Transformative Technologies Strategy 2022 – 2024

Mid Sweden University

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Mid Sweden University in partnership with

Knowledge Foundation

Transformative Technologies Strategy 2022 – 2024
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Photo: Olle Melkerhed

Executive Summary

Mid Sweden University is working to raise its profile in research and education with the ambition to become a *global university with regional commitment* ("Ett globalt universitet med regionalt engagemang"). This ambition reinforces the long-term goals of the Research Environment for Transformative Technologies—TransTech – formulated in the long-term vision *Transforming the Industrial Ecosystem*, in short *TIE Vision*, which has guided our development since 2012.

Since 2012, the Knowledge Foundation has supported the development of TransTech. The Strategy at hand defines the development focus for the next three years, 2022–2024, in a strategic collaboration with the foundation. Our strategic choices are based on the progress we achieved in the implementation of the previous 4-Year Plan 2018–2021, initially described in the Progress Report 2021. An important additional input to our discussions and analysis came from the results of the ARC21 evaluation.

In 2022–2024 we will emphasise the following three main areas for development:

- *A combination of stronger Research Profiles and high scientific impact*, meaning that in addition to our focus to strengthen **NIIT** and **NeoPulp**, the cultivation of emerging areas of high scientific potential is also very important for the renewal of our research and creation of future Research Profiles.
- *A broader industrial and regional relevance*; this is crucial for sustained funding. We have exciting new opportunities for education programs combined with research co-production, and for research and innovation in advanced materials and manufacturing technologies.
- *A more dynamic academic environment*; we aim to make greater use of guest professors and new academic collaborations, especially for the benefit of early-career researchers and graduate students in a developing academic environment that relies on good collaboration between TransTech and the new Departments of the faculty.

In comparison to the preceding plans, the enthusiasm and development of researchers and teams is even more important, not least for national and international collaborations.

Contents

Please note our notation: **Research Actions** are marked with bold font, key concepts with Capital Initials, and development areas and capabilities with *italics and underlining*.

1. TransTech in the beginning of 2022

TransTech is very important for MIUN

Mid Sweden University (MIUN) is working to raise its profile in research and education with a vision to become a *global university with regional commitment*. The Research Environment for Transformative Technologies—TransTech— is a central driver of this vision. For example, in 2020 TransTech stood for one-half of all external research funding at the university. Since 2012, the development of TransTech has been guided by a regional vision of *Transforming the Industrial Ecosystem*, in short *TIE Vision*, where it is the university that connects the region to the international scientific community and the opportunities it offers. With two strong research programs (**NIIT** – Next Generation Industrial Internet of Things and **NeoPulp** – New perspective to the development of pulp fibre properties) and several smaller research, innovation, and education activities, TransTech gives national profile and international visibility for the university in engineering research and education.

TransTech consists of two research centres, FSCN and STC. FSCN studies process technologies for forest-based fibres and lignocellulosic materials for new applications, such as electrical energy storage. The foundation of STC is in sensor technologies and wireless communication, which have enabled us to build strong research on the Internet of Things. The Research Profile **NIIT** forms the core of research at STC and **NeoPulp** at FSCN.

In the next period, 2022–2024, the Additive Manufacturing (AM) group of the Sports Tech Research Centre (STRC) will join TransTech and further enhance our transformative efforts. In connection to this, we will update the structure of our Research Program and its communication. Research centres are a central instrument in the communication and profiling of the university, and therefore the university-wide ARC21-evaluation first focused on the eight research centres of MIUN. We have used the results of the evaluation for FSCN, STC and STRC in the planning of this strategy for TransTech. Together the three centres will make TransTech an even stronger driver of the global and regional ambitions of the university in the areas of engineering research and education. This chapter covers TransTech as it was at the end of 2021, in addition to brief information about the contributions that the AM-group will bring in 2022.

Scope and revision of our Research Program

The scientific foundation of TransTech consists of six main disciplines:

- Chemistry of lignocellulosic materials (FSCN): Organic Chemistry, especially Catalysis, and Physical Chemistry, especially Surface and Colloid Chemistry
- Chemical Engineering (FSCN) of fibre materials and related manufacturing processes
- Computer Engineering (STC), especially wireless communication, machine learning and multidimensional imaging
- Engineering Physics (FSCN), with focus on functional nanomaterials, especially for energy harvesting, storage, and use
- Electronics of enabling technologies (STC), with focus on embedded systems, energy harvesting, power electronics, hybrid electronics integration
- Electronics of sensor systems (STC) with a focus on sensor systems and photonics

The research groups in each discipline and research centre are given in Appendix 1. The AM-group will significantly strengthen TransTech in the area of new metallic and composite materials and make Mechanical Engineering a strong discipline. We already had researchers (aluminium, solid mechanics of wood) and an education program (Technical Design) in Mechanical Engineering.

In our Research Program, we have combined the scientific disciplines into cross-disciplinary Strategic Actions that develop new knowledge and competence needed in industry and the transformation of the ecosystem (see Fig. 1). Currently, we have four Strategic Actions. Two of them, **EISS** and **InFibra** have a KK Research Profile as a core, **NIIT** and **NeoPulp** respectively, the latter which started just recently. The profiles give identity to these Strategic Actions. In addition, **NIIT** profiles the research of STC, and **NeoPulp** that of FSCN. We would gain nothing by keeping the identities **EISS** and **InFibra** in our communication, and it is better to simplify our communication by replacing **EISS** with **NIIT**, and **InFibra** with **NeoPulp**.

- Connecting sensors to the Internet of Things for AI-models—**EISS → NIIT**: There is a rapidly growing interest in IoT implementation integrated with AI in many industrial and public sectors. This initiative by STC supports companies that develop and deliver IoT and industrial AI solutions, with the KK Research Profile **NIIT** at the centre.
- Generating IoT and AI data—**XGeMS**: The development towards data driven development will require new measurement systems to generate datasets for machine learning models. Machine learning also has a potential to drive new solutions in measurement systems.
- New technology to pulping and new cellulosic materials —**InFibra → NeoPulp**: We envision a broadening market for new fibrous and new cellulosic materials. Research to this end is driven by FSCN in the KK Research Profile **NeoPulp** and supporting projects.
- Large surfaces for green electricity—**KM2**: The transition to zero-emission power systems is one of the global grand challenges. It will create new business opportunities that can become important for our industrial ecosystem, too. Our goal is to support the emergence of a new industrial sector with cost-effective materials, devices, and system solutions, in part through the KK Synergy project **STORE**.

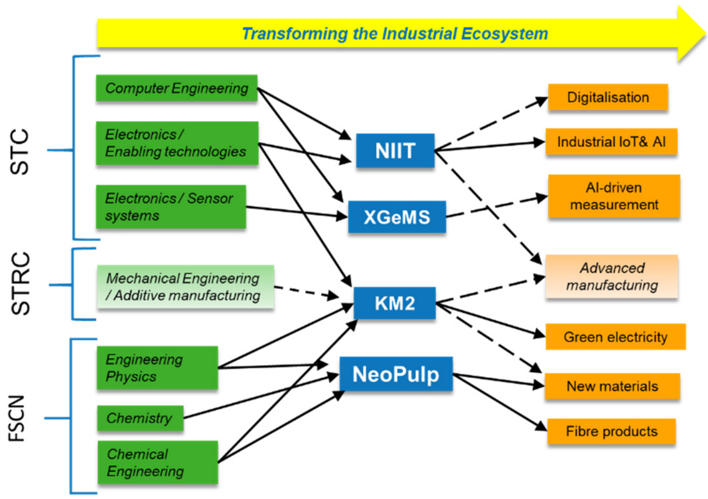


Figure 1: *Strategic Actions (in the middle) form the structure of our Research Program and connect our scientific expertise (left) to the global challenges and industrial opportunities (right, taken from Fig. 1). The structure of Strategic Actions will be reconsidered in 2022 along with the inclusion of the AM-group of STRC.*

The Strategic Actions form the basic research and education environments in TransTech. They also drive growing collaboration between the research centres, up to now STC and FSCN. This is, by construction, very clear in **KM2**, while the Research Profile **NeoPulp** of FSCN will rely on the AI-technologies and sensors for inter- and intra-fibre measurements from STC-researchers. With **NIIT** and **NeoPulp** now launched, the next step is to consider is if our researchers could gain even more from and further strengthening these two Research Profiles. The opposite direction can also be fruitful, e.g., researchers engaged in **NeoPulp** already contribute to **KM2**. An additional synergy opportunity comes from the Additive Manufacturing group of STRC, now joining TransTech. Their Mechanical Engineering researchers have common interests with Engineering Physics, Electronics and Chemical Engineering. For these reasons, we have already started a review of the connections and positioning of our Strategic Actions. We return to this review in Chapter 3.

Scientific production

For many years we have worked to increase the scientific production and impact (Fig. 2), which has been successful. International collaborations have boosted the positive development in recent years and enabled growth despite decreasing research capacity (FTE). The data in Fig. 2 and Fig. 3 of the Strategic Actions includes all publications of our guest professors. From now on, we will include only papers with MIUN as affiliation.

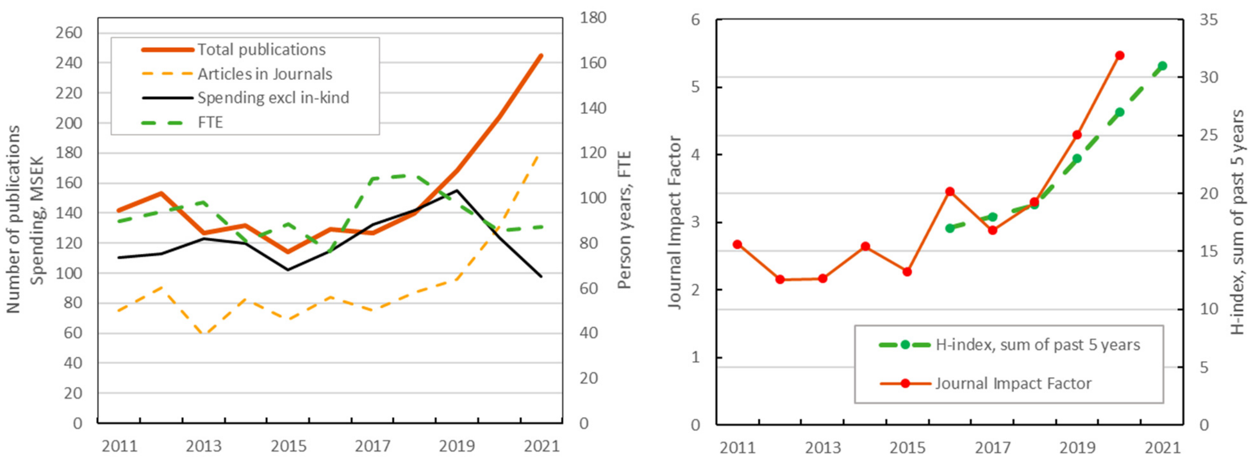


Figure 2*: On the left, the number of publications of TransTech, research spending, and person-years in research (= FTE). On the right, the Journal Impact Factor and H-index of the publications produced by TransTech. For each year, the H-index comes from the papers we published that year and the four preceding years.*

Table 1 shows the distribution of our co-authors. The most important conclusion for our strategy is the proportionately low number of publications with other Swedish universities. We must increase collaboration and joint publication with Swedish universities before we can expect them to recognise our research.

Table 1: *Collaboration in publications from TransTech*

Year	2019	2020	2021
Number of scientific publications with representatives from society (not academia)	42	39	37
Number of scientific publications with national academic co-authors	13	11	10
Number of scientific publications with international co-authors	78	84	83
Number of scientific publications with representatives from both academia and society	24	31	23

The results for the Strategic Actions shown in Fig. 3 demonstrate that **NIIT** stands for much of TransTech's improvement. **NeoPulp** underwent major changes a few years ago but is now recovering with a target of 60 publications in 2024. The Research Group of Additive Manufacturing that is joining TransTech is relatively young. Its production has increased to an average of 9 per year in 2019-21. Over half of these are with international co-authors and roughly half also include co-authors from industry.

