure which consists of drilling a narrow tunnel to the cochlea for placement of a cochlear implant. This rigorously precise surgical operation is going to be more extensively described later in these lines.
- LightProbe, presented by Pascal Hager (pictured), proposed a new type of portable system for ultrasonography for use in places where size, cost and flexibility matter, like in emergency cases or in rural areas for medical use or during inspections of pipes and channeling infrastructures for industrial use. This new ultrasonograph includes its piezoarray, its ultrasound pulses emitter as well as its processing module packed together in the same hand-holdable body. In addition to this, the user can have access to the raw data stream thanks to a fully open development platform.



- NerveSafe developed a neuromonitoring drill for robotic cochlear implantation. The challenge in the new surgical operation for cochlear implants is to be able to drill through the mastoid without touching or damaging the facial nerve. This highly delicate operation currently needs the insertion of a multi-electrode probe in order to test the proximity to the facial nerve. The idea here is to include stimulating electrodes inside the surgical drill in order to reduce the time consuming and complex procedure of drill-test-drill by an all-in-one procedure.

- SolCelMeas, established a series of tests to measure the efficiency of gallium arsenide vertical nanowires solar cells for the production of ultrathin and highly flexible equipment. These tests gave some indications for low efficiency reasons that could be compensated by introducing an AlGaAs (aluminium gallium arsenide) capping layer.
- With her MultiHaptic project, Huaiqi Huang exposed a way for amputees to get tactile feedback by embedding miniaturized pressure sensors in a glove and wirelessly transmit the information to the patient so that he or she can feel what the prosthesis is holding in its artificial hand. The main idea is to combine two kinds of haptic receptors, pressure and vibration, and generate a third kind of sensory receptor for more precise feedback.



Key statement 10

Nano-Tera.ch has encouraged stronger **entrepreneurial spirit** in the community of PhD students involved in the program.

NEXTSTEP PROGRAM FOR PHD STUDENTS: TRACK 2 – ENTREPRENEURSHIP TRACK

GOAL

A survey of the Nano-Tera PhD students who were involved in the program during its earlier phase (2009-2013) has shown that only about 40% of PhD students stayed in academic research, while the other 60% have moved on to the industry or other activities. It is therefore important for them to think as early as possible about their next steps, in particular to consider how to exploit the experiences gained in their PhD work for future professional activities outside of academia.

This is the purpose of Track 2 of the NextStep program. It allows them to interact with experts and coaches in entrepreneurship, in order to learn how to

- describe the skills they have acquired in an efficient way for potential future industrial contacts (“elevator pitches”).
- develop ideas on how to economically exploit their thesis results and skills for goals such as licensing or startup creation.

Concretely, NextStep gives them the possibility to follow a coaching program to elaborate their own business idea and present it to a real investor panel to seek funds. For example, they were given the opportunity to dry run a pitch, with the possibility to win a trip to a high impact event such as CeBit or CES.

The **NextStep** program, **Entrepreneurship Track** was set up as a “Coaching Program & Support for participation to High Impact Events” to develop an early-stage entrepreneurial mindset, to help PhDs explore how to generate economic value from research results, how to identify market opportunities and how to transform an idea into business. Out of about 150 PhD students who were active at the time, 31 were interested, 15 benefited from support, 4 business ideas went to an Impact Event and 3 startups were created (end of 2016) out of 4 created in total! This corresponds to one of the shortcomings (“lack of entrepreneurial spirit”, see KOF survey 2011) mentioned by the Swiss companies.

TIMELINE

The entrepreneurship track also consisted of 4 modules, with a first one taking place in March 2015: this track introduced the students to the ideas of business development and helped them think of their own ideas that they can safely test run.

The second module took place during the 2015 Nano-Tera Annual Meeting, giving participants the possibility to present their initial business ideas (Track 2) to a panel of experts composed of Nano-Tera Executive Committee members and scientists. Following their pitch, the PhD students involved in Track 2 have been awarded a grant to attend an impact event or their choice.

These pitches cover interesting ideas on a variety of topics: in a third stage of the program, the students involved have received mentoring support (two workshops and monthly personalized coaching) in order to help develop and refine their business project.

In addition, Nano-Tera has offered other actions open to all PhD students interested, consisting of:

- 6 coaching sessions (30 min each), from October 2015 to February 2016, to work on the business case
- 2 half day workshops (Sept. 2015 and January 2016) to support the project development, prepare the presentation, etc.
- selection of existing entrepreneurial contests in the Swiss ecosystem, to participate
- among all groups having submitted a project to the Swiss ecosystem, 3 have been selected to present at the 2016 Annual Meeting

Finally, the last module took place at the Nano-Tera Annual Meeting 2016, where Track 2 participants got the opportunity to make a business pitch in front of the whole Nano-Tera.ch audience.

THE BUSINESS IDEAS

The ideas developed by the students are summarized below:

Name	NT Project	Idea title	Key concepts
Alevtina Dubovitskaya, EPFL	ISyPeM II	EzeCHiel	Attaining personalized medicine. Prediction engine (Bayesian approach). Ergonomic software.
Arthur Hirsch, Hadrien Michaud, EPFL	SpineRepair WiseSkin	Wearable sensing devices	B2B technological solution. Wearable electronics: conformal, lightweight and unnoticeable to maximize users comfort and acceptance.
Federico Matteini, EPFL	Synergy	Solstice	Solar wearable devices: better performance, flexible batteries.
Saurabh Tembhurne, Meng Lin, EPFL	SHINE	SoHHytex	Solar Fuel. On site H2 production system – cost effective, cleaner and greener.

As mentioned, the final step of the program took place at the 2016 Nano-Tera annual meeting. At that final event, three finalists were invited to defend their entrepreneurship project in front of the Nano-Tera community and of a panel of experts. Instead of a show of hands, the audience was encouraged to vote by SMS and see the progression of the result live on screen.

- Arthur Hirsch and Hadrien Michaud started the NextStep entrepreneurship session by presenting their project Feeltronix of soft bioelectronic interfaces that could equip a wide variety of wearables and body devices such as watch bracelets or a headband for sleep monitoring.



- Federico Matteini then presented his Solstice project of solar energy collection through vertical nanowires instead of the classical planar solar panels. Nanowires offer the great advantage of reducing the amount of materials used for the construction of solar panels by a factor of one thousand. Which means that for the same energy production a solar panel could weigh a few grams instead of several kilograms and could be as flexible and soft as plastic foil.



- Saurabh Tembhurne closed the chapter by presenting his SoHHytec business project for the production of cleaner and greener hydrogen for fertiliser industries and in the residential sector. Today 95% of H₂ production comes from off-site and non-renewable facilities. SoHHytec proposes to use a mix of solar energy and grid electricity to produce H₂, using an integrated photoelectrochemical device. This system is not only cleaner, but cheaper, since one kilogram of H₂ would cost US\$1.69 only instead of today's US\$2 or more.



The audience vote went for the SolStice project and the SoHHytec project was awarded by the experts.



IV.4 KEY STATEMENTS RELATED TO ECONOMIC IMPACT

Key statement 11

Nano-Tera.ch has fostered research with **high economic potential**.

NUMBER OF PATENTS

In total, at end of 2016, 67 patents were filed on results stemming from Nano-Tera.ch projects. The distribution of these patents over the various project types is provided in the table below.

Phase	Type	Nb. Projects	Nb. Patents
1	RTD	19	28
1	RTD-ADD-ON	8	1
1	NTF	15	3
2	RTD	25	34
2	GTW	8	0
2	NTF	9	1
	Total	84	67

Table 8. Statistics of Patents.

NUMBER OF STARTUPS/CTI PROJECTS

In total at the end of 2016:

- 10 startups resulted from Nano-Tera.ch (out of which 4 were under creation at the time of this report)
- 9 CTI follow-up projects have been approved.

The distribution of these start-ups/CTI projects over the Nano-Tera.ch projects is provided in the table below.

	Startups created	Startups being created	Approved CTI projects
BodyPoweredSenSE	1	1	
Envirobot			
FlusiTex			2
HearRestore + HearRestoreGate			5
HeatReserves			
IcySoC			
IrSens II	2		
ISyPeM II	1		1
MagnetoTheragnostics			
MIXSEL II		1	
NewbornCare			
ObeSense			
OpenSense II			
PATLiSci II		1	
SHINE		1	
SmartGrid	1		1
SmartSphincter			
SpineRepair			
Synergy + SynergyGate			
UltraSoundToGo			
WearableMRI			
WearMeSoC			
WiseSkin			
X-Sense II	1		
YINS			
Total	6	4	9

Table 9. Statistics of startups and CTI projects.

ECONOMIC POTENTIAL RESULTING FROM THE INVOLVEMENT OF INDUSTRIAL PARTNERS AND END USERS

The presence of industrial partners and end-users (e.g. hospitals) has been strongly recommended in all Nano-Tera.ch RTD calls and made mandatory (“must meet” criterion) for Nano-Tera.ch Phase 2 RTD and Gateway projects.

As a consequence, all RTD and Gateway projects receive support in the form of matching fund from various industrial partners and/or end-users. In total, 103 such partners have been involved, and provided a total of 18.2 million CHF of matching funds (see the two tables below).

Type	Role	RTD	GTW	Total
Industry	Partner	13	0	13
	3rd Party	44	14	58
End user	Partner	25	0	25
	3rd Party	7	0	7
Total		89	14	103

Type	Role	RTD	GTW	Total
Industry	Partner	2 930 340	0	2 930 340
	3rd Party	5 969 122	1 456 840	7 425 962
End user	Partner	6 963 303	0	6 963 303
	3rd Party	845 500	0	845 500
Total		16 708 266	1 456 840	18 165 106

Table 10. Involvement of industrial partners and end-users.

Furthermore, the RTD project consortia consisted on average of 57% of research partners, 31% of industrial and translational partners, and 12% of end-users.

Such a presence of industrial partners and end-users, combined with the long duration of the RTD projects, represents a strong economic potential for the program. Indeed, with adequate partner profiles, the projects can valuably contribute to Knowledge and Technology Transfer by playing the role of an information exchange platform, with various project consortium level meetings and events leading to numerous formal and informal contacts between partners. In particular, it allows the industrial partners to be well informed about new technologies, to evaluate the associated business potential, to estimate the consequences that these technologies may have on the existing production lines, to identify possible normative and regulatory issues, etc. In short, by participating in RTD projects, industrial partners increase their capacity to absorb research results and thus get ready to initiate “market pull” actions, such as participating in the production of system demonstrators.

Notice that this type of KTT (formal and informal information exchange) has been identified as the preferred transfer channel by more than 60% of the Swiss Industry active in KTT (see KOF Knowledge and Technology Transfer Survey 2011).

In addition, the KTT potential resulting from the presence of industrial partners in RTD project is further strengthened by the fact that the technologies and applicative areas in which Nano-Tera.ch has been focusing (“Environmental technologies”, “New materials”, “Energy technologies”, “Medical technologies”) strongly overlap the ones considered as most critical by the Swiss industry (see the KOF Knowledge and Technology Transfer Survey 2011 in which the afore mentioned technologies are ranked n°2, n°3, n°4 and n°7 respectively in the list of most critical technologies resulting from the survey of the Swiss industry).

ECONOMIC POTENTIAL RESULTING FROM THE TRAINING OF PhD STUDENTS

One of the important economic impacts of the Nano-Tera.ch program is the training of the substantial number of PhD students who pursue their activity in the industry. This responds to strong demand from Swiss companies who consider the lack of qualified staff as a deficiency (see KOF Knowledge and Technology Transfer Survey 2011). This integration of Nano-Tera.ch PhD students into Swiss companies also has the advantage of increasing the ability of companies to interact with researchers and thus absorb the research results.

In order to evaluate this aspect, Nano-Tera.ch has surveyed all the PhD students involved in the program to know what they were doing after completing their PhD. Among the 308 students who replied the survey, 7 were unemployed and 93 were still working on their PhD at the time. Among the 208 others, 126 were working in the industry (61%), while 82 were pursuing a career in academia (49%). In addition, about 75% of the students working in the industry did so in Switzerland, while 57% of students working in academia stayed in Switzerland.

The detail of the various PhD distributions is given below.

Occupation	Number	Switzerland	Abroad
Academia	82	47	35
Industry	126	95	31
Still PhD student	93		
Unemployed	7		
Total who replied	308		

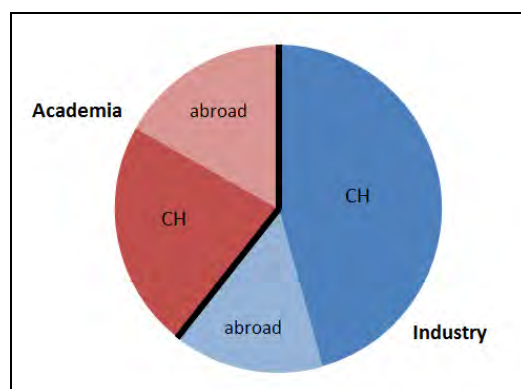


Figure 35. Distribution of PhD students working in academia or in the industry.

Among students working in the industry, the breakdown by size of company (below) shows that about 60% of them work in large companies (with 200 employees or more).

Type of company	Number
Micro(1-10)	22
Small(11-50)	16
Medium(51-200)	13
Large(200+)	75
Total Industry	126

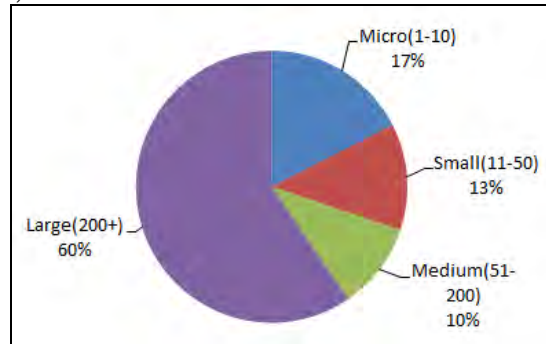


Figure 36. Distribution of the PhD students working in the industry by size of company.

In addition, the coaching provided in the Entrepreneurship Track of the NextStep program helps several Nano-Tera.ch PhD students develop an early-stage entrepreneurial mindset by making them explore how to generate economic value from research results, identify market opportunities and transform an idea into business. four business ideas have been presented at an Impact Event and three startups were created (end of 2016).

ECONOMIC POTENTIAL RESULTING FROM THE PRODUCTION OF EXPLOITABLE DEMONSTRATORS/PLATFORMS

To evaluate the economic potential of the achievements generated in the program, Nano-Tera.ch hired an external consultant to analyze the main outputs of Phase 2 RTD and Gateway projects. In this analysis, the outputs have been first categorized as:

- **Demonstrators** focused on specific use cases and integrating the required technologies.
- **Platforms** consisting of larger sets of integrated technologies and functionalities. Such platforms encourage the involvement of a diversity of partners and promote interaction, facilitate the sharing of scientific knowledge and application expertise.

Second, the identified demonstrators and platforms have been further characterized in terms of marketability (expressed in terms of expected time to market – TTM – where lower TTM corresponds to higher marketability) and technology readiness (expressed in terms of technology readiness levels – TRL – where higher TRL identify results closer to industrialization, see Appendix B for details).

The results of the categorization are provided in the table below for the 25 Phase 2 RTD projects and the 4 Gateway projects running at the time of the analysis:

	Demonstrators / Platforms		
	TRL4	TRL5	TRL6
BodyPoweredSenSE	>2023		
Envirobot		>2023	
FlusiTex + FlusiGate	2020-23		2017-20
HearRestore + HearRestoreGate			2017-20
HeatReserves	2020-23		
IcySoC	2020-23		
IrSens II	2017-20		2020-23
ISyPeM II		2020-23	
MagnetoTheranostics	>2023		
MIXSEL II	2x 2020-23		
NewbornCare		2017-20	
ObeSense	2020-23		2017-20
OpenSense II			2017-20
PATLiSci II	2020-23		
SHINE			2020-23
SmartGrid			2020-23
SmartSphincter	>2023		
SpineRepair	>2023		
Synergy + SynergyGate			2x 2017-20
UltraSoundToGo		2020-23	
WearableMRI	>2023		
WearMeSoC		2020-23	
WiseSkin	>2023		
X-Sense II			2x 2017-20
YINS			2017-20
Total: 31 demonstrators & platforms	10 + 4	3 + 2	12

Table 11. Statistics of demonstrators and platforms.

The analysis shows that important fraction (56%) of the Phase 2 RTD projects have led to highly exploitable results (15 demonstrators and 2 platforms in technology readiness level of 5 or above) and clearly substantiates the fact that, by encouraging the creation of research results with a high potential to be rapidly transformed into products (estimated time to market in 2017-2023), Nano-Tera.ch was able to create favourable conditions for Knowledge and Technology Transfer, thus increasing its economic potential.

ECONOMIC POTENTIAL RESULTING FROM NOVEL FUNDING MECHANISMS

The Gateway program

Gateway, the Nano-Tera.ch program focusing on innovation stemming from “on the edge research” (see the Key Statement 12 for a detailed description), demonstrated a strong potential for Knowledge and Technology Transfer.

First, the Gateway program led to project consortia with a substantially stronger presence of industrial partners, which, as mentioned above, further increases the potential for Knowledge Transfer.

Second, the Gateway program strongly channeled the activities performed in the projects on increasing the industrial exploitability of research results, thus accelerating the production of demonstrators directly exploitable by the industry, and thus also contributed to Technology Transfer. Altogether, at the end of the first wave of Gateway projects, 5 demonstrators were produced: one with Technology Readiness Level 4 (TRL4), 2 with TRL5 and 2 with TRL6 (the definition of the various TRLs is given in Appendix B).

Notice that the above mentioned activity channelling has been achieved by excluding the research activities from the ones eligible for funding, which was a necessary measure, as illustrated by the following comparison between the Gateway projects and the Phase 1 RTD Add-On extensions:

- In the Phase 1 RTD Add-On extension (for which no specific constraints had been imposed in the call on the eligible activities), 78% of the allocated budgets went to research partners, 7% to the translational partners, and 1% to end users; while
- In the Phase 2 Gateway projects, 94% of the allocated budgets went to translational partners (CSEM and Empa) and only 6% to research partners.

The Industrial Valorization Fund (IVF)

In 2014, Nano-Tera.ch decided to set up a funding framework, specifically dedicated to technology transfer with the objectives to strengthen industrial valorization. This is the Industrial Valorization Fund, jointly managed with Nano-Tera.ch and the Tech Transfer Office of EPFL. The eligibility conditions imposed to proposals for this program have been defined as follows:

- The requested funds should be exclusively used to cover the specific actions required to acquire a suitable industrial partner (market study, conversion of a lab prototype into an industrial demonstrator, etc.); in particular, these funds could not be used to finance the patenting procedure itself
- The application is indicated as generated in the framework of a Nano-Tera.ch RTD project
- The application must be linked to an Invention Disclosure; an initial patent application ("priority application") is filed
- The decision for funding shall be taken by a committee composed through Nano-Tera.ch and EPF Tech Transfer Office representatives
- The funds requested should be allocated on an overall 1-to-1 matching basis, i.e. the global funding provided by the EPF TTO should be (at least) equivalent to the funding provided by the Nano-Tera.ch Industrial Valorization Fund
- The cumulated funds should not exceed 60 KCHF.

Within this framework, Nano-Tera.ch supported 4 industrial valorization actions with promising the Knowledge and Technology Transfer perspectives:

- Fastree3D (laser based 3D cameras, low cost and low power consumption): Fastree3D is very promising: in the top 25 Swiss Startup 2015, awarded Venturekick III, named among top 15 startups at SPIE Photonics West, Top 10 transportation startup at Verizon Powerful Answers 2014, etc.
- IVF_Mixel (production of high power optically pumped lasers at 1300/650 nm): RTI-Research S.A. at Y-park in Yverdon has invested more than one million CHF in modern wafer bonding equipment and related infrastructure to produce wafer-fused vertical cavity laser structures on 2-inch and 3-inch wafers.
- IVF_SoHHytec (onsite cost effective hydrogen and power generation systems): IVF_SoHHytec was able to attract its first customers for two products including industries like GNFC, MRF and government entities like HOPCOMs and Goa State pollution control board in India. A startup was found in April 2015.
- FixPosition (real-time dynamic GNSS algorithm). The Industrialization Valorization action started May 2017.

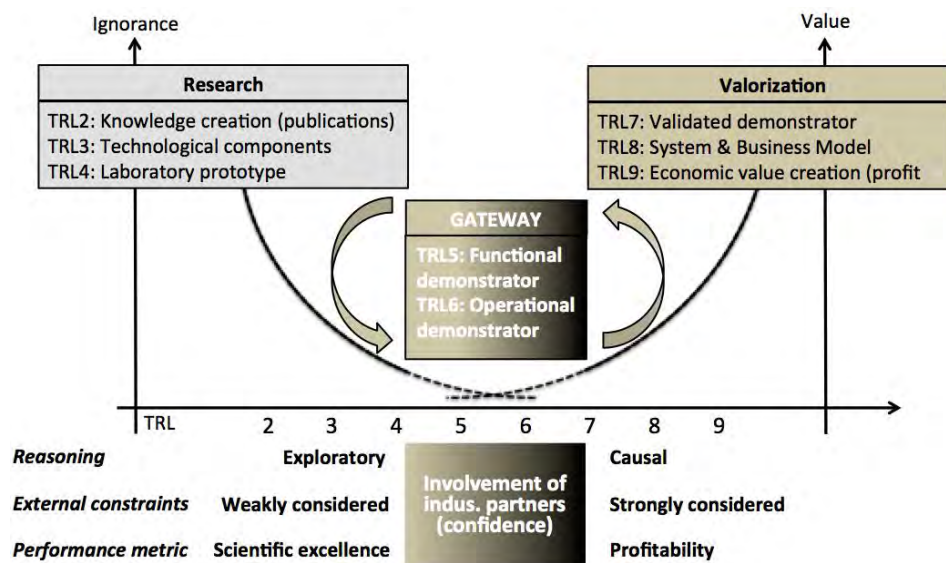
Key statement 12

Nano-Tera.ch has deployed a novel pilot funding instrument (the “Gateway” program) **efficiently combining support for research and innovation** and integrating an appropriate **monitoring mechanism**

THE GATEWAY PROGRAM

In 2015, at the mid-term of Phase 2, the Nano-Tera.ch ExCom decided to use a fraction of the Strategic funds to launch a new funding instrument, the Gateway program, intrinsically positioned at the frontier between research and innovation, to explore new approaches to transform results from forefront research into economic value, with the objective to further increase the Knowledge and Technology Transfer potential of the Nano-Tera.ch program.

The main ambition of the Gateway program was to support the translation of research results obtained within Nano-Tera.ch RTD or NTF projects (typically research prototypes at Technology Readiness Level, or TRL, 4 or 5; a more precise description of the TRLs is provided in Appendix B) into operational industrial demonstrators, tested in relevant environments (i.e. at TRL 6), and directly exploitable by the involved industrial partners. This ambition has been implemented by providing funding for a new type of projects, the “Gateway projects” (often referred to in this report as GTW projects), the positioning of which is illustrated in the following diagram, which summarizes the main aspects to be considered when transiting from research prototypes to operational industrial demonstrators.



One of the evident characteristics of this type of transfer is the change it requires in the definitions of the overall objectives of the funded activities. While a research project intrinsically aims at creating new knowledge (thus the “Ignorance reducing” trajectory in the above diagram), economic exploitation naturally focuses on generating economic value (thus the “Value increasing” trajectory in the diagram).

However, the targeted transfer further entails additional changes on several important dimensions. One concerns the quality metrics to be used to quantify progress, with novelty and research excellence indicators being progressively replaced by exploitability and profitability measures. Another dimension is the way of reasoning about expected results, with very exploratory approaches focused on feasibility proofs being progressively replaced by a more causal logic, driven by the targeted applications and the associated external constraints.

In short, a Gateway project is a transition between two very different worlds. It thus requires the involvement of a specific partner, explicitly responsible for the transfer, in addition to the researchers providing the research results/prototypes and the industrial partners potentially interested in their exploitation. These specific partners (also called translational partners in this report) are typically industry-oriented research institutions specialized in technology transfer, such as the Centre Suisse d'Electronique et de Microtechnique (CSEM), or the Swiss Federal Laboratories for Materials Science and Technology (Empa).

Finally, it is also important to notice that the deployment of Gateway projects also required the creation of a new monitoring mechanism, better adapted to the specificities of these projects. This monitoring mechanism is described in the Key Statement 19.

IMPLEMENTATION

To implement the Gateway program, Nano-Tera.ch proceeded in two steps.

First, Nano-Tera.ch joint forces with CSEM and Empa to analyze the running RTD projects and identify the most suitable ones for benefitting from a Gateway extension. Criteria such as the availability of a promising research prototype, the presence of interested industrial partners, or the perspective of a convincing market potential have been considered and discussed with the partners of the RTD projects. The resulting proposals have been evaluated by a jury consisting of representatives of Nano-Tera.ch, CSEM and Empa, and, as a result, 4 pilot Gateway projects have been selected and launched in November 2015, for a planned duration of 18 months.

The launched projects respectively focused on the following technology transfer objective:

- The Flusigate project aimed at transferring to the involved industrial partners specialized in smart textiles and biosensors of a prototype of novel wound pad integrating the non-invasive monitoring of the wound healing process based on indicator dyes and fluorescence lifetime imaging (FLIM), developed in the FlusiTex RTD project.
- The Syngate project, associated to the Synergy RTD project, targeted two main demonstrator transfers: (1) the transfer to the involved industrial partners (Meyer Burger and Solaronix) of prototype high performance encapsulated perovskite/Si heterojunction tandem cell, with an active area of 4x4cm², full metallization and external contacts; and (2) the transfer to the involved industrial partner (Flisom) of a demonstrator implementing a perovskite solar module on a 5x5cm² flexible and transparent substrate with external contacts.
- The Heargate project, associated with the HearRestore RTD project, aimed at providing a highly precise and accurate tracking system for minimally invasive microsurgery (in particular cochlear implants); the transfer to the involved industrial partners (Atracsys) led to the currently smallest surgical tracking device when compared to the state-of-the-art, with a highly improved accuracy of the 6D position and a reduced distance of the tracking device to the operating site.
- The Paragate project, associated with the ParaTex NTF project, : The “ParaTex” project aimed at developing textile sensors for long-term pressure monitoring (typically for patients lying in hospitals), and targeted the transfer of a lab-scale prototype based on textiles integrating polymer optical fibers (POFs) will be a very good alternative for long-term monitoring of such patients.

Based on the experience gained within this first pilot action, an official Gateway call has been launched in July 2016, with the following eligibility conditions:

- The main applicant for a Gateway extension must be a PI or Co-PI with a strong record in technology transfer, involved in a running RTD or NTF project.
- The Gateway extension must involve an industrial partner able to efficiently support the transfer of the research results achieved within the associated RTD project into activities with high economic potential.
- The Gateway extension is restricted to the funding of activities aimed at increasing the industrial exploitability of research results and therefore should not fund any additional research.
- The Gateway extension must be relatively short, with typical durations from 12 to (max) 18 months.

The 11 received submission have been evaluated by a selection committee specifically set up for the Gateway call, and consisting of 4 external members:

- Sophie Pellat, associate partner of the investment fund IT translation;
- Olivier Picard, Senior Manager in Altran Prisme, a consulting company specialized in support for the creation and development of startups;
- Thomas Ernst, senior researcher at CEA Tech, France;
- Jan Madsen, professor at the Technical University of Denmark.

The evaluation consisted of 3 phases:

1. Each panel member was assigned 6 proposals to review, with an evaluation form including 9 specific quality metrics;
2. The full selection committee met at EPFL for a one day « consolidation meeting » resulting in a recommendation to the Nano-Tera.ch Executive Committee in the form of a consolidated ranked list of the submitted proposals;
3. Based on the received recommendation, the Nano-Tera Executive Committee decided to accept and fund the top 4 submissions, respectively associated with the RTD projects IrSensII, ObeSense, and FlusiTex, and with the NTF project Nambp.

The 4 Gateway projects have then been launched in November 2016, with a planned duration of 12 months.

Key statement 13

Nano-Tera.ch has fostered **user-centric research** with an early involvement of field practitioners through field tests, clinical studies, etc.

NANO-TERA.CH POSITIONING

Two of the Nano-Tera.ch strategic objectives, namely:

- The decision to focus on technologies aiming at improving the quality and security of health and environment systems in Switzerland; and
- The decision to embody the research outcomes into prototypes, acting both as demonstrators and technology drivers; clearly had a strong impact on the ability of the program to foster user-centric approaches.

The combination of concrete technological goals (the demonstrators) with socially relevant application areas made it indeed possible for potential end users to envision and propose concrete applications for the targeted research, and thus strongly encouraged them to participate in Nano-Tera.ch projects.

EXPLOITING THE ELIGIBILITY CONDITIONS

While the participation of end-users was strongly recommended in Nano-Tera.ch Phase 1 RTD calls, it has been made for all Nano-Tera.ch Phase 2 RTD projects. This decision led to the set-up of RTD project consortia including on the average 12% end-users, which further strengthened the targeted user-centric approach.

BENEFITING FROM THE CONVERGENCE OF ENGINEERING AND MEDICINE/LIFE SCIENCES

In the second phase of the program, many of the funded research projects were exploring topics combining engineering with life sciences or medicine (e.g., projects on smart prosthetics and body repair, or projects focusing on various health monitoring systems, or innovative medical platforms).

In consequence, the project consortia truly needed expertise of partners from the health domain to be able to achieve their research objectives. This translated into the participation in the RTD projects of a large number of hospitals (CHUV, HUG, UZH, Inselspital, Kinderspital, etc.), who played an important role in the specification of precise applicative goals for the research, and for the validation of the achieved results (e.g. by conducting clinical tests or through the deployment of concrete prototypes in clinical environments).

EXAMPLES

IST (Institut de Santé au Travail) is the only institute in Switzerland devoted entirely to Occupational Health: the OpenSense II project has benefitted from IST's Particles and Health Group, whose team provided considerable experience in the assessment of personal and population exposure to ambient and industrial fine and ultrafine particles, noise, gaseous co-pollutants.



The InselSpital in Bern is involved in the Phase II RTD projects HearRestore, MagnetoTheranostics and SmartSphincter. In particular, the Department of Ear, Nose and Throat Surgery, actively involved in HearRestore, is one of the early adopters of computer assisted and image-guided procedures around the head. Early work in the field

dates back to 1995, when some of the first of such interventions were carried out. Today, the department's research focuses on the advancement of technologies towards a combination with the latest developments in hearing aid technology and physiological measurements.

The University Hospital of Zurich (USZ) is involved in the Phase II RTD projects NewbornCare, ObeSense and WearMeSoC. In particular, at the Division of Neonatology, the head of the Biomedical Optics Research Laboratory and the head of Clinical Research provide their combined expertise in neonatal intensive care medicine, lung physiology, intelligent data analysis, quantitative measurements of tissue composition, oxygenation and perfusion to the NewbornCare project.



Key statement 14

Nano-Tera.ch has contributed to the **dissemination of the scientific results achieved** to the Swiss industry

INFO DAYS

Nano-Tera.ch organized information days for industrial players in March 2014. In the perspective of technology transfer toward the industry, the objective of the information sessions was to present the industrial potential of some of the projects financed in the period 2008-2012. The presentations have been followed by an interaction with the participants in order to discuss the various possibilities for industrial involvement in the program. Nano-Tera.ch decided to focus on "Sensors of tomorrow" because Switzerland (both in German-speaking and French-speaking parts) has a strong industry of sensors and measuring instruments, made up of many SMEs.

The first Info Day session was held on March 12th in Yverdon with presentations in French from 6 Co-PIs. There were **86 participants** from various companies, ranging from Logitech to Piaget.



The second Info Day was held on March 25th in Zurich with presentations in German from the same 6 projects and mostly different Co-PIs. There were **48 participants** from various companies, including ABB, Alstom or Phonak.



Figure 37. General introductory video on Nano-Tera.ch (left); Dr. Harry Heinzelmann presenting the PATLiSci project (right).



Figure 38. Prof. Karl Aberer presenting OpenSense (left), Prof. Gerhard Tröster presenting TecInTex (right).

Based on the observation that several Nano-Tera.ch projects address medical problems, Nano-Tera.ch decided to provide research teams with information on regulatory constraints (at what time in the project and how to address them), also to facilitate the transfer of technology. This “Medical Technology Regulations” Info Day took place on February 5th 2015; it presented an overview of the medical regulations, notifying bodies and competent authorities (Swissmedic, etc.) to the researchers. It also helped in classifying the research activity according to applicable regulations (well-being, diagnostics, treatment, implants, etc.), and explaining at what time in the project the regulations apply, and how to address them. The 89 participants represented all the partner institutions of Nano-Ter.ch (ETHZ, EPFL, CSEM, Empa, Universities, HES-SO, etc).

Thus, as explained above, Nano-Tera.ch has combined "Techno push" (such as PhD training and their transition in the industry or the production of enabling technologies or the “Sensors of tomorrow” Info Days) and "Market pull" (such as the production of demonstrators or the “Medical technology regulations” Info Day) approaches in order to increase the Knowledge and Technology Transfer.

IV.5 KEY STATEMENTS RELATED TO SOCIETAL IMPACT

Key statement 15

Nano-Tera.ch has contributed to steering the research funded toward **current social needs** (health, environment, energy, etc.)

APPROACH

Four nationwide sources of data and information have been identified, which address current social needs, trends or concerns over the period 2008-2016:

- The media are the vehicle of the populations' centres of interest and worries. Swissdox is a Swiss media database listing any article published in 243 different magazines, newspaper, web portals, news agencies, etc.
- The Credit Suisse Worry Barometer/gfs Institute is a nationwide survey which has been gathering information about the mood and the worries of the Swiss population since 1976.
- Curia Vista is the mirror image of Swissdox but from the parliamentary proceedings point of view, where any Federal Council dispatches, procedural requests, elections, petitions, etc. are listed. The members of the parliament pay close attention to what the voters are concerned about or foresee the major changes the society will face in the future
- Public spending: as an echo of parliamentary proceedings, did the concerned federal offices invest funds in the fields of health, energy and environment?

CURRENT SOCIAL NEEDS INFERRED FROM THE MEDIA

We selected the most popular Swiss daily and week-end newspapers (18 in total), covering the French and German-speaking part (see "Sources" below for more details). The service provided by Swissdox allows users to search by channel (newspaper, website), by year and by keywords. The 3 criteria were combined. Key words – related to the various projects – were chosen in English, French and German, with the caveat that some keywords are not easily translated into French or German (such as "wearables" or "e-health"). The table below shows the number of articles published in a given year including certain keywords that are representative of Nano-Tera research interests.

	Keyword	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
HEALTH	cancer treatment	596	583	693	593	734	859	709	820	1'052	6'639
	intelligent sensors	194	217	247	287	344	521	875	869	1'102	4'656
	advanced diagnosis	412	446	216	209	271	274	264	332	349	2'773
	life sciences applications	220	221	201	210	233	197	250	298	346	2'176
	sensors health	177	164	115	108	205	236	363	364	418	2'150
	personalized medicine	73	91	136	183	193	220	198	276	273	1'643
	wearables	0	1	0	3	5	19	269	340	349	986
	connected health	69	56	64	81	99	117	139	104	174	903
	e-health	51	78	94	73	71	44	60	135	118	724
	Total Health	1'792	1'857	1'766	1'747	2'155	2'487	3'127	3'538	4'181	22'650
ENERGY	renewable energy policy	5'203	5'534	5'174	9'600	6'544	6'332	5'433	5'720	6'374	55'914
	nuclear energy	2'258	1'907	1'805	7'865	3'535	2'199	2'007	2'278	3'567	27'421
	solar hydrogen energy	2'342	2'561	2'641	3'279	2'993	2'730	2'347	3'052	3'160	25'105
	fossil fuels	2'302	2'154	1'832	2'488	2'031	2'013	1'931	2'768	2'762	20'281
	photovoltaic solar energy	426	556	1'500	782	746	545	466	527	605	6'153
	smart grid	12	88	189	278	245	233	140	142	140	1'467
	Total Energy	12'543	12'800	13'141	24'292	16'094	14'052	12'324	14'487	16'608	136'341
ENVIRONMENT	environment energy	5'945	5'531	2'515	2'690	2'436	1'972	1'731	1'899	1'684	26'403
	environment protection	2'700	2'494	1'842	1'750	1'748	1'593	1'616	1'606	1'580	16'929
	global warming	852	1'156	777	640	616	603	524	1'019	1'821	8'008
	water pollution	353	277	350	338	362	295	369	422	404	3'170
	water quality control	319	290	306	217	262	266	255	291	239	2'445
	quality water air	235	219	221	233	225	210	224	242	247	2'056
	Total Environment	10'404	9'967	6'011	5'868	5'649	4'939	4'719	5'479	5'975	59'011
	Total Nano-Tera issues	24'739	24'624	20'918	31'907	23'898	21'478	20'170	23'504	26'764	218'002
	Total articles published	560'253	597'634	603'512	598'550	596'908	589'613	566'978	530'685	504'528	5'148'661

Table 12. Number of articles published in a given year including certain keywords that are representative of Nano-Tera research interests.

