PRIMUS ARC-REPORT 2018

Preface

The mission of University West is to be an engaged actor within society, working closely with partners in industry, public sector and other organisations to create knowledge in mutual collaboration and make it accessible to a wider range of people.

The university's KK-environment Primus, which started in 2018, is right in line with this mission. With Primus, we aim to strengthen research and education in strategic areas, and in co-production with the surrounding society. Primus means "the first", which symbolises its role as a driving force for development of high quality research and the building of strong research environments. The vision is that Primus in ten years will grow to be an internationally recognized and nationally leading research environment in production technology and work-integrated learning that contributes to industrial sustainable development and growth.

ARC18 is University West's baseline assessment of research and co-production in Primus. The results will be used to further develop and strengthen research and education in co-production at University West in general and in Primus specifically, and will have great impact on the strategic development of our university.

Martin Hellström
Vice-chancellor

Summary

ARC18 is the baseline assessment of University West's KK-environment Primus. It will serve as a point of reference for future assessments, and as an input of ideas for improvements to make the environment reach the goals set up for the coming ten years. ARC18 consists of a self-evaluation, an external evaluation of co-production, a bibliometric analysis and a peer-review by an external expert panel. The following report is an overall presentation and discussion of the findings.

An evaluation of Primus as a whole is not possible, since one of the three core areas (I-WIL) is new. The evaluation is based on track records in production processes and production systems.
The production technology research is generally of high quality in terms of both relevance to the industry and the number of publications and citations. In some areas, mainly in production processes, the quality is excellent. The proportion of publications is very high, also in comparison with international standards, and there are very good international networks and research collaborations. International co-publishing is at a high level.

At the same time, the high volume strength may be a problem for the environment, since the high proportion of publications and citations are related to the high proportion of senior researchers in the environment. The expert group therefore recommends that the management develop strategies to secure the regrowth in the environment by adopting more doctoral students and by allowing junior researchers to qualify through higher involvement in the projects. Senior researchers should use a greater extent of their time to supervise doctoral students. This may temporarily reduce the proportion of publications, but it is important for long-term growth and quality of the environment.

The environment is still relatively small, and needs to grow to be sustainable. The expert group also highlights the major importance of the master's program, in order to create a basis for the recruitment of doctoral students and to increase collaboration with industry through exam projects. The quality of the environment is largely dependent on a small number of key researchers and a high proportion of collaboration with a few large companies and other universities. In terms of staff, the proportion of women in the environment is too small in relation to national gender equality goals.

Work-integrated learning is a unique profile for the environment, but the integration and development of Primus as a cohesive research environment poses a major challenge. The expert group sees great potential, and gives several recommendations to strengthen the whole and the possibilities of achieving the long-term vision. Specifically, the expert group emphasize the management's responsibility to develop clear strategies and control the development of the environment in a proactive manner. There should be comprehensive strategies for recruitment, publication, selection of projects and other things that encourage and influence the research towards a more cohesive environment.

Co-production is a strength in Primus. The external evaluation notes that the companies are satisfied and seem engaged. Primus has a high proportion of articles co-authored with the industry, and research holds high industrial relevance. The companies express high confidence in the scientific level at the University West, which is also evident from the bibliometric analysis. The doctoral students have good contact with the companies.

So far, there is too little evidence to assess the impact on society and industry. What one can say is that the research seems to have high industrial relevance. Otherwise, the impact is through training of qualified future staff in the companies, and through deepened contact networks between the university and the companies.

The expert group believes that the strategy work in Primus is good, but there are important development areas. Above all, there is no connection between the three core areas' strategies, and the whole in Primus.

Primus steering committee has identified the following recommendations as being the most important to prioritise:

Management

- Develop a clear strategy for better integration between the core areas of Primus.
- Develop clear strategies for the application process, with more top down control.
- Ensure that everyone in the management communicates around Primus in a uniform manner, and that it reaches all the way to the researchers and doctoral students in the environment.

Infrastructure

- Develop a clear strategy for recruitment and promotion of researchers. Consider more adjunct professors, more post-doc employment, career plans for junior researchers.

Co-production with industry

- Reduce the vulnerability of co-production by collaborating with more companies.
- Be more proactive in contacts with companies. Show what they can get out of the collaboration instead of just waiting for their demand, especially true for I-WIL
- Increase knowledge about Primus among companies other than those most closely involved, for example by strengthening the connection between doctoral education, the master's program and the research groups/industry.

1 Introduction

University West is a middle-sized university with about 15 000 students and 650 employees. The campus is located in Trollhättan, north of Gothenburg. The university started in 1990 as a university college, and received its first direct government funding for research in 1997. The study programmes and individual courses centres on technology, media, computing & IT, economy & leadership, health & care, teaching & languages and the individual & society. There are third cycle educations in production technology and work-integrated learning since 2012.

The university overall profile is work integrated learning (WIL), which permeates education as well as research. In education, work integrated learning means that students gain work experience already while studying. An example is Co-op, where studies are sandwiched with periods of paid work. WIL also constitutes an interdisciplinary field of research, focusing on learning in and for the new working life. The university also houses strong research environments in child and youth studies, as well as in production technology. The research in WIL Is connected to the research in production technology by the KK-environment Primus, supported by the national Knowledge Foundation (KK-stiftelsen).

Primus started in January 2018 and is a ten-year agreement between University West and the KK-foundation, with the aim to develop a strong research and education environment in collaboration with industry. The vision states that Primus is an internationally acknowledged and nationally leading research environment in production technology and work integrated learning, contributing to industrial sustainable development and growth. There are three core areas in Primus: production processes, production systems and industrial work integrated learning, I-WIL. The research and

competence development takes place in close cooperation with industry. The utilization of research results in co-production with industry is an important goal for reaching sustainable and competitive production. Primus also aims to identify and develop core area knowledge based on future needs, develop human resources and education and have an effective organization and leadership supported by a functioning quality system. All activities in Primus should include perspectives of sustainable development, digitization, competence development and innovation.

2 Assessment of research and co-production (ARC18)

In the first year of the program, KK-foundation requests all KK-environments to present a baseline assessment of research and co-production, abbreviated ARC, against which to assess the environment at the end of the ten-year program. The KK-environments at the universities Mid Sweden, Skövde and Halmstad did their ARCs in 2013 (ARC13), while the universities of Jönköping and West did their ARCs in 2018 (ARC18).

University West and Jönköping University collaborated in the planning of ARC18. The assessment included an internal self-evaluation, an external evaluation of co-production, a bibliometric analysis and a peer review by an external expert panel. The self-evaluation took place in the autumn 2018, at the same time as the external assessment of co-production, by DAMVAD analytics. These two reports provided the background material for an external panel of scientific experts coming for two days on site visit to each university. The expertpanel included Professor Torbjørn Digernes form Norges Teknisk-Naturvitenskaplige Universitet, Professor Erik Höglund from Luleå Tekniska Universitet, Professor Gunilla Jönson from Lunds Tekniska Högskola and Professor Håkan Wiklund from Mittuniversitetet. The same expert panel did the assessment at both universities.

The expert panel was asked to assess the quality of research and co-production with external partners of Primus in a national and international perspective, and identify strong research areas and areas that have potential to grow strong. The material consisted of the self-evaluation report, the DAMVAD report on co-production, the bibliometric analysis and the findings at the onsite visit in December 2018. The instructions to the expert panel was to rate the overall quality of Primus, and give a rating of Primus in terms of scientific quality, productivity, management and infrastructure, academic cooperation, co-production with industry, impact and strategies and plans for renewal. The instruction was to grade each dimension using the scale "excellent", "very good", "good" and "Insufficient". The expert panel had a template to guide the assessment.

During the visit at University West, the expert panel interviewed the vice chancellor, the steering group, the core area leaders, researchers and PhD students. University West provided staff to assist the expert panel to take notes during the interviews and in writing the assessment report. The expert panel got a draft of the report, based on written assessments from each expert submitted to the university in advance and on notes from the interviews and expert panel discussion at the onsite visit. The expert group processed and completed the draft, and submitted the final report to University West in January 2019. During the spring term 2019, the strategic reference group, the steering group and the three core areas have discussed the findings.

3 Core areas

Primus presently consist of three core areas, some with sub-areas. The core areas are productions processes, production systems and I-WIL, see Figure 1.

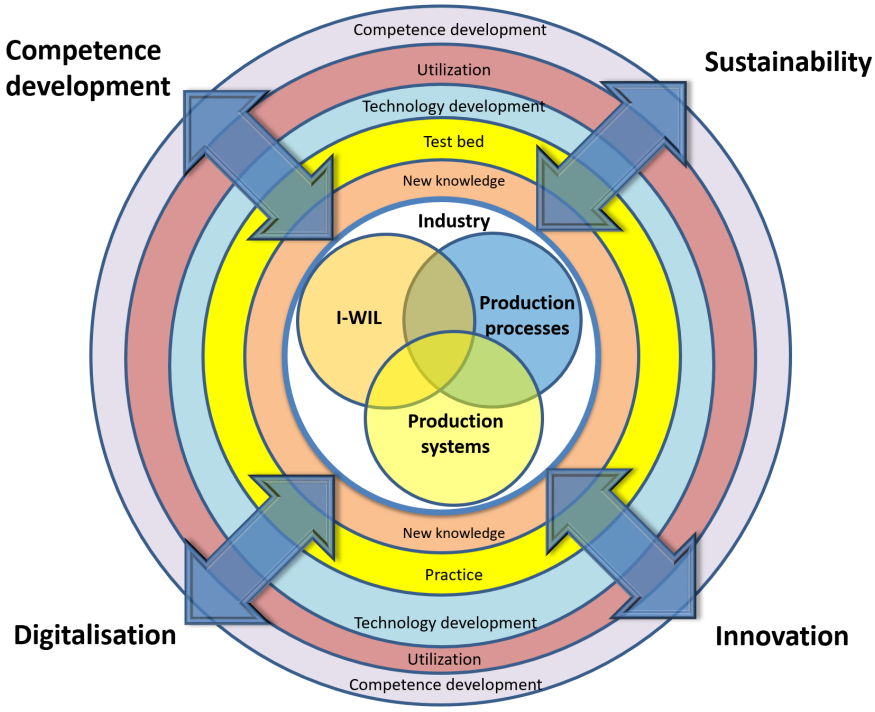

Figure 1. The core areas in Primus

The first two are parts of acknowledged vital research environment Production Technology West (PTW) at University West. The third has its scientific base in another acknowledged research environment at the university, called LINA (Learning in and for the new worklife). The following sections aim to give a short presentation of each core area, including subareas.

3.1 Production processes

Production processes have three subareas: thermal spray, machining, welding and additive manufacturing.

3.1.1 Thermal Spray

Thermal spraying (TS) was the first area with research projects at University West. The research group is now mature and well established nationally as well as internationally. The group's research projects have spanned varied aspects including process development, on-line diagnostics, characterization of microstructure, determination of thermo-mechanical properties, assessment of coating performance in simulated environments and investigation of failure mechanisms.