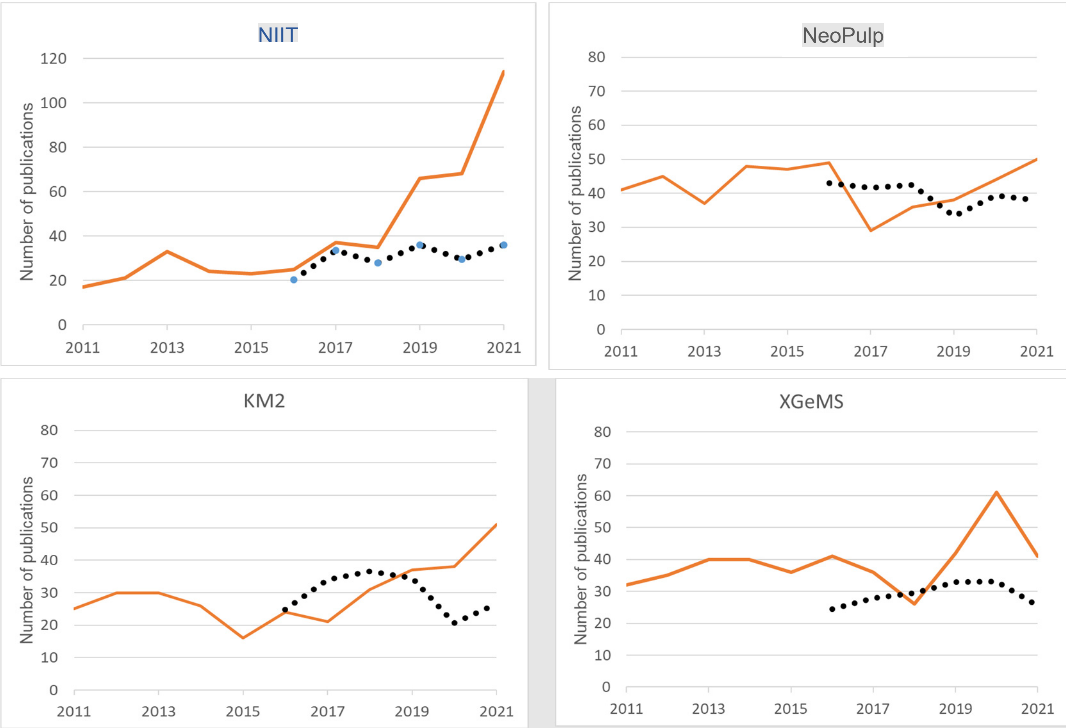


***Figure 3**: Publication volumes in the Strategic Actions. Dotted lines show the mean level of 1.5 publications per FTE that roughly agreed with the total of TransTech's publications in the early years, as can be seen in Fig. 2.*

Education and competence development programs

In parallel with research, the environment of TransTech includes a portfolio of four MSc programs that have synergies with the Strategic Actions on one hand and with the competence needs of industry on the other. The programs in Electrical Engineering and Computer Engineering were already running prior to the establishment of TransTech, but we renew them continuously as companies developing industrial Internet of Things need personnel with skills in machine learning. A new program in Engineering Chemistry was created as a response to requests from the forest, energy, and chemical process industries in the region; the development of Engineering Physics has started for similar reasons. The MSc program will be launched in 2023.

In addition to these four programs, two new MSc programs in Mechanical Engineering are in the process of being included in TransTech's environment. Several efforts are in progress for the creation of synergies between the Technical Design program and the research in **NeoPulp:** the recruitment of a new professor, laboratory instrumentation and data-driven methodologies for that can strengthen the scientific foundation of Technical Design and allow updates to its scope. The inclusion of Technical Design students lies behind the strong increase in 2021 of Indicator Table 1c in App. 4. Originally outside TransTech, a Bachelor of Science program in Mechanical Engineering was launched in 2020 with focus on Additive manufacturing. It will now be connected to TransTech and the Master of Science program is being prepared to launch in 2023.

We have also run two initiatives towards competence development of professionals in IoT/AI (**IProf**) and pulp and paper technology (**P&P Prof**), in connection to **NIIT** and **NeoPulp**. We merged the two initiatives into the proposal **DRIVEN** - Expert Competence for Data-Driven Industrial Transformation that was submitted in April 2022. The combination will increase the value we can deliver to industry and the integration of the program with our research profile. The program will be developed in synergy with our other advanced-level education programs, which means that **DRIVEN** will strengthen the role of industry even in the latter. We expect that it will also lead to new forms of co-production with industry.

Personnel and capacity development

Our personnel profiles for the past three years can be found in Table 2. The development is positive for guest professors, but we have not been able to maintain the number of professors and associate professors. Five professors have retired in the past five years (2 from STC, 3 from FSCN) and only 1 new has started (at FSCN), even though 3 additional positions have been advertised. We have therefore shifted the senior recruitment target towards associate professors, which has improved the outlook considerably.

Another important area is the number of on-campus graduate students working in our academic environments. This is not immediately obvious in Table 2, which includes industrial students. Their number has increased from 11 in 2019 to 18 in 2021, and the number of on-campus students has correspondingly decreased from 41 to 34. The decrease of on-campus students is concentrated to FSCN, where only 4 remain by the end of 2021. The low number of graduate students was pointed out by the ARC-reviewers as an improvement area.

***Table 2**: Personnel of TransTech and each Strategic Action 2019-21, grouped as they will be in 2022-24. Staff and researchers without PhD degrees are not shown separately but are included in the totals. The personnel of the AM-group in 2021 is not included in TransTech's total.*

Year	2019	2020	2021
TransTech, total	158	168	157
- Professors and associate professors	23	26	23
- Other MIUN researchers with PhD degree	67	66	55
- Doctoral students	52	55	50
- Guest professors	7	11	15
- Adjunct researchers	9	10	12
NIIT, total	36	46	49
- Professors and associate professors	5	5	7
- Other MIUN researchers with PhD degree	16	18	13
- Doctoral students	13	17	18
- Guest professors	1	4	9
- Adjunct researchers	1	2	2
NeoPulp, total	52	53	47
- Professors and associate professors	9	12	8
- Other MIUN researchers with PhD degree	22	19	15
- Doctoral students	14	16	16
- Guest professors	4	4	5
- Adjunct researchers	3	2	3
KM2, total	32	28	30
- Professors and associate professors	4	4	4
- Other MIUN researchers with PhD degree	16	15	17
- Doctoral students	10	8	5
- Guest professors	1	0	3
- Adjunct researchers	1	1	2
XGeMS, total	38	41	31
- Professors and associate professors	5	5	4
- Other MIUN researchers with PhD degree	13	14	10
- Doctoral students	15	14	11
- Guest professors	1	3	1
- Adjunct researchers	4	5	5
Additive Manufacturing, not included in TransTech total			9

In the recent years the support to the career development of researchers has improved. Resources have been allocated from the faculty and guest professors recruited as mentors and co-supervisors. This should soon show as an increase of promotions to professor and associate professor positions from the average one of two per year. Progress has been negatively influenced by the how the pandemic has prevented scientific missions and visits. We will continue to develop the support for the studies and career development of researchers. One observation in the ARC-review was that the academic environment has an important role here and that must be considered in personnel development.

On the team level, better support than before is now available for research leaders through MIUN's Grants Office and a TransTech function of professional project managers that relieve project leaders of several administrative project duties. However, professional support for incoming international researchers is still missing.

Partnerships

Until now we have mainly followed the number of industrial organisations that collaborate with us. Since 2012, their number has grown almost three-fold, from 24 to 90 in 2020. We would like to argue that our capability to *Co-produce* is on the highest level (level 4). From now on, we want to make the judgement objective, and therefore count only signed collaboration agreements. We also include academic and institute collaborations since they are important for us, too. This gives us Table 3.

The scope of our co-production and collaboration has clearly increased. In education and competence development we benefit from adjunct lecturers from industry. Adjunct professors are now complemented with adjunct lecturers and affiliated researchers from institutes, especially RISE. This development is valuable for both our own capacity and industrial relevance.

Table 3: *Number of organisations / number of projects with a signed agreement*

Year	2019	2020	2021
Partners from industry (SME)	51	48	38
Partners from industry (non SME)	43	42	31
National partners from society excl. industry and academia	24	24	20
International partners	25	25	6
Projects with national academic partners	12	11	11
Projects with national institutes	12	12	18

Important national platforms for us are IoT Sweden where STC has made considerable impact, SIO Grafen for **KM2** and the platform for new materials from the forest – Treesearch with 35 researchers from different parts of MIUN. The AM-group represents MIUN and leads a committee in the Swedish Arena for Additive Manufacturing of Metals.

International exchange (Table 4) showed a promising development until the pandemic struck and it now needs to recover, since it is very important for our academic environment and the development of early careers.

Table 4: *International Exchange*

Year	2019	2020	2021
Number of international guest researchers	10	12	16
FTE	1,47	1,31	2,72
Number of international PhDs and postdocs	22	24	23
FTE	13,35	11,61	12,76
Number of international research missions - In	21	6	5
Number of international research missions - Out	30	11	0
International projects, funding granted million SEK	2,01	3,40	5,98
Number of publications with international co-authors	78	84	83

Funding

Figures 4 and 5 show the funding of TransTech as a whole and each Strategic Action separately. Shown in Fig. 4 is the actual annual spending of funds for 2011–2021, granted funding according to project budgets for 2022 and targeted funding for 2024 (to be explained in Chapter 6). Figure 5 shows granted funding according to project budgets. The difference between the perspectives (spending vs budgets) was particularly great in 2020-21 when Covid-19 required extra resources in education and caused delays in research. This is shown in Fig. 4 as a large drop in the total research spending from 2019 to 2021 whereas the granted external funding (cf. Fig. 5 and Indicator 2d in App. 4) only decreased from 79 to 63 MSEK (in-kind excluded). At the time of writing, the external funding granted for 2022 is 85 MSEK according to project budgets, and the total including MIUN Faculty funding is 111 MSEK. Added to this will be the funds postponed from 2020-21, new projects still to be granted and the 4-5 MSEK that Additive Manufacturing will bring. Thus, the total research spending in 2022 may well reach 120 MSEK, the targeted level for 2021.

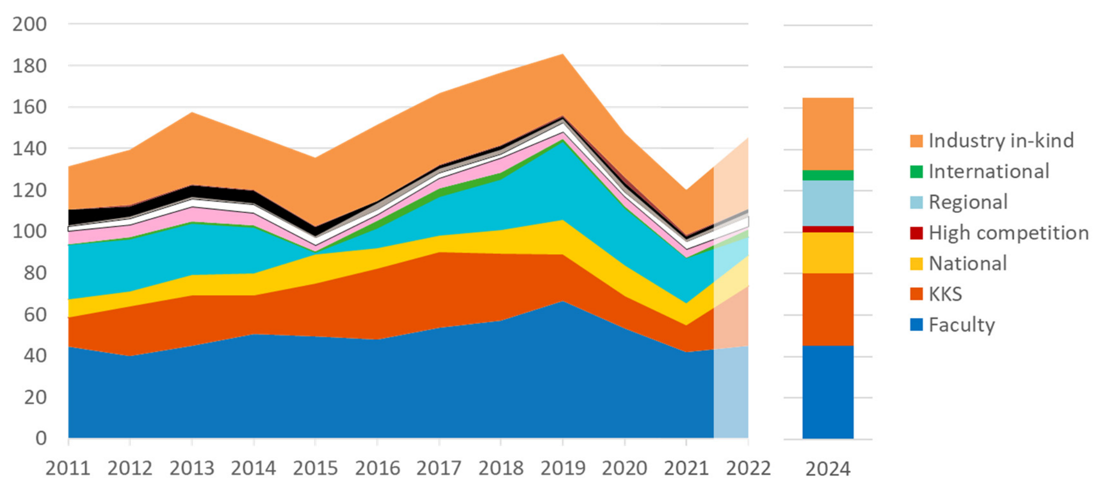


***Figure 4**: Funding in million SEK of TransTech, in terms of spending for 2011-2021, we explain granted project budgets for 2022 and the funding plan for 2024 in Chapter 6. One set of categories applies up until 2022, and another 2024. The new legend for 2024 can be found to the right, and the legend for previous years in Fig. 5.*

The greatest challenge in our funding portfolio is the oscillation of the regional ERDF program whose effect is amplified by the co-funding of MIUN and other project participants. The required level of co-funding will be higher in the next program period, which will require us to increasingly direct ERDF funds for strategic projects that accelerate our development. Another more qualitative challenge is the relatively low level of international and competitive funding. In that respect, we must continue to work systematically to strengthen our academic environment and international networks.

