Fachhochschule Nordwestschweiz
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M2 Final Report

Systemic evaluation of the AM-TTC-Alliance (and its overlaps with CSEM and inspire)

On behalf of the Swiss Science Council, Federal Department of Economic Affairs, Education and Research

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Table of contents

Short version

Introduction

The Advanced Manufacturing Technology Transfer Centers (AM-TTC) initiative has been designed to promote innovation and to speed up knowledge transfer in the field of Advanced Manufacturing through operating a network and alliance of centers, which offer access to relevant technology transfer infrastructures. Five new centers (m4m, ANAXAM, hipC, M2C, and M4IVD) applied for federal funding for 2021 to 2024 as research institutions of national importance under Art. 15 RIPA (Federal Act on the Promotion of Research and Innovation).

This document has been complied under the mandate of the Swiss Science Council (SSC). It contains an assessment of these five applications drawing on the application documents, a survey of the five new centers (plus the established centers inspire and CSEM), interviews with experts in the field of AM, and last but not least academic and specialist literatures on AM, technological innovation systems (TIS), and infrastructure. It provides information on the services, which the new centers intend to provide, the organisations involved in providing the services, the target groups and potential user bases of these services in Swiss industry, the expected impacts, and the coordination with existing other suppliers of similar services (above all CSEM and inspire).

Theoretical framework

The assessment draws on the literature on 1) technological innovation systems (TIS) and 2) technological infrastructure.

1) Technological innovation systems (TIS). The TIS concept has been used to describe and analyse the functioning of *"socio-technical systems focused on the development, diffusion and use of a particular technology (in terms of knowledge, product or both)"* (Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008). TIS can be defined through one or several products/artefacts or knowledge fields at different geographical levels. They consist of four types of structural components (Bergek et al., 2008; Wieczorek & Hekkert, 2012): (1) actors, (2) institutions, (3) infrastructure and (4) interactions. These components determine how well a TIS functions. Each of the components can be subject to problems, i.e. *"factors that negatively influence the direction and speed of innovation processes and hinder the development and functioning of innovation systems"* (Wieczorek & Hekkert, 2012, p. 79). First, problems of absence, i.e. missing actors, institutions, infrastructure or interactions, and second problems of quality of any of the four structural components may limit the performance of a TIS (Wieczorek & Hekkert, 2012).

The new AM-TTC initiative and centers can be understood as an initiative that aims at strengthening different TIS in the wider domain of advanced manufacturing, with a particular focus on the solution of infrastructure-related problems.

2) Technological infrastructure. Justman and Teubal (1995) suggested a distinction between conventional infrastructure, basic technological infrastructure and advanced technological infrastructure. Whereas conventional infrastructure meets well-defined needs in a largely standardised way, basic and advanced technological infrastructures demand more efforts from providers and customers to fulfil their roles. Basic (or sectoral) technological infrastructure provides routine services, such as testing and analytics, design, and/or information to companies in one or a few industries or sectors of the economy. It involves only little R&D, if any and companies might need help with the articulation of their needs ("market building") by the service provider. In contrast, advanced technological infrastructure is more specific and useful only to a small constituency delimited in terms of a function (e.g. superconductivity, optical coating) rather than an industry. The provision of advanced technological infrastructure entails a strong R&D component, as the services and required capabilities do not yet exist. Customers, e.g. high-tech firms, and service providers need to engage in a set of joint and coordinated activities to co-create the infrastructure. Whereas public policy can support the market building for basic technological infrastructure, it overall has a more passive role in advanced technological infrastructure and mainly facilitates the (private) efforts of setting up the infrastructure and capability creation.

Drawing on this line of work on technological innovation systems (TIS) and technological infrastructure we selected the criteria shown in the table to describe and compare the AM-TTC proposals, evaluate their role in one or several TIS, and discuss their degree of development towards infrastructures for advanced manufacturing in Switzerland.

Table. Criteria for assessing the AM-TTC centres

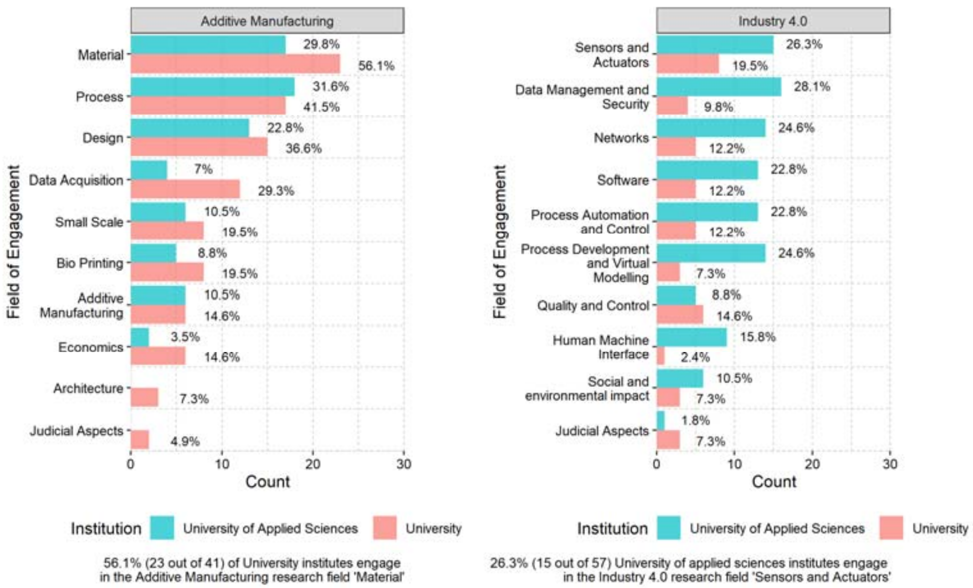
Measure	Explanation
General characteristics of the centers	
Partner structure	Participation of partners by type (research, industry, government, NPO, and other organizations) and geography
Revenue model	(Expected) revenues under Art. 15 RIPA, from public research funding, and from other sources and revenue generating activities
Governance	Legal form, owners and governing bodies of the centers
TIS definition	Delimitation of the TIS to be served by the new center and its technological infrastructure
Supply-side aspects of the centers	
Missions and service portfolio	Missions and planned infrastructure
Scope	Does the center mainly serve a geographical catchment area, a sector or industry or a (more narrow) function within one or few industries?
Activities supported by the infrastructure	Activity focus of the infrastructure distinguishing between production, diffusion of technology, innovation
Development of supply	Planned measures to broaden service supply
Complement/substitute services	Availability of complementary or substitutive services
Dependency on public funding	Possible service level without public funding under Art. 15 RIPA
Implementation risks	Perceived implementation risks and risk management plans
Demand-side aspects of the centers	
Customer-base	Size, structure and dynamics of the customer base
Embeddedness in user communities	Degree of embeddedness in user communities
Definition of need	Definition of need for the infrastructure on the side of the users is complete, within reach, or still largely inarticulate
User involvement in need determination	Degree to which users must be involved in the determination of their needs

Advanced Manufacturing

It is not trivial to define what Advanced Manufacturing (AM) is and how it is different to traditional manufacturing. The Australian CSIRO (2016) report defines five global megatrends in AM that affect the global value chain of manufactured goods (and services) as a whole:

a. *Made to measure:* tailor-made, customized, manufacturing goods, where e.g. material characteristics are made to measure or customers can interact at the designing stage with engineers. This trend causes a shift from mass production to bespoke solutions.
b. *Service expansion:* The role of manufacturers is expanding from the role of pure producers to tightly integrated service and product providers.
c. *Smart and connected:* Progress in data mining and (real-time) data-analytics is contributing to optimising operations across the manufacturing value chain as well as on the factory floor (e.g. maintenance prediction).
d. *Sustainable operations:* Resource scarcity and increasingly valued environmental and social credentials are encouraging manufacturers to look out for efficient and sustainable processes and operating models
e. *Supply chain transformations:* Specialisation is raising the need for more collaboration in some markets, whereas technological advances enable vertical integration in others.

Figure: Swiss university and university of applied sciences (UAS) research groups by fields of Additive Manufacturing and Industry 4.0



How well these trends have been taken up in Switzerland can be seen from existing documents such as the SATW report (2016), but only with regard to AM research. According to our knowledge no analyses of AM practice in Swiss industry exist. In addition, we conducted seven expert interviews. The SATW report identified two main areas of AM: (1) additive manufacturing, which refers to the pure production processes, and (2) industry 4.0, which broadly consists in process innovations like the communication between production devices, data collection and management, or predictive maintenance. The SATW report can be used to get an understanding of the main AM field of engagement in Swiss public research institutions.

Out of 98 analyzed Swiss research institutes which engage in advanced manufacturing, 41 are university institutes which rather conduct basic research and 57 are university of applied sciences (UAS) institutes which focus on applied research with industry. A majority of university institutes research additive manufacturing, while it is the UAS institutes who are engaged in industry 4.0 related topics (Figure). UAS institutes more often also bridge industry 4.0 and additive manufacturing topics.

The interviewed industrial experts voiced the opinion that this view on advanced manufacturing with two branches, additive manufacturing and industry 4.0, is a research-driven view. They consider also process innovation activities of more basic or conventional processes, such as drilling, milling, grinding and casting, as important topics of advanced manufacturing practice.

In additive manufacturing, most research projects concern research on material characteristics such as quality assurance, up- and down-process improvements of the pure manufacturing process and projects related to product design. Expert interviews identified exactly these fields, quality management and quality assurance, post-process improvements and process standardization as the current key topics in the industry. A lack of knowledge in industry in exactly these fields hinders AM to penetrate the industry more deeply. On the whole, the interviews brought to light that Swiss SMEs often do not exhibit sufficient knowledge on what is going on in research and it is criticized that SMEs do not have sufficient financial and personal resources to take part in technology transfer with research institutes. Importantly, experts which are close to industrial SMEs state that research on materials in additive manufacturing, quality assurance of components and standardization is not enough in Switzerland and that more efforts are needed. Accordingly, it seems that the industry or at least industrial SMEs either are not fully aware of current research due to a lack of participation in technology transfer or they judge research efforts in these fields still as too low.

Both, the documents analyzed and experts interviewed, depict AM as a chance for the Swiss manufacturing sector, particularly because the production processes are not personnel-intensive. Experts, however, state that the industry is still hesitant to adopt advanced manufacturing processes and identified as reasons:

1. Lack of knowledge and research on management and assurance of the quality of advanced manufactured components,
2. Lack of standardization of production processes that particularily hinder advanced manufacturing to penetrate highly regulated industries such as medtech, aerospace or automotive more deeply,
3. Insufficient technology transfer efforts from research institutes to industry, particularly to SMEs who themselves often are short of human and financial resources and have no knowledge on ongoing research,
4. Inertia of Swiss vocational schools with regard to including AM topics and methods in their curricula for future mechanics, technicians, designers or constructors which are frequently the key personnel when it comes to (re-)designing components or production processes in SMEs.

Basically all experts agree that new initiatives are helpful for increasing the penetration of AM in industry. However, the current initiative is perceived as too strongly research-driven. New initiatives should not solely focus on technological aspects alone, which are partially already considered state of the art, such as the 3D-printing of metal or plastic components. They should also include

(a) innovative post-processing improvements and general improvements up- and down-stream of the production process,
(b) quality assurance and management of produced components and standardization of production processes, most importantly in highly regulated industries such as medtech or aerospace,
(c) stepping up efforts in technology transfer particularly to SMEs and providing educational services to key persons responsible for production processes at SMEs and
(d) communicating research efforts and results of Swiss research in a way that is suitable to produce higher visibility.

Individual assessment of each AM center

m4m: Swiss Center of Manufacturing Technologies for Medical Applications

M4m is the largest center with regard to the number of organizations involved in it and its partners are widely distributed across the German speaking part of Switzerland. It has strong participation from industry which contributes the majority (57%) of the partners. It is the only centre which has requested fewer Art. 15 funding for 2024 than for 2021.

M4m is an advanced technological infrastructure in the medical industry. It wants to enable this industry, and in particular Swiss medicinal technology (medtech) SMEs, to use 3D printing technologies to develop patient-specific implants or small series of innovative implants, produce them in a reliable and cost-efficient manner and thereby contribute to a better care and health of patients. The TIS in which it will be active is clearly delimited by one application (3D printing), product (metallic implants) and two industries (medtech and health). Its service offer will be developed around an ISO 13485 certified pilot manufacturing line which can be used to support production, technology diffusion and innovation projects. This service offer is currently unique in Switzerland and the interaction between m4m and its partners is well developed in the proposal. The center rated several outputs as very important, i.e. materials, equipment, processes, physical goods and research results (Table 14, p. 53), which is neither a clear strength nor weakness, but points to a wide set of planned activities around its core technologies. All centers were asked whether they plan to engage in activities suitable to broaden the supply of Advanced Manufacturing services, which draw on their infrastructure and competencies, but go beyond the centers themselves. M4m pointed to spin-offs and applied training in additive manufacturing. These are rather limited measures to increase the number of other service providers. However, this must be seen not least in the light of the fact that 41medical, a medtech company, is the central protagonist of the centre. 41medical itself provides already a broad set of complementary services, including the design of implants, machining, and marketing services. The center also pointed to the inclusion of offers for students which strikes us as particularly important given the experiences with older action programmes such as CIM and Microswiss in the 1990s (see section 6.1).

Center: m4m	Strengths	Weaknesses
General characteristics	Large center with strong participation from industry Only center with decreasing Art. 15 funding between 2021 and 2024	–
Supply-side aspects	Clear focus on 3D printing of metallic medical implants including support to production (pilot manufacturing line), technology diffusion and innovation projects Unique services in Switzerland	Limited contribution to growing the base of AM service suppliers.
Demand-side aspects	Embeddedness in user community makes it likely that the demand from the users can be met Definition of customer needs within reach and linked to pilot manufacturing line	Overrepresentation of regional customers

M4m will be active in a narrow market with a clearly defined customer base of medtech companies, hospitals/doctors, and researchers. In order to succeed, it must meet the needs of this customer base, for which the preconditions are good, however, due to its strong embeddedness in the community. As the services offered by m4m and its partners are comprehensive in all aspects of medical implants, customers need to define and articulate their needs precisely, for which the centre offers support and has experience. In this respect, it seems realistic that this can be achieved. A slight weakness is the high importance of regional customers, which might be due in part to a concentration of the industry in the region. Financial contributions of the cantons of Berne and Solothurn can offset this and could be a condition for the granting of Art. 15 funding to the center.

Main findings on experts’ views on the **m4m** new centre application

- Experts considered 3D-printing of metal components with regard to the production technology itself to be state of the art but welcome a new initiative in the medtech sector. They perceived a lack of research (and technology transfer) on standardization of production processes, quality management and quality assurance as the main reasons for the low penetration of AM in highly regulated industries, e.g. medtech.
- In their opinion, the main strength of the m4m application is the focus on quality management systems, down-stream process analysis, and post-processing improvements.
- Experts were surprised that a new legal entity has been founded and that the center has not been established as part of EMPA. These experts considered the initiative to be of a research-push rather than an industry-pull nature.
- Experts have stressed the importance that the center is not too strongly focused on technology but reaches-out to industry and engages in down-stream process improvements as well as education.

hipC: Hot Isostatic Pressing Center

hipC is a is a basic technological infrastructure with headquarters in Biel and a widely distributed set of partners. The center intends to give founders, initial supporters and general users access to customized cycles on a state-of-the-art Hot Isostatic Pressing (HIP) facility, including guidance, consulting and engineering, to build up knowledge and expertise on HIP at a centralized location. At CHF 1.8 million, hipC requests the lowest contribution under Article 15 of all five new centers in the years 2021-2024. In addition, hipC has planned to raise revenues through selling customized hip cycles, charging for high tech investigations contributed free of charge by hipC’s partners, consulting and engineering services, as well as by organizing events. CHF 0.36 million should come from competitively acquired public research funding, and the lead partner Switzerland Innovation Park Biel/Bienne (SIPBB) committed to a financial contribution of more than CHF 0.5 million, of which a CHF 0.3 million loan should be paid back by the center in 2025. This revenue model comes with “considerable risks” (hipC application, p. 10), if interest among customers is lower than expected and partners are not able or willing to provide free services. It is also notable, that according to the application none of the main industry partners, ProtoShape, Deloro, and Quintus, committed itself to funds (but more than 0.5 mCHF in-kind contributions).

The service offer of the center is clearly defined with HIP and combined HIP/high-temperature (HT) cycles which are suitable to improving the density, ductility and fatigue resistance of high-performance materials resulting from additive manufacturing. Industrial HIP services of lower pressure are already on offer by Deloro HTM, one of hipC’s partners, who also provides the space for the HIP machine in the funding period 2021-24. Deloro is described as the ideal partner for taking over the HIP machine after 2024, however, the company has not yet committed itself in writing to doing so. While the public hipC partners take a (sometimes considerable) risk in financial terms, the private partners, especially Deloro, largely refrain from doing so, even though they can derive great benefits from expanding their HIP equipment and customer base, if the project is successful.

It is difficult to assess the risk of finding market acceptance, but the strong embeddedness of hipC in the application community and the fact that similar services are already provided suggests that overall a market for the described HIP/HT services exists. However, the question is also who the customers in this market are and whether the infrastructure and services address the needs of Swiss industry. In reference to this three points should be noted: 1) hipC anticipates that nearly half of its customers in 2021 (and still 40% in 2024) will come from research, and not from industry – this is a lot more than for any other center. 2) While in 2021 90% of the expected customers are Swiss (23 out of 25), this share goes down to 53% in 2024 (40 out of 76); hence, throughout the entire funding period only slightly more than half of the customers will come from Swiss industry. 3) hipC is also very optimistic with regard to growing its number of customers expecting more than a tripling from 2021 to 2024.

Center: hipC	Strengths	Weaknesses
General characteristics	Good geographical distribution in the various parts of CH Funding requested under Art. 15 is the smallest of all new centers	Revenue model could be difficult to implement, as it is based on fees for infrastructure services and (unpaid) in kind contributions from partners
Supply-side aspects	Clear focus on HIP cycles for additive manufacturing and support to innovation projects using HIP in additive manufacturing	Narrow set of outputs expected, but R&D included which raises questions with regard to the division of labour between the center and its partners Industry partner already offers industrial HIP services of lower pressure Contribution to growing the base of AM service suppliers only towards end of funding period and strongly linked to one partner
Demand-side aspects	Embeddedness in user community makes it likely that the demand from the users can be met Definition of customer needs already complete or within reach	Strong representation of research institutes among the expected users Very optimistic expectations with regard to growth in customers

Main findings on experts’ views on the **hipC** new centre application

- Among the 7 experts hipC was very controversially discussed: Some experts found it logical that if centers with focus on 3D metal printing are taken into account that also centers with focus on post-processing should be considered for funding. Other experts thought that the innovation aspect of the center is rather limited and that third-party service providers for post-processing of advanced manufactured products already exist.
- Experts criticized that there are no aspects apart from process research that ensured an effective reach-out to industry and that the initative has a too strong research focus which might complicate effective reach-out to (potential) industrial customers.

M2C: Micromanufacturing Science and Engineering Center

M2C is the smallest center with four out of nine partners coming from industry. It is strongly concentrated on western Switzerland and above all the canton of Neuchâtel and described in the application as an integral part of the Microcity innovation pole. The revenue model draws on fees for use of the infrastructure, training, consulting and other services to be contributed by M2C and its partners and eventually membership fees and the center has not provided a convincing description of how the risk of missing revenues would be managed.

M2C wants to provide the microengineering community with a basic technological infrastructure, i.e. a micro-manufacturing platform (femtosecond laser system and 3D printer for high-precision multi-material free form additive manufacturing) and the related services to foster collaborations and improve the advanced manufacturing skills of its staff and stakeholders in the microengineering ecosystem. Among the supply-side aspects of the M2C application, we consider the service focus of M2C a weakness: the technologies can be used across a broad set of industries with very different requirements and customised services seem to be a must for supporting technology diffusion and efficient use in developments. Such customised services, however, entail an R&D component which will not be contributed by the center itself, but mainly by its academic partners (who could also own the infrastructure and use it for both, research and transfer projects). The ultimately too little defined range of services is also underpinned by the variety of possible outputs that can result from the work of the center. The application and replies to the survey on other supply-side aspects, such has how coordination with providers of complementary services will be achieved or how the center will contribute to growing the supply of AM services beyond its own activities, generally are rather vague.

M2C has pointed to several industries which could benefit from its services, but its partner structure does not suggest that the center is well connected in these industries. In addition, as M2C provides a basic, multi-purpose technological infrastructure the precise identification and articulation of each customer's needs seems to require considerable efforts on the user's side as well as support from the personnel running the infrastructure.

Center: M2C	Strengths	Weaknesses
General characteristics	–	Small center with rather little participation from industry Concentrated on western CH and above all canton of Neuchâtel Revenue model could be difficult to implement, as it is based on fees for infrastructure services and (unpaid) in kind contributions from partners Only very generic listing of implementation risks
Supply-side aspects	–	Indefinite set of services around the diffusion of free form micro-manufacturing technologies and their use in development Wide set of outputs expected Very limited contribution to growing the base of AM service suppliers
Demand-side aspects	–	Limited embeddedness in user community my create challenges with identifying and meeting users' needs Overrepresentation of regional customers Definition of customer needs within reach, but analytical and multi-purpose infrastructure requires strong contribution from cus-tomers

Main findings on experts’ views on the **m2c** new centre application

- Two experts considered M2C as a “must” for the Swiss manufacturing sector which has already developed a reputation in metrology. Building up advanced manufacturing competences in line with this reputation could be beneficial. These experts see the relevant customer base for M2C in the metrological industry.
- Other experts stated that from the description of the center it did not become clear to them who the target group in industry would be. The initiative was also described as too strongly research-driven with perhaps no or only few efforts in technology transfer to industry.
- There are already important Swiss research institutions in the research field of M2C and the added value of a new center for industry is not clear.

ANAXAM: Analytics With Neutrons And X-Rays For Advanced Manufacturing

ANAXAM is the second largest project with regard to partners from industry and overall funding, but with CHF 3.2 million (13% of total funding 2019-24) it has requested considerably less in relative terms than the other centers under Art. 15 RIPA. Hence, the leverage effect is the biggest for this center: CHF 1.00 of funding under Art. 15 generate additional CHF 4.70 of revenues/expenditures for AM from other sources. ANAXAM and its partners are strongly concentrated on the German speaking part of Switzerland and above all in the host canton of PSI, Aargau.

ANAXAM is a basic technological infrastructure with strong connections to existing research infrastructures in the field of analytics at PSI, supporting the use of neutron and X-ray radiation for analytical purposes in a wide set of industries. The division of labour between ANAXAM and its partners is clear and ANAXAM plans to provide services related to the sample environment/equipment, sample pre-characterization and preparation, data analysis and data interpretation. Drawing on previous experiences of its main partner PSI with life science spin-offs, it also showed among all centers the highest awareness of the need to develop the supply side for AM services beyond center’s own services. However, as with the previous center M2C, the core multipurpose infrastructures of the center have to be used in different ways according to industry-specific and product-specific requirements. Even though it will not be easy for the center to accommodate these differing needs, the four real use cases described in the application, the above mentioned previous experiences with life science applications, and last but not least the embeddedness in AM user communities suggest that ANAXAM will be able to work intensively with its customers and customize its services. In addition, the center is aware of the risk of achieving recognition and visibility of its analytical potential and prepared to work on this (Anaxam response to the survey). In the long run, the inclusion of educational offers and training of students on the infrastructure also contributes to establishing an industrial customer base.

Center: ANAXAM	Strengths	Weaknesses
General characteristics	Strong industry participation among its partners Share of funding under Art. 15 is the smallest of all new centers	Concentrated on the German-speaking part and above all canton of Aargau
Supply-side aspects	Clear division of labour between center and partners and focus on processes and technological services (no research outputs) Strongest focus of all centers on developing the supply of independent services related to its infrastructure, previous experiences of PSI with life science spin-offs	Rather diffuse offer of advanced analytical services that draw on imaging, diffraction or spectroscopy beamlines for innovation projects
Demand-side aspects	Embeddedness in user community makes it likely that the demand from the users can be met	Definition of customer needs within reach, but analytical and multi-purpose infrastructure requires strong contribution from customers

Main findings on experts' views on the **ANAXAM** new centre application

- Almost all experts have recognized ANAXAM as valuable due to its focus on quality control, quality assurance and down-stream testing in the advanced manufacturing process.
- Since knowledge on qualification and testing can be brought to industry by the center, it is considered a beneficial initiative and experts thought that potential customers for its services certainly exist. Other experts stated that the communication on the usefulness of the center particularly to SMEs will be very challenging and crucial for the success of the center. Efforts necessary for "marketing" the center to industrial SMEs should not be underestimated. The center, in addition, chould focus on a wider set of known qualification techniques, such as computer tomography, to simplify the industrial reach-out.
- One expert questions the effectiveness of creating ANAXAM outside PSI.