The initial research focus was mainly about development of coatings for thermal insulation, so-called thermal barrier coatings (TBCs), for gas turbine applications. The foundation laid in the course of meeting the extremely stringent specifications demanded by TBCs has enabled the research group to extend its expertise during the past ten years to developing coatings for solid oxide fuel cells, for wear resistance, and more recently for corrosion protection. In recent years, specific attention has been paid to exploring new thermal spray processes that can create novel coating architectures. Particularly noteworthy are examples of suspension plasma spraying (SPS) that enables spraying with nano/submicron feedstock to create novel TBC coatings with columnar microstructures, and high velocity air fuel (HVAF) spraying permitting deposition of very dense coatings for superior wear and corrosion resistance.

The TS research is located within the Division for Additive and Subtractive Processes. Current staff (2018): 3 professors, 4 lecturers, 1 engineer and 2 PhD students (employed by University West).

3.1.2 Machining

The research within machining at University West is devoted to supporting the industry in meeting the challenges connected to relationships between the machine tool characteristics, machining processes parameters, microstructure, and component characteristics. It often involves new and challenging hard-to-machine materials. Research on drilling processes has the longest history in the group. It focused initially on design of high feed drill geometries for difficult-to-cut materials. Later, this research area broadened, adding research on cooling technologies, temperature measurement and numerical modelling of cooling and chip formation.

In 2006, Volvo Aero (now GKN Aerospace) initiated the area machining dynamics to establish a research competence at University West. In this field, the studies are about the processes of drilling, turning and milling with focus on frequency domain and in-process identification and optimization of milling systems. Along with these studies, the group has developed the field of monitoring of machining processes with a focus on signal processing. These studies create a deeper physical understanding of the machining process, including what happens to the machine tool, the work piece and the tool as a consequence of machining.

The machining research is located within the Division for Additive and Subtractive Processes. Current staff (2018): 1 professor, 1 docent, 1 engineer, 2 PhD students employed by University West and 3 industrial PhD students.

3.1.3 Welding Technology

The research group of welding technology comprises nearly 30 people (including senior research staff, PhD students and engineers) and focus around three main areas in relation to welding technology; metallurgy, process physics modelling, and process development and control. The research performed within the area of metallurgy is by far the largest and most dominating one within the group. The metallurgy research focus on fundamental research of welding and deposition technologies to improve understanding of microstructure and defects and their influence on mechanical performance. Most of the research has been carried out on various steels and super alloys, but titanium alloys in particular and also aluminium alloys research are now slowly growing through both national and international research projects. The area of metallurgy research involves six senior staff researchers.

Regarding the research area of process physics and modelling, focus lies on laser, arc and melt pool physics. Here, the project proposal is to develop models for heat sources as well as the melt pool that can be used to predict e.g. formation of porosity, susceptibility towards solidification cracking etc. The process physics & modelling research area is managed by one senior staff researcher. There is a strong link between the research area of process development and control and research performed within the division of production systems, and in particular the group of control and monitoring. The aim with the research performed in process development is to study and improve process parameterization, automation (sensing, monitoring and control), and consumables.

The welding research is located within the Division of Welding Technology. Current staff (2018): 3 professors, 2 docents, 3 lecturers, 6 engineers, 2 research engineers, 9 PhD students (employed by University West) and 3 industrial PhD students.

3.1.4 Additive Manufacturing

The team at HV has vast experience (more than ten years) in metal wire additive manufacturing (AM), powder deposition by laser and thermal spraying, as well as laser and electron beam processing in general, with about 200 publications in peer reviewed journals. University West is also considered to be among the top groups globally in robotized laser wire AM. Its technologies in collaboration with industry are now industrialized and used in operating aero engine components. Although University West's entry into AM technologies based on powder-bed methods is only recent, it ideally complements the significant existing expertise in Laser Metal Deposition (powder and wire), thermal spraying and welding to create a unique environment.

Consciously, the AM research at University West is not performed (and neither planned to be) within a single specific division or group in the research environment. Instead, a multi-disciplinary research team comprising researchers from all three divisions within production processes and production system is involved in the ongoing efforts to investigate varied aspects of AM, to make it relevant for the Swedish industry. Although about 30 persons in PTW are actively involved in AM research today, the core team focused only on AM consists currently (2018) of 1 professor, 2 visiting professors, 1 adjunct docent, 2 post docs, 1 engineer and 5 PhD students. At the end of 2020, the staff is expected to comprise 5 professors, 4 docents, 4 PhDs, 3 engineers, 10 academic PhD students and 5 industrial PhD students.

3.1.5 Master programs

At present, the university offers two master programs related to the research in production processes: Manufacturing Engineering Technology, 60 credits and Advanced Manufacturing Engineering, 120 credits. Both are in English and lectures are largely located in the research environment premises. In addition, there are several 2.5 credits (partly on-line) courses for professionals in industry, among them several courses in additive manufacturing as well as in machining.

3.2 Production systems

The subareas in production systems are robotics & automation and control & inspection. At University West, the research concerns how to configure and operate production systems in an efficient manner. The common base for the group is a system and control view of production technology. An example of a system can be a welding robot with its specific welding tool, various IT systems, embedded control systems, sensors and information infrastructure. Further, the system view might also include other control structures such as Manufacturing Execution Systems (MES) and humans. On the detailed level, the group has specific research challenges related to control of production and processes, inspection methods and related data analysis. This also involves data for controlling processes, configuration of production systems with optimization issues, simulation, virtual commissioning, safety issues and human machine interaction (HMI).

3.2.1 Robotics and Automation

In recent years, research in robotics and automation has focused on highly flexible systems and autonomous operation within a robot cell or robot systems comprising a limited number of robots and machines. Within this area, digital twins, automatic code generation and autonomous agents are in focus, having formed a new direction towards artificial intelligence (AI) for the group. An example of application can be collaboration operator/robot, where issues such as task sharing, safety and sensor systems are in focus.

3.2.2 Control and Inspection

For control and inspection, the research has had an emphasis on model-based concepts related to in-process control and monitoring. Applications for this area has been welding processes and additive

manufacturing, with connection to researchers in production processes. Inspection has concerned sensor systems and data analysis that relate to identification and classification of actions to be taken concerning further processing of a product, such as in-process control or post control and inspection. Specifically, thermography is a research area with promising results as a non-destructive testing method.

Both research areas described above target common challenges related to the trend towards mass customization and Industry 4.0. Manufacturing should be highly flexible and based on autonomous systems, often localized controllers, which can communicate within an information infrastructure. Furthermore, methods need to be developed that can be applied to processing and manufacture of a product during several stages, within the context of a model-based approach. A model-based approach makes it possible to adapt different processes including monitoring, control, inspection and system configuration, in accordance with specification for the product. Moreover, in-process-monitoring and control create opportunities to adapt and alter subsequent process stages for the product to be aligned with specifications. Thus, future systems in manufacturing including control and inspection must be highly flexible and adaptable. In summary, the research areas represent core subjects within production systems in general and they represent important areas of both research and education within PS.

The production system research is located within the Division of Productions Systems. Current staff (2018): 2 professors (part time), 2 docents, 4 lecturers, 4 engineers, 4 PhD students (employed by University West) and 2 industrial PhD students.

3.2.3 Master programs

The university offers two study programs related to the research in production systems: a master program in Robotics, 60 credits and a master program in Robotics and Automation, 120 credits. Both programs are in English and are closely connected to the research environment. For 2019, the two master programs will be available on-line to attract more international students and industry. In addition, there are several 2.5 credits (partly on-line) courses for professionals in industry, for example in automation, in machine safety and in logistics.

3.3 Industrial Work Integrated Learning (I-WIL)

Industrial work integrated learning (I-WIL) acts within a work context and specifically targets learning, knowledge exchange and development within industrial areas such as production systems. I-WIL can take different forms, including I-WIL as a research area, I-WIL as a method to interact with society and industry and I-WIL as a pedagogical approach.

The ongoing trend in manufacturing to move from mass production to mass customization pushes the frontier in automation and digitalization of workplaces towards new challenges. During the last decades, much research has been devoted to reconfiguration of manufacturing systems. Sub-systems within a manufacturing plant are for example replaced by autonomous agents with various forms of configuration capabilities. Such changes in manufacturing systems challenge the professional context in which they occur; including the organization of work processes, recruitment strategies, demands of competences and internal and external education programs. However, not much research has focused on such contextual, organizational aspects of manufacturing change, and rarely together with the industry. Most research has been limited to academic research and demonstrators with little impact on manufacturing processes or systems in industry. There are many reasons for this, including that real-world problems are far more complex than working conditions set up in a demonstrator, and few, if any, are willing to risk substantial investments in production systems with new and unproven technology. In addition, human training and adoption in relation to new technology implementation is more challenging to predict and accommodate in a demonstrator

context. The actual human and organisational adoption and diffusion of technology need also to be continuously managed and measured in real work situations in order to make room for work-integrated learning, on the job training as well as competence and performance management.

The ambition is to initiate research grounded in our own research competence and from there collaborate with partners in Sweden or internationally. I-WIL projects take a common approach where co-production of both academic and practical, or experienced-based, knowledge is crucial in order to understand what constitutes the workers' competences in the wave of digitalization. Organizational maturity is another measure of an organization's readiness and capability in relation to competent acting, expressed through its people (competence), processes, data and technologies and the consistent measurement practices that are in place. Where organizational maturity comes to meet digitalization/automation/robotics are evaluating, measuring and learning processes. Thus, competence and conditions in industrial organizational practices with maturity issues related to digitalization form the overall framework of I-WIL research projects.

I-WIL has a long tradition of working in co-production projects and innovations. Ongoing and active collaboration with industry include GKN Aerospace, Siemens, NEVS, Volvo Cars, Nolato, Raybase and Samsung. Company collaboration and projects exist in a number of ways, from education oriented to cooperation and co-production in research projects. Within the ongoing project ProdEx, Primus has established a network with industry that will continue to grow. More than 30 companies will collaborate in this network. The project is related to education, and much data is available on how and what learning outcomes are achieved on such a co-constructive educational model. There will be further research on this particular project base. Our collaboration partners consist of large enterprises, SMEs and consultancy companies. The larger enterprises form the basis for collaboration on a strategic level.

In 2018, there are only a few projects running within the core area. The number of researchers in I-WIL projects are therefore at a start-up level. Current staff (2018): 2 associate professors with a background in WIL, 5-6 lecturers with a background in WIL, 3-4 lecturers with a background in production technology and 2 PhD students (employed by University West).

The planning for recruitment is expansive and includes four assistant lectures/post docs and 2-4 PhD students and possibly one professor. In addition, 2-3 lectures are about to be qualified for associate professor in WIL and the ambition is that more researchers within WIL will be involved in research connected to industrial problems in the coming years.