The funding graphs of each Strategic Action for the past five years in Fig. 5 reflect differences in the nature and profiling of research. Although the past trend has been decreasing in three out of four cases, the outlook is now more promising than before. The new efficient application processes created at STC are starting to yield results, and at FSCN the funding curve for **NeoPulp** has finally gone up after the renewal of the research program started in 2018. It is also important to pay attention to the fact that, unlike previous Work Plans and Progress Reports, we have left out all planned projects. The graphs here include only funding that we have secured through granted projects.

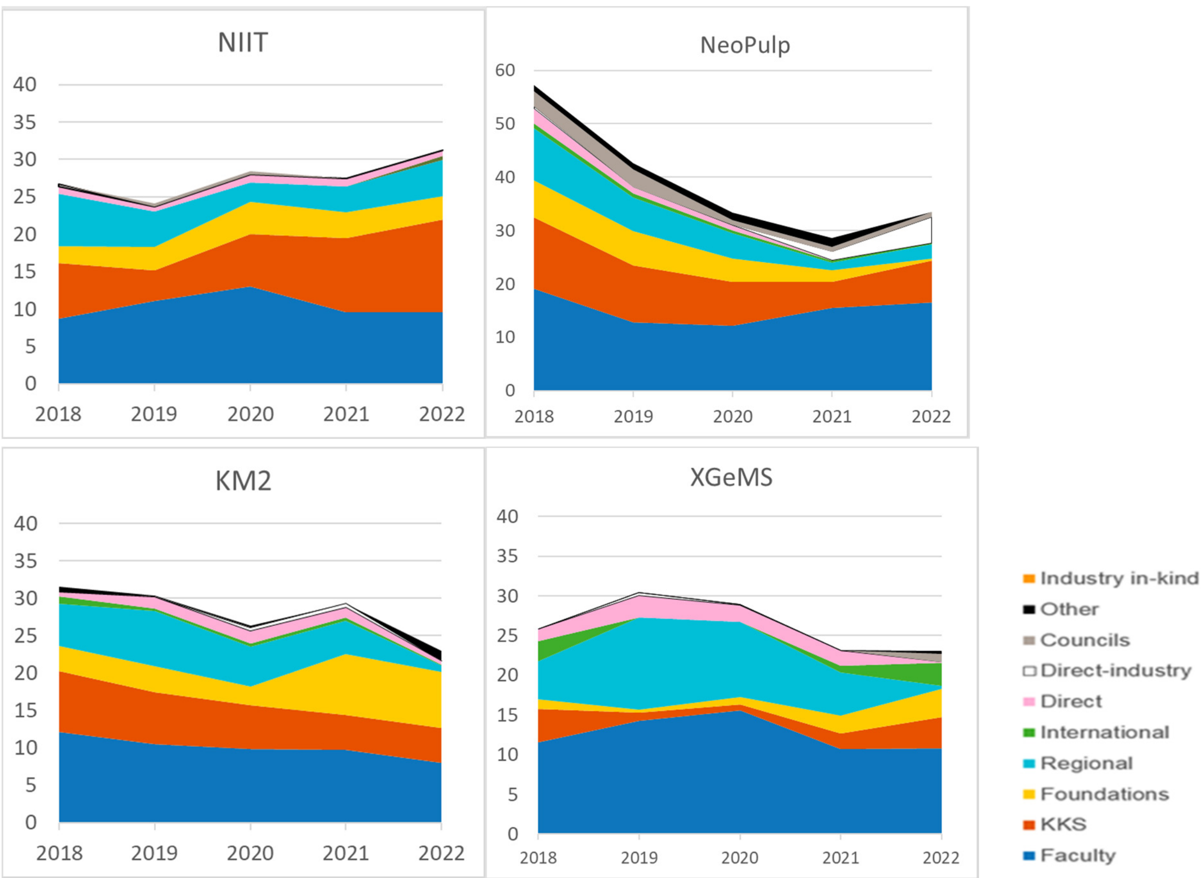


Figure 5: *Funding in million SEK according to granted project budget in each of the Strategic Actions.*

2. National and international context

The Strategic Actions and Research Profiles **NIIT** and **NeoPulp** both have clear research focus and goals. In this chapter, we will discuss their position and outlook in the national and international context. In the rest of our research, we do not (yet) aim for a corresponding focused research position. The research projects cover a range of topics of high scientific impact and international networks and offer large transformative potential, including the research group of Additive Manufacturing. Our next Research Profile after **NIIT** and **NeoPulp** may well grow from these research initiatives. We point out some currently promising areas where this might happen. The time for a systematic analysis comes later.

A great deal of our belief in **NIIT** and **NeoPulp** comes from potential synergies within data-driven research and development that they together stand for. We believe that the combination of the two profiles, industrial IoT and process phenomena from a particle perspective, in an already well-established research environment is unique even internationally. It will also give TransTech a strong position in the development of education programs for digitalized industry. An excellent example of the latter is the Expert Competence Stage 2 plan that we are preparing. Figure 6 summarises the academic landscape in which we position the combination of **NIIT** and **NeoPulp**.

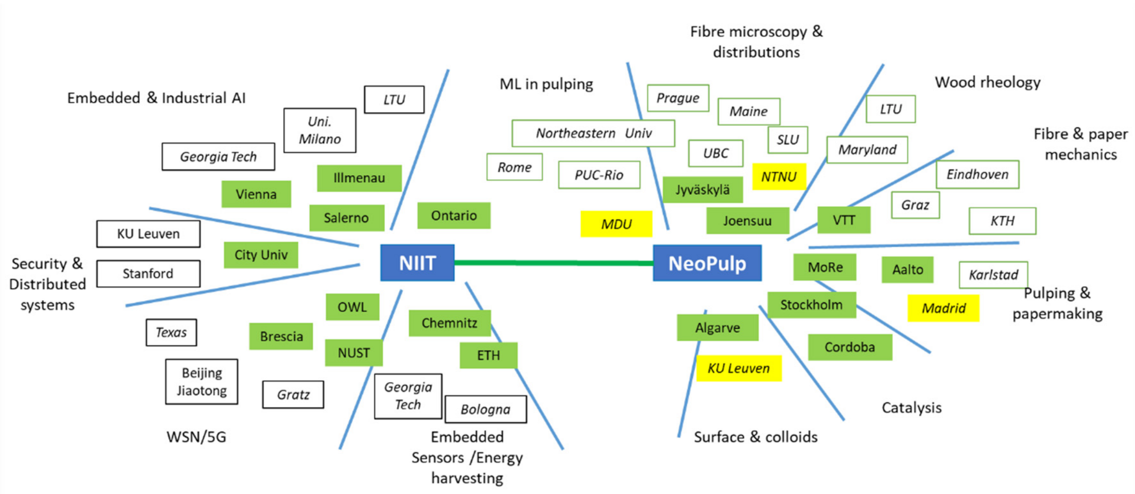


Figure 6: *Research Profiles **NIIT** and **NeoPulp** in the landscape of partner universities and institutes (green), prospects (yellow) and universities to monitor because of similar interests (white).*

Our research program in **NeoPulp** is based on the expertise we have previously built on the mechanical processing of pulp fibres and the use of lignin-rich fibres for new materials. It is supported by strong fundamental expertise in the physical and organic chemistry of lignocellulosic materials. The closest similarity that **NeoPulp** has is with the pulp and paper centre of UBC, Vancouver. However, there, as is the case almost everywhere, research focus has moved from pulp and paper to nanocellulose and biorefineries. Research on chemical pulping has always been a much larger research field than the mechanical phenomena that we study, and it is now almost synonymous with biorefinery research. All the other universities in Sweden with research in pulping (KTH, Chalmers, Lund, Umeå, Luleå, Karlstad and SLU) are focused on chemical pulping and biorefineries. Three of these, KTH, Karlstad and SLU also have research activities that are like ours (see Fig. 6). We follow the development of their research, but also collaborate with them on undergraduate and graduate education programs. We are also starting an educational collaboration with NTNU.

Internationally we have a growing network of academic and institute partners through guest professors or researchers, but also several other universities that we find important to follow (Fig. 6). Of the latter, UBC, Graz and Maine are currently especially interesting because they have strong experimental programs with support from forest industry and suppliers that are similar to ours. Many places such as KTH, Eindhoven and Aachen, are very strong in the modelling of fibre networks and continuum materials – traditionally called paper physics. Therefore, this direction of modelling is not among our research priorities. Since we work a lot with lignin-rich fibres, wood rheology is a potential area of cross-disciplinary collaboration. We see several possible new partnerships in the above landscape as soon as we start to publish new results. Academic collaborations are crucial for the scientific impact of **NeoPulp**; without collaboration, making an impact would be difficult.

The industrial and societal relevance of the **NeoPulp** is clear. It seems sustainable despite the move of industrial R&D focus to biorefineries and nanocellulosic materials for two reasons: climate change and biodiversity requirements mean that continuously improving resource efficiency and decreasing the environmental footprint are crucial for the future forest industry in Sweden, and competent mill personnel is already a bottleneck in their development. **NeoPulp** was constructed as a response to these challenges, and to introduce students to combining process solutions and new exciting tools. Our next task is to broaden the industrial network, which becomes possible when we demonstrate new expertise resulting from **NeoPulp**.

The research in **NIIT** has been established to meet an external need in IoT and its connection to AI. The research program is based on research in embedded sensor systems and distributed systems complemented with the external recruitment of Prof. Mikael Gidlund, expert in wireless communication. From this, a research program in IoT and distributed AI has been developed during the last seven years. The establishment of the research program has led to a strong scientific production and impact that has also been driven by a strong international network strengthened by the recruitment of 9 guest professors in the targeted research areas.

Internationally, there are large research initiatives focusing on industrial IoT; the most prominent environments are unsurprisingly located in Germany, China, and the United States. The leading environment in Europe is the Institute Industrial IT (inIT) of the OWL University of Applied Sciences in Lemgo, carrying out research in the field of industrial informatics and industrial automation for cyber-physical systems. At inIT, there is no research on energy harvesting and time-critical wireless communication. Another excellent German environment is IFAK in Magdeburg. IFAK is a research institute mainly funded by industry with a long history of applied research in areas such as industrial communication, device integration and safety, but lacking research on energy harvesting and data analytics. Recently, a new IoT centre opened at Denmark Technical University, where Industrial IoT is a key area. Hence, their focus is on real-time communication and software. In 2015, Graz University of Technology in Austria initiated a large research initiative targeting dependable IoT. Their focus is very similar to the focus of NIIT, but they place more emphasis on software and networked embedded control. In China, the main research centre for industrial IoT is found at Shenyang Institute of Automation (SIA) and Chongqing University of Post and Telecommunications. These environments are involved in research that span from electronics to software and has more than 500 employees. Another growing environment in Industrial IoT can be found at Beijing Jiatong University. In the United States, the leading environment when it comes to sensors and actuators for IIoT is Berkley Sensor and Actuator Center at UC Berkley. Another large and growing research centre is the Center for the Development and Application of Internet of Things Technology (CDAIT) located at Georgia Tech. CDAIT and the centres cover research from sensors to software. Recently, a new IoT centre opened at the University of Wisconsin-Madison with projects on topics such as data analytics and security.