M4IVD: Manufacturing for in-vitro diagnostics

M4IVD is rather small with regard to the amount of partners overall and from industry in particular. However, in budgetary terms it is by far the largest application and requests almost as much Art. 15 RIPA funding as the other four centers together. In addition, the funding requested under Article 15 will double between 2021 and 2024. The costs are considerable, even though the center is an advanced technological infrastructure in the rather narrowly defined TIS of in-vitro diagnostic (IVD) tests for point of care health services with a small projected customer base.

The main mission of the center is to bridge the hurdle from lab development to small scale production of point of care IVD tests to initiate clinical trials, by offering a centralized IVD pilot line and assuring full Good Manufacturing Practice (GMP) and ISO 13485 compliance. The clear focus on the development and pilot manufacturing of point of care IVD tests is certainly a strength of the center and the narrow range of primary outputs, i.e. the IVD tests as products, data and information surrounding these tests, and last but not least the production processes, underscores this focus. In addition, the applicants correctly perceived that the development of IVD tests entails a sizable R&D component which they included in their service portfolio, blurring, however, the boundaries between the offers of the center and its partners.

The clear definition of the TIS in which M4IVD wants to be active also entails a good understanding of the potential customer base of mainly biotech and diagnostics SMEs, pharmaceutical companies and research. As of Dec. 1st, 2019, the center has had only one partner from the application community (and four corporate partners classified as "Suppliers & consultants"), which suggests that it is not too well embedded in this community. However, this need not be a problem in view of the clearly delimited TIS. A major weakness, in our view, is the relatively limited impact of the infrastructure, which is further underlined by the projected small number of clients.

Center: M4VD	Strengths	Weaknesses
General characteristics	–	Rather little participation from industry Most expensive initiative: funding requested under Art. 15 is almost equal to the funding requested by all other new centers together, strong increase of requested funding between 2021 and 2024
Supply-side aspects	Clear focus on in-vitro diagnostic tests including support to production (pilot manufacturing line) and innovation projects	Narrow set of outputs expected, but R&D included which raises questions with regard to the division of labour between the center and its partners Very limited contribution to growing the base of AM service suppliers
Demand-side aspects	Definition of customer needs within reach and linked to pilot manufacturing line	Low user base of only 7-11 organizations annually from 2021-24

Main findings on experts' views on the **M4IVD** new centre application

- Only two experts out of seven had an opinion related to m4ivd. They find it suitable that on one hand, m4ivd also is focusing on the medtech industry and also focuses on down-stream process-improvements.
- One expert mentioned that M4IVD is the only center that focuses (weakly but at least) also on industry 4.0 process improvements related to innovations in sensors and actuators. Experts did, however, not really recognize enough innovation character and stated that the application field was very limited which makes an effective reach-out to industry questionable.

Concept evaluation of the AM-TTC initiative

The set-up of the new centers with regard to partners and funding, overall aims, and activity portfolios is generally in line with the paradigm of Swiss innovation policy. It has traditionally placed a strong focus on advancing the technological frontier through funding basic and applied research in universities and transferring the resulting knowledge and technologies through qualified graduates and different mechanisms of knowledge and technology transfer to companies. The new AM-TTC center initiative follows the model of older action programmes in particular knowledge fields, such as computer-integrated manufacturing (CIM), microelectronics, software, and nanotechnology. Evaluations have shown that these older programmes were less effective with regard to generating measurable economic outcomes (e.g. new firms, product innovations or process innovations), but they succeeded with advancing technology diffusion, developing technological competencies, and networking organisations (Barjak, 2013; Hotz-Hart &

Rohner, 2013). The establishment of educational and training offers and strong links to higher education were identified as important aspects of those action programmes contributing to success in several cases, and such offers should also be considered by the new centers in coordination with their partners. However, this should not be understood as a call for a one-size-fits-all approach to supporting technological innovation systems. To the contrary, the evaluations of the previous action programmes have clearly shown that initial conditions and contexts of the TIS have mattered a lot for the reception and success of their measures among companies. Another point stressed also in the expert interviews is the need to limit services not only to technological assistance in a narrow sense, but include issues such as compliance with regulations, above all in industries like medtech and aerospace with high regulation intensity, development of standards, communication and marketing.

Beyond using the infrastructure for technological services and providing consulting the centers’ planned service portfolios are partially quite narrow and partially quite broad. The centers do not only want to support innovation, but also diffusion and in two cases even production through (pilot) manufacturing lines. Other than in the mentioned older action programmes funding for R&D has to come in the new initiative from other sources, and at least some of the centers have opted for a division of labour between the centers and their partners that leaves the R&D function with the partners only. According to our knowledge this separation is actually a novelty in the set-up of technological action programmes in Switzerland. Though a clear division of labour and definition of the centers as “external infrastructure service units” might be functional, if it reduces misunderstandings or even haggling and competition over the research function, it remains to be seen how the centers manage to coordinate the different projects, interests, partners and stakeholders.

The overall projected demand of the five applying centers adds up to 76 customers in 2021 and 177 customers in 2024 (+133%). And the main customer segment are in all centers but one (hipC) Swiss SMEs. If all centers were funded and the projections could be realized the centers would start with approximately the size of inspire in 2021 (inspire expects for 2021 90 customers) and almost reach the size of CSEM (215 customers in 2021) by 2024. While these are overall promising numbers, the main question is, of course, whether they could be really achieved. This depends not at last on the value proposition of the centers and whether their services address pressing needs. The applicants (centers and their partners) surely know their respective TIS and probably have developed over the years an in-depth understanding of the problems and necessary contributions to advance a TIS and raise its innovation capacity. However, the provided application documents and answers to our questions do not make this explicit and it is therefore not possible to conclusively judge the centers on the suitability of their service portfolios for bringing progress to their TIS. In addition, basic technological infrastructures, such as those provided by M2C and ANAXAM, are multi-purpose, potentially serve different needs, and need strong involvement on the side of the customers with defining and formulating their needs. Not all centers seem to have the needed strong relationships to their application communities. The overall estimate of customer growth between 2021 and 2024 therefore strikes us as too optimistic. These uncertainties with regard to supply and demand aspects make it challenging to assess ex ante the likely impact of the initiative.

Extended version

1. Introduction

The Advanced Manufacturing Technology Transfer Centers (AM-TTC) are an initiative in the policy area of education, research and innovation included in the Swiss federal action plan for digitalization. It has been designed to promote innovation and to speed up knowledge transfer in the field of Advanced Manufacturing through operating a network and alliance of centers which offer open access to relevant technology transfer infrastructures.

In 2018 the ETH Board granted CHF 10 million to support the AM-TTC initiative and to enable the establishment of first centers already in the pilot phase in 2019 and 2020. The "AM-TTC Alliance" is the umbrella association of different technology transfer centers having a range of different members representing the scientific and technical community in advanced manufacturing in Switzerland. Following a call for proposals, nine proposals for centers were submitted until April 2019. The AM-TTC Alliance accepted one proposal (m4m) without change requests. Four proposals (ANAXAM, HIPC, M2C and SMM) were conditionally accepted and recommended for funding, under the condition that they resubmitted modified proposals that complied with the change requests described in the evaluation reports (https://www.am-ttc.ch/application-process.html). Three of the four conditionally accepted centers resubmitted modified proposals and one was accepted by AM-TTC for being included in the initiative and obtaining funding in the pilot phase 2019/2020.

As originally foreseen, the new centers can apply for federal follow-up funding for 2021 to 2024 as research institutions of national importance under Art. 15 RIPA (Federal Act on the Promotion of Research and Innovation). AM-TTC recommends the funding of its two approved centers, ANAXAM and m4m. Three further proposals, hipC, M2C and M4IVD, submitted applications with regard to receiving Art. 15 funding which have to be evaluated. The applications will be formally checked by SERI and submitted to a (simplified) evaluation of the “package” of all center applications together with the funding recommendations of the Alliance by the Swiss Science Council (SSC) on mandate of SERI. The evaluation needs to take into account the context of all submitted requests under Art. 15 RIPA. This implies for the new centers and applications that a particular focus needs to be taken on how they are coordinated in terms of content, strategy, organisation, etc. with the two established research and technology centres, CSEM and inspire.

The present document by FHNW answers a request from SSC to support this concept evaluation. In order to meet the objectives it needs to provide information on the services, which the new centers intend to provide, the organisations involved in providing the services (suppliers), the target groups and potential user bases of these services in Swiss industry, the expected impacts, and last but not least the coordination with existing other suppliers of similar services (above all the established centres CSEM and inspire). This requires answering the following questions:

1. Do the centers address pertinent technological areas of (advanced) manufacturing?
2. Do the centers contribute to resolving problems of Swiss manufacturing and contribute to making progress towards advanced manufacturing? Do the planned activities of the centers concentrate on the needs of Swiss industry? Are their services relevant for SMEs?
3. Do the centers provide services, which are complementary to services already provided by CSEM, inspire, universities of applied sciences, and other stakeholders in the Swiss manufacturing research and innovation system? What gaps do the new centers close?
4. Are the centers’ approaches consistent with the Swiss research and innovation system and policy? In which ways do they follow or add to the current paradigms of Swiss innovation policy?

2. Theoretical framework

2.1 Technological innovation systems

We use for this assessment the conceptual framework of technological innovation systems (TIS). The TIS concept has been used to describe and analyse the functioning of "socio-technical systems focused on the development, diffusion and use of a particular technology (in terms of knowledge, product or both)" (Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008). The first crucial step, that determines the scope of the analysis, is the definition and delimitation of the TIS. Bergek et al. (2008) point to products/artefacts or knowledge fields as two possible anchors for defining a TIS. Either choice then requires a decision on the breadth, i.e. whether one or several products, knowledge fields and applications of a technology should be covered. Bergek et al. (2008) stress that this is not necessarily only an empirical decision, i.e. that the TIS already exists in practice, but that it could also be a conceptual delimitation which integrates different application areas of a technology in order to facilitate interdisciplinary knowledge development and learning processes. Last but not least, a geographical delimitation may also be necessary, which does not have to be at national level but may be broader or narrower.

Any TIS of one or several products/artefacts or knowledge fields then consists of four types of structural components (Bergek et al., 2008; Wieczorek & Hekkert, 2012):

(1) *Actors* may be private or public, including, for instance research institutes, public bodies, interest organizations and the like.
(2) *Institutions* like laws, norms, routines need to be aligned to TIS development to provide for the diffusion of a technology.
(3) *Infrastructure* has a physical, knowledge-based or financial character.
(4) *Interactions* refer to formal networks, such as cluster organizations, public-private partnership initiatives, as well as informal networks and contacts between individuals, which are particularly difficult to detect in an emerging TIS.

These structural components fulfil different functions in the TIS. Drawing on previous work, Bergek et al. (2008) differentiate between seven functions:

(1) *Knowledge development and diffusion.* Often a (too) narrow focus on R&D is taken, which is insufficient, as a TIS may provide different types of knowledge (scientific, technological, commercial, environmental etc.) which are generated through different activities and come from a variety of sources.
(2) *Influence on the direction of the search.* The second key function of a TIS consists in its contribution to bringing actors on board and growing the system. To achieve this, the insight and opinion that this is necessary needs to spread. For instance, the development of technological visions, commercial opportunities, ideas for tackling grand challenges, anticipation of policy and regulatory pressures, or discussion of insights in other national TIS might contribute to raising awareness and directing resulting search processes among the actors.
(3) *Entrepreneurial experimentation* serves to cope with technological uncertainties in the development and growth of a TIS.
(4) *Market formation* refers on the one hand to the size, timing and type of markets, on the other hand also to the drivers behind it. For instance, a quick establishment of national markets might be due to regulatory pressures or subsidies which do not exist in other national markets and are difficult to generate from the outside.

(5) *Legitimation* refers as well to the degree of legitimacy that a TIS has gained, as well as to the processes behind obtaining this legitimacy, which differ between TIS. Institutional alignment, manipulation of the rules of the game, conforming to existing rules or developing a new institutional framework have been listed as possible legitimation strategies.
(6) *Resource mobilization.* The development of a TIS requires a range of different resources, human, financial, complementary assets etc.
(7) *Development of positive external economies.* The growth of the TIS gives rise to external economies in the Marshallian sense, with regard to labour, intermediate goods and services, or information and knowledge, which need to be captured:
"In sum, the analyst needs to capture the strength of these functional dynamics by searching for external economies in the form of resolution of uncertainties, political power, legitimacy, combinatorial opportunities, pooled labor markets, specialized intermediates, as well as information and knowledge flows." (Bergek et al., 2008, p. 418)

The structural components actors, institutions, infrastructure, and interactions determine, how well these seven functions can be fulfilled. Each can be subject to problems defined as *"factors that negatively influence the direction and speed of innovation processes and hinder the development and functioning of innovation systems"* (Wieczorek & Hekkert, 2012, p. 79). First, problems of absence, i.e. missing actors, institutions, infrastructure or interactions, and second problems of quality of any of the four structural dimensions may limit the performance of a TIS (Wieczorek & Hekkert, 2012).

The new AM-TTC initiative and centers can be understood as an initiative that aims at strengthening different TIS in the wider domain of advanced manufacturing. Their focus is on the solution of infrastructure-related problems either for particular TIS or across different TIS encountering similar infrastructural problems (multipurpose infrastructures). Hence, the AM-TTC assessment must place a particular focus on their contribution to solving infrastructural problems. As pointed out above, the TIS literature distinguishes between physical, knowledge and financial infrastructures whose absence or lack of quality might lead to bottlenecks in TIS (Wieczorek & Hekkert, 2012). However, the concept of infrastructure itself has not been discussed in this line of work, as far as we know. It is necessary to define clearly what an infrastructure is and what elements and processes are necessary to establish an infrastructure, to be able to evaluate whether its existence or quality influences the performance of a TIS. Existing work on technological infrastructure can fill this gap.

2.2 Technological infrastructure

The economic growth literature has often taken a narrow view on infrastructure and limited it to publicly owned tangible infrastructure capital that is usually subject to natural monopolies, such as highways, other transportation facilities, water and sewer lines, and communications systems (Gramlich, 1994). Privately owned infrastructure capital, human investment spending for health or education, and public research and development expenditures have been excluded, due to problems of delimitation and measurement (ibid.). Still, above all the latter is key for the task at hand and we follow Justman and Teubal (1995), who suggested a distinction between a) conventional infrastructure, b) basic technological infrastructure and c) advanced technological infrastructure (cf. Table 1).

a) *Conventional infrastructure* meets well-defined needs in a largely standardised way. Depending on national regulations conventional infrastructure is provided by governments themselves or private infrastructure providers acting in existing regulated markets. The user base is large and the output is little differentiated which makes it comparatively easy to determine the technological specificities of the infrastructure without having to consult the customer base ex ante – e.g. for determining the width of a road the future drivers do not need to be consulted.
b) *Basic (or sectoral) technological infrastructure* provides routine services, such as testing and analytics, design, information, to companies in one or a few industries or sectors of the economy. It involves only little R&D if any. Industry associations typically organize the establishment of basic technological infrastructure and governments might take over an active intermediary role. Companies might need help with the articulation of their needs ("market building") by the service provider.
c) In contrast, *advanced technological infrastructure* is more specific and useful only to a small constituency delimited in terms of a function (e.g. superconductivity, optical coating) rather than an industry. The provision of advanced technological infrastructure entails a strong R&D component, as the services and required capabilities are not yet existing. Customers, e.g. high-tech firms, and service providers need to engage in a set of joint and coordinated activities to co-create the infrastructure. Public policy can support this capability creation, and overall has a more passive role in facilitating the (private) efforts to set up the infrastructure.

Table 1. Differences between types of infrastructure

	Conventional	**Basic technological**	**Advanced technological**
Nature of output	Production inputs	Technological services	R&D inputs
Activity supported	Production	Diffusion	Innovation
Focus	Geographic	Sectoral	Functional
User-base structure	Indefinite	Many SMEs	Select few
Differentiation of output	Little	Some	Very high
Definition of need	Complete	Within reach	Inarticulate
User involvement in need determination	Unnecessary	Moderate	Intensive
Market for outputs	Exists	Does not exist, but feasible	May not be feasible
Possibility of independent entrepreneur	Yes	Initially unlikely	Unlikely
Typical entrepreneurial organization	Government	Industry association	Consortium of users
Government's role	Investor, regulator	Knowledgeable catalyst	Catalyst, broker
Policy focus	Capacity, pricing	Market building	Capability creation

Source: Justman and Teubal (1995, p. 265)

The typology suggests different requirements for the provision of basic and advanced technological infrastructure services:

- Basic technological infrastructure has a broader reach and often serves technological catch-up processes and technology diffusion. It is typically being run by industry associations or their offshoots, as there is a strong need to link up with many (small and medium-sized) companies. Technological competencies are more important than R&D competencies, as the main purpose is not to develop new technology, but diffuse existing technologies more widely. Public infrastructure/innovation policy plays a strong role in helping companies to understand and formulate their needs, facilitating collective learning processes in the target industry, i.e. catching up with their foreign counterparts or learning from other, more advanced industries in the country.
- The more advanced the services are, the narrower is the target community and the stronger must be the involvement of customers/users to define and create the services. Consortia of users need to form to organize the provision of such advanced services which feed into their R&D activities. The public role is limited to that of a catalyst and broker that supports the development of capabilities in the participating companies.

The emergence of (scientific) infrastructures and their characteristics were also conceptualised in the context of e-infrastructure, i.e. new computer-based infrastructure for science. Star and Ruhleder (1996) understood infrastructure as a relational concept becoming infrastructure *“in relation to organized practices”* (p. 113) depending on the circumstances and context of use. They characterised the provision of infrastructure as embedded (in other structures, social arrangements and technologies), transparent (i.e. pre-existing, standardised, self-explaining, and invisible except in breakdowns), of more than local and short-term scope, learned as part of membership in a community, and shaped by conventions of practice in these communities (and shaping them in turn). Last but not least, infrastructure embodies standards which serve its compatibility with other infrastructures and is backward-compatible with older systems. Barjak et al. (2013) list 1) size and scope, 2) embeddedness in user communities, 3) purpose and responsibility, 4) mechanisms of coordination, 5) formality of governance, and 6) sustainability of funding as six criteria which differentiate infrastructures from mere project-level support mechanisms in science (cf. Table 2).

Table 2. Two types of support systems

	Support system in the project environment	**Infrastructure**
Size and scope	Few providers, few users, local scope of service	Distributed providers, many users, non-local (in spatial, thematic, or other respects)
Embeddedness in user communities	Not widely embedded, mainly pilot users and early adopters with a particular interest	Embedded, qualification to use the infrastructure is part of the socialisation into the community
Purpose and responsibility	Academic organizations focussing on technical development and scientific discovery	Non-academic organizations focussing on service provision
Mechanisms of coordination	Solidarity, trust	Routines, procedures and orders
Formality of governance	Informal governance	Formal governance
Sustainability of funding	Short-term, grant-based, eventually renewable (upon application)	Long-term, renewable grants, user fees or budgetary contributions

Source: Barjak et al. (2013, p. 119)

2.3 Conceptual framework used for the evaluation of the AM-TTC centres

Drawing on this line of work on technological innovation systems (TIS) and technological infrastructure we selected the criteria shown in Table 3 to describe and compare the AM-TTC proposals, evaluate their role in one or several TIS, and discuss their degree of development towards infrastructures for advanced manufacturing in Switzerland.

Table 3. Criteria for assessing the AM-TTC centres

Measure	Explanation
General characteristics of the centers	
Partner structure	Participation of partners by type (research, industry, government, NPO, and other organizations) and geography
Revenue model	(Expected) revenues under Art. 15 RIPA, from public research funding, and from other sources and revenue generating activities
Governance	Legal form, owners and governing bodies of the centers
TIS definition	Delimitation of the TIS to be served by the new center and its technological infrastructure
Supply-side aspects of the centers	
Missions and service portfolio	Missions and planned infrastructure
Scope	Does the center mainly serve a geographical catchment area, a sector or industry or a (more narrow) function within one or few industries?
Activities supported by the infrastructure	Activity focus of the infrastructure distinguishing between production, diffusion of technology, innovation
Development of supply	Planned measures to broaden service supply
Complement/substitute services	Availability of complementary or substitutive services
Dependency on public funding	Possible service level without public funding under Art. 15 RIPA
Implementation risks	Perceived implementation risks and risk management plans
Demand-side aspects of the centers	
Customer-base	Size, structure and dynamics of the customer base
Embeddedness in user communities	Degree of embeddedness in user communities
Definition of need	Definition of need for the infrastructure on the side of the users is complete, within reach, or still largely inarticulate
User involvement in need determination	Degree to which users must be involved in the determination of their needs

3. Approach and methods

3.1 Overview

In line with good practice in innovation policy evaluations (Edler, Berger, Dinges, & Gök, 2012) and the available time the assessment has relied on qualitative methods. These have included:

1. Analyses of documents from AM-TTC, CSEM and inspire, such as the applications and previous evaluation reports, websites, and internal documents as made available,
2. A structured survey of the five new Art. 15 RIPA applicants, CSEM and inspire,
3. Interviews with (AM-TTC) external experts from Swiss academia and industry on advanced manufacturing in general and the particular areas put forth by the new centers in particular.

Due to the short time frame the expected efficiency, goal attainment/effectiveness, and impacts of the centers have not taken centre-stage in this evaluation, as they would require quantitative methods, such as cost-efficiency techniques, cost-benefit analyses or simulations (Fahrenkrog, Polt, Rojo, Tübke, & Zinöcker, 2002).

3.2 Data collection

1) Analysis of documents. All five centers have submitted applications to AM-TTC until April 2019 which were evaluated according to the following criteria: 1) Focus area, demand, and importance; 2) Competences and capabilities; 3) Financials; 4) Readiness to start. Three of the four proposals, which were conditionally accepted in this evaluation, submitted modified proposals, which were re-evaluated according to the same set of criteria in September 2019. In addition, CSEM and inspire submitted applications for Art. 15 RIPA funding.

The present evaluation has used these AM-TTC applications and the existing evaluation reports as starting points. Moreover, it used the Art. 15 RIPA application documents of CSEM and inspire and further documents on their advanced manufacturing strategies as available to describe their approaches in the domain.

2. Structured survey of the center management. To answer supply-oriented questions on the activities and structures of the new centers, which are not or not fully covered in the application documents and evaluation reports, and cover further demand-side aspects we have used a structured questionnaire that each applying center as well as CSEM and inspire answered. The questionnaires covered, for instance, questions on aspects of the expected demand for the services of the center, their service provision, funding models and the relationships to other service providers in the field of AM (see the questionnaires in the annex).

3. Interviews with external experts from Swiss academia and industry. Interviews with advanced manufacturing experts from research and industry should serve to get an overview of the position of the five centers in the field of advanced manufacturing. The main purposes of the interviews have been threefold:

- First, they served to describe the landscape of advanced manufacturing and identify the hot topics for Swiss companies involved in the introduction of advanced manufacturing products and processes.
- Second, they helped to place the new applications in this landscape and provide an (independent) second opinion on the technological focus of the suggested centers.
- Third, they shed light on other barriers, which have been perceived with regard to the spread of advanced manufacturing in Switzerland.

The identification of the experts drew on existing sources, such as the SATW report on Advanced Manufacturing (2016), as well as the AM-TTC alliance. A list of interview partnes is included in the annex.

3.3 Data analysis

The data collected from the documents and through the survey have been entered into tables which facilitate a structured comparison of the two new centers (ANAXAM, m4m), the three proposals (HIPC, M2C, and M4IVD), and the two established centers (CSEM and inspire). The tables consist of a mix of quantitative and qualitative data. In addition, figures have been included to illustrate certain topics.