The proportion of all articles published per year in each category is shown below, along with the corresponding graphs showing the prevalence of each keyword for the three Nano-Tera domains.

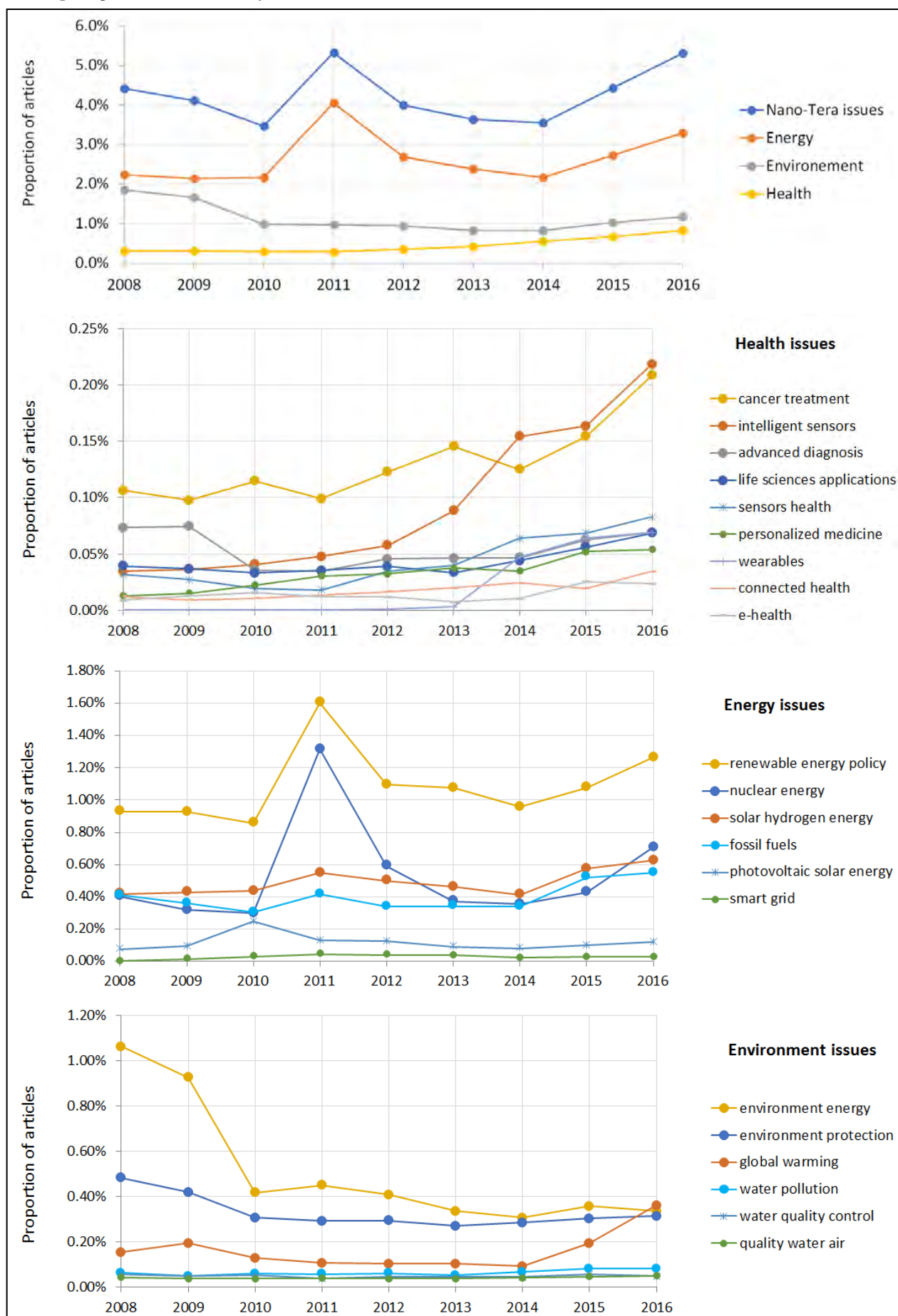


Figure 39. Proportion of all articles published per year in each Nano-Tera domain (top), and graphs related to specific issues in Health, Energy and Environment issues (respectively, below).

The first chart shows that, despite the overall number of articles in the period decreasing by almost 20% from 2010 to 2016, the number of articles related to Nano-Tera issues has remained steady and even slightly increased. The interest is general very high, with about 5% of all articles devoted to these few specific Nano-Tera-related keywords.

The increase is particularly strong when it comes to **health**-related articles, whose proportion has almost tripled during that period. More precisely, the concept of wearables was virtually unheard of until 2011, picking up considerably in the past few years, and the concept of intelligent sensors appearing more than 5 times more frequently in 2016 than in 2008. Most themes related to **energy** have also attracted considerable interest during the period, with a peak in 2011 which is probably related to the Fukushima disaster. Regarding the **environmental** issues, the high points of 2008 and 2009 are likely related to the fact that new energy programs were implemented, leading to debate in the media and more articles on those issues. However, from 2010 on, the interest in environment/energy remained important throughout the period. The interest in the media is stronger for the protection of the environment and the impact of energy consumption than for the quality of air and the water.

SOURCES

We have selected the most popular Swiss daily and week-end newspapers (18 in total), covering the French and German-speaking part. [Data : REMP (Recherches et études des médias publicitaires)]. No Italian newspaper were considered in this survey as there's no Swiss-Italian newspaper collaborating with Swissdix database. The selected publications are:

20 Minutes – Blick am Abend – SonntagsBlick – 20 Minutes – Schweiz am Sonntag – SonntagsZeitung – Blick – Tages Anzeiger – Berner Zeitung BZ – Le Matin Dimanche – NZZ am Sonntag – Neue Luzerner Zeitung – Sankt Galler Tagblatt – Neue Zürcher Zeitung – Le Temps – 24 Heures – Le Nouvelliste – La Liberté

Note that the Neue Zürcher Zeitung was added even though it didn't belong to the most popular newspapers; it is however one of the leading newspapers in Switzerland. The 4 last ones were also added as they are newspaper of reference in the French-speaking part of Switzerland.

CURRENT CONCERNS OF THE SWISS POPULATION

Every year, the Swiss research institute GFS Bern, mandated by Credit Suisse, interviews a representative panel of the population about their concerns and the main characteristics of the country's identity. Since 1976, if the structure of the survey hasn't changed, new items have been regularly added to the list of questions such as terrorism, migration issue or EU integration.

The study includes a total of 49 questions. We have selected the questions related Nano-Tera and also took into account the most cited items (unemployment, immigrants, etc.) as a benchmark. The graph below plots the ranking of these top concerns, showing for example unemployment as being the top worry of the population between 2008 and 2014.

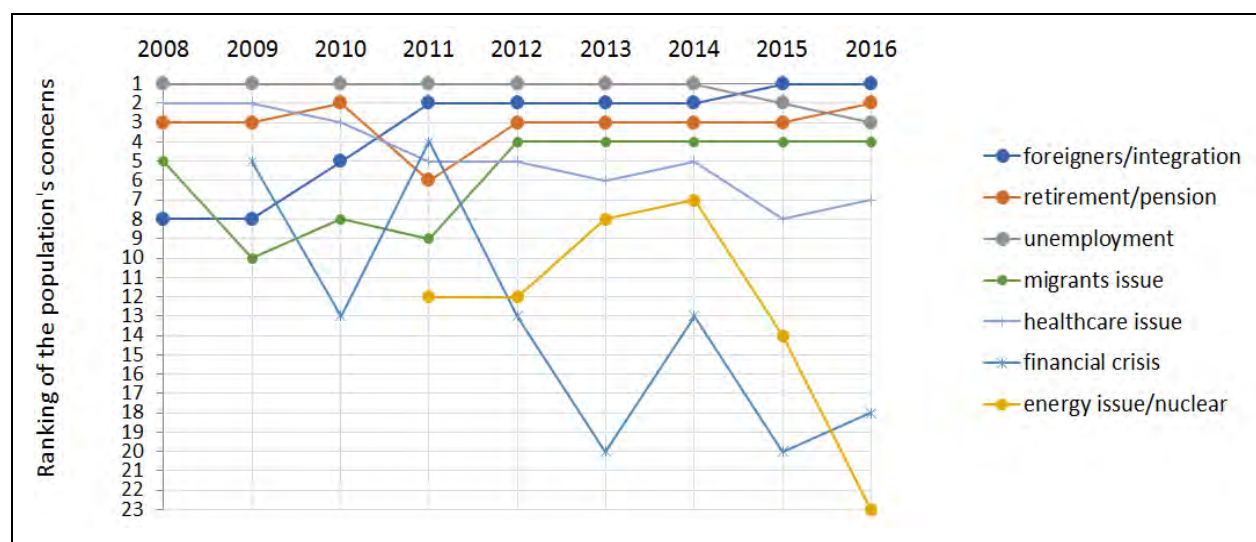


Figure 40. Ranking of the Swiss population's top concerns according to the GFS Bern survey.

In 2011 (Fukushima), as the energy/nuclear problem was raised, it only appeared at the 12th position. The Swiss were constantly more worried about their pension, the unemployment, the integration of increasing flow of foreigners and the problem with the refugees. Two new items were added to the survey: nuclear energy and the financial crisis but they did not become a major and constant worry.

Among all the 49 questions, the energy, the healthcare and the environment are a concern for the Swiss people, as the subjects are part of the annual survey. They rank in the first third among all the topics.

PUBLIC POLICIES (CURIA VISTA AND PUBLIC SPENDING)

PARLIAMENTARY PROCEEDINGS - CURIA VISTA

The observation of the parliamentary proceedings offers a complementary viewpoint on the society's priorities: the legal perspective. The service provided by the secretary of the Swiss parliament allows to search parliamentary proceedings by supervisory department, by year, by theme (energy, health, defence, etc.), and by keywords (sensors, cancer treatment). The four criteria were combined. The number of parliamentary proceedings by topic and by year is given below.

Categories	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Health	157	241	192	166	251	185	232	188	164	1'776
Energy	119	93	110	250	123	123	111	120	105	1'154
Environment	87	103	100	75	114	95	138	153	95	960
Total Nano-Tera issues	363	437	402	491	488	403	481	461	364	3'890
Total annual proceedings	1'952	2'477	2'266	2'127	2'264	2'327	2'339	2'284	2'115	20'151

Table 13. Number of parliamentary proceedings by topic and year.

The following graph shows the corresponding proportion of proceedings per topic and year.

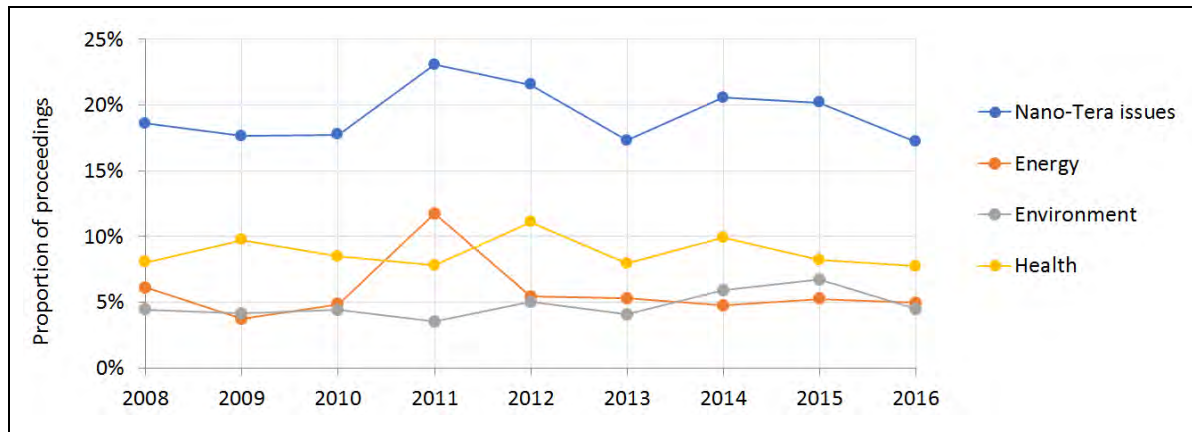


Figure 41. Proportion of parliamentary proceedings by topic and year.

The data collected show a constant interest of the Parliament in health, environment and energy matters. From 2008 to 2016, the total numbers of proceedings related to health, energy and environmental issues represented almost 20% of all the proceedings handled by the parliament. In other words, 1/5 of the attention was spent on these 3 issues; it witnesses the importance attached by the legislature, with health-related proceedings being the most prominent of the three issues.

PUBLIC SPENDING

A look at the federal spending provides crucial information about the actions taken by the authorities to tackle the various problems. The Swiss government's data center enables to select expenditure according to the function (e.g. social welfare, national defence, transportation, health program, etc.)

For the public spending, we have identified the three offices in charge of the energy, health and environmental policies; we then looked for the spending – related to specific tasks and/or programs – which were carried out.

- The Federal Office of Public Health (FOPH) is responsible for public health in Switzerland; it develops Switzerland's health policy and works to ensure that the country has an efficient and affordable healthcare system in the long term
- The Swiss Federal Office of Energy (SFOE) is the country's competence center for issues relating creating a crisis-proof, broad-based, economic and sustainable energy supply, ensuring the maintenance of high safety standards in the production, transport and utilisation of energy, as well as promoting efficient energy use, an increase in the share of renewable energy and a reduction in CO2 emissions.
- The Federal Office for the Environment's (FOEN) responsibility is to ensure the sustainable use of natural resources including soil, water, air, quietness and forests, protection against natural hazards, protection of the environment and human health against excessive impacts, and conserving biodiversity and landscape quality.

The following table and graph show the amount of spending per year for various programs and measures in these three offices, in million CHF. [Note that in 2015, a new management model of the federal administration was implemented. Even though, the financial accounts are available, it isn't possible to compare the figures, therefore timeframe is here limited to the period 2008-2014]

	Tasks	2008	2009	2010	2011	2012	2013	2014	Total	var. 2008-14
Federal Office of Public Health	Health implementing measures	10.7	17.5	17.6	19.6	19.7	20.6	21.0	126.8	+97%
	SwissEnergy Program	19.0	19.8	18.9	17.1	21.6	22.5	30.6	149.6	+61%
Swiss Federal Office of Energy	Management of radioactive waste	1.5	3.3	4.0	6.2	6.4	6.3	5.0	32.8	+247%
	Buildings Program	14.0	98.6	62.0	67.0	43.2	46.0	39.5	370.3	+182%
Federal Office for the Environment	Environment implementing measures	13.8	14.9	14.9	14.1	16.6	15.9	16.1	106.4	+16%
	Observing the environment	16.1	20.4	19.9	18.2	18.5	18.1	18.2	129.3	+13%
	Remediation of contaminated sites	29.4	23.3	14.3	9.9	19.1	62.1	41.4	199.6	+41%
	Environmental Technologies	2.1	3.5	4.3	3.5	2.9	4.1	4.3	24.6	+103%
Total		106.7	201.2	155.9	155.6	148.1	195.6	176.2	1'139.4	+65%

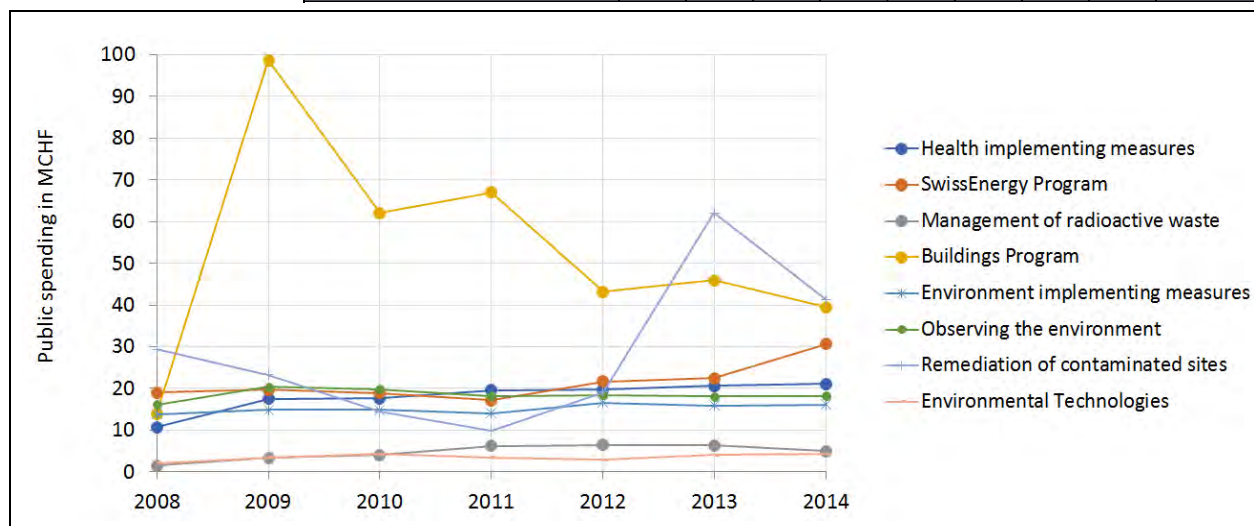


Figure 42. Spending per year for certain programs and measures in three federal offices (see text for details).

In the Federal office of public health, the spending has almost doubled between 2008 and 2014 for health implementing measures. Overall, several issues in these three offices benefit from substantial funding, all of which have increased (by 65% overall) in this period.

Key statement 16
Nano-Tera.ch has contributed to disseminating the results achieved within and beyond the Nano-Tera.ch community

OVERVIEW

Dissemination of information is an important factor leading to societal impact by reaching various audiences. The communication actions were aimed at: developing the program's notoriety in the media, keeping its governing bodies informed about the program's progress, federating the PI and the PhD students, by exchanging information around the results, as well as presenting the program results to the global scientific community. Nano-Tera has undertaken several dissemination measures, though printed documents, events, and various media channels (website, newsletters, wiki and social media) in order to achieve these goals.

PRINTED DOCUMENTS

The Management Office published an annual scientific report and public activity report to inform its different stakeholders on the advancement of the program and the achieved results. In addition to the activity report, project reference sheets have been created, providing a self-contained summary of each project's research challenges and results highlights.



EVENTS

Nano-Tera.ch has organized its annual meeting – with ca. 250 participants – every year starting in 2010, always with overwhelmingly positive feedback from the community (more details below). In addition to Nano-Tera scientists presenting their results in numerous conferences worldwide, members of the Nano-Tera Management Office have participated to several international events as speakers or exhibitor in order to present the program and its main achievements. While the annual meetings were held in Switzerland, the other events took place in Italy, China, USA, Germany, Korea, Greece, France, Japan, etc. In total, Nano-Tera organized 48 events and participated to 62.

MEDIA CHANNELS

173 interviews were given to leading newspapers or national Swiss TV such as Neue Zürcher Zeitung, CNN, Euronews, Radio Télévision Suisse Romande, Berner Zeitung, etc. On average, it corresponds to 1-2 interviews/month from 2008 to 2016. Given the complexity of subjects – complex engineering systems, this shows the interest of the society for the problems Nano-Tera has been addressing.

The Nano Tera website (www.nano-tera.ch) is the main dissemination tool used throughout the lifetime of the program. From 2008 to 2016, it has been visited by about 160'000 unique users who visited almost 800'000 pages. The sessions originate from virtually every country in the world, with the top 3 being Switzerland (52% of all sessions), the United States (7%) and Germany (5%). On average, 1'500 unique users have been visiting the website every month from 2008 to 2016, each of them visiting about 7-8 pages among the website's 386 pages. The yearly breakdown shows the following evolution:

Item	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total	Average
visitors	9'854	12'777	15'069	13'867	16'028	19'063	20'145	17'658	13'791	1'132'182	15'361
sessions	15'594	19'875	24'159	23'619	26'940	30'402	29'970	26'920	21'051	993'930	24'281
pages viewed	59'786	82'426	90'580	87'246	90'060	102'132	101'604	94'593	66'973	775'400	86'156

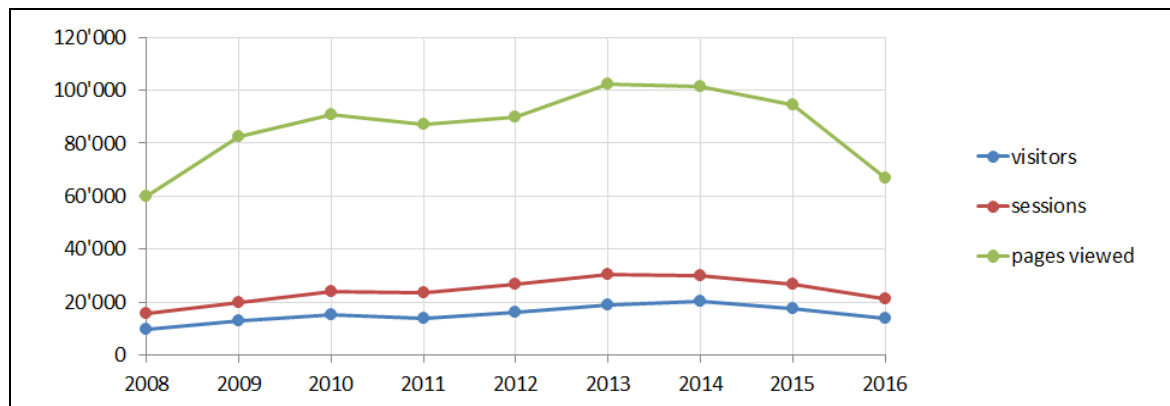


Figure 44. Nano-Tera.ch website statistics.

In terms of dissemination, the website has been a key element giving the opportunity to people inside and outside the Nano-Tera community to have access to the projects and their results. To this end, Nano-Tera.ch encouraged and helped researchers produce videos about their results (so about 250 videos can be found on the website). Furthermore, the Nano-Tera website also represented an efficient way to make information available for the industry, which have ranked the need for information as a key element of technology transfer (see KOF Survey 2011, Information being the category used to Knowledge and Technology Transfer with 62.9%).

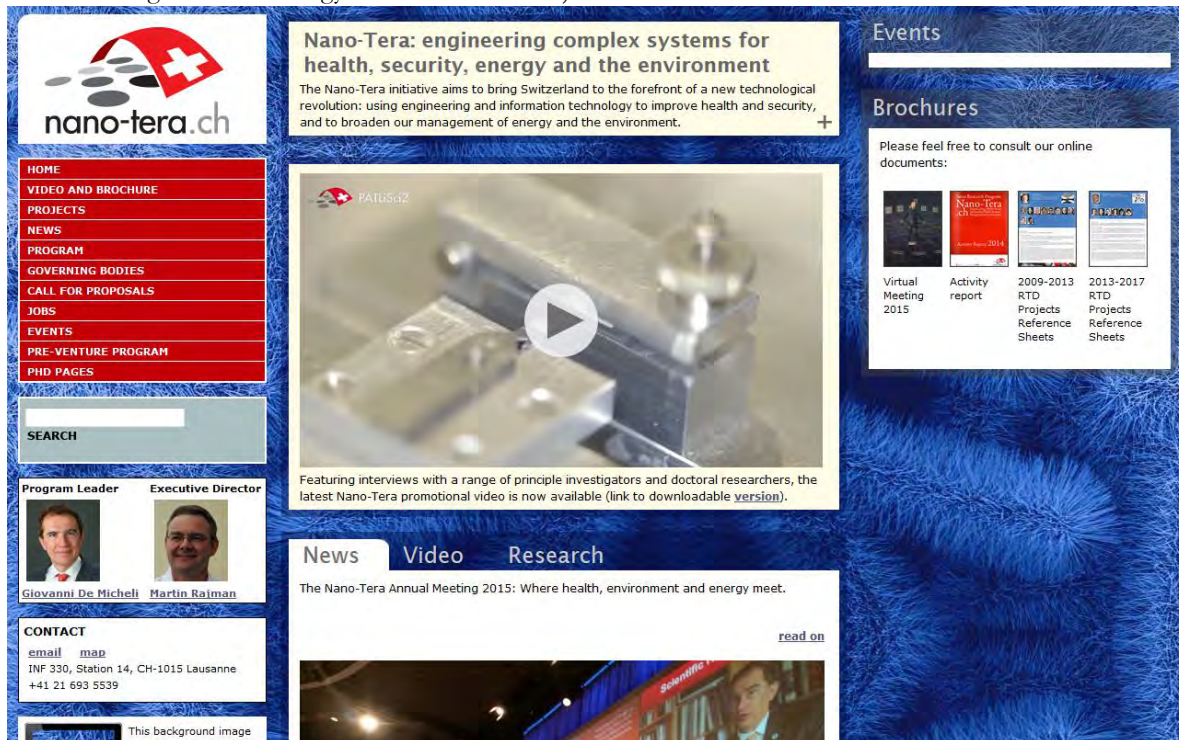


Figure 45. Main page of the Nano-Tera.ch website.

Finally, Nano-Tera circulated an electronic newsletter to its community, announcing various events and presenting the latest scientific breakthroughs and success stories.

The following table summarizes the various actions:

Item	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Printed documents										
Activity report			X	X	X	X	X	X	X	
Scientific report		X	X	X	X	X	X	X	X	
Project reference sheets			X	X	X	X	X	X	X	
Other brochures		X		X						
Events										
Annual meeting			X	X	X	X	X	X	X	X
Virtual meeting	X	X	X	X	X	X	X	X	X	X
International Exchange Program						X	X			
Participation to external events			1	15	6	11	10	8	6	5
Organization of internal events			3	13	4	7	11	4	5	1
Media channels										
Videos			X	X	X	X	X	X	X	X
Newsletter	X	X	X	X	X					
Website	X	X	X	X	X	X	X	X	X	X

THE NANO-TERA ANNUAL MEETING

Nano-Tera.ch has organized 7 annual plenary meetings, from 2010 to 2016. Typically organized over 1 or 2 days, the Nano-Tera annual meeting took place 4 times in Bern, twice in Lausanne and once in Zurich. The event attracted about 200 participants in its first year, later on growing to about 250-300 participants and even reaching 350 participants in its final 2016 edition.



Figure 46. Keynote speech by Prof. Jan Rabaey (UC Berkeley) at the 2015 Nano-Tera.ch annual meeting.

The Nano-Tera annual meetings have adopted different formats over the years, but have usually included presentations of the progress made in the various projects by the PIs. There has typically been one of two keynote presentations delivered by prominent scientists. One of the most important aspects of the meeting is the possibility for PhD students and younger researchers to present their research in the form of posters (or, on one occasion, to deliver the oral project presentation), with about 140-150 posters being presented each year in the exhibition hall.

Year	Day(s)	Date	Location	Participants	Posters
2010	1	29.04.2010	Bern	~200	64
2011	2	12-13.05.2011	Bern	~250	109
2012	2	26-27.04.2012	Zurich	~250	130
2013	2	30-31.05.2013	Bern	~310	140
2014	1	20.05.2014	Lausanne	~330	141
2015	2	04-05.05.2015	Bern	~320	147
2016	2	25-26.04.2016	Lausanne	~350	152

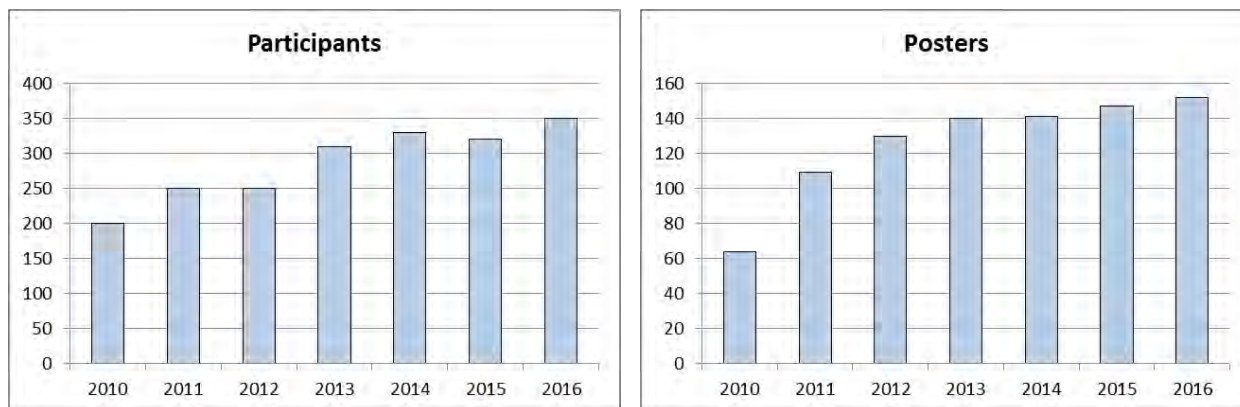


Figure 47. Statistics of the number of participants (left) and posters (right) at the Nano-Tera.ch annual meetings.

The projects have also had the opportunity to present concrete early demonstrators and prototypes of their research. This aspect logically took more and more importance with the advancement of the program, with a wide range of projects presenting devices and elaborate demonstrations of their systems.

The Nano-Tera annual meetings have received very positive feedback from the participants. In systematic surveys, particularly in the last 3 years where comparable questions have been used, the results have been overwhelmingly positive, the audience showing great interest in the presentations, recognizing the importance of the meeting as a support for networking within the Nano-Tera community, and lauding the quality of the organization in general.

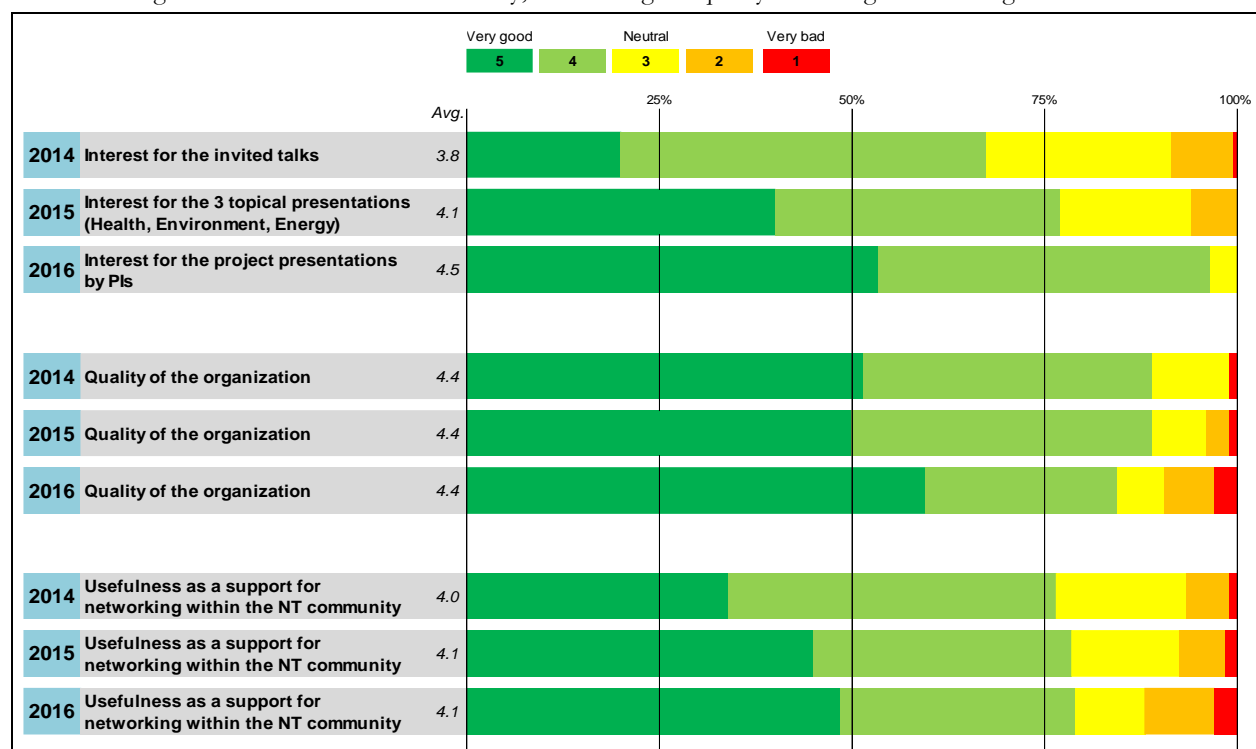
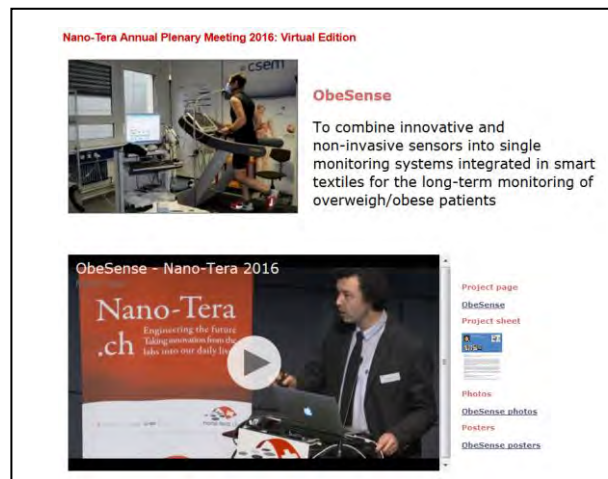


Figure 48. Left: Presentation of demonstrators in the 2015 annual meeting exhibition area. Right: Address by former Italian Minister of Education Francesco Profumo at the 2013 annual meeting.

Virtual annual meeting

Every year, the content of the Nano-Tera.ch meetings has been made available online on a virtual annual meeting platform.

All the posters, as well as the available videos of presentations can be browsed directly from the page, and provide a way for anyone to consult the content of the meeting.



SYMPOSIA WITHIN THE NANO-TERA.CH INTERNATIONAL EXCHANGE PROGRAM

Organized in the framework of the Nano-Tera.ch International Exchange Program and chaired by Prof. Giovanni De Micheli, the **Symposium on Emerging Trends in Electronics** has brought to Montreux in December 2014 almost 100 renowned scientists and business leaders and addressed the means to grow the European economy by creating new jobs and products enabled by advances in electronics.

Representatives from the European Industry presented the latest semiconductor processes for high-performance, low-power applications and the Internet of Things. Academic and industry leaders discussed the advantages and limitations of the American and European models for design and product creation.

The symposium featured presentations in technology applications, ranging from A. Chandrakasan (MIT) who addressed miniaturized circuit design, to T. Sakurai (U. Tokyo) who described flexible electronic circuits to achieve electronic skin, and K. Shepard (Columbia University) who demonstrated electrical circuits applicable to sensors and DNA sequencers. S. Furber (U. Manchester) explained progress in neuromorphic energy sustainable high-performance computing with the Spinnaker chip, while G. Fettweis (U. Dresden) showed how 5G communication technology will improve our living standards, from automatic driving to the connected smart city. Giorgio Cesana (STMicroelectronics) presented a brief history of FD-SOI.

The symposium featured several round tables, including one panel of University Presidents, Rectors, Vice-Presidents and Vice-Rectors addressing how electronic means influence education (e.g., through MOOCs) and how education should address more emerging technologies. Emphasis was placed on students and the universities' task to forge thinking skills, while educating the best scientists, engineers and managers for a rapidly evolving world. This event included excellent presentations and discussions that are available on the Nano-Tera.ch web portal in the form of a virtual meeting.



Similarly, in the **Symposium on Emerging Trends in Computing** in October 2016, more than 80 prominent researchers and business leaders gathered in Montreux and addressed new computing paradigms and systems design, ranging from Yankin Tanurhan (Vice President Engineering, Synopsys) who addressed IoT optimized IT, to Prof. Jason Cong (UCLA) who discussed options and opportunities of customizable computing, and Dave Liu (President Emeritus Tsing Hua university) who presented an overview of the IT revolution since the 1950s. Prof. Luca Benini (ETHZ) addressed parallel computing in CMOS and Prof. Subhasish Mitra (Stanford) discussed carbon nanotube computing.