The need for development of IoT technologies has been further accelerated by the rapid development of AI and machine learning. **NIIT** is relevant to boost the development of both the IoT and AI parts of digitalization in both industry and public organizations. The technology has a huge potential in making the whole value chain of industry and public sector much more efficient and provide higher quality processes. Additionally, the combination of IoT and AI has a major impact on addressing climate and sustainability challenges. This also reflected by the industrial networks in **NIIT**, which has a core in industry but is extended by several other areas that will contribute to further accelerate technological advancements in IoT.

We have important initiatives also outside the Research Profiles **NIIT** and **NeoPulp** with good scientific impact and innovative potential. Within **KM2** we are, among other things, Swedish leaders in the high-impact area of triboelectric nanogenerators and collaborate with the international leaders (Beijing Institute of Nanoenergy and Nanosystems China and Georgia Inst. of Technology USA). This research also engages scientifically strong cellulose researchers from **NeoPulp.** In June, we will organise the leading scientific meeting of this area, the 6th International Conference on Nanogenerators and Piezotronics, NGPT2022. The challenge for **KM2** as a whole is the industrial landscape that is only starting to form in Sweden.

In additive manufacturing, MIUN's research group was among the international pioneers in metal AM with the installation of the first Arcam EBM A2 system in 2007. Today the group has its strength in the specific area of electron beam-based powder bed fusion (EB-PBF). Through the partnership agreement with Sandvik Additive, the group will have a second machine of unique functionality in terms of beam control. In Sweden only we, University West, KTH, Swerim and recently Linköping University are involved in EB-PBF research while other Swedish universities mostly work with laser-based processes. Additive manufacturing is a globally fast-growing area in industry and research.

In our research on measurement systems for industrial processes that interact with the surrounding environment, we have a well-established collaboration with CERN on X-ray imaging with good access to a state-of-the-art network on sensors and detectors in the X-ray area. Another important area of strong international collaboration is in plenoptic imaging where, among other things, we participate in a Marie Curie joint degree program with twelve companies and research institutions across Europe. Measurement systems is an important competence area for all the Strategic Actions of TransTech.

3. Challenges

In this chapter, we describe the main challenges that TransTech must address during 2022-24. These are the next steps in (1) the development of our Research Profiles (**NIIT** and **NeoPulp**) and our scientific impact, (2) Industrial relevance for sustained funding, and (3) Development of personnel. These three areas have been chosen based on the overview of the status and achievements/ encountered problems in Chapter 1. The ARC21 evaluation offered new observations and useful suggestions that we have considered in the actions explained in Chapter 5. In the following, we will also relate our challenges to the progress needed in the capabilities. Our organisation is already quite well equipped, except for being able to *Secure resources* (see Appendix 3). A breakdown into the nine development goals that follows the same model as in the previous Work Plans, can be found in Chapter 5.

Research Profiles and Scientific impact

Two of TransTech's strengths are its capabilities to *Develop and implement strategy* and *Build scientific profile* (cf. Appendix 3). With two large Research Profiles, **NIIT** and **NeoPulp** now running, we have moved from strategy to implementation, with Data-Driven Process R&D as a vision that combines the two. We have good industrial support for both Research Profiles and for the joint Expert Competence

Stage 2 program that we are currently working on. As demonstrated in Chapter 1, the scientific impact of TransTech has grown fast. Nevertheless, we must continue to work diligently even in **NIIT** and **NeoPulp** to really establish a strong national position for MIUN and reach level 4 in our capability to *Build scientific profile*.

In addition to recruitments and academic collaborations, all our research areas can gain strength from collaborations between research groups**.** Figure 7 shows all our groups roughly positioned relative to the Strategic Actions and what collaborations exist between Strategic Actions. The collaborations demonstrate that research groups see synergy benefits in **NIIT** and **NeoPulp**, but also in the opposite direction. The Strategic Actions **KM2** and **XGeMS** are shown without clear "boundaries" since we will reconsider them during 2022.

Dynamic evolution of collaborations between research groups continuously tests the balance between stronger consolidation of profiles and other research opportunities. A relatively large share of our scientific impact and production comes from research groups that are currently not included in **NIIT** and **NeoPulp**. The goal of the review of Strategic Actions is to develop the research program so that all researchers can contribute even better to our Research Profiles and scientific impact. The better we succeed in this, the stronger our profile and scientific impact can become.

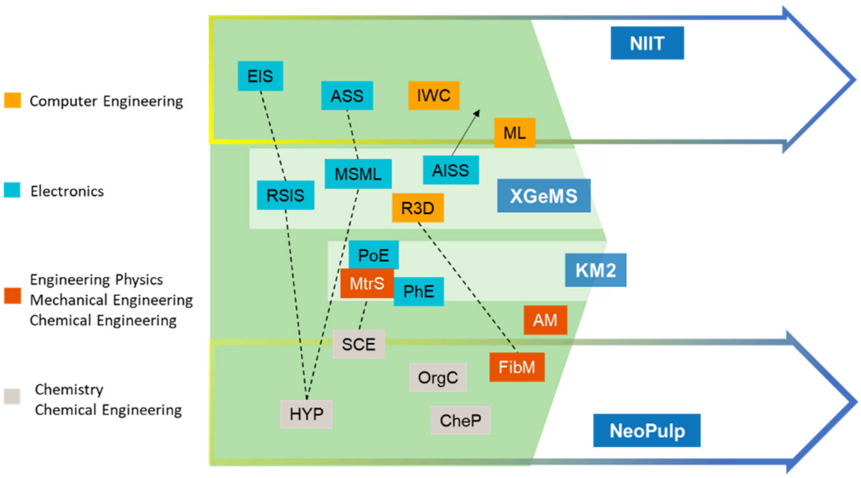


Figure 7: *Rough position of our research groups (see Appendix 1 for full group names) relative to the four Strategic Actions. The research groups that have a long history in TransTech are to the left and the "newcomers" to the right. Overlap and lines show how joint projects connect research groups in different Strategic Actions.*

The ARC21-reviewers advised both STC and FSCN to move towards "larger groupings" and "larger research context". In the case of Additive Manufacturing, the recommendation was to broaden the research scope. In our management process, these recommendations refer to the Strategic Actions, increasing their internal synergies (STC and FSCN) and bringing the AM-group along in one or more Strategic Actions. Thus, even the ARC-results motivate the review we will perform during 2022.

Industrial relevance for sustained funding

For TransTech as whole, the accelerating digitalisation of industry and society has been the strongest development driver in research and education. Digitalisation created the needs that motivated the Research Profile **NIIT** and opened the new research avenues of **NeoPulp**, and increasingly accentuates the market for new education and competence development programs. The result is significant synergy opportunities in research and education, and a shared vision of Data-driven Process R&D. Several technology companies with whom we collaborate, such as ABB and Valmet, are already developing their businesses in the direction of new processes enabled by digitalisation. They and their customer companies will need both new knowledge and new competence related to digitalisation. Connected to Data-driven Process R&D, the outlook for integrated research and education collaborations with established industries is good.

However, TransTech's funding outlook is not without challenges. We have worked a few years now for a balanced funding profile but have yet not achieved clear improvement. We therefore judge that we are at a low level 2 in the capability to *Secure resources*. This is a problem because the funding share that we can expect to receive from the European Regional Development Fund ERDF will most probably drop significantly from the level of one-third of TransTech's external funding, or one-quarter of all funding. For this reason, we have implemented efficient processes for funding applications, which has resulted in an increase of new approved projects. We also have several areas where continued good collaboration with the regional organisations and increased networking with SMEs and RISE has led to a growing number of regional and national research and innovation projects. These range from additive manufacturing technologies through new lignocellulosic materials in **NeoPulp,** to materials and solutions for the electrification of society in **KM2**. One of our goals is for the review of Strategic Actions to strengthen our industrial relevance in the area of new advanced materials and their manufacturing technologies.

In the on-going transition towards a bio-based circular economy and society, TransTech's research and education programs have, in comparison to digitalisation, a somewhat smaller industrial relevance despite **NeoPulp** and the chemical engineering research of FSCN. We still have a few long-term research partners in forest industry and a number of other, mostly smaller partner companies. However, securing sustained funding of **NeoPulp** requires that we can broaden the industrial scope. In the short term, a promising area for this is the development of education and industrial competence programs, in particular the Expert Competence Stage 2 plan connected to **NIIT** and **NeoPulp** that we will submit later this spring. In the longer term, we can make progress in industry networks by demonstrating the relevance of the new expertise that we will develop in **NeoPulp.**

If approved, the Expert Competence program will also make an important contribution to our capability to *Integrate research and education*. Furthermore, we believe that with the AM-group and other improvements of our competences in Mechanical Engineering within TransTech, we can finally connect the MSc-program Technical Design to TransTech. Both of these steps forward will improve the integration of research and education in a manner that will simultaneously significantly increase industrial relevance. Once they are implemented, we will be able to safely argue that we have reached level 4 in our capability to *Integrate research and education*.

Finally, the capability to *Co-produce* is already one of our strengths (c.f. Appendix 3), especially in the research related to **NIIT** and **NeoPulp**. Nevertheless, as also noted by the ARC-reviewers, there are still some areas that need improvement. For example, industrial graduate students are one way to increase our industrial relevance. Some progress is already underway at STC through the industrial graduate school Smart Industry that includes all past and current KK Environments.

Development of personnel

Although we have struggled with the recruitment of new professors, the outlook has now improved. A new professor was hired for **NeoPulp** in May 2022, and during 2022 we should also succeed in hiring two new associate professors for **NIIT**. The focus shift from full professors to associate professors was also urged by the ARC-reviewers of FSCN and STC, in part for the purpose of not adding new unconnected research groups to TransTech. We should be able to fulfil our needs of new senior-level expertise this way. For the maintenance of senior capacity, we already have several associate professors in all Strategic Actions who will be promoted to full professor within a few years. However, we may need to recruit a new leader for research in the **KM2** area if the current leader is unable to continue because of illness.

Stronger academic collaborations internationally and in Sweden are crucial for our ambitions for scientific impact and for the academic careers of individuals. In parallel with this we need better interaction between research and education, and in some research groups, stronger industry networks and improved external project funding. Balancing between all these expectations is not easy for individual researchers or research groups. Experienced researchers are good coaches for industrial networking and guest professors can be good mentors for the entry into the international science community, but progress is possible only if people are eager to develop either way – or both.

Discussions following the ARC results have led us to the realisation that the academic environment – its culture – plays a central role in the development of individuals. The pandemic has further reduced the size and dynamics of functional working environments. This also affects graduate students. The ARC-reviewers correctly pointed out that a dynamic body of guest professors, visiting researchers and PhD students is important to nurture the academic environment. New systematic approaches are needed here.

In these developments the closest managers – Department Heads and Group Leaders – have a crucial role and are part of our capability to *Build organisation*. Improvements are still needed in the processes between the line organisation of departments and the research centres of TransTech. A new opportunity to make progress in both aspects has opened since the department structure of the faculty will be reorganised. The new organisation is due to be in place 1 January 2023.