There are no master programs ongoing with strong connection to industrial work integrate learning. However, in 2019 the new master programs in Informatics (IT & Management) as well as those in Business administration (Master in International Business and Master in Leadership) will include several courses with a content is related to I-WIL, for example VR/AR technology etc.

3.4 Collaboration between core areas

As Primus is in an initial phase, the internal collaboration 2018 has so far been limited. The only areas with a long or fairly long history of internal collaboration is welding technology (PP) and control & monitoring (PS) and all projects focused on education, both for industrial PhD students and also courses for professionals. In the latter case, courses are offered in forms developed within the area of I-WIL.

However, there is a strong commitment for the future from the management of Primus (including the university vice-chancellor) to expand the collaboration between Primus core areas. Therefore, this is an important criterion when prioritising projects in the environment.

4 Quality assurance system

The purpose of the KK-environment program is to support strategic development and profiling of universities in Sweden, by giving the university management a tool to drive long-term development in a structured way within a defined part of the university. Thus, it is more than just a funding program. After completing the program, the university should have a clear overall profile and complete academic environments in selected areas, increased scientific impact and enhanced ability for co-production of knowledge with the industry.

The university defines a vision and goals for projects within the KK-environment and involve external partners. During the program time, the university has a responsibility to drive development according to the chosen strategy, and to monitor and assess the work progress in systematic way. It is an important part of the program that the university itself is responsible for quality assurance of all projects in the KK-environment. The quality assurance system includes quality assurance of planned efforts, but also the ability to make strategic decisions, to monitor and to assess progress of work. Each year, the university presents an activity plan to the KK-foundations, including strategic activities and a budget for the coming year, and receives funding from the KK-foundation. The KK-foundation also supports and monitors the university's quality assurance system and has regular dialogues with the university management.

The Primus program manager chairs the environment's steering group at University West. The steering group also includes the deputy vice-chancellor, the heads of department of the two institutions involved in Primus and the three core area leaders. There is also a strategic reference group, including the program manager, the vice-chancellor of University West, representatives from other universities, from the surrounding society and, not least, from the industry. The operational management team includes the program manager, an administrator, a grant and innovation officer and a quality coordinator.

In November each year, Primus submits an activity plan to the KK-foundation. The activity plan includes a list of prioritised projects, thoroughly assessed in a structured process. The KK-foundation's expert group revises the activity plan before approval by KK, who then finances the projects in accordance with the plan.

The quality assurance process of projects starts about one and a half year before the submission of the activity plan for the coming year. The researchers from all core areas meet in workshops to discuss project proposals for new research projects in October/November, in relation to needs identified by the steering group for activities supporting long-term goals for Primus. The steering group then assesses the rough project proposals in the beginning of the following year. An internal reviewer comments on the proposals approved by the steering group, giving the researchers a chance to develop the proposals to full applications. The next step is a scientific review and review of co-production of each project application by several external experts. In September, a group of two internal and two external scientifically competent persons will prepare and discuss the external reviews and present them to the steering group, who then gives a proposal to the vice chancellor, who ultimately decides which projects to include in the plan to KK.

A ten-year signed agreement between University West and the KK-foundation forms the basis of the program. There are additional agreements for every consecutive three-year period. Each year, the environment submits a follow up report to KK, describing the past activities and commenting on their success or lack of success.

5 Evaluation and self-assessment

This section is a merging of the self-evaluation (Appendix Report PART A and B, Appendix Report PART C, the DAMVAD report on co-production and the appended external expert panel report. The presentation follows the outline of the expert panel review, with an overall assessment followed by assessment of quality of research, productivity, management and infrastructure, research networks and academic collaboration, co-production and cooperation with industry, impact and strategies and renewal.

5.1 Overall assessment

Overall, the expert panel assess the research in Primus to be of high quality, to have high relevance for industry and good impact in terms of international collaboration and citations. However, it is only possible to assess two out of three core areas, since there is very little prior research in I-WIL. Overall, Primus is a relatively small environment with high dependency on a few key researchers, their personal networks and cutting-edge research in limited areas. The fact that a large part of the funding comes from one source, the KK-foundation, reinforces the vulnerability of the environment.

Out of the three core areas, production processes is the most developed of Primus Core areas. The research team in production systems also have a good record, while the I-WIL research is still to be developed. Primus goal is not only the strengthening of each core area, but also the creation of new research at the intersection of them. The expert panel agrees that this is an interesting and unique project proposal with good prospects, but notes that the development will take time and strategic efforts. At present, there is too little collaboration between the core areas. Developing the intersection between the areas stands out as a major challenge.

According to the expert panel, research in the intersection of the core areas and the focus on WIL should have great potential. Different research groups can collaborate around issues related to the structural transformation of industrial production, which ought to be of great interest and demand from the industry. Research in this area requires a broader and more formalized collaboration and co-production with industry, including the management as well as the production level of the industrial partners. The demand must come from the industry itself, which is more likely if the scope of co-production also includes the management and HR-level at the companies. This way, the joint research questions will include more than technical challenges and require interdisciplinary work, addressing both technical and social aspects of industrial transformation.

5.2 Quality of research

The expert panel grading of the quality of research in production processes and in production systems is very good, in in some cutting-edge areas even excellent.

According to the self-evaluation, there has been a significant intensification of production technology research at University West over the past ten years. The majority of teachers in engineering science now have a doctoral degree, enabling research production to grow even further. The research profile SUMAN has undoubtedly had a significant role in this development.

Since 2011, the university can pass doctoral and licentiate degrees in production technology. The research within production technology (PTW, Production Technology West) has been a prerequisite for the development, by creating a supervisor platform for PhD students. The research schools have also played a very important role in this development, for example the KK-funded SiCoMap/SiCoMap+.

There have been several external evaluations of the research in PTW. They have stated that published material, articles, papers and theses are well in parity with highest international standard. National and international collaborations in the environment have ensured that the quality of research stays at a high level. The results over the period from 2012 to 2017 have been very good. The research volume has almost doubled when it comes to external funding. There are now four times as many publications in scientific journals. The international collaboration has also been important 2012-2017, with 8 international visiting professors, 10-15 PhD students going abroad on research/internship at other universities, several senior researchers being guest researchers at international universities and the portion of EU-Horizon 2020 funding having grown, currently (2018) amounting to 5-10 % of the total project volume.

Thermal spray (TS) is the most established of the subareas in production processes. During the last five years, the research has developed from a strong focus in thermal barrier coatings (TBC) into several other application areas. This has been possible through investments of new equipment providing several TS methods, like HVAF and SPS. The sub area group has been very productive over the last three years, resulting in a high number of selected publications papers (see Self-evaluation p. 14, table A2.1, TS1 - TS7). The papers illustrate the spectra of research results from TS application areas like TBCs, corrosion protection, wear protection, multilayer TBCs etc. They also illustrate a high international collaboration.

The machining research has developed in strong collaboration with the local aero engine industry, through several industrial PhD students and the cutting tool manufacturing companies in Sweden. There has been much focus on machining in tough materials from a machining processing point of view and on improving the conditions, like minimizing wear. Another perspective is machine dynamics, for example how to minimize vibrations in the process. The grade of co-authoring with industry is relatively high. The selected papers illustrate the variety of research results in the group (see Self-evaluation p. 14, table A2.1, M1 – M3).

Welding is a relatively new area, but has grown to be among the largest groups within PTW (and Primus) during the last five years. The research and connected third cycle education is the only existing similar in Sweden. The results span from understanding weldability aspects and how to improve performance in different types of steel and nickel-based alloys (welding metallurgy), but also fundamental understanding of welding presses through and how to improve the process. The selected papers illustrate the variety of research results in the group, (see Self-evaluation p. 15, table A2.1, W1 – W6). The international collaboration is strong, just like the internal collaboration in Primus, as the process control and monitoring group work closely to welding process development.

Additive manufacturing (AM) is the youngest sub area within production processes, even though research, in particular control of one specific type of AM, has been going on for nearly ten years. The broad combination of research in thermal spray, welding and process control was the basis for a kick-start in the field. Three years later, the sub area group is among the leading research groups within metal-based AM in Sweden. The selected papers illustrate the research areas within AM, covering areas like simulation of the AM process, metallurgy connected to AM built structures, process development and control of the process (see Self-evaluation p. 15, table A2.1, AM1 – AM6).

The core area production systems consist of the subareas robotics and automation and inspection and control. In the former, research has focused on optimization of production processes. Since 2017, it also includes digitalization aspects connected to industry 4.0. In particular, the focus is on self-configuration systems and challenges connected to this type of automation, for example safety issues. Through the availability of investments in state-of-the-art automated industrial equipment, several demonstrators of different applications of industrial automation is and have been used in the co-produced research with industry. In control & inspection a major focus is laid on in-process

control and monitoring. Applications for this area have been welding processes and additive manufacturing, linking the group to other groups within production processes in Primus. The selected publications illustrate the various research initiatives that are within the research of production systems, (see Self-evaluation p. 15, table A2.1, PS1 – PS6).

The research in industrial work integrated learning is still in its infancy and the output has therefore been limited so far. The research has been connected to models for competence development of production technology professionals and to some extent also skill training of operators. Therefore, the selected publications mainly cover this specific area, (see Self-evaluation p. 15, table A2.1, IWIL1 – IWIL5).

The number of individuals and full-time equivalents of permanent research staff in production processes and production systems has steadily grown over the years. During 2014 and 2015, there was a special effort on recruiting professors to strengthen the research environment as a whole, and specifically to strengthen the group of supervisors. This activity resulted in several visiting professors and a part time employed professor. At the same time, University West was able to attract several professors, and therefore the target to increase the number of supervisors was successful. During the last two years the number of researchers, as seen in Self-evaluation, p. 34 table B1.1.1, has been on the same level. The plan ahead is to increase recruitment, with a special focus on recruiting postdocs in all core areas.

The project volume for PTW has steadily grown. From 2012, external funding has increased by nearly 10 % annually and the level 2017 of external funding from research funding organizations was 47 MSEK. As the internal university funding is limited, the PTW environment has been successful in terms of leveraging. Over the years, the percentage external funding has varied between 69 percent and 83 percent. When it comes to distribution between funding bodies, the major part comes from sources like Vinnova, EU, KK foundation, Swedish Energy Agency. The plan is to increase the volume even further and establish a balance between KK and all other funding bodies, with a defined ambition that funding from KK exceeds 50 % on average.

PTW has well-established partnerships with internationally leading and prominent institutions. Expanded and deepened cooperation is an important means of environmental development. The researchers can go to partner institutions in order to utilize specific equipment, or for doing joint research studies. Examples of such network institutions are Forschnungszentrum Jülich, Manchester University, Fraunhofer Dresden, University of British Columbia, Pennsylvania State, Federal University of Uberlandia, Strathclyde University and Politecnico di Bari. Some ongoing activities include a professor from Uberlandia in Brazil and a professor from Bari in Italy who participates in several long-term projects and regularly lives in Trollhättan, currently 50 percent and 20 percent respectively. They actively participate in both research and supervision of postgraduate students.