4. Advanced Manufacturing at global level and in Switzerland

4.1 Global developments in the field of Advanced Manufacturing

We derive global trends by drawing on the CSIRO outlook for Advanced Manufacturing (AM) in Australia (CSIRO, 2016). The report defines five global megatrends in AM that affect the global value chain of manufactured goods (and services) as a whole:

a. *Made to measure:* tailor-made, customized, manufacturing goods, where e.g. material characteristics are made to measure or customers can interact at the designing stage with engineers. This trend causes a shift from mass production to bespoke solutions, at a probably insignificant cost increase as long as the whole value chain is adapted with regard to digitalization that at last is an enabler for customer interaction.

b. *Service expansion:* The role of manufacturers is expanding from the role of pure producers to tightly integrated service and product providers.

c. *Smart and connected:* Progress in data mining and (real-time) data-analytics is contributing to optimising operations across the manufacturing value chain as well as on the factory floor (e.g. maintenance prediction).

d. *Sustainable operations:* Resource scarcity and increasingly valued environmental and social credentials are encouraging manufacturers to look out for efficient and sustainable processes and operating models

e. *Supply chain transformations:* Specialisation is raising the need for more collaboration in some markets, whereas technological advances enable vertical integration in others.

The CSIRO reports several important action fields in order to cope with the aforementioned trends. In most countries, including Switzerland though still from a relatively high level compared to other countries, manufacturing industries have seen declining shares in GDP during the past decade. Therefore, it is important to recognise opportunities for growth and allow enabling technologies and knowledge to spread from research to the industry.

Opportunities for growth

Rapidly changing markets and technology environments create the need for adoption of both the research landscape and SME activities in advanced manufacturing. The following Table 4 describes the most important opportunities for growth:

Table 4: Summary of opportunity themes for growth of AM

Opportunity for Growth	
Customised high-margin solutions	DESIGN SERVICES: From bespoke co-design with customers to manufacturer-less manufacturing SUPERIOR COMPONENTRY: From components with improved to components with completely new characteristics NOVEL PRODUCTS: From upgrades to integrated novel solutions
Sustainable manufacturing	BUSINESS MODELS & PROCESSES: From reduced land use and waste to closed-loop material use PRODUCTS: From energy efficient products to products designed with recycling and recovery
Selling services	MAINTENANCE & REPAIR SERVICES: From static monitoring and diagnostics to predictive maintenance through embedded intelligent sensors WORKFLOW MANAGEMENT SERVICES: From wearable tracking devices to interactive platforms that allow data-driven decision making HEALTH & BIOSECURITY SERVICES: From discrete monitoring to continual reporting and advanced warning

Source: CSIRO (2016)

The content of Table 4 can additionally be divided into short-term and long-term scenarios. The following text gives exemplary insights into developments to be expected and is by far not exhaustive.

Opportunities for customised high-margin solutions are …

- in the short term rapid prototyping services for new product and components, sensors and actuators, which in the medium term are designed to be easily retro-fitted to existing equipment and in the long term platforms where customers can send electronic designs as part of customer interaction.
- in the short run light-weight carbon fibre composites, 3D-printed prosthetics and dental implants. In the medium run, 3D printed products should come along with tailored characteristics and in the long run, advanced surface materials (or integrated sensors), which can communicate properties of the component.

Opportunities for sustainable manufacturing are …

- in the short term improved industrial symbioses where waste and by-products from one industry are used as raw material by another, in the medium term the development of technologies that allow software-based energy monitoring of production plants and in the long term an integrated approach to a sustainable value chain involving business partners located nearby.

Opportunities for selling services are …

- in the short-run condition monitoring and predictive maintenance of heavy machinery, in the medium-run multi-site orchestration and control of autonomous equipment and in the long-run sensors that directly are incorporated into materials that allow monitoring of the infrastructure

In order to realize opportunities for growth, different technologies must be developed further and become ubiquitous.

Table 5: Enabling science and technology summary

	Now	Future
Sensors and data analytics	Used during production and remote monitoring of single attributes	Applied across the value chain for predictive maintenance, logistical tracking, operational efficiency, quality control and service offering
Advanced materials	Reactive use to address specific product limitations (weight, look, haptic)	Pro-active integration at early design phase to offer multiple novel attributes (biocompatibility, biodegradability, self-repairing)
Smart robotics and automation	Replace workers for task complex, high precision, repetitive or hazardous operations	Assistive robots that work collaboratively with improved sensing and capability for full automation
Additive manufacturing	Prototyping of customized high-value complex metal and plastic componentry	Reduced capital costs will allow adoption of production technologies for complex products associated with advanced business models such as customer-led design
Augmented and virtual reality	Dominantly restricted to gaming and electronic (consumer) markets	Use to overlay product designs with end-use environment, facilitate remote collaboration

Source: CSIRO (2016)

The table is not comprehensive but exhibits the same content as we draw a Swiss manufacturing landscape in research based on the SATW report in Figure 5, mainly by splitting advanced manufacturing in one branch consisting in additive manufacturing technologies and one branch being industry 4.0 related activities with process innovation character. However, our expert interviews brought to light that this view on advanced manufacturing might be too strongly research driven. The experts underlined the importance of also incorporating more conventional production processes (as drilling, milling or grinding) with a process innovation either down- or up-stream of the pure production process into advanced manufacturing. Also, components produced by additive production methods almost always require post-processing with conventional methods and therefore, these methods also should be covered under the headline of advanced manufacturing.

4.2 The Swiss Advanced Manufacturing landscape

Information on the Swiss AM landscape and on the relevant players and driving forces was collected from publicly available documents and through qualitative interviews. This section analyses the current state and key drivers in Advanced Manufacturing by describing:

(a) the Swiss research landscape in AM,

(b) the operating environment of Swiss companies engaged in AM.

According to the CSIRO report that sketches comparative advantages and disadvantages for Australia, we apply the logic of comparative advantages and disadvantages in the advanced manufacturing sector for Switzerland (though without having conducted a survey but drawing on the CSIRO report in combination with expert interviews).

Table 6: Switzerland's comparative advantages and disadvantages in advanced manufacturing

Comparative Advantages	Comparative Disadvantages
Education and research skills	High labour costs and high property costs, difficult conditions for exporters due to a very strong currency
Quality and standards, Swissness, public perception	Small and rather dispersed domestic market
Agile and internationally connected SMEs	Risk averse culture (not "early" adopters) on high-tech innovations
Political and economic stability	Digital infrastructure (partially) behind schedule compared to other economies with high-tech industries (Singapore, China)
Intellectual property laws	No (geographical) direct access to Asia
Culture of innovation in the manufacturing sector	Lack of natural resources
Reputation as a manufacturer world-wide: Across first world countries, Switzerland has one of the highest GDP shares in manufacturing despite high labour costs and despite the strong currency (Gates, Gampenrieder, Mayor, & Simpson, 2018)	Integration in the European market not secure for the long-term future

Source: Adapted from the CSIRO report (CSIRO, 2016)

Several industries have strong dependencies with progresses in advanced manufacturing: aerospace & defence, agriculture, automotive, chemicals, computers & electronics, semiconductors & watches, engineering, micro- & nano-technology, industrial equipment, food & beverages, infrastructure, construction, health, pharma & biotechnology, mining, oil, gas & energy, textiles. Not all of these industries are important for the Swiss economy (of low or no importance are mining or natural resources, for instance).

4.2.1 The Swiss research landscape in AM

This section mainly relies on an overview published by the Swiss Academy of Engineering Sciences SATW (Schweizerische Akademie für technische Wissenschaften, 2016). The report identifies 41 tertiary research and education institutes at Swiss universities that engage in AM and 57 institutes at universities of applied sciences. Advanced Manufacturing (AM) is split into two main areas of research and engagement, additive manufacturing and industry 4.0 (see Figure 1).

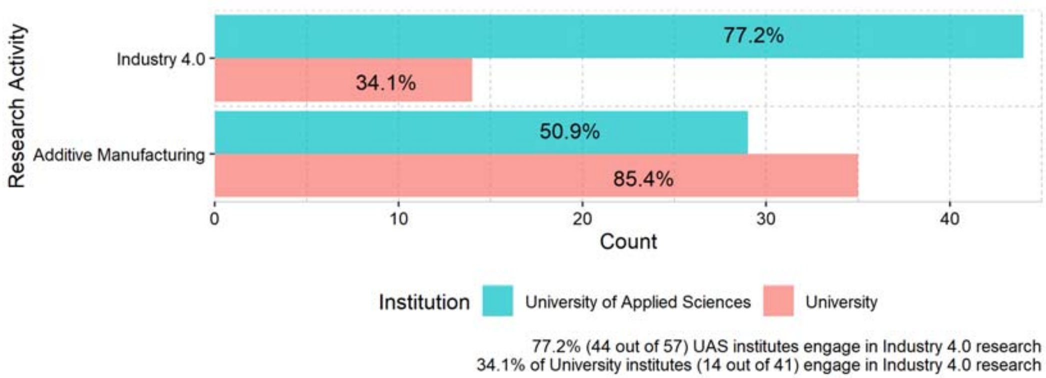
Additive manufacturing includes manufacturing procedures that use a three-dimensional model to construct components in layers from a formless substance. The break-down of construction of a 3D-object into 2D layers means that the complexity of a particular component has a very minor impact on constructability and production costs. This leads additive manufacturing to be subject to several advantages such that small batches can be produced economically, that there is a huge degree of freedom in design for engineers and that products can be produced in a customised way. Switzerland has, although being a high-cost country in terms of labour costs, one of the largest shares of GDP in the manufacturing sector compared to other first-world countries. The production possibility of small tailor-made batches without big cost-impacts thus strengthens the comparative advantage of Switzerland in manufacturing.

Key engagement fields of research in additive manufacturing, according to SATW (2016), are research in additive manufacturing procedures in a narrow sense, e.g. selective laser sintering technology for the manufacturing of plastic products or selective laser melting for metallurgic components). However, also various other fields that center on the industrial use of additive manufacturing in order to improve the whole value chain of a product are common. Those research activities particularly involve applications of additive manufacturing in architecture, bio-printing, but also data acquisition at the intersection to Industry 4.0 applications: e.g. predictive maintenance, tailored design with customer interaction, but also tailored characteristics with the help of nano-structures, new business models that cover the whole value chain from the supplier to the customer (customer interaction) as a management topic, process improvements, legal aspects and others.

Advanced Manufacturing can thus be seen as an interaction of additive manufacturing and research in Industry 4.0 applications, which aim at collecting process data through high-performance sensors that can be used to influence the processes themselves (Figure 5). At the value chain level, this implies that entities must be connected with each other through high-performance wireless connection with both big up- and download capacity and small latency in order to achieve real-time information on the state of the value chain (Internet of Things IoT).

Figure 1 distributes 41 university institutes and 57 UAS-institutes on the two domains of AM, additive manufacturing and industry 4.0. Accordingly, university institutes more frequently perform research in additive manufacturing, UAS institutes more frequently related to Industry 4.0 (due to multiple responses percentages do not add up to 100%).

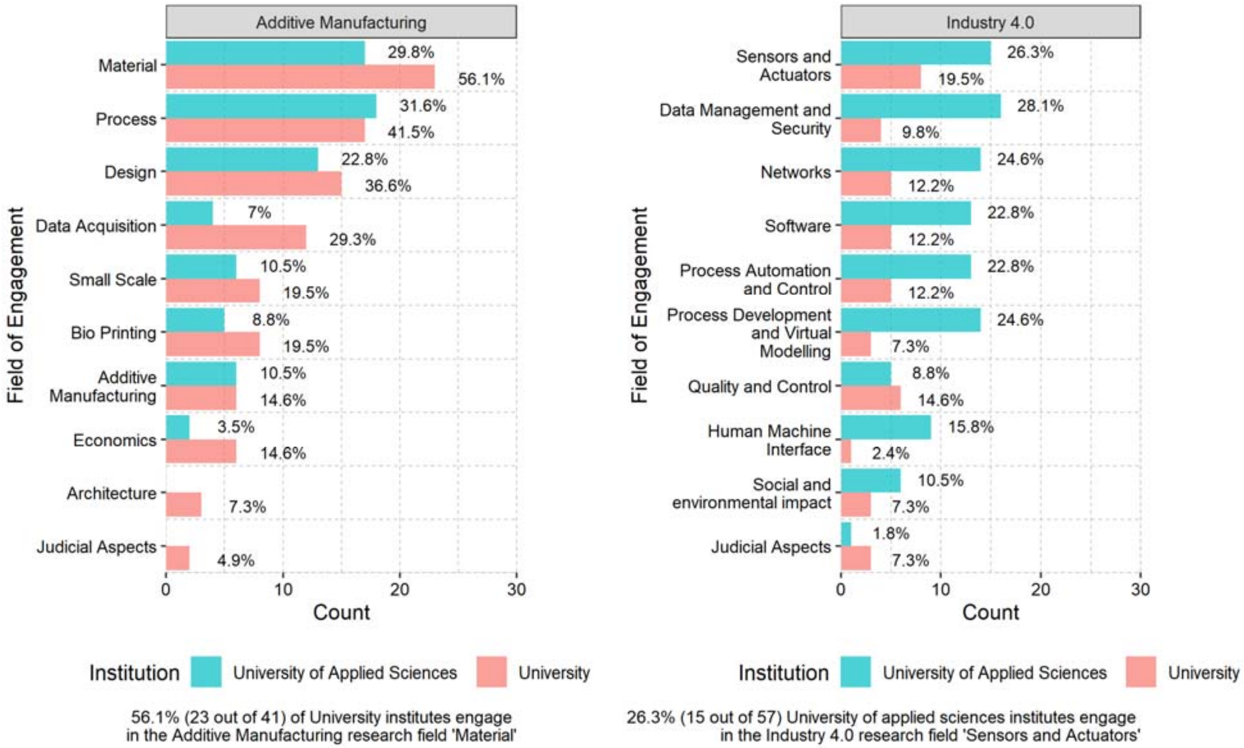
Figure 1: Swiss university and university of applied sciences (UAS) institutes by domain of research activity



Source: Authors based on data from SATW (2016).

The fields of research are further differentiated and sorted by the share of institutes doing research in a field (Figure 2). In additive manufacturing, material-related research (customization of characteristics), process-related research and design are the fields with the highest frequencies. In the domain of Industry 4.0, current research takes place to roughly equal shares on the construction of new sensors and actuators, data management and security, networks, software, process automation and last but not least virtual modelling.

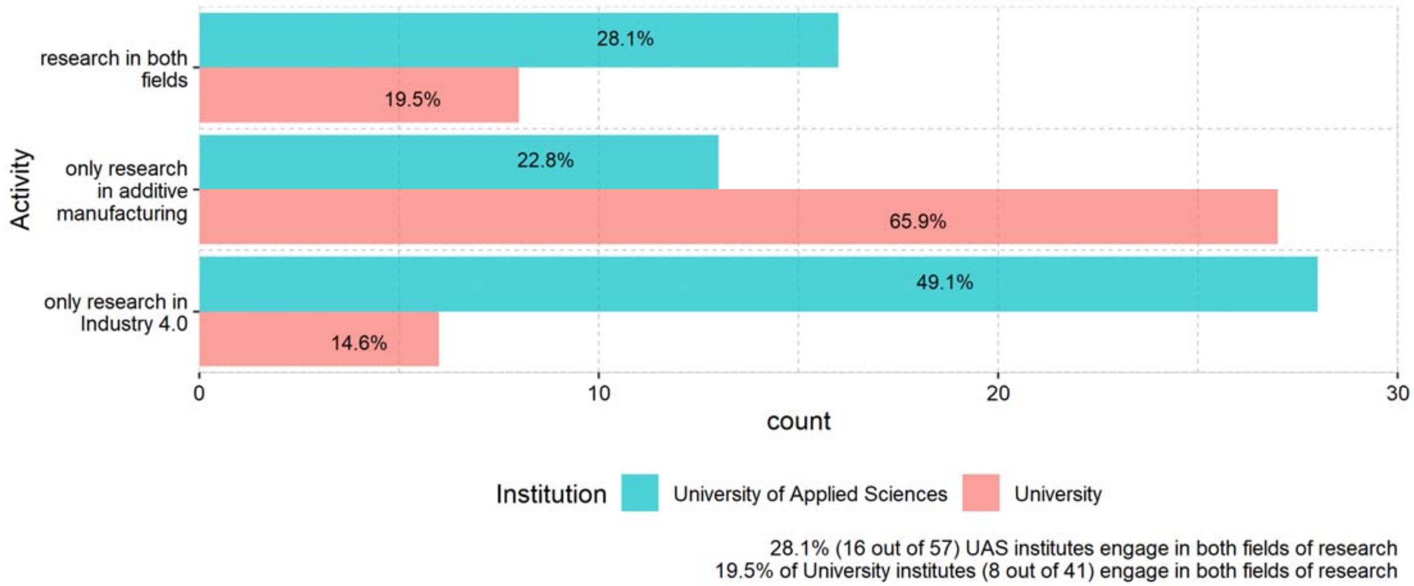
Figure 2: Swiss university and university of applied sciences (UAS) research groups by fields of Additive Manufacturing and Industry 4.0



Source: Authors based on SATW (2016).

Again, the two domains of AM research are interconnected. The 98 institutes in total participated according to SATW (2016) in 320 research activities, yielding an average of 3.3 fields of activity per institute. 40 institutes indicated that they only perform research in additive manufacturing, with an average of 3.0 activities per institute. 34 Institutes indicate only to perform Industry 4.0 related research, with an average of 2.7 activities per institute. The remaining 24 research institutes do research at the intersection of additive manufacturing and Industry 4.0. Institutes belonging to Universities of Applied Sciences significantly more often engage at the intersection of both domains (Figure 3). Only 14.6% of University institutes engage in both Industry 4.0 research and additive manufacturing, while for UAS institutes, this share accounts for almost 50%. In total, as mentioned, 34 institutes are researching in both domains.

Figure 3: Interconnectivity of research branches on AM



From Figure 4 we can see that for instance 4 research institutes mention that on the same time they perform research in 'Data Acquisition' (additive manufacturing) and 'Sensors and Actuators' (Industry 4.0). Generally, the overlap between additive manufacturing and Industry 4.0 is driven by Process and Design research in combination with data acquisition, sensor and actuator research and process automation within the Industry 4.0 branch.

Figure 5 illustrates currently ongoing research activities in advanced manufacturing and explicitly splits the research field into two branches: additive manufacturing and Industry 4.0. This representation of the AM landscape has been used in the expert interviews in order to define or delimit other activities that experts consider relevant for the industry.

Figure 4: Co-Research-Activities between Industry 4.0 and additive manufacturing

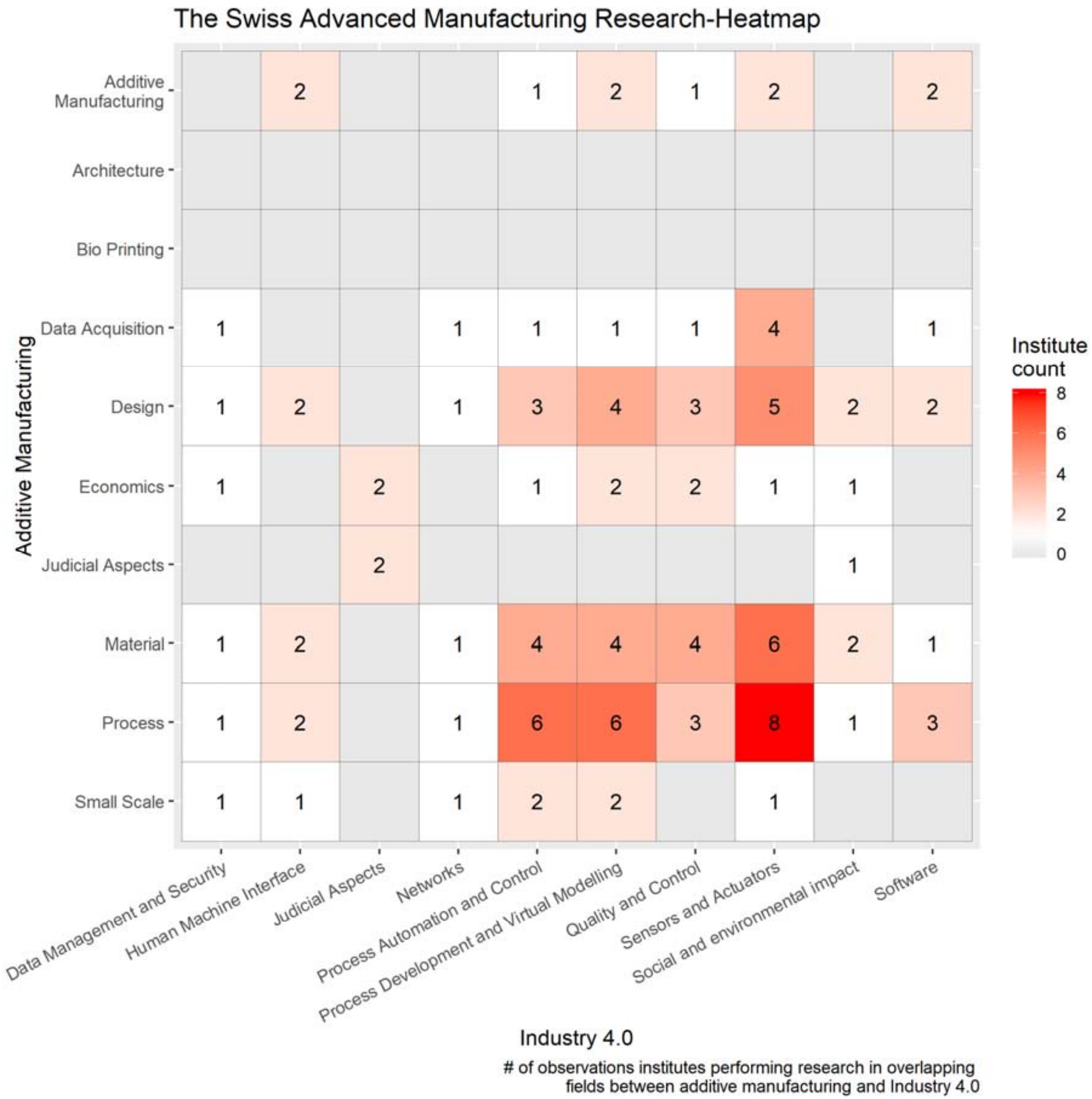
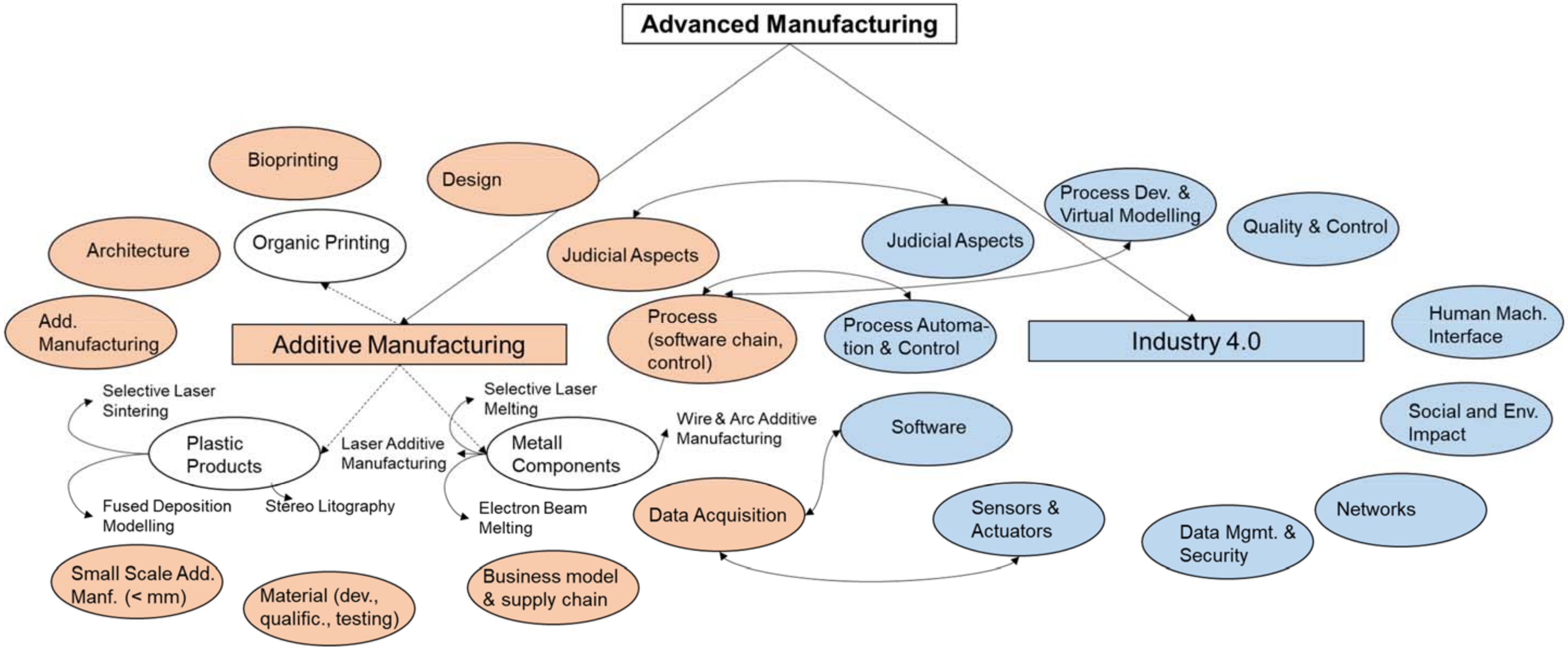


Figure 5: The Swiss Advanced Manufacturing Research Landscape, own illustration



Source: Authors based on SATW (2016)

4.3 Expert Interviews on Advanced Manufacturing

We conducted seven interviews with industrial and research experts in order to obtain an external view on

a. the definition and understanding of advanced manufacturing
b. trends in advanced manufacturing and potential gaps in Swiss advanced manufacturing, both in industry and research
c. the the AM-TTC initiative itself and its suitability with regards to new center applications to boost strengths of Swiss advanced manufacturing in industry and research

Initially, it was planned to conduct 10-15 interviews. Due to the limited timeframe of the present report and the tight schedules of potential interviewees, only seven interviews could be conducted and evaluated. Table 25 in the annex (p. 82) presents the seven experts with whom interviews were held. They were chosen from an initial sample of 35 persons from industry and research, which was identified using documentation on the Swiss Advanced Manufacturing Group (SAMG), the Swissmem network and websites of chambers of commerce. In addition, the sample was constructed to include experts from both industry and research, experts from different industries as the metallic, chemical and mechanical engineering industry while at the same time assuring that the included experts show only little or no direct involvement in the AM-TTC initiative with regard to the evaluation of the new center applications. Approximately one third of contacted experts replied to our request for scheduling an interview date, two experts were excluded after the initial contact due to potentially too tight involvement in one of the new centers. Nine remaining experts agreed on an interview appointment and with seven experts the appointment could be scheduled on time. Interviews were planned to last between 45 and 75 minutes. All experts apart from one have experience of ten years or more either in the industry, in research or in both fields. The minimum amount of professional experience is five years. We describe expert opinions related to parts (a) and (b) in this subsection and opinions related to suitability of the AM-TTC initiative as a whole in subsection 5.6.