4. Long-term development process

Implementation of TIE Vision

Our Research Environment TransTech provides the profile for engineering research and education at Mid Sweden University. In this area, TransTech makes by far the strongest main contribution to the vision of the university to become a *global university with regional commitment*. Aligned with this, the development of TransTech is guided by the transformative *TIE Vision* of for the region. For this strategy, we have made a second update of *TIE Vision* so that it better reflects the current challenges and opportunities of both the region and the university. As before, we expect TransTech to have a strong positive effect on the following five areas:

- **Competent people**: To attract talented people to MIUN and the regional ecosystem
- **Well-known research**: To raise the research and innovation community to national recognition
- **New technologies**: To promote research and education that support the industrial renewal and innovations in the region
- **Attractive education**: To develop programs that produce talented students for the employers of the region and our own research.
- **International networks**: To connect us to globally leading academic institutions and companies to attract more people and ideas to MIUN and the region

As explained, digitalisation offers many transformative opportunities for our research and underlies many of the new needs of our education programs. From this external perspective, our two Research Profiles are important for the further development of existing process industry. Data-Driven Process R&D is the area where both **NIIT** and **NeoPulp** are focused and together develop education programs for the needs of industrial value chains. Also, many researchers currently in **XGeMS** are working in this direction, with new sensors for monitoring and new ways of representing complex data from processes and the environment. For the remaining research, **KM2** and the incoming AM research group, are strongest in new advanced materials and the manufacturing processes that enable them. It is here that TransTech could make truly transformative contributions for the region, in addition to which the monitoring and visualisation methods from **XGeMS** can play a major role. This also shows that it is crucial that we carefully evaluate our options for making the Strategic Actions even more relevant for the industrial transformation of the region.

Management Structure and Quality System

The present Management Structure and Organisation of TransTech is described in Appendix 1. As indicated in Work Plan 2021, the organisation includes an upgraded international Reference Group to support the development of the strategies and plans of TransTech on an annual basis. The reorganisation of the department structure at the faculty level during 2022 will also influence TransTech. One of the goals of the reorganisation is to clarify the role of research centres and thereby TransTech in management processes. For example, it should become possible to better align personnel development activities within departments with the guest professors and funding opportunities that TransTech offers. Enabling stronger teacher teams to education programs has been another important starting point for changes at faculty level. In addition, this is a new opportunity for TransTech in the development of complete academic environments.

The Quality System is described in Appendix 2. In addition to securing the quality of research projects, the system also drives the organisational development of TransTech. For this purpose, we have slightly modified our indicators (see App. 4) so that they match the same nine areas of development that we have followed since the previous 4-Year Plan and Work Plans. They are again shown in Fig. 8. Progress in the green development areas is good, even if challenges (old and new) remain as discussed in Chapter 3. For example, we have good capabilities (App. 3) to *Develop and implement strategy* and *Build scientific profile* and therefore trust that the review of Strategic Actions will further strengthen our Research Profiles. Also, as demonstrated in Chapter 1, progress is good in *Scientific Impact*. For further progress in these two areas, we judge that it is crucial for *National academic partners*, *International collaborations* and of course *Funding* to increase. Progress in these three development areas is in turn very dependent on individual engagement that we can support with personnel development, measured with *Individuals and teams*. Individual efforts are also crucial for progress in *Industry networks and co-production* and *Synergy of education and research*. Finally, partners not only from industry and academia but also from *Institutes and society* are crucial for sustainable funding. This effect logic demonstrates the crucial importance of the enthusiasm and development of individuals and teams.

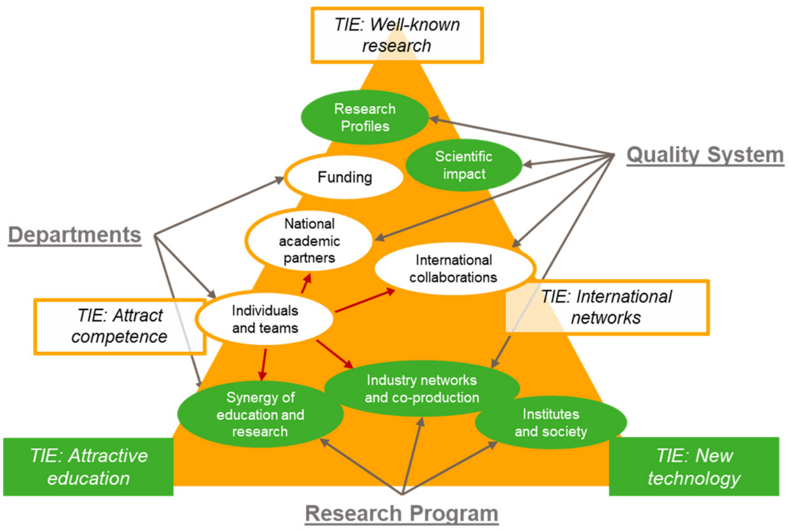


Figure 8: *Connection between the long-term effects that we pursue in the TIE Vision (boxes) and our development areas (ovals). The arrows and short distance show the most important parts of our effect logic. The white areas are of special importance in this Strategy and green are progressing well. The Quality System, Departments and Research Program are the main drivers of our development.*

Governance of the Research Program

We continue to organise our Research Program into Strategic Actions as the main areas. A five-point definition of a good, strong Strategic Action emphasises how it takes more than "just" a good research agenda to become strong in the strategic time scale. The five elements of a strong Strategic Action are:

- A good research agenda that enables good scientific impact, academic networks and, ultimately, a nationally well-known position for MIUN in the chosen research area
- Good networks with the industry and with the regional innovation system
- Clear synergies between education and the competence needs of the industry
- Strong personnel resources; and
- A balanced funding profile that matches the ambitions above

The following six guidelines guide the implementation of the *TIE Vision* in the Research Program:

1. Exploit the competitive advantages of the mid Sweden region
2. Choose opportunities of global importance
3. Use information technology as a key enabler
4. Respond to the changing needs of society
5. Supply relevant competence and skills to industry
6. Build on the most exciting research opportunities

As already explained, we will review the Strategic Actions during 2022. This is part of our Strategy Process and any decisions are made by the Management Group of TransTech (cf. Appendix 1).

5. Ambitions, goals, and main actions 2022-2024

The synthesis of the above review of our development status (Chapter 1), external research landscape (Chapter 2) and main challenges (Chapter 3) has led us to the following three Strategic Ambitions:

- **Stronger Research Profiles and high scientific impact (RPSci)**: During 2022 we will review the structure of our Research Program with the goal of an even stronger profile for TransTech and the university. Our ambition is that MIUN will be known nationally and internationally for the Data-Driven Process R&D that the Research Profiles **NIIT** and **NeoPulp** already represent. We also see a good potential for TransTech to become scientifically stronger and regionally more relevant in the research and innovation area of new advanced materials and their manufacturing technologies. The message we want to convey by emphasizing scientific impact is that, in addition to our Research Profiles (i.e. **NIIT** and **NeoPulp**), the cultivation of emerging areas of high scientific potential is also very important for the renewal of our research and creation of future Research Profiles.
- **Broader industrial and regional relevance (IRRel)**: Relevance is crucial for sustained funding. We have exciting new opportunities for education programs combined with research co-production, and for research and innovation in advanced materials and manufacturing technologies, especially important for regional transformation, and for collaboration with the region's RISE units for stronger offers in education and new technology.
- **A more dynamic academic environment (DAEnv)**: Good collaboration between TransTech and the Departments of the faculty lays the foundation for a strong academic environment – especially in recruitments, career support and education programs – and the reorganisation of the faculty is a good opportunity to make progress in these areas. We want to further strengthen the role of guest professors and visiting researchers in our academic environment and create new forms of academic collaboration, especially for the benefit of early-career researchers and graduate students and for the targeted increase of international funding and high-competition funding.

We have again planned development actions towards these Strategic Ambitions and other improvements that we want to achieve during 2022-24. The main Development Actions are summarised and connected to the Strategic Ambitions in the following Table 5. We then explain the action plan from the perspective of the Research Program (i.e. Strategic Actions) and collaboration between TransTech and Departments, and finally summarise the expected effects of the planned actions in our development areas, with relevant indicator values.

Table 5. *The most important development actions of TransTech during 2022-24 in relation to the Strategic Ambitions (RPSci = Stronger Research Profiles and Scientific impact, IRRel = Broader industrial and regional relevance, DAEnv = More dynamic academic environment), schedule and responsible persons.*

Development Action	Ambition	Scheduled goals	Responsible
NIIT:	RPSci IRRel	3 new Horizon applications by 2023. New large national project by 2024. 10 new partner companies by 2024.	Mattias O'Nils Bengt Oelmann
NeoPulp: Academic collaborations	RPSci DAEnv	3 new guest researcher-TransTech pairs working 2022 2 projects with e.g., Leuven, Joensuu or SLU funded by 2024	Kaarlo Niskanen Birgitta Engberg
KM2: Upgraded agenda	IRRel	AM group included in the KM2-planning process 2022 Agenda for best scientific and innovation effects 2023 Horizon or other internationally funded project 2024	Jonas Örtegren Lars-Erik Rännar
XGeMS: New role for research groups	RPSci IRRel	New positions ready in 2022, research groups' role in other Strategic Actions by 2023. 5 new partner companies by 2024.	Mattias O'Nils, Kaarlo Niskanen
Collaboration of TransTech and Departments	DAEnv	New Departments/TransTech interface in operation 2023 Collaboration program with other universities for early-career researchers and graduate students in operation 2024 4 new advanced-level programs connected to TransTech by 2024 Demonstrated benefits of AM included in TransTech by 2024	TransTech management and Department Heads

NIIT*:* Research production and quality demonstrate a good progression. In this area we have the largest number of guest professors, guest researchers and international collaborations, which will improve our scientific impact and helps us to build international projects. The main challenges then become to increase diversity in Funding, both national and international. The level of national funding is increasing because of the improved process for initiation of new projects that we use.

- For the continuation of this positive development, we need to identify and attract new partner companies and to strengthen the environment with more researchers. Responsible for this is Bengt Oelmann.
- After Horizon Europe started, we have been invited as partners to three Horizon initiatives, all from well-established international networks. The conclusion from this is that we need to consolidate the established networks beyond the guest professor projects. Responsible Mattias O'Nils.
- Several processes are involve developing large national initiatives in Industrial IoT/AI. The most promising ones are a Vinnova-funded pre-study of some other universities and several large companies around Information-driven Forest industry; and a cluster of several universities and institutes that is establishing a European Digital Innovation Hub targeted at Smart Industry. Mattias O'Nils is coordinating the **NIIT**-connection of these two initiatives.

NeoPulp: Production is increasing steadily towards the goal of 60 papers in 2024. Strategically even more important is to increase impact through new research questions that can lead to publications in journals with impact factor > 4 in our research field. To that end, our main priority is to build academic collaborations nationally and internationally. Treesearch is the main platform for this in Sweden. With the funding already approved, the number of international guest professors and researchers will increase by 3 in 2022. To establish effective interaction with them is our first goal in internationalisation and will be followed by more joint project applications than the 1-2 in recent years. In industry networks we should win new partners in areas that complement the fibre-focus of **NeoPulp** by 2024. The MSc program in Engineering Chemistry will grow, and the new professor in Mechanical Engineering will connect Technical Design to **NeoPulp.** Responsible persons: Kaarlo Niskanen and Birgitta Engberg.

KM2 is in a special situation because its leader has been seriously ill since last summer. Fortunately, we have very good resources, and research production, project planning, and the development of collaborations, especially with Uppsala University and Georgia Tech, have not suffered much. However, it is easy to understand that the team of researchers is discussing the future of **KM2**, and new collaboration possibilities with the research group of Additive Manufacturing and other research groups of TransTech. **KM2** is clearly in need of a review during 2022. For this Strategy document we have therefore just updated the goals and Development Actions of the previous Work Plan 2021.

- Establish contacts with a few large companies in order to improve co-production and funding possibilities,
- Build collaboration with RISE for the same reason – this is in good progress, and
- Develop a Master of Science program for Engineering Physics

The Research Group of Additive manufacturing has analogous goals for networking, recommended by the ARC-reviewers, and an on-going process to launch an MSc program in 2023. Responsible persons: Jonas Örtegren and Lars-Erik Rännar (AM-group).

XGeMS: As the Research Program of TransTech has developed, we have concluded that research on measurement systems could see better development if the research groups worked within the other Strategic Actions rather than trying to create one consolidated agenda for **XGeMS**. The restructuring has already started; one research group has joined the Research Profile **NIIT**, two groups are collaborating with **NIIT**-researchers and three with **NeoPulp**-researchers. The change will increase synergies between the Research Centres STC, FSCN and STRC. In 2022 **XGeMS** has three-quarters of TransTech's 4 MSEK of international funding and half of TransTech's 2 MSEK of council funding and it is very important is maintain this momentum of international collaborations and council projects. Responsible persons: Mattias O'Nils and Kaarlo Niskanen.