In the Self-evaluation report, Table B1.4.1 (participation in academic community) p. 37-38, shows international activity 2016-2017, and indicates a good start for the environment. The activities include plenary or keynote talk at international conferences (5), member of international scientific councils (4), chair of program committee (international conferences) and (5) member of program committee (international conferences) (9).

PTW has stressed the need to let the graduate students utilize and enrich the international community. About half of the graduate students in production technology have so far participated in such exchanges. So far, the following institutions have been visited by one or more people: TWI (Cambridge and Yorkshire, England); CENIM (Madrid, Spain); INNOVNANO (Coimbra, Portugal); University of Manchester (England); Forschungszentrum Jülich (Germany); University of British Columbia (Canada); TWI Technology Centre (Yorkshire, England); University of Warwick (England);

University of Manitoba (Canada); University of Kentucky, Lexington (USA); University of Nottingham (England).

As the DAMVAD-report shows, the quality of research in PTW is high in terms of impact (citation rate with adjustment for research field and publication year). Scientific impact in is 4 percent above average for Sweden and 15 percent above average in the OECD, which implies that research is of international standard. This is even more noteworthy as competition is tougher in similar research fields in Sweden than it is on average within the OECD. The research impact is also clearly above average in the existing KK-environments at Mid-Sweden University, Skövde University and Halmstad University, as much as 30 percent.

Compared to impact, the proportion of articles published in top rated journals is slightly below the other mentioned KK-environments. The proportion of most quoted publications in Primus is slightly above the global average, and in line with the rest of Sweden in the same research area.

With reference to the DAMVAD figures and the bibliometric analysis, the ARC18 expert panel notes that there has been a positive trend in research quality and impact over the last years. There has been an increased focus on publication in journals rather than on conference proceedings. The co-production with industry is high, around 41 percent of the articles, as well as with international co-authors, 40 percent of the articles, implying a high quality of research.

However, the expert panel also points out some problems concerning the quality of research. One is the absence of research in the intersection of the three core areas, which reduces the expert panel's overall rating of quality in Primus. Another problem has to do with the strategic choice to invest in senior researchers rather than PhD students and junior academic staff. Although the quality of research is very good or in some cases even excellent in terms of output, a few researchers stand for a large proportion of the articles. Primus has a high proportion of senior staff, professors and associate professors, which can explain much of the high impact of research. This is good in the short run, but it also constitutes a threat in the long term, if it impairs regrowth of the environment. Primus management argues that the investment in senior staff is a strategic choice. It is better to stabilize the number and competence of senior staff with qualifications to supervise before increasing the number of PhD students. The expert panel disagree, seeing that there is room for more PhD students, as the senior staff/PhD student ratio is lower in Primus than in other research environment. They stress that doctoral education is indispensable for the long-term regrowth and development of a research environment.

The expert panel does not assess research quality in I-WIL, since they have not had any access to impact scores comparable to those for production processes and production systems. They do note that the conditions for good future publications within I-WIL seems to be all in place, but it remains to be seen whether the existing research competence in WIL can be transferred into I-WIL research. The expert panel also notes that so far joint publications have been scarce.

In sum, the expert panel concludes that research in production processes has a strong position in Sweden and to some extent also internationally. Professors are well qualified, and co-publication with industry is extensive. There is a good standing with industry overall. A significant share of publications has international co-authors, and journal publications is above average. Citation impact is above average. The new research in industrial work integrated learning has a solid base in the wider research area within WIL.

The weaknesses lie mainly in the size of the environment, and the ratio between senior researchers and PhD students. The research groups are small, which makes it a challenge to cover a wide field of subject areas. Activity depends on a small group of core people, making the environment vulnerable.

I-WIL is a new area, and the integration between the I-WIL group and the production technology groups is low. The management has no obvious strategic plan on how to strengthen I-WIL research and how to overcome cultural differences between research groups. There is no clear publishing strategy for Primus as a whole.

Recommendations

The expert panel argues that integration between the three core research fields is of the utmost importance if Primus will be able to achieve its goals. The overall connection between production technology, I-WIL and the overall vision of Primus needs to be developed. The recommendations of expert panel largely follow the suggestions of the DAMVAD report and focus on the formal organization and leadership of Primus. They underline the need to develop formal strategies for a number of areas: the application process, publication, promotion, recruitment, research collaborations and the masters and PhD education connected to Primus.

The application processes

The application process in Primus is mainly bottom-up. The research groups are free to formulate their research questions in collaboration with the industry. This process has many advantages, since it guarantees that the projects and recruitments are relevant to the researchers and to the companies. However, there is a risk of getting more of the same rather than research contributing to the vision of Primus. The steering group should consider creating clear incentives for the various research groups to collaborate on applications connected to digitalization, knowledge transformation as well as sustainability and innovation in the transformation of production industry.

Publication

Primus needs to develop a publishing strategy for each of the core areas as well as for the whole research environment. The strategy should give a direction as to how much to publish in journals within the fields of the three research groups, and how much in journals with an interdisciplinary approach. Which journals are possible? What ought to be the balance between excellent research in core areas and the transfer of knowledge to industrial transformation?

Promotion

It is important that staff can do integrative research within Primus, i.e. bridging technology and learning, and still qualify for a promotion to docent and professor within their research field. As it is now, there are strong incentives to stay in your own field of research.

Masters and PhD education

The management should take actions to increase the number of master program students. There is a large production of bachelor degrees in production technology, while the master production is weaker. Master students are important, though, connecting research with the industry through exam works. Without a solid base on the master level, the environment will have difficulties to increase the number of PhD students, with detrimental effects on the quality of the environment and the future supply of qualified personnel at the university as well as in the industry. Producing well-qualified researchers to academia, industry and society in general is equally as important as delivering research papers. Primus is in a good position to produce licentiates and doctors with relevant competence to work in the industry. The expert panel notes that Primus has a comparatively low degree of in cash funding from the industry, and suggests that the management try to convince the industry to contribute more in cash, as an investment in qualified future candidates for employment. Furthermore, the strategies and action plans of Primus must link research and connected educations.

Recruitment

The management must ensure recruitment of new key personnel is in tune with the needs of Primus as a whole, not just with each research area. It must pay close attention to the age distribution in projects and plan to reduce the risk that people participating from the beginning will not be there when the project ends. To balance and competence and seniority as well as project management and supervision it was proposed to increase number Post-doc positions within the environment is a good strategy.

Research networks

In order to keep up with the latest research the environment should endeavour to develop more networks and research collaboration in Asia. The expert panel recommends that the management encourage researchers in Primus to lead research projects to a greater degree than today. Although resource-intensive, it will be a good experience to coordinate EU projects.

Organisation and leadership

The management needs to devote much attention to building strategies to encourage joint projects within Primus, to create a feeling for Primus, not just the separate areas. It would probably be conducive to have representation from the management level in partner companies in the steering group. With their insight about future strategies, they should be able to put more pressure on integration between technology and learning.

Funding

It is natural that Primus at this stage is very dependent on KK-funding, but this dependency needs to decrease over time. In addition, GKN stands for a large part of the industrial funding, which makes the environment vulnerable. Primus must broaden the co-operation with industrial partners and if possible, convince the industry to contribute more in cash.

5.3 Productivity

The expert panel grades research productivity – defined as the impact in relation to the resources spent – to be good in the production research groups within Primus. Again, the productivity within the I-WIL group is impossible to evaluate at this stage as there are too few publications (three journal articles from 2015 to 2018).

Publications and citations

Regarding journal publications, there is a clear and strong positive trend. The scientific leaders have jointly decided to prioritize journal publications in favour of conference papers. The trend is also due to many PhD students approaching the end of their education, which naturally gives results in more journal publications. The growth of the research environment and the number of PhD students has resulted in a huge increase of journal publications, from 19 (2012) to 80 (2017). The citation level is on average 1.06, which according to DAMVAD (Appendix Report Part C, chapter 4.12) is above national benchmark.

The number of publications during the period from 2012 to 2017 is on average 2.25 per FTE (full time equivalent) researchers per year. This is in line with, or slightly above, the Primus three-year goal of two publications per FTE per year. The international collaboration is also positive: 1.53 countries on average over the period. According to the analysis made by DAMVAD (Appendix Report Part C, chapter 4.3), 40 % of all publications are authored in collaboration with international researchers.

The expert panel finds that the impact in publications and citations of the production process group is relatively high in a national context. The relatively low production of dissertations reduces the overall grading from very good to good. The expert panel notes that senior professors seem to

increase their involvement in research rather than taking leader positions in the research environment and in adjacent educations. It is questionable they are used in the most effective way for the environment.

The panel also notes that the total volume of scientific publications seems to be adequate in relation to the size and funding of the technology research groups. You cannot expect an academic publication activity comparable to basic research environments in industry-near research like Primus. Publishing has increased both in absolute numbers and per senior researcher between 2012 and 2017. In addition, the quality of the journals is good. The same applies to citation impact, which is 4 percent above average in Sweden, 8 percent above average in the Nordic countries and 15 percent above OECD average.

The citations are however decreasing between 2014 and 2017, which might be a sign of decreasing quality, despite the increase in publications during the period. Since citations have a time lag of 3-4 years, it is difficult to say (Appendix Report PART B, Self-evaluation table B2.2.3, p. 41). An increase in the number of publications must not be made at the price of citations going down. Over time, the publications have developed a greater focus on journals and less emphasis on conference proceedings. When it comes to publication impact, the materials science (production processes) is the dominant area within Primus (DAMVAD, p. 24). No data is available on publications within I-WIL.

Doctoral degrees

Before 2011, when University West first got the right to pass doctoral degrees in production technology, PhD students affiliated to PTW had their main supervision at another university. PTW and Primus now have now full capacity and supervision and right to graduate for PhD at University West. The average has been three doctoral dissertations per year since 2011. There were four dissertations in 2017, and in 2018, the expected number is six. The first two female PhD students graduated in 2016 and 2017.The promotion of docents or professors has also increased, with one professor and two docents in 2017. In 2018 one docent and one professor was promoted.

The expert panel notes that the involvement of professors in research is extensive. This could be a strength but also a weakness, as senior faculty is needed to educate new professionals and researchers. The expert panel considers the production of PhD students and licentiates too low to fulfil the vision of Primus. The number of PhD exams seems unchanging between 2012 and 2017, and the number of PhD students has been relatively stable from 2014 to 2017 (varying between 29 and 33). Between 2012 and 2017, the number of doctoral theses produced were 18 and licentiate theses 27, on average 3 doctoral theses and 4.5 licentiate theses each year (Appendix Report PART B, Self-evaluation, table B1.1.2 and B2.2., p. 29, 39). In 2017, there were 17 professors qualified to be head supervisors for PhD candidates. As the stated number of PhD students was 33, the ratio is 1.9 students per supervisor, which should be possible to increase. Top international research environments would have a ratio of 3-5 PhD students per supervisor.