The symposium featured several round tables, including one panel of University Presidents, Rectors and VPs/VRs which addressed key questions such as the impact of data-driven science on research, education and human interaction.



In addition, an **EPFL Workshop on Logic Synthesis and Verification**, as well as an **EPFL Workshop on Logic Synthesis and Emerging Technologies** were organized in Lausanne in 2015 and 2017, respectively.

Year	Title	Date	Location	Speakers	Panelists
2014	Symposium on Emerging Trends in Electronics	01-02.12.2014	Montreux	9	31
2015	EPFL Workshop on Logic Synthesis & Verification	10-11.12.2015	Lausanne	22	-
2016	Symposium on Emerging Trends in Computing	10-11.10.2016	Montreux	9	29
2017	EPFL Workshop on Logic Synthesis & Emerging Technologies	28-29.09.2017	Lausanne	21	-

PRESENTATION OF THE PROGRAM AT CONFERENCES AND EXHIBITIONS

Nano-Tera.ch was present at numerous conferences, selected for being major events in the fields covered by the program. The program was visible either in the form of oral presentations delivered by members of the Management Office, or with booths in the exhibition areas of these events.

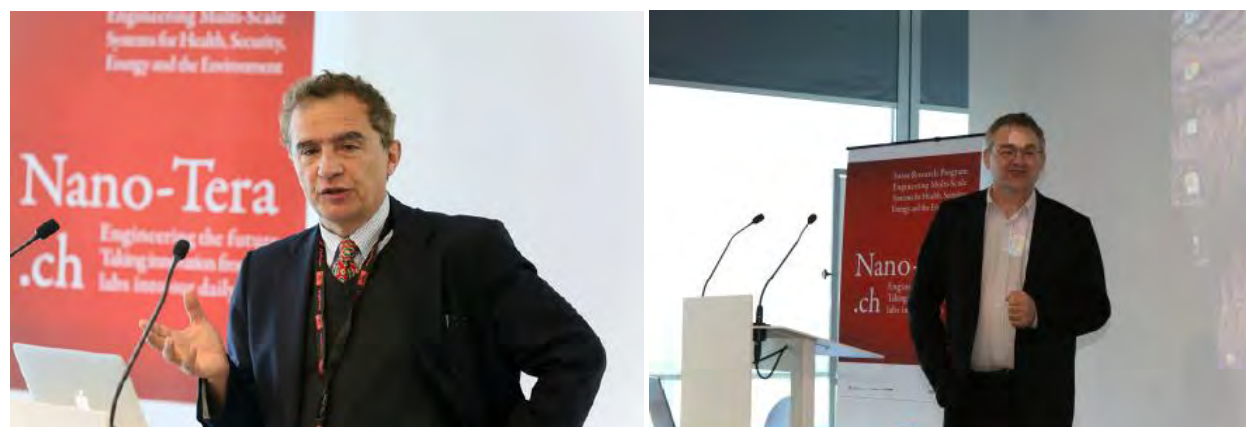


Figure 49. Examples of presentations delivered by Prof. Giovanni De Micheli (left) and Dr. Martin Rajman (right).



Figure 50. Examples of Nano-Tera.ch booths at conferences, presented by Dr. Patrick Mayor.

SWITZERLAND-KOREA JOINT WORKSHOPS

The 4th Korean Swiss Science Days were held at EPFL in May 2013: the Science Days have been held yearly alternating in Korea and Switzerland since 2010 and are an integral part of the bilateral Korean-Swiss Science and Technology Program. That year's edition was jointly organized by EPFL's International Relations, Nano-Tera.ch (responsible for the scientific content) and ETH Zurich as the Swiss Leading House. The Science Days were financed with a conference grant from Nano-Tera.ch and from the bilateral program through ETH Zurich and the Korean National Research Foundation (NRF). 75 participants from Korea and Switzerland registered and 17 posters were displayed.



The Science Days opened directly with a highlight, the welcome dinner at the Korean Ambassador's Mr. YoungHan Bae Residence in Bern on May 6. The two following days saw a series of lectures within four key topics: 1) bio-sensing and health management, 2) energy-aware electronics, 3) architectures and networks for the Internet of things, and 4) emerging devices. Talks included outstanding speakers from EPFL, ETH Zurich and CSEM on the Swiss side and from KAIST, Seoul National University (SNU) and Yonsei University on the Korean side. Speakers from LG Electronics Ltd and Samsung Advanced Institute of Technology (SAIT) complemented the program from the private industry perspective.

The purpose of the Science Days to increase scientific collaboration between the two countries was clearly met, in particular because of the match of interests between the Nano-Tera.ch and the Korean scientists. The lively discussions after the talks demonstrated the large interest in each other's research. Several Korean participants also visited EPFL laboratories after the symposium to discuss cooperation opportunities.

The Science Days were a high level event that also attracted many Swiss researchers from various institutions including the Universities of Applied Sciences to participate. They also provided a platform for students to present their research to the Korean partners. Unfortunately, the participation of Korean students was only marginal despite the offered travel grants, it is hoped that it will be easier to include them in a next edition of the Science Days in Korea.



Following this successful event, Nano-Tera participated in a joint workshop hosted by the Center for Integrated Smart Sensors (CISS) at the Korea Advanced Institute of Science and Technology (KAIST), which took place on October 17-18, 2013. The invited Nano-Tera delegation consisted of Prof. Giovanni De Micheli, Dr. Martin Rajman, Prof. Karl Aberer, Prof. David Atienza, Prof. Yusuf Leblebici and Prof. Peter Ryser of EPFL, as well as Prof. Luca Benini and Prof. Qiuting Huang of ETHZ. The Swiss researchers and their Korean counterparts (including Prof. Byeong Guk Park of SNU, Prof. Hoi-Jun Yoo of KAIST) delivered presentations on topics such as smart healthcare, biosensing or sensing architectures.

The workshop was a good opportunity to strengthen partnership between Nano-Tera.ch and CISS and hold comprehensive discussions on the future of next generation smart sensors, including advanced implantable biosensors, mobile sensor networks and low-power sensors for applications such as ECG monitoring.

Key statement 17

Nano-Tera.ch has implemented efficient **pilot actions** to promote the activities of the programs in high school and towards younger children

SCIENTASTIC – SCIENCES FESTIVAL

In 2015, the EPFL organized its first festival of science. With the creation of the Department for the Promotion of Science in 2015, EPFL expressed its willingness to consolidate mediation efforts with the young and the general public for all the MINT branches (mathematics, computer science, natural sciences and technical).

The goal was to promote dialogue between science and society, make scientific knowledge accessible to a wide audience by presenting them in a comprehensible manner, encourage succession and generate enthusiasm for scientific and technological research. Nano-Tera.ch provided Scientastic with a film on hydrogen storage, describing the research carried out in the project SHINE, which was used and shown in an interactive workshop "How does it work?". It provided a module for visitors to understand how hydrogen storage works, for example for hydrogen cars. The festival was a success: more than 6'000 people participated and a large number of visitors showed a marked interest and would have enjoyed an extension of the event over two days, according to testimonies collected on the day of the festival.



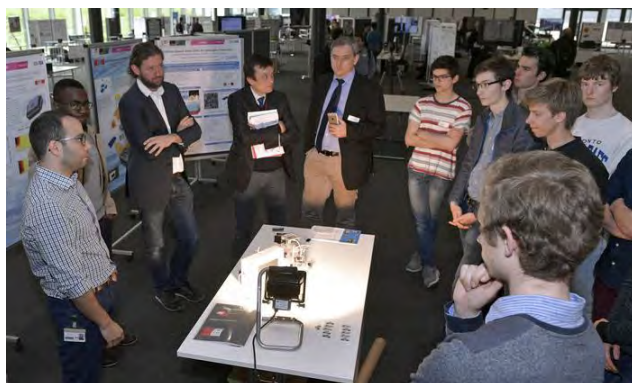
HIGH-SCHOOL STUDENTS MEET PHD STUDENTS

Two classes of students from the high school of St-Maurice were invited to the EPFL campus to meet PhD students on March 23 and April 26, 2016. In total, 40 high school students studying biology, chemistry and physics were present. Prior to the visit, a delegation of the Nano-Tera Management Office and 4 PhD students went to St-Maurice to present the research program, its clusters and provide the students with the necessary background information.

The main visit took place during Nano-Tera's final event. Four groups of 10 students visited the demonstrators of 4 projects: SmartGrid, SHINE, NewbornCare and Envirobot. Each group was under the responsibility of a Nano-Tera PhD students while visiting each booth. The exhibitors had been briefed to tune their explanations in order to make them understandable for high school students. The potential applications for the various technologies developed within each of the projects was a key message.

After the visit, a workshop was organized, where the high-school students were asked to imagine a different application (co-design sessions) to what they had seen. At the end, each group presented their option.

The day generated a real interest not only from the high school students but also from the Nano-Tera researchers presenting their demonstrators, who were delighted to share their results with potential future scientific/engineering students. The latter got a glimpse of what a student's life would look like and what their current studies could lead them to.



IV.6 KEY STATEMENTS RELATED TO INSTITUTIONAL IMPACT

Key statement 18

Nano-Tera.ch has substantially contributed to the setup of the **joint SNSF-CTI program “BRIDGE”**, a novel funding instrument aiming at better exploiting the economic and societal potential of scientific research by promoting the transfer from scientific knowledge to innovation

MOTIVATION

Nano-Tera.ch has provided its expertise to contribute (through meetings, preparatory discussions and positioning documents) to the setup of the joint SNSF-CTI program **BRIDGE**, a novel funding instrument deployed at the federal level for the budgetary period 2017-2020. The BRIDGE program aims at better exploiting the economic and societal potential of scientific research by promoting the transfer from scientific knowledge to innovation. BRIDGE has been designed as a new concept for jointly funding research and pre-competitive innovation in Switzerland in the domain of Engineering Sciences. It proposes to strengthen the translation of publicly-funded research results into pre-competitive innovation. To do so, it plans to better connect academic and industrial players through ambitious research projects, thus creating suitable platforms for collaborative knowledge and technology transfer based on cross-exposure and inter-connection of personnel, with a special focus on junior researchers/engineers.

THE BRIDGE PROGRAM

The first motivation of BRIDGE was to correct the fact that current research and innovation funding models in Switzerland address the transition from research to innovation in a sequential way: research first, with objectives related to the advancement of science and technology, and only later considers (usually competitive) innovation (products or services) in collaboration with industry. BRIDGE seeks to introduce continuous interactions between researchers and industrial players to leverage the influence of both research achievements on new product ideas and of market needs on research directions.

The second motivation of BRIDGE is linked to the way graduate education is currently carried out in the Swiss Polytechnics and Cantonal Universities. In these institutions, most research is performed by doctoral and post-doctoral researchers under professorial supervision, funding is specifically targeted to research and success/reward indicators mainly related to publications. As a consequence, there is little interaction with industry, and doctoral students have limited exposure to Swiss industrial players and needs. BRIDGE proposes that graduates are in constant interaction with industry, through regular meetings and mutual visits, to strengthen the economic and social impact of scientific result.

To answer these motivations, BRIDGE has been designed as a new concept for jointly funding research and pre-competitive innovation in Switzerland in the domain of Engineering Sciences. It proposes to strengthen the translation of publicly-funded research results into pre-competitive innovation. To do so, it plans to better connect academic and industrial players through ambitious research projects, thus creating suitable platforms for collaborative knowledge and technology transfer based on cross-exposure and inter-connection of personnel, with a special focus on junior researchers/engineers.

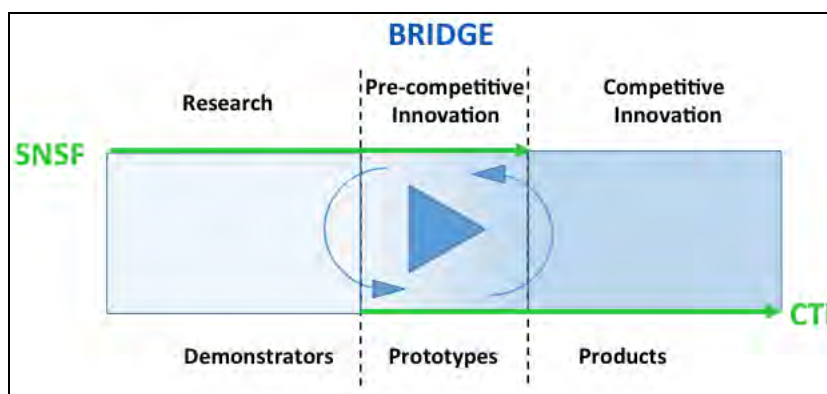


Figure 51. The BRIDGE concept.

The goals of BRIDGE will be achieved by creating a new funding instrument that: i) Integrates a granting mechanism addressing both research and innovation deliverables; ii) Introduces a continuous interaction between researchers and industrial players to leverage the influence of both research achievements on new product ideas and of market needs on research directions; iii) Relies on a new dual evaluation mechanism involving both scientific and economic dimensions.

BRIDGE is intrinsically positioned at the frontier between research and innovation, and its launch and operation require a concerted effort of institutional players (SERI, SNSF and CTI), as well as a consortium involving the Polytechnics, the

Cantonal Universities, the Universities of Applied Sciences and Swiss Research/Innovation Centers (e.g., CSEM, Empa, etc.). Representatives of the Swiss economy will also be integrated through an Industrial Advisory Board.

BRIDGE consists of two funding opportunities:

- Proof of Concept is aimed at young researchers who wish to develop an application or service based on their research results. These projects may target innovations of all kinds from all research areas.
- Discovery is aimed at experienced researchers who aim to explore and implement the innovation potential of research results. Only technological innovations that have a societal and economic impact will be funded.

These two funding schemes Proof of Concept and Discovery are being rolled out in the 2017-2020 test phase, for which a budget of CHF 70 million has been made available.

Experts from research, industry and administration are responsible for the successful execution of BRIDGE. Together they form the Steering Committee, which is elected by the presiding boards of the two funding organizations. The BRIDGE office set up by the SNSF and CTI is responsible for the operational management of the program. Each funding scheme will have its own evaluation panel, which will be appointed by the Steering Committee. The panels are composed of experts from science, business and industry.

From the perspective of Nano-Tera.ch, Gateway can be seen as a form of pilot program for BRIDGE. Note that Lothar Thiele, former founding member of the Nano-Tera.ch Executive Committee, is now serving as President of the BRIDGE Steering Committee.

Key statement 19

The **operational procedures** deployed and tested during the Nano-Tera.ch program represent an interesting example of innovative mechanisms for financing and monitoring research with high economic potential

THE GATEWAY MONITORING MECHANISM

The success of a technology transfer project requires three key factors: a shared vision of the goal to be achieved, the quality and density of interactions between the participants and the contribution of the project to the strategic objectives of the company. In this perspective, a specific monitoring mechanism has been created for the Gateway projects within the Gateway program.

This mechanism is characterized by three main innovations:

- The appointment of an "innovation manager" specifically responsible for the monitoring of the Gateway projects. The innovation manager must be a specialist with a general technical culture (typically in engineering), and an excellent knowledge of the state-of-the-art tools for innovative project management (iterative cycles, Lean Management, Minimum Viable Product, etc.). His/her role is to remain focused on the expectations of the industrial partners, the progress of the targeted demonstrators, and the evaluation of their exploitability for the industrial partner strategy. The innovation manager is directly reporting to the Executive Director and the Executive Committee of the program, and provides recommendations on potential corrective measures to be considered in relation with the Gateway projects.
- The replacement of the standard annual reporting describing the obtained results by quarterly progress meetings, corresponding to short face-to-face meetings (typically 1-1.5 hour) between the Innovation Manager and the project PI. The goal of these meetings is to dynamically assess the progress of the project, and to evaluate potential corrective measures if necessary.
- The creation of a new monitoring tool, the Balanced Score Card, specifically designed to serve the purposes of the quarterly progress meetings (see below for a more detailed description of the tool).

The general goal is to target an efficient, but very light monitoring mechanism (compatible with a quarterly occurrence), well adapted to the specificity of innovation projects. In particular, the main objectives were:

- To provide a framework specially adapted to monitor innovation, and, more specifically, to provide a grid of analysis for the iterations/exchanges taking place between researchers and industrial partners;
- To feed the quarterly interaction between the PI and the Gateway program manager with an overview able to foster efficient discussions;
- To provide the PI with a useful synthetic information that (1) allows them to self-assess the project progress, (2) represents a snapshot of project status, and (3) tracks the project dynamics and expected development;
- To contribute to prepare a successful CTI application at the end of the project.

During its design, the monitoring based on the Balanced Score Card has been presented to and discussed with Prof. Yves Pigneur (Lausanne University), one of the world-leading specialists in the domain of innovation management. It has been further discussed with him after its first 12 months of operation. The approach has also been presented to more than 200 representatives of major French companies during a "Mardi de l'Innovation" conference, organized by the "Club de Paris des Directeurs de l'Innovation" on March 14, 2017, in Paris-La Sorbonne.

The general adequacy of the Gateway monitoring mechanism has been confirmed, both by the positive feedback received from the PIs of the Gateway project, and by its ability to rapidly highlight potential difficulties faced by the running Gateway projects, which made it possible to propose timely and appropriate corrective measures.

THE BALANCED SCORE CARD

The Balanced Score Card consists of three main components: the demonstrator status table, the stakeholder network display, and the industrial credibility assessment plot.

The demonstrator status table is a way to represent the status and the dynamics of the development of the targeted demonstrators. At each progress meeting, each of the targeted demonstrators is positioned within an iterative cycle relying on a 3 stage model:

1. Built: this stage concerns the development of the demonstrator; it is associated with the following possible statuses: "on going" (the development is in progress), "finalizing" (the technical solution is almost finalized) or "done" (the demonstrator is built with the expected features);
2. Exposed: this stage concerns the delivery of the produced prototypes/demonstrators to the involved industrial partner(s); it is associated with the following possible statuses: "started" (the person responsible for the development of the prototype/demonstrator has been identified), "providing prototype" (a prototype has been provided to the industrial partner), "providing demonstrator" (a demonstrator resulting from the prototype has been presented to the industrial partner and they used it), and "delivered" (the research team considers the development of the demonstrator is completed);

- Revised: this stage concerns the integration in the development of the demonstrator of the feedback provided by the industrial partner; it is associated with the following possible statuses: “started” (the person in charge of the testing of the demonstrator by the industrial partner has been identified), “testing prototype” (the prototype is tested in a simulated environment), “evaluating demonstrator” (the demonstrator is evaluated in quasi-real environment), and “satisfied” (the industrial partner has clearly stated their satisfaction with the delivered demonstrator).

A concrete example of a demonstrator status table is given in the figure below:

October 23, 2017				Operational CO2 sensor Low-Power network for Switzerland and Zurich		
				Planned Delivery Month	Reviewed Delivery Month	
Changes vs previous monitoring				December-17	December-17	
	03/02/17	25/06/17	12/09/17			
Built	on-going	on-going	finalizing	Finalizing		x the technical solution is almost finalized
Exposed	providing demonstrator	providing demonstrator	providing demonstrator	Delivered		x the research team considers the development of the demonstrator is completed
Revised	evaluating demonstrator	evaluating demonstrator	evaluating demonstrator	Delivered		x the industrial partner has clearly stated its satisfaction with the delivered demonstrator

Figure 52: Example of Demonstrator status table.

The **stakeholder network** is a way to visually represent the various partners (“stakeholders”) involved in a Gateway project (with their type identified by a color coding), and their interactions (automatically derived from their co-presence in the various meetings reported in the project). The stakeholder network allows to question the organization of the project and the involvement of various players, in order to detect potential anomalies.

A concrete example of a stakeholder network is given in the figure below. Typical possible questions emerging from this network are: Why is “People10” (in a real network “People 10” would of course correspond to the name of a specific person) not connected to anyone? Why are “People1” and “People7” directly interacting without the intervention of a translational partner? Does this represent a sign that the objectives of the demonstrator are questioned?

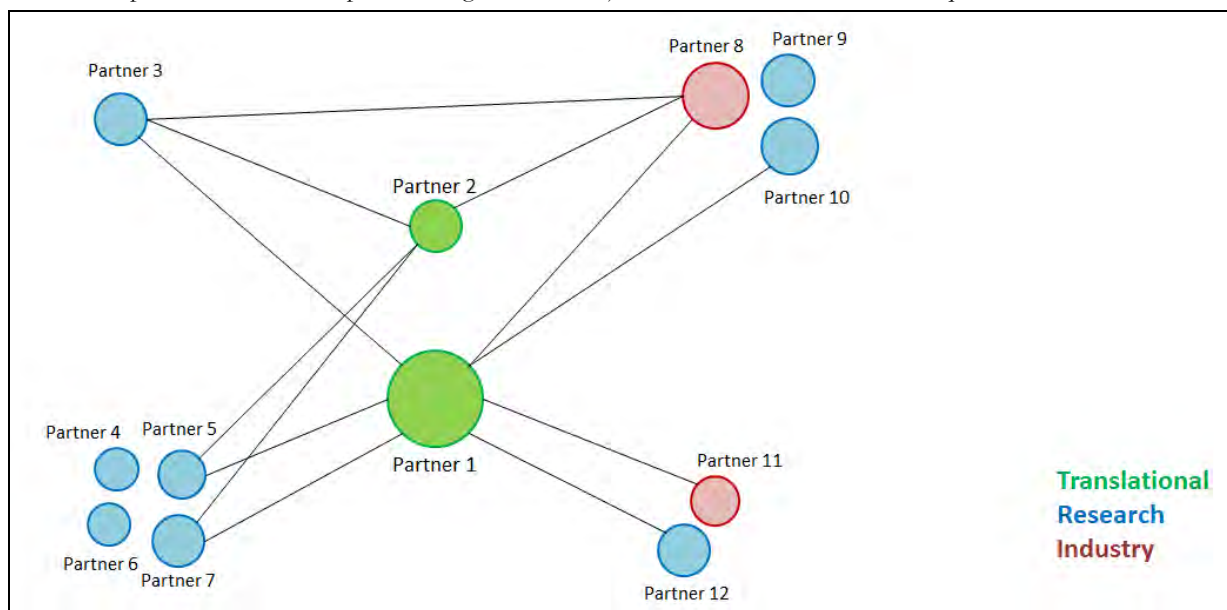


Figure 53: Example of Stakeholder Network.

The **credibility assessment plot** is a way to represent the confidence of the industrial partner(s) in the results of the Gateway project, and, more precisely, to their confidence in the contribution of the Gateway project to their strategic objectives. The level of confidence is monitored through three complementary aspects:

- The current level of matching funds provided by the industrial partner(s);
- A set of questions related to the perception of how the Gateway project allows the industrial partner(s) to position with respect to their competitors. The associated 5 questions concern planned market segments, product positioning, regulation or certification obligations, income generation and challenges as perceived by the industrial partners; the answers correspond to quantitative importance assessments ranging from 0 to 5, which allows to display the answers in the form of a 5-dimensional radar plot.
- A set of questions related to the evaluation of the amount of market considerations brought by the industrial partner(s) in the Gateway project. This associated 4 questions concern growth strategy (optimization, diversification,

etc.), potential internal impact the developed technology on the industrial partner, costs required to put it in production, and possible changes in the associated revenue model(s); the answers corresponds to quantitative importance assessments ranging from 0 to 5, which allows to display the answers in the form of a 4-dimensional radar plot.

A concrete example of a credibility assessment plot is given in the figure below:

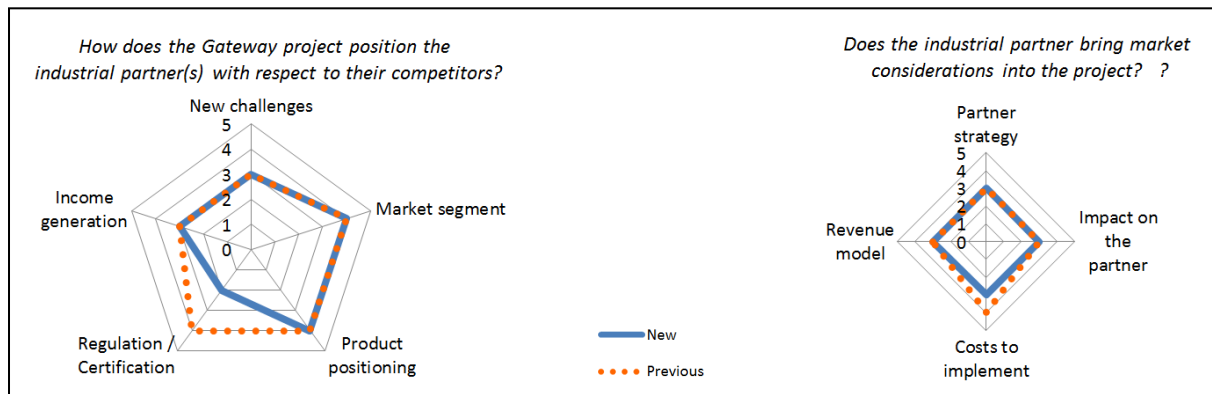


Figure 54. Example of Credibility Assessment Plot.

PART V

CONCLUSION

CONCLUSION

Nano-Tera.ch is a very successful research program that has strongly impacted the Swiss research landscape in the domain of Engineering Sciences. It has led to numerous scientific and technological breakthroughs exploiting synergies between micro/nanocomponent technology and large-scale system design, and generated highly exploitable demonstrators with socially relevant applications in the areas of health, energy, and the environment.

At the scientific level, Nano-Tera.ch has significantly impacted Swiss research in Engineering Sciences by strongly promoting ambitious cutting-edge research, and strengthening inter-institutional collaboration at the boundary of traditional disciplines. The program operated through competitive calls for proposals, with an average acceptance rate of about 30%, to support 44 large, long-lasting, collaborative research projects. These projects have resulted in a large number of scientific results, with a level of scientific excellence consistently acknowledged over the lifetime of the program by annual evaluations conducted by the Swiss National Science Foundation and the Nano-Tera.ch Scientific Advisory Board.

This success confirms the crucial importance of two of the salient characteristics of the strategic vision of the Nano-Tera.ch program: (1) the clear decision to focus on a targeted research space at the intersection of industrially relevant technologies and socially relevant application areas. This has avoided spreading the available budget across too many research directions, thus making it possible to support truly large, ambitious collaborative research projects; and (2) careful use of the eligibility conditions associated with the planned calls for proposals to shape the targeted research consortia in accordance with the strategic aims of the program.

At the educational level, Nano-Tera.ch has achieved a major impact by focusing on training the next generation of scientific talents and funding more than 360 PhD students. The program further amplified this impact by establishing a specific NextStep program, designed to help the PhD students involved increase their autonomy, collaborative spirit, entrepreneurial mindset, and communication abilities.

With more than 68% of its PhD graduates pursuing their career in Switzerland, Nano-Tera.ch has been instrumental in providing the Swiss academic community and Swiss industry with the highly skilled staff they need to efficiently develop their research and innovation.

This success stresses the importance of a research program that contributes to scientific and technological progress. One that not only generates actual breakthrough results, but also secures the conditions for future achievements by injecting young graduates with fresh ideas and substantial, new knowledge of up-to-date technologies into the Swiss academic community and industry.

At the economic level, a major impact of the program stemmed from its contribution to strengthening the economic potential of the research results by focusing on creating the proper conditions for economic value creation. By requiring major projects to include industrial partners and end users, Nano-Tera.ch achieved a strong impact in terms of knowledge transfer. The resulting project consortia were able to satisfy the needs of the industrial partners involved by giving them access to experts in fields they consider to be strategic for their development and competitiveness. This impact has been furthered by Nano-Tera.ch funding a large number of PhD students who transferred to industry after graduation. This is an invaluable mechanism to transfer knowledge and skills which Swiss industry needs to innovate.

In addition to once again emphasizing the importance of the highly skilled young graduates trained in a research program such as Nano-Tera.ch, this success also highlights the importance of the regular interaction between industrial and research partners in long-lasting collaborative projects. This aspect has been repeatedly mentioned by the industrial partners involved in Nano-Tera.ch projects as one of the major reasons for their involvement.

Finally, in terms of Technology Transfer, Nano-Tera.ch required major projects to deliver exploitable research prototypes, and accelerated their absorption by the industrial partners involved by launching the Gateway program, specifically focused on translating research results into industrial-grade demonstrators.

The impact of the Gateway Program illustrates how crucial it is for a program such as Nano-Tera.ch to benefit from an autonomous management structure providing the required flexibility to quickly implement novel instruments such as Gateway (or NextStep).

At the societal level, the primary intention of Nano-Tera.ch was to promote a vision of engineering with true social objectives. This was a result of the strategic decision to strongly encourage the funded research partners to target concrete prototypes helping the industrial partners and end-users to take advantage of their involvement in the research projects. The aim was to envision and propose concrete applications for the scientific results achieved, associated with actual needs and potentially benefitting society as a whole.

It is important to note that the societal impact has been greatly amplified by the strategic positioning of the research targeted within Nano-Tera.ch at the intersection of industrially relevant technologies and socially relevant application areas (health, environment, and energy).

At the institutional level, Nano-Tera.ch spearheaded an intense nationwide collaboration between various Swiss research institutions involved in Engineering Sciences, such as the two Federal Institutes of Technology (EPFL and ETHZ), several universities and universities of applied sciences, and industry-oriented research and technology institutions (CSEM and Empa). In particular, the creation of a Nano-Tera.ch community involving about 1,600 members from more than 40 different institutions, and interacting through structured communication platforms (such as the Nano-Tera.ch annual meetings) and tools (such as the Nano-Tera.ch web site) have resulted in very substantial institutional impact, which is of crucial importance to the Swiss academic community.

In addition, the specific organizational structure of Nano-Tera.ch presents an interesting opportunity to define and validate innovative interaction mechanisms with Federal research management institutions. This is true in particular for aspects such as the distribution of the evaluation responsibility between the Nano-Tera.ch Committees, which was in charge of the strategic monitoring of the program, and the Swiss National Science Foundation, which was responsible for the scientific evaluation of the submitted proposals and the running of RTD projects.

Finally, one of the undeniable signs of the overall success and impact of Nano-Tera.ch has been that many of the new ideas developed and tested within the program have been included in BRIDGE, a new funding instrument deployed by the Swiss government for the funding period 2017–2020 to jointly support research and precompetitive innovation in the field of Engineering Sciences.

The Nano-Tera.ch scientific community would like to thank the Swiss authorities for their trust and foresight. We strongly believe that the Swiss government made a bold move by financing Nano-Tera.ch, and, ten years after the inception of the program, facts show that the country has significantly benefitted from it.

APPENDICES

A. TIMELINE OF MAIN PROJECTS

PHASE 1

RTD		2009	2010	2011	2012	2013
CabTuRes	C. Hierold					
CMOSAIC	J Thome					
GreenPower	J-A. Manson					
i-IronIC	G. De Micheli					
IrSens / IR-N-ox	J Faist					
ISyPeM / TWPeM	C. Guiducci					
LiveSense	P. Renaud					
MIXSEL	U. Keller					
NanowireSensor	C. Schönenberger					
Nexray / COSMICMOS	A. Dommann					
NutriChip / Ca-NutriChip	M. Gijis					
OpenSense / OpenSense+	K. Aberer					
PATLiSci / MINACEL	H. Heinzelmann					
PlaCiTUS	Q. Huang					
QCrypt	N. Gisin					
SelfSys / SelfSys+	J Brugger					
SmOS / SmOS+	P. Ryser					
TechTex	G. Tröster					
X-Sense	L. Thiele					

SSSTC		2009	2010	2011	2012	2013
i-Needle	S Carrara					
M3W SN	T. Braun					
NaNiBo	A. Züttel					
NetCam	J Lygeros					
SC-nanomembranes	J Brugger					
3DOptoChemImage	D. Psaltis					

NTF		2009	2010	2011	2012	2013
BioAnt	A. Skrivervik					
BioCS-Node	P. Vandergheynst					
EMoA	F. Tièche					
Enabler	A. Ionescu					
G-DEMANDE	M. Schumacher					
MicroComb	T. Kippenberg					
NanoUp	A. Senkiewicz					
NaWiBo	T. Zambelli					
NeoSense	M. Wolf					
PMD-Program	S Maerkl					
SecWear	M. Sami					
SMTS	C. Dürager					
TWIGS	D. Briand					
ULP-Logic	Y. Leblebici					
ULP-Systems	Y. Leblebici					

PHASE 2

RTD		2013	2014	2015	2016	2017
BodyPoweredSenSE	P.-A. Farine					
Envirobot	J van der Meer					
FlusiTex	B. Nelson					
HearRestore	S. Weber					
HeatReserves	J Lygeros					
IcySoC	A. Burg					
IrSens II	J Faist					
ISyPeM II	C. Guiducci					
MagnetoTheragnostics	H. Hofmann					
MIXSEL II	U. Keller					
NewbornCare	P. Vanderghelynst					
ObeSense	J-P. Thiran					
OpenSense II	A. Martinoli					
PATLiSci II	E. Meyer					
SHINE	C. Moser					
SmartGrid	M. Kayal					
SmartSphincter	B. Müller					
SpineRepair	S. Lacour					
Synergy	C. Ballif					
UltraSoundToGo	G. De Micheli					
WearableMRI	K. Prüssmann					
WearMeSoC	Q. Huang					
WiseSkin	J Farserotu					
X-Sense II	L. Thiele					
YINS	D. Atienza					

NTF		2013	2014	2015	2016	2017
Breathe	M. Liley					
D1NAMO	K. Aberer					
IronIC++	S. Carrara					
MiniHolter	J-M. Vesin					
NAMBP	J Solà					
ParaTex	M. Wolf					
TANDEM	A. Weidenkaff					
3D-SensTex	D. Briand					
3D-Systems	Y. Leblebici					

GATEWAY		2013	2014	2015	2016	2017
CarboSense	L. Emmenegger					
FlusiGate	L. Boesel					
FlusiSafe	B. Nelson					
HearRestoreGate	E. Franz					
NambpGate	J Solà					
ObeSenseGate	M. Bertschi					
ParaTexGate	R. Rossi					
SynergyGate	C. Ballif					

STRAT. ACTIONS		2013	2014	2015	2016	2017
InUse	C. Hügin					
Transcend	D. Atienza					
Tera-Health	P. Pu					
BioDev	G. De Micheli					
MSSdevices	E. Meyer					
OpenSWISS	A. Martinoli					

B. TECHNOLOGY READINESS LEVELS

TRL	Technology readiness level	Description	Supporting information
1	Basic principles observed and reported	Scientific research begins to be translated into applied research and development (R&D). Examples might include paper studies of a technology's basic properties.	Published research that identifies the principles that underlie this technology.
2	Technology concept and application formulated	Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.	Publications or other references that outline the application being considered and that provide analysis to support the concept.
3	Analytical and experimental proof of concept	Analytical and laboratory studies to physically validate the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.	Results of laboratory tests performed to measure parameters of interest and comparison to analytical predictions for critical subsystems.
4	Component and breadboard system validation in laboratory environment	Basic technological components are integrated to establish that they will work together. Examples include integration of "ad hoc" hardware in the laboratory.	System concepts that have been considered and results from testing laboratory-scale system(s).
5	Component and breadboard system validation in relevant environment	The basic technological components are integrated with reasonably realistic supporting elements so they can be tested in a simulated environment. Examples include "high-fidelity" laboratory integration of components.	Results from testing laboratory breadboard system are integrated with other supporting elements in a simulated operational environment.
6	Prototype system demonstration in a relevant environment	Prototype system is tested in a relevant environment. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment.	Results from laboratory testing of a prototype system that is near the desired configuration in terms of performance, weight, and volume.
7	Prototype system demonstration in an operational environment	Prototype near or at planned operational system. Requires demonstration of an actual system prototype in an operational environment.	Results from testing a prototype system in an operational environment.
8	Actual system completed and qualified through test and demonstration	Technology has been proven to work in its final form and under expected conditions. Examples include developmental test and evaluation (DT&E) of the system to determine if it meets design specifications.	Results of testing the system in its final configuration under the expected range of environmental conditions in which it will be expected to operate. Assessment of whether it will meet its operational requirements.
9	Actual system proven through successful deployment	Actual application of the technology in its final form and under conditions, such as those encountered in operational test and evaluation (OT&E). Examples include using the system under operational conditions.	

Annex C –SSC expert panel report and position statements, 2017–2018

Annex C1 – Terms of reference of external experts (TOR)



Impact evaluation “Nano-Tera.ch”

Terms of reference for external experts (TOR)

April, 2017

1 Purpose of TOR

The following TOR are to clarify the rights and obligations of the panel of experts on the one hand and the Swiss Science and Innovation Council (SSIC) and its staff on the other. These TOR also determine procedures and deadlines.