Collaboration between TransTech and Departments: The reorganisation of the faculty is a good opportunity to develop the collaboration between TransTech and the Departments we work in. Together we can improve in recruitments, career support and education programs – all central elements of a strong academic environment. In education we will continue the development of new advanced-level programs (cf. Ch. 1), but we can also make much better use of TransTech's research in the recruitment of students and teachers to these programs. We will further strengthen the role of guest professors and visiting researchers in our academic environment, including guest lectures in education programs. For a further increase of dynamism, we envision a new academic exchange program with professors at other universities, including shared supervision of our graduate students. An important task during this strategy period is also to ensure that the inclusion of the Research Group of Additive Manufacturing in TransTech proves rewarding for both. Responsible for the progress are the TransTech management and the new Department Heads.

The above plans are connected in Table 6 (next page) to the nine development areas that we follow for the fulfilment of this Strategy (cf. Fig. 8 in Chapter 4). When appropriate, we use quantitative targets for selected indicators in Appendix 4. When setting the target values, we made simulations to determine what improvement levels are challenging but possible to reach given our track record and resources. In some cases (Research profiles, education programs), setting a number as a goal would be inappropriate.

***Table 6:** Goals for TransTech to reach by 2024 in each of our nine development areas, status (without the AM-group) and corresponding actions. Indicator numbers and values refer to Appendix 4.*

Goals to be reached in 2024	Indicators		Development actions in 2022-24
	No.	Value 2021	
Scientific impact - Journal Impact Factor = 5.5 - H-index = 33 - Production 200 publications - High-competition funding 3 MSEK	 2b 2b 2b 2d	 4.83 30 143 1.1	**NeoPulp**: Manuscripts to journals with Impact Factor > 4
Research profiles - **NIIT** & **NeoPulp** known in Sweden - New agenda for **KM2** + AM group - New role for **XGeMS** researchers	NA	*See text*	**NIIT**: Build national action around industrial IoT/AI **NeoPulp:** Collaborations with Swedish university groups **KM2**: Determine how to gain best in science & innovation **XGeMS:** Determine and implement best alternatives
National academic partners - 16 joint projects in progress - 20 joint publications	 3b 3c	 11 10	New projects to all Strategic actions, especially to **NeoPulp**
International collaborations - 18 guest professors & researchers - 30 joint projects in progress - 90 joint publications	 1b 3b 3c	 15 18 83	Better engagement of existing guest professors in Horizon and other international applications in all Strat Actions More guest professors to **KM2** + AM
Industry networks and co-production - 100 companies in on-going projects	 3b	 69	New strong partners, especially to **NeoPulp** and **KM2** + AM **NIIT & NeoPulp:** Launch Expert Competence Stage 2
Institute & society collaboration - 20 adjunct and affiliate researchers - 20 projects with RISE in progress - 40 joint publications	 1b 3c 3d	 12 18 37	Implementation of MIUN-RISE collaboration agreement New RISE projects, especially to **KM2** + AM Higher project volume → more joint publications
Individuals & teams - 6 new external prof / associate prof - 40 on-campus doctoral students - 60 international missions in + out	 1a 1a 4a	 0 34 51*	Collaboration between TransTech and Departments in recruitments, career support and education programs. Collaboration program with other universities
Synergy of education and research - 50 MSc degrees - MSc program for each Strat. Action - Expert Competence Stage 2 running	 2a N/A N/A	 24 Not KM2 planned	Marketing of education: Use more research results MSc programs in Technical Design, Engineering Physics, Additive Manufacturing and DRIVEN Expert Competence
Funding (granted for each year) - Total research funding 130 MSEK - National non-KKS funding 20 MSEK - International funding 5 MSEK	 2d 2d 2d	 105 17.6 1.8	*See Chapter 6*

**Pre-Covid-19 value from 2019*

6. Funding plan 2022-24

Table 7 gives our targets for the volume and balance of funding in 2024. Based on the track record shown in Fig. 4, we think that a modest 5% growth per year in the total funding level, from the current 110 to 130 million SEK in 2024, is very realistic. Among other things, we can roll out the new efficient application processes created at STC throughout TransTech. In 2021, we submitted over 100 funding applications, twice as many as in 2019. More specifically, we will pursue the following opportunities:

- Research in Additive Manufacturing (**AM**): 4-5 million SEK in 2022, more later
- **NIIT**, **NeoPulp** and **XGeMS**: Combination of Data-Driven competence development, education programs and research (KKS, Vinnova, ERDF, the Swedish Energy Agency)
- **AM**, **KM2** and **NeoPulp**: Research of new materials and manufacturing technologies, new industry for Norrland (Vinnova, ERDF)
- **NIIT**: International advanced-level education program (KKS)
- Exchange program for a more dynamic academic environment (KKS)

Table 7: *Targeted funding volume and balance in 2024, volume granted for 2022 so far, and expected growth areas.*

Funding source	Volume, MSEK	Share, %	2022, MSEK	Expected growth areas
Faculty	45	35	45	
The Knowledge Foundation	35	27	29	AM, Competence
National (e.g. Vinnova, the Swedish Energy Agency)	20	15	20	Data-Driven & New industry
Regional (e.g. ERDF, regional organisations)	22	17	12	New industry, Competence
International (e.g. EU Horizon)	5	4	3,9	All Strategic Actions
High competition (e.g. VR, FORMAS, KAW)	3	2	1,9	All Strategic Actions
Total	130	100	111	

Our goal is to use more of ERDF and KKS funding to develop new operating models and platforms that strengthen the dynamic academic environment, such as those listed above: competence development, international education, and academic exchange. We also want to launch new offers in education and technology development in collaboration with RISE units close to us.

The most difficult targets in Table 7 are for international and high-competition financiers. However, past achievements (cf. Indicator 2d in App. 4) show that the funding levels that we aim at are fully realistic. We already have some international funding (Horizon and Transnational projects) in all the Strategic Actions.

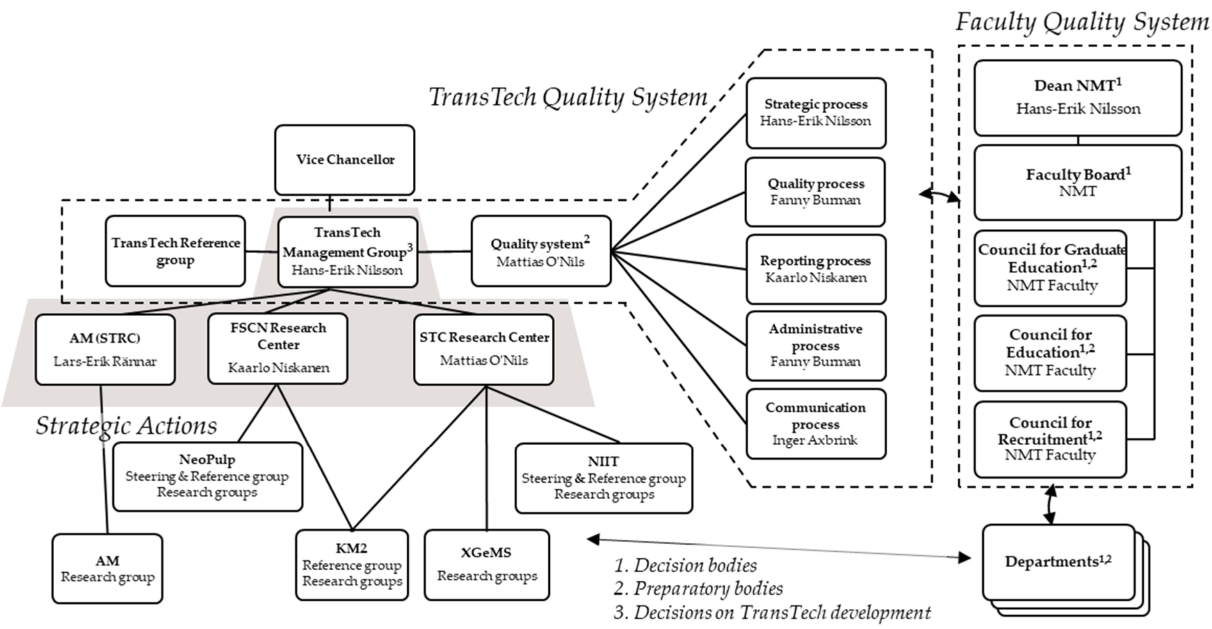
To win a greater volume of international funding, we will continue to strengthen our international networks especially with the help of guest professors and guest researchers. These networks are strongest in **NIIT,** where we are already receiving many invitations to join EU consortia. As the next step, we will allocate resources in the creation of MIUN-led Horizon consortia with **NIIT** as the pilot case. In NeoPulp, the first task is to strengthen the early-stage networks and in parallel identify the most promising areas for a larger international project. In the other two areas, **KM2** and **XGeMS**, we continue to target project participation.

Our council funding has consisted of only 1–3 projects and has therefore fluctuated. One new council project was granted last year[1]. We believe that the build-up of strong scientific track records by many younger researchers and our large application numbers (14 submitted in 2021) are bound to give results.

More collaborations with universities in Sweden and abroad, and a generally stronger academic environment are crucial for the development of good research questions and hence success with international and council project applications. In such a scenario, the large research volume of TransTech can really strengthen the national and international position of Mid Sweden University. For this reason, the importance of the academic environment is emphasised in this Strategy more clearly than before.

[1] Progress Report 2022 erroneously indicated that no new council projects were granted in 2021

Appendix 1. Management and organisation



Organisation chart with the decision-making, advisory and preparatory bodies of Transformative Technologies, distribution of responsibilities and roles, and division into Strategic Actions.

Research Groups in each Strategic Action with their scientific disciplines indicated by the colour codes. The acronyms refer to Fig. 7 in Chapter 3.

NIIT	NeoPulp	KM2	XGeMS
Autonomous sensor systems (ASS) Prof. Bengt Oelmann	Fibre Mechanics (FibM) Assoc..Prof. Birgitta Engberg Experimental Mechanics New Prof.	Materials Science (MtrS) *Prof. Håkan Olin (2026)*	Radiation Sensing and Imaging Systems (RSIS) Assoc. Prof. Benny Törnberg Assoc. Prof. Börje Norlin
Industrial Wireless Communication (IWC) Prof. Mikael Gidlund	High-Yield Pulping (HYP) *Prof. Per Engstrand (2024)*	Power Electronics (PoE) Prof. Kent Bertilsson	Realistic 3D (R3D) Prof. Mårten Sjöström
Embedded IoT Systems (EIS) Prof. Mattias O'Nils	Chemical pulping (CheP) Prof. Juha Fiskari	Physical Electronics (PhE) Assoc. Prof. Henrik Andersson	Measurement Systems / Machine Learning (MSLML) Assoc. Prof. G.Thungström New Assoc. Prof.
Machine Learning (ML) New Assoc. Prof. *Prof. Tingting Zhang (2024)*	Surface & Colloid Engineering (SCE) Prof. Magnus Norgren		
AI-based Sensor Systems (AISS) Assoc. Prof. Jan Lundgren	Organic Chemistry (OrgC) Prof. Armando Córdova	Additive Manufacturing (AM) Prof. Lars-Erik Rännar	

Electronics   Chemistry & Chemical Engineering   Computer Engineering   Eng. Physics, Mechanical Eng., Chemical Eng.

Appendix 2. Quality system processes

The purpose of the Quality System processes is to ensure that we reach our long-term goals set up in the TIE-vision, the Transformative Technologies Strategy 2022-2024 and the strategy, vision and aims for Mid Sweden University. It includes many different processes, such as securing the quality of our research activities and strengthening the process for strategy development.