Parts a and b: The first part of the interview focuses on the experts' understanding of advanced manufacturing and experts were asked to summarise their own view on AM first and subsequently were confronted with Figure 5 and asked to give their opinion on the suitability of this representation of industrial and research topics related to advanced manufacturing.

Main findings on experts' view on advanced manufacturing

- Experts judged the split of AM in two main fields of activities - additive manufacturing and industry 4.0 activities related to process innovation - to be a strongly research-driven view. From an industrial perspective, also basic or conventional production processes as drilling, milling, or grinding along with industry 4.0 process innovations are within the scope of AM.
- Hot topics identified by all experts are quality assurance and quality management of advanced manufactured components, together with process-innovations that improve the production process up- and down-stream in terms of quality management and standardization.
- Approximately half of experts stated that not enough research is done in the fields of quality management and standardization while the other half thought that although relevant research projects may be ongoing, technology transfer to the industry and particularly to SMEs is not efficient and up-to-date knowledge on innovations is not spread in a proper manner within the industry.
- The lack of standardization was identified as the most important impediment to a successful penetration of AM into highly-regulated industries such as medtech or aerospace.

Three out of seven experts felt initially insecure about the term 'advanced' manufacturing and guided the conversation to 'additive' manufacturing. However, all experts mentioned that AM should be a combination of an additive manufacturing technology along with a process innovation related to either quality control, data collection and usage for process improvement, standardization of products and processes. Four experts mentioned the keywords 'industry 4.0' or 'internet of things (IOT)' as a necessary combination with additive manufacturing technologies in order to define the term ‘advanced manufacturing’. Three experts stated that research efforts are not well enough communicated to the industry and industrial experts say that SMEs often are limited in human and financial resources to actively take part in technology transfer. One expert criticized the transformation from CTI to Innosuisse explicitly with regard to the expertise of the project evaluation committees, with regard to the allocation of financial resources to industrial project participants and with regard to bureaucratic difficulties when it comes to flexible project durations or similar. Also, the expert has addressed impediments such as high bureaucratic effort needed for participation in EU research projects.

The majority of experts evaluated Figure 5 as a suitable representation of ‘hot topics’ in AM at the first glance. Three experts mentioned that the figure appears as too strongly research-driven compared to what industrial activities are concerned with. All experts mentioned the importance of material research, qualification and testing of materials in the advanced manufacturing framework and that more efforts in technology transfer to industry would be desirable. Three experts explicitly identified the lack of effort in material research as an impediment for AM to penetrate the industry more effectively. Five out of seven experts insisted on the importance of process control up- and downstream of the production process itself. Much more research effort in process and production standardization should be done and the lack of standardization rules is probably the most important impediment for advanced manufacturing to more deeply penetrate strongly regulated industries such as aerospace and medical engineering. The majority of industrial experts believe that current research too strongly focuses on hyped topics related to process communication (IoT) and too little on conventional fields such as material qualification and standardization of production processes. This opinion seems to be somewhat contradictory to findings upon analysis of the SATW report (2016) as depicted in Figure 3 and Figure 4, but rather congruent to aforementioned opinions that industrial SMEs, cannot efficiently enough take part in the technology transfer with research institutes. Two experts, both having an industrial expertise, stated that in their opinion more should be done with regard to the standardization of processes from a legal point of view (focussing on judicial aspects). One expert addressed judicial aspects from the industry 4.0 perspective: Who owns the data collected from machines sold to customers and operating at customer sites? The expert said that substantial legal uncertainty is hindering process innovations in process communication, data collection, data management, data acquisition and especially in predictive maintenance of machinery equipment.

Three experts stated that from an industrial perspective, it is important to augment Figure 5 with conventional processes as drilling, grinding and milling, since practically all additive manufacturing production processes impose the necessity of post processing with conventional production. They stated that therefore, also innovations in conventional processes should be considered AM activities. Two experts also detailed that in their eyes it is not necessarily a basic requirement to combine industrial 4.0 activities with production innovations, but that also process innovations on the industry 4.0 side alone can be understood as advanced manufacturing as long as the production process takes place in Switzerland.

Main findings on experts' opinions on strengths and weaknesses of Swiss advanced manufacturing

- Advanced manufacturing still represents a valid chance for the Swiss manufacturing sector.
- SMEs must better be integrated in technology transfer from research to industry, which is currently being judged as inefficient due to (a) the small size of research institutions, (b) research between institutions not being sufficiently coordinated in terms of ambiguity or lack of complementary nature of research activities, (c) a too strongly industry-driven research landscape from large companies (pull from large companies, no push from research institutes, no or very minor pull from SMEs) and (d) limited human and financial resources in SMEs.
- Manufacturing could grow in Switzerland since AM production processes are not cost-intensive from a human resource perspective.
- Key success factors for advanced manufacturing in Switzerland are less about technology and more about education. The Swiss dual education system with the professional apprenticeship is well suited for a shift to AM, but the fact that additive manufacturing technologies have not yet penetrated vocational education of mechanics, technicians, designers, or constructors and that almost exclusively conventional manufacturing processes are taught at vocational schools is a very important impediment.
- Three experts clearly stated that they do not believe that infrastructure provision to SMEs is a major concern as third party providers of production services already exist, but rather education of target persons in SMEs, research in quality and process control of up- and down-stream processes and more efficient technology transfer from research to SMEs would play a crucial role.

We asked experts also to identify strengths and weaknesses of the Swiss advanced manufacturing landscape, both in industry and research, and point out potential reasons. Basically, all experts rated AM as important for Swiss industry as a whole and as a chance to (re-)strengthen the Swiss manufacturing sector. On the industry side, experts agreed on the fact that particularly industrial SMEs do not know (well enough) the current focus areas in research. To keep the Swiss manufacturing sector alive, the industry must manage the transition to AM, which according to experts would only be feasible if SMEs are well integrated into technology transfer activities. From this point of view, they also judged that the AM-TTC initiative can generate added value for the manufacturing sector. Two experts criticized that up to now research results are not communicated to industry by research institutes. In their eyes this is a consequence of a strong pull from large (research-intensive) companies with large financial resources. Research results accordingly do not find their way to SMEs. Potential reasons to this shortcoming that are mentioned are (a) too small research institutions, (b) uncoordinated research between institutions, and (c) a too strongly industry-driven research landscape (pull from large companies, no push from research institutes). One expert also mentioned that in his eyes the formerly strong research institutions in engineering have focused more and more on 'hyped' research topics and less on engineering. Thus, engineering research institutions got smaller and smaller and are worse equipped with financial resources compared to former decades and dominantly seek research funds from large enterprises. Also, two experts stated that the research institutions' "thirst" for third party funding renders research activities uncoordinated among institutions and that several activities thus are not complementary but rather of substituting nature. The experts believed that the communication of research results to industry through conferences and fairs is better coordinated in Germany due to a few large players in research, rather than many small institutes as it is the case in Switzerland.

Two experts were sceptical about the Swiss industry's flexibility and willingness to adopt new production technologies. Typically, SMEs are either not willing nor find it beneficial to pursue the effort of gathering the necessary experience and therefore outsource the production activity to a few third party service providers. One expert actually works at such a third party service provider claiming that companies (SMEs) that were not involved in additive manufacturing technologies up to now will never engage in it, since the barriers for building up application knowledge are too high already.

Three experts mentioned the Swiss education system, both in terms of strengths and weaknesses: One expert stated that the Swiss dual education system with the professional apprenticeship is well suited for making the shift to AM, stating that professional attitude and quality assurance would still be strong Swiss employee characteristics that are needed for a successful advanced manufacturing sector. Two other experts criticized the fact that additive manufacturing technologies yet did not penetrate education of designers, constructors and engineers and that almost exclusively conventional manufacturing processes are taught, apart perhaps from tertiary education. Another expert finds that without proper education of the technology users, the market potential for advanced manufacturing technologies cannot increase since technologies (as metal printing) were, in his eyes, developed rather research-driven than industry-driven and that the industry would need to find relevant fields of applications on its own. Accordingly, the same expert believes that the initiative which aims at bringing advanced manufacturing technologies more closely to SMEs will probably not succeed since relevant human resources as designers and engineers in SMEs are not well enough educated in terms of possibilities of these technologies. In addition, two experts again mention the importance of more research being undertaken in quality assurance, process control and standardization of processes, since highly regulated sectors will not adapt advanced manufacturing technologies even if it were beneficial unless standardization issues are resolved. Summing up, three experts clearly state that they do not believe that infrastructure provision to SMEs is a major concern as third party providers of production services already exist, but rather education of target persons in SMEs, research in quality and process control of up- and downstream processes and more efficient technology transfer from research to SMEs might play a more crucial role. Therefore, of potential less key relevance for the new center applications is infrastructure, but more partner structure (variety among industries and depth within industries), experience in technology and knowledge transfer. Most important seems to be additional value creation down- and up-stream of production and provision of infrastructure alone, being efforts in quality and process control of potentially already mature technologies and standardization of processes for the industry.

5. Analysis of the new center applications

5.1 Overview of the centres

The Federal Act on the Promotion of Research and Innovation (RIPA) foresees in its Article 15 contributions to research facilities of national importance (https://www.admin.ch/opc/en/classified-compilation/20091419/index.html). According to Article 15(3) these research facilities may either be

a. *non-commercial research infrastructures* based outside higher education institutions or which are associated with them (in particular auxiliary scientific services in the field of scientific and technical information and documentation);
b. *non-commercial research institutes* based outside higher education institutions or which are associated with them;
c. *centres of technological excellence* which work with higher education institutions and businesses on a non-commercial basis.

Art. 15(4) formulates two funding requirements which are that the facility performs tasks of national importance which cannot be carried out expediently by existing higher education institutions and other institutions within the higher education sector and that it receives substantial funding from cantons, other public institutions, higher education institutions or private persons and legal entities.

The AM-TTC initiative formulated as its main aim “to build the competences and facilities that are currently missing to upscale and transfer new manufacturing technologies from science into industry” (https://www.am-ttc.ch/). The initiative aims to close the gap between lab research and industrial application by operating a network and alliance of centers which offer an open access to technology transfer infrastructures. The technology transfer centers are planned to be positioned between public research organizations and industrial companies. They have been designed as public-private partnerships receiving public and private funding for their establishment and operations.

This description is in accordance with Art. 15 and determines the character of the AM-TTC centres as centres of technological excellence according to Art. 15(3c) – and not as research infrastructures (3a) or research institutes (3b). Still, providing access to infrastructure plays a strong role in the center idea, however not primarily for serving research, but for upscaling lab-scale prototypes and demonstrators, or developing product and process pilots.

In this section we give an overview of the five new centers, in part also comparing them to the established centers CSEM and inspire. We look at their partner structure, the planned revenues, the governance schemes, and their planned missions and services.

5.1.1 Partner structure

The structure of the partners included in the new center applications is shown in Table 7 and Figure 6. We counted partners at the level of the organisation, i.e. several institutes of ETH Zurich participating in one project were counted as one partner only.

Overall, 89 partners have been listed by the centers, however without controlling for duplicates, i.e. partners participating in more than one of the new centers are counted more than once in the total. m4m is the largest center with 30 participants and a slight majority coming from industry. M2C is the smallest center with nine partners, three from research, four from industry, and one NPO.

Table 7. Partner structure of the new centers as of Dec. 1st, 2019

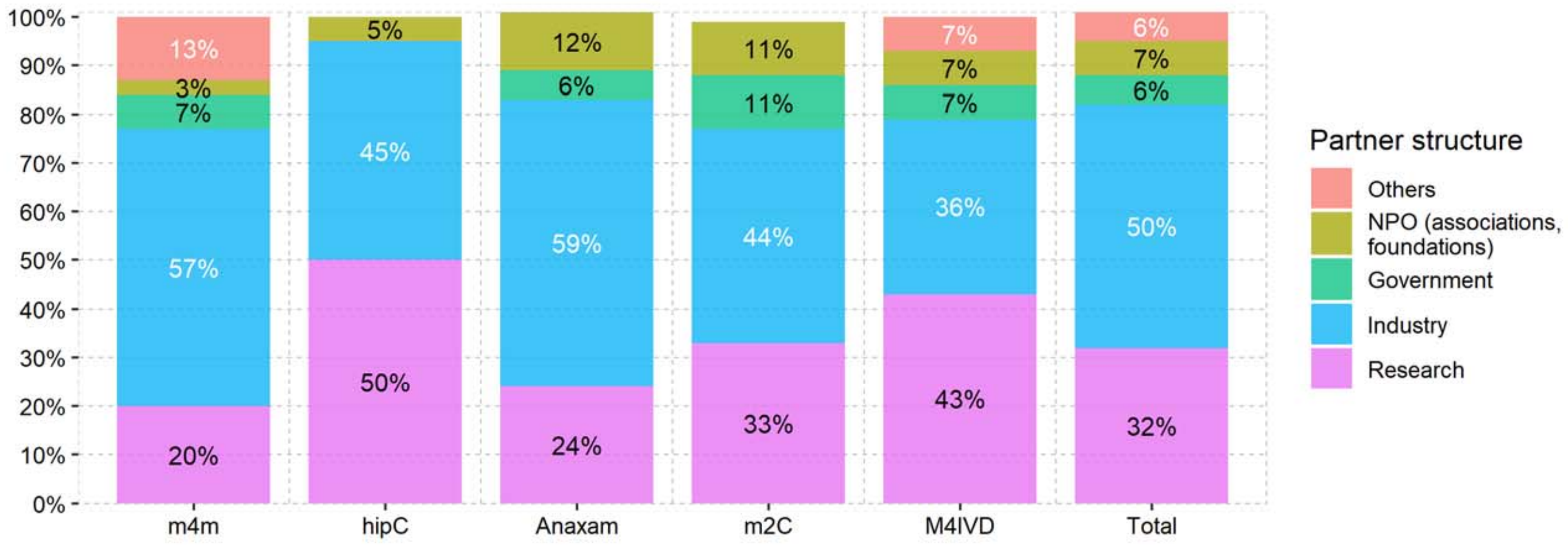
	m4m	hipC	M2C	Anaxam	M4IVD	Total new centres
Research	**6**	**10**	**3**	**4**	**6**	**29**
ETH domain	1	2	1	1	1	**6**
Universities	1	–	–	1	1	**3**
UAS	3	4	1	1	2	**11**
Others	1	4	1	1	2	**9**
Industry	**17**	**9**	**4**	**10**	**5**	**45**
Application community	13	8	4	9	1	**35**
Suppliers & consultants	4	1	–	1	4	**10**
Government	**2**	**–**	**1**	**1**	**1**	**5**
Federal	–	–	–	–	–	**–**
Cantonal	2	–	1	1	1	**5**
Municipal	–	–	–	–	–	**–**
NPO (associations, foundations)	**1**	**1**	**1**	**2**	**1**	**4**
Others	**4**	**–**	**–**	**–**	**1**	**7**
Clinical partners	4	–	–	–	–	**4**
TOTAL	**30**	**20**	**9**	**17**	**14**	**90**
Lead partner	Company	Other research	ETH domain	ETH domain	Other research	–

Source: Survey of centers.

As Figure 6 illustrates, partners from industry are the biggest group with approximately three quarters of the partners coming from the application community and the remaining partners serving as suppliers and consultants to the centers (plus eventually their customers). Research institutions are the second most important group of partners, with universities of applied sciences and other research institutions dominating. However, institutions from the ETH domain are also present in all centers. All five centers have participants from non-profit organizations, three from (cantonal) governments, and m4m additionally has four clinical partners.

The centers with the most diverse partner structure are m4m and M4IVD (Figure 6). The centers with the strongest participation from industry (in relative terms) are ANAXAM and m4m. hipC and M4IVD have the strongest representation from research.

Figure 6. Partner structure of the new centers as of Dec. 1st, 2019

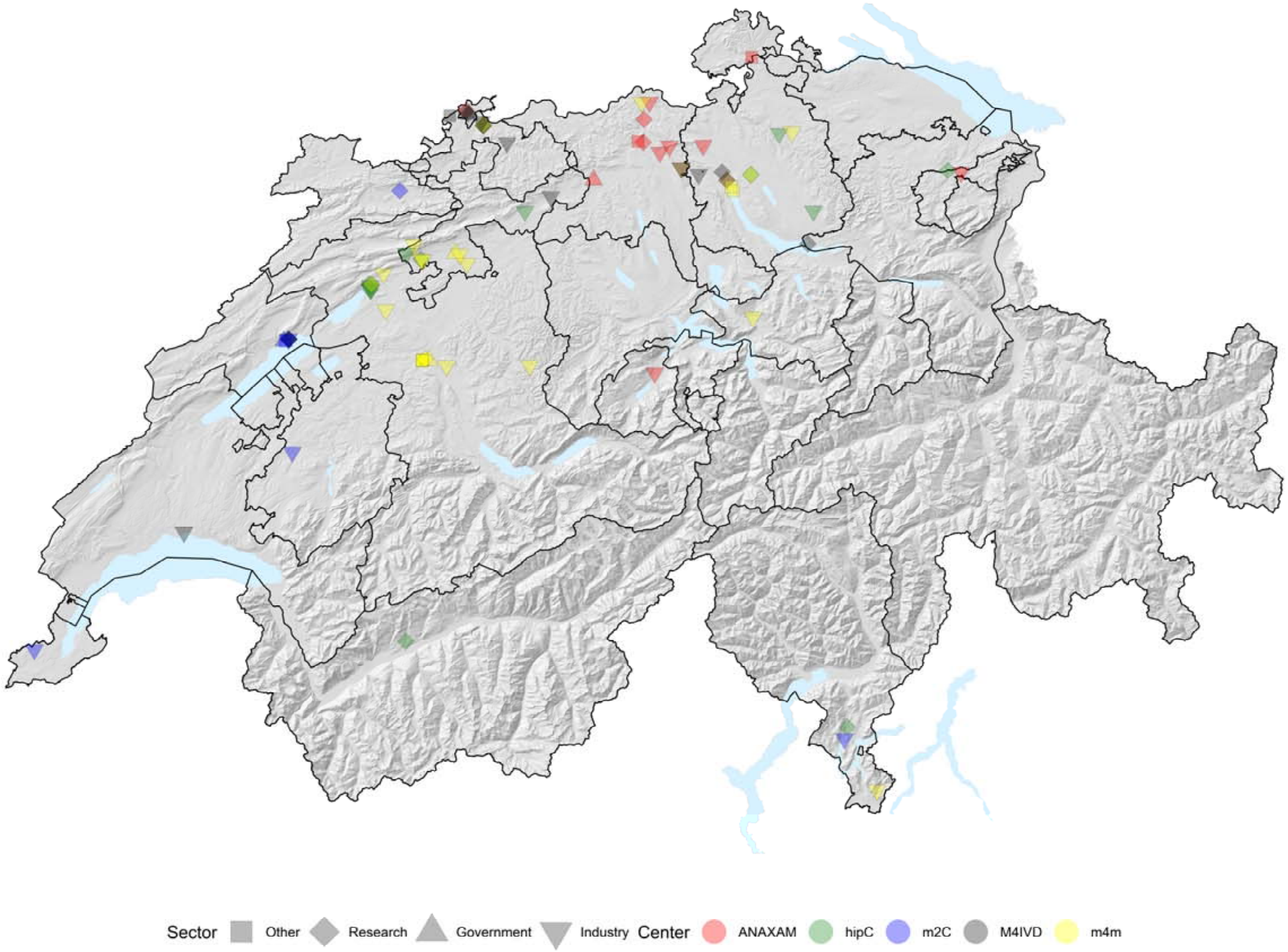


Source: Own calculations based on survey of centers.

The geographical distribution of the partners of the new centers shows strong concentrations in the cantons of Zurich, Aargau, Bern, Solothurn and Basel (BS and BL) (Figure 7). Some centers are geographically concentrated: ANAXAM has a strong presence in the vicinity of the PSI in the canton of Aargau, m4m is more widely distributed lacking however partners in eastern and western Switzerland. M2C is not present in the German-speaking part of Switzerland with 50% of its partners in the canton of Neuchâtel. hipC and M4IVD have the widest coverage geographically, though in the case of MI4VD 8 out of its 14 partner organizations are based in either of the two Basle cantons.

Even though without doubt customers of the centers are not evenly distributed across Switzerland, but are clustered according to the concentration of industries, it seems that above all the centers that aim for providing services in knowledge fields beyond specific products and industries, hipC, M2C and ANAXAM (see Table 11, p. 48) should aim for a broad national presence. The examples of CSEM and inspire also point in this direction, as both have established further regional branches outside their headquarter cantons in recent years.

Figure 7. Geographical distribution of the partners of the new centers



Source: Own elaboration based on survey of centers.

5.1.2 Funding structure

The following Table 8 and Figure 8 summarise the revenues 2019-24 projected by the five new centres according to the application documents in thousand CHF and in percent. As three of the five centers, hipC, M2C and M4IVD, did not obtain the requested funding from the ETH board, they would have to come up with new budgets which compensate for this. Out of an accumulated total budget of more than 80 mCHF the centers have planned to finance more than half (54%) from public or private sources. 24 mCHF (30%) have been requested under Art. 15 RIPA funding and a small share of 4% overall shall be obtained from competitively acquired public research funding. Approximately CHF 10 million of funding was planned for 2019-20 to come from the ETH board (none in 2021-24) of which, however, more than half was not granted.