Promotions

The number of promotions of docents and professors is still relatively low. Between 2012 and 2017, there were two promotions to docent and two promotions to professor. For docents there is an increase over time, with four promotions over the last two last years. For Primus to fulfil its visions this number need to increase, which requires clear strategies and an increase of PhD students and post-docs. Since Primus has a strong focus on co-production with the industry, the lack of adjunct professors from the industry in the research environment is surprising (Appendix Report PART B, Self-evaluation, table B1.1.2. p. 35). The industry tends to be positive to adjunct professors, which makes this a potential way to connect new industries to the research environment and to ensure that the industrial partners contribute with resources in co-production.

There are difficulties in evaluating productivity in relation to the time spent by researchers from the data in the DAMVAD report and the self-evaluation. From the aggregated data about personnel and publications, it is not possible to analyse this on a sub-unit or individual level. As mentioned before, the impression of the expert panel is that professors are responsible for a large part of the publications. The expert panel maintains that this is an ineffective way to distribute resources; in fact, it is even counter-productive since it takes time from supervision and teaching of new researchers. As it is now, many of the senior lecturers and lecturers do most of the teaching at bachelor and master levels. As a result, they have less time for research, which they need to get promotion. In addition, a professor has an important role to train future researchers, presently students at the bachelor and master's level. The expert panel therefore recommends that resources be spent on giving junior lecturers the means to take a PhD exam and for senior lecturers to be promoted to docents. Teachers also should be active researchers.

The main strengths in terms of productivity is the good publication record for the technology sciences in Primus. The record of co-produced research with industry is also strong. Among the weaknesses is the fact that the publication volume varies widely between different research areas in Primus, with a domination in materials science. There are few publications within I-WIL, and the number of docent promotions and professor promotions is relatively low. The volume of PhD education is still at a low level and the number of PhD exams is unchanged between 2012 and 2017.

There is a strong positive trend in publications, less so in citations, however still above average. The expert panel notes that there is a desirably high rate of co-authoring with industry within Primus. The expert panel maintains that this can be explained the high rate of senior staff in Primus, in relation to junior staff and PhD students. As Primus is a comparatively small KK-environment, the panel recommend that Primus develop strategies to grow by increasing the number of PhD-students. Having more PhD students will mean that professors have less time for their own research, which can have a temporary negative effect on publications and citations, though it will strengthen the research environment in time. Investing in junior staff will make the environment less vulnerable, less dependent on a small group of senior researchers.

The expert panel also notes that there has been no increase in the number of PhD-students since 2014, when the university first started third cycle education in production technology. The answer given in the interviews at the onsite visit was that the strategy is to increase the number of professors and docents capable of supervising first. Against a ratio of 1.2 PhD-students per professor, the expert panel does not agree that there are too few supervisors. They also recommend recruiting more post docs. Master students are valuable as a means for bridging the gap to industry through exam works and being base for future recruitment of PhD students.

Recommendations

The assessment of research quality tends to overlap with the assessment of productivity, since they are both based on impact in terms of publications and citations. Therefore, the suggestions concerning productivity have some overlaps with the suggestions presented in the previous section.

Clarify the present situation

The operational plan for Primus already includes several activities, but needs further development to overcome the weaknesses identified in the SWOT-analysis for research and scientific production in the self-evaluation. It is not sufficiently clear on the utilization of time.

Publication strategy

Establish clear publication strategies according to the recommendations in section 2. Clarify the strategies concerning conference contributions, considering the drastic decrease of conference contributions over time. Are there any risks connected to this decrease? Do the individual

researchers have clear goals when it comes to number of publications in journals/conference contributions?

Increase the number of doctoral theses

In order increase the number of dissertations, the expert panel suggests an increase of the number of industrial PhD-students. To achieve this, Primus needs to expand the number of industry partners, and increase funding from other research funding bodies than the KK-foundation. Primus also needs to establish a clear strategy for the relative distribution of senior researchers/PhDs, and let senior researchers supervise more students than today.

Integrate education and research

From the provided documentation, it is unclear whether research and education are sufficiently well integrated. The production of master students should be higher in order to use them to disseminate state-of-the-art research to industry and society. Therefore, the expert panel recommends that Primus expand the education of master students, closely integrating it with the activities of the research environment.

5.4 Research environment and infrastructure

Organisation and management

The University Governing Board is highest decision-making body at University West. The University's executive manager is the Vice-Chancellor. The university has four academic departments, a university library and student service and an administration.

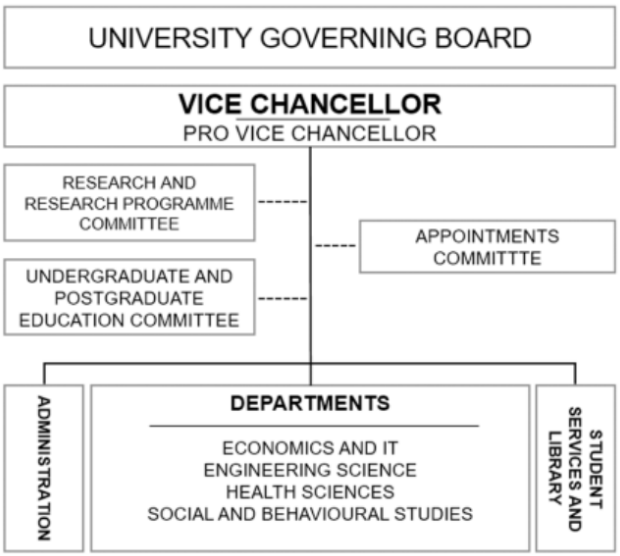

Figure 2: Organisation of University West

University West has three so-called “vital research environments”, established by the university governing board. They conduct research considered to be of particular strategic importance for the university. The first, Production Technology West (PTW), was established more than ten years ago. The purpose of Primus is to further develop, deepen and integrate the research projects undertaken within PTW and in the vital research environment LINA (Lärande I och för det Nya Arbetslivet), in the latter case focusing on work-integrated learning in an industrial context (I-WIL). The goal is to build high-quality research and education in co-production with industry, based on existing research projects.

Primus started in January 2018, and has a planning horizon of ten years. With long-term funding from e.g. the Foundation for Knowledge and Competence Development (KK-Stiftelsen) and in collaboration with strong partners, University West can take a strategic approach to a significant part

of the university's research efforts. There are also some educational initiatives within Primus, aimed at profiling and positioning the university in the national and international arena.

From an organizational point of view, Primus does not constitute its own entity. Instead, it means to be a focused virtual platform for research, education and collaboration. The university has chosen to place Primus in the Department of Engineering, where most of the research was done at the start of Primus. The entire vital research environment "Production Technology West" (PTW) is a part of Primus, together with parts of the LINA-environment which organizationally belongs to another academic department. Primus uses the university's administrative support functions for budget and financial control, innovation development, library, communication and human resources as well as for communication. In addition to this, Primus has its own management and organizational structure for steering and control of the environment. This structure also includes the organization of a quality assurance system, with the intention of realizing strategic initiatives and securing the activities carried out within the environment.

The bodies and management structures created specifically for Primus deal with issues related to strategic development, coordination and anchorage, implementation and follow-up of decided activities. The steering group, the strategic reference group and the operational management all have different functions and responsibilities within Primus operations.

The vice chancellor is ultimately responsible for Primus and takes all strategic decisions regarding the environment. Primus operations are an integral part of the university's total activities. Decisions involving work-leading actions or similar are governed by the general rules of the University and other applicable regulations (as stated in the Executive Order No. 2016/72).

The steering group is responsible for leading the development of Primus by developing proposals for strategies and business plans as well as following up and feedback. The steering group also discuss, develop and anchors proposals for research activities at different stages in the quality assurance process.

The operational management team has no decision-making mandate on its own, but is responsible for gathering information, preparing and presenting issues for the steering committee. It is also responsible for disseminating information, as well as anchoring and coordinating the focusing decisions that the steering group takes, and the decisions taken by the vice chancellor. The vice chancellor appoints the roles within the operational management team. Scientific leaders for the university's vital research environments "Production Technology West" (PTW) and "Learning in and for the New Workplace" (LINA) act as strategic support for the operational management team.

The strategic reference group gives valuable input to external monitoring and supports strategic long-term development of the research environment. The strategic reference group meets twice a year and consists of representatives from the industry and from the public sector, and the university vice-chancellor.

Quality assurance

Primus applies for funding from several research funding bodies. The proportion of funding from KK should not exceed 50 % of the entire environment's funding. The long-term plan is to make all applications, including open calls, pass through an internal quality assurance process before submitting, but so far only KK-funded project applications are covered.

In November each year, the university submits to the KK-foundation a work plan for the coming year, including quality assured “actions”. Those can be research projects, educational projects or

recruitments such as guest professors. The university is responsible for the quality assurance of all actions needing funding from KK. The quality assurance process starts already in the autumn more than one year in advance. In August and in October, there are two workshops for bottom-up discussions of suggestions and project proposals among the core area researchers and teachers. The purpose is to find ideas for joint projects. At the workshop in October, the discussion and prioritizing of research project suggestions is supplemented by external review and the university's management priorities (top-down). The researchers continue to develop selected project proposals during the autumn, in cooperation with external parties and prioritized preliminary projects are started.

In January, there is a new workshop for discussing the research project proposals in relation to each other and in relation to existing research, development and education. In February, the steering group discuss these research proposals in relation to the goals and strategies of the university and Primus. In March, there is a presentation and discussion in the strategic reference group, in relation to external, industrial needs. At the end of March, the steering committee selects which proposals to develop into complete proposals.

The action proposals are further developed and internally reviewed during April and May. Simultaneously, the university's faculty board selects external scientific reviewers and co-production reviewers for each action proposal, on suggestion from the project leader. In June, the revised proposals are presented to the steering group, which decides which projects will go on external review in June and July.

In mid-August, the project leaders receive the external review protocol with the reviewers' assessments, and can make improvements of the application (a change-log must written). A preparation group consisting of two internal and two external scientists go through all the external assessment reports and the change-logs, and prioritize the action proposals per type of project. The chairperson presents the proposal for the steering group in September. The steering group can send strategically important proposals back to the project leader, for further improvements. On the recommendations of the steering group, the vice-chancellor decides in the end of October which project that will be included and motivated in Primus' work plan for the coming year. The KK-Foundation gets the work plan in the beginning of November and finally decides to approve it in December. The included projects normally start in January.