Transformative Technologies' (TransTech's) Quality System's five main processes are:

1. **Strategic Process:** involves actions to develop and implement strategies of Transformative Technologies. Process leader is Hans-Erik Nilsson.
2. **Quality Assurance Process:** includes processes to ensure the quality of the environment and new and ongoing activities. Process leader is Fanny Burman.
3. **Reporting Process**: includes preparing the reports and plans of the KK Research Environment to the Knowledge Foundation, other financiers and internal communication. Process leader is Kaarlo Niskanen.
4. **Administrative Process:** provides administrative support to all processes within the Quality System. Process leader is Fanny Burman.
5. **Communication Process:** involves planning and handling all internal and external communication. Process leader is Inger Axbrink.

The Quality System also contributes to developing into an attractive and successful research environment. The work with all five main processes is done at all levels of the organization, from individual researchers to research groups, projects and research centre level.

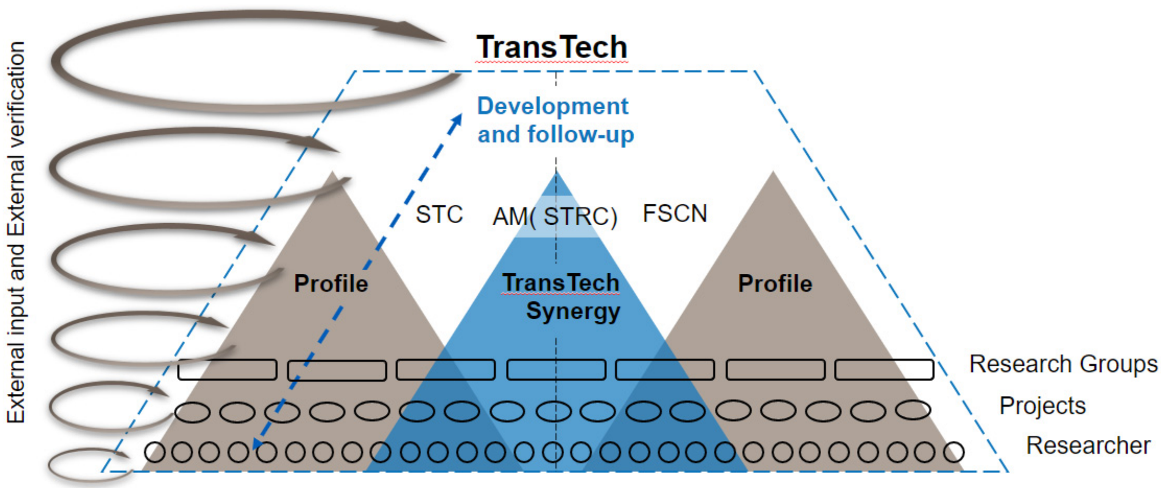


Figure 1. *Strategic Process and External Analysis*

The strategic work and development of our Strategic Actions is affected by activities in all the five different processes. The role of the processes is to develop, implement and follow-up the strategies in Transformative Technology through the development of the Strategic Actions. The work mentioned involves both internal development and follow-up and external analysis through input and external verification at all levels, from individual researchers to the whole research environment, as illustrated in Figure 1. Development and analysis are done iteratively within our five processes, with a goal to gradually achieve a sharper focus in our strategic development as illustrated with a gradually sharper focus of a flower in Figure 2 (e.g. the work towards the establishment of the NIIT profile). The result of such a process could also lead to the conclusion to terminate a Strategic Action, to move research groups from one Strategic Action to another or to redirect the research agenda entirely.

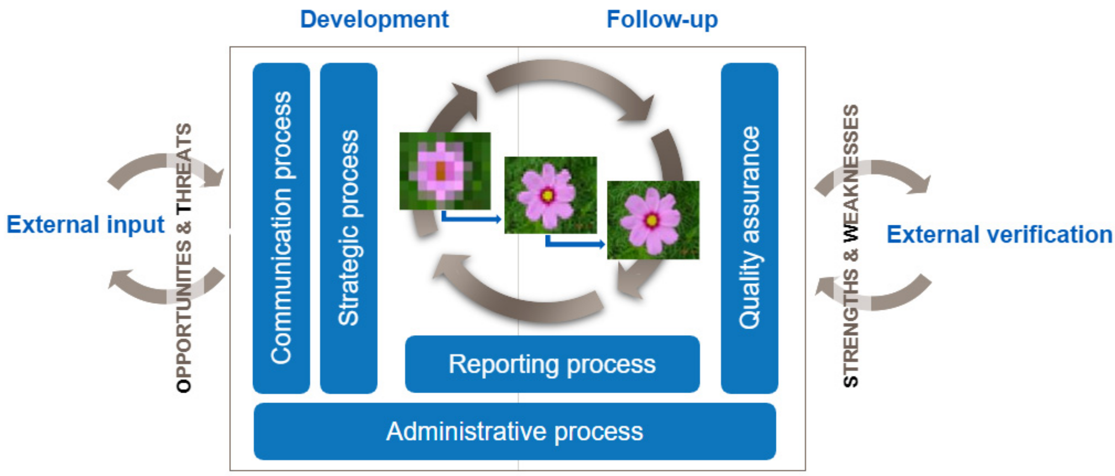


***Figure 2**. The roles and movements of our processes.*

The illustration in Figure 2 explains how our processes use internal development and follow-up and external verification/input to achieve the iterative refinement that is described above. The figure describes the cycle, the movement between the different processes and how external input and verification of the strategic development contribute to constant follow-up and development of all operations within TransTech (gray arrows in the two-field). In each process, there are activities that help to refine and focus our strategies, while at the same time verifying that we are on the right track, working on the right things.

This implements an embedded and continuous SWOT analysis in our strategic development, in which internal and external factors can affect the work in different directions. External input allows us to assess possible *Opportunities* and *Threats*. External verification helps us to identify our *Strengths* and *Weaknesses* and ensure that we make the right decisions in our strategic development.

External input: an important part of our external analysis is various forms of external input. The purpose of the external input is to find new perspectives and information to formulate new opportunities and identify possible threats. Information is used together with our competence in formulation and reformulation of our research agenda, Strategic Actions. This information is captured through different activities: bibliometric analysis to find possible research directions, communication activities (BID/SID) to obtain new input from companies, seminars to for inspiration and new perspectives on grand challenges and other trends. Two other important inputs for our development is the TransTech Reference Group and the close cooperation with RISE. The Reference Group consists of national and international participants from academia and companies. The composition of the group is currently being reviewed. At research group level, the international exchange and guest professors play an important part in getting new input and new perspectives into the research process.

External verification: another part of our external analysis is external verification. Our development, research agenda and strategic decisions are verified through the reporting of our strategic decisions and progress and evaluated by our Reference Group and the Knowledge Foundation expert group. The implementation of the strategy is evaluated by peer-review of new project proposals and final reports. Strategic decisions and development are evaluated through positioning and measurement using bibliographic analysis and initiating external projects to evaluate targeted profile areas validity and evaluation of competence within Strategic Actions.

Development: The development process at management-level is the aggregation and analysis of the external input, results from external verification and internal follow-up into making decisions that develop the research environment towards our goals. The management-level development is connected to the bottom-up development through dialogue, documentation, and benchmarking of progress.

Follow-up: the follow-up of strategic decisions is described in the section External verification above. The internal follow-up includes pulse meetings, strategic discussions and decisions making in order to iteratively refine the Strategic Actions and to meet the formulated development goals.

Quality System development

The overall structure of the current Quality System has been the same since 2016, but various improvements have been made and are being made continuously to adapt the system to goals and strategies. In 2018, an improvement was made to the Quality System by increasing the development focus to prepare for a change in connection with the end of the KK Research environment. Annual workshops for TransTech's management and department heads were introduced with the aim of reformulating or adding goals to better prepare for the "time after". The quality system has been changed further to suit the new collaboration model with the Knowledge Foundation. For example, the routine of strategic discussions with researchers has been adapted to follow the Knowledge Foundation's two call rounds.

Strategic process

We define the strategic process as the overall process to develop and refine the vision, goals and strategy of the TransTech environment. This work has led to the formulation of the TIE-vision and the 10-year goals, 4-year goals and yearly work plans that led the work in the Knowledge Environment program. The main focus for this process in the coming years is to be able to maintain a good and legitimate process for planning, implementing and evaluating strategy from vision to work plans and progress reports.

The strategic process's main target is to develop the research groups, Strategic Actions, and their research. This includes managing the formulation of the research content and building competence to profile the research environment and accomplish high scientific quality. We formulated six Strategic Actions in 2014; the number was reduced to five in 2015 when the research part of **FORIC** was absorbed into mechanical pulping (**e2mp**). In 2018 we reformulated the research of the Strategic Action **Manufacturing**, and it became **InFibra**, which later came to include **CellFUNC** as well. Now the Strategic Actions InFibra and EISS has been merged into one with the respective research profile **NeoPulp** and **NIIT** This means that the four Strategic Actions remaining are: **NIIT**, **NeoPulp**, **KM2** and **XGeMS**.

The work of the strategic process is led by Hans-Erik Nilsson and is coordinated in the management group with support of the Reference Group. The operative work is carried out in regular meetings with the Strategic Actions and in development projects.

New activities

The work with new activities takes place continuously. The TransTech management holds strategy meetings with all senior researchers in each Strategic Action twice a year. The meetings are scheduled according to the Knowledge Foundation's two rounds of calls for proposals and can be seen as an introduction to the quality assurance process for new initiatives to the Knowledge Foundation. At the meetings, development, goals and measures/programs needed to further develop and strengthen each environment are discussed. Each Strategic Action is asked to formulate goals and briefly describe the research group's needs to be able to achieve these goals. The needs analysis must cover all aspects and financiers, but also contain proposals for new initiatives financed by the Knowledge Foundation. Several strategy meetings are held with the same group if needed, in order for Strategic Actions to provide supplementary information on goals and needs or for the purpose of providing feedback to Strategic Actions after discussions within the management group or discussions with the Reference Group. The feedback is based on strategic considerations, the significance of the proposals for the continued development of the Knowledge Environment, long-term goals for the research environment and the views expressed in discussions with the Reference Group. The Strategic Actions receive recommendations on which initiatives they should continue with in the quality assurance process.

Quality assurance process

The Quality Assurance Process of TransTech has continuously been developed to suit the upgrades of the Strategy Process and the development of the process with new activities. Raising the ambition level to become a leading research and innovation location requires an implementation of indicators for the management to use in order to follow up on progress in prioritized areas. For example, one important goal is to improve internationalization, hence we continuously track our success rate in attracting international funding, co-publishing with international authors etc. We have also implemented research goals for Strategic Actions and aim to update research goals for individual researchers, to be used as tools to reach the common goals stated in the TIE-vision.

The Quality Assurance Process also includes research projects: external reviews of proposals for new Knowledge Foundation projects and reviews of final reports for completed projects.

Review of new proposals: All reviews are carried out by independent experts. The experts are chosen for their expertise in specific fields and their experience of research and research projects. They are selected by the faculty office from a list of names suggested by the project leaders. Some experts are selected based on recommendations by other reviewers. Before contact, a check to ensure that there is no conflict of interest between reviewer and research team is performed by the faculty office together with the university library.

Proposals for research activities are scientifically reviewed by a minimum of two peers. The proposals are also reviewed with respect to co-production and industrial relevance by at least two independent reviewers. Projects that do not meet all the quality requirements, i.e., that do not pass the threshold of a score of at least three on a five-point assessment scale in all categories of criteria of the evaluation forms, are given a second chance to revise the projects for a second review. The experts are also asked to comment on each criteria of the evaluation form, in order to point out strengths and weaknesses.

Review of ended activities: Reports for completed projects are evaluated by at least two experts. We ask the same experts that reviewed the proposal initially to carry out the final evaluation as well. This has proved positive in two ways: we get valuable input to our Quality Process by someone who, through comments and grades, contributed to the intentions expressed in the application and who is now given the opportunity to follow up the actual outcome. In addition, the experts are generally keen to learn about the project and its results, which is a feedback on the work with the application.