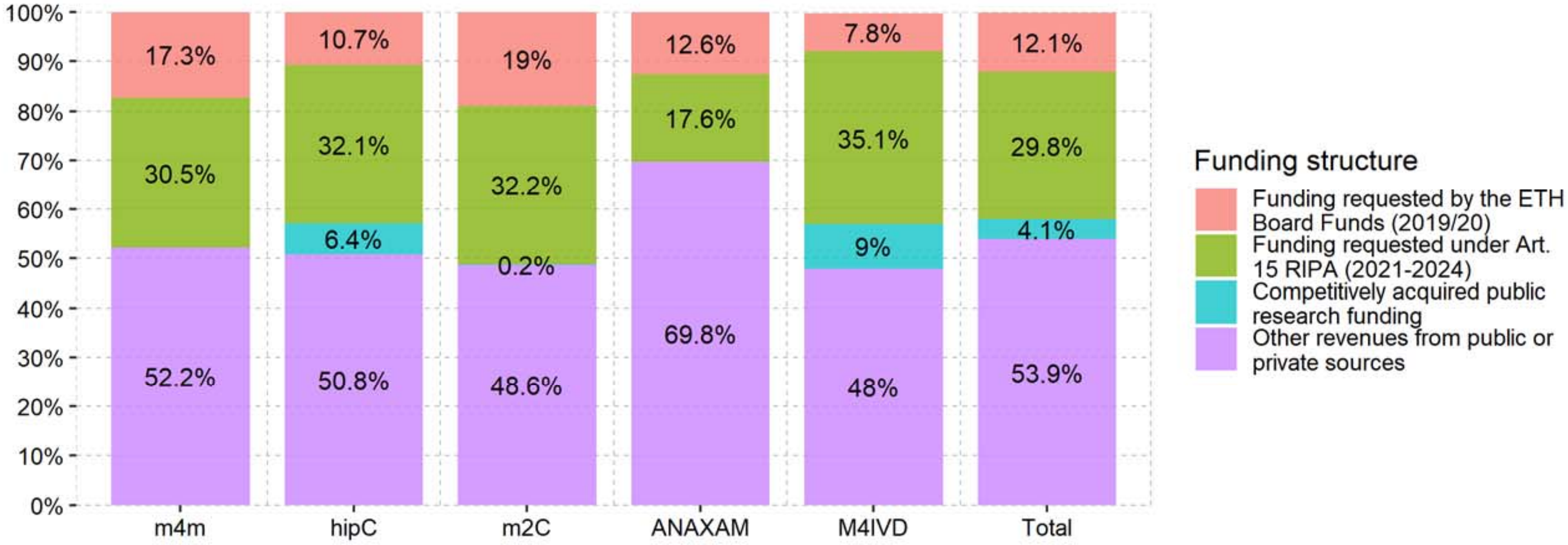
For the total and all types of revenues M4IVD has put together the largest budget. M4IVD also projected significant public research funding of 9%. ANAXAM is the second largest project with regard to overall funding, but with CHF 3.2 million (13% of total funding 2019-24) it has requested considerably less in relative terms than the other centers under Art. 15 RIPA (Figure 8). Hence, the leverage effect is the biggest for this center: CHF 1.00 under Art. 15 generate additional CHF 4.70 of revenues/expenditures for AM from other sources.

Table 8. Revenues 2019-24 in kCHF

Revenue type	m4m	hipC	M2C	ANAXAM	M4IVD	TOTAL
Funding requested by the ETH Board Funds (2019/20)	2'500	600	1'800	2'300	2'590	**9'790**
Funding requested under Art. 15 RIPA (2021-2024)	4'400	1'800	3'060	3'200	11'678	**24'138**
Competitively acquired public research funding	0	358	19	0	2'986	**3'363**
Other revenues from public or private sources	7'542	2'844	4'618	12'704	15'968	**43'676**
Total revenues	**14'442**	**5'602**	**9'497**	**18'204**	**33'293**	**81'038**

Source: Application documents.

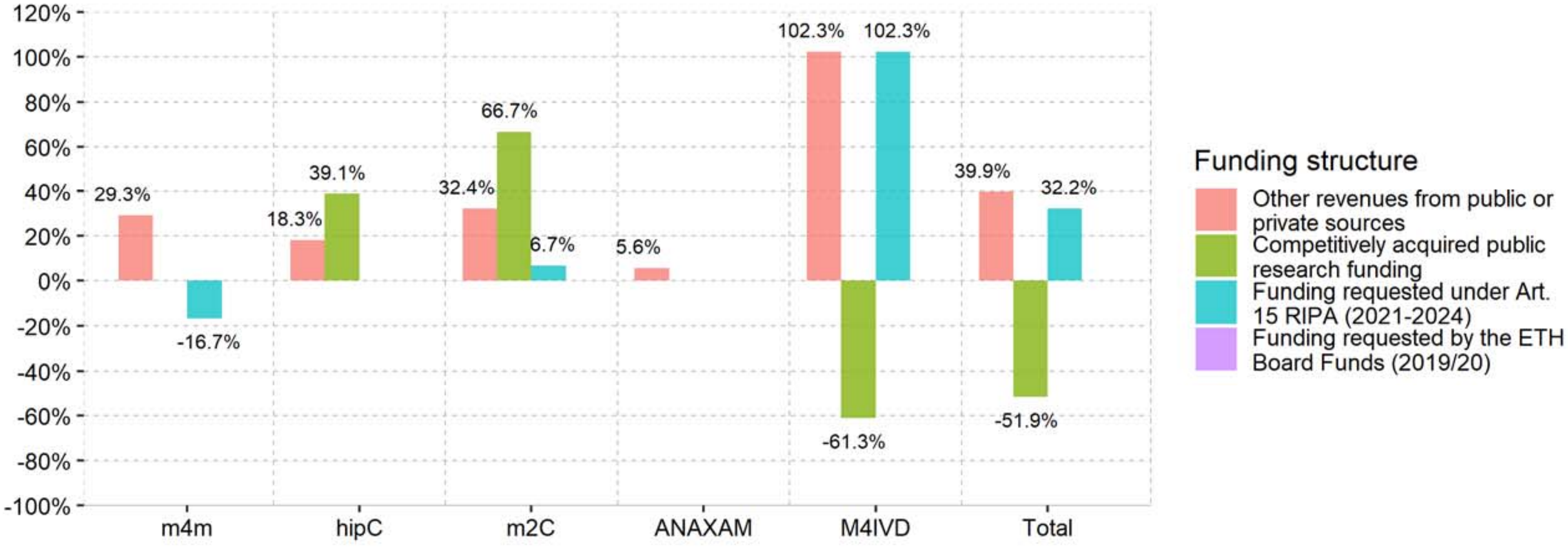
Figure 8. Revenue structure 2019-24 in %



Source: Own calculations based on application documents.

In Figure 9 we show the planned revenue development of all centers for the Art. 15 RIPA funding period 2021-24 in percent. Due to the size of M4IVD it influences very much the total for all centers: M4IVD foresees growing funds from Art. 15 and other revenue sources, whereas competitively acquired research funding is expected to go down. All centers expect growing revenues from other public or private sources. hipC and M2C expect to acquire more funds in 2024 than in 2021 from public research funding, however, it should be noted that the large relative increase of 67% for M2C reflects in absolute numbers an increase from 3'000 to 5'000 CHF contributing only a marginal share of 0.2% to its total budget. m4m is the only center that plans to request less under Art. 15 RIPA in 2024 than in 2021 (-17%).

Figure 9. Planned revenue development 2021-24 in %



Source: Own calculations based on application documents.

The centers were asked in the structured questionnaire to explain in detail their revenue models: *“Please explain in detail the revenue model of the center, i.e. how revenues are generated from the use of the infrastructure and the provision of services.”*

The replies by the centers suggest in most cases fee-for-service models, where services are unbundled and revenues are distributed according to the use time of infrastructure, type of service, and provider (Table 9). Two of the new centers, hipC and M2C, also pointed out that they intend to rely on in-kind service provisions of their partner organizations, which will be charged to customers. M4m intends to participate with its infrastructure and personnel in development collaborations along the process and value chain of designing, manufacturing, supplying and using 3D-printed implants and other medical devices.

The revenue models of the new centers differ clearly from those of the two established centers, inspire and CSEM: the latter rely on R&D and transfer projects funded directly by clients from industry or funding organizations like Innosuisse or the European Union. Both organizations also pointed out, that for different reasons the infrastructure itself does not generate significant revenues. This raises doubts with regard to the feasibility of all revenue models, especially those of hipC and M2C, which are additionally partly based on free services provided by the partner organizations.

We asked the centers to justify their Art. 15 RIPA application. The replies stress the costs of the equipment (hipC), the higher accessibility of the equipment than in research organizations (M2C), the need of equipment that is additional to the already existing research infrastructure at the center’s partners to obtain full benefits from the infrastructures (ANAXAM), and last but not least the costly set-up of ISO 13485 certified pilot manufacturing lines (m4m, M4IVD).

Table 9. Revenue models and Art. 15 RIPA contributions

	m4m	hipC	M2C	Anaxam	M4IVD	Inspire	CSEM
Revenue models	Revenues will be generated through participation in development collaborations, access to the 3D pilot manufacturing line at an hourly rate, offering consulting, support and training services.	Revenues will be generated through selling customized hip cycles, high tech investigations (contributed for free by hipC’s partners), consulting and engineering services, as well as by organizing events and an annual HIP conference.	Revenues depend on a critical mass of partners and clients. Initially, training services, the sale of machine and instrument time, the provision of consulting and project management services, and the manufacturing of pilot series of components or systems will generate revenues; in a later phase membership fees might be levied. Other income can be generated through characterization and performance tests on products (relying on the partners’ capabilities). Pilot scale manufacturing equipment could be offered to end-users.	Drawing on PSI experience, customers were classified into 3 types: low, medium and high in terms of value, including a breakdown of the cost/ value split between new infrastructure investments, PSI infrastructure (e.g. Beamtime/Cleanroom costs), data analysis and general admin costs.	Fee-for-service model will be established, due to the long-term nature of IVD developments.	Income mainly stems from transfer projects with industrial customers (Innosuisse, EU and bilateral projects) and industrial services. Income mainly covers the personnel costs of the project staff. Infrastructure costs are hardly chargeable and are covered by federal contributions under Art. 15c FIFG.	Main revenue source are R&D projects, financed either by funding agencies (EU, Innosuisse) or by private industrial partners. Smaller revenues are generated from small scale production, and licensing. The infrastructure cannot be open (except for PhD students from EPFL-Neuchâtel), and therefore does not generate any significant revenues.
Justification for Art. 15 RIPA funding	To follow its mission, the Swiss m4m Center will require a funding contribution enabling to invest in best in class Additive Manufacturing equipment, highly qualified personnel and maintain	The very high cost of a HIP machine is prohibitive to do the research by just one or few partners. Nevertheless, the sharing of this costly HIP infrastructure in the hipC by the consortium	The infrastructures existing at M2C partner institutions is mainly equipment and instruments intended for research work. The use of these devices requires advanced training and access to	To allow industrial customers, especially SMEs, to profit from the complete analytical service chain several infrastructure gaps need to be closed. This is on the one hand the sample	To provide the service to innovative Swiss start-ups and spin-offs M4IVD needs to build a centralized infrastructure with an established quality management system according to ISO 13485,	The federal contributions under Art. 15c FIFG are of decisive importance for the maintenance and expansion of a modern infrastructure for research in advanced manufacturing.	–

	m4m	hipC	M2C	Anaxam	M4IVD	Inspire	CSEM
	an ISO 13485 quality management system. The investment will also support the center expansion during the period 2021 to 2024.	members and all other customers does not allow custom-tailored HIP and combined HIP-HT cycles to be performed at acceptable cost. The funding makes this research period possible, before the costly machine should be transferred to the service provider for industrial usage. Unfortunately, as can be seen in the application, the cycle costs must be increased at that stage as the funding is no longer available.	them is often, if not always, restricted to employees of research institutions. Thus, RIPA's contribution to the financing of the center is intended to equip the center with more secure and accessible equipment, which can be used by people with a technical background but not necessarily specialists in one or other of the center’s focus areas.	preparation infrastructure, the pre-characterization analytics on the laboratory scale. On the other hand, to perform each customized experiment with dedicated equipment is indispensable to guarantee the best possible experimental conditions. Such infrastructure could be devices that allow the investigation of a large quantity of samples, or measuring samples in-situ, in-operando or under various environmental conditions. This infrastructure could not be built, operated and maintained without the financial support under Art. 15 RIPA.	which requires significant investments.		
Possible services without Art. 15 RIPA funding	Without funding contribution (Art. 15 RIPA), it will be not possible to maintain the Swiss m4m Center activities after the period 2019-2020. It will not be possible to maintain a validated additive manufacturing supply chain according to ISO 13485 and maintain a sustainable customer base supporting the center’s activities and	Due to the fact of the high investment cost and operation cost of the machine, the financial risk cannot be taken by the consortium members. Therefore, if no Art. 15 RIPA funding is provided, the hipC will not go into operation as planned with combined custom made HIP and HT cycles. What the center can provide is the consulting at very low level	Without RIPA's contribution for the acquisition of equipment, the partners' contributions to the M2C are mainly in-kind and the center’s services would be those currently provided by its academic and research partners, namely collaborations and mandates with industry according to existing modalities (competitively funded projects and others). In this case, the center	The presence of a tailor-made sample environment is indispensable to let industry benefit from the analytical capabilities of ANAXAM. This tailor-made infrastructure would not be provided to the customers without Art. 15 RIPA funding. Simple services might still be possible, however it is then questionable, whether ANAXAM can achieve its aim of providing	We would only be able to provide consulting and prototyping services, based on the existing infrastructures of the partners like FHNW, ETHZ, UNI Basel, CSEM etc., without being able to pursue the original purpose of the association, i.e., provide pilot manufacturing services, which enter into the development towards clinical trials.	–	–

	m4m	hipC	M2C	Anaxam	M4IVD	Inspire	CSEM
	expansion during the period 2021 to 2024.	and high-tech investigations offered by some of the supporting members.	would have more difficulty in establishing its position and growth to ensure its role in technology transfer between research laboratories and industry.	technology transfer of the advanced analytics which Synchrotron and Neutron radiation to industrial customers.			

Source: Survey of centers.

5.1.3 Governance

According to the application documents two of the new centers (m4m and hipC) have been registered as companies and the three remaining centers are associations according to Art. 60 ff. of the Swiss Civil Code (CC). The two companies are public-private partnerships with shareholders from research and from the private sector (Table 10). This reflects the ownership structure of CSEM and inspire and can be considered state-of-the-art.

Table 10. Governance of the new centers, CSEM and inspire

	m4m	hipC	M2C	ANAXAM	M4IVD	Inspire	CSEM
Legal form	Corporation	Limited company	Association in accordance with Art. 60 ff. CC, to be converted into a limited company after 2021	Association in accordance with Art. 60 ff. CC	Association in accordance with Art. 60 ff. CC	Corporation	Non-profit public limited company (NPO)
Owners	Three initial shareholders: 41medical AG (40%), Empa (40%) and Berner Fachhochschule (20%); further shareholders can be permitted.	Two initial shareholders: Swiss Innovation Park Biel/Bienne (60%) and ProtoShape (40%).	–	–	–	(24 corporate shareholders mentioned)	27%: EPFL (on behalf of the ETH Board and the Confederation), NE (canton & city) 73%: org. from Swiss industry and the economy
Governing bodies	Board of Directors CEO installed by the Board (head of center management) Non-executive Advisory Board	Board of Directors Steering/advisory panel General manager	Operational director at EPFL [Governance to be set up after funding decision] Strategic advisory board planned	Assembly of full and associate members Board of directors Executive Committees CEO Auditors	General assembly Board of directors Statutory auditors	Management Board of Directors 6 ETHZ chairs as research partners	Executive Board Board of Directors Scientific Advisory Board

Source: Application documents.

5.1.4 Delimitation of the technological innovation system

The literature on technological innovation systems stresses the importance of an adequate system delimitation prior to any analysis of its structures, performance, and eventual problems limiting performance (Bergek et al., 2008). As each of the centers pursues the aim of providing infrastructure-related services in innovation systems, it is important to get an understanding of the scope of these systems. Table 11 shows that the innovation systems differ between the centers:

- Three centers see their contributions to particular knowledge fields. These fields can be very specific, like hot isostatic pressing (hipC), or more generic, as in the case of ANAXAM, which described its knowledge field as analytics in a wide sense. M2C is located in between.
- Two of the five new centers have a product-specific focus on metallic implants (m4m) or in-vitro diagnostic tests (M4IVD) in specific application areas. Overall, their technological innovation systems are more narrowly defined.

The established centres inspire and CSEM point to more generic knowledge fields and a large number of applications, for which their services have been used.

Table 11. Delimitation of the technological innovation systems

	Products	Knowledge fields	Applications
New centers			
m4m	Metallic implants		3D printing in the medicinal technology and health industries
hipC	–	Hot Isostatic Pressing: HIP for improving the density, ductility and fatigue resistance of high-performance materials resulting from additive manufacturing	–
M2C	–	Micro-engineering: Femtosecond laser micro processing and high-precision multi-material free form additive manufacturing across a wide set of industries	–
ANAXAM	–	Analytics: Applied materials analytics using neutron and X-ray radiation across a wide set of industries	–
M4IVD	In-vitro diagnostic (IVD) tests		Point of care health services
Established centers			
Inspire	–	Production technology: production engineering, mechanical engineering, production plant engineering, materials engineering, materials science, continuum mechanics	–
CSEM	–	Precision manufacturing: microelectromechanical systems (MEMS), additive manufacturing, photonics, functional surfaces, tools for life sciences, scientific instrumentation Digitization: edge processing, data and AI, IoT, quantum technologies, industry 4.0, digital health Sustainable energy: PV & solar buildings, digital grid, mobile harvesters, storage	

Source: Application documents.

5.2 Supply-side aspects of the centers

5.2.1 Missions and service portfolio

The missions of the five new centers, the technologies they offer, and the services that they plan are shown in Table 12. Summing up, each of the five centers follows a different mission and offers specific services based on its technologies.

- *m4m* plans to enable the medical industry – and in particular Swiss medtech SMEs – to use 3D printing technologies to develop patient-specific implants or small series of innovative implants, produce them in a reliable and cost-efficient manner and thereby contribute to a better care and health of patients.
- *hipC* intends to give founders, initial supporters and general users access to customized cycles on a state-of-the-art Hot Isostatic Pressing (HIP) facility, including guidance, consulting and engineering, to build up knowledge and expertise on HIP at a centralized location.
- *M2C* wants to provide the microengineering community a micro-manufacturing platform (femtosecond laser system and 3D printer for high-precision multi-material free form additive manufacturing) and the related services to foster collaborations and improve the advanced manufacturing skills of its staff and stakeholders in the microengineering ecosystem.
- *ANAXAM* intends to transfer analytics with neutrons and X-rays from the research scale to industrial usability, supporting industry to improve their products and processes by providing analytical services to SMEs, large companies, and others; further development of analytic methods in combination with the sample environment; accumulate competencies to build, operate, and further develop the infrastructural equipment; raise companies’ awareness of the capabilities in the area of analytics; and function as catalyzer for the development of spin-off companies.
- *M4IVD* plans to bridge the hurdle from lab development to small scale production of point of care in-vitro diagnostic (IVD) tests to initiate clinical trials and offer a centralized IVD pilot line and assure full GMP and ISO 13485 compliance.

Established centers inspire and CSEM:

- *Inspire* transfers production technology know-how from ETH Zurich to Swiss industry, bridging the valley of death between basic research and product development by conducting applied research and technology development in the field of advanced manufacturing (understood as the combination of existing production technologies, digitisation and additive manufacturing).
- *CSEM* develops and transfers cutting-edge technologies to Swiss industry and functions as a transmission belt between research and industry

The new centers mainly attempt to close infrastructure gaps by offering access to specific infrastructure: a 3D-printing manufacturing line (m4m), high-temperature high-pressure HIP machines (hipC), femtosecond laser and 3D printer (M2C), and pilot manufacturing lines for point of care in-vitro diagnostics (M4IVD). ANAXAM plans to set up complementary infrastructure for easing the access to PSI’s large research infrastructures. The five proposals differ from the two established organizations, inspire and CSEM, above all because of the absence of own R&D activities – except for the hipC and M4IVD centers which explicitly plan R&D activities. While R&D with industry is key for inspire and CSEM, the R&D services complementary to the use of the infrastructure will be provided in virtually all five planned new centers mainly or exclusively by the organizations carrying the centers.

Table 12. Overview of technologies and services

	m4m	**hipC**	**M2C**	**Anaxam**	**M4IVD**	**Inspire**	**CSEM**
Technological content of the infrastructure for AM	Pilot manufacturing line for 3D-printed implants using powder bed fusion technology "Selective Laser Melting" (SLM), integrated into an ISO 13485 certified quality management system (to produce medical devices of the classes I, II and III), powder handling, post processing and cleaning equipment, (probably later) coating equipment	HIP machine capable of high pressure (2000bar) and uniform rapid cooling, allowing the combination of HIP and heat treatment, uniform rapid quenching.	Femtosecond laser system and 3D printer for high-precision multi-material free form additive manufacturing	Tailor-made sample environment/equipment, automated sample manipulators and detectors, to be used on SINQ, SLS and SwissFEL at PSI Supplementary infrastructure for pre-characterization (e.g. electron microscopy) and sample preparation Hardware and software for data analysis and data interpretation	Centralized and audited infrastructure, including up to 4 printing stations, embossing and nanoimprint station, reagents deposition by inkjet, converting and lamination station, die and laser cutting. 2nd generation line includes high precision manufacturing of microfluidics, optical structures and electrical sensors, 3rd generation line printing and assembling of active components on the disposable cartridge. Supporting manufacturing stations for calibration, labelling and pouching.	Simulation and software systems, machine tools for prototype testing (e.g. selective laser melting, selective laser sintering, direct metal deposition), measuring instruments, access to the IT systems of ETH Zurich. Access to machines and equipment of the cooperating 6 ETH Institutes.	a) 700 m^2 cleanroom for precision manufacturing (in NE) b) 650 m^2 cleanroom for coating and surface processing (in NE) c) additive manufacturing equipment including SLM, UV stereolithography, aerosol jet, fused filament d) full characterization facilities (X-Ray, AFM SEM, TEM). e) cleanrooms (in BS) for the manufacturing of micro-optical elements & printed-sensors. f) infrastructure for advanced packaging and automation solutions, including AI-based solutions for manufacturing and assembly (in OW)
(Planned) Services	1. Hub and technological platform for development collaborations that jointly develop a process chain that enables design and manufacturing of 3D-printed implants. Center provides infrastructure, in particular pilot manufacturing line(s), as well as the personnel to manage	1. Combining state-of-the-art HIP and high temperature (2000 bar, 1400°C), uniform rapid cooling, uniform rapid quenching. 2. Customized HIP cycles for research and production for small batches in the Q-HIP pilot line.	1. Providing access to knowledge and novel micromanufacturing systems and tools for the free form fabrication of high precision, small- scale components and smart microsystems combining polymers, metals and ceramics. 2. Support and services for designing,	1. Single entry point for facilitating access to analytical services at PSI linking (customer need identification, consulting on the use of imaging, diffraction or spectroscopy beamlines) 2. Providing supplementary infrastructure such as pre-charac-	1. Manufacturing and development services up to pilot-scale production of in-vitro diagnostic tests, with a focus on consumables. 2. Entrepreneurial consulting and coaching (provided by Basel Area.Swiss)	1. R&D projects 2. Support of research and teaching at ETHZ 3. Continuing education of experts from industry in the Inspire Academy 4. Commercialization of own inspire developments via spin-offs and start-ups.	Advanced technological R&D services (from feasibility to process industrialisation), access to first class and IP protected technologies, and transfer of technology, of manufacturing processes and of knowhow to the customer's operations. In certain limited specific cases,

	m4m	hipC	M2C	Anaxam	M4IVD	Inspire	CSEM
	the trials in the pilot plant. 2. Use of the pilot manufacturing line outside larger development collaborations to medtech companies and surgeons at a fixed price, e.g. an hourly rate. 3. Consulting and support services to medtech companies or toll manufacturer on installing and starting 3D printing process chains, including provision of contacts to hardware partners. 4. Hosting guests to show the center's facilities and learn about implementation and use of 3D printing to produce medical implants and other medical devices. 5. Organize training on AM for medical applications for scientists and students, and 3D printing of medical implants for engineers.	3. Guidance, consulting and engineering by scientific process engineer 4. Analysis services (metallo, microsope, SEM, EDX, EBSD, surface roughness, tensile tests, CT, etc.) 5. Lab scale HIP cycles on very small machine	modelling, manufacturing, testing and validating small-sized micro-engineered components and systems. 3. Consulting and training of partners 4. Contribution to the development of AM standards	terization instrumentation and sample preparation equipment. 3. Providing tailor-made sample environments 4. Providing specific IT hard- and software infrastructure for the analysis of the experimental data 5. Training of industry staff and students in engineering and materials science 6. Act as a development laboratory for spin-off ideas			small scale production services are provided to support the customer's ramp-up phase.

Source: Application documents.

5.2.2 Characteristics of service supply

Table 13 evaluates the characteristics of service supply according to the criteria outlined in section 2, the nature of the output that will be generated (production inputs, technological services, R&D inputs), the activities supported by the infrastructure and the focus (geographical, sectoral, functional).