Facilities

Since 2008, the Production Technology Centre (PTC) houses the research in production processes and production systems. This site, approximately 5000 m2, includes offices for all researchers and teachers connected to the environment and a 2500 m2 workshop housing advanced production-related equipment with industrial standards, used to carry out research and postgraduate education in the area of production technology. In addition, large parts of the master's programs and some parts of the undergraduate education, the mechanical and electrical power engineering programs, have courses located at PTC. In order to be at the forefront of the research, equipment is in line with the rapid technological development. It is therefore a continuous task to find different ways to fund new equipment. At the PTC, therefore, a lot of advanced equipment is used in joint research projects with the industry, which results in cost sharing. Ownership conditions vary between the equipment, with written agreements regarding usage for each specific equipment. The infrastructure is organized in a number of laboratories, each maintained and managed by appointed responsible research engineers. These are also active in parts of the education (mainly master theses and laboratory sessions) posted at PTC.

In broad terms, the researchers in Primus have access to a wide range of software for simulation of production processes but also for control, data management/storage, modeling, etc. The

environment has several computational clusters and in general, a majority of software used in industrial contexts in industry are available for researchers in the environment. In some cases, there are also software a more open in nature and therefore a good choice for some types of research problems.

For the welding research, four robotized welding cells are available. For laser based welding and AM processes, there are two cells that both use a common fiber laser source (IPG), shared between University West and GKN. The cells offer laser welding experiments, laser welding based AM with wire as feed stock and laser welding AM with powder as feed stock. In the third cell, research is linked to robotized arc welding and brazing. In the fourth cell, research is carried out on robotized FSW, friction stir welding. Three of the cells use conventional ABB industrial robots while the fourth, mainly used for AM with additive powder, has a smaller gantry robot. In cooperation with GKN, researchers utilizes a specific laser machine that includes laser welding, laser cutting and powder based AM.

The thermal spray lab has several processes available in a common robot-controlled spray booth: APS Plasma Spray, Flame Spray, HVAF, HVOF, Axial III High Power APS and Axial III SPS Plasma Spray. There are several measurement systems for measuring process properties.

For machining, there are two CNC machines at the PTC: a three-axes multifunction machine from DMG MORI (2015) and an older two-axes lathe, Storebro. The arena can also rent hours in several brand new CNC milling machines, which GKN, in collaboration with Innovatum, has placed at PTC. These are the same type of machines as used in GKN's production and have three or more axes. For process measurement, there are several cutting force sensors and measuring instruments for measuring temperature via a two-color pyrometer.

The automation lab consists of several cells. One part of the lab includes five robot cells intended for education and research. Each cell is equipped with ABB industrial robot systems, upgraded with the latest version of communication interface, safety system and control systems. It also includes external axes, power sensors, vision systems, etc. installed on multiple robots. The robots have a common material handling system, a gantry robot and all units in the cells communicate with each other in several ways. All equipment is connected to a safety system that meets the latest industry standard. There is also an advanced automation cell for a new concept of "plug and produce" supporting IoT, OPC-UA, AI, and flexible security.

The additive manufacturing lab has a dedicated powder bed AM equipment, an electron beam based powder bed machine (EBM, ARCAM A2X) is installed. In addition, there is a powder handling and cleaning of finished components equipment. In collaboration with RISE IVF (formerly SWEREA), there is also a laser-based powder-bed machine (SLM) that is being used in several projects. This machine is located at RISE/IVF in Mölndal.

As the research in production technology has a strong link to how the manufacturing process affects the metallic material, there is a lab with basic equipment for making material characterization. This includes cutting machines, injection equipment, grinding and polishing equipment, drawer cabinets for etching metallographic samples, microscopes with associated analysis software, hardness testers, etc. More advanced equipment for characterization and property testing includes several SEM (scanning electron microscopes) with analysis equipment and several laboratory ovens. Furthermore, a Gleeble equipment is used for physical simulation of manufacturing processes, a fatigue rig, a tensile test machine, a vaerestraint equipment (for analysis of welding strength), etc.

Recently, work-integrated learning and production engineering researchers have started to use VR and AR technology for analysis and visualization. This technology is a promising technique for knowledge transfer and learning, not least in industrial applications. By 2018, University West has granted special funds to build a university common environment, aimed at creating research infrastructure, focusing on learning aspects in this area. This also becomes an area and a lab resource common to all core areas within Primus, creating a platform for new collaborations. Within production systems, the technology has been frequently used to visualize future factory environments. The core area I-AIL has recruited a postdoc, who will become an important resource enhancement and to develop a joint research infrastructure between Production Systems and I-AIL.

External funding

The only way to develop a strong research environment in a small university, like University West, is to lean on external funding. The DAMVAD report shows that research funding in production processes and production systems has doubled between 2012 and 2017. The table below shows the funding for all research and undergraduate projects, including overhead (OH) costs.

Table 1. Growth of funding

[MSEK]	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
External funding	28,5	33,0	35,8	33,5	40,3	46,9
University in-kind (egeninsats)	4,8	7,2	4,6	3,9	7,8	7,7
University co-funding (OH-cover)	3,2	3,8	3,8	3,0	5,5	5,3

In summary, the development over the six last years has been positive, 5-10 % growth per year. The distribution between the KK Foundation and other financiers has been varied, but the KK Foundation has had a stable share of 40-50 % of all external financing for the past three years. Other important funding bodies have been Vinnova, EU (mainly regional funding) and Västra Götalandsregionen (VGR). In the last years the portion of the externa funding dedicated for development of master programs/courses and competence development has grown and constitutes approximately 20% In 2017, the KK Foundation accounted for 48 % of external funding for Primus as a whole. The total amount funding was 56.6 MSEK, out of which 46.9 was external.

Human resources

Staff resources are essential for a research environment. PTW has monitored and planned staff resources annually since 2012. The main function of the recruitment plans and promoting plans has been to secure the supervisor resources for PhD education. The plans also take advanced level education and natural retirements into consideration. Supervisor resources in all research areas has increased and strengthened over recent years, as the university has recruited several professors both internationally and from industry. Many supervisors have long experience, supervising and co-supervising at other universities before University West received examination rights for third cycle education. The interdisciplinary collegial competencies of the environment is a strength in research and in supervision of doctoral students. For example, experts in welding processes can support those who work with automation of these processes. The university also has competence in related subjects such as mathematics and informatics, which are utilized in some cases. Internal promotion programs to docent or professor, supervisor education and research leader programs are regularly organized to improve the existing staff competence.

Recommendations

The facilities at PTC are excellent, according to the expert panel assessment and the evaluation from DAMVAD Analytics. There seems to be good access to lab equipment and smooth co-operation between academy and industry. When needed, researchers in Primus have access to special equipment through co-operation with Chalmers. The expert panel's interviews with PhD students at the onsite visit confirm that using the equipment at Chalmers works well. The close co-operation with industry seems to provide access also to industrial labs. The expert panel notes that such access is a common in-kind contribution from industry in joint projects.

The staff profile seems to be relatively traditional. The expert panel notes that there are no positions as post-doc or adjunct professors. The gender balance is a challenge, like for most environments in these scientific fields. Compared to similar research environments, the present situation with more than 20 percent women in the permanent research staff puts the group in a relatively good position, though. In relation to the national government goal of at least 40 percent of the underrepresented sex, the current situation is insufficient. As for the temporary scientific staff, the share is below 20 percent, which is cumbersome as they are the coming generation. Apart from the gender balance, for the other ingredients of research environment and infrastructure are good.
The expert panel notes that Primus is a multidisciplinary research environment, however not yet interdisciplinary. From the provided documentation, the degree of cross-disciplinary integration and co-operation in the environment seems to be very limited.

The research environment is still under construction, but some core areas are already well established and internationally successful. Still, it is a relatively small research environment. Growth is necessary to create more impact in industry. The expert panel argues that if this can be achieved while retaining the culture of co-production with industry, it would provide a good situation for expanding the market. The reliance on a small group of key people to initiate new projects with industry probably is among the strongest limitation to achieve growth. Therefore, it is one of the major challenges for Primus.

The organisation of project initiation, planning and quality assurance is satisfactory, assuring a professional management of Primus. The expert panel underlines the importance of strong leadership. This is essential for Primus to reach its long-term vision. Vice-chancellor, heads of department, core area leaders and the steering group must speak the same language. At the onsite visit, the expert panel got a mixed impression. The leadership did not seem coherent. The further down the hierarchy, the more watered down the message and idea of integrating the different research areas in Primus, and the more weight put on individual research merit. Leadership must exercise control all the way down by encouraging researchers to engage in interdisciplinary integration between technology and I-WIL. Currently, this does not always appear to be the case.

The panel's impression is that the steering group has more of a coordinating role than a steering role. The group does not control budgets to implement its own strategic agenda. This means that the success of the Primus strategic initiatives is strongly relying on the departments rallying behind them with management attention and department resources. This situation needs to be closely monitored by top management, to ensure that integrative strategies are implemented. Allocating some resources for integrative projects and building new initiatives directly to the steering committee should be considered.

The main strength of Primus in terms of infrastructure is the access to well-equipped industrial labs and networks. PTC gives the researchers a unique opportunity to test and validate their models and hypotheses in collaboration with industry. Strong industrial relations provide for access to other equipment. Another strength is the organizational structure of Primus, which seems very appropriate. There is a structured method for identifying new projects. As for funding, the

percentage of external funding is 78 percent, which is good but may lead to problems in terms of adequate internal co-financing of projects. Overall funding is gradually increasing, pointing in a positive direction.

The weaknesses of the infrastructure lie in size of the research environment. Primus is a small environment with respect to staff, only 51 full-time equivalents (FTE) at start-up (which is small also compared to the other KK-environments). Some research areas in Primus, e.g. I-WIL, are very small. There are only 6.2 FTE professors all in all, and no more than 1.1 FTE professor in Production Systems (see Self-evaluation, table B1.1.1, p. 34). The environment appears to be highly dependent on key personnel with key contacts in industry and other networks. There are no post-docs or adjunct professors, however some guest professors. The academic staff seem to have limited capacity to initiate new industrial cooperation. In addition, Primus is relatively unknown as a research environment, which may hamper the recruitment of researchers and PhD-students.

The heavy domination of funding from the KK-foundation is also a risk for Primus. There is very little funding from the national research councils. I-WIL presents no track record of funding. In comparison to other KK-environments, there is little funding from partner companies in-cash, as opposed to in-kind. As noted in the DAMVAD report, there is a somewhat unclear role distribution within Primus. The expert panel confirms this during the onsite visit. There are no external participants in the steering group, and the steering group seems to have very few tools to influence the focus of the research groups.

The expert panel recommends priority to build up the I-WIL environment. They emphasize its unique profile for Primus, and sees that the results of I-WIL research should have significant impact on the companies' adaptation to new technology. Primus also needs to work on recruiting well-qualified personnel at all levels and particularly more key persons in order to reduce the vulnerability. The recommendation is to prioritize the increase of post-doc and adjunct professor positions as well as PhD students. The recruitment of women researchers should be a strategic task for the coming years. The Primus projects are mainly devoted to technical solutions in research. It could be fruitful to explore economic issues connected to the current technological transformation. An idea would be to seek contact with researchers within Industrial Economy, if needed through networking with other universities or recruiting guest professors in this field.