2 Purpose and context of the impact evaluation by the SSIC

In accordance with the official mandate of the State Secretariat for Education, Research and Innovation (SERI) delivered in September 2016, the SSIC conducts an impact evaluation of the national funding program “Nano-Tera.ch”.

The impact evaluation focusses on the following dimensions:

- Scientific impact (excellence in science)
- Educational impact (promoting young talents)
- Economic impact (knowledge and technology transfer)
- Societal impact (social needs are taken into account)
- Institutional impact (structural changes in the Swiss research landscape)

3 Procedure of the impact evaluation

The complete evaluation procedure consists in three phases:

- A. Self-evaluation report
Internal impact evaluation carried out under the responsibility of the Nano-Tera.ch Consortium.
The requirements and conditions are stated in the SERI mandate
- B. Panel report
Independent external assessment by a panel of international experts, based on the self-evaluation report by Nano-Tera.ch, additional documents provided by the SSIC and the information gathered during a site visit incl. interviews
- C. SSIC report
Synthesis and overall assessment of the information gathered from national sources, from the self-evaluation report and from the panel report by the SSIC

See Annex for a timetable of the complete procedure.

4 Objectives of the assessment by the panel of experts

The assessment by the panel of experts focusses on a list of questions of the SSIC (based on the “dimensions” mentioned above, especially on scientific impact and economic impact).

Based on the documentation delivered by the SSIC as well as other sources (i.e. interviews at the site visit, see 7 below), the panel of experts shall critically assess the findings from an international

perspective. The panel can draw comparisons with funding schemes or programs from other countries.

The SSIC will use the results of the expert panel assessment for its own analysis. Furthermore, the panel report will be addressed to the Swiss Federal Government as an annex to the SSIC report.

5 Procedure of the assessment by the panel of experts

A	2017, Oct. 4	The SSIC provides general documentation and the SSIC's main questions to the expert panel
B	2017, Oct. 31	The SSIC provides the self-evaluation of Nano-Tera.ch to the expert panel
C	2017, Nov. 13-14	The site visit will take place in Lausanne: coordinated by the SSIC, the expert panel will meet the Nano-Tera.ch Consortium and other actors
D	2018, Jan. 8 (at the latest)	A first draft of the expert report will be delivered to the SSIC
E	2018, Feb. 14	The SSIC will send the positions of the Nano-Tera.ch Consortium and of the Swiss National Science Foundation on the draft report to the expert panel
F	2018, Feb. 28 (at the latest)	The expert panel will decide about making a comment to the positions and, if appropriate, send the comment to the SSIC on February 28, 2018, at the latest

6 Constitution of the panel of experts

The assessment will be carried out by an international panel of 3 independent experts. The SSIC is responsible for selecting the panel.

The panel organizes itself and will nominate a contact person for the SSIC. Every member of the panel can address the SSIC's office for any questions.

7 Documentation

The SSIC will provide the panel of experts with all the necessary documentation and information. This includes:

- General information on Swiss higher education system
- A summary of the SERI mandate
- The self-evaluation of the Nano-Tera.ch Consortium
- Additional documents and questions by the SSIC
- Administrative information (i.e. on participants and agenda of the site visit)

8 Tasks and responsibilities of the experts

At their discretion, experts can gather additional information they regard as relevant. In its report, the panel must disclose all sources of additional information.

The SSIC will receive the draft report from the contact person of the experts' panel on January 8, 2018, at the latest. This report will contain the panel's findings and recommendations, in accordance with the SSIC's questions, as well as a statement on the methods and documentation used by the panel.

The report will be in English. It will be no longer than 20 pages. The report must be delivered in electronic form, both as a PDF and as a Word file.

The report is meant to have group authorship. If the panel cannot reach a consensus, each member of the panel will sign his own text.

9 Independence, confidentiality and conflicts of interest

The members of the panel work independently and do not represent any organization. Panel members are required to declare any personal or other conflicts of interest.

Discussions between the panel of experts and the SSIC occurring during the site visit are not public and their content is confidential. No official minutes will be kept, but all participants are free to take notes for their own use.

Panel members may not make any use of, and may not divulge to third parties, any non-public information they learned or accessed during the procedure, including but not limited to information, knowledge, documents or other matters that are communicated to them or brought to their attention.

Annex

Impact evaluation Nano-Tera – Scheduling (12.04.2017)																	
	2017											2018					
	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	
	A First analysis									B Site Visit	C External evaluation						
(1) Scheduling agreed - Done																	
(2) Concept + Kick-Off - Done																	
(3a) Experts selection + Decision final panel																	
(3b) First analysis																	
(3c) Analysis (following), Org. Site Visit + Ext. evaluation																	
(4) Autoevaluation NTCH																	
(5a) Analysing autoevaluation																	
(5b) External evaluation																	
(6a) Site visit (Experts, SSIC, NTCH, SNF)																	
(6b) Experts report – production																	
(6c) Experts report – position NTCH / SNF																	
(6cbis) Experts report - experts position (if wished)																	
(7a) Final report first discussion in plenum																	
(7b) Final report final vote																	

Annex C –SSC expert panel report and position statements, 2017–2018

Annex C2 – SSC questions to the expert panel

1 Questions for the international expert panel

Introduction

In September 2016, the Swiss Science and Innovation Council (SSIC) received a mandate from the Swiss State Secretariat for Education, Research and Innovation (SERI) to conduct an impact evaluation of the National Funding Program Nano-Tera.ch.

The complete evaluation procedure consists of three phases:

- a) Internal impact evaluation (*self-evaluation report, delivered to the SSIC on November 1, 2017*) carried out by the Nano-Tera.ch Consortium. The requirements and conditions are stated in the SERI mandate.
- b) Independent external assessment by a panel of international experts (*panel report, to be delivered to the SSIC on January 8, 2018*)
- c) Synthesis and overall assessment of the information gathered from national sources, from the self-evaluation report and from the panel report by the SSIC (*SSIC report, to be delivered to the SERI end of June 2018*)

Following, the SSIC formulates questions to the international experts, in order to benefit as much as possible from their view, which will underpin SSIC's overall assessment.

Questions (explanations and eventual complementary questions will occur during the briefing with SSIC on November 13, 2017, 12.15)

Dimension I: Scientific impact

- I/1. To what extent has the Nano-Tera.ch initiative contributed to foster excellence in research in Swiss engineering sciences? And in other scientific fields?
- I/2. How well did the research activities comply with the a) collaborative, b) interdisciplinary and c) interinstitutional orientation of the program?
- I/3. To what extent did the initiative contribute to bridge the gap between fundamental and applications-oriented research resp. between science and engineering?
- I/4. How do you assess the originality of the projects funded (mainstream or cutting-edge)?
- I/5. The selection and evaluation procedure for the main funding scheme (Research, Technology and Development Projects, RTD) was organized by an external panel from the Swiss national science foundation (SNSF). Was this procedure an advantage or a disadvantage to a) interdisciplinary research and b) the coverage of the whole spectrum of disciplines involved in the program?

Dimension II: Educational impact

- II/1. How do you assess the measures taken to promote PhDs, especially the funding scheme NextSteps, introduced in 2015?

Dimension III: Economic impact

- III/1. How do you assess a) the strategy to promote KTT on program level and b) the realization within the projects?

III/2. How do you assess the funding scheme Gateway?

III/3. How do you assess the measures taken by Nano-Tera.ch to promote KTT in comparison with similar initiatives at the international level?

Dimension IV: Societal impact

IV/1. How do you appreciate the societal impact of Nano-Tera?

Dimension V: Institutional impact

V/1. Which elements will remain in place after the end of the program, what was just part of a passing phase?

V/2. How do you assess the sustainability of the KTT after the end of the program, and especially the funding scheme Gateway?

Overall appreciation

VI/1. To what extent was the program Nano-Tera.ch able to implement the underlying vision?

VI/2. What are strengths and weaknesses? What might be the general lessons learned from the program?

VI/3. Do you see an added value of such a comprehensive program or would some smaller but focused programs be more efficient?

Overall schedule

When	What
Now, present paper	The expert panel gets the SSIC's questions and additional documents
2017, November 1	The SSIC provides the self-evaluation of Nano-Tera.ch to the expert panel
2017, November 13-14	The site visit and other meetings take place in Bern (see below)
2018, January 8 (at the latest)	The draft of the expert report is submitted to the SSIC
2018, February 14	The SSIC sends the comments of the Nano-Tera.ch Consortium and of the Swiss National Science Foundation on the draft report to the expert panel
2018, February 28 (at the latest)	The expert panel decides about making an addition or a change to their report and, if appropriate, sends a final version of the report to the SSIC
2018, June 30	The SSIC submits the complete impact evaluation to the SERI. The expert report is included in the SSIC evaluation report.

Annex C –SSC expert panel report and position statements, 2017–2018

Annex C3 –SSC expert panel report



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs,
Education and Research EAER

Swiss Science Council SSC

Swiss Science Council

Impact Evaluation of the National Funding Programme Nano-Tera.ch

Report on Nano-Tera.ch by the expert panel

Authors:

- **Prof. Dr. Jeremy Baumberg, Professor of Nanophotonics, University of Cambridge, UK**
- **Prof. Dr. Rudy Lauwereins, Vice President IMEC, Leuven, Belgium**
- **Prof. Dr. Mark Lundstrom, Professor of Electrical and Computer Engineering, Purdue University, USA**

January, 2018

Swiss Science Council
Einsteinstrasse 2, 3003 Bern
Phone +41 58 463 00 48, Fax +41 58 463 95 47
praesidium@swr.admin.ch
www.swr.ch

Nano-Tera.ch Impact Evaluation: Report of the Expert Panel

Prof. Jeremy Baumberg (Cambridge)

Prof. Rudy Lauwereins (Leuven)

Prof. Mark Lundstrom (Purdue)

Final Report December 18, 2017

Preface:

The Swiss Science and Innovation Council (SSIC) has a mandate from the Swiss State Secretariat for Education, Research and Innovation (SERI) to conduct an impact evaluation of the National Funding Program Nano-Tera.ch. One part of the evaluation procedure consists of an independent evaluation by a panel of international experts. The SSIC posed a set of questions to the Expert Panel and organized a “site visit” on Nov. 13, 2017 followed by a meeting with the Swiss National Science Foundation (SNSF) on Nov. 14, 2017. The site visit was chaired by Jean-Marc Triscone, SSIC and attended by the Nano-Tera.ch PI, Giovanni De Micheli, and several Nano-Tera.ch faculty participants. Prior to the site visit, the Expert Panel was provided with a self-study Impact Analysis Report 2017. The site visit consisted of short presentations that summarized the self-study report, followed by questions, answers, and discussion. On November 14, the Expert Panel met with scientists from the SNSF, who provided their perspectives on the program and participated in a discussion with the Expert Panel. Following the meeting with the SNSF, the Expert Panel was provided with additional information:

- RTD Calls 2008-2016
- Recommendations of SNSF Panel to the PIs and on phase 2 (2013-2016)
- External report on KTT by Interface
- Analysis of Nano-Tera.ch grants related to SNSF grants

The specific objectives and expected outcomes of the program were summarized for the Expert Panel in Annex 1 (The SERI Mandate) of the document: “Questions for the international expert panel and documentation”. Fifteen specific questions were posed to the Expert Panel. Before responding to the specific questions, we briefly summarize our main conclusions and recommendations.

Summary Conclusions and Recommendations

By way of preface, the panel would like to say that we understand both the considerable challenges and opportunities of running large, comprehensive programs like Nano-Tera.ch. The Nano-Tera.ch leadership team should be complimented on their hard work, dedication and achievements. It is the Panel's conclusions that Nano-Tera.ch was a highly successful and innovative program. Some of the specific successes are identified below along with some suggestions that can be considered for future programs.

- Nano-Tera.ch was very successful in establishing a collaborative, multi-disciplinary, inter-institutional program, but the project selection mechanism made it difficult for Nano-Tera.ch leadership to establish a coherent, overall vision.
- The creation of 40 startup companies is convincing evidence that Nano-Tera.ch succeeded in its mission to bridge fundamental and application-oriented research, but stronger connections to advisors from industry would have benefitted the program.
- The decision to allocate 80% of the budget to large, multi-disciplinary projects was wise. It allowed Nano-Tera.ch to address science to applications research in a way that differentiated Nano-Tera.ch from smaller scale programs.
- Nano-Tera.ch provided Ph.D. students with a unique research experience. The connection of research to applications provided them with a strong foundation for success in industry and in academic research, which is increasingly driven by applications. The NextSteps program can be a good model for the future.
- The KTT program was largely a traditional academic one that would have benefitted from an examination of KTT models from programs in other countries. Gateway stands out as an example of a new approach to KTT. Gateway and the overall KTT program would have benefitted from stronger connections to industry.
- Nano-Tera.ch addressed broad, societal challenges in health, the environment, and energy that are strategic research goals in most countries. The focus of Nano-Tera.ch on broadening academic research to include applications significantly increases the potential for societal impact. This was a major success of Nano-Tera.ch, but more emphasis on outreach to industry, pre-college students, and government could have increased the visibility and impact of Nano-Tera.ch.
- Significant successes have been achieved but the panel is concerned about the legacy of Nano-Tera.ch. Enduring outcomes of Nano-Tera.ch do not appear to have received strong consideration in the definition, review, or operation of the program. The panel did not see evidence that successful programs and practices have been institutionalized at the participating universities. The SNSF should consider a set of small follow-on grants specifically directed institutionalizing some of the key programmatic successes.

Dimension I Questions: Scientific impact

I/1. To what extent has the Nano-Tera.ch initiative contributed to foster excellence in research in Swiss engineering sciences? And in other scientific fields?

The large number of publications and awards attest to the excellent research that has been done. Research quality benefitted substantially from the real-world application focus embedded in the projects thanks to the multi-disciplinarity that brought together application domain experts with enabling technologies experts, as well as scientists with engineers. Unfortunately, the project selection mechanism, being focused solely on the quality of an individual project proposal, hampered strategic steering based on one central high-level vision per domain (health, environment, energy). This led to a collection of very high quality but disjoint projects rather than to a coherent visionary program of complementary projects. One challenge in Nano-Tera.ch was maintaining balance between high impact science and translations to applications. It was not clear how different teams made this trade-off. Finally, while it was clear to the Expert Panel that Nano-Tera.ch fostered excellence in engineering science, the connection to “other scientific fields” was less clear.

I/2. How well did the research activities comply with the a) collaborative, b) interdisciplinary and c) inter-institutional orientation of the program?

The specific structure and ambition of Nano-Tera.ch effectively led to cross-disciplinary and cross-institutional cooperation between teams that did not cooperate with each other or even did not know each other before the start of this program. Since the most important innovations happen at the boundaries of scientific disciplines and at the boundary between science and engineering, the nano-tera.ch management should be complimented for having been able to realize this cooperation in a Swiss university organizational structure that was not favorable to such cooperation and that was mainly built on a mutual competition model. This cooperative spirit fostered by Nano-Tera.ch was an important outcome of the program, but the Expert Panel is concerned about whether it can be maintained after the Nano-Tera.ch program has ended.

The Expert Panel noted that fewer than a one-third of the resulting journal papers were jointly authored by two or more partners within the same project. The Nano-Tera.ch team's response was that individuals tend to publish research papers on their own discipline-specific contributions to the larger project. Putting these disciplinary components together creates larger impact at the project scale, but this did not seem to be documented in jointly authored papers on the larger project. The Nano-Tera.ch team emphasized that the added motivation for the researchers in being supported in projects that brought different specialists together was extremely effective. While this seems reasonable to the Expert Panel, it raises the question of what metric can be used to assess successful collaboration and interdisciplinary, if not joint publications or patents?

1/3. To what extent did the initiative contribute to bridge the gap between fundamental and applications-oriented research resp. between science and engineering?

The fact that the program created 40 startup companies is strong evidence that the goal to bridge the gap between application-oriented science and engineering was realized. Startup companies create disruption at the engineering level by creatively solving important scientific problems and, at the same time, end user pain by creating disruption at the application level. It was unclear specifically how much Nano-Tera.ch funding had contributed to each startup (since only 10 were specified in the reporting). We were surprised that this reporting back from the teams was not specifically built into their contracts, nor was there a larger understanding of the spin-out space from Nano-Tera at this end stage of the program.

While it was clear to the Expert Panel that the gap between “engineering science” and applications was bridged, it was not at all clear that the gap between “fundamental science” and applications was addressed. Most of the participants were applied scientists already on the engineering science/applications edge. Nevertheless, Nano-Tera.ch provided crucial funds to bridge the applied science to applications gap, and this was an important outcome.

1/4. How do you assess the originality of the projects funded (mainstream or cutting - edge) ?

The choice to allocate 80% of the budget to larger multi-disciplinary projects with enough critical mass was wise. Because funding of this kind is rare, it differentiated Nano-Tera.ch from more traditional, smaller scale programs. Allocating a smaller amount of money to projects that glued existing large projects was an excellent decision too. The Expert Panel did not, however, see a scientific justification for the small cooperation projects with China.

The quality of the projects was high and helped achieve the goal of bringing Switzerland to the forefront of a new technological revolution. There were few highly original, “signature projects” that set Switzerland apart. The program looks to have taken most of the strong engineering science teams in Switzerland and extended their reach further into application spaces, rather than insisting on completely original research.

1/5. The selection and evaluation procedure for the main funding scheme (Research, Technology and Development Projects, RTD) was organized by an external panel from the Swiss national science foundation (SNSF). Was this procedure an advantage or a disadvantage to a) interdisciplinary research and b) the coverage of the whole spectrum of disciplines involved in the program?

Selection of projects through a panel that was independent from the groups submitting the proposals, i.e. independent from the ExCom of Nano-Tera.ch was essential to ensure fairness in selecting the scientifically highest quality multi-disciplinary projects. However, when scientific excellence is not the only criterion, but when also potential future economic

impact and the fit to an overall strategic vision has to be taken into account, the SNSF-only selection procedure led to a collection of disjoint projects rather than to a coherent visionary program of complementary projects. It emphasized scientific quality and fairness for the applicants above originality, thought leadership and economic impact for Switzerland and, in fact, underutilized the scientific leadership of the ExCom.

Dimension II Questions: Educational impact

II/1. How do you assess the measures taken to promote PhDs, especially the funding scheme Next Steps, introduced in 2015?

The focus of Nano-Tera.ch was on research, so the strong focus of the educational activities on Ph.D. students made sense. A large number of Ph.D.'s was produced (366), and the program gave them a kind of training in applications that should make them especially attractive to industry (61% entered industry). It was clear to the Expert Panel that the PhD experience through Nano-Tera was very different than the typical Ph.D. experience in Switzerland as a result of exposing research students to a much wider range of disciplines, motivations, and interactions than is common.

The Next Steps scheme is excellent, though participation (15%) was not as large as might have been expected - possibly because individual PIs were less supportive of this use of Ph.D. students' time. The possibility of offering Next Steps to all PhD students in Switzerland should be considered; it would make Ph.D. students much more capable of taking the next steps in their careers with confidence. Questions raised by the Nano-Tera.ch team about who would mandate Ph.D. students to participate and who would monitor the program would need to be considered, but if done, Next Steps could be a Nano-Tera.ch contribution with lasting impact.

On top of the Next Steps program for PhD students, a program to increase the business awareness of the PIs would have been beneficial since the projects aim at developing demonstrators and proof-of-concepts with high economic valorization potential. Specially to prepare Gateway project proposals, concepts like unique selling proposition, red/blue, ocean, go-to-market strategy, IP protection strategy, business models, ... are of high importance and typically less familiar to academic PIs.

The total amount of funding devoted to education per se (i.e. exclusive supporting Ph.D. students) was small (<1%). Much was accomplished with little funding, but this raises the question of what could have been accomplished with more funding. For example, there was no mention of MOOCs and other kinds of online education that are widely discussed today. Such an initiative could have provided students across the spectrum of Switzerland's educational institutions with access to some of the rich educational resources available at EPFL and ETHZ as well as serving as a resource for working engineers in a period of rapid technological change.

Dimension III Questions: Economic impact

III/1. How do you assess a) the strategy to promote KTT on program level and b) the realization within the projects?

One of the goals of the SERI mandate was “a significant strengthening in the domain of Knowledge and Technology Transfer and an increased collaboration with the interested players from the private sector.” The Expert Panel hoped to find some innovative and successful new idea, but the KTT program appears to have been a traditional academic one. There were a large number of publications (1600, 700 of which were journal publications). The nano-tera.ch team pointed out that people are the most effective means of KTT. The large number of Ph.D.’s produced (366) and the high percentage that took non-academic positions (61%) reflects a high degree of success in people-based KTT.

Despite a very traditional approach to promote knowledge transfer, the nano-tera.ch program obtained substantial, though local, economic impact through e.g. the creation of 40+ startup companies. Although the program aimed clearly for future valorization and addressed challenges that are matching industrial needs, the program did not install an Industry Advisory Board, not at the program level nor consequently within each project. Other programs have found value in associating “industrial mentors” with university-based research projects. Such people are often friends with experience in industry who visit the team regularly to discuss progress. Good mentors ask hard questions about where the team is really going, how best to get to a strong demonstrator, and in what timeframe and with what resources. In addition to the benefits to students, industry mentors can help educate PIs in the issues involved in application development.

Despite the strategic basic research nature of the projects, the Expert Panel feels that having an industrial sounding board is necessary to ensure that the boundary conditions assumed in those projects are not conflicting with industrial needs. There was no detailed mechanism to get feedback from industrial partners and outside industry as to what they wanted to see in this engineering science programme. With only one industrialist on the scientific advisory board, this was not sufficient feedback for an industry-connecting programme like this. How did the team know if industry would find other approaches more effective than theirs, and how did they try to find this out? Were industry partners in the projects suggesting of some improvements, and how were these acted on in a concerted way?

III/2. How do you assess the funding scheme Gateway?

Funding for Gateway was modest, but it was a good idea and would naturally look like the new Bridge scheme. Selection of the projects seems reasonable, but little is available to describe how the projects were really pushed forward, and how the outcomes to commercialisation will really be improved. In our view, this scheme should have been instigated from the very beginning and given greater funding, however it would also have to have robust evaluation of which projects are suited to this acceleration of TRL level.

For the Gateway projects, the Expert Panel also feels that having a critical industrial sounding board should have been mandatory for every project, thereby ensuring a smoother knowledge transfer to industry after the end of the project. One measure of success would be the number of projects commercialized, but an equally important measure (especially given the level of funding) would be the educational value to Ph.D. students learning how to translate science into real applications. This educational value of the program could have been greatly enhanced by a strong set of industry advisors.

III/3. How do you assess the measures taken by Nano - Tera.ch to promote KTT in comparison with similar initiatives at the international level?

In contrast to the Next Step program, which introduced some innovations to prepare Ph.D.'s for careers in industry, the Expert Panel did not see innovations in KTT.

Because the Nano-Tera.ch program was led by science not industry, there was a strong element of technology push. Because of the project selection process, Nano-Tera.ch was also not very focused and ended up being rather diffuse, with no apparent cohorts of projects to help support each other or attract panels of potential investors. Other countries use a range of initiatives. In the UK there have been Eu2-4M 5 year Basic Technology projects which occupied a similar space, however these were successfully run by the research councils, rather than making another body. There are also Impact Acceleration Accounts (IAAs) in the UK which the research councils provide as funding to universities, who are then able to freely fund Gateway-type programs from, involving industrial mentors (or anything else to help this stage).

In Flanders, fundamental research projects and single-disciplinary strategic basic research is carried out by the universities and universities of applied sciences via the FWO funding agency. Multidisciplinary research is strategically driven by the Strategic Research Centers (SRCs) (imec, VIB, VITO and FlandersMake) that either have close relationships with universities (imec-process technology and hardware; VITO) or are a virtual organization of research teams of multiple universities (imec-software; VIB; FlandersMake), and that have at the same time very close ties with industry and have an industrial knowledge transfer end goal. The central leadership of these Strategic Research Centers ensures strategic domain thinking, fast adaptation to economic changes and fosters an application pull mindset. The PhD students working at the SRC and graduating at one of the affiliated universities all get a Next Steps-like training on entrepreneurship and public speaking. The SRCs thereby fulfill the roles that were taken up or aimed at by Nano-Tera.ch. Gateway-like projects are run by the SRCs in close cooperation with universities and with friendly but critical industrial guidance. Closer to market projects are the so-called ICON projects where the Vlaio funding agency (cf CTI) ranks projects according to quality and the SRC finally decides among the projects surpassing the quality threshold based on strategic and valorization criteria. ICONs must be executed for more than 50% by industry and should involve multiple university groups to ensure multi-disciplinarity.

These experiences from just a few countries make us question how much Nano-Tera looked at outside models for ways to structure their program most beneficially. It appeared that the programme management did not explore collaborative industry-science models already tested in different countries (not necessarily the USA), as there are many established ideas for linking the science and technology base. It is not clear if this arises from the feeling of Swiss participants that there are particular difficulties special to them related to the federalised structure. On the other hand, many specific delivery schemes (wording of call documents, formulation of graduate training, use of mentors,..) have been tried in many other EU countries, and the team was slower to develop many of theirs because they did not reach out to see best practice elsewhere. The team emphasized their ability to try new ideas due to their separate structure, but then did not evidence so much.

The international visitors program could have played a stronger role in Nano-Tera.ch. The Expert Panel was unable to discern a strategy for inviting specific speakers. Which parts of the agenda were they invited to impact? The number of visitors also seems low for a 10-year program. The international visitors program could have played a strong role in helping Nano-Tera.ch strongly reach out to involve other countries.

Nevertheless, Nano-Tera.ch successfully filled two gaps in the existing Swiss landscape: (1) it did an excellent job to encourage multidisciplinary strategic basic research in the diverse university landscape of Switzerland and (2) it experimented with making technology push results ready for industry uptake by matching it with some application pull. As such, it positioned itself between the traditional SNSF projects and CTI projects. With the end of Nano-Tera.ch, the Expert Panel fears that this gap will again become more prominent, despite the synergy between SNSF projects and the Bridge program since these by nature can only focus on per project evaluation and miss the strategic leadership domain thinking that is essential at the boundary between technology push and market pull.

Dimension IV Questions: Societal impact

IV/1. How do you appreciate the societal impact of Nano - Tera ?

Potential for societal impact is the relevant measure for projects of this kind, and the range of projects with a strong potential impact on society is extremely good. This is partly the result of the very broad goals of Healthcare, Environment, and Energy, which are the strategic paths of all countries, but there must also have been a sensible selection of projects in Phase II. We note that many of the individual projects were able to generate strong publicity and reach through press reports to the public. Another measure of potential for impact is the increased number of faculty and students interested in using nano- and tera-technologies to address societal challenges. Nano-Tera.ch has been a success from this perspective.

Efforts to increase societal impact in ways beyond the ongoing projects and increased number of people appear rather less strong. Opportunities to combine different themes together and engage with schools and the parliament were missed. For instance, using the school kids brainstorming on the societal impact of projects if they come to fruition, could

then have been connected to their feeding back to politicians to both raise the standards of political debate as regards science futures, while bringing young generations with an attitude to embrace technologies into this debate with a key stake in the outcomes.

Dimension V Questions: Institutional impact

V/1. Which elements will remain in place after the end of the program, what was just part of a passing phase?

One hopes that a program with the size, scope, and duration of Nano-Tera.ch would make lasting contributions. The emphasis on multi-disciplinary research, on application-driven research, and the connections between Swiss institutions and between academia and industry were important contributions, but the concern is that these contributions do not appear to have been institutionalized. In fact, it appears that very little will be left in place after a quite significant investment of time and funding. The individual projects having birthed spin-outs, and some new research focus will continue (many of these seem to be applying for the Bridge program). The earlier stage work of Nano-Tera.ch, despite being seen as a success, does not seem to have settled in the institutions as a permanent feature. Rather the pervasive nature of interdisciplinary research seems to have caught hold better, with institutional provision now for cross-faculty and theme-based appointments and support. For specific appetite in pushing engineering science to engage with end-users much more, it seems this is left to individuals rather than institutions.

Even the significant increase in PhD students emerging with these key skills demanded by industry (broad focus, strong training, applications oriented) will just disappear with no legacy. This is a problem for the Swiss economy, which seems to be demanding ever larger numbers of these skilled researchers.

Perhaps even more worrying is the breakdown in support for long-lived projects between ETH/EPFL/universities and industrial partners. This has been highlighted as a key gain, opening up continuous dialogue that is not only valuable for the specific projects being worked on, but generally allowing industry to gain expert feedback and insights into changes in the technologies that are emerging, and thus to better plan their developments. This dialogue will not happen without programs like NanoTera.

Many of the projects involved collaborations with hospital partners. These apparently went well, but this is a notoriously difficult interface, and it would be valuable to understand if there was anything in the current structure that helped this (not obvious), or the teams had already good interactions with hospitals (dealt with issues already or outside the knowledge of NanoTera), or there were in fact problems. It is noted that SNSF was able to bring in division III reviewers to help on these grants, but it is not clear if there were additional interactions with strategic focus of this division, linking to division II. Some strategic overview of the engineering science to bio-healthcare interface would have been helpful.

V/2. How do you assess the sustainability of the KTT after the end of the program, and especially the funding scheme Gateway?

Overall the early stage nature of the investments in Nano-Tera.ch make it very unlikely to be self sustaining, as if it were some Venture Fund. In the latter case, it would avoid too much risk and demand a later stage than the Nano-Tera.ch projects were at (more like Bridge). Instead, it is more appropriate to ask how these projects will feed back to the Swiss economy after 10 years, and this is much more likely to be a positive success with new companies, new relationships, new agendas, and new partnerships all developed.

The Gateway scheme is unlikely to generate revenue that will make it self-sustaining. It should help cross the “valley of death” between R & D, not act as a resource to give funds for future project support. It is possible that individual institutions will support some of this, but considering of providing governmental funding to this should be given.

The Bridge program, as it is currently implemented, does not address the gap created by the end of Nano-Tera.ch for several reasons. It does not support the upstream multidisciplinary research, and it also does not provide the strategic leadership and vision necessary to go beyond the level of selecting interesting disjoint projects. The Bridge projects themselves and their selection process are heavily dominated by scientific quality with economic valorization potential only considered a second criterion (more SNSF than CTI); there is, for example, no mandatory industrial advisory board per project; the selection panel consists almost entirely of people with a university appointment and less than 20% of the external experts have an industrial affiliation.

Questions about Overall appreciation

VI/1. To what extent was the program Nano - Tera.ch able to implement the underlying vision?

The vision was a program on large-scale, multidisciplinary research on complex systems for health, the environment, and energy. Nano-Tera certainly provided a strong platform to bring engineering science towards applications. It had a strong management team, and eventually strong buy-in from a range of PIs. The vision evolved over the duration of the project, which makes implementation measures harder to evaluate. Was the over-arching vision to change practice in academics, or was it to found new companies, or was it to generate patents, or to educate young researchers about innovation, or to bring together different teams to focus on applications? Nano-Tera found implementations for all of these; some were stronger than others. Nano-Tera did manage to correct issues as they were identified, and this has been a major strength of the management structure that it had.

In summary, the program strengthened connections between engineering science and applications. It connected scientists throughout Switzerland. Nano-Tera also strengthened connections between academia and industry. The Expert Panel is concerned about where these accomplishments have been institutionalized to a degree that will ensure their continuation.

VI/2. What are strengths and weaknesses? What might be the general lessons learned from the program ?

The strength of Nano-Tera.ch was to enable cross-disciplinary research across teams from (competing) federal and cantonal universities and universities of applied sciences, resulting in high quality and highly visible research projects with tangible demonstrators and in some cases also proof-of-concepts. At the same time, it educated a large group of PhD students in skills that are essential for the Swiss economy and only sparsely available.

It was not clear why the program did not at the earliest time after funding, scout around a number of other countries to look at what worked well in similar programs, and what worked less well. This could also have been done at the end of Phase I. Instead they seemed to develop everything themselves, which led to patchy incorporation of different schemes (like Next Step which seems anyway to have emerged from EPFL) and reduced impact among their own researchers as well as in wider society.

The lack of serious, sustained efforts to ensure a legacy of the Nano-Tera program can be viewed as a weakness. While it appears the Bridge program is now a downstream version of Nano-Tera.ch, there appears to be nothing like it on the horizon, doing the crucial job of connecting early-stage promising research with technological development and innovation into applications. Perhaps the legacy among the specific researchers is an appetite for engaging in this, but they may become now frustrated that there is no instrument to help them on this journey. We understand that some of the PI's are now looking for private resources to bridge this "funding gap", but this will not be suitable for the full Swiss engineering science community.

VI/3. Do you see an added value of such a comprehensive program or would some smaller but focused programs be more efficient ?

This comprehensive program is very strong in changing the practice and vision of engineering research and in injecting trained people into the industrial base. Now that Nano-Tera has demonstrated what is possible, similar results could probably be delivered from within a funding council rather than outside it, as long as a specific manager is given the responsibility for delivery and there are suitable evaluations, and no turf warfare in between science and application-based research funders. Both NanoTera and SNSF recommended in our site visit that decisions of excellence and strategic direction are integrated into the same committee, to avoid tensions between them (Excom and SNSF panels). This would also require clear guidelines on how to balance these tensions to the committee, but would lead to better transparency of decision making.

We asked if NanoTera could have been achieved as a dedicated ring-fenced fund inside SNSF delivering multiple calls for different themes, twinned with funding for a network and PhD training programme. One reason not to do this would be added value from Excom (though this also could be integrated into the SNSF delivery) and other management. It is

not clear where the added value was, since many of the components like NextStep were produced separately from the NanoTera management. The team gave not so obvious help to the different projects in market/business/mentoring directions, nor much engagement with industry (for instance no workshops for industries along themes as originally promised). The main dangers for a nanotera model embedded within SNSF are several fold: thought-leadership aside from internal review can be lacking, and extra funding promised by government to such programmes would not arise if they were vested in the existing research councils, and instead would take away money from existing funding for science. However the ranking system from SNSF, combined with another ranking by CTI or separate industrial board, and final decision by the ExCom, might combine the different aims well as long as a neutral but strong body oversaw it.

Annex C –SSC expert panel report and position statements, 2017–2018

Annex C31 – SNSF position paper on the SSC expert panel report

Dr. Frédéric Joye-Cagnard
Swiss Science Council SSC
Einsteinstrasse 2
CH-3003 Berne

Director
+41 (0)31 308 22 22
gs@snf.ch

Berne, 2 February 2018/AK

SNSF comments on the « Report on Nano-Tera.ch by the expert panel »

Dear Dr. Joye-Cagnard,

We would like to thank you for the «*Report on Nano-Tera.ch by the expert panel*» and the opportunity to offer our comments with respect to the role of the SNSF evaluation panel.

A) SNSF Panel criteria/composition. The SNSF Panel applied a set of criteria that can be split into two groups. First, the SNSF project evaluation criteria: Scientific quality, originality, adequacy of the methodology, feasibility, scientific track record. Second, a NT specific set of criteria, see for instance the [Call Document 2013](#)

- Integration into the overall Nano-Tera.ch vision
- Potential of the proposal in extending the state of the art in the Nano-Tera.ch domains
- Significant and genuine collaborative effort and synergy of the participants
- Ability to deliver realizations of the proposed results within the NT program lifespan
- Proven industrial interest in the research via financial and/or technical contributions
- Differentiation of the proposed activities when compared to other funded programs

The SNSF Panel had members from various industries: ICT (*IBM*, U. Dürig), medical technology (*Straumann*, M. Wieland), ICT (*Bell Labs*, D. Bishop), industrial consulting (*Crossbow Consulting*, A. Dunlop) and several from applied research.

Thus, we would like to emphasize that the “SNSF-only selection” included also NT specific criteria beyond scientific excellence and non-academic experts, which is in contrast to the statement by the Expert Panel:

I/5 “However, when scientific excellence is not the only criterion, but when also potential future economic impact and the fit to an overall strategic vision has to be taken into account, the SNSF-only selection procedure led to a collection of disjoint projects rather than to a coherent visionary program of complementary projects.”