Two of the five centers, m4m and M4IVD, explicitly stressed that their manufacturing lines generate inputs into production. hipC and M2C aim to provide inputs into innovation projects and into the diffusion of high-pressure heat treatments (hipC) respectively multi-material free form additive manufacturing (M2C). ANAXAM offers access to existing PSI research infrastructure, closes gaps with regard to knowledge and supplementary infrastructure for sample preparation and pre-characterization, and above all focuses on supporting mainly R&D and innovation in companies. It is therefore most similar to the existing organizations inspire and CSEM, which support and carry out R&D and innovation projects.

The scope of the planned new centers is mostly more narrow than the scope of the existing centers inspire and CSEM which serve several TIS and industries. In part, this may be due to their newness, smallness and the resulting necessity to focus. Three of the planned new centers (m4m, hipC, M4IVD) have narrow functional foci. M2C stressed its sectoral scope, supporting the adoption of emerging technologies in materials, processes and tools, with a special emphasis on free form micro-manufacturing, but made strong geographical references (to the Neuchatel region in which it is located). ANAXAM has the broadest scope due to its several infrastructures.

Table 13. Characteristics of service supply

	m4m	**hipC**	**M2C**	**Anaxam**	**M4IVD**	**Inspire**	**CSEM**
Scope (geographical, sectoral, functional focus)	**Functional:** 3D printing of metallic medical implants	**Functional:** Development of HIP cycles for additive manufacturing	**Geographical:** Technology platform and competence center in Neuchâtel. **Sectoral:** Supporting the adoption of emerging technologies in materials, processes and tools, with a special emphasis on free form micro-manufacturing	**Sectoral:** Advanced analytical services for additive manufacturing industry and R&D	**Functional:** Development and manufacturing of point of care in-vitro diagnostic tests	**Sectoral:** Advanced services for companies in the machine, electronic and metal industries (MEM)	**Functional:** Development of cutting-edge technologies in several fields of AM **Sectoral:** Advanced services for companies in watchmaking, space, medtech, energy and further industrial sectors
Nature of output (Production inputs, Technological services, R&D inputs)	**Technological services** in support of 3D printing of metallic medical implants Enhanced by **research** and **production** services provided by the involved partners (if needed)	**Research** on and **development** of HIP cycles for additive manufacturing. **Technological services** of HIP to reduce imperfections and improve mechanical properties of advanced manufacturing parts.	Inputs to **development** in order to improve existing products (i.e. miniaturize, integrate new materials, embed increased functionalities) or develop new products	**Analytic services** that draw on imaging, diffraction or spectroscopy beamlines to support product and process **development** and **R&D** projects	**Development services** and **audited pilot manufacturing** of point of care in-vitro diagnostic tests.	**Development of** innovative products, production processes and services for manufacturing companies.	**Research, development and transfer** of cutting-edge technologies to Swiss industry
Activities supported by the infrastructure	**Production:** Operation of a pilot manufacturing line	**Innovation:** Support Swiss academia and industry to evaluate new HIP cycles for	**Diffusion** of emerging free form micro-manufacturing technologies	**Innovation:** Support industry in their product and process development and R&D	**Production:** Operation of pilot manufacturing lines for point of care IVD tests	**Innovation**: Applied research and technology development in	**Innovation**: Applied research and technology development in several fields of AM

	m4m	hipC	M2C	Anaxam	M4IVD	Inspire	CSEM
	Diffusion of 3D printing technologies and processes for metallic medical implants **Innovation**: Development of a 3D printing process chain and establishment of a pilot line for 3D printing and manufacturing patient-specific/small series of implants	additive manufacturing applications. **Diffusion** of HIP knowledge	**Innovation:** Supporting and allowing exploratory projects from the design to pilot and industrialization phases	projects with analytic services that draw on imaging, diffraction or spectroscopy beamlines	**Innovation**: Development of point of care IVD tests	the field of production technology **Diffusion** of digitization and additive manufacturing technologies	**Diffusion** of digitization and additive manufacturing technologies

Source: Application documents.

Table 14. Importance of outputs in the centers' portfolios

	m4m	hipC	M2C	ANAXAM	M4IVD	Inspire	CSEM
1. **Materials** (ceramics, glasses, metals, polymers, hybrids etc.) created as input into manufacturing processes	1	1	1	2	5	2	4
2. **Equipment** (machines, instruments, tools, fixtures etc.) for manufacturing processes	1	4	1	5	3	1	3
3. Manufacturing and other **processes** to be implemented by the customers	1	2	2	1	1	1	1
4. Computer **software**	3	5	3	3	4	3	2
5. **Research results** (proof-of-concepts, validations etc.)	1	1	1	4	1	1	2
6. Results of **technological services** (testing, analytics, design, modelling, simulation etc.)	2	2	2	1	1	1	1
7. Results of **technology and systems development** (prototypes, demonstrators etc.)	4	3	1	3	2	1	1
8. Other **intangible goods** (intellectual property etc.)	3	2	2	3	2	3	2
9. **Physical goods** (products, objects, hardware, artefacts etc.) that result from manufacturing processes	1	4	2	2	1	3	2
10. **Other outputs**[a]	2	1	5	1	5	5	2

a Other outputs are: m4m "Training & Education", hipC "Know-how building for HIP material science and processes for AM unique in Europe", ANAXAM "tailor-made infrastructure (sample environment)», CSEM "small scale production if necessary to help SMEs in the ramp-up process".

Source: Survey of centers.

Table 14 shows a heat-map of the centers' outputs according to their importance. The lower the output number/the stronger the red colour, the more important an output is. Manufacturing and other processes and the results of technological services have been classified as important or very important by all centers. All centers except for Anaxam also considered research results as important. Computer software and intangible goods are the least important outputs across all centers.

Each center has a specific pattern of outputs and it is difficult to compare them. hipC, ANAXAM and M4IVD have selected a slightly narrower range of outputs than the other four centers (including CSEM and inspire), but overall the differences are small.

5.2.3 Complementary and substitutive services

The applications of the centers were analysed with regard to the mentioning of related services provided currently by other organizations and all new centers were asked for other service providers in Switzerland who provide complements or substitutes to the centers' services. The centers replied in unison that no substitutive services existed (Table 15).

Three centers pointed out in their application documents that the combination of technologies and services planned by their centers does not yet exist in Switzerland. The two other cases, hipC and ANAXAM, also stressed the uniqueness of the underlying infrastructure, but pointed to related services which already exist: in the case of hipC, its partner Deloro HTM offers lower pressure industrial hip services, and in the case of ANAXAM, PSI spin-offs offer specialized services to other industries outside AM drawing on the PSI infrastructure.

Drawing on these descriptions of competing services it strikes us as not fully impossible that existing companies or new spin-off companies could provide the services in the (near) future. Even though no private service providers seem to exist at the moment, the centers could focus their activities on finding and nurturing such private service providers and developing market-based supply (see the discussion below).

All centers were asked how they plan to coordinate with providers of complementary services in Switzerland. The replies, shown in Table 15, suggest that the centers still need to develop plans and activity sets for coordinating with other players in their TIS. At present, the prevailing view is that coordination will be achieved simply due to the uniqueness of the infrastructure and through the participation in the corresponding TIS. This, however, might not be so easy to achieve, especially if the TIS are more diffusely defined by fields of knowledge as in the cases of hipC, M2C, and ANAXAM. At least four of the five new centers, m4m, hipC, ANAXAM and M4IVD, seem to rely also to large degree on their members and partners when it comes to defining and delimiting their own services versus the services offered by their partners.

Table 15. Other related services and coordination with providers of complementary services

	m4m	hipC	M2C	Anaxam	M4IVD	Inspire	CSEM
Services provided by other service providers	**None** Existing 3D-printing facilities of Swiss medtech companies are not accessible, different focus on mass manufacturing of implants. Center will not offer products or services that are 1) needed for 3D printing of implants or other medical devices, 2) available in the requested quantity and quality and 3) offered by other parties under reasonable conditions.	**Related and specific** One partner (Deloro) offers industrial level HIP on 4 HIP machines with lower pressure. Older small lab scale HIP machines exist at HES-SO, EPFL and ETHZ. Suboptimal due to low usage volume, no uniform rapid cooling and no combination of HIP and HT in one operation.	**None** Femtosecond lasers are in use in manufacturing, but no academic or private labs offer combination of femtosecond laser and 3D printer for additive fabrication of hybrid systems	**Related and specific** PSI spin-offs offer specific analytics services to life sciences drawing on PSI infrastructure, but no services for advanced manufacturing. Several specialized service providers offering related services employing mainly lab X-ray sources EMPA Center for X-ray Analytics uses lab-scale equipment for material science and technology in support of scientific and industrial innovation	**None** Only the development and manufacturing of lateral flow tests, microfluidic chips and cartridges, customized plate or single tube-based kits for PCR, qPCR and dPCR, IVD instrumentation and readers are being offered by Swiss and foreign companies.	**Related and specific** Services are complementary to the basic research conducted in the ETH domain Complementary to UAS services as well due to direct access to basic research (at ETH), high scientific standards, broad range of scientific and technical services in production engineering. Complementary to CSEM with its focus on electronics and microtechnology	**Na**
Coord. with providers of substitutes	None	None	None	None	None	–	–
Coordination with providers of complements	The reason why the center has been approved for initial financing is that its business is complement to what is existing today in the Additive Manufacturing field and especially in Switzerland. The goal is to bridge additive manufacturing research to the medical industry. The validation of the entire supply chain under an ISO 13485 quality management	1) Deloro – the only service provider of HIP in Switzerland – will house the hipC HIP machine and submit its operation to the same stringent health and safety requirements as their own 4 industrial HIP machines. They have many requests for special cycles which they currently must turn down. Being member of the hipC, Deloro can accept these requests and	Coordination with organizations providing complementary services will be achieved by acquiring an increasing knowledge of the actors who offer complementary services, through participation in the events they offer in the AM community, by organizing dissemination and outreach events to promote exchanges between people active in these organizations; by researching and	The analytical services provided by ANAXAM go far beyond the analytics achievable on the laboratory scale. It is obvious that ANAXAM will complement such services either available at the EMPA or in the private industry. Hence, with ANAXAM the analytical limits of what is possible will be shifted offering industry completely new analytical possibilities. In context with PSI, ANAXAM	The technologies which are being developed in the Swiss research facilities, will be put into practice into real world IVD tests by our center. Such a service is currently not available in Switzerland	–	–

	m4m	hipC	M2C	Anaxam	M4IVD	Inspire	CSEM
	system is today unique. This will provide a best in class environment enabling a faster medical additive manufacturing. This is also a complement to any existing activities in the field of medical AM.	channel them over to the hipC. 2) HES-SO in Sion will give its hip machine to the hipC as a reference machine and scientific baseline. As the center is unique for special HIP cycles, it will create direct and strong links to all relevant Swiss research and industrial institutions, strengthened e.g. through yearly HIP conference and information events.	proposing themes that could lead to projects that benefit from cross-fertilization.	with its focus on building tailor-made infrastructure will fully complement PSI and provide industry with advanced analytics for advanced manufacturing.			

Source: Application documents and survey of centers.

We asked the two established centers, inspire and CSEM, as well, whether they perceive any overlaps between their own offering and the planned offerings of the new centers (see Table 24, p. 81 in the annex). In sum, such overlaps are not perceived as meaningful, as the business models of the two established organizations do not rely on the provision of infrastructure and open access to their infrastructure is not possible but only within R&D collaborations or contract research.

5.2.4 Development of supply

All applicants were asked for planned measures to broaden the supply of AM services, which draw on their infrastructure and competencies, but go beyond the centers themselves, e.g. in the form of activating their partners, training consultants, or spinning-off personnel and activities. Such measures could contribute to building markets for the centers’ services and broadening their impact, as more independent suppliers will also lead to a greater diversity of the supplied services. All centers listed at least one valid measure to broadening supply:

- *Spin-offs.* m4m points to the possibility of spinning-off its different services and contributing to the emergence of independent service providers, which is also stressed by ANAXAM and M4IVD. It should be noted however, that this alone might not be sufficient to broaden supply. The creation of spin-offs depends on many factors and requires considerable resources. The numbers of spin-offs from academic organizations is overall not that big, which the case of inspire also demonstrates (four spin-off companies over a period of several years).

- *Training of staff and education offers for users.* Three centers, m4m, M2C, and ANAXAM, explicitly provide training to their staff and/or customers on the centers' technologies capacitating staff and users in the process.
- *Movement of personnel.* Only ANAXAM points to the movement of personnel and hipC suggests this at the end of the center's funding period. This is a measure that CSEM has developed into a program, "Postdoc4Industry", illustrating the potential that his may have.

Research and consulting offered by the centers themselves, as listed by CSEM and inspire (Table 16), actually do not meet the criterion of going beyond the center's own offer. Moreover, hipC, M2C and M4IVD expect spill-over effects resulting from the involvement with the center, its partners, and the wider community, which should lead to increasing awareness of the potentials of the available technologies, cross-fertilization in the community, and the emergence of (business) opportunities. This is without doubt quite likely and could result in a growing demand base for the services, however, it does not directly broaden the supply of services.

Table 16. Measures for broadening supply beyond the center

	m4m	hipC	M2C	ANAXAM	M4IVD	Inspire	CSEM
Measures for broadening supply beyond the center	Several services could be spun-off: Supply chain validation services (under an ISO 13485 QMS) could become a commercial service for additive manufacturing machine suppliers. The demand is today already very high as a penetration in the MedTech market is only possible by offering validated equipment. Education services in the field of applied education in additive manufacturing Consulting services in the field of medical additive manufacturing	1. With the community building, hipC will create awareness for the technology and help in assessments whether or not a cycle is necessary for a specific application. 2. Events and yearly HIP conference will help to divulge the information to relevant industry and research organisations. 3. At the end of the research funding period, with the transfer of the machine it is foreseen that operational personnel will be transferred to the service provider and management and or scientific personnel can be transferred to consortium companies or other institutions.	1. M2C directly is located in an environment conducive to innovation and in the professional networks of the microengineering industry (Microcity innovation cluster). Clients of the center will be exposed to other trades and various applications, which leads to opportunities for new business relationships and new ventures 2. Training of staff and users in new AM technologies, complementing the educational offer of academic partners and institutions in the region (FSRM, aCPLN, CIFOM). 3. If the business model is successful,	1. Training of industry staff (e.g. imaging and powder diffraction school for industry, hosting senior staff for short term sabbaticals), training of students in engineering and materials science. 2. Transfer of capabilities and competences to industry through movement of personnel. 3. Development lab for spin-off ideas, e.g. with regard to specific services using the large scale facilities at PSI especially for AM, environment conducive to explore new ideas and concepts and finally transfer them to a spin-off company.	1. Active contribution to the center by all partners will result in cross-fertilization, exchange and networking effect can already be seen inside the association, and with partner networks like Toolpoint (letter of support provided). 2. Spinning-off a commercial branch of M4IVD is a possible future scenario	1. Four spin-offs dealing with AM topics. 2. inspire carries out consulting and service contracts for industrial customers.	1. Internal research benefiting from the federal and cantonal support in order to develop technology and IP. H2020 projects contribute to research and strengthen knowledge. 2. Knowledge is transferred to industrial partners with direct bilateral projects, or with dedicated Innosuisse projects. 3. Creation of start-ups is encouraged. 4. Movement of PhD students and post-docs contributes to the transfer of knowledge. Program "Postdoc4Industry" allows the hosting and support of people to transit to industry

	m4m	hipC	M2C	ANAXAM	M4IVD	Inspire	CSEM
			the center could become an independent legal entity.				after their PhD, including in AM.

Source: Survey of centers.

5.3 Demand-side aspects of the centers

After discussing the supply-side aspects and service provision of the centers, we will now focus on the anticipated demand from users and customers. We first discuss the customer bases of the centers, the types of customers and the regional distribution. Next we compare how much effort still needs to be taken to articulate the needs of the users. In the final section, we assess the state-of play with regard to market building and what measures have been foreseen to broaden demand.

5.3.1 Size of the customer base and expected demand

We asked all centers in the questionnaire to provide an estimate of their potential customer base as well as its regional distribution (questions 2 and 3 in Annex 2, p. 83). However, this was not properly understood and answered in the majority of the cases. The applications give overviews of the centers' user bases and they are reflections of the TIS in which the centers are active (see also Table 11, p. 48):

- M4IVD and m4m expect demand from the market players in two application areas, i.e. above all from companies, health institutions, and research organizations: medicinal technology and in particular metallic implants in the case of m4m and pharmaceuticals and in particular producers of in-vitro diagnostic tests in the case of M4IVD.
- The three other centers expect to find users for their services across several industries, which could hypothetically benefit from the offered services: hipC listed additive manufacturing in industries like automotive, aerospace, energy, medtech; M2C pointed to watchmaking, precision mechanics, medical technologies, pharmaceutics, instrumentation, optics and micro-optics, microfluidics and electronics; last but not least, ANAXAM enumerated automotive, aerospace, energy, medtech, and additive manufacturing among others.

This suggests two conclusions: 1) M4IVD and m4m are active in narrower markets with a smaller, but more clearly defined customer base. In order to succeed both centers have to ensure that they exactly meet the needs of their customer bases. m4m seems to be better positioned in this regard than M4IVD, as it has three times more partners from its application community and is a lot more embedded in it. 2) hipC, M2C and ANAXAM will have to invest time and efforts into learning about and accommodating potentially diverse customer needs or narrow down their user communities. hipC and ANAXAM seem currently better prepared for this, as their involvement with their user communities seems more developed than in the case of M2C.

Table 17. Customer base of the centers

	m4m	hipC	M2C	ANAXAM	m4ivd
User-base structure (indefinite, many SMEs, few selected)	**Medtech companies, doctors, researchers** Small and medium-sized Swiss medtech companies Toll manufacturers of medical devices Medical implants equipment manufacturers 3D printing software manufacturers Manufacturers of raw materials Medical scientists and surgeons Research institutions	**Many companies** in CH and abroad producing parts through additive manufacturing in several industries, including automotive, aerospace, energy, medtech Research institutions	**Indefinite** Several industries, including, watchmaking, precision mechanics, medical technologies, pharmaceutics, instrumentation, optics and micro-optics, microfluidics and electronics Industrial organizations using the provided infrastructure for process and product development, de-risking technology transfer, (i.e. testing, getting advice for selecting investment goods) Laboratories of partnering institutions for R&D Other transfer and competence centers (i.e. life-sciences, diagnostics, healthcare) SMEs and start-ups for R&D, new product development, industrialization	**Indefinite** Several industries in the field of AM, including automotive, aerospace, energy, medtech, additive manufacturing Universities, research institutions, technology centers etc.	**Biotech and Diagnostics SMEs, pharmaceutical companies and research** Many Swiss SMEs develop biomarkers (input into IVD tests). Pharmaceutical companies need point of care IVD for personalized medicine, but this is outside their core-business and competences Research organizations can be envisaged in the framework of national and international research programs.
Embeddedness in user communities	**Embedded** Range of partners, including research institutes, medtech companies, certified test labs, raw materials, equipment and software manufacturers, and clinical partners.	**Embedded** Range of partners, including research institutions and companies expressing the need of using HIP	**Not widely embedded** Mainly pilot users and partners with a particular interest	**Embedded** Number of pilot users and application partners is growing swiftly since registration	**Not widely embedded** Only R&D partners, suppliers and consultancies

Source: Application documents.

In the survey, we also asked the centers, including CSEM and inspire, about their expectations on the development of the number of customers per year in 2021 and 2024. All centers projected increasing numbers of customers (Figure 10): hipC expects a tripling of its customers, m4m and M2C after all a doubling. Projected growth at ANAXAM and M4IVD is much more moderate at around 60% and at the established centers it is in the order of 10-20%. The projected structure of customers by type, differentiating between SMEs, large companies, research institutes and others is similar over the years, except for ANAXAM which expects only slow growth among SMEs and faster growing interest from larger companies and other organizations. Inspire and CSEM find two thirds or more of their customers among SMEs. ANAXAM, M2C and M4IVD also focus on SMEs, however from a small basis in 2021. m4m expects that one fourth of its demand will come from other organizations, which are in this case other players in the medical implant market, such as hospitals or medical doctors. hipC is to some extent special, as it pictures other research institutes as its largest customer group.

Figure 10. Development of customer numbers 2021-2024

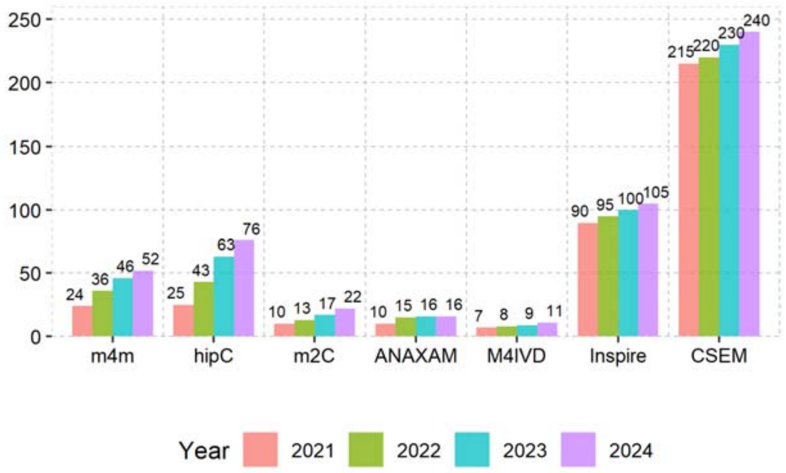
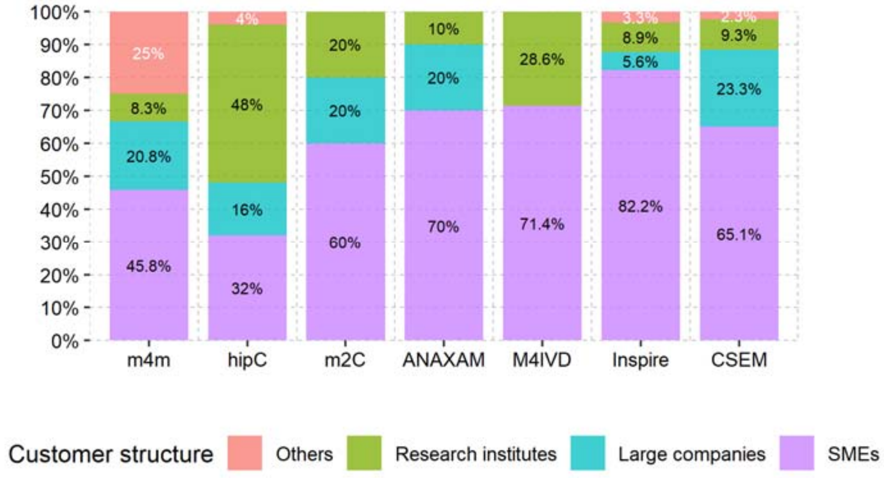


Figure 11. Customers 2021 per center and type of customer in %

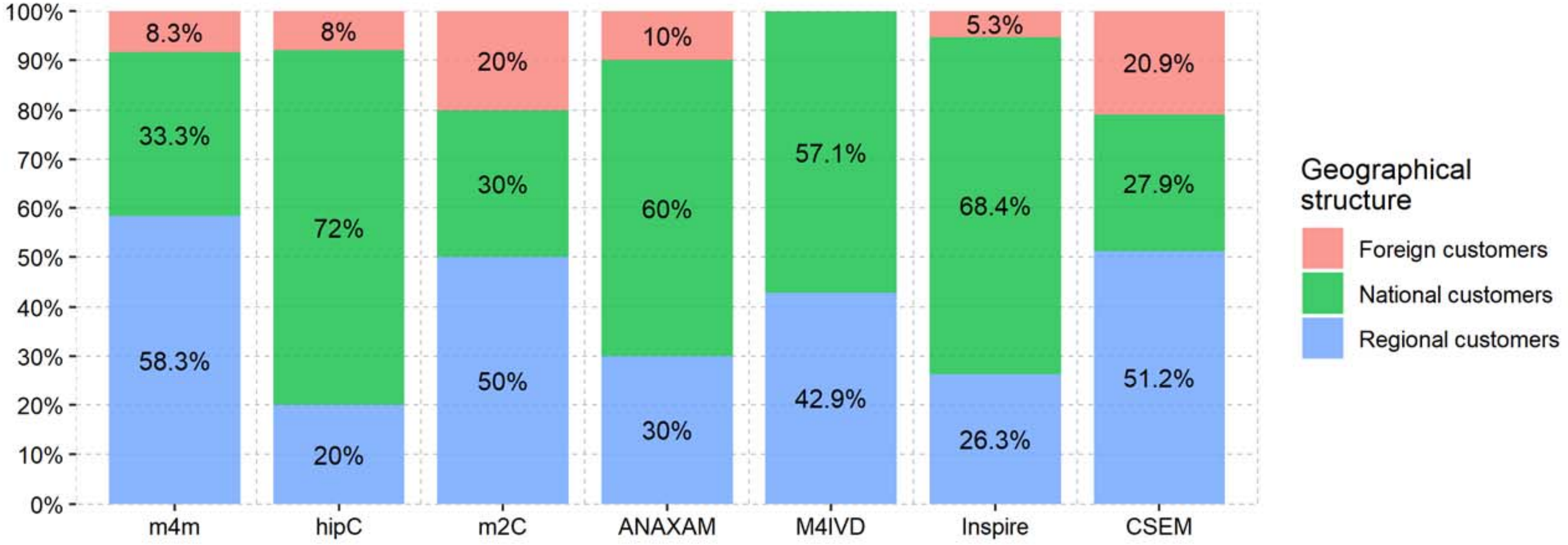


Source: Survey of centers.