5.5 Research networks and collaboration

PTW has well-established partnerships with internationally leading and prominent institutions. An expanded and deepened cooperation with internationally leading researchers is as an important means of environmental development (for research as well as for PhD education). For example, researchers go to partner institutions in the network in order to utilize specific equipment, or for doing joint research studies.

Some examples of such network institutions are Forschnungszentrum Jülich, Manchester University, Fraunhofer Dresden, University of British Columbia, Pennsylvania State, Federal University of Uberlandia, Strathclyde University and Politecnico di Bari. Ongoing projects include for example a professor from Uberlandia in Brazil and a professor from Bari in Italy. Both participate in several long-term projects and regularly live in Trollhättan, currently 50 percent and 20 percent respectively. They actively participate in both research and supervision of postgraduate students.

Table B1.4.1, Self-evaluation p. 37 shows current international activity 2016-2017, indicating a good starting level for the environment. The activities include five plenary or keynote talk at international conferences, four members of international scientific councils, five chairs of program committee (international conferences) and nine members of program committees at international conferences.

An important part is to let the graduate students utilize and enrich the international community. About half of the graduate students in production technology have so far participated in such exchanges. So far, the following institutions have been visited by one or more people: TWI (Cambridge and Yorkshire, England); CENIM (Madrid, Spain); INNOVNANO (Coimbra, Portugal); University of Manchester (England); Forschungszentrum Jülich (Germany); University of British Columbia (Canada); TWI Technology Centre (Yorkshire, England); University of Warwick (England); University of Manitoba (Canada); University of Kentucky, Lexington (USA); University of Nottingham (England).

On average, the expert panel assess that Primus' research networks and collaborations are good, and for some parts of the environment even very good or excellent. Since I-WIL is a new area, it is impossible to judge the extent, quality or intensity of its international cooperation yet. There is a good number of guest professors from other universities. The expert panel points out the international co-operation on the technology side appears to be very good, although there is a bias towards the Western hemisphere. At the on-site visit, the panel understood that co-operation also with universities in India and China is being started.

The high degree of international co-authorship in publication - 15 universities and several research institutes - indicates good integration of the international network with Primus research projects. For a research environment of Primus' size, this is a good track record. Of all publications, 40 percent are co-authored with researchers from other countries, which is higher than average for the other KK-environments. The number of authors per publication has gradually increased during the period and is now up to 4.5. The same applies to the increasing number of average countries per publication (1.6), which indicates a positive development regarding the academic networks.

A dilemma is that much of the research networks are based on individual contacts and collaborations, and with a noticeable concentration to GKN and Chalmers. Out of 211 co-authored articles between 2012 and 2017, 80 is with companies and 131 with other universities or research institutes. GKN and Chalmers stand for 26 percent of all co-authored publications during the period. Of co-authored articles with industry, GKN stands for 32 percent (DAMVAD, Tabell A.1, p. 38). This is something that the environment need to address, since it makes Primus very vulnerable to loss of key competence or a loss of key partners.

Among the weaknesses, the expert panel notes that participation in the scientific community between 2016 and 2017 is still low to normal compared to the total number and FTE permanent and temporary staff (including activities in Self-evaluation, table B1.4.1 p. 37-38). Networks are based more on bilateral contacts on the researcher level than on contacts between Primus as an environment and other institutions. Networks do not seem to benefit Primus as a whole.

Recommendations

When it comes to research networks and collaboration, the expert panel has few recommendations, apart from inviting PhD students from other universities to the labs or developing the international cooperation in I-WIL, which seems to be weaker than in the production technology areas. They also recommend stronger participation in EU-programs. Primus-researchers should also lead such projects. Another recommendation is to ensure that the PhD students can utilize and enrich the international co-operations and research community.

5.6 Co-production and external non-academic co-operation

On request from University West, DAMVAD Analytics did a review of Primus by the autumn 2018. The report analyses the implementation, significance and effects of co-production within research, education and competence development efforts; for the university as well as for the industry. The studied period was 2011-2017, which means that only production processes and production systems are included.

The collaboration between the university and industry has worked very well. There has been close cooperation with a few, previously established industry contacts. There is a mutual trust between industry and university, built up over time and beneficial for the collaboration. The industry partners state that they are generally very pleased with the collaboration with University West. They think that the university is solution oriented and that communication is easy. According to the industry partners, the cooperation projects have resulted in deeper collaborations with the university and increased access to materials and competence. They also find that the academic standard of University West is high, which is confirmed in the bibliometric analysis. The research within projects associated with Primus is of a high academic level. Research in Primus is largely co-authored and jointly published with both industry partners and researchers associated with international institutions: four out of ten publications. In terms of publications, DAMVAD notes collaboration is concentrated to relatively few core partners, including GKN and Chalmers University of Technology.

Based on the DAMVAD report, the expert panel concludes that non-academic co-production and co-operation in Primus is good. In relation to production processes and production systems, it is even very good, whereas there is not enough basis for commenting on I-WIL.

Primus seems to have well-developed co-operation with non-academic partners and society, both nationally and internationally. The quantitative data in the DAMVAD report indicate close to a hundred partners from industry. Around 10 of them are co-authors on academic publications, and several of those are foreign companies. This co-production vouches for industrial relevance of the research output, confirmed by the good grading of the co-operation from the companies in the DAMVAD survey. The co-operation has provided the companies with material and competence. The expert panel notes the absence of patent activity, somewhat unexpected for a technological research environment.

The expert panel notes that the PhD students in production technology have good industrial contacts. However, in some cases it seems that the companies use the students to do testing work for them, not really related to research problems. The supervisors should be more attentive to this problem, as it takes time from the PhD education and the students are in a position making it hard to turn down requests from the companies.

Close integration with industry can have both positive and negative aspects. Outside the university sector, GKN is a dominant Primus co-operation partner. This has a positive impact on the conditions for and the quality of the research in Primus. However, the strong dependence on one large, international company is problematic. Primus has much to lose should GKN for some reason choose to terminate the co-operation. To reduce vulnerability, it is important to increase co-operation and co-productions with other companies. The link between I-WIL and the industry is markedly weaker, likely due to this part of Primus being new. By their own statement, the research on WIL has so far largely applied to public organizations. At this stage of the environment, the expert panel cannot evaluate contribution from any non-academic partners.

Primus' main strengths lie in a vast industrial network and extensive co-production of research. The industrial partners are relevant, they are committed and they contribute to high research quality and

productivity. The potential for further co-production seems to be good. Another strength is that the research clearly relates to industrial problems, which is stimulating for the researchers. Co-publishing is a good way to ensure the integration of research results in an industrial context.

On the weak side is the concentration of knowledge of industry collaboration and industry networks to a few people in the Primus environment. Co-publication is concentrated to a few companies, dominated by GKN. The link between I-WIL and industry is weak, and the expert panel calls for some mention on how Primus will make research results accessible to a non-technical audience. It is also not clear how researchers ensure that problems given by industry have a long-term focus. The expert group points out the there are few publications and little co-operation in the interface between the different parts of Primus, which seems problematic in relation to the overall vision of the environment.

Recommendations

To achieve the vision, Primus need to increase co-operation that specifically aims to strengthen Primus as whole, not just the separate areas. As mentioned, Primus should have a strategy for co-publishing with companies. In relation to the industry, Primus should strive to take the initiative in contacts with companies, to be proactive rather than just reactive in response to industrial demands and interests.

To enhance co-operation and establish links, master students and PhD candidates should make presentations to the companies. It is important to find the balance between longer, more basic, research projects, and shorter, industrially initiated, projects to ensure an international impact on the scientific arena. The expert group also thinks that a closer integration of I-WIL and production technology can serve as a door opener to promote I-WIL´s industrial contacts.

The expert panel notes that the funding in cash from the industry is surprisingly low for a KK-environment of Primus's size. The industry seems to receive more than they contribute. Primus should investigate if the industry would be willing to contribute more in cash. That would enable the desirable growth of the environment by recruiting more PhD students.

5.7 Impact

As Primus started only one year ago, it is too early to evaluate any real impact of its research in society. The expert panel finds that the work for sustainability ought to have impact on the society, but the self-evaluation report does not explain how. The vision includes industrial sustainable development, but the issue is not clearly addressed in strategies and the self-evaluation. The research in Primus has a national reach, international in some core areas. It is clearly of significance to industry in the region and to society, as confirmed in the DAMVAD-report. So far, one of the most obvious benefits to society seems to be well-educated students, and a valuable contact net between the industry and the university.

The expert panel notes that collaboration with industry has resulted in deepened collaboration, as well as materials and competence for the companies. The citation rate for research is higher than corresponding articles produced by researchers in the rest of Sweden, the Nordic countries and the OECD. Thus, the research should have a high impact. The industrial relevance seems to be high, according to the answers from industrial partners in the DAMVAD report. Scientific publishing in Primus has brought many new findings to the academic world and thus also to the benefit of society in general.

The unclear definition of I-WIL seems to be a problem. It stands out as an important and unique area, but the concept is not intuitively easy to understand. The university needs to clarify impact on industry and society in relation to I-WIL.

The impact increases if research results from Primus are communicated to companies outside the ordinary collaboration partners.

Recommendations

Primus seems to be on the right track, and the expert panel recommends to keep going in the started direction. The environment should put additional efforts into making the work in Primus more widely known.

One of the greatest benefits to society is the knowledge transfer from university to industry through qualified students. The integration between research and teaching is a very good tool for making an impact. Therefore, Primus should keep strengthening the link between master programs, PhD program and the research groups/industry.

The management of Primus should make greater efforts to get the I-WIL area more integrated with the other areas, and to make companies see the need and state it in a clear way. For this reason, the expert panel recommends Primus to include industry senior management and HR in the strategic reference group, where they can promote the importance of I-WIL.

5.8 Strategies and plans for development and renewal

The ten-year goal of Primus is to become a nationally leading and internationally recognized research environment by developing core areas and providing a significant contribution to skills in the cross-cutting themes of sustainability, innovation and digitization including automation and competence development. The strategy identifies research projects to be prioritized in each of the cutting themes.

The expert panel concludes that the strategies and plans for future development and renewal are good in several parts. The strategic starting points for Primus seem reasonable and the ten-year vision represents a realistic goal for the entire KK-environment. The five goals (2027) are ambitious and reasonable, and the feasibility appears to be good.

The scientific content seems relevant to the industry, even though the panel points out that their understanding of the needs of the industry partners is not detailed enough to make a fair assessment. The research of Primus should however not be limited to the immediate needs communicated from industry. It should also aim to be in front of the immediate industrial needs to be able to assist industry in creating new state-of-the-art industrial applications of new technology.