B) Conflicts of interest. It is an inherent challenge to embed a coherent program in a small country, as a participation of the leading people is desirable in both the governance of the

program as well as in the execution of the program. In the case of NT, members of ExCom were at the same time in the role of applicants. For the SNSF, it is in such a situation of utmost importance to perform an independent evaluation. This is the reason for the “underutilization” of ExCom by the SNSF Panel that the Expert Panel stated:

I/5 *“the SNSF selection procedure underutilized the scientific leadership of the ExCom”*

- C) Overall strategic vision.** The Expert Panel states that the success of NT in implementing a coherent “overall strategic vision” of the program was limited and connects this observation to the selection mechanism:

I/1 *“the project selection mechanism, being focused solely on the quality of an individual project proposal, hampered strategic steering based on one central high-level vision per domain (health, environment, energy). This led to a collection of very high quality but disjoint projects rather than to a coherent visionary program of complementary projects...”*

V/1 *“Some strategic overview of the engineering science to bio-healthcare interface would have been helpful”*

The design of the selection mechanism (call documents and evaluation criteria) was in the responsibility of ExCom based on the mandate by SEFRI. The SNSF panel was responsible of implementing the selection procedure (see point A) above).

- D) Sustainable impact/legacy.** There is no strategic follow program of NT as correctly stated by the Expert Panel:

V/2 *“...The Bridge program, as it is currently implemented, does not address the gap created by the end of Nano-Tera.ch for several reasons. It does not support the upstream multidisciplinary research, and it also does not provide the strategic leadership and vision necessary to go beyond the level of selecting interesting disjoint projects.”*

However, the Bridge program targets the same critical step in a bottom-up instrument open for a broader range of disciplines. From the [terms of reference](#): “The goal of BRIDGE is to foster knowledge transfer in the critical precompetitive phase when a vision of potential applications of a scientific result exists, but further efforts are needed to bring the corresponding product, technology or service to a marketable form”.

The observed demand (see point E) below) confirms that the following statement by the Expert Panel is not to the point:

VI/2 *“...there appears to be nothing like it on the horizon, doing the crucial job of connecting early-stage promising research with technological development and innovation into applications”*

- E) Bridge.** Innosuisse and SNSF launched the Bridge Program in December 2016 with two instruments: Proof of Concept (young researchers, small grants, short duration) and Discovery (established researchers, substantial grants). In the meantime, Bridge has evaluated one

Discovery Call and five Proof of Concept Calls. The demand in both types of calls was strong, potentially also due to the preparation of the community by NT.

The evaluation in Proof of Concept focuses on the potential of innovation and economic impact and uses the implementation strategy based on a scientific idea by the applicants as the main evaluation criteria. The evaluation in Discovery attributes in the evaluation an equal weight to the potential of innovation/economic impact and to scientific quality. Thus, the following statement by the Expert Panel is in our opinion not justified:

V/2 *"The Bridge projects themselves and their selection process are heavily dominated by scientific quality with economic valorisation potential only considered a second criterion (more SNSF than CTI)"*

The Bridge evaluation panels must have a balanced mix of people. Currently, in Proof of Concept, we have a distribution between panel members with an industrial (43%), an applied research (28.5%) and a basic research (28.5%) affiliation. In Discovery, where the scientific impact is more important, the distribution is different with industrial (18%), applied research (32%) and basic research (50%). These numbers are in contrast with the statement:

V/2 *"... the selection panel consists almost entirely of people with a university appointment ..."*

The Discovery Evaluation Panel uses reviews from external experts as a part of the funding decision. In 90% of the proposals, there is at least one review from experts from industry or universities of applied science. These numbers are in contrast with the statement:

V/2 *"...less than 20% of the external experts have an industrial affiliation"*

The large demand for Bridge indicates that the offered funding schemes fill an important gap. The potential frustration mentioned by the Expert Panel is rather a result of the limited available funding (success rates of 11% after first call Proof of Concept, stabilizing at ca. 20% now; 4.2% in first call for Discovery) than of the lack of an appropriate instrument:

VI/2 *"Perhaps the legacy among the specific researchers is an appetite for engaging in this, but they may become now frustrated that there is no instrument to help them on this journey"*

Comment: One of the authors of the report of the Expert Panel, Prof. Rudy Lauwereins, is co-authoring three publications¹ with Prof. Giovanni De Micheli.

We hope that these clarifications will be useful in finalizing the SSC report on Nano-Tera and remain at your disposal for any other questions.

Yours sincerely,

A handwritten signature in black ink, appearing to read 'A. Kalt'.

Dr. Angelika Kalt

¹ The titles and links to the publications are:

[Wave pipelining for majority-based beyond-CMOS technologies,](#)

[Inversion optimization in Majority-Inverter Graphs,](#)

[Design and benchmarking of hybrid CMOS-Spin Wave Device Circuits compared to 10nm CMOS.](#)

Annex C –SSC expert panel report and position statements, 2017–2018

Annex C32 –Nano-Tera.ch position paper on the SSC expert panel report

Département fédéral de l'économie, de la
formation et de la recherche DEFR
Conseil Suisse de la Science
Einsteinstrasse 2, CH-3003 Berne

Lausanne, February 16th, 2018

Ref: Nano-Tera.ch Impact Evaluation: Answer to the report from Expert Panel

We would like to thank the Expert Panel for the effort and time spent for the evaluation. We agree with most findings of the Panelists: here we rebut some of the issues that were raised. First of all, it has to be understood that the Nano-Tera.ch program operated under the Rules and Regulations that were imposed on us at the start of the program. In some cases, these rules were limiting. Nevertheless a strong effort was put into making the best program within the given constraints. Second, we focus here on rebutting only the main criticisms.

Lack of a coherent, overall vision in the selection of the funded projects: the project selection (and yearly evaluation) was based on intrinsic excellence and performed by the Swiss National Science Foundation Panel. The Nano-Tera.ch EXCOM objected to some of the project choices during Phase 1, because the EXCOM required more continuity among projects and a better fit with the strategic vision. This concern was echoed by both the Scientific Advisory Board and the Steering Committee. The issue was formally brought to the highest level of SNF in a meeting in Bern in February 2009, but unfortunately the SNF rejected any dialog on the project selection issue. The situation improved in Phase 2, when the SNF Panel agreed on some cooperation, such as adding women to the evaluation panel, as the female gender was unrepresented. In Phase 2, the SNF panel was also more open to receive some indications from the EXCOM on the strategic fit of the projects, but it still executed selection decisions singlehandedly. There were two other unfortunate outcomes of the project selection policy: 1) only six projects (out of 19) were continued from Phase 1 to Phase 2 (thus hurting continuity) and 2) the SNF Panel had a bias against selecting projects involving industry, as considered not in the direction of pure research. However, it has to be noted that the panel executed its duties according to their marching order. There was no adverse feeling between SNF Panelists and NT EXCOM members. Rigidity, which is deprecable, was a result of the imposed Rules and Regulations.

The KTT dimension: The nature and extent of Nano-Tera's KTT-related measures have been strongly constrained by the imposition to work under SNF's umbrella, while typically projects involving industry are run by CTI/KTI which was not involved in Nano-Tera.ch. Within this rather unfavorable context, the program nevertheless fostered people-based KTT by requiring the presence of industrial, translational, and use-oriented partners in the project consortia. This approach turned out to be very successful (with 50% of non-academic partners active in the project consortia) and has been considered as a very efficient KTT channel by the KOF expert mandated by NT to evaluate the economic impact of the program. In addition, Nano-Tera.ch also invested much of the residual funds of Phase 1 and a fraction of the strategic funds of Phase 2 into additional specific KTT measures, selected because of

their synergistic value with research. Namely, the *Gateway* program for the transfer of research results into industry-level prototypes, and the *NextStep* entrepreneurial track helping PhD students explore the economic value of their research. Both efforts have been considered as successful and original, and it is very questionable whether additional actions (such as the setup of an Industrial Advisory Board or Industrial Mentoring program) would have been realistically possible with the financial and human resources available.

The institutional legacy: the specific legal status of Nano-Tera.ch (“National Joint Action”) did not provision for any potential legacy of the program. In particular, it did not require from the involved institutions any commitment in terms of long-term structural investment (such as the creation of permanent chairs, or institutionalized entities), while this is the case for other funding instruments such as the SNF’s NCCRs. As a consequence, the 9-year funding provided to Nano-Tera.ch has to be considered as transitory, and not targeted to the setup of a permanent structure. Within this framework, Nano-Tera.ch proposed BRIDGE as a continuation and implementation plan, and produced BRIDGE’s first concept. However, for various reasons, it was decided (above the Nano-Tera.ch level) to exclude Nano-Tera.ch from the BRIDGE constituency, thus impeding an explicit institutional legacy for the program. Nevertheless, Nano-Tera’s impact on BRIDGE has been clearly substantiated by the fact that about 60% of the selected projects in the first BRIDGE Discovery call were building on results achieved within Nano-Tera, thus providing a scientific legacy of Nano-Tera.ch.

Overall, we want to stress that Nano-Tera.ch research has achieved a worldwide strong impact while staying within the rules and framework that were imposed. We believe that the relative autonomy of Nano-Tera.ch from funding agencies was a key to the overall success, and that eventual drawbacks just came from limitations in project selection and evaluation. We would hope that future program have more autonomy from funding agencies and be based on real trust of scientists in pursuing and managing independently research objectives, because they can decide better and return more value of taxpayer money in terms of research and innovation.

I am available after February 19 for any further clarification.

Best regards



Giovanni De Micheli
Program leader, Nano-Tera.ch

Annex D – Knowledge and technology transfer in Nano-Tera.ch, October 2017

Meyer, L. and Rieder, S. (Interface) (2017), Wissens- und Technologietransfer von Nano-Tera.ch. Schlussbericht zuhanden der Geschäftsstelle des Schweizerischen Wissenschafts- und Innovationsrates (SWIR), 3. Oktober 2017, Luzern, Interface-Politikstudien.

Wissens- und Technologietransfer von Nano-Tera.ch

Schlussbericht zuhanden der Geschäftsstelle des Schweizerischen Wissenschafts- und Innovationsrates (SWIR)

Luzern, den 3. Oktober 2017

IMPRESSUM

Autorinnen und Autoren

Dr. Lea Meyer (stv. Projektleitung)

Dr. Stefan Rieder (Projektleitung)

INTERFACE

Politikstudien Forschung Beratung

Seidenhofstrasse 12

CH-6003 Luzern

T +41 41 226 04 26

interface@interface-politikstudien.ch

www.interface-politikstudien.ch

Auftraggeber

Schweizerischer Wissenschafts- und Innovationsrat (SWIR)

INHALTSVERZEICHNIS

ABKÜRZUNGSVERZEICHNIS	5
EXECUTIVE SUMMARY	6
I ZUSAMMENFASSUNG DER ERGEBNISSE UND SCHLUSSFOLGERUNGEN	8
1.1 Ergebnisse	8
1.2 Folgerungen	11
2 EINLEITUNG	13
2.1 Ausgangslage	13
2.2 Zielsetzung und Fragestellungen des Auftrags	14
2.3 Methodisches Vorgehen	15
2.4 Grenzen der Untersuchung	16
2.5 Aufbau des Berichts	17
3 DAS WTT-KONZEPT VON NANO-TERA.CH	18
3.1 Die zwei Phasen von Nano-Tera.ch	18
3.2 Theoretische Überlegungen zum Thema Wissens- und Technologietransfer	21
3.3 WTT-Konzept von Nano-Tera.ch	24
3.4 Befund 1: Der WTT von Nano-Tera.ch entspricht am ehesten einem reflexiven Konzept mit vereinzelt Interfaces	24
3.5 Befund 2: Es wurde eine breite Palette von Instrumenten zur Umsetzung des WTT eingesetzt	27
4 WTT IN DREI AUSGEWÄHLTEN PROJEKTEN	32
4.1 Verständnis und Umsetzung des WTT in den untersuchten Projekten	32
4.2 Instrumenteneinsatz	36
4.3 Stärken und Schwächen in der WTT-Umsetzung	38
5 KURZVERGLEICH MIT DER ERSTEN SERIE DER NATIONALEN FORSCHUNGSSCHWERPUNKTE (NFS)	41
5.1 Konzeptvergleich	41
5.2 Instrumentenvergleich	42

ANHANG 1: ANALYSEMASTER	44
ANHANG 2: LISTE DER INTERVIEWTEN	45
ANHANG 3: AUSGEWÄLTE DATEN ZU NANO-TERA.CH	46
ANHANG 4: TECHNOLOGY READINESS LEVELS (TRL)	47
ANHANG 5: VERWENDETE LITERATUR ZUM THEMA WTT	48
ANHANG 6: WEITERFÜHRENDE LITERATUR ZUM WTT	49

ABKÜRZUNGSVERZEICHNIS

CCMT:	Competence Center for Medical Technology
ED:	Education and Dissemination Activities
EPFL:	École Polytechnique Fédéral de Lausanne
ETH:	Eidgenössische Technische Hochschule
KMU:	Kleine und mittlere Unternehmen
KTI:	Kommission für Technologie und Innovation
NCCR:	National Center of Competence in Research (Nationaler Forschungsschwerpunkt)
NFS:	Nationaler Forschungsschwerpunkt
NFT:	Nano-tera focused Project
RTD	Research, Technology and Development Project
SBFI:	Staatssekretariats für Bildung, Forschung und Innovation
SFI:	Swiss Finance Institute
SNF:	Schweizerischer Nationalfonds zur Förderung der wissenschaftli- chen Forschung
SNI:	Swiss Nanoscale Institute
SWIR:	Schweizerischer Wissenschafts- und Innovationsrat
WTT:	Wissens- und Technologietransfer

EXECUTIVE SUMMARY

Nano-Tera.ch is a Swiss national program supporting research in multi-scale system engineering for health, security, energy, and environment. The main objectives are: excellence in collaborative research in engineering disciplines, educational programs, design of applied demonstrators, and transfer of acquired research results to the Swiss industry.

The program is partly financed through public contributions and partly through matching funds from project partners. Running between 2008 and 2016, the overall costs of the program have been approximately CHF 259 million. As the program came to an end, the Swiss Science and Innovation Council mandated *Interface Policy Studies, Research, Consulting* to carry out an analysis on the knowledge and technology transfer (KTT) of Nano-Tera.ch. The goal was to collect and analyse relevant information concerning the KTT.

Interface has analysed relevant documents and interviewed 15 persons involved with the program. It has further conducted three case study analyses of projects that received Nano-Tera.ch funding. As a result, the following conclusions on the KTT concept and its implementation in the Nano-Tera.ch program have been reached:

Nano-Tera.ch has no explicit and integrated KTT concept. This is somehow surprising as the main objective of the program was to promote the step from fundamental research to its application. The lack of an explicit KTT concept may render its practical implementation and monitoring difficult. Based on the documents and the interviews, an implicit reflective concept can be identified. Its aim is to promote the exchange between science, industry, and users, and to bridge the gap between fundamental and applied research. The concept of Nano-Tera.ch has evolved over time, and resulted in a shift towards the implication of end-users in the research, rather than of industrial partners. Further, in a second phase of the program a specific instrument (Gateway) was introduced in order to turn demonstrators into potential industrial prototypes.

Nano-Tera.ch was mainly promoted indirectly. In literature it is argued that the best effect of KTT is to use a mix of instruments promoting a direct transfer across people, rights, and technologies, and an indirect transfer through communication, and implementation structures. Nano-Tera.ch mainly makes use of instruments promoting an indirect transfer, namely the standard academic knowledge-transfer instruments such as publications, presentations, and conferences. Furthermore, Nano-Tera.ch implemented structures and special programs for PhD students. A unified, consistent, and systematic monitoring of the numbers and the extent to which the instruments are applied in order to promote KTT appears to be lacking. Nano-Tera.ch is currently undertaking much-needed efforts to collect data in this area.

The understanding of KTT differs across projects. To illustrate the implementation of KTT in the funded projects, Interface conducted three case studies. These showed that the understanding of KTT differs from project to project: some of the interviewed per-

sons saw KTT as the sharing of knowledge, whereas others linked it to the development of an application that has a potential for the industry. Such differences could also be related to the maturity level of the projects. Those with a more fundamental research orientation seem to see KTT more on the knowledge-sharing side. More advanced and applied projects focus more strongly on the technological aspects of KTT.

Different concept, but similar application as in former programs. Compared to the previous NCCR (National Centres of Competence in Research) research program (so-called NFS Nationale Forschungsschwerpunkte), Interface observes a very similar approach to KTT. Like Nano-Tera.ch, the NFS projects have no explicit concept. However, the implicit concept found for the NFS shows a more linear approach towards KTT, with industrial users and end-users not being included in the research from the beginning. Furthermore, like Nano-Tera.ch, the NFS projects also used very similar and mainly indirect instruments to promote KTT.

I ZUSAMMENFASSUNG DER ERGEBNISSE UND SCHLUSSFOLGERUNGEN

Der SWIR beauftragte Interface Politikstudien, eine Beurteilung des Wissens- und Technologietransfers (WTT) von Nano-Tera.ch vorzunehmen. Ziel des Auftrags war es, das Konzept und die Umsetzung des WTT von Nano-Tera.ch zu analysieren und zu beurteilen. Zu diesem Zweck wurden eine Reihe von Dokumenten ausgewertet und mit 15 Personen Interviews geführt. Ferner wurden drei Fallstudien erstellt und ein Vergleich mit den NFS der ersten Serie durchgeführt. Wir fassen an dieser Stelle die wichtigsten Ergebnisse zusammen und ziehen einige Schlussfolgerungen.

I.1 ERGEBNISSE

Die Ergebnisse lassen sich in vier Gruppen einteilen, die gleichzeitig auch den Gegenstand der Analyse bildeten.

Ergebnisse zur Konzeption: Welches Konzept des WTT liegt vor?

Nano-Tera.ch verfügt über kein explizites und geschlossenes Konzept zum Wissens- und Technologietransfer. Dies ist erstaunlich für ein Programm, das sich explizit zum Ziel gesetzt hat, den Sprung von der Grundlagenforschung in die Anwendung zu überbrücken. Das Fehlen eines expliziten, dokumentierten Konzeptes erschwert vermutlich die Umsetzung des WTT in der Praxis und den Aufbau eines entsprechenden Monitorings.

Betrachten wir die analysierten Dokumente und die Ergebnisse der Interviews, so lässt sich bei Nano-Tera.ch ein *implizites reflexives WTT-Konzept* erkennen. Es soll ein Austausch zwischen der Wissenschaft, der Industrie und den Endnutzern gefördert werden. Gemessen an seinen Zielen ist dieses reflexive WTT Konzept angemessen: Nano-Tera.ch will einen Bogen zwischen Grundlagen- und angewandter Forschung schlagen, um so das Potenzial zur Nutzung von Forschung durch Industriepartner zu erhöhen. In einer ersten Phase wurden Industriepartner in den Projekten vorgeschrieben. In einer zweiten Phase, wurde der Einbezug von Endnutzern in den Projekten obligatorisch. Die Industriepartner und Endnutzer mussten zudem einen finanziellen Beitrag (in bar oder Sacheinlagen) leisten. Was dem WTT von Nano-Tera.ch in der Praxis im Vergleich zum theoretischen Anspruch eines reflexiven Modells abgeht, ist ein substanzieller Input der Industriepartner zu den Forschungsfragen vor allem zu Beginn des Forschungsprozesses. Wir haben keine Indizien dafür gefunden, dass dieser Einbezug stark ausgeprägt war, wie es für ein reflexives Modell an sich postuliert würde.

Nano-Tera.ch hat im Verlauf der Programmdauer sein WTT-Konzept etwas verändert und sich stärker den Endnutzern seiner Forschung zugewendet, um den Transfer von Wissen zu stärken. Dies erscheint angesichts der Ziele konsequent. Für die zweite Phase des Programmes konnten *Interfaces* identifiziert werden, die den WTT befördern: Mit der Einführung von Gateway-Projekten wurde ein Instrument gestaltet, das die Brücke zwischen Forschung und Industrie schlägt. Zudem hatte Nano-Tera.ch in der zweiten Phase einen Innovation Manager angestellt, der den Fortschritt der Gateway-Projekte

überwachte. Dieser traf die Programmverantwortlichen alle drei Monate zu einem Gespräch und evaluierte den Projektfortschritt anhand von Balanced Scorecards. Betrachten wir den Mitteleinsatz, so muss dennoch festgestellt werden, dass die Verschiebung hin zur Anwendungsorientierung gemessen an den Mitteln für die Gateway-Projekte eher klein ist.

Ergebnisse zur Umsetzung

Nano-Tera.ch hat eine breite Palette von Instrumenten eingesetzt, um den WTT zu fördern. Dies ist positiv, ist aus der Literatur doch bekannt, dass der WTT idealerweise über *direkten* (über Personen, Rechte und Technologien) wie auch über *indirekten Transfer* (Kommunikationsmittel, Aufbau von Strukturen) erfolgen muss, um besonders erfolgreich zu sein. Positiv fällt auf, dass dem Transfer von implizitem Kontextwissen über Personen ein grosses Augenmerk geschenkt worden ist. Allerdings wird dieser Eindruck dadurch getrübt, dass wenig systematisch erhobene Zahlen vorhanden sind, die den Umfang dieser Aktivitäten beschreiben würden. Zudem fällt auf, dass die Beurteilung des WTT ausschliesslich quantitativ erfolgte (Anzahl Start-ups, Publikationen etc.) und keine qualitative Beurteilung, z.B. in Form von Interviews mit Industriepartnern, erfolgte.

Die grösste Zahl von Instrumenten werden im Bereich des indirekten Transfers eingesetzt: Es handelt sich dabei um die im akademischen Umfeld üblichen Publikationen, Präsentationen und Konferenzen. Auch wurden Strukturen geschaffen und spezielle Programme für Doktorierende geschaffen.

Ergebnisse aus den Fallstudien: Wie wird der WTT im konkreten Fall umgesetzt?

Für drei Projekte von Nano-Tera.ch wurde der WTT mittels Dokumentenanalyse und Interviews genauer untersucht. Die drei Projekte sind erstens *HearRestore* (Image-guided microsurgery for hearing aid implantation), zweitens *OpenSense* (Crowdsourcing High-Resolution Air Quality Sensing) und drittens *FlusiTex* (Fluorescence sensing integrated into medical textiles). Die Erhebungen führten zu folgendem Befund: In keinem der drei untersuchten Projekte existierte ein explizites, in Dokumenten festgehaltenes WTT-Konzept. Auf Grund der Recherchen konnte in zwei der drei Projekte ein implizites reflexives WTT-Konzept ermittelt werden. OpenSense entspricht eher einem linearen WTT-Verständnis.

Die Projekte zeigen auch einen unterschiedlichen Forschungsverlauf: Zwar haben alle drei im Rahmen der Fallstudien untersuchte Projekte eine Entwicklung in Richtung Markt hinter sich. Allerdings verfügten die zwei Projekte (HearRestore und FlusiTex) mit einem eher reflexiven WTT-Verständnis schon bei Projektstart über eine engere Vernetzung mit den Marktpartnern. Logischerweise ist die Marktnähe dieser beiden Projekte am Schluss ihrer Laufzeit vergleichsweise höher.

In der Umsetzung der Fallstudien zeigt es sich, dass verschiedene Instrumente für den WTT benutzt werden. Es überwiegen aber die indirekten Instrumente, zum Beispiel Publikationen und Konferenzen. Der Einbezug von Partnern scheint für den WTT zentral zu sein, er ist aber aufwändig und benötigt Zeit und Ausdauer. Die Gateway-Projekte haben sich dafür bewährt und wurden geschätzt.

Die Interviews wiesen auf verschiedene Stärken und Schwächen in der Umsetzung des WTT hin. Demnach funktioniert der WTT dann besonders gut, wenn die Konsortien (Hochschulen, Industrie, Anwender) einen klaren Willen zur Zusammenarbeit bekunden, früh im Forschungsprozess mit dem Austausch beginnen und sich bereits aus früherer Zusammenarbeit gut kennen. Ebenso dürften Folgeprojekte wie die Gateway-Projekte und der gezielte Einsatz von Instrumenten den WTT voranbringen.

Es haben sich im Rahmen der Fallstudien aber auch Schwächen im WTT gezeigt. Bedeutend sind dabei strukturelle Aspekte. Nachfragen bei den Programmverantwortlichen, wieso die Gateway-Projekte als erfolgreiches Instrument erst am Schluss im Verlaufe der zweiten Phase von Nano-Tera.ch eingeführt worden seien, führten zu folgendem Befund: Offenbar war die Verteilung der Mittel bereits zu Beginn des Programmes festgelegt worden. Die Gateway-Projekte konnten daher nicht mehr aus dem ordentlichen Programmbudget sondern mussten aus dem (wesentlich kleineren) strategischen Budget der Programmleitung finanziert werden. In diesem Kontext wurde von einigen Interviewten weiter kritisiert, dass der SNF bei seiner Beurteilung der Projektanträge primär die wissenschaftliche Exzellenz im Auge gehabt, das Potenzial eines Projektes für den WTT hingegen eher gering gewichtet habe. Diese beiden Aspekte können als zwei wichtige strukturelle Schwächen von Nano-Tera.ch in Bezug auf den WTT gewertet werden.

Eine dritte Schwäche betrifft das Monitoring des WTT. Es überrascht, dass die Projekte nur einmal jährlich anlässlich des Jahrestreffens beurteilt wurden. Nachfragen bei den Verantwortlichen zeigten, dass bei den RTD-Projekten (Forschung, Technologie und Entwicklung), kein vertraglicher Mechanismus vorhanden war, der ein Monitoring des WTT erlaubt hätte. Das Reporting beschränkte sich daher auf die Jahrestreffen und die Präsentationen der Projektteams vor dem Evaluations-Panel.

Vergleich mit der ersten Serie der nationalen Forschungsschwerpunkte (NFS)

Ein Vergleich mit der ersten Serie der NFS zeigt, dass bei beiden Programmen kein explizites Konzept für den WTT vorlag. Der Ansatz ist aber unterschiedlich, da die Mehrheit der Programme der ersten Serie des NFS im Gegensatz zu Nano-Tera.ch einen linearen WTT-Ansatz verfolgt hat. Bei den WTT-Instrumenten sind viele Ähnlichkeiten zu beobachten und in beiden Programmen werden am häufigsten Instrumente für den indirekten Transfer benutzt. Was auffällt ist der Umstand, dass die Ausgaben für den WTT bei Nano-Tera nicht wesentlich höher liegen als beim Schnitt der Programme der ersten Serie des NFS. Dies ist für ein besonders auf WTT ausgerichtetes Programm doch eher erstaunlich. In Bezug auf die Outputs des WTT (im Sinne von Patenten, Transfer von Doktorierenden, Produkten etc.) lässt sich festhalten, dass viele Daten bei Nano-Tera.ch (noch) fehlen, um einen aussagekräftigen Vergleich anstellen zu können.

1.2 FOLGERUNGEN

Es ist nicht das Ziel dieses Berichtes, Empfehlungen an Nano-Tera.ch oder an den SWIR zu formulieren. Wir beschränken uns daher an dieser Stelle auf einige Schlussfolgerungen allgemeiner Natur.

Explizite WTT-Konzepte formulieren

Der Wissens- und Technologietransfer lässt sich nicht einfach beschreiben. Er hängt in hohem Masse von den Eigenschaften von Disziplinen ab, von der Bereitschaft der beteiligten Forschenden und dem bestehenden Beziehungsnetz zwischen Forschung, Industrie und Endanwendern, um nur einige Faktoren zu nennen. Dennoch oder gerade wegen der situativen Unterschiede von Fall zu Fall scheint es uns sinnvoll, Konzepte für WTT in Forschungsprogrammen *explizit zu formulieren*. Diese WTT-Konzepte sollten im Minimum spezifische Ziele für den WTT, die Benennung von Instrumenten, die erwarteten Outputs, ein Budget und eine Verantwortlichkeit für WTT umfassen. Ein solches Konzept hat drei Vorteile: Erstens zwingt die Formulierung eines WTT Konzeptes die Verantwortlichen von Forschungsprogrammen, sich mit den Zielen und Wirkungsweisen des WTT auseinanderzusetzen. Zweitens ist der WTT gegenüber den Forschenden, der Industrie und den Anwendenden einfacher zu kommunizieren, wenn er schwarz auf weiss beschrieben ist. Auch wenn sich nicht alle Parteien über den Sinn des WTT einig sein dürften, wird ein explizites Konzept die Diskussion über den WTT erleichtern. Drittens lässt sich mit einem expliziten Konzept auch der Erfolg des WTT besser überprüfen. Bei impliziten Konzepten ist umgekehrt die Versuchung gross, ex-post beobachtete Entwicklungen in ein bewusstes Konzept umzumünzen.

Verstärktes Monitoring der WTT-Aktivitäten

Die Analyse hat gezeigt, dass ein begleitendes Monitoring der WTT-Aktivitäten sinnvoll ist. Ein nachträgliches Erfassen von Monitoring-Grössen ist zwar sicherlich interessant und eröffnet Einsichten. Es erlaubt aber keine aktive Steuerung des WTT-Prozesses, ist aufwändig und führt wegen fehlender Daten oft nicht zum Ziel. Voraussetzung für ein solches Monitoring ist allerdings seine Verankerung in den Projektentscheiden. Dabei ist nicht entscheidend, dass besonders viele Daten erhoben werden, sondern dass jene Daten erhoben werden, welche bei der Überprüfung der Ziele des WTT-Konzeptes notwendig sind. Die Auswahl der möglichen Indikatoren ist gross und kann leicht erstellt werden.

WTT als Selektionskriterium bei der Auswahl von Projekten festlegen

Im Rahmen der Interviews wurde immer wieder auf das Dilemma bei der Auswahl von Projekten hingewiesen: Bei der Selektion von Forschungsgesuchen werde den akademischen Kriterien mehr Gewicht eingeräumt als den Fragen des WTT. Wir glauben, dass erstens eine ex-ante Festlegung der Art der auszuwählenden Projekte im Diagramm von Ruttan sinnvoll wäre, um die Bedeutung des WTT im Auswahlprozess zu stärken. Wenn der WTT eine wichtige Rolle spielen sollte (also Projekte im Bereich der angewandten Grundlagenforschung, der Ressortforschung oder der industrienahen Forschung gefördert werden sollten), wäre dem WTT bei der Auswahl der Forschungsgesuche angemessene Rechnung zu tragen.

WTT-Erwartungen an Projekte anpassen und Flexibilität erlauben

Die von Nano-Tera.ch finanzierten Projekte haben einen unterschiedlichen TRL (also Reifegrad in Bezug auf den Transfer zur Wirtschaft). In den Projekten zeigt es sich, dass die WTT-Aktivitäten auch darum nicht gleich gut gestaltet worden sind, weil gewisse Projekte ausschliesslich als Grundlagenforschung gestaltet worden sind. Für solche Projekte kann von vornherein die Erwartung an den WTT gesenkt werden, was Forschende und WTT-Verantwortliche gleichermassen entlastet.

Im September 2016 beauftragte das Staatssekretariat für Bildung, Forschung und Innovation (SBFI) den Schweizerischen Wissenschafts- und Innovationsrat (SWIR), eine Wirkungsprüfung des Förderprogramms Nano-Tera.ch 2008–2016 durchzuführen. Ein spezielles Augenmerk sollte auf den Wissens- und Technologietransfer (WTT) gerichtet werden.

Der SWIR beauftragte Interface Politikstudien, ihn hinsichtlich des zuletzt genannten Punkts zu unterstützen. Ziel des Auftrags ist die Zusammenstellung und Analyse von relevanten Unterlagen und Informationen bezüglich des WTT von Nano-Tera.ch. Parallel dazu wird das Programm Nano-Tera.ch eine Selbstevaluation durchführen, die dem SWIR zugeleitet wird. Die Untersuchung des WTT durch Interface soll es dem SWIR erlauben, die in der Selbstevaluation von Nano-Tera.ch dokumentierten Ergebnisse besser beurteilen und Schlüsse im Rahmen der Gesamtevaluation ziehen zu können.

2.1 AUSGANGSLAGE

Bei Nano-Tera.ch handelt es sich um ein Forschungsprogramm, das mit ca. 249 Millionen Franken insgesamt ungefähr 150 Projekte finanzierte.¹ Die Finanzierung wurde mit ungefähr 110 Millionen Franken aus öffentlichen Geldern unterstützt², der Rest wurde durch Projektpartner finanziert.³ Das Programm unterschied zwischen zwei Phasen: 2008 bis 2012 und 2013 bis 2016. In der zweiten Phase wurden total 134 Millionen Franken für Projekte ausgegeben. Nano-Tera.ch fördert gemäss Jahresbericht 2016 vier Arten von Projekten:⁴

- Der überwiegende Teil der Projekte von Nano-Tera.ch zählt zur Gruppe der RTD-Projekte, die eine Laufzeit von zwei bis drei Jahren aufweisen und mit 1 bis 2 Millionen Franken pro Projekt gefördert wurden. In der zweiten Phase wurden 25 solche Projekte gefördert. Diese entsprechen 95 Prozent der gesamten Nano-Tera.ch Finanzierung und sind deshalb der Kern der Analyse zum WTT.
- Ein Teil der Projekte fokussiert auf bestimmte ausgewählte Fragestellungen; sie werden als Nano-Tera.ch Focused (NTF) Projekte bezeichnet. Deren Laufzeit beträgt ein bis zwei Jahre und die Unterstützungssumme betrug zwischen 100'000 und 200'000 Franken. In der zweiten Phase wurden neun solche Projekte unterstützt.
- Nano-Tera.ch finanzierte auch Ausbildungs- und Verbreitungsaktivitäten. Dazu zählen Konferenzen, Minikonferenzen, Workshops und neue Curricula, welche die

¹ Zahlen aus Nano-Tera.ch, Scientific Reports 2013 und 2016, S. 7.

² Die öffentlichen Gelder werden durch jährliche Beiträge der Schweizer Universitätskonferenz und des ETH-Rats zur Verfügung gestellt (Nano-Tera.ch, Ordinary Partnership Contract, January 2008, art. 35 abs. 1).

³ Nano-Tera.ch, Scientific Report 2016, S. 3.

⁴ Nano-Tera.ch, Scientific Report 2016, S. 7.

Schweizer Hochschulen nicht anbieten. Diese Projekte sind vergleichsweise klein und wurden mit Beträgen zwischen 15'000 und 30'000 Franken unterstützt. In der zweiten Phase wurden 21 solche Aktivitäten gefördert.

- Die kleinste Gruppe bilden die sogenannten Gateway-Projekte, die eng mit der Industrie kollaborieren. In der zweiten Phase wurden acht solche Projekte durchgeführt. Diese werden in der Analyse ebenfalls berücksichtigt, da sie gezielt den WTT fördern.

Im Kontext der Wirkungsprüfung durch den SWIR soll auch der Wissens- und Technologietransfer zwischen dem Programm und den Forschenden an den beteiligten Universitäten einerseits und den potenziellen Nutzenden der Forschungsergebnisse andererseits untersucht werden. Zu den Nutzenden gehören insbesondere die Wirtschaft (Unternehmen) wie auch die Verwaltung und weitere Organisationen.

2.2 ZIELSETZUNG UND FRAGESTELLUNGEN DES AUFTRAGS

Das Ziel des Auftrags an Interface lässt sich wie folgt umschreiben:

- Das Konzept des Wissenschafts- und Technologietransfers (WTT) von Nano-Tera.ch ist zu beschreiben und aus einer theoretisch Perspektive heraus zu würdigen.
- Anhand von ausgewählten Fallbeispielen soll die Umsetzung des WTT exemplarisch beschrieben werden.
- Soweit möglich soll der WTT von Nano-Tera.ch mit jenem der ersten Serie der Nationalen Forschungsschwerpunkte (NFS) verglichen werden.

Der SWIR wird die gemäss diesen Zielen gewonnen Erkenntnisse in seine eigene Evaluation einfließen lassen. Ausgehend von den drei Zielen lassen sich drei Gruppen von Fragestellungen identifizieren.

Fragestellung zum Konzept des WTT: Wie sieht das WTT-Konzept von Nano-Tera.ch aus?

- Ist ein Konzept zum WTT erkennbar und dokumentiert?
- Welcher Ansatz wird gewählt?

Fragestellung zur Umsetzung des WTT: Welche Elemente des WTT sind in der Umsetzung erkennbar?

- Sind Informationen zur Umsetzung der Konzeption verfügbar (Statistiken, Output-Daten usw.)?
- Lassen sich die in der Konzeption vorgefundenen Prozesse in ausgewählten RTD-Projekten exemplarisch erkennen und nachvollziehen?

Fragestellung zum Vergleich mit den NFS der ersten Serie: Wie sieht das WTT-Konzept von Nano-Tera.ch im Vergleich aus?