We asked the centers also about the expected geographical distribution of their customers. Across all centers we see a mix of regional (defined as being located in the vicinity, e.g. same canton or region), national and foreign customers (Figure 12). There are no clear decision criteria about a good distribution, however, national centers should not cater to regional customers only and, as the centers receive Swiss public funding, their clients should also not be primarily foreign. Still, in some cases it might be beneficial to have a mix of Swiss and foreign customers, in order to add competencies and resources from abroad if they are not available in Switzerland. Figure 12 shows that the established centers, inspire and CSEM, could serve as benchmarks, with a mix of 25-30% regional, 50-60% national, and 10-20% foreign customers.[1] Among the new centers ANAXAM and M4IVD follow most closely these benchmark values. m4m and M2C have an overrepresentation of regional customers. hipC expects above all strong growth between 2021 and 2024 among foreign customers (nearly 50% of all customers in 2024).

[1] It should be noted that due to CSEM's four regional centers in Obwalden, Basel-Country, Grisons, and Zurich, the share of its customers classified as "regional" must be higher.

Figure 12. Customers 2021 per center and location in %



Source: Survey of centers.

5.3.2 Development of needs

Another aspect of demand development is the ability of users and customers to formulate their needs and to recognise that an infrastructure could help them to meet those needs. Justman and Teubal (1995) refer to this as the "definition of needs" that can be made by users together with the providers of an infrastructure. If we compare the five new centers with regard to the competencies that they require from their users and the degree to which the needs have already been formulated and need further involvement and collaboration between the centers and the customers to become manifest, we can distinguish three groups of centers:

– It seems that at hipC the need level is most developed, as large numbers of users (according to hipC) have already formulated their service needs, and they know what they need from the existence of similar, however less sophisticated, industrial services. Hence, the need definition seems to be either complete or, for customers lacking own HIP/HT experiences, within reach.

- The needs of M4IVD and m4m customers are also widely advanced, as the pilot manufacturing lines offer specialized (production) services in two specific application areas. The M4IVD and m4m service personnel also considers it as its core task to support and consult the users with selecting the appropriate services for interacting with the center.
- The same applies to M2C and ANAXAM. However, as the infrastructures in these two centers are analytical and multi-purpose, the precise identification and articulation of each customer's needs seems to require more efforts on the user's side as well as support from the personnel running the infrastructure.

Table 18. Development of needs

	m4m	hipC	M2C	ANAXAM	m4ivd
Minimum competencies of customers	No minimum level of competencies required, but interest in entering MedTech market. Service offerings will be adapted to customer's competence level, to enable adoption of additive manufacturing in MedTech. Expected customer segments: 1. Customers with experiences and competencies in medical product development, conventional manufacturing, regulatory and quality affairs, but additive manufacturing and 3D printed medical devices not yet adopted. 2. Customer with additive manufacturing experiences but not yet active in MedTech sector.	Any customer can interact with the hipC center. Customers with background knowledge on heat treatments modifying the microstructure of materials and mechanical properties benefit most. As combined HIP and HT cycles are new, most customers will want to use the possibility of consulting, engineering, help, advice of the hipC scientists and technicians.	The skills required by customers are to already have components, systems and/or development projects that could benefit from the capabilities of the center's platform. Ideally, the center's customers should already be active in utilizing precision manufacturing methods for micro engineered components and products.	The customers of ANAXAM "just" have to recognize their problem/challenge that they are facing with their products and/or individual process/ production steps that with the help of the analytical tools of ANAXAM can be solved. In addition a basic understanding of material analytics and maybe even experiences in the usage of analytical techniques of ANAXAM would be beneficial in order to get faster to a solution and get a better feeling where the advanced analytics of ANAXAM could help. However, this is not mandatory since this expertise is provided by ANAXAM.	Services will be addressed towards SMEs, which do not have the experience on how to translate their technology into a commercially marketable in-vitro diagnostic test. They need in-depth knowledge of their technology, to be complemented by M4IVD development know-how. Customers need to have partners to test the performance of the IVD in an in-vivo setting (clinical trials in accordance with IVDR). Projects with M4IVD cover the set-up of the pilot line; additional costs to develop the IVD would have to be borne by the customers, i.e. with their own funds or 3rd party development funds.
Definition of need (complete, within reach, inarticulate)	**Within reach** First decision point for determining services by the center/other service providers	**Complete – Within reach** 20 customers have formulated requests for special HIP / HT treatments.	**Within reach – inarticulate** Initial focus areas correspond to bottom-up requests from the industrial partners in the consortium	**Within reach – inarticulate** Users understand their needs from product and process requirements and lab scale analytics	**Within reach** Customers understand their own technologies and need for IVD which is implemented w. the center
User involvement in need determination (unnecessary, moderate, intensive)	**Moderate to intensive** Users need to articulate what services they request and depending on these needs and their own competencies the service level will differ.	**Moderate** Users need guidance on HIP/HT cycles and advice on adequate pressures and temperatures according to material	**Moderate to intensive** Users need to articulate what services they request and depending on these needs and their own competencies the service level will differ.	**Moderate to intensive** Consultation between customer and center to evaluate the appropriate analytical methods	**Moderate to intensive** Users need thorough understanding of their own technologies and cooperate with center to develop a commercially marketable IVD test

	m4m	hipC	M2C	ANAXAM	m4ivd
		and desired microstructural effects.			
Measures for building demand for center services	1. Close collaboration with partners to multiply visibility, word of mouth of partners and board of directors; 2. Presence in the news (8 newspapers and magazines in 2019); 3. Webpage with news feed, linked with social media; 4. Contributions to associations such as Swiss Medtech, IHVG (Industrie- und Handelsverband Grenchen und Umgebung), Solothurner Handelskammer.	1. Once funding has been secured, all consortium members will distribute the hipC cababilities in their networks; 2. This includes trade shows, websites but also social media. 3. Management plans to use all relevant conferences, trade shows and networks (national & European networks) to make services known in Europe; 4. Yearly HIP conference will gather the community in CH and EU	1. Promotion of the M2C capabilities; 2. Strong interaction with the Swiss manufacturing community, thematic events on research topics and applications related to AM. 3. Research and dissemination of use cases and success stories from other (foreign) platforms and competence centers (serving e.g. Swiss competitors).	1. Specific industry events (workshops and seminars); 2. Promotion through National thematic networks (NTNs); 3. Reaching out to industry through the contact networks of involved researchers; 4. Hiring of people that mostly work in this topic; 5. Hightech Zentrum Aargau (HTZ) and ITS Industrie- und Technozentrum Schaffhausen (ITS) serve as hubs for innovation consulting and knowledge and technology transfer, having large networks within industry; 6. Office in the PARK INNOVARE AG (PIA), providing access to national and international networks and resident companies; 7. Networks of ANAXAM partners, AM-TTC and AM-TTC alliance.	1. Word of Mouth; 2. Existing network of the partners; 3. Website and LinkedIn page 4. Newspapers (1st article released in Sept. 2019); 5. Social Media 6. Fairs and conferences (already presented by Hemex and CSEM collaborators at CSEM Business Day 2019)

Source: Application documents and survey of centers.

5.4 Implementation risks

Asked for the main implementation risks of service provision through the center and the existing risk management plans, the replies show similar risks but differing degrees of awareness and preparation with regard to counter measures.

- *Resource-related risks:* four of the five new centers point to risks that relate to the recruitment of qualified staff (m4m), the purchase and installation of expensive equipment (hipC, ANAXAM), the availability of human resources and accessibility of infrastructure in the partner organization (m4m, ANAXAM), and the access to expertise not available in-house (M4IVD). The suggested solutions center in all cases on the collaboration with partners or external organizations to make the missing resources available.

- *Demand-related risks:* three of the centers, m4m, hipC, and ANAXAM see risks related to the demand for their services, the awareness of the benefits in industry, and possible challenges with regard to market adoption. All three centers suggest the use of marketing measures and broadening their networks in collaboration with their partners as possible actions to counter this risk.

One center, M2C, only listed operational, environmental, competitive and legal risks at a very generic level.

Table 19. Implementation risks and suggested actions

	m4m	hipC	M2C	ANAXAM	M4IVD	Inspire	CSEM
Implementation risks and actions	1. Market adoption of a relatively young Additive Manufacturing (AM) technology in regards of application in the MedTech market Action: Invest in marketing and active prospecting to make the center visible, collaborate intensively with partners that will play the role of multiplier. 2. Supply Chain validation A: Close collaboration with partners and institution (notified body), invest in up to date quality assurance training and audits. 3. Collaboration with partners, being able to manage expectation A: Close collaboration with partners, correct project portfolio selection and onboarding. 4. Hiring of specialized staff dedicated to AM A: Invest in specific collaboration with the industry and schools / universities to attract talents. Apply word of mouth within our network to get awareness.	1. Long delivery time of a state-of-the-art HIP machine (8 to 12 months), resulting in late operational start Action: We have already iterated the type of machine with the hipC initial supporters, we have planned the positioning at Deloro. 2. Installation takes too long or service is needed too often A: We have the machine manufacturer Quintus on board who is offering its service technician free of charge. Moreover, Quintus will want to use the services of hipC for their internal requests. With this we have created an aligment of interest to ensure continuous operation of the machine. 3. Not enough users and projects A: With the initial consortium of 20 entities with commitment for cycles this risk is heavily reduced. Moreover, as soon as the funding is granted, we will start the advertising on the	The management of operational, environmental, competitive risks with the private sector, as well as legal risks, will be carried out through periodic risk assessment according to a DMAIC approach, with the implementation of the necessary indicators for their monitoring and mitigation by mutual agreement between partners.	1. Planned or unforeseen shut-downs of the PSI infrastructure. would directly affect the service provisions. Action: Use of other large scale facilities in the world, however entailing higher cost and longer queue time for the customers and the projects as well as limited reaction ability for analytical service requests. 2. Delays in realizing large and complex infrastructure projects with the partner PSI. A: Parallel planning and close monitoring. ANAXAM will be supported by PSI via its in-kind contribution with engineers and technicians to realize the shared infrastructure. 3. Achieving recognition and visibility of the analytical potential. A: The already remarkable number of companies in the association as well as the marketing and acquisition activities will help to understand and guide ANAXAM along the market	1. Need to obtain specific external advice for certain highly technological/scientific tests, for which the know-how is not available in-house. Action: We will continue to expand our network to get access to this in-depth know-how in order to be able to support our clients.	–	–

	m4m	hipC	M2C	ANAXAM	M4IVD	Inspire	CSEM
	5. Establishing and maintaining an ISO 13485 QMS A: Maintain a collaboration with 41medical and work closely with external auditors and notified body.	European level to gain traction, requests and also European supporters.		needs. Offering of training classes in order to increase the understanding of the service offered by ANAXAM in industry.			

Source: Survey of centers.

5.5 Center-specific questions

Due to requests from SSC the survey of the centers included in two cases, m4m and ANAXAM, specific questions which were only asked to these two centers. We reproduce these questions and the replies in this section without including them further in the analysis, as comparable answers from the other centers are missing.

5.5.1 m4m: center-specific questions

What is the status of the financing commitments by the involved cantons Berne and Solothurn?

The canton Berne is financing the Swiss m4m Center according its commitment made at the beginning of 2019 (75’000 for the period 2019-2020). The discussion with the canton Solothurn is ongoing and promising, an official request will be sent until the end of 2019. If necessary, a presentation will be organized in collaboration with the economic promotion of the canton Solothurn.

The planned centre is primarily concerned with the transfer and application of 3D technology in the medical industry. What is the significance of the research and development dimension?

The significance of the research & development is very high. Additive manufacturing is a fast-growing field where research plays an important enabling role. New materials, new or improved production processes, new or improved monitoring and control processes are coming from research initiatives. These new developments will support in a positive manner the center's future activities and development. The goal is that the center integrates new mature developments into its validated chain and bridge them to the medical industry and its market. It will be the perfect example where research may be implemented in an industrialization setup.

The application envisages synergies with sitem Insel AG in the area of training. Are all possible synergies with the translation center sitem Insel AG exhausted?

The collaboration – mainly in the fields of course, lectures and training – with sitem Insel is in development and will be effective in the middle of 2020, today the discussion is in an early phase as the effective course offering at sitem will start in 2022. Our main contact is Dr. Jürgen Burger. Additionally, the opportunity to get an office space in Bern at the Sitem is under discussion. This may add regional reach to the center and bring its activity close to an hospital setup.

Additive manufacturing is also a focus of the inspire AG. In addition, CSEM has a focus on advanced manufacturing as well as expertise in implants. Has a cooperation with either inspire and/or CSEM been examined?

First discussions with inspire and CSEM have taken place. The discussion with Adriaan Spierings from inspire have been very constructive. Some ideas to collaborate around QM4AM (quality management for additive manufacturing) have been discussed. Concrete cooperation with inspire and CSEM are definitely a topic for 2020. An interesting collaboration with inspire may be on QM4AM, process optimization and software integration. A collaboration with CSEM may be on 3D printed smart implants.

5.5.2 ANAXAM: center-specific questions

What is the status of the financing commitment by the canton Aargau?

With its decision of March 19, 2019 the Government of the canton of Aargau will provide ANAXAM start-up funding of up to CHF 1.00 million per year in the pilot phase in 2019 and 2020.Assuming that ANAXAM receives federal funding from SERI in the years 2021-2024, the current financing plan contains a contribution from the canton of Aargau of 600kCHF annually for this period. Pursuant to § 24 (1) of the Act on the Effects-Oriented Management of Duties and Finances (Gesetz über die wirkungsorientierte Steuerung von Aufgaben und Finanzen (GAF)) the approval of the cantonal parliament is required. The cantonal parliament is scheduled to vote on the commitment loan for ANAXAM in June 2020. Based on initial non-binding discussions with members of the cantonal parliament, a positive decision is expected.

The CSEM also has competences in the field of surfaces. Have synergies been examined? What is the delimitation like?

ANAXAM will have the competences in providing industry new analytical possibilities which among other can surely be used to investigate surface structure. The focus of ANAXAM is not to build up competences in the field of surfaces but more to provide dedicated analytical techniques to study surfaces. It is also clear that the CSEM cannot provide analytical services with neutrons and X-rays as ANAXAM will do.

5.6 Expert opinions on AM-TTC initiative and individual centers

Naturally, not all experts were able to judge multiple new center applications. The following table is presenting experts' **opinions** on the new center applications.

Table 20. Expert opinions on the new centers

	m4m	hipC	M2C	ANAXAM	m4ivd	AM-TTC initiative as a whole
Expert 1	3D printing of products for the medtech industry is a high potential goal. A big challenge will be proper quality assurance of products and processes, there are very few companies world-wide that are able to penetrate the medtech industry with AM processes due to high regulatory and related requirements on standardization. This would leave the centre in a quasi monopolistic situation with a potentially very high demand for its services.	HIP processes are one of the most important down-stream processes of advanced manufacturing. The technology alone may be well known, but it is an important part of quality assurance of additively manufactured products and for me presents a substitute to the lack of material research in processes such as powder sintering and melting.	This is a "must" for the Swiss advanced manufacturing landscape. Switzerland has a strong tradition in both manufacturing and metrology, it is therefore only a logical step to push AM in this direction which would be a clear comparative advantage for the Swiss manufacturing sector. I'm not sure however whether I understand the initiative as a whole correctly from the given information.	For us, a center like ANAXAM where the mentioned infrastructure for material analytics and testing can be evaluated for our manufactured products would be of high value. I think that PSI currently has such an infrastructure but I think it is worth to open it to the industry in a broader sense. For me, Anaxam is similarly positioned as hipC related to the fact that it serves quality assurance and process control.	In vitro diagnosis seems to be based in the medtech industry where I do not have expertise. Packaging and package labelling are clearly down-stream processes which I value as additional support to additive manufacturing. However, I do not understand the innovation contribution of this initiative.	Without more accurate knowledge on the initiative from AM-TTC, it seems very research-driven to me and I think an additional committee of industrial exports would not only be beneficial but absolutely needed for a successful transfer to the industry. There is no centrally coordinated industrial expert forum on current topics in AM and I consider it important to organize yearly conferences and exhibitions between research and industry on progresses in manufacturing technologies that are pushed by a committee established by research and industry. In the current setting, I doubt that the initiative has high outreach to industry, but I do not know the variety of potential customers nor partners of all initiatives. In Switzerland, there is a lack of coordination mechanisms between research and industry, Germany is better related to this fact.
Expert 2	The idea is interesting but I am not sure about the market potential. I do not see why the goal of the initiative cannot be fulfilled by a university (of applied sciences) institute. In my eyes, they already have knowledge related to technological transfer to the industry, so there is no clear gap closed.	I consider hipC to be an important part of downstream process handling in the AM industry for metal components. I think HIP can close gaps for the penetration of AM technologies also for more strongly regulated industries such as medtech or aerospace and metrology. From the description, I do not	not addressed	The center seems to cover broader issues in qualification of materials down-stream AM processes. I consider such efforts as beneficial for the industry.	not addressed	On most centers I have doubts about the market potential – working in the AM sector for several years, I see clear concerns in the industry related to issues such as quality and process control, education of involved persons in SMEs and lack of efficient communication between research and industry. I doubt that the initiative as a whole can fill this gap without more proactive representation from industry. In addition, I feel a clear lack of awareness in the industry. The initiative

	For me, the hurdle in adapting such technologies is not the access to infrastructure but rather related to quality and process control, a part which the initiative is at least trying to address.	know whether such broad fields of application could be covered by this initiative.				should also aim at knowledge transfer to designers and engineers on AM methods.
Expert 3	I judge the initiative to be a push from research institutes rather than being a pull from the industry. As such, I am not surprised that the m4m application obtained approval and that is also the opinion from various industrial experts. In my eyes, EMPA is moving into market competition due to the tight involvement with this initiative. To me, it would be more credible if m4m would be incorporated into EMPA rather than representing a legal entity (or a center) on its own. In the same vein, ANAXAM could and should be integrated into PSI – there is no need to build new centers.	Additive manufacturing technologies such as 3D printing suffer from lacks of elaborated quality control and standardization. HIPing is known to be a very important down-stream process for quality assurance of such products. 3D printing is a well mature technology but there is a research gap in material science.	This center has in my eyes a potential for Switzerland (metrology) but lacks the collaboration with industry and planned other centers.	If SMEs would obtain infrastructure to benefit from subsidies to qualify products from AM processes, this would certainly be beneficial. I doubt, however, that such complex topics can be made aware to the industry to follow process innovations in order to improve testing results. I also doubt that the outreach to the industry, particularly SMEs, would be satisfying in terms of customer acquisition. A key success factor for ANAXAM might be that persons with industrial knowledge and contacts are involved, PSI has done an insufficient job so far related to these issues.	not addressed	We found it irritating that the State Secretariat has not approached industrial organizations such as chambers of commerce nor other entities representing the manufacturing sector. Criteria for resource allocation such as being a legal entity are in my eyes completely out of date and do not present state-of-the-art of promoting innovation. I consider the initiative to be too strongly research and too little industrial driven and have concerns about its success for reaching customers in the whole value chain. The initiative seems to be strongly pushed by EMPA and PSI. In conventional engineering, EPFL and ETH cannot keep their ranking and the outsourcing to small clubs like the proposed centers is a potentially unsuccessful trial to reduce the backlog of Swiss manufacturing. Also, I am puzzled by the fact that the majority of centers is active in 3D printing which is a mature technology by now. 3D printing cannot substitute conventional production processes completely and I would have expected, as a whole, more innovation related to down- and up-stream process innovations. I think EMPA is trying to reachout to industrial applications and imposes competition to the industry. I think EMPA is also involved (in-)directly in m4m and – despite the quality aspect of m4m – represents a distortion of competition. For

						the whole set-up of the AM-TTC initiative, the industry should have been onboarded in a more serious way.
Expert 4	Medtech imposes very high regulation requests for industrial suppliers, if SMEs can learn from such an initiative how to overcome this gap in terms of education, networking within the industry and training, I would consider it as beneficial.	HIPing is considered as a very important downstream process to us. I cannot say, however, whether the contact to such a center would be more beneficial to SMEs than a contact to a third party supplier.	not addressed	Quality assurance is very important. Any initiative related to material testing would be beneficial for us, shall it be only to reach out to experts from research.	Similarly to m4m, I consider the provision of infrastructure as interesting 'to have a look'.	I am not well enough informed about the planned centers and think this also has to do with our rather geographically remote location. Also, I think this represents a potential problem of enough range of attraction of current research to SMEs. Generally, I think more should be done in order to provide a basis for technology transfer to SMEs. SMEs represent the majority of Swiss companies and not enough effort is done in order to provide them not only infrastructure but also knowledge.
Expert 5	Metal components have broader fields for innovative applications than m4m is pursuing. More interesting would be fields of applications related to ceramic and composite materials rather than metal printing. Many UAS are researching (in my eyes) in the field of quality assurance and material testing of printed metal products. The strength of 3D printing is individuality of mass-specific customized products, but metals are out of-date in terms of material usage for medtech applications.	I am not an expert but certainly interested in terms of post-processing of applied AM technologies.	We are producing machines in the same market as M2C, but in our eyes, customers are not necessarily interested in innovations since not yet well established and partially too fast.	Potentially useful since related to quality control. I think that addressing potential customers will be challenging.	not addressed	We are not an SME, but I think a successful transfer is related to addressing designers and constructors within SMEs. SMEs are not well addressed by current research activities and also Innosuisse is of no big help. Our direct interaction with univ. or UAS is much better. The majority of centers focus on 3D printing of metal components, which requires a post-processing with conventional technologies. In all 5 centers, there is a persistent lack of AI or industry 4.0 related topics. More research has to be done related to industry 4.0 and quality assurance of products.
Expert 6	As a third-party service provider for 3D metal printing, I do not see m4m as a competitor	Again related to quality management and assurance, HIPing is an important down-stream	not addressed	ANAXAM is certainly also interesting for quality assurance of (our) production processes. It	not addressed	For me as an expert in the metal printing industry, all 3 centers m4m, hipC and ANAXAM make sense to be subsi-

	but much more as an enabler for the broad industry, this is at least my hope. As a rather small service provider, we do not have the capacity to reach more potentially interested companies. Also, we face big challenges when producing printed components for the automotive and medtech industry in terms of quality management. If the center really is pursuing best practice in standardization, this certainly would represent value added for the industry.	process after 3D metal printing. I am not fully convinced if a center actually is really needed in the proposed form but from our perspective, if a center like m4m is subsidized, then it surely makes sense to take the downstream value chain also into consideration, which would be HIPing of components.		also could be that less sophisticated analytic processes are easier to communicate as a need for the industry, for instance CT technology (computer tomography).		dized all together and they offer complementary services and might act as a technology enabler in the industry. What is lacking for me or what I cannot see from the present documents is, how they plan to reach out to SMEs and second how to reach medtech companies and automotive companies: up to now, there are still doubts on the production possibilities of 3D printing and those problems are strongly linked to the needs of post-processing for quality assurance of components and standardization. So, the real challenge may be more on the marketing side than on the technology or infrastructure level.
Expert 7 *(involved in ANAXAM)*	I think that basically what m4m is intending to provide already exists and companies interested in 3D printing already have enough process knowledge. Certainly, it is interesting to access the medtech industry more deeply and it is necessary to provide services and infrastructure as a 'playground' for SMEs. For instance, many SMEs would be interested in prototyping parts on production machines at UAS, but machines often are congested with industrial production assignments.	From an innovation perspective I have the biggest doubt regarding this center. The project has a clear research character which is nothing that UAS would not be able to fulfil and pursue. There is nothing new about HIPing and there are also industrial service providers, so there is no need to create a new center for HIPing of components.	There are already important players in research (EPFL, ETH, UniBE, SwissPhotonics) working on the same or on similar applications that this center is trying to achieve. Also here, I am not convinced whether the foundation of a new center is meaningful, but more effort should be put in centralizing these research efforts and trying to manage technology transfer to the industry. If the center puts focus on technology transfer and on centralizing research efforts in this field, then the creation of such a	Anaxam aims at making large-scale facilities usable to the broader industry and aims at actually doing technology transfer for PSI. A high value added to SMEs would be to control production process weaknesses as a result of the analyses. A big effort however has to be done on the 'marketing'-side in order to effectively reach out to SMEs and to communicate advantages of the process for quality improvement of their processes.	not addressed	For all centers, I do not recognize any innovation related to digitalization of processes or industry 4.0 related topics. For hipC and M2C I do not see a clear value added to the industry since already many service providers or research institutes are working on that and the creation of new centers is exaggerated.