Reporting Process

The Reporting Process involves both reporting to the Knowledge Foundation according to given instructions and guidelines provided and reporting within the environment. The reporting to the Knowledge Foundation serves as support in the environment's own work on implementation and follow-up and as well as a support in the dialogue with the Knowledge Foundation. The indicators in the report present a picture of the development of the research environment, which together with the written reports form the basis of the Foundation's assessment work and follow-up, as well as the university's follow-up and planning ahead.

Follow-up of ongoing projects takes place mainly via pulse meetings once per semester. Meetings are held by the research group or subject, and all project leaders, head of department, economist, and responsible centre leader, participate in the meeting. The purpose of these pulse meetings is to follow up the overall status of the projects: scientific production, any deviations or changes in the research plan and future forecast. The follow up also includes financial status, and any deviations and changes from the planned budget are discussed. The status of coproduction is also an important point of discussion: whether the project in question is able to stick to the plan for cooperation, if there are any changes in the companies' contributions to the project, etc.

Administrative Process

The administrative process includes description and documentation of all processes and parts of the quality system – anything from role descriptions and timetables, meeting documents and documentation of changes. It is in the administrative process that the work with collecting indicators and project reporting takes place: preparing templates and forms, communication with involved researchers and project leaders, preparing data from the university's various support systems, etc.

The work with the administrative process is discussed and synchronized at weekly working meetings with TransTech's management team. There are faculty officers and administrative project managers at the research centres to support the work. Processes and routines relating to the administrative process are constantly being developed to improve and increase the systematization of data collection.

Communication Process

In the current communication plan of TransTech, we have identified several different activities as important to strengthen our profile, as well as strengthen our strategic development and build a strong coproduction. We have development processes that investigate how we can utilize communication better in our profiling and improvement of scientific visibility through more systematic use of search engine optimization, search word ads and videos. This is motivated by the findings in the bibliometric-based external analysis that we have developed.

Our research information is published through the University's and the centres communication channels to show our research results and improve visibility. Additionally, we organize several events together with the regional innovation system to fulfil several of our goals in strategic development, improving the coproduction and communication of our research. Examples of events are:

- Science and Innovation Day (SID), a conference aiming to provide a meeting place for companies and researchers. SID also has a strategic development role and serves as an arena for discussions with our partner companies. Targeted effect: Present our research and enable strategic discussions with partner companies.
- Business and Innovation Day (BID), a one-day event taking place twice a year, where companies are given the opportunity to present a specific challenge which will be coached by selected researchers from TransTech to identify how the challenge could be addressed. Targeted effect: Introduce companies without prior knowledge of the university to cooperation with the University.

We are continuously improving the communication plan to verify that our communication activities support the Quality System development towards the improved TIE-vision and upcoming goals.

Appendix 3. Assessment of capabilities

Development status of TransTech in the capabilities followed. Critical areas are shown in white, those with stable improvement in lighter green and those with good status in darker green.

Capability, the level achieved (1-4; 4= best)	**Main strengths**	**Improvement needs**	**External risks and opportunities**
Can develop and implement strategy: 4	Good and legitimate process to plan, implement and evaluate strategy from vision to plans and follow-up	The spread of strategic ability should increase in the new faculty organisation	
Can build scientific Profile: 3	Iterative process to define and implement a renewed profile, using systematic assessment of the research field when relevant	Reach the desired national position. Better collaboration of Strategic Actions and Departments in project implementation	Opportunity: Shared supervision of graduate students with external professors
Can co-produce: 4	Can interact on all time scales with a few large companies, and on project level with many (> 100)	Clarify expected benefits for MIUN from the collaboration with RISE	Opportunity for MIUN + the regional RISE: Competitive offer for education and new technology
Can integrate research and education: 3	Can build complete academic environments in all areas	Attract more students for better balance between income and expected deliveries	Opportunity: Education combined with research co-production
Can secure quality: 4	Good, continuously improving processes from strategic level to individual projects Clearly improved scientific production	Strengthen the academic environment to support scientific ambition, from PhD studies onward	Opportunity: Guest professors co-supervise PhD students and work with early career researchers
Can build organisation: 4 (*concerns faculty level*)	Two well-established research centres combined with good leadership and support from the Faculty	More support to Departments in research and education	Opportunity: New faculty organisation enables good collaboration with TransTech
Can secure resources: 2 *(level = 2 because of funding profile)*	Can attract strong international guest professors and postdocs. Improving support to funding applications	Better ability to succeed with senior recruitments and to balance funding profile	Risk: Less national research funding accessible Opportunity: Invitations to EU consortia are growing

Appendix 4. Indicators

1. **Volume of activities (research and advanced level education): Number of individuals and full-time equivalents**
   a) Doctoral students (not including industrial doctoral students), Postdocs and research assistants (temporary employment, PhD)
   b) Assistant professors, Associate professors, Professors, Adjunct researchers, Guest professors, Supporting staff
   c) Number of students in education on advanced level
   d) List of active programs and specializations

2. **Results of research activities and advanced level education**
   a) Number of doctoral-, licentiate and master degrees
   b) Number of scientific publications:
   Articles in journals, Conference articles, H-index, Journal impact factor
   c) Promotions:
   Associate professors (docent), Professors
   d) Funding granted:
   Faculty funding, National high competition funds, Swedish Foundations, KKS, Regional funds, International funds, Direct funding industry, Other
   e) External funding: Applied /approved

3. **Volume and results of coproduction and collaboration activities**
   a) Indirect funding from industry and non-industrial org.
   b) Number of collaborative doctoral students
   c) Number of collaborative organizations
   d) Collaborating in publishing

4. **International exchange**
   a) Number of international guest researchers, Number of international PhD’s and postdocs, Number of international research missions – In, Number of international research missions – Out, International projects, volume, Number of publications with all international co-authors.

Indicator values 2019-2021

Outputs of the indicators for 2021 (if there are outcomes) and two years back if the indicators were used in the past.

1. Volume of activities (research and advanced level education): Number of individuals and full-time equivalents

Table 1.a *Doctoral students, postdocs and research assistants*

Year	2019		2020		2021	
Gender	M	W	M	W	M	W
PhD students*	29	12	34	10	22	12
FTE	24,45	9,06	24,13	7,16	16,25	10,84
Postdocs and research assistants**	28	9	26	7	21	5
FTE	13,37	4,71	15,36	3,45	12,54	3,68

Table 1b*. Assistant professors, associate professors, professors, adjunct researchers, guest professors, supporting staff*

Year	2019		2020		2021	
Gender	M	W	M	W	M	W
Assistant professors	25	5	23	4	21	3
FTE	14,08	2,88	11,99	2,75	11,34	1,51
Associate professors	5	1	7	1	5	2
FTE	3,71	0,68	4,18	0,75	2,99	1,36
Professor, permanent	16	1	16	1	14	2
FTE	10,05	0,57	7,74	0,27	7,02	1,43
Adjunct researchers*	8	1	8	2	9	3
FTE	2,02	0,2	1,4	0,2	1,7	0,35
Guest professors	6	1	10	1	12	3
FTE	0,86	0,1	1,73	0,1	2,36	0,48
Supporting staff **	11	4	14	6	10	7
FTE	7,99	3,4	9,29	4,9	4,45	4,9

* Includes both professors and lecturers

** Administative project managers, technicians, communicators etc.

Table 1c. *Number of students in education on advanced level*

Year	2019		2020		2021
Gender	M	W	M	W	M/W
Master students	221	55	224	57	416

Table 1d. List of active programmes and specialisations

Name	Level	Hp
Automationsingenjör	First cycle	180
Elkraftingenjör	"	180
Energiingenjör - Hållbara fastigheter	"	180
Datateknik	"	180
Nätverksdrift	"	120
Webbutveckling	"	120
Processoperatör	"	120
Civilingenjör i datateknik	Second cycle	300
Civilingenjör i elektroteknik	"	300
Civilingenjör i teknisk design	"	300
Civilingenjör i teknisk fysik	"	300
Civilingenjör i teknisk kemi	"	300
Civilingenjörsutbildning i teknisk kemi Mittuniversitetet-KTH	"	300
Internationellt masterprogram i datateknik	"	120
Master by research i datateknik	"	120
Master by research i elektronik	"	120
Master by research i kemi	"	120
Master by research i kemiteknik	"	120
Master by research i teknisk fysik	"	120
Masterprogram i inbyggda sensorsystem	"	120
Masterprogram i teknisk yt- och kolloidkemi	"	120

2. Results of research activities and advanced level education

Table 2a. Number of doctoral, licentiate and Masters degrees

Year	2019		2020		2021	
Gender	M	W	M	W	M	W
No. Doctoral degrees	4	2	7	0	6	3
No. Licentiate degrees	8	3	1	3	2	3
No. Masters degree	28	6	18	4	13	11

Table 2b. *Number of scientific publications**

Year	2019	2020	2021
Articles in Journals	92	102	111
Conference Articles	65	45	32
H-index			30
Journal impact factor	3,35	4,16	4,83

* only affiliated publications

Table 2c. *Promotions*

Year	2019		2020		2021	
Gender	M	W	M	W	M	W
No. Associate professors (docent)	2	0	1	0	1	1
No. Professors	3	0	0	0	0	0

Table 2d. *Funding granted, million SEK*

Financiers	2019	2020	2021
Faculty funding (MIUN)	66,42	53,20	41,91
National high competition	3,77	1,37	0,91
Swedish Foundations	14,71	13,84	17,64
KK-stiftelsen	22,57	21,75	21,35
Regional funds	36,26	27,91	19,12
International funds	1,10	0,84	1,83
Direct funding industry	0,38	0,70	2,15
Other	0	0	0
Total Funding	**145,21**	**119,61**	**104,91**

Table 2e. External funding applied/approved

Financiers	2019 success rate*	2020 success rate*	2021 success rate*
National high competition	0 / 2	0 / 6	1 / 14
Swedish foundations	13 / 18	15 / 36	24 / 61
KK-stiftelsen	10 / 10	8 / 9	11 / 15
Regional funds	3 / 4	6 / 7	5 / 6
International funds	2 / 4	0 / 2	2 / 3
Direct external funding from industry	3 / 3	4 / 4	1 / 1
Other	0 / 0	1 / 1	0 / 0
Total	31 / 42	33 / 66	45 / 102

* Number of approved / applied projects. The latter includes pending applications.

3. Volume of coproduction activities

Table 3a. Indirect funding received from industry and non-industrial organizations

Year	2019	2020	2021
Indirect funding (in kind) in SEK	31 558 453	23 659 953	22 319 717

Table 3b. Number of collaborative doctoral students

Year	2019	2020	2021
No. of collaborative doctoral students	11	11	16

Table 3c. *Collaborative organizations*

Year	2019	2020	2021
Partners from industry (SME)	51	48	38
Partners from industry (non SME)	43	42	31
National partners from society excl. industry and academia	24	24	20
International partners	25	25	6
Projects with national academic partners	12	11	11
Projects with national institutes	12	12	18

Table 3d. *Collaboration in publishing**

Year	2019	2020	2021
Number of scientific publications with representatives from society (not academia)	42	39	37
Number of scientific publications with national academic co-authors	13	11	10
Number of scientific publications with international co-authors	78	84	83
Number of scientific publications with representatives from both academia and society	24	31	23

* Only affiliated publications

4. International exchange

Table 4. *International Exchange*

Year	2019	2020	2021
Number of international guest researchers	10	12	16
FTE	1,47	1,31	2,72
Number of international PhDs and postdocs*	22	24	23
FTE	13,35	11,61	12,76
Number of international research missions - In	21	6	5
Number of international research missions - Out	30	11	0
International projects, funding granted, million SEK**	2,01	3,40	5,98
Number of publications with international co-authors***	78	84	83

* PhDs enrolled in Sweden but with foreign domicile, postdocs with PhD from a country other than Sweden

**All projects that contribute to internationalization, for example International guest professors

*** Only affiliated publications

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