- Wie ist das Konzept von Nano-Tera.ch im Vergleich mit den Konzepten der NFS der ersten Serie zu beurteilen?
- Wo ergeben sich Unterschiede in der Umsetzung?

2.3 METHODISCHES VORGEHEN

Um den Wissens- und Technologietransfer in Nano-Tera.ch zu untersuchen, wurden vier Arbeitsschritte durchgeführt.

Schritt 1: Analyseraster und Dokumentenanalyse

Um erste Informationen über die WTT-Aktivitäten von Nano-Tera.ch zu erhalten, erstellte Interface ein Analyseraster (vgl. Anhang A1). Dieser wurde auf die vorhandenen Dokumente von Nano-Tera.ch angewendet. Die wichtigsten ausgewerteten Dokumente seien hier aufgeführt.

- Dokumente von Nano-Tera.ch wie die Jahresberichte („Scientific Reports“), die Ausschreibungen („Calls“) für die Unterstützung von Projekten und die Jahresreportings („Scientific Project Reports“) der einzelnen Projekte
- Informationen auf den Internetseiten von Nano-Tera.ch
- Vom SWIR zur Verfügung gestellte Dokumente wie zum Beispiel die Programmvereinbarungen zwischen dem Schweizerischen Nationalfonds (SNF) und Nano-Tera.ch, der Business Plan von Nano-Tera.ch, Angaben zu den finanziellen Kennzahlen, die Beurteilung des SNF von Projekten und Sitzungsprotokollen
- Vereinzelte, von den Gesprächspartnern zur Verfügung gestellte Dokumente und Daten zu Projekten und WTT-Aktivitäten

Daneben standen eine Fülle von Informationen aus rund 200 Dokumenten des Programmes und der Fallstudien zur Verfügung. Diese Unterlagen wurden in Hinblick auf die Fragestellung zum WTT nur grob gesichtet und mit verschiedenen Schlagworten in drei Sprachen (Technologie, Zusammenarbeit, Austausch, Wissenstransfer, Transfer, WTT) durchsucht. Eine Synthese findet sich in Anhang A3. Eine vollständige Analyse aller Inhalte war im Rahmen dieser Untersuchung aber nicht möglich.

Schritt 2: Interviews mit Nano-Tera.ch-Verantwortlichen und Programm-Partnern

Basierend auf den Ergebnissen der Dokumentenanalyse wurden mit vier Verantwortlichen von Nano-Tera.ch Gespräche geführt (vgl. Liste der Gesprächspartner im Anhang A2). Daneben wurde mit einer Partnerorganisationen auf Programmebene ein Interview geführt. Hier stehen generelle Fragen zum WTT auf Stufe des Gesamtprogramms im Zentrum.

Schritt 3: Durchführung der Fallstudien

Es wurden drei Fallstudien durchgeführt. Die möglichen Kriterien für die Auswahl der Fallstudien waren zahlreich: Fälle konnten entweder nach den thematischen Schwerpunkten (Bioengineering und Electronics), nach den vier Bereichen (Gesundheit, Sicherheit, Energie, Umwelt) oder aber nach Art des Projektes (RTD, NTF, Gateway and Strategic Action) ausgewählt werden. Schliesslich war auch eine Auswahl von Projekten aus den zwei Projektphasen 2009 bis 2013 oder 2013 bis 2016 denkbar.

Angesichts der Zahl von drei Fallstudien waren die Auswahlkriterien zu hoch. Die Auswahl erfolgte deshalb sehr pragmatisch: Die Fallstudien konzentrieren sich auf die finanziell betrachtet wichtigste Gruppe der RTD-Projekte. Die SWIR-Geschäftsstelle, Nano-Tera.ch und Interface wählten je zwei Projekte aus. Die Projekte sollten möglichst typisch sein für die jeweilige Serie und zwar im Hinblick auf die Grösse des Projekts, den Einbezug von Unternehmen und Verwaltung in den Forschungsprozess und dem WTT-Konzept, das in den Projekten zur Anwendung kommt. Aus dieser Auswahl wählte der SWIR gemeinsam mit Interface zwei Projekte. Ein drittes Projekt wurde vom SWIR und von Interface unabhängig vom Vorschlag von Nano-Tera.ch ausgewählt. Als Fallstudien wurden schliesslich folgende Projekte ausgewählt:

- HearRestore: Image-guided microsurgery for hearing aid implantation
- OpenSense: Crowdsourcing High-Resolution Air Quality Sensing
- FlusiTex: Fluorescence sensing integrated into medical textiles

Die Fallstudien wurden alle nach dem gleichen Verfahren erstellt:

- Die wichtigen Dokumente und Ergebnisse des WTT wurden analysiert.
- Anschliessend wurden jeweils der Projektverantwortliche oder ein Stellvertreter sowie ein bis zwei Projektpartner interviewt. Die Interviews gaben Aufschluss darüber, ob ein WTT bei den Zielgruppen bekannt ist, welche WTT-Förderungsaktivitäten stattfanden und wie das Ergebnis des WTT durch die Partner und Nutzer beurteilt wird.
- Die Ergebnisse wurden entlang der theoretischen Kriterien gemäss Kapitel 3.2 aufbereitet. Alle Fallstudien haben den gleichen Aufbau und sollen zeigen, ob und in welchem Masse sich Indizien und Beispiele finden lassen, die einen WTT zu illustrieren und zu verdeutlichen vermögen.

Schritt 4: Erstellen der Synthese

Die ersten Ergebnisse der Analyse wurden mit dem Auftraggeber anhand eines Berichtsentwurfes besprochen. Anschliessend wurde die vorliegende Synthese fertig gestellt.

2.4 GRENZEN DER UNTERSUCHUNG

Die vorliegende Untersuchung weist einige Grenzen auf: Der zeitliche Rahmen war sehr knapp gesetzt und der Untersuchungshorizont fiel in die Sommerpause, was gerade im

universitären Umfeld aufgrund von Ferienabwesenheiten schwierig ist. So musste auch eine der Fallstudien im Verlaufe der Untersuchung ausgewechselt werden, da der Programmverantwortliche im Ausland weilte und keine Zeit für ein Gespräch fand. Weiter erlaubte das begrenzte Budget nicht, eine repräsentative Anzahl Fallstudien zu untersuchen. Auch waren die Gespräche mit den Partnern unterschiedlich ergiebig. Partner, die nicht eigentliche Nutzer oder Vermarkter der Technologie sind, konnten nur begrenzt über den WTT Auskunft erteilen. Schliesslich waren einzelne Gesprächspartner irritiert darüber, dass Nano-Tera.ch gleichzeitig eine Selbstevaluation durchführte, wodurch sie teilweise zweimal Auskunft geben mussten. Mit einer Ausnahme haben sich aber alle angeschriebenen Personen zum Interview bereit erklärt. Es fiel auf, dass sich die Verantwortlichen in der Geschäftsstelle von Nano-Tera.ch von der vorliegenden Analyse inspirieren liessen und Denkanstösse aufgenommen haben.

2.5 AUFBAU DES BERICHTS

Der Bericht enthält in Kapitel drei das WTT-Konzept von Nano-Tera.ch. Im vierten Kapitel wird die Umsetzung besprochen. Im fünften Kapitel werden Schlussfolgerungen zum WTT von Nano-Tera.ch gezogen. Der Anhang enthält die Liste der interviewten Personen, weitere Analysen sowie die ausgefüllten Raster der Dokumentenanalyse, Interviews und Fallstudien.

In diesem Kapitel steht das WTT-Konzept von Nano-Tera.ch im Zentrum. Zunächst wurde analysiert, wie sich das Konzept darstellt. Anschliessend wird es mit Ansätzen verglichen, die in der Literatur für den Wissens- und Technologietransfer entwickelt worden sind. Im Einzelnen sind wir wie folgt vorgegangen:

- *Kurzbeschreibung der Phasen von Nano-Tera.ch:* Für die Analyse ist es zentral, die beiden Phasen von Nano-Tera.ch zu unterscheiden, weil sich der WTT in den Phasen jeweils anders darstellt und sich mit dem Programmfortschritt gewandelt hat. Die Beschreibung findet sich im ersten Abschnitt dieses Kapitels.
- *Theoretische Konzepte zum WTT:* Aus der Theorie werden drei gängige Modelle des WTT vorgestellt. Wir haben dabei auf eine frühere Studie zurückgegriffen, welche wir für den SWIR erstellt haben.⁵
- *Beurteilung der Konzeption:* Basierend auf der Beschreibung und der Theorie wurde geprüft, welches der theoretischen Konzepte wir bei Nano-Tera.ch in Gänze oder wenigstens in Teilen explizit oder implizit wiederfinden.
- *Instrumenteneinsatz zur Förderung des WTT:* In der Theorie finden sich verschiedene Gruppen von Instrumenten für den WTT. Es wird überprüft, welche der Instrumente wir bei Nano-Tera.ch wiederfinden und welche Messgrössen für das Monitoring des WTT bei Nano-Tera.ch vorgesehen sind.

3.1 DIE ZWEI PHASEN VON NANO-TERA.CH

Nano-Tera.ch ist ein Förderprogramm, das sich als eine einfache Gesellschaft konstituiert hat.⁶ Die Gründungsmitglieder sind die EPF Lausanne, die ETH Zürich, die Universitäten Basel, Neuchâtel, der italienischen Schweiz und das „Swiss Center for Electronics and Microtechnology (CSEM)“.⁷

Ziele

Das Ziel von Nano-Tera.ch ist die Förderung der Entwicklung von komplexen Systemen im Bereich der grundlagenorientierten Ingenieurwissenschaften und Informationstechnologien. Damit sollen zukünftige Anwendungen in den Gebieten der Gesundheit, Sicherheit, Energie und Umwelt angestossen werden.⁸ Das Kooperationsprogramm hat sich explizit das Ziel gesetzt, die Lücke in der Finanzierung zwischen Grundlagenforschung und der anwendungsorientierten Forschung zu schliessen. Im Rahmen von Nano-Tera.ch sollen innovative Systeme mit sehr kleinen Komponenten

⁵ Rieder et al. 2014.

⁶ Nano-Tera.ch, Business Plan, 19. November 2007, S. 24.

⁷ Nano-Tera.ch, Ordinary Partnership Contract, January 2008, S. 23.

⁸ Nano-Tera.ch, Business Plan, 19. November 2007, S. 3.

(„Mikro“- und „Nano“-Bereich) und Systeme, die mit sehr grossen Datenmengen arbeiten („Tera“) erforscht und entwickelt werden.⁹

Das Programm zielt auf die Exzellenz in der Forschungszusammenarbeit in den Ingenieurwissenschaften und will Demonstratoren entwickeln, Bildungsangebote auf- und ausbauen und die Forschungsergebnisse in die Schweizer Industrie transferieren.¹⁰

Budget und Finanzierung

Nano-Tera.ch verfügte insgesamt über ein Budget von ca. 259 Millionen Franken und wurde mit ca. 110 Millionen Franken an öffentlichen Mitteln unterstützt. Diese finanzierten der ETH-Rat und die Schweizer Universitätskonferenz. Die Gesamtverantwortung von Nano-Tera.ch oblag dem SBFI. Die öffentlichen Mittel wurden jeweils vom Parlament bewilligt. Die Projektpartner brachten insgesamt ca. 149 Millionen Franken an Matching Funds in Nano-Tera.ch ein.

Anhand von Ausschreibungen (sogenannten „Calls“) wurden die finanziellen Mittel zur Unterstützung von Projekten vergeben. Die unterstützten Projekte können in drei Kategorien eingeteilt werden:

- *Grosse Forschungs-, Technologie-, Entwicklungsprojekte (RTD)*, die in der Regel 3 bis 4 Jahre dauern und durch ein Konsortium von 3 bis 10 Forschungsgruppen unterschiedlicher Schweizer Institute umgesetzt werden.
- *Kleinere Forschungsprojekte (nano-tera-focused NTF)*, die sich auf Technologien konzentrieren.
- *Bildungs- und Verbreitungsmassnahmen (Educational and Dissemination ED)*. Die Projekte widmen sich unterschiedlichen Themen wie beispielsweise Technologien für Nano-Systeme, Gesundheits-, Sicherheits-, Umwelt-Anwendungen oder die Kombination von Ingenieurwissenschaften mit Life Sciences, Medizin und Energie.¹¹

Projektphasen

Das Programm verlief in zwei Phasen:

- *Die erste Phase dauerte von 2008 bis 2012*. Es wurden primär RTD Projekte lanciert. Das Jahr 2012 war zudem ein Übergangsjahr, da der SNF vorschlug, gewisse gut laufende RTD-Projekte als RTD-add-on Projekte zu verlängern und sie zusätzlich mit rund 2,5 Millionen Franken zu unterstützen.¹²
- *Die zweite Phase dauerte von 2013 bis 2016*. Neben den RTD-Projekten wurden neu Gateway-Projekte lanciert. Gateway-Projekte haben explizit den Technologie-

⁹ Schweizerischer Nationalfonds,

<<http://www.snf.ch/de/foerderung/ehemalige-foerderungsinstrumente/nano-tera/Seiten/default.aspx>>, zuletzt besucht am: 25. August 2017.

¹⁰ Nano-Tera.ch, Scientific Report 2016, S. 3.

¹¹ Nano-Tera.ch, Scientific Report 2016, S. 3.

¹² Schweizerischer Nationalfonds, Nano-Tera.ch: Genehmigung Add-on Projekte, Schreiben vom 23. November 2011.

transfer zum Ziel. Es handelt sich um Projekte, welche aus RTD-Projekten entstanden sind und ein grosses Potenzial für den Transfer in die Wirtschaft aufweisen. Ziel von Gateway war es, industrielle Prototypen zu entwickeln, um so das Potenzial für den Technologietransfer zu erhöhen. Bei den Gateway-Projekten wurde das Monitoring des WTT verstärkt und in einem Bericht festgehalten. Für die Gateway-Projekte wurde zudem ein Innovation-Manager eingestellt, der den WTT in den Gateway-Projekten verfolgte und diese regelmässig evaluierte.¹³

Ausgaben

Die nächste Tabelle stellt für die zwei Phasen die unterstützten Projekte und deren finanzielle Unterstützung nach Beitragsgeber dar.

D 3.1: Ausgaben von Nano-Tera.ch

	Anzahl Projekte	Gesamtmittel	Öffentliche Mittel	Eigenmittel Partner	Drittmittel
RTD insgesamt	44	210'762'613	86'339'165	118'809'831	5'613'617
davon Phase 1	19	105'757'200	44'768'101	57'684'410	3'304'689
davon Phase 2	25	105'005'414	41'571'065	61'125'421	2'308'928
RTD-add-on (Phase 1)	8	5'723'982	2'550'006	2'323'640	850'336
Gateway (Phase 2)	8	4'170'032	1'666'975	986'217	1'516'840
NTF insgesamt	24	13'922'149	5'598'835	7'841'879	481'435
davon Phase 1	15	7'459'765	3'147'850	4'311'915	0
davon Phase 2	9	6'462'384	2'450'984	3'529'964	481'435
ED insgesamt	59	4'347'553	1'520'571	1'805'573	1'021'409
davon Phase 1	29	3'082'927	1'122'452	1'267'067	693'408
davon Phase 2	30	1'264'626	398'120	538'506	328'001
Total	143	238'926'329	97'675'553	131'767'140	9'483'637

Quelle: Darstellung Interface basierend auf Daten aus Dokument Project Evaluation Impact vom SWIR (März 2017).¹⁴

Legende: NTF = Nano-Tera focused projects, ED = Education and Dissemination Activities, RTD = Research, Technology and Development Projects.

Auf der Tabelle lassen sich folgende Beobachtungen machen:

- Die grösste finanzielle Unterstützung kam den RTD-Projekten zugute. Diese wurden mit rund 86,3 Millionen Franken an öffentlichen Mitteln unterstützt. Dazu

¹³ So fand alle drei Monate ein Treffen mit den Projektteams statt. Der Projektverantwortliche erstellte vor dem Treffen jeweils eine Balanced Scorecard (BSC), in der über den Status des Demonstrators bzw. Prototypen anhand einer Skala mit den Stufen built; exposed; revised berichtet wurde. Das Stakeholder-Netzwerk wurde erfasst und dem Industriepartner wurden folgende Fragen gestellt: 1. Höhe seines Beitrages; 2. inwiefern das Projekt dem Partner hilft, sich von Wettbewerbern abzugrenzen, und 3. ob der Industriepartner seine Markt-Perspektive in das Projekt einbringt. Die BSC wurde von Innovations-Manager und Programmverantwortlichem besprochen; nach dem Treffen wurde eine Synthese erstellt.

¹⁴ Die Tabelle wurde auf den Werten zu den "actual budget" erstellt. Es fällt auf, dass sich die Zahlen von den Angaben in den Scientific Reports von Nano-Tera.ch unterscheiden.

kamen rund 118,8 Millionen aus den Eigenmitteln der Projektpartner und weitere 5,6 Millionen von Drittmitteln durch Industriepartner und Endnutzer.

- Die RTD-add-on-Projekte wurden mit 3,2 Millionen Franken durch eigene bzw. Drittmittel und mit 2,5 Millionen Franken aus öffentlichen Beiträgen finanziert.
- Die Verteilung ist sehr ähnlich bei den Gateway-Projekten. Diese wurden mit rund 2,5 Millionen Franken durch eigene und Drittmittel finanziert. Dazu kamen ungefähr 1,7 Millionen Franken aus der Nano-Tera.ch Finanzierung.
- Die Finanzierung der NTF-Projekte beläuft sich insgesamt auf 13,9 Millionen Franken. Der grösste Beitrag stammt dabei aus den eigenen Beiträgen der Projektpartner (ca. 7,8 Millionen Franken). Die Finanzierung aus den Drittmitteln beträgt rund 0,5 Millionen Franken.
- Die ED-Projekte (Ausbildung) sind finanziell kleinere Projekte und wurden relativ gleichmässig durch die öffentlichen Mittel (1,5 Millionen Franken), die Mittel der Projektpartner (1,8 Millionen Franken) und die Drittmittel (1 Million Franken) finanziert.

Die rund 20 Millionen Franken, dies sich aus der Differenz zwischen der Gesamtfinanzierung (rund 259 Millionen Franken) und der Projektfinanzierung (ca. 239 Millionen Franken) ergeben, wurden (gemäss unseren Annahmen) für den Betrieb von Nano-Tera.ch (wie dem Management Office), für strategische Tätigkeiten und Doktoranden-Programme verwendet.

Die Budgetaufteilung lässt vermuten, dass der spezifisch für den Bereich WTT reser-vierte Betrag im Programm relativ klein ist: Fassen wir die Gateway-Projekte und die ED-Projekte (Ausbildung) zusammen, so beläuft sich der Mitteleinsatz auf 8,5 Millionen Franken (4,1 Millionen Franken Gateway und 4,4 Millionen Franken für Ausbildung), was etwa 3,5 Prozent der Gesamtmittel des Programmes ausmacht. Wie viele Mittel darüber hinaus aus allgemeinen Programmmitteln für den WTT eingesetzt worden ist, konnten wir nicht ermitteln.

3.2 THEORETISCHE ÜBERLEGUNGEN ZUM THEMA WISSENS- UND TECHNOLOGIETRANSFER

In diesem Abschnitt stellen wir kurz einige ausgewählte theoretische wie praktische Ansätze zur Konzeptualisierung von WTT vor. Die nachfolgende Darstellung beruht auf dem Schlussbericht von Interface zum Wissens- und Technologietransfer im Rahmen der ersten Serie der NFS. Dieser Bericht wurde im Auftrag der Geschäftsstelle des Schweizerischen Wissenschafts- und Innovationsrates (SWIR) im Jahr 2014 verfasst.¹⁵ Generell lassen sich aus der Literatur folgende Modelle ableiten:

Klassisches lineares Konzept des WTT

Basis bildet eine Unterscheidung verschiedener Stufen der Wissensgenerierung: Grob lässt sich zwischen der Grundlagenforschung, der angewandten Forschung, der Ent-

¹⁵ Rieder et al. 2014.

wicklung von Produkten und Dienstleistungen, deren Verbreitung auf dem Markt und der Anwendung durch bestimmte Nutzergruppen unterschieden. Das Konzept postuliert für den WTT ein Nacheinander der Wissensgenerierung, wobei das Wissen in jeder Stufe transformiert wird. In der Theorie werden die Stufen unterschiedlich differenziert. Ein WTT ist dann erfolgreich, wenn die verschiedenen Stufen der Wissensgenerierung vollständig durchlaufen werden und er in einer Diffusion des Wissens im Markt in Form von Produkten oder Verfahren, Wissen oder Dienstleistung resultiert.¹⁶

Folgende einfache Darstellung soll diesen Prozess illustrieren:

D 3.2: Lineares Konzept des WTT

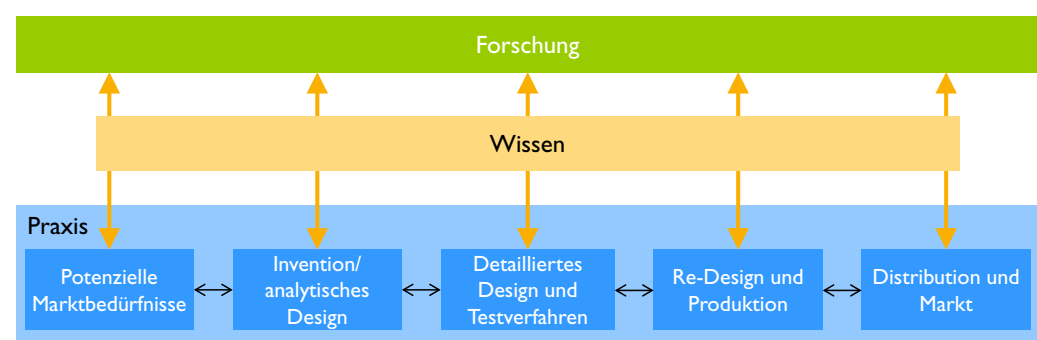


Quelle: Darstellung Interface nach <<http://innovate.ucsb.edu/89-benoit-godin-making-science-technology-and-innovation-policy-conceptual-frameworks-as-narratives>>, Zugriff am 10. März 2014.

Reflexives Konzept

Beim reflexiven Konzept wird im Unterschied zum linearen Konzept eine starke, parallel stattfindende Interaktion zwischen den verschiedenen Akteuren der Wissensproduktion postuliert. Diese Interaktion findet nicht erst beim Transfer in die Praxis statt, sondern ist prägend für den gesamten Prozess der Wissensgenerierung. Der Einbezug kann dabei graduell unterschiedlich sein: Die einfachste Form liegt bei der Beteiligung von Zielgruppen in den Leitungsgremien von Forschungsprojekten vor und kann bis hin zu gemischten Forschungsgruppen reichen, die gemeinsam am Prozess der Wissensgenerierung beteiligt sind. Das folgende Modell des Innovationsprozesses soll die Reflexivität des Konzepts illustrieren.

D 3.3: Reflexives Modell des WTT (Kline/Rosenberg)



Quelle: Darstellung Interface nach Koschatzky 2001, S. 47.¹⁷

Interfaces

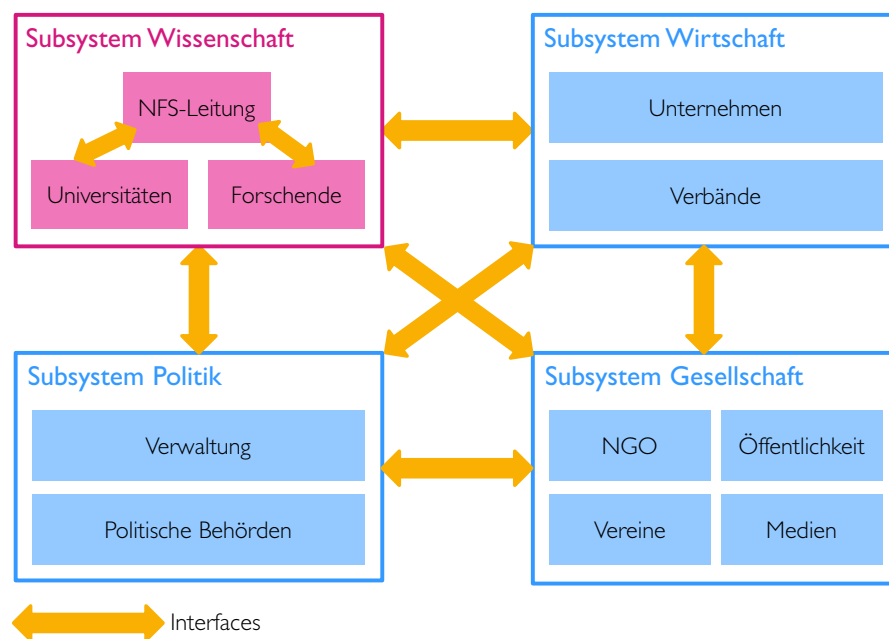
Aus der Systemtheorie stammt der Begriff der Interfaces. Im Kontext des WTT hat Dieter Freiburghaus in Rückgriff auf die Systemtheorie den Begriff verwendet und da-

¹⁶ Campbell/Carayannis 2012.

¹⁷ Koschatzky 2001.

rauf hingewiesen, dass die verschiedenen Systeme der Wissensgenerierung und Wissensverwendung (sowohl im linearen wie auch reflexiven Modell) unterschiedlichen Rationalitäten gehorchen und unterschiedliche „Sprachen“ sprechen. Ein Transfer von einem System in das andere ist daher wahrscheinlicher, wenn Interfaces auftreten (wobei dies sowohl für lineare wie reflexive Modelle gilt). Diese haben die Eigenschaft, in beiden Systemen „daheim zu sein“ und beim Austausch vermittelnd tätig werden zu können. Einfache Formen sind der Einbezug von ausgewählten Personen in die Führungsgremien von Forschungsprogrammen oder Forschungseinrichtungen, die die Interaktion fördern sollen. Aufwändigere Formen von Interfaces können eigene WTT-Organisationen darstellen.¹⁸ Schliesslich können auch einzelne Projekte oder Vorhaben den Charakter von Interfaces wahrnehmen. Voraussetzung ist es, dass die Projekte Personen und Institutionen zusammenführen, welche sich jeweils aus anderen Subsystemen rekrutieren. In der Theorie wird hier von sogenannten Boundary-Projekten gesprochen.¹⁹ Die folgende Darstellung soll die Funktion von Interfaces illustrieren.

D 3.4: Interfaces als Förderer



Quelle: Rieder et al. 2014.

In der praktischen Umsetzung wird vielfach nicht explizit auf ein theoretisches Konzept von WTT Bezug genommen. Vielmehr werden Listen von Instrumenten erstellt, die zur Anwendung gelangen, um den WTT zu fördern. Obwohl rein deskriptiv geben die Listen doch Einblick in die Art und Weise, wie WTT interpretiert wird (vgl. dazu Abschnitt 3.3.2).

¹⁸ Freiburghaus 1989.

¹⁹ Guston 2001.

3.3 WTT-KONZEPT VON NANO-TERA.CH

Wir prüfen in diesem Abschnitt, welche der geschilderten Konzepte oder Teile davon wir in den Dokumenten und den Gesprächen mit den Programmverantwortlichen eruieren konnten. Aufgrund der Dokumentenanalyse und der Interviews haben wir nachfolgende zwei Befunde zum WTT innerhalb des Nano-Tera.ch Programms gemacht.

3.4 BEFUND I: DER WTT VON NANO-TERA.CH ENTSPRICHT AM EHESTEN EINEM REFLEXIVEN KONZEPT MIT VEREINZELTEN INTERFACES

Wir haben zunächst nach Dokumenten gesucht, welche das Konzept des WTT von Nano-Tera.ch explizit beschreiben würden. Wir konnten aber kein Dokument finden, welches sich explizit und ausschliesslich dem WTT von Nano-Tera.ch widmet, diesen theoretisch reflektiert und eine Strategie für dessen Umsetzung im Rahmen von Nano-Tera.ch beschreibt.

Was wir vorgefunden haben, sind einerseits Teilelemente der Beschreibung des WTT, die auf verschiedene Dokumente verteilt sind. Darüber hinaus haben sich in den Interviews implizite Vorstellungen des WTT ergeben. Wir würden daher von einem impliziten Konzept des WTT sprechen. Dieses lässt sich wie folgt beschreiben. Wenn wir die Auswertung von *Dokumenten* betrachten, so lassen sich namentlich aus dem Business-Plan von Nano-Tera.ch nicht weniger als sieben Ziele zum WTT ableiten:

- Es ist eine nationale Koordination zwischen Forschungsinstituten in den Projekten vorzunehmen und die Zusammenarbeit von unterschiedlichen Disziplinen in den Konsortien zu fördern.²⁰
- Die Ergebnisse von Nano-Tera.ch sollen den Schweizer Industriezweigen wie dem Banken- oder dem Versicherungssektor dienlich sein.²¹
- Es ist die Bildung einer Plattform für die Zusammenarbeit mit der Industrie und gut etablierten Schweizer Kompetenzzentren anzustreben.²²
- Die führende Rolle von universitären Einrichtungen, die im Projekt vertreten sind, soll den Transfer von Ergebnissen in Bildungsprogramme sicherstellen, es sollen zudem Bildungsprogramme erweitert und geschaffen werden.²³
- Die Zusammenarbeit zwischen Schweizer Forschungszentren in Konsortien und die Zusammenarbeit mit Industriepartnern in den Projekten soll gestärkt werden.²⁴

²⁰ Nano-Tera.ch, Business Plan, 19. November 2007, S. 3.

²¹ Nano-Tera.ch, Business Plan, 19. November 2007, S. 3.

²² Nano-Tera.ch, Business Plan, 19. November 2007, S. 4.

²³ Nano-Tera.ch, Business Plan, 19. November 2007, S. 15.

²⁴ Nano-Tera.ch, Business Plan, 19. November 2007, S. 16.

- Es soll der Technologie-Transfer durch Nano-Tera.ch gesteigert werden, dies vor allem durch die Gründung von Start-ups und Partnerschaften mit der Industrie.²⁵ Es sollen neue High-Tech Unternehmen nach Schweizer Qualität entstehen.²⁶
- Die Konstruktion von Demonstratoren und Prototypen bis zur Stufe der vorindustriellen Anwendung soll gefördert werden, um die Ergebnisse in die Schweizer Industrie transferieren zu können.²⁷

Die oben genannten Ziele lassen auf ein eher reflexives Modell des WTT schliessen, der in ausgewählten Bereichen mit Interfaces (Gateway-Projekten) ergänzt wird. Die Ergebnisse aus den *Interviews* mit den Programmverantwortlichen haben diesen Befund bestätigt und ergänzt. Unter WTT, so wird es in den Gesprächen dargestellt, wird vor allem die Zusammenarbeit verschiedener Disziplinen in den Konsortien, die Einbindung von Industrie-Partnern und die Ausbildung von neuen Forschungskräften durch die PhD-Programme verstanden. Interessant war die Positionierung von Nano-Tera.ch in der Schweizer Finanzierungslandschaft von Forschungen durch die Programmverantwortlichen: Bis anhin gebe es auf der einen Seite die Finanzierung durch den SNF, die auf Grundlagenforschung ausgerichtet sei. Auf der anderen Seite des Spektrums seien die KTI-Projekte anzusiedeln, die explizit die Vermarktung von Forschung zum Ziel haben. Nano-Tera.ch sei in der Mitte dieser zwei Pole anzusiedeln und habe zum Ziel, die Lücke zwischen der Grundlagen- und der angewandten Forschung zu schliessen, indem Forschungsprojekte unterstützt werden, die ein Potenzial für die Vermarktung haben, aber noch nicht für den Markt bereit sind. So ziele Nano-Tera.ch darauf ab, beide Welten, die Forschung und die Praxis, zu vereinen.

Die Auswertung von Dokumenten und Interviews zeigt, dass sich das WTT-Konzept von Nano-Tera.ch über die Zeit verändert hat. Um dies zu illustrieren, verwenden wir das Modell zur Beschreibung verschiedener Arten von Forschung von Ruttan an.²⁸ Dieses Modell erlaubt es, verschiedene Arten von Forschungsprojekten und ihre Institutionen zu kategorisieren und zwar in vier Gruppen von Forschungsvorhaben. Je nachdem, wo sich die Forschungsprojekte einordnen, ist der Grad der internen Kontrolle durch die Forschenden selber respektive jene der externen Partner wie etwa der Unternehmen oder Verwaltungen unterschiedlich gross. In der folgenden Abbildung haben wir die zwei Phasen des WTT-Konzepts von Nano-Tera.ch abgebildet.

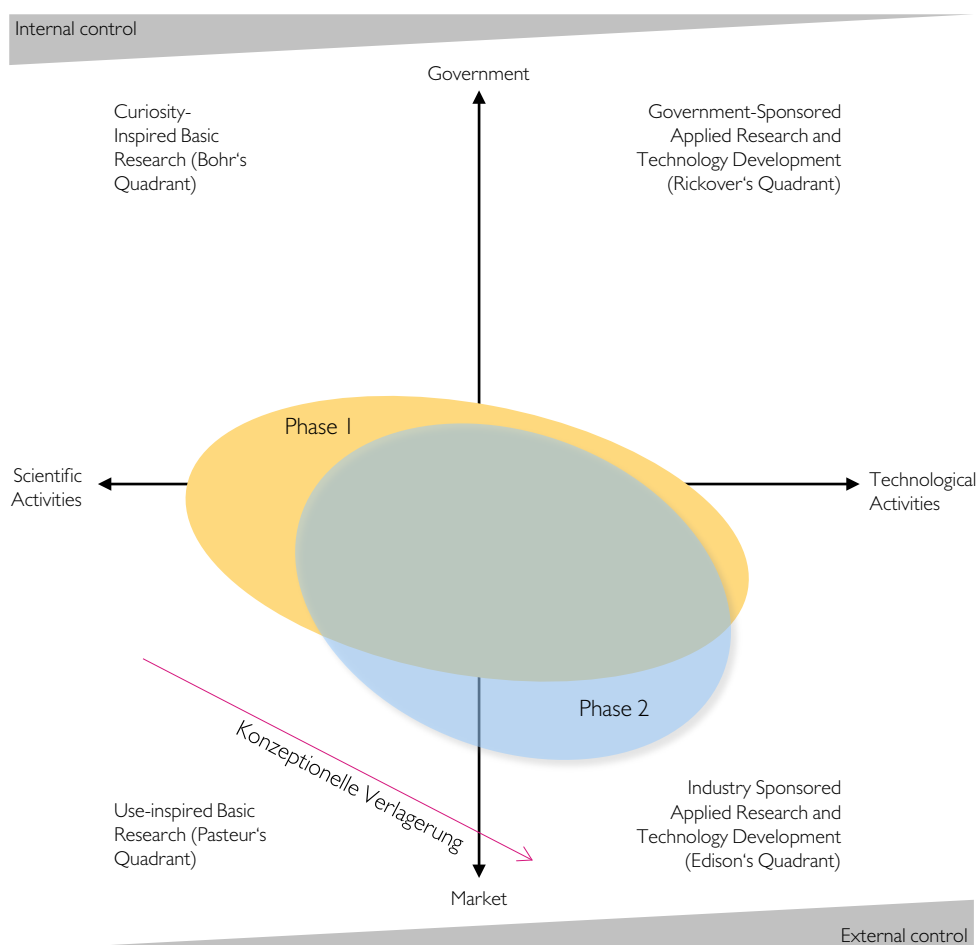
²⁵ Nano-Tera.ch, Business Plan, 19. November 2007, S. 17.

²⁶ Nano-Tera.ch, Business Plan, 19. November 2007, S. 3.

²⁷ Nano-Tera.ch, Business Plan, 19. November 2007, S. 21.

²⁸ Ruttan 2001.

D 3.5: Mögliche Positionierung der Institute nach Forschungstypen



Quelle: Darstellung Interface nach Ruttan 2001.

Die Veränderung der Ausrichtung von Nano-Tera.ch in seinen zwei Phasen kann wie folgt beschrieben werden:

- In einer *ersten Phase* positioniert sich Nano-Tera.ch auf der wissenschaftlich-technologischen Achse eher auf der wissenschaftlichen Seite. Ein Indiz dafür ist das in diesem Zusammenhang von den Verantwortlichen von Nano-Tera.ch verwendete Technology Readiness Level (TRL) für die Positionierung von Nano-Tera.ch Projekten.²⁹ Mittels TRL werden Forschungsprojekte auf einer Skala von Grundlagenforschung (TRL 1) bis zur vollständig kommerziellen Umsetzung (TRL 9) eingeteilt.³⁰ Nach Angaben der Nano-Tera.ch Verantwortlichen haben viele der unterstützten Projekte in Phase eins ein TRL von 3 bis 5 (wobei auch Projekte mit kleinerem TRL dabei waren). Dies sei genau die Lücke, die Nano-Tera.ch mit dem Slogan „bridge the gap“ zu füllen versuche.