Some of the research groups present a strategy for the future, including an increase in the number of PhD students. According to the self-evaluation there are 13 assistant professors attached to Primus. The expert panel calls for career plans for this staff category. They also return to the problem that Primus as a KK-environment of this size has only a limited number of PhD students, which was discussed during the onsite visit.

With the present dependency of the KK-foundation for financing, it is important to develop a good strategy to attract financing for other sources as well. As the environment succeeds in building enhanced senior capacity, in time it should be able to develop a balanced portfolio including more postdoc and doctoral education, which is the normal model for strong international research groups.

The expert panel notes that industry partners to Primus give financing in kind, but surprisingly little financing in cash. With more in cash-funding Primus would be able to have more PhD students, which would be very beneficial for the research environment. This is of interest also for the industry, because there will be more qualified researchers to recruit in time. According to the numbers given in the self-evaluation, there are 1.5 PhD students per senior faculty staff. The expert panel argues that at is not an exceptionally high rate. Each professor or docent should normally be able to supervise 3-4 PhD students, so the argument for not taking on more PhD students is weak.

The SWOT analyses in the self-evaluation report are insightful, but the panel remarks that the future plans are only about the separate research areas, not about the environment as an integrated whole. The three-year plan should be more clearly connected to the SWOT-analysis, as should the operational plan. The main problem with the strategy and plans for future development and renewal is that they fail to address the issue of integration between the core research areas. There is a plan and a strategy for each of them, but none for the whole. The expert panel stresses that it is the responsibility of the university and the management to decide whether Primus shall be an integrated arena or different sub areas with little interaction. The plans need to address the problem of limited cooperation in a clear way. The strategy for external funding must be clearer, as must the strategy for equality. It is not clear how the environment will attract more female and foreign researchers.

Recommendations

The recommendations of the expert panel include priority to develop the “softer” side of production systems, integrating business model development, innovation and industrial learning with the new technologies. It seems particularly important to enable industry to create value from the ongoing digitalisation. Emphasis should also be on development of education programs at the advanced level, and integration of research and education. This constitutes an important channel of dissemination of new knowledge and will make I-WIL more integrated in Primus.

Primus should invest more in post-doc and PhD students. Career plans for junior faculty with a doctorate should be developed and implemented, in order to enhance the number of senior faculty. There should also be more emphasis on supporting junior faculty is important, not least by exposing them to international experiences.

If it is not possible to get the industry to give more financing in-kind, permitting the admission of more PHD students, Primus should try to influence the companies to support industrial PhD-positions in their own organization. A further way to strengthen synergies is to increase the number of adjunct professors.

6 Self-reflection and ideas for the coming three year plan

The university agrees with most of the views of the expert panel. We need to develop our strategies further to get Primus to grow as a cohesive environment, by promoting more cooperation between the core areas. At a few points, though, we disagree with the expert panel. In the following sections, we comment each of the expert panel's recommendations for improvement, broken down by headings and supplemented by our own comments, priorities and plans for improvement actions.

Table 2. Recommendations, comments and priorities

	EXPERT RECOMMENDATION	PRIMUS COMMENT	PRIORITY
A	*SCIENTIFIC QUALITY*		
A1	Develop a clear publication strategy for the Primus environment as a whole, not just the separate core areas.	We will develop a publication strategy for the whole environment, based on the strategies for the different core areas. We need to list prioritised journals and appropriate conferences for the collaboration areas and target publication volumes (number of publication and co-authorships) for coming years.	*1-2 years*
B	*PRODUCTIVITY*		
B1	Reduce the vulnerability of research quality by adopting more PhD students and allowing junior researchers to increase their participation in research projects. Senior researchers should spend more time on supervising PhD students.	We see that the panel has an important point regarding future competence in the environment. In the short term, however, we see the build-up of senior researchers as crucial. Despite the numerical relationship between supervisors and doctoral students, the reality looks different. There are not enough qualified supervisors in all sub-areas where we want Primus to expand. We do agree that it is important to change priorities in the slightly longer term.	*3-5 years*
C	*MANAGEMENT*		
C1	Develop clear strategies for the application process, with more top down control.	We agree with the expert panel, although we want to keep the overall bottom-up working mode in Primus, to keep engagement. We will prioritize more management involvement in the development of the projects in the environment.	*1-2 years*
C2	Develop a clear strategy for better integration between the core areas of Primus.	The integration clearly needs to be improved. However, projects connected to a single core area will play a significant part also in future. The number of integrated projects will grow over time, the goal being up to 50 percent of total project volume (funding) after 10 years.	*3-10 years*

C3	Ensure that the steering group or reference group has representatives from corporate HR departments or senior management, for better understanding and advocacy of the I-WIL perspective.	We already have representatives with HR and competence development responsibilities development in the strategic reference group, but we will keep the perspective in mind when changes in participation occur. As for the steering group, we have no plans for a change. The reason why we prefer to keep the steering group internal is that external persons have little interest in the actual work of the steering group. They have more to contribute in the strategic reference group.	*1-10 years*
C4	Ensure that everyone in the management communicates around Primus in a uniform manner, and that it reaches all the way to the researchers and doctoral students in the environment.	We agree that this is very important, and will prioritise this in a short-term perspective.	*1-2 years*
C5	Review the composition and mandate of the steering committee. The steering group should be able to control and influence the direction of research in the environment. Give the steering committee some funds to allocate directly for integrative projects and new initiatives.	We understand the panel's view. The mandate of the steering group is prioritize and sort out projects that do not appear to contribute to the fulfilment of Primus' vision. This control often comes early in the quality assurance process. So far, the steering group has turned down few project proposals, which is because they have been of good quality as assessed by the external auditors. We do not really agree with the expert group's criticism that the steering group does not exercise control. However, we take into account that the steering group can in future increase the clarity in which areas we want projects, and steer through "calls".	*1-2*
D	*INFRASTRUCTURE*		
D1	Develop a clear strategy for recruitment and promotion of researchers. Consider more adjunct professors, more post-doc employment, career plans for junior researchers.	This is an on-going work that will be improved and better controlled over the years. High priority!	*1-10 years*
D2	Ensure that participation in interdisciplinary projects and in educational projects is not detrimental for promotion to associate professor and professor.	We agree. The university has guidelines for applying to become associate professor, which could point out that this kind of project should be as meritorious as pure research and in that way guide the external assessments.	*1-3 years*
D3	Develop a clear strategy for equal gender distribution.	This is linked to the overall university equality policy. Primus needs its own indicators. We intend to develop a strategy in the coming year.	*1-3 years*
D4	Develop a clear strategy for PhD education linked to Primus and the recruitment of doctoral students.	This work is initiated and has started with identifying supervisor resources and recruitment needs. Prioritize PhD project integrating core areas in Primus	*1-3 years*

D5	Develop a clear strategy for master education.	This work is initiated and has started with developing a plan for future masters educations, market analyses, (international demand) and how the to strengthen the link between research and undergraduate education through new masters programs and to identify recruitment needs in order to build complete academic environments.	*1-3 years*
D6	Reduce the dependence on funding from the KK-foundation.	The goal is not to exceed 50 percent funding from KK in relation to total funding (on average). The increase of funding volumes from other bodies, including EU, is highly prioritized already. A strategy is a work in progress.	*3-10 years*
D7	Increase funding in-cash from the companies with regard to doctoral students.	Perhaps this can be possible in the future, but presently there is no tradition in manufacturing industry for cash funding for PhD students. It needs to be done in a national context, and cannot be a local university issue. The university have no resources for traditional fund-raising. We fail to see how companies can be induced to finance PhD-students in cash, as there are no guarantee that they will profit from the resulting competence. We will, however, check all further possibilities for in-kind-finance.	*No priority*
E	*RESEARCH NETWORKS AND ACADEMIC COLLABORATION*		
E1	Develop a clear strategy for research collaboration and academic networking in relation to Primus as a cohesive environment.	*The composition of production technology and WIL is likely unique and it is hard to find a similar environment. Still, this is very important. We should strive to identify universities and research groups that are partially similar to us when it comes to education and research (linked to Primus). We will also strive to make Primus visible in various context, more than the individual researchers or research teams.*	*3-10 years*
E2	Reduce the vulnerability of networking by initiating collaborations with more universities both within and outside the country.	*Connected to and included in comment E1.*	*3-10 years*
E3	Reduce bias towards Western research by building up more collaborations with Eastern universities.	*On-going, and will be further prioritized in the long term, connected to E1 & E2.*	*3-10 years*
E4	Reduce dependence on key personnel by building up collaborations at institutional level rather than individual level.	*Collaborations will always be dependent on staff members' own activity and relations to counterparts. GIO may act as support. See comments E1.*	*1-5 years*
E5	Invite doctoral students from other universities, even abroad, to use the equipment at PTC.	*Is already ongoing, can be improved.*	*No priority*

E6	Increase participation in EU programs for research, and strive to take project leader roles.	*Important, in the long term we need to be more visible in the European arena. Networking is of crucial importance to get the right contacts. Coordinating EU-projects is a challenge, we must see where the possibilities are great in relation to resources. See comments for financing strategy.*	*3-5 years*
F	*CO-PRODUCTION WITH INDUSTRY*		
F1	Reduce the vulnerability of co-production by collaborating with more companies.	*On-going.*	*1-10 years*
F2	Be more proactive in contacts with companies. Show what they can get out of the collaboration instead of just waiting for their demand, especially true for I-WIL.	*Must be prioritized in short term.*	*1-5 years*
F3	Increase knowledge about Primus among companies other than those most closely involved, for example by strengthening the connection between doctoral education, the master's program and the research groups/industry.	*On-going.*	*1-5 years*
G	*IMPACT*		
G1	Prioritize growth of the environment in order to have a greater impact on the industry and society. Prioritise to increase the number of students at the master's level and the number of PhD students.	*This needs to be balanced due to internal resources, recruitment, and possible in-kind funding available from industry. As the environment is now expanding significantly (2019- 2020), priority need to be mid-, long-term. New distance education for master's programs in robotics and automation has had a significant increase of students (tripled).*	*6-10 years*
H	*DEVELOPMENT AND RENEWAL*		
H1	Prioritise the construction of the I-WIL area.	*Agree. Several recruitments are on-going.*	*1-5 years*
H2	Examine the possibilities of broadening the perspectives in research from production technology to industrial economics, perhaps through collaboration with other universities.	*There may be other areas more interesting to develop. We will look into that on a medium-term priority, possible areas being logistics and work science.*	*6-10 years*
H3	Link the three-year development plan to the SWOT analysis in the self-evaluation.	*As the environment has developed significantly during 2018-2019, we will update the SWOT and after this develop the next 3-year plan.*	*1-2 years*

7 Appendices

1. Self-evaluation report: “Part A_and_B Självvärdering Primus”
2. External co-production report: ”Part C_ DAMVAD analys_Samproduktion_Primus”
3. Evaluation template to expert panel ARC18 HV
4. Expert panel report ARC18 HV