²⁹ Vgl. Anhang 4 zum Technology Readiness Level für eine Übersicht.

³⁰ Armstrong 2014.

Auf der „Government-Market“-Achse positionierte sich Nano-Tera.ch in seiner ersten Phase näher beim Markt-Pol: Man war sehr darauf bedacht, Projekte mit den Nano-Tera.ch-Mitteln zu finanzieren, die Partner aus der Industrie von Beginn an in die Projekte integrieren. So war der Einbezug von industriellen Partnern obligatorisch.

- In seiner *zweiten Phase* beobachten wir eine konzeptionelle Verlagerung in Richtung Anwendungsorientierung und Marktorientierung. Es wurde vermehrt Wert auf technologische Aktivitäten gelegt und die anwenderinspirierte Forschung verstärkt. Dies manifestierte sich erstens in einem Wechsel von industriellen Partnern zu den Endnutzern der Technologien. Die industriellen Partner waren keine Voraussetzung mehr für die Projektunterstützung, wurden aber immer noch empfohlen. Die Endnutzer waren in dieser Phase aber für die Projektunterstützung obligatorisch. In den Interviews wurde dieser Wechsel damit begründet, dass die Industriepartner zu wenig daran interessiert seien, von Beginn an in einem Projekt tätig zu werden. Sie seien schwer für die konzeptionelle Phase zu motivieren und eher später im Projektverlauf an einer Zusammenarbeit interessiert. So wurde dann in der zweiten Phase der Fokus auf Endnutzer (d.h. Spitäler) gelegt, da diese direkt von den Entwicklungen profitieren würden und die wirtschaftliche Vermarktung für sie zweitrangig sei.
- Über die Phasen hinweg zeige sich auch, dass die finanziellen Beiträge der Endnutzer (in Bar- oder Sacheinlagen) in der zweiten Phase bedeutender wurden, als die Beiträge der Industriepartner in der ersten Phase. Die konzeptionelle Verschiebung zeigt sich zudem durch die gezielte Schaffung eines WTT-Instrumentes bei den Gateway-Projekten: Damit sollten Technologien aus RTD-Projekten unterstützt werden, welche ein TRL von 5 oder 6 aufweisen. Ziel der Projekte war, die Labor-Demonstratoren in industrielle Prototypen umzuwandeln (und einen TRL 7 zu erreichen), um so das Potenzial für den Technologietransfer zu erhöhen.

Insgesamt können wir mit Hilfe der Darstellung von Ruttan eine Verschiebung von anwendungsorientierter Grundlagenforschung hin zu einer stärker industrieorientierten Forschung feststellen. Die Projekte haben im Vergleich zur reinen wissenschaftlichen Grundlagenforschung einen stärkeren Fokus auf die Problemlösung und die Kooperation mit der Industrie und den Endnutzern.

3.5 BEFUND 2: ES WURDE EINE BREITE PALLETE VON INSTRUMENTEN ZUR UMSETZUNG DES WTT EINGESETZT

In der praktischen Umsetzung ist eine Vielzahl Instrumenten denkbar, mit deren Hilfe sich der WTT in der Praxis umsetzen und befördern lässt. Die nachfolgende Darstellung beruht auf dem Schlussbericht von Interface zum Wissens- und Technologietransfer im Rahmen der ersten Serie der NFS.³¹ Dabei werden die Instrumente zur Förderung des WTT in zwei Gruppen eingeteilt, je nachdem welche Art von Wissen sie helfen sollen zu transportieren: Eine erste Gruppe von Instrumenten soll explizites Wissen

³¹ Rieder et al. 2014.

transportieren. Dies ist jenes Wissen, das von einem Empfänger durch die Konsultation von Literatur, Kursen, Ausbildung und ohne Unterstützung von Dritten erworben werden kann. Unter implizitem Wissen wird das Verständnis von Prozessen und Verfahren verstanden, die notwendig sind, um Wissen jeweils situationsspezifisch anwenden zu können.³² Dieses implizite Wissen ist offenbar stark an Personen gebunden und kann nur schwer mittels Publikationen oder anderer Instrumente vermittelt werden. Vielmehr ist dazu eine Interaktion zwischen Personen oder aber ein Transfer von Personen, die Wissen besitzen, notwendig (zweite Gruppe von Instrumenten).

Inwiefern ist diese Einteilung in Instrumente zum expliziten oder impliziten Wissenstransfer hilfreich? Es wird in der Literatur oft davon ausgegangen, dass WTT besonders erfolgreich ist, wenn sowohl implizites *und* explizites Wissen übertragen wird und somit eine breite Palette von Instrumenten zum WTT eingesetzt wird.

Mittels der zur Verfügung stehenden Unterlagen und den Ergebnissen der Interviews haben wir nun geprüft, welche Instrumente von Nano-Tera.ch effektiv eingesetzt worden sind, um den WTT zu fördern. Als *erstes* haben wir dabei festgestellt, dass es keine Gesamtplanung über den Einsatz der Instrumente gibt und ihr Einsatz auch nicht systematisch und explizit mit einer Gesamtübersicht dokumentiert ist. Aus den Dokumenten³³ und aus den Gesprächen lässt sich aber eine Gesamtübersicht rekonstruieren. Unsere Hauptquelle waren dabei die jährlichen Scientific Reports auf Programmebene.³⁴ Basierend auf diesen Informationen haben wir folgendes Inventar an Instrumenten erstellt, das im Rahmen von Nano-Tera.ch eingesetzt worden ist. Wo immer möglich, haben wir quantitative Daten zum Umfang des Instrumenteneinsatzes angefügt (im Anhang haben wir einzelne Messgrößen im Detail aufgeführt).

³² Meissner/Sultanian 2007.

³³ Nachfolgende Zahlen basieren aus den Scientific Reports 2009 - 2016 von Nano-Tera.ch.

³⁴ Nano-Tera.ch erstellt aufgrund ihrer Selbstevaluation gegenwärtig eine Zusammenstellung von Messgrößen, welche aber nicht auf jährlicher Basis gemessen und berichtet wurden und uns noch nicht vorliegen.

D 3.6: WTT-Instrumente

Direkter Transfer		
Instrumententypen	Bei Nano-Tera.ch eingesetzte Instrumente	Quantitative Angaben
1 Transfer über Personal	Start-up-Firmen gegründet von Forschenden	4 gegründet; 6 im Gründungsprozess
	Transfer von Personen von der Akademie in die Praxis (Doktorierende und Post-docs)	<i>Keine Angaben verfügbar</i>
	Gezielte Rekrutierung von Personen, welche WTT durchführen können (Interfaces)	<i>Keine Angaben verfügbar</i> (in den drei untersuchten Fallstudien kein Fall dokumentiert)
	Austausch von Personen (Personen wechseln von Industrie und Praxis in die Akademie und umgekehrt)	<i>Keine Angaben verfügbar</i>
2 Transfer über Technologien	Demonstratoren und Prototypen	<i>Keine Angaben verfügbar</i>
3 Transfer über Rechte	Patente	67 Patentanmeldungen ausgefüllt
Indirekter Transfer		
Instrumententypen	Instrumente	Quantitative Angaben
4 Kommunikationsmittel	Publikationen	1309
	Konferenzen und Workshops	2165
	Internetseiten	80'000 Besuche in 2016
	Umfragen	1 (nach Jahrestreffen 2016)
	Weiterbildung und Ausbildung	<i>Keine Angaben verfügbar</i>
5 Finanzielle Förderung	Programme für Doktoranden	2 auf Nano-Tera.ch-Programmebene
6 Aufbau von Strukturen	Gateway	8 (1 Innovation Manager angestellt)
	Jahrestreffen	7 2016: 350 Teilnehmer; 152 Poster und 15 Videos. Grosse Anzahl von RTDs zeigten Demonstratoren und frühe Prototypen.
	Strategic Actions	3 in 2015
	Einrichtung von Kooperationen mit Universitäten und Partnern	u.a. I Sino-Swiss collaboration

Quelle: Darstellung Interface basierend auf Interviews und Dokumenten der vorliegenden Analyse.

Betrachten wir die Tabelle, so lässt sich folgendes daraus ableiten: Es wird eine breite Palette von Instrumenten zum direkten wie auch indirekten Transfer eingesetzt. Dies ist aus theoretischer Sicht sinnvoll und wünschenswert. Betrachten wir den *direkten Transfer* fällt folgendes auf:

- Für ausgewählte besonders interessante Instrumente zum Transfer von implizitem Wissen über *Personen* sind leider keine quantitativen Daten verfügbar: So existieren für den Transfer von Personal in die Praxis keine Messgrössen. Das gleiche gilt für die Rekrutierung von Personen, die WTT durchführen. In den Gesprächen wurde das Fehlen von Daten zwar eingeräumt, der Transfer von Doktorierenden und Postdocs in die Praxis aber als wichtiges Instrument für den WTT bezeichnet. Weiter wurde in diesem Zusammenhang auf die Start-up-Firmen als wichtige Messgrösse für den WTT hingewiesen. So wurden bis jetzt 4 Start-ups gegründet und weitere 6 finden sich im Gründungsprozess.
- Die *Demonstratoren und Prototypen* wurden in den Gesprächen mit den Nano-Tera.ch-Verantwortlichen und einigen Projektverantwortlichen als wichtige Messgrösse für den Transfer von *Technologien* erwähnt. Auch ist es ein erklärtes Ziel in den Dokumenten von Nano-Tera.ch. Dazu gibt es aber in den Unterlagen bisher keine statistischen Angaben. Weiter wird die Weiterführung der Projekte mittels neuer Finanzierungen als wichtiger WTT-Effekt erwähnt. So hätten 9 Projekte eine KTI-Finanzierung erhalten.
- Zum Transfer *von Rechten* über Patente wird die Anzahl der Patentanmeldungen erhoben. Im Nano-Tera.ch Programm wurden insgesamt 67 Patentanmeldungen eingereicht. Deren Aussagekraft ist allerdings relativ gering. Entscheidend sind die Art der Patente (in welchem Land wurden sie eingereicht und haben sie Geltung) und die daraus resultierenden Lizenzen. Dazu liegen uns keine Informationen vor (es wäre dazu eine Aufbereitung der Daten von Seiten der Projekte notwendig gewesen).

Im Bereich des *indirekten Transfers* lassen sich viele Instrumente erkennen:

- Am häufigsten werden die *klassischen Kommunikationsmittel* eingesetzt. Im Verlauf der Nano-Tera.ch Projekte gab es ca. 1300 Publikationen und über 2165 Konferenzen und Workshops. Die Internetseite wird gerade auch bei den Nano-Tera.ch-Verantwortlichen in den Gesprächen als wichtiges Instrument für den WTT eingestuft. 2016 wurden 80'000 Seitenbesuche aus 140 Ländern verzeichnet. Im Rahmen von Nano-Tera.ch fanden verschiedene Umfragen statt. Eine Umfrage erfolgte nach dem Jahrestreffen von 2016 und fragte die Zufriedenheit der Teilnehmenden mit dem Event ab. Weiter müssen die Programmverantwortlichen vor den Quartaltreffen gegenüber Daten zur Balanced Scorecard melden. Im Rahmen der Jahresreportings machen alle Programmverantwortlichen der RTD-Projekte schriftliche Angaben zum Projektverlauf anhand eines strukturierten Formulars. Das Nano-Tera.ch-Office organisierte im Verlauf des Programms verschiedene Weiterbildungen und Ausbildungen. Dazu sind allerdings keine statistischen Angaben verfügbar.

- *Finanzielle Förderprogramme* für Doktorierende im klassischen Sinne (Stipendien) wurden keine eingerichtet. Es wurden aber zwei spezielle Förderprogramme gestaltet: Erstens das NextSteps-Programm, welches erst im Jahr 2015 entwickelt wurde, in welchem Doktorierende sich mit dem Unternehmertum vertraut machen konnten. Zweitens das Projekt „My thesis in 180 seconds“, in welchem Doktoranden lernen, ihre Forschung einem breiten Publikum zu vermitteln. Bei beiden Gefässen handelt es sich allerdings nicht um klassische Förderprogramme mittels Stipendien.
- Beim Aufbau der *Strukturen* gibt es ebenfalls verschiedene Instrumente: Erstens das bereits erwähnte Pilot-Programm Gateway, das gezielt die Weiterentwicklung von Demonstratoren in Prototypen finanziert. Zweitens die Jahrestreffen, bei denen jeweils die Projektverantwortlichen dem SNF-Panel in einer 30-minütigen Evaluation das Projekt vorstellen mussten. Drittens sogenannte strategic actions von Nano-Tera.ch selber. Diese können die Finanzierung von Projekten oder Konferenzen sein. Dazu gibt es keine systematische Statistiken. Im Jahr 2015 wurden drei solche Tätigkeiten lanciert. Viertens organisierte Nano-Tera.ch auch Kooperationen mit Universitäten und anderen Partnern. Auch hierzu gibt es keine statistischen Angaben. Ein Beispiel ist die Sino-Swiss Collaboration, die 2011 gestartet wurde.

In diesem Kapitel werden Ergebnisse aus den Fallstudien zur Umsetzung des WTT in den Projekten dargestellt. In einem ersten Abschnitt beschreiben wir das Verständnis und die Umsetzung des WTT von Nano-Tera.ch auf Stufe der drei untersuchten Projekte. In einem zweiten Abschnitt gehen wir auf die eingesetzten Instrumente zur Förderung von WTT ein. Im letzten Abschnitt beschreiben wir Stärken und Schwächen im Zusammenhang mit dem WTT in den Projekten.

4.1 VERSTÄNDNIS UND UMSETZUNG DES WTT IN DEN UNTERSUCHTEN PROJEKTEN ---

In einem ersten Schritt haben wir erfragt, ob bei den untersuchten drei Projekten ein explizites WTT-Konzept dokumentiert ist. In den Unterlagen zu den Projekten gab es dazu keine Hinweise. Auf Nachfrage bei den Programmverantwortlichen wurde bestätigt, dass es kein explizites Konzept zum WTT in den Projekten gebe. Daher wurde die Frage des WTT in den Gesprächen mit den Programmverantwortlichen und den Partnern besprochen. Aufgrund der Interviews können wir folgende Beobachtungen zum WTT-Verständnis in den drei untersuchten Projekten machen.

OpenSense

OpenSense durchlief zwei Phasen (OpenSense I und II), die mit den zwei Phasen von Nano-Tera.ch korrespondieren. Es handelt sich gemäss unserer Auffassung um ein klassisches Grundlagenprojekt, was in den Gesprächen auch bestätigt worden ist.

Wie wurde WTT interpretiert? In den Interviews mit den Programmverantwortlichen von OpenSense I und II zeigte sich, dass in diesem Projekt vor allem die Zusammenarbeit der verschiedenen Disziplinen und das Teilen von Wissen als WTT verstanden wird. Das Projekt ist denn auch mit einem sehr tiefen TLR innerhalb von Nano-Tera.ch gestartet (je tiefer der TLR auf der Skala von eins bis neun, desto näher ist ein Projekt an der reinen Grundlagenforschung). OpenSense hat auch keine eigentlichen industriellen Partner. Dies, so Aussagen aus den Gesprächen, sei aber von Seiten von Nano-Tera.ch auch nicht gefordert worden. Es sei allen klar gewesen, dass es sich eher um ein Grundlagenforschungsprojekt handle. Es hätte auch nicht viel Sinn gemacht, bereits zu Beginn industrielle Partner für eine potenzielle Kommerzialisierung einzubeziehen. OpenSense habe zum Ziel gehabt, Disziplinen zusammenzuführen (in diesem Falle Forschungsbereiche wie künstliche Intelligenz, Medizin, Computerwissenschaften, Material Science und Computer Engineering). Es sei ein grosser Schritt gewesen, die Zusammenarbeit zu fördern. Im Verlaufe der Zeit stieg der TLR etwa auf Stufe fünf. Gemäss den Gesprächen hat dies auch damit zu tun, dass man mit OpenSense II „das Labor verlassen habe“, um die Technologie in der realen Umwelt anzuwenden. OpenSense II verfügt über verschiedene Partner (wie die Transports Public Lausanne [TL], das Universitätsspital des Kantons Waadt [CHUV], die Verkehrsbetriebe der Stadt Zürich [VBZ] etc.) welche helfen, Daten anhand der entwickelten Technologie zu sammeln (z.B. Sensoren auf den Bussen des TL). Diese Partner sind aber nicht Industriepartner, die die Technologie kommerzialisieren wollen. Sie waren konzeptionell

nicht in die Forschung eingebunden, indem sie z.B Inputs zu Forschungsfragen gaben. Gemäss den Gesprächspartnern müsse die Kommerzialisierung in einem nächsten Schritt erfolgen. So sei vorgesehen, das Projekt für eine Bridge-Finanzierung anzumelden. Der TL habe dafür beispielsweise schon einen letter of intent verfasst. Insgesamt lässt sich in diesem Projekt ein klassisch lineares WTT-Konzept erkennen. Anzumerken wäre aber, dass ein Gateway-Projekt (CarboSense) entstand, dessen Ursprung in OpenSense II liegt. Somit wurde ein Instrument eingesetzt, um den WTT für eine aus dem Projekt entstandene Technologie zu fördern.

FlusiTex

FlusiTex ist ein Nano-Tera.ch Projekt der zweiten Phase, in das von Beginn an industrielle Partner eingebunden waren. Die Verantwortlichen geben an, dass der WTT schwierig zu realisieren gewesen sei: Industrielle Partner zu finden, brauche viel Überzeugungsarbeit und es sei viel Zeit dafür investiert worden. Mittlerweile gebe es einen regelmässigen Austausch zwischen den Partnern, die Industrie-Partner seien an der Entwicklung interessiert. Der Input der Industriepartner bestehe heute beispielsweise darin, Marktanalysen zu verschiedenen Technologien im Projekt zu verfassen. Das Zusammenspiel im Konsortium sei sehr wichtig für den WTT.

Das Projekt mündete in zwei verschiedene Gateway-Projekte (FlusiGate und FlusiSafe). Ein Industriepartner von FlusiSafe gab im Gespräch an, dass heute ein regelmässiger Austausch stattfinde, Laborbesuche stattfinden würden und man das Know-how für die Vermarktung in das Konsortium einbringe. Dies werde sehr gut aufgenommen. Bedauert wird, dass die Finanzierung bald zu Ende gehe und das weitere Vorgehen noch offen sei.

FlusiTex und die daraus resultierenden Gateway-Projekten können aus unserer Sicht als ein Beispiel für ein reflexives WTT-Modell gelten. Was dem Modell entspricht, sind die Forschungsinputs in Form von Analysen zu Machbarkeit, Marktchancen und Produkteentwicklung. Was eher schwach ausgeprägt ist, ist der Beitrag der Industriepartner zur Formulierung der Forschungsfragen und des Forschungskonzeptes.

HearRestore

HearRestore ist ein Projekt der zweiten Phase von Nano-Tera.ch. Es vereint ein Konsortium an Partnern, welche hauptsächlich an der Universität Bern angesiedelt sind. Die Gespräche mit den Projektverantwortlichen und Partnern zeigen, dass die Forschungen schon vor Nano-Tera.ch begonnen hatten und es von Beginn an industrielle Partner im Projekt hatte. Industriepartner zu finden, sei aber aufwändig und zeitintensiv gewesen und es brauche viel Glück. Ein Industriepartner müsse ein Potenzial für ein Produkt sehen.

HearRestore ist offenbar schon weit fortgeschritten in Bezug auf den Transfer in die Praxis: Gemäss den Interviewten sei das Projekt klinisch ausgerichtet und man operiere mit der entwickelten Robotertechnik schon erfolgreich am Patienten. In den Gesprächen kam zum Ausdruck, dass die Universität Bern auf solche Finanzierungen wie sie Nano-Tera.ch anbiete, angewiesen sei und man bereits in einem Netzwerk von Partnern eingebettet sei. Dies sei ein grosser Vorteil der Institution.

HearRestore vereine industrielle Partner sowie Endnutzer und sei geprägt von einem engen Austausch zwischen diesen Partnern und der Forschung. Die Nähe zu den Partnern aus der Praxis erlaubt es, effizient zu forschen und zu testen. Man habe rasch in die klinische Phase einsteigen können, was als Vorteil für den WTT sei. WTT wird in diesem Projekt somit als Entwicklung von einer in der Praxis anwendbaren Technologie verstanden. In einem nächsten Schritt werde man sich für eine Bridge-Finanzierung bewerben. HearRestore habe alle TRL-Stufen vorbildlich durchlaufen; man könne es aus Forschungssicht nicht besser machen.

Aus den Gesprächen ergibt sich aus unserer Sicht, dass HearRestore am ehesten dem reflexiven Modell zugeordnet werden kann. Die Endnutzer und Industriepartner geben Forschungsinputs und man tauscht sich zum Projekt aus. Zudem mündete das RTD HearRestore in ein Gateway-Projekt (HearRestore Gate), um den WTT weiter zu stärken.

Vergleich der drei Fallbeispiele

Die drei ausgewählten Fallstudien zeigen die Vielfalt der Verständnisse von WTT in Nano-Tera.ch auf. Wenn wir die Ergebnisse zusammenfassen und mit den theoretischen Ansätzen in Kapitel 2 vergleichen, ergibt sich in etwa folgendes Bild: In keinem der Projekte gibt es eine explizite Reflexion über die Gestaltung des WTT. Implizit lässt sich aufgrund der Interviews und Dokumente OpenSense eher dem linearen, die anderen beiden Fallstudien eher dem reflexiven Modell eines WTT zuordnen. Alle drei Projekte weisen einen Follow-up in Form eines Gateway-Projektes auf, das als Interfaces interpretiert werden kann. Dass alle Fallbeispiele ein solches Element aufweisen, ist eher untypisch, da die Zahl und der Umfang der Gateway-Projekte insgesamt doch beschränkt ist.

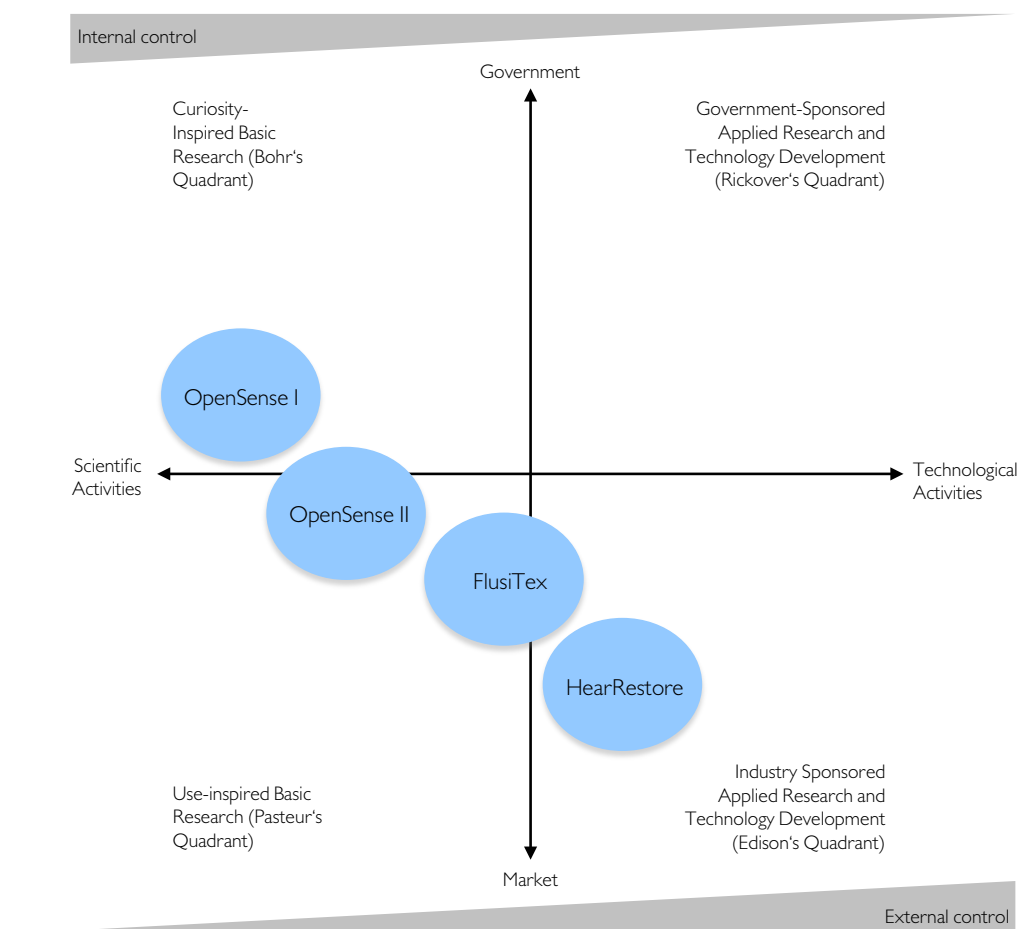
D 4.1: Theoretische WTT-Konzepte

Nano-Tera.ch Projekt	Konzept explizit vorhanden?	Klassisches lineares Konzept	Reflektives Konzept	Interfaces
OpenSense I und II	Nein	X		1 Gateway Projekt: CarboSense
FlusiTex	Nein		X	Zwei Gateway-Projekte: Flusi-Safe und Flusi-Gate
HearRestore	Nein		X	Ein Gateway-Projekt: Hear-Restore Gate

Quelle: Darstellung Interface.

Wenn wir die drei Fallstudien in unser weiter vorne in Kapitel 3 eingeführtes Diagramm gemäss Ruttan einordnen, so lässt sich folgende Beobachtungen machen: OpenSense I und II sind Projekte, die sich von der Grundlagenforschung in Richtung der angewandten Forschung entwickelt haben. Sie sind im Vergleich zu FlusiTex und HearRestore noch weiter vom Markt entfernt.

D 4.2: Mögliche Positionierung Fallstudien



Quelle: Darstellung Interface nach Ruttan 2001.

Aus den Gesprächen ergibt sich, dass vier Faktoren das unterschiedliche Verständnis des WTT in den drei Fallstudien beeinflussen.

- *Forschungsfortschritt im Projekt:* OpenSense I hat sich von einer sehr grundlagenorientierten Forschung zu einer vermehrt anwendungsorientierten Forschung in OpenSense II entwickelt. Im Gegensatz dazu ist FlusiTex durch eine höhere Praxisorientierung geprägt. HearRestore schliesslich ist beides: Nahe bei der Nutzung mit der klinischen Anwendung, aber auch schon weit fortgeschritten mit der Robotertechnik und deren Potenzial für die Industrie.
- *Vernetzung der Partner:* Es zeigte sich, dass sich die Partner in den Konsortien unterschiedlich gut kennen und dies womöglich den WTT beeinflusst: Die Partner bei HearRestore, so wird in den Gesprächen gesagt, kennen sich gut und arbeiten auch in anderen Projekten zusammen. Bei FlusiTex sei die Zusammenarbeit ebenfalls eingespielt. In den Gesprächen mit OpenSense wird demgegenüber unterstrichen, dass man sich in einer ersten Zeit zuerst kennenlernen und die Zusammenarbeit der unterschiedlichen Disziplinen aufbauen musste.

- *Unterschiede zwischen den Disziplinen:* Der WTT bei den Computerwissenschaften, den klinischen Projekten und den Nano-Technologien in den Labors gestaltete sich jeweils anders. Es habe Zeit gebraucht, die verschiedenen Disziplinen (künstliche Intelligenz, Medizin, Computerwissenschaften, Material Science und Computer Engineering) in OpenSense miteinander vertraut zu machen. In den Gesprächen wird unterstrichen, es sei ein essentieller Erfolg von OpenSense gewesen, dass die Forschung aus dem Labor herauskam und eine praktische Anwendung entwickelt wurde. Dies ist an sich erstaunlich, denn die Computerwissenschaften sind gemäss den Erfahrungen der Autoren eine Disziplin, die vergleichsweise nahe am Markt operiert und bei der es viele positive Beispiele von WTT gibt.
- *Unterschiedliches Interesse am Markt:* Es zeigt sich im Vergleich der Fallstudien, dass das Interesse des Marktes unterschiedlich hoch ausgeprägt ist: OpenSense hat noch keine Industriepartner (im Sinne von Partnern, die die Technologie kommerzialisieren wollen) im Projekt integriert. FlusiTex und HearRestore sind näher am Markt und bekommen von Industriepartnern Feedback; diese produzieren schon Teile der Technologie (z.B. die Roboter bei HearRestore).

4.2 INSTRUMENTENEINSATZ

Wir haben auch in den Fallstudien untersucht, welche Instrumente in den Projekten zum Einsatz kamen. Folgende Tabelle fasst die Informationen aus den Dokumenten und Gesprächen zu den WTT-Instrumenten pro Fallstudie zusammen.

D 4.3: Instrumententypen zur Förderung des WTT in den Fallstudien

		OpenSense II	FlusiTex	HearRestore
Direkt	Transfer über Personal	Hoch (ein Forscher arbeitet in einer neuen Einheit in der Stadt Paris)	Keine Angabe	Hoch: Zwei Lizenzen der Technologie mit CASCination, Bern Med-el GmbH Innsbruck
	Transfer über Rechte			3 Patente
	Transfer über Technologien	Hoch: Sensoren auf Bussen, Autos und Bauten in Lausanne und Zürich Health Optimal Route Planner App wird von der Stadt Zürich empfohlen	Hoch: Flusi Tex Prototyp und verschiedene Sensoren entwickelt	Hoch: 2 neue Produktlinien geschaffen Roboter in Produktion
Indirekt	Kommunikationsmittel	Hoch: 45 Forschungsartikel Verschiedene Presseartikel	Mittel: 7 Publikationen	Hoch: 40 Forschungsartikel, Presseartikel
	Finanzielle Förderung	Mittel-Hoch: 8 PhD Studierende, mehrere PostDocs	Tief: Keine PhD Studierenden gefördert	Mittel-Hoch: 6 PhD Studierende
	Aufbau von Strukturen	Mittel: Gesundheits-APP; Zusammenarbeiten mit Unternehmen für die Sensoren Gateway	Mittel: Gateway, Zusammenarbeiten mit verschiedenen Industrie-Partnern	Hoch: Gateway, 3 KTI-Projekte 1 weiteres geplant, in Gespräch mit privaten Investoren

Quelle: Darstellung Interface auf Basis der Interviews.

Wir gehen nacheinander auf die sechs Instrumententypen ein und illustrieren diese mit Beispielen aus den Gesprächen.

- *Transfer über Personal:* Hierzu haben wir nur für das Projekt OpenSense eine Angabe: Im Gespräch mit dem Projektverantwortlichen wurde erwähnt, dass ein Forscher aus dem OpenSense-II-Projekt, bei der Stadt Paris in einer neuen Abteilung zur Luftverschmutzung angestellt wurde. HearRestore hat zwei Lizenzen mit Firmen. Bei FlusiTex wurden keine Aussagen über Transfer zu Personal gemacht.
- *Transfer über Rechte:* Das HearRestore Projekt hat drei Patentanmeldungen hervorgebracht. Nach Angaben aus den Dokumenten und Gesprächen gibt es für OpenSense und FlusiTex bis jetzt keine Patentanmeldungen. Die Gesprächspartner bei OpenSense gaben an, dass Patente in ihrer Disziplin nicht wirklich eine Rolle spielen.

- *Transfer über Technologien (Demonstratoren oder Prototypen)*: Dieser Typ von Instrumenten ist in allen drei Fallstudien stark präsent. OpenSense hat Sensoren auf Bussen, Autos und Bauten in Lausanne und Zürich installiert. Es gibt eine Applikation für das Handy, über die gesundheitsoptimierende Routen in der Stadt Zürich abgefragt werden können. FlusiTex hat ebenfalls einen hohen Transfer über Technologien: Es existieren ein Prototyp und verschiedene Sensoren. Zudem werden die ersten Pflaster an Tieren getestet. Auch bei HearRestore ist der Transfer über Technologien hoch: Es wurden Roboter produziert und zwei neue Produktelinien geschaffen. Zudem wird mit der Technologie schon erfolgreich an Patienten operiert.
- *Kommunikationsmittel*: Bei den Kommunikationsmitteln sind OpenSense und HearRestore sehr gut positioniert: Es gibt je über 40 Forschungsartikel und zudem Pressemeldungen. FlusiTex nutzt dieses Instrument mit nur sieben Publikationen weniger.
- *Finanzielle Förderung*: Bei der finanziellen Förderung von Doktoranden ist nur FlusiTex nicht aktiv. Die anderen zwei Fälle finanzieren mehrere Doktoranden.
- *Strukturen*: Beim Aufbau von Strukturen haben alle drei Projekte ein Gateway Projekt vorzuweisen. FlusiTex und HearRestore sind durch ihren nahen Einbezug von Industriepartnern und den guten Austausch mit diesen noch etwas stärker im Strukturaufbau. HearRestore hat zudem schon drei KTI-Finanzierungen erhalten und die Folgefinanzierung steht somit fest.

4.3 STÄRKEN UND SCHWÄCHEN IN DER WTT-UMSETZUNG

In den Gesprächen haben sich neben den weiter vorne dargestellten Konzepten und Instrumenten des WTT die Stärken und Schwächen in der Umsetzung abgefragt. Wir stellen das Ergebnis aus den Interviews dar.

Stärken

- *Zusammensetzung der Konsortia und Wille zum WTT*: Eine wichtige Rolle bei der Umsetzung des Ziels der WTT-Förderung spielt die Zusammensetzung des Konsortiums im Projekt. Der Wille zur Zusammenarbeit müsse gegeben sein, ansonsten könne kein WTT erreicht werden. Dies wurde in den Gesprächen mit HearRestore- und OpenSense-Verantwortlichen losgelöst von ihren Projekten zum Ausdruck gebracht. In manchen Gesprächen mit Projektverantwortlichen wurde generell unterstrichen, dass gerade Universitäten und Technische Hochschulen vor allem an der Grundlagenforschung und der Anzahl Publikationen interessiert seien. Dies sei aber nur ein Teil des WTT. So brauche es den Willen im Konsortium, den WTT auch mit anderen Instrumenten zu fördern.
- *Kooperationen mit Industriepartnern und Endnutzern*: Als wichtiges Element wird die Kooperation mit den Industriepartnern und Endnutzern beschrieben. In den Gesprächen mit den Programmverantwortlichen von Nano-Tera.ch wird festgehalten, dass ein zu früher Einbezug weniger effizient sei, da die Industriepartner bei einem tiefen TRL wenig Interesse hätten, sich einzubringen. Andere Gesprächs-

partner widersprechen dem. Ein früher Einbezug erlaube es, dass schon in der Konzeptphase die Anwendbarkeit und der wirtschaftliche Nutzen diskutiert werden könne. In Gesprächen mit Industriepartnern wurde deutlich, dass ein solcher Einbezug für KMU elementar sei, da diese die Forschung nicht selber bezahlen können. Solche Kooperationen seien darum äusserst wichtig.

- *Weiterführung der Aktivitäten nach dem Ende der Nano-Tera.ch-Laufzeit:* Alle Gesprächspartner aus den Fallstudien geben an, dass sie die Forschungen weiterführen wollen – auch nach der Nano-Tera.ch Finanzierung. In den Gesprächen wird fast immer auf das Bridge-Programm und die Möglichkeit, sich zu bewerben, verwiesen. Das Bridge-Programm sei das Nachfolgeprogramm von Nano-Tera.ch, wobei es für alle Disziplinen und Bereiche offensteht. Zudem wurde für HearRestore ausgesagt, es stünden KTI-Finanzierungen bereit.
- *Veränderung der Forschungskultur:* Nano-Tera.ch, so die Aussagen von vielen Gesprächspartnern, füllt eine Finanzierungslücke in der Schweizer Forschungslandschaft, nämlich jene, die zwischen Grundlagen- und praktischer Forschung entsteht. So wurde in mehreren Gesprächen darauf hingewiesen, dass der SNF primär grundlagenorientierte Forschung, die Kommission für Technologie und Innovation (KTI) unterstütze praxisorientierte Forschung (sogenannte KTI-Projekte). Die dazwischenliegenden Forschungsvorhaben kämen damit eher zu kurz. Nano-Terra.ch decke genau diese Finanzierungslücke ab. Dies wird von allen Personen als sehr positiv bewertet. Die drei Fallstudien sind sich darin einig.
- *Gezielte Instrumente:* In fast allen Gesprächen mit den Projektverantwortlichen wurden die WTT-Aktivitäten des Nano-Tera.ch-Office unterstrichen: die Videos, die Jahresanlässe, die Massnahmen für die Doktorierenden usw. Eine Mehrheit der Personen meint, es sei viel unternommen worden, um den Austausch zu stärken. In allen Fallstudien wird das Gateway-Instrument durchgehend als positiv beurteilt. Es wurde zudem auch bedauert, dass in der Nachfolge-Finanzierung Bridge bis jetzt kein solches Instrument vorgesehen sei. Für den WTT wäre es daher sinnvoll, auf den Erfahrungen mit den Gateway-Projekten aufzubauen und vergleichbare Instrumente einzusetzen.
- *Gute WTT-Outputs:* Die Programmverantwortlichen in allen Fallstudien nennen Messgrössen für den WTT in ihren Projekten. Genannte Beispiele sind der Personentransfer von der Hochschule in die Wirtschaft (OpenSense); die Publikationen und Konferenzen (alle Fallstudien); die Anwendung der Technik an den Patienten (HearRestore); die Tests der Technologie an Tieren (FlusiTex), die Prototypen (alle Fallstudien) oder die Start-ups (HearRestore).

Schwächen

Die Verantwortlichen der Projekte sahen bei der Realisierung der WTT-Aktivitäten Schwächen, die in den folgenden Abschnitten erläutert werden.

- *Strukturelle Faktoren bei der Projektvergabe:* In einigen Gesprächen mit Programm- und Projektverantwortlichen kam zum Ausdruck, dass die strukturellen Faktoren von Nano-Tera.ch ein Hindernis für den WTT darstellen würden. Die Struktur von Nano-Tera.ch inklusive die Finanzierungsanteile für die verschiedenen Tätigkeiten wurden im Voraus festgelegt. Für die RTD-Projekte war der SNF

für die Vergabe verantwortlich; Nano-Tera.ch konnte zwar seine Meinung abgeben, aber der Entscheid lag beim SNF. Einige Gesprächspartner gaben an, der SNF habe bei seiner Beurteilung der Projektanträge primär die wissenschaftliche Exzellenz im Auge gehabt, das Potenzial eines Projektes für den WTT hingegen eher gering gewichtet.

- *WTT ist personenabhängig:* In verschiedenen Gesprächen zum WTT von Nano-Tera.ch wurde generell darauf hingewiesen, dass der WTT stark von den Personen in den Projekten abhängig sei. In jedem Fall – egal bei welchen Partnern – müsse der Wille zur Zusammenarbeit bestehen. Bei den Industriepartnern müsse eine gewisse Neugierde da sein und sie müssten gewillt sein, ein Risiko einzugehen. Dies sei nicht immer der Fall gewesen. Eine weitere Schwierigkeit des WTT seien die Kosten für die Suche nach Industriepartnern. Dies sei zudem auch mit Glück verbunden und nicht immer planbar. Erschwerend bei der Suche nach Industriepartnern komme manchmal hinzu, dass Universitäten ihr Eigeninteresse (Publikationen und Kongressteilnahmen) manchmal zu stark betonten und damit zu wenig auf die Interessen der Partner eingehen würden.
- *Unterschiedliche Dauer für die Entwicklung des WTT-Potenzials:* Im OpenSense-Projekt wurde darauf hingewiesen, dass zu Beginn viel Zeit notwendig war, damit die verschiedenen Disziplinen zusammenfanden und ein gemeinsames Verständnis für den WTT entwickelt hätten. Auch im medizinischen Bereich braucht der WTT gemäss Aussagen der Interviewten Zeit, bis eine Technologie wirklich am Patienten getestet werden kann.
- *Angemessenes Monitoring:* Manche Gesprächspartner hinterfragen die Monitoringgrössen zur Erfassung des WTT-Potenzials (zum Beispiel die Anzahl PhD-Studierende, Start-ups, Patente, Publikationen oder der Werdegang von Doktoranden). Bei den Patenten beispielsweise komme es darauf an, ob es um eine Patentanmeldung oder den Erhalt eines Patentes gehe. Zudem seien für gewisse Disziplinen, zum Beispiel in den Computerwissenschaften, Patente weniger aussagekräftig; die Lizenzierung sei entscheidend. Es gehöre zum Werdegang von Doktoranden, dass sie einmal eine Stelle finden, ob dies wirklich WTT sei, wurde in manchen Gesprächen hinterfragt. Ferner ist festzuhalten, dass das WTT-Monitoring durch Nano-Tera.ch zu wenig regelmässig vorgenommen worden ist. Nachfragen bei Nano-Tera.ch ergaben, dass bei den RTD-Projekten (im Gegensatz zu den Gateway-Projekten) keine vertragliche Vereinbarung bestand, die WTT-Umsetzung systematisch zu überwachen. Das einzige Instrument des Monitorings waren die Jahresmeetings und die Vorträge der Programmverantwortlichen über den Stand der Arbeiten an das SNF-Panel. Weiter fällt auf, dass das Monitoring (ausser bei den Gateway-Projekten) fast ausschliesslich aus quantitativen Daten bestand, wohingegen qualitative Beurteilungen, beispielsweise über Interviews mit Industriepartnern, fehlen.

Dieses Kapitel zieht einen kurzen Vergleich des WTT von Nano-Tera.ch mit den 16 Programmen der ersten Serie der Nationalen Forschungsschwerpunkte (NFS). Wir vergleichen zunächst die Befunde zu den WTT-Konzepten und widmen uns anschließend dem Vergleich der eingesetzten Umsetzungsinstrumente. Als empirische Basis für den Vergleich dienen uns die Ergebnisse aus dem Bericht von Interface aus dem Jahre 2014.³⁵

5.1 KONZEPTVERGLEICH

Ein Vergleich der Konzepte führt uns zu folgendem Befund:

- Sowohl bei Nano-Tera.ch wie bei der ersten Serie der NFS existiert kein Konzeptpapier, das den WTT für die Programme beschreibt und Ziele definiert, Umsetzungsmassnahmen festsetzt und das Vorgehen für das Monitoring beschreibt. Die WTT-Konzepte ergeben sich implizit aus den Zielsetzungen der Programme oder lassen sich über Interviews mit den Programmverantwortlichen erschliessen.
- Im Vergleich zur ersten Serie zeigt sich bei Nano-Tera.ch ein viel stärker reflexives Modell kombiniert mit Interfaces. Bei den NFS der ersten Serie hatten 12 der 14 Programme ein klassisch lineares WTT-Konzept, sieben hatten zusätzlich Interfaces. Lediglich zwei Programme der NFS wiesen reflexive WTT-Konzepte auf. Insofern ist Nano-Tera.ch ein Programm, das konzeptionell die Industrie und die Anwendungspartner früher und intensiver in den Forschungsprozess einbindet.
- Der WTT ist für Nano-Tera.ch ein wichtiger Aspekt und bedeutender als über alle Programme der ersten Serie der NFS betrachtet. Hier haben nur fünf von 16 Programmen angegeben, dass der WTT eine grosse Rolle spielen würde. Allerdings darf bei dieser Betrachtung nicht ausser Acht gelassen werden, dass es auch bei den NFS Programme gab, die eine sehr stark ausgeprägte WTT Strategie verfolgten.
- Bei Nano-Tera.ch und den NFS waren die WTT-Verantwortlichen innerhalb der Leitungsgremien von nano-tera.ch angesiedelt. Bei Nano-Tera.ch ist dies der Executive Director. Die Ausnahme sind die Gateway-Projekte, die durch einen Innovation Manager des Nano-Tera.ch-Office betreut wurden. Auch bei den NFS war meistens ein Mitglied der Programmleitung für den WTT zuständig, wobei auch externe WTT-Verantwortliche eingesetzt worden sind. Dies ist bei Nano-Tera.ch nicht der Fall.

³⁵ Rieder et al. 2014.

5.2 INSTRUMENTENVERGLEICH

Auf der Ebene der Umsetzung zeigt es sich *erstens*, dass die Instrumente zur Förderung des WTT in der ersten Serie der NFS und bei Nano-Tera.ch sehr ähnlich sind. So waren Patente, Kooperationen mit Industriepartnern, Prototypen, eingeworbene Drittmittel, Start-up-Firmen, die Weiterführung der Aktivitäten nach dem Ende der Programmlaufzeit sowie die Anzahl Doktoranden und deren Werdegang bei beiden Programmen wichtige Messgrössen.

Zweitens sind alle Typen von Instrumenten (direkter/indirekter Transfer) in beiden Programmen anzutreffen.

Drittens sind das Reporting und das Monitorings der beiden Programme zu den WTT-Aktivitäten etwa vergleichbar. Für Nano-Tera.ch lässt sich ergänzen, dass die Messgrössen nicht alle regelmässig und auch nicht systematisch überwacht wurden. Einige der Daten (Start-ups, Patente, KTI usw.) werden erst bei Programmende aufbereitet. Bei der ersten Serie der NFS sind die Daten eher regelmässig erhoben worden.

Interessant ist *viertens* ein Vergleich der Ausgaben für den WTT: Bei den Programmen der ersten Serie der NFS betrug der durchschnittliche Anteil der Ausgaben für WTT 1,29 Prozent der gesamten Ausgaben von 1,528 Milliarden Franken (Rieder et.al, 2014:29). Bei Nano-Tera.ch können die Ausgaben für die Gateway-Projekte als Ausgaben für den WTT gelten: Sie machen rund 1,7 Prozent der Ausgaben von Total 249 Millionen Franken aus und liegen damit nur wenig höher als bei der ersten Serie der NFS. Einzelne der Teilprogramme des NFS weisen durchaus höhere Ausgaben für WTT aus. Der grösste Anteil liegt bei 3,3 Prozent, der kleinste Anteil bei 0,1 Prozent.

Ein Vergleich der Outputs muss vorsichtig vorgenommen werden, da die einzelnen NFS-Projekte viel grösser sind als die RTD-Projekte von Nano-Tera.ch. Die nächste Tabelle gibt eine Übersicht über die Outputs der zwei Programme. Um die Relationen zu vergleichen, muss jeweils berücksichtigt werden, dass den Programmen der ersten Serie des NFS etwa 6 mal mehr Mittel zur Verfügung standen als Nano-Tera.ch.

D 5.1: Vergleich der WTT-Outputs der NFS mit Nano-Tera.ch

Output	Total aller NFS der ersten Serie	Total Nano-Tera.ch
Gegründete Start-up-Firmen	81	4 (6 noch in Gründung)
Eingereichte Patente	330	67 Patentanmeldungen ausgefüllt
Zugesprochene Patente	163	Keine Angaben
Lizenzen	70	Keine Angaben
Prototypen/Demonstratoren	271	Keine Angaben
Produkte/Prozesse	213	Nicht zutreffend
Kooperationen mit Industriepartnern	737	74 (in 53 Projekten)
KTI-Projekte	127	9
Drittmittel Industriepartner (in Mio. CHF)	164,28	9,5
Durchschnittlicher Anteil der Doktorierenden und Postdocs, die eine Stelle im privaten oder öffentlichen Sektor (d.h. ausserhalb der Akademie) fanden	22,4%	Keine Angaben

Quelle: Darstellung Interface. Daten: Scientific Reports von Nano-Tera.ch und der Bericht von Interface zu den NFS der ersten Serie, welcher auf die Daten der 14 Schlussberichte des Schweizerischen Nationalfonds (SNF) zuhanden des Staatssekretariats für Bildung, Forschung und Innovation (SBFI) zurückgreift.

Wir beobachten folgendes:

- *Es werden die gleichen Daten zur Beschreibung der Outputs verwendet:* In Nano-Tera.ch und den NFS werden die Outputs der gegründeten Start-up-Firmen, die eingereichten Patente, Kooperationen mit Industriepartnern, die KTI-Projekte (obwohl erst am Schluss des Programms) und die Höhe der Drittmittel gemessen.
- *Für einige Outputs von Nano-Tera.ch liegen keine Zahlen vor:* Diese Outputs werden zwar in Dokumenten oder Interviews genannt, ohne aber Angaben zu deren Grössenordnung. Dies gilt für die Lizenzen, Prototypen/Demonstratoren und den durchschnittlichen Anteil der Doktorierenden und Postdocs, die eine Stelle im privaten oder öffentlichen Sektor (d.h. ausserhalb der Akademie) fanden. Diese letzte Messgrösse wird von Nano-Tera.ch für die Selbstevaluation aufbereitet.
- *Einige Outputs des NSF sind für Nano-Tera.ch nicht verfügbar:* So liegen bei Nano-Tera.ch beispielsweise noch keine Angaben über die zugesprochenen Patente vor; es wird bisher nur die Anzahl der Patentanmeldungen erfasst.
- *In einigen Bereichen liegen die Werte eher tief:* Die Zahl der Startups und die Zahl der KTI-Folgeprojekte ist auch unter Berücksichtigung des sechs Mal kleineren Budgets von Nano-Tera.ch eher tief.

Insgesamt stellen wir fest, dass Nano-Tera.ch die Outputs bis jetzt weniger systematisch erfasst als die NFS. Dies liegt eventuell daran, dass die Daten für die NFS aus den Schlussberichten stammen, während für Nano-Tera.ch noch kein Schlussbericht vorliegt.

ANHANG I: ANALYSERASTER

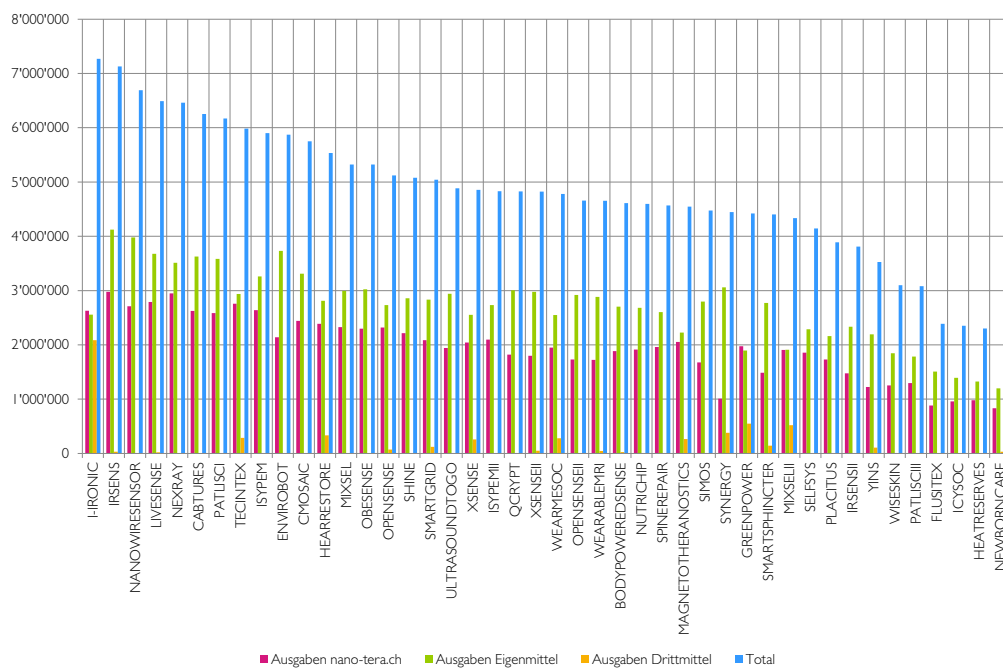
Fragen
Begriffsverständnis von WTT: Welche Arten des WTT finden sich in auftrags-relevanten Dokumenten?
Was sind die Ziele anhand welcher der WTT in Nano-Tera.ch erreicht werden soll?
Wie sollen die Ziele erreicht werden?
Was sind die Umsetzungsinstrumente für den WTT von Nano-Tera.ch?
Wie hat sich das WTT-Konzept von Nano-Tera.ch auf der Programmebene und in den Projekten entwickelt?
Messgrössen von WTT: Wie werden die Konzepte in den Dokumenten präzisiert?
Wie wurde das Niveau des WTT auf Programmebene und in den Projekten beurteilt? Welche Indikatoren werden verwendet?
Was wurde bei ungenügender Leistung im WTT-Bereich unternommen?
Was sind Stärken und Schwächen des WTT von Nano-Tera.ch?
Was ist ihre Gesamteinschätzung des WTT von Nano-Tera.ch?

ANHANG 2: LISTE DER INTERVIEWTEN

Interviewpartner	Funktion
Martin Rajman	Executive Officer Nano-Tera.ch (3 Gespräche)
Giovanny De Micheli	Director Nano-Tera.ch (zusammen mit Martin Rajman)
Roland Pesty	Pre-Venture Program Coordinator (Gateway)
Bengt Alexandre Elmér	NextStep Community Manager (zusammen mit Martin Rajman)
Stefan Weber	Programmverantwortlicher HearRestore
Marco Cavesaccio	User/Partner HearRestore
Daniel Ahmed	Programmkordinator FlusiTex/FlusiSafe
Karl Aberer	Programmverantwortlicher OpenSense Phase 1 (zusammen mit Martinoli Alcherio)
Martinoli Alcherio	Programmverantwortlicher OpenSense Phase 2 (zusammen mit Karl Aberer)
Jonas Reinhardt	Industrial Partner FlusiSafe
Paul Burkhard	Ehemals SNF
Harry Heinzelmann	CSEM, Partner Nano-Tera
Marco Matulic	CTO CAScination (Partner HearRestore)
Muriel Bochud	CHUV (Partner Open Sense)
Laurent Mudry	TL Lausanne (Industrial Partner Open Sense)

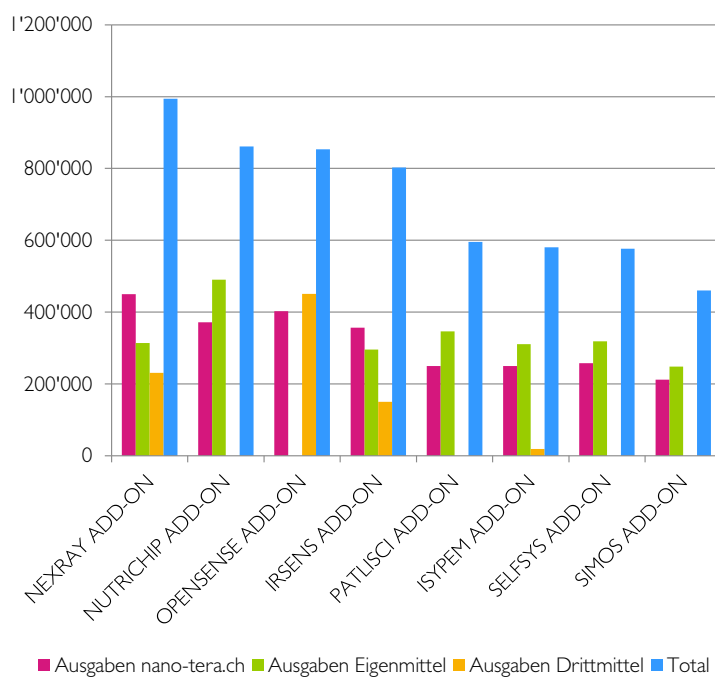
ANHANG 3: AUSGEWÄLTE DATEN ZU NANO-TERA.CH

DA 1: RTD-Projekte 2008–2016



Quelle: Darstellung Interface basierend auf Daten aus Project Evaluation Impact vom SWIR.

DA 2: RTD add-on Projekte 2012



Quelle: Darstellung Interface basierend auf Daten aus Project Evaluation Impact vom SWIR.

ANHANG 4: TECHNOLOGY READINESS LEVELS (TRL)

Forschungsprojekte können folgende Niveaus durchlaufen:

TRL 1 – basic principles observed

TRL 2 – technology concept formulated

TRL 3 – experimental proof of concept

TRL 4 – technology validated in lab

TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)

TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)

TRL 7 – system prototype demonstration in operational environment

TRL 8 – system complete and qualified

TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Quelle: <https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf>.

ANHANG 5: VERWENDETE LITERATUR ZUM THEMA WTT

- Armstrong, Katy (2014): Emerging Industrial Applications, in: Styring, Peter; Quadrelli, Elsje A.; Armstrong, Katy (Hrsg.): Carbon Dioxide Utilisation: Closing the Carbon Cycle, Elsevier, Amsterdam.
- Campbell, David F. J.; Carayannis Elias G. (2012): Lineare und nicht-lineare Knowledge Production: innovative Herausforderungen für das Hochschulsystem, in: Zeitschrift für Hochschulentwicklung, 7(2), S. 64-72.
- Freiburghaus, Dieter (1989): Interfaces zwischen Wirtschaft und Politik, in: Schweizerisches Jahrbuch für Politikwissenschaft 29, S. 267-277.
- Guston, David H. (2001): Boundary Organizations in Environmental Policy and Science. An Introduction, in: Science, Technology, & Human Values, 26(4), S. 399-408.
- Koschatzky, Knut (2001): Räumliche Aspekte im Innovationsprozess. Ein Beitrag zur neuen Wirtschaftsgeographie aus Sicht der regionalen Innovationsforschung, Lit Verlag, Berlin-Münster-Wien-Zürich-London.
- Meissner, Dirk; Sultanian, Elena (2007): Wissens- und Technologietransfer – Grundlagen und Diskussion von Studien und Beispielen, Center für Science and Technology Studies (CEST), Bern.
- Rieder, Stefan; Knubel, Stefanie; Gärtner, Stefan (2014): Der Wissens- und Technologietransfer im Rahmen der ersten Serie der Nationalen Forschungsschwerpunkte (NFS). Schlussbericht zuhanden der Geschäftsstelle des Schweizerischen Wissenschafts- und Innovationsrates (SWIR), Interface Politikstudien Forschung Beratung, Luzern.
- Ruttan, Vernon W. (2001): Technology, Growth, and Development: An Induced Innovation Perspective, Oxford University Press, New York.

ANHANG 6: WEITERFÜHRENDE LITERATUR ZUM WTT

- European Commission (2009): Metrics for Knowledge Transfer from Public Research Organisations in Europe. Report from the European Commission's Expert Group on Knowledge Transfer Metrics, <http://ec.europa.eu/invest-in-research/pdf/download_en/knowledge_transfer_web.pdf>, Zugriff 28.09.2017.
- Reinhard, Michael; Schmalholz, Heinz; Schneider, Leander (1996): Technologietransfer in Deutschland. Stand und Reformbedarf, Duncker & Humblot, Berlin/München.
- Rösner, Helmut; Strassburger, Gunter (2003): Erfahrungen und Probleme des Technologietransfers externer Industrieforschungseinrichtungen, in: Pleschak, Franz (Hrsg.): Technologietransfer – Anforderungen und Entwicklungstendenzen, Fraunhofer IRB, Karlsruhe, S. 53–64.
- Sabisch, Helmut; Esswein, Werner; Meissner, Dirk; Wylegalla, Jörg (1998): Quantifizierung und Messung des Erfolgs von Technologieförderprogrammen. Studie im Auftrag des Sächsischen Rechnungshofs, Rechnungshof des Freistaates Sachsen, Leipzig.

Annex E – Nano-Tera.ch: related grants awarded by the SNSF, April 2017

Nano-Tera.ch: related grants awarded by the SNSF

The impact of the Nano-Tera.ch program is currently being evaluated by the SWIR. To support this evaluation, the SNSF in this document provides data on its funding in the research areas of the Nano-Tera.ch program. To identify the relevant research areas we choose a simple approach: we assume that all applicants for Nano-Tera.ch applications are active in the relevant field. We therefore identify all involved responsible applicants and co-applicants in the program and list all other SNSF grants that these researchers have been awarded (after the earliest submission date to Nano-Tera.ch until the present date). We include both researchers whose Nano-Tera.ch applications were approved as well as those whose were rejected, as both groups can safely be assumed to consist of active researchers in the relevant research area. The following tables provide information about their non-Nano-Tera.ch SNSF grants¹.

The first application to Nano-Tera.ch was submitted on 2008-04-24, and has since involved:

Total Applications	Total People (primary and co-applicants)
147	472

These researchers were also funded by the following SNSF grants, not related to Nano-Tera.ch:

Awarded projects with same people	Funding to same people (MCHF)	Publications from same people
1077	401.7	3172

These funded SNSF projects can be broken down into funding categories, which were awarded the following funding, representing the following percentages of total SNSF funding in each category (since the first submission to Nano-Tera.ch until the present date).

SNSF Funding Category	# grants	MCHF	% total funding
Project funding	728	225.5	7.4
Programmes	179	133.3	13.7
Infrastructure	122	31.5	10.7
Science communication	33	1.2	2.7
Careers	15	10.3	0.9

¹We include projects in all funding schemes of the SNSF except for NCCRs, where - for technical reasons - we do not have fine-grained information on involved researchers on a project or sub-project level. The numbers we report are therefore probably lower than the effective total SNSF funding.

Annex F – SSC interviews: list of interviewees and interview guides, 2017–2018

Deux séries d'entretiens ont été réalisées. La première (mars 2018) concernait des entretiens de recherche portant sur Nano-Tera.ch et SystemsX.ch. La seconde série (novembre 2017 à février 2018) consiste en des entretiens d'analyse consacrés à Nano-Tera.ch uniquement. Toutes les personnes contactées pour des entretiens n'ont pas pu être rencontrées.

Entretiens de recherche

Prénom Nom	Principale fonction
Dr Paul Burkhard	Responsable pour Nano-Tera.ch à la Division II du secrétariat du FNS
Dr Daniel Höchli	Directeur du secrétariat du FNS
Dr Charles Kleiber	Secrétaire d'Etat à la recherche
Dr Martin Rajman	Executive Director, Nano-Tera.ch
Dr Raymond Werlen	Secrétaire général adjoint de la CRUS

Entretiens d'analyse

Prénom Nom	Principale fonction
Prof. Dr Gabriel Aeppli	Prof. de physique EPFL et EPFZ, membre du CSS
Prof. Dr Murielle Bochud	Prof. à l'Institut Universitaire de Médecine Sociale et Préventive (UNIL). Co-PI du projet Nano-Tera.ch «OpenSense II»
Dr Christian Brunner	Coordinateur du programme Bridge FNS-Innosuisse
Prof. Dr Nico De Rooij	Prof. Microengineering EPFL, Membre de l'ExCom de Nano-Tera.ch (2008-2017)
Prof. Dr Ralph Eichler	Président de l'EPFZ 2007-2014 ; membre du Steering Committee de Nano-Tera.ch (2007-2014)
Dr Philippe Fischer	Directeur de la Fondation suisse pour la recherche en microtechnique
Prof. Dr Lutz-Peter Nolte	Prof. Institute for Surgical Technology & Biomechanics, Université de Berne, Co-PI du projet Nano-Tera.ch «SmartSphincters»
Prof. Dr Laurent Sciboz	Prof. Haute école du Valais, directeur Institut Icare, Co-PI du projet Nano-Tera.ch «Selfsys»
Prof. Dr Gabor Szekely	Prof. Computer Vision Laboratory EPFZ, Head MedTech CTI ; directeur du PRN CO-ME Computer Aided and Image Guided Medical Interventions (série 1)
Prof. Dr Stefan Weber	Prof. Center for Biomedical Engineering (ARTORG), Université de Berne, PI du projet Nano-Tera.ch «HearRestore»

Guide utilisé pour les entretiens de recherche

1. Positionnement de l'institution resp. de la personne

- Comment avez-vous pris connaissance du lancement de l'Initiative NTCH / SXCH?

2. Origine de NTCH / SXCH + Contexte général

- Quelle était l'analyse de fond qui a motivé son lancement? Quelles étaient les principales motivations de cette initiative?
- Comment caractériser le contexte d'alors sur le plan de l'encouragement de la recherche? Quels enjeux? quel positionnement des acteurs?

3. Appréciation de l'initiative (au niveau interne à NTCH / SXCH)

- Quels sont les principaux résultats de NTCH / SXCH?
- Les succès? Les échecs? «More of the same»? Les problèmes?
- Quelle est la valeur ajoutée de NTCH / SXCH en général et par rapport à un PRN?

4. Appréciation de l'initiative (niveau système FRI)

- Est-ce que NTCH / SXCH peut être considéré comme un instrument resp. un programme d'encouragement de la recherche, au même sens que les PRN ou que les SCCER, ou bien est-ce qu'il

s'agit d'une initiative ad hoc, unique «One shot program»? Y avait-il une volonté d'influer sur le paysage de l'encouragement de la recherche?

- Comment faut-il comprendre les demandes faites par différents acteurs lors de la révision de la LERI en 2011 de placer SXCH et NTCH dans la LERI et non plus dans la LAU (Contributions liées à des projets / Projektgebundene Beiträge)?
- Y a-t-il eu des conséquences particulières de NTCH / SXCH sur les formes d'encouragement de la recherche en Suisse? p. ex. est-ce que BRIDGE est une conséquence? et les SCCER? Autres (i.e. SPHNI) ?
- Le contexte d'encouragement a passablement changé depuis 2008. Serait-il aujourd'hui encore possible / justifié / nécessaire de lancer une initiative de ce type? avec ce mode d'organisation?

Guide utilisé pour les entretiens d'analyse

Scientific impact

- 1 What was the main goal of Nano-Tera on the scientific level?
- 2 To what extent has Nano-Tera.ch contributed to fostering excellence in research in Swiss engineering sciences? And in other scientific fields?
- 3 Did the initiative contribute to bridging the gap between fundamental and applications-oriented research and between science and engineering?

Educational impact

- 4 What was the main goal of Nano-Tera on the educational level?
- 5 How do you assess the measures taken to promote PhDs? Original?
- 6 The main educational impact of Nano-Tera.ch is 366 PhD students. Is that “enough” considering the funding scope (approx. CHF 200m) and the duration (9 years) of the programme?

Economic impact

- 7 What was the main goal of Nano-Tera on the economic level?
- 8 Did Nano-Tera.ch formulate an explicit strategy to promote KTT on the programme level? How was it organised in the projects funded (for example at your institution)?
- 9 What would you consider best practices for KTT in a similar research programme (interface science-engineering)?

Societal impact

- 10 What was the main goal of Nano-Tera on the societal level?
- 11 How would you measure the societal impact of such a programme?

Institutional impact

- 12 Which was the main goal of Nano-Tera on the institutional level?
- 13 To what extent did your institution benefit from Nano-Tera from an institutional and/or structural perspective? What was the institutional interest in Nano-Tera? (scientific profiling, attract scientists, funding source, ...?)
- 14 What is your opinion of SNSF-CTI Bridge funding scheme? Is it related to Nano-Tera?

Broader impact

- 15 What is your opinion of the Nano-Tera programme under the governance of the initiative?
- 16 To what extent is Nano-Tera an open network and/or community? (to: other scientists, other institutions such as UAS, etc.)
- 17 Which are the strengths and weaknesses of Nano-Tera?
- 18 What is the overall added-value of this programme within your scientific domain and for Switzerland (sustainability)?

Annex G – Programme and participant list for site visit, November 2017

Impact evaluation “Nano-Tera.ch” – Meetings in Bern, 13 and 14 November 2017

Schedule and Participants

Place & Contact

The meetings take place at [Hotel Kreuz](#), Zeughausgasse 41, Meeting room “Bovet”, 1st floor
Contact Hotel: +41 (0)31 329 95 95 / Contact SSIC: +41 (0)58 463 28 89

Participants

SSC	Jean-Marc Triscone (chair), Fariba Moghaddam (Staff: Frédéric Joye-Cagnard, Eva Herrmann, Claudia Acklin)
Expert panel	Jeremy Baumberg, Rudy Lauwereins, Mark Lundstrom
Nano-Tera.ch	Giovanni De Micheli, Giorgio Margaritondo, Mario El-Khoury (Nov. 14), Harry Heinzelmann (Nov. 13), Heinrich Meyr, Christofer Hierold, Martin Rajman
SNSF	Dieter Imboden, Paul Leiderer, Urs Dürig, Albert van den Berg, Liz Kohl

13 November 2017 – Meeting “Site visit”

Chair: Jean-Marc Triscone, SSIC

Participants: SSIC, Expert panel, Nano-Tera.ch

Aim of the meeting is a discussion, especially between the international experts and the Nano-Tera.ch Consortium, in order to help them to answer the SSIC's questions. The structure of the discussion complies with the SERI Mandate. Each part will be introduced by a short presentation of Nano-Tera.ch.

14.00 – 14.15	Welcome address
14.15 – 14.40	Nano-Tera.ch main achievements (20' presentation by programme leader G. De Micheli + 5' discussion)
14.40 – 15.40	Dimension I – Scientific impact 20' Introduction by Nano-Tera.ch (including a short video) 40' Discussion
15.40 – 16.00	<i>Coffee break</i>
16.00 – 16.45	Dimension II – Educational impact 15' Introduction by Nano-Tera.ch (including a short video) 30' Discussion
16.45 – 17.30	Dimension III – Economic impact 15' Introduction by Nano-Tera.ch (including a short video) 30' Discussion
17.30 – 18.15	Dimension IV + V – Societal & Institutional impacts 15' Introduction by Nano-Tera.ch (including a short video) 30' Discussion
18.15 – 18.20	Closing remarks

November 14, 2017 / 09.15-10.15 – Meeting with SNSF

Chair: Jean-Marc Triscone, SSIC

Participants: SSIC, Expert panel, SNSF

Aim of the meeting is a discussion between the expert panel and scientists who accompanied the Nano-Tera.ch funding processes for the Swiss National Science Foundation SNSF. The SNSF was

responsible for the evaluation of the RTD projects and has a well-founded external view of the programme.

10.15 – 10.30 *Coffee break: arrival of Nano-Tera.ch*

14 November 2017 / 10.30–11.30 – Meeting “final round”

Chair: Jean-Marc Triscone, SSIC

Participants: SSIC, Expert panel, SNSF, Nano-Tera.ch

Aim of the meeting: Discuss unresolved issues / Exchange information on procedure and scheduling

Annex – Full participants list

Name	Group, function	Attends ...
Moghaddam, Fariba	SSIC Member	All meetings
Triscone, Jean-Marc	SSIC Member	All meetings
Baumberg, Jeremy	Expert Panel	All meetings
Lundstrom, Mark S.	Expert Panel	All meetings
Lauwereins, Rudy	Expert Panel	All meetings
De Micheli, Giovanni	Nano-Tera, Executive Committee, Chair	Site visit + Final round
El-Khoury, Mario	Nano-Tera, Steering Committee Member	Final round
Heinzelmann, Harry	Nano-Tera, Steering Committee Member	Site visit
Hierold, Christofer	Nano-Tera, Executive Committee	Site visit + Final round
Margaritondo, Giorgio	Nano-Tera, Vice-President EPFL (2004-2010)	Site visit + Final round
Meyr, Heinrich	Nano-Tera, Scientific Advisory Board, Chair	Site visit + Final round
Rajman, Martin	Nano-Tera, Executive Director	Site visit + Final round
Faist, Jérôme	Nano-Tera, PI IrSens2	Site visit (Scientific)
Lacour, Stéphanie	Nano-Tera, PI SpineRepair	Site visit (Scientific)
Hager, Pascal	Nano-Tera, PhD student	Site visit (Educational)
Murali, Srinivasan	Nano-Tera, Post-Doc	Site visit (Educational)
Dommann, Alex	Nano-Tera, Executive Committee	Site visit (Economic)
Pesty, Roland	Nano-Tera, Pre-Venture Program (Gateway)	Site visit (Economic)
Duval, Etienne	Nano-Tera, Producer, reporter and trainer	Site visit (Societal)
Weber, Stefan	Nano-Tera, PI HearRestore	Site visit (Societal)
Leiderer, Paul	SNSF, Expert Panel for Nano-Tera, Chair	SNSF + Final round
Dürig, Urs	SNSF, Expert Panel for Nano-Tera	SNSF + Final round
Van den Berg, Albert	SNSF, Expert Panel for Nano-Tera	SNSF + Final round
Imboden, Dieter	SNSF, President (2005-2012)	SNSF + Final round
Kohl, Liz	SNSF, Office Division II: Mathematics, Natural and Engineering Sciences	SNSF + Final round
Acklin, Claudia	SSIC, Head of secretariat	All meetings
Herrmann, Eva	SSIC Staff	All meetings
Joye-Cagnard, Frédéric	SSIC Staff	All meetings

Prof. Stefan Weber was not able to attend the meeting.