	In my eyes, 3D printing alone is not enough and to focus on standardization is a good approach, but I do not think that the center is really creating a value added compared to what already exists at UAS and similar. A key factor for me would be whether the center could achieve an effective outreach to SMEs and that it is able to realize important innovation down-stream the production process related to quality assurance of components.		center could be a value added. I do not know whether this center would seek collaboration with aforementioned research groups in order to communicate research results to the industry.			

Source: Expert interviews.

6. Summary and Conclusions

At the beginning of this report we asked four questions on the technological focus areas and services of the five new centres and whether they have been designed in a way that contributes to making progress towards advanced manufacturing in Switzerland; whether they meet the needs of Swiss industry; whether they are complementary to services provided already by other organisations in the field; and whether they are consistent with the Swiss research and innovation system and policy.

We found that the centers differ considerably with regard to their size and funding, the technological innovation system or systems in which they intend to become active, their service portfolios and further supply-related aspects, volume and structure of demand, as well as state of development of converting (often diffuse) user needs into actual demand. The summary section at the beginning of this report summarises these insights for the five centers individually and this section gives an overview over all centers together.

6.1 Technological focus areas and services

The five centers intend to serve different TIS. Whereas two (m4m, M4IVD) focus on specific products in specific application areas and industries, the other three focus on knowledge fields which can be relevant for a wider set of applications (Table 21). Individual experts expressed dissatisfaction with the TIS and technologies covered by the centers and missed topics relates to the digitization of processes, industry 4.0, artificial intelligence, but also more traditional production processes like grinding, drilling or milling which are still very important.

Not only the centers’ TIS but also their service portfolios vary. Technological and consulting services have been included in the service portfolios of all centers, but beyond these two the service portfolios differ and can be quite narrow (hipC, M2C) or broad (m4m, ANAXAM, M4IVD).

Table 21. Overview of technologies and services

	m4m	hipC	M2C	Anaxam	M4IVD
Technological innovation systems	3D-printing of metallic implants in the medicinal technology and health industries	Hot Isostatic Pressing (HIP) for improving the density, ductility and fatigue resistance of high-performance materials resulting from additive manufacturing	Micro-engineering using femtosecond laser micro processing and high-precision multi-material free form additive manufacturing across a wide set of industries	Applied materials analytics using neutron and X-ray radiation across a wide set of industries	In-vitro diagnostic (IVD) tests for point of care health services
Service portfolios					
Research	☐	☒	☐	☐	☒
Collabortive tech. development	☒	☐	☐	☐	☒
Technological services	☒	☒	☒	☒	☒
Pilot production	☒	☐	☐	☐	☒
Consulting	☒	☒	☒	☒	☒
Demonstrations and visits	☒	☐	☐	☒	☐
Educational offers (students)	☒	☐	☐	☒	☐
Training offers (professionals)	☒	☐	☒	☒	☐
Standards dev.	☐	☐	☒	☐	☐
Spin-off support	☐	☐	☐	☒	☒

Sources: Application documents and survey of centers.

The crucial question is, of course, whether these services are suitable to advance AM and the TIS in which the centers are active. As pointed out above (section 2.1), the absence or insufficient quality of any of the components of a TIS can limit its functionality, and whether the new centers address such problems would have to be answered through an analysis of the TIS. Such differentiated analyses have not been conducted according to our knowledge and the center applications do not provide enough details on the TIS either. However, this would be crucial as not only theory, but also past experiences with action programmes in Switzerland have taught us. It should be noted that the AM-TTC initiative is not the first action programme that Swiss research and innovation policy has initiated in the past 30 years. Previous technology-oriented innovation support programmes were, e.g.:

- Computer-integrated manufacturing (CIM) action programme (1990-96),
- Action programme microelectronics (MICROSWISS) (1991-96),
- Support programme soft[net] (2000-03),
- Action programme TOP NANO 21 (2000-03).

These programmes were primarily aimed at technology diffusion and increasing the application and/or production competence of companies in the corresponding technology areas. TOP NANO 21 was also aimed at building competence in the education and research sector related to nanotechnologies and contained a strong science and basic research component. The programmes differed with regard to the measures and in the earlier programmes CIM and Microswiss separate centres were set up to offer specific services, quite similar to the current AM-TTC initiative. The more recent programmes soft[net] and TOP NANO 21 on the other hand, only provided for the establishment of “virtual centres” by networking existing institutions and companies. In essence, however, the range of services was similar across the four programmes and included education/training, R&D, consulting and technology transfer. Within the frameworks of soft[net] and TOP NANO 21 start-up activities and networking were also supported.

With regard to the effects of these programs, mixed conclusions were drawn in the programme evaluations and later evaluation syntheses.[2] According to Barjak (2013) the programmes had almost no measurable economic outcomes (such as new firms, new products and markets, new processes, cost reductions, or employment effects), but they were strong with regard to raising technological competences and establishing education and training offers (see also Hotz-Hart & Rohner, 2013). While the two centre-based programmes CIM and Microswiss, which had established separate CIM/MICROSWISS centers early on in their implementation phases, were attested to support technology diffusion and adoption, particularly among SMEs (Barjak, 2013; BBT, 2001; Arvanitis, Donzé, & Hollenstein, 2005), this was not the case for the later programmes with virtual centres. However, CIM and MICROSWISS have achieved these effects not at last through strong links to the (technical departments of) universities of applied sciences and their training programmes, which were being established around the same time (Hotz-Hart & Rohner, 2013). In addition, the CIM evaluation stressed that this outcome was more obtained through training/information and consulting than the support of development projects (Arvanitis, Donzé, & Hollenstein, 2005). This was different in the case of MICROSWISS, where cooperative projects were evaluated as more effective than training offers

[2] Each of the programmes was subjected to summative evaluations after its implementation (Arvanitis et al., 2005; Balthasar & Lehmann, 2005; Bierhals, Ebersberger, & Edler, 2005; Bundesamt für Berufsbildung und Technologie BBT, 2001; Dreher & Balthasar, 1997) and additionally the former Federal Office for Professional Education and Technology commissioned in 2012 two evaluation syntheses of Swiss innovation policies which included these programmes (Barjak, 2013; Hotz-Hart & Rohner, 2013).

(Bundesamt für Berufsbildung und Technologie BBT, 2001). Soft[net] and TOP NANO 21 were perceived as strong with regard to creating stable relationships between the organisations in their fields, above all between firms and research institutes (Balthasar & Lehmann, 2005; Barjak, 2013).

In our view, the analyses of the older programmes suggest a number of conclusions, which are highly relevant for AM-TTC:

1. Generating outcomes in economic terms, e.g. in the form of entrepreneurship and new firms, product innovations or process innovations, has been a common goal of action programmes, but at the same time challenging to achieve for obvious reasons (e.g. multiple influences on innovation success, no or very limited ability to influence market reactions, too little funding). Hence, economic impacts should not be the first priority of technological action programmes.
2. Technological outcomes above all with regard to technology diffusion, raising technological competencies, and networking organisations have been easier to achieve in past programmes. Which measures are most effective to achieving this is hard to say, as this varied across the programmes and the evaluation results differ. This suggests, that the initial conditions and contexts influence the effectiveness of measures. If a detailed analysis of the latter is missing, the chances rise that the chosen measures do not meet industry needs and encounter only a reserved reception. The new AM-TTC centers should have a clear understanding, what the main deficits among their customers in the TIS are and adjust their offers accordingly: Do companies, for instance, merely lack access to AM equipment to implement well understood processes? Do they miss knowledge about the benefits of using AM technologies (and therefore stick to older technologies)? Do they need help with customising flexible and multi-purpose technologies according to their needs and processes? Do they miss the necessary competencies for working with AM technologies? Are they burdened by a scarcity of qualified and experienced staff for implementing their decisions on the introduction of AM technologies? The replies to these questions most certainly differ between TIS and lead to very different service portfolios of the centers.
3. The establishment of educational and training offers and strong links to the emerging universities of applied sciences were identified as important aspects of the action programmes contributing to success in several cases. The new AM centers should also take the educational task in the field of advanced manufacturing seriously and use the infrastructure in cooperation with the universities precisely for this purpose (m4m and ANAXAM have described such initiatives in their applications).

Returning to the initial question we must concede that the centers and their partners surely know their respective TIS and probably have developed over the years an in-depth understanding of the problems and necessary contributions. However, the provided application documents and answers to our questions do not make this explicit and it is therefore not possible to conclusively judge the centers on the suitability of their service portfolios for bringing progress to their TIS.

6.2 Finding demand in Swiss industry

The question whether the new centers meet the needs of Swiss industry and will therefore encounter demand needs to be answered separately for each center. For three of the five centers (m4m, hipC, and ANAXAM) we expect that sufficient demand for their services will emerge, and for two of the centers we are rather skeptical in this regard (M2C, M4IVD).

- m4m: The center is well embedded in its application community of Swiss medtech SMEs and health organisations. It explicitly plans to start the process of working with its customers with an analysis of their needs and intends to provide its services to a large and growing number of customers every year.
- hipC: The center is well embedded among its application community and, as providers of similar industrial services are involved, it is likely that the industrial community can be reached. The center also intends to work with other market segments, research institutes and in the longer term foreign companies.
- M2C: Market-building is in an early stage and users need to be involved intensively in order to define their demand from the center. The center is not well embedded in its user community and it expects to work with a small customer base only.
- ANAXAM: The small customer base applies for ANAXAM as well, but the center seems to have stronger linkages to its application community and, above all, it can draw on experiences collected with providing its analytical services to the life sciences community. This raises the chances, that it will be able to generate demand among Swiss AM companies as well.
- M4IVD: This center is also not widely embedded and its demand expectations are the lowest of all five centers. In addition, funding could become an issue for the center's customers, as they would also have to be able to raise funds for further in-vivo testing (in clinical trials) of the in-vitro diagnostic tests resulting from their collaboration with M4IVD.

Table 22. Demand-related aspects of the centers

	m4m	**hipC**	**M2C**	**ANAXAM**	**m4ivd**
User-base structure	Medtech companies, doctors, researchers	Companies in CH and abroad producing parts through additive manufacturing in several industries	Indefinite: Several industries and research organisations	Indefinite: Several industries in the field of AM, research organisations	Biotech and diagnostics SMEs, pharmaceutical companies and research organisations
Embeddedness in user comm.	Embedded	Embedded	Not widely embedded	Embedded	Not widely embedded
Size of projected annual demand	Large	Large	Small	Small	Small
Main customer segment	Swiss SMEs	Swiss and foreign research institutes	Swiss SMEs	Swiss SMEs	Swiss SMEs
Definition of need	Within reach First decision point for determining services by the center/other service providers	Complete – Within reach 20 customers have formulated requests for special HIP / HT treatments.	Within reach – inarticulate Initial focus areas correspond to bottom-up requests from the industrial partners in the consortium	Within reach – inarticulate Users understand their needs from product and process requirements and lab scale analytics	Within reach Customers understand their own technologies and need for IVD which is implemented w. the center
User involvement in need determination	Moderate to intensive Users need to articulate what services they request and depending on these needs and	Moderate Users need guidance on HIP/HT cycles and advice on	Moderate to intensive Users need to articulate what services they request and depending on these needs and	Moderate to intensive Consultation between customer and center to evaluate the appropriate analytical methods	Moderate to intensive Users need thorough understanding of their own technologies and cooperate with center

	m4m	hipC	M2C	ANAXAM	m4ivd
	their own competencies the service level will differ.	adequate pressures and temperatures according to material and desired microstructural effects.	their own competencies the service level will differ.		to develop a commercially marketable IVD test
Markets for the center	**Not yet, high feasibility** Markets for other 3D printing services exist with regard to medical implants (e.g. design, testing, surface treatment).	**Existing** One partner has received requests for special HIP / HT treatments which had to be rejected.	**Not yet, low feasibility** Emerging technologies in free form micro-manufacturing might be demanded, but market-building in very early stage.	**Feasible, partly existing** Market exists for life sciences, possibility of market building and spin-off creation to supply services have been mentioned.	**Not yet, low feasibility** Point of care IVD test market not addressed by bigger companies; SMEs strong in development of biomarkers, but overall development of IVD tests is costly.

Sources: Application documents and survey of centers.

6.3 Complementarity to other offers

The complementarity of the activities of the new centers was explicitly addressed in sections 5.2.3 and 5.5 (specific questions to m4m and ANAXAM). The results will not be reported again in detail, but a few general conclusions can be drawn.

1. The risk of overlaps or insufficiently coordinated service provision between the centers and their partners and other players in a TIS grows, if the value proposition of the center and division of labour between center and partners have not been defined clearly. Four of the five centers are subject to such risks for different reasons.

Table 23. Possible overlaps with R&D and industrial partners

	Possible overlaps with R&D partners	Possible overlaps with industrial partners
m4m	–	Low risk of overlaps, but service portfolio of m4m and 41medical are complementary, but closely linked, e.g. when it comes to the design and subsequent (pilot) production of metallic implants.
hipC	Risk of overlap with regard to research function, as hipC plans own research activities.	Considerable risk of overlaps, as industrial partner Deloro HTM offers lower pressure HIP.
M2C	Some risks of overlaps with research and/or industrial partners as the value proposition and service portfolio of center are not well developed.	
ANAXAM	–	–
M4IVD	Risk of overlap with regard to research function, as M4IVD plans own research activities and even considers recognition as Innosuisse research partner.	–

Source: Application documents and survey of centers.

2. The survey among the centers suggests that they still need to develop plans and activity sets for coordinating with other players in their TIS (see Table 15, p. 54 and section 5.5). At present, the prevailing view is that coordination will be achieved simply due to the uniqueness of the infrastructure and through the participation in the corresponding TIS. This, however, might not be so easy to achieve, especially if the TIS are more diffusely defined by fields of knowledge as in the cases of hipC, M2C, and ANAXAM.

3. CSEM and inspire have perceived the overlaps between their own offering and the planned offerings of the new centers as not meaningful (see Table 24, p. 81), above all as their business models do not rely on the provision of infrastructure and open access to their infrastructure.

6.4 Consistency with the Swiss research and innovation system and policy

The last question on the overall consistency of the new initiative with Swiss innovation policy would require a closer analysis of these policies which is not possible within this report. Arvanitis and Hollenstein (2012) described Swiss innovation policy as "fundamentally oriented" ("grundlagenorientiert"), as it rests on the premise that business innovation is the task of companies, which produce close to the technological frontier in the technologically advanced Swiss economy and know better than others, for instance policy-makers, which innovations have commercial potential. The federal government practically does not provide innovation funding directly to companies, but supports them indirectly. On the one hand, Switzerland's innovation policy ensures innovation-friendly framework conditions, for example with regard to tax law, competition law, labour law or sectoral policies (energy, health, transport, environment). On the other hand, in the spirit of educational federalism, the Confederation and the cantons ensure that a sufficient number of qualified graduates are available to companies through vocational and academic education (Hotz-Hart & Rohner, 2014). Swiss federal research policy finances basic research and applied R&D (Arvanitis & Hollenstein, 2012; Hotz-Hart & Rohner, 2014; OECD, 2016). It concentrates on universities and non-university R&D institutions and grants practically no innovation funding directly to companies. The responsibility for collecting knowledge and technology from universities and non-university R&D institutions and translating it into innovations remains with the companies.

A clear identification of innovation funding and separation from spending for R&D and education is difficult with the existing published documents, above all the federal dispatches for education, research and innovation (Schweizerischer Bundesrat, 2016). However, most of the innovation-related funding goes to basic and applied research in the higher education sector, i.e. the ETH domain, cantonal universities and universities of applied sciences. The results are then transferred to companies through qualified graduates and the knowledge and technology transfer activities of the universities and their faculty. Innosuisse supports this with various measures, above all the collaborative R&D projects between research and application partners, coaching and training of start-ups, mentoring of companies and networks, and – with a particular focus on the energy sector – the Swiss Competence Centers for Energy Research (SCCER).

These SCCER and the older action programmes that have been discontinued in the meantime, CIM, Microswiss etc. (see above), indicate that a focus on technology- or industry-specific action programmes is not new in Swiss innovation policy. The logic of funding cooperative activities of universities and research institutions, companies and other actors in the TIS is also not new. However, whereas in the past a focus was placed on financing R&D, this is not the case with the AM-TTCs. Nevertheless, this focus will undoubtedly be ensured in the activities because research partners are involved in all centers and in four out of five centers have also taken on the coordination and lead of the center. As already mentioned above (see section 6.1) the link to teaching and educational offers of the tertiary education institutions but also of vocational schools and professional training centers might have to be stressed further, as this was an important ingredient to success in previous technological action programmes in Switzerland, such as CIM, MI-CROSWISS, or soft[net]. It was also explicitly requested by some of the interviewed experts.

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Annex

Table 24. Complementarities or overlaps between the technologies planned by the five new applications for Art. 15 RIPA funding and CSEM & inspire

	Inspire	**CSEM**
Complementarities or overlaps	Complement: ANAXAM, hipC, m4m. These institutions have infrastructures that inspire could use only in a few projects, but the potential is a maximum of 1-2 projects per year, each for only a few days. Competition (substitutes): The AM-TTC will mainly provide pilot plants to ensure scaling from laboratory prototypes to serial production, with the participation of several industrial companies in a precompetitive phase. Based on 15 years of experience with projects in the MEM industry, inspire is of the opinion that this model will find only a few applications in this important industrial sector. Together with its 6 partner institutes in "Advanced Manufacturing", inspire is mainly active in the phases "application-oriented basic research" and "applied research/technology development" of the technology lifecycle. The subsequent phase of scaling to series production level is usually carried out by the individual industrial partners, not in precompetitive mode, but by each industrial partner alone. At the technical level, there is therefore no competition between inspire and the AM-TTC. At the financial level, a competitive situation could arise at best, as the AM-TTC also fall under the category of technology competence centres according to Art. 15c FIFG. It would be fatal, however, if the funding of the AM-TTC were to reduce inspire's federal contributions to research activities in advanced manufacturing in the strategically important phases of "application-oriented basic research" and "applied research/technology development", above all because the AM-TTC's infrastructure character would tend to make it one of the competence centers under Art. 15a FIFG.	CSEM has accepted to join the Board of AM-TTC and supports this initiative through M2C and M4IVD. However, the mission and positioning of the AM-TTC as a whole is still not very clear to us. Stricto sensu, they are mainly based on building infrastructures and equipment that will be accessible for both research and industry partners, similar to the UK’s Digital Catapults. As such, there will be no overlap with CSEM, which itself is a “pure” Technology Competence Center, much like the Fraunhofer (FhG) centers, as defined by RIPA Art.15.3c. Furthermore, the inclusion of the AM-TTC centers in Art.15.3c “Technology competence centers” is somehow confusing, since they seem more aligned with the “research infrastructures” of art.15.3a, although with a stronger emphasis on valorization. From a thematical point of view, CSEM focuses its Advanced Manufacturing activity on precision and smart systems. All our past and future investments, technology platforms, and solutions concentrate on pushing the limits of AM in high precision (i.e. the micro scale) and in hybridization (printing sensors, actuators, and flextec© structures). These are the prerequisites for serving at least two important industries in Switzerland, namely watch manufacturing (65’000 jobs) and scientific instrumentation. However, the challenge of AM is by far not only a matter of infrastructure and equipment (which are necessary, but clearly not sufficient). The main effort and key to success lies in completely changing the design paradigms of classical manufacturing, in the thorough characterization of the manufactured objects, and in the development and deployment of tailor-made manufacturing processes for relevant applications. This last and important task is rarely compatible with open, shared and flexible infrastructure, which is why CSEM is investing and will continue to invest in both equipment and manpower to maintain its successful business model. This is the USP of CSEM and its added value as a Technology Competence Center, serving the innovation in industry.

Table 25: Expert interviews conducted

#	Expert name	Expert organization	Interview date, duration and remarks	Conflict of interest
1	Mr. Fouad Cheaitani Head customer support and business development Stellba AG	Stellba AG Wohlerstrasse 51 5605 Dottikon	06.12.2019 13:30 – 14:30 (conversation recorded: 51min)	None
2	Mr. Alexander Teuber Business Development SLM Trumpf AG	Trumpf AG	09.12.2019 10:00 – 11:00 (conversation recorded: 53min)	None
3	Mr. Anton Demarmels Head research comission Swissmem	Swissmem	09.12.2019 13:45 – 14:55 (conversation recorded: 68min)	None / person is well connected to involved researchers
4	Mr. Martin Graf CEO Admantec AG	Admantec AG Kesselbachstrasse 38 9450 Altstätten SG	11.12.2019 09:00 – 10:00 (conversation recorded: 30min, interviewee arrived late due to traffic)	None
5	Mr. Fred Gaegauf VR United Grinding Group AG	United Grinding Group Jubiläumsstrasse 95 3005 Bern	11.12.2019 13:30 – 15:00 (conversation recorded: 76min)	None reported / is involved in the administrative board of inspire
6	Mr. Daniel Kündig Founder Ecoparts AG	Ecoparts AG Zürcherstrasse 62 8340 Hinwil	12.12.2019 13:30 – 15:00 (conversation recorded: 71min)	None
7	Mr. Markus Krack Head Technology Transfer Center FHNW, School of Engineering	FHNW School of Engineering Klosterzelgstrasse 2 5210 Windisch	16.12.2019 16:00 – 17:00 (Status: open)	

Note: If no address is reported, the interviews took place at UAS NorthWestern Switzerland, 4600 Olten.

University of Applied Sciences and Arts Northwestern Switzerland
School of Business

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Annex 2: Questionnaires

Swiss Science Council SSC

Assessment of the research facilities of national importance

Survey of the University of Applied Sciences and Arts Northwestern Switzerland, on behalf of SSC

Dear xyz

SSC conducts with the help of the School of Business of FHNW the simplified evaluation foreseen in the application process for Art. 15 RIPA funding for which your center has applied.

This document contains questions which need to be answered in the process. Please be aware that the questions have been sent to all new AM-TTC centers and that some aspects may have already been answered in your application document. In this case, please copy the corresponding part of the application into this questionnaire.

Please answer the questions and send the document back by email or regular mail as soon as possible but until **December 13th** the latest.

We apologise for the very short timeframe, but we hope that you will contribute to ensure a correct and fair evaluation of your centre.

Thank you very much for your support!

Dr. Claudia Acklin, Swiss Science Council

Prof. Dr. Franz Barjak, School of Business, University of Applied Sciences and Arts Northwestern Switzerland

Prof. Dr. Fabian Heimsch, School of Business, University of Applied Sciences and Arts Northwestern Switzerland

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Theme A: User base of the center

1. **Please describe the minimum competencies your customers need to have in order to carry out projects with your center.**

   Klicken oder tippen Sie hier, um Text einzugeben.

2. **Please estimate the size of the center's potential customer base in 2021 by type of customer.**
   Note: Potential customers are all organisations which are likely to request any of the services offered by the center according to its terms of reference.

   Number of customers

   … … … … Small- and medium sized enterprises

   … … … … Large enterprises

   … … … … Research institutes (from universities, ETH sector, universities of applied sciences, other public sector)

   … … … … Other organisations, please describe: … … … …

   … … … … TOTAL

3. Please differentiate the potential customer base in 2021 by location.

Number of customers

… … … … Regional customers (located in vicinity of the center, e.g. same canton or region)

… … … … National customers (located in other Swiss cantons)

… … … … Foreign customers (located abroad)

… … … … TOTAL

4. Please provide an estimate for the number of customers which will be served by the center per year (and if applicable per customer type).

	2021	2022	2023	2024	TOTAL
Small- and medium sized enterprises					
Large enterprises					
Research institutes (from universities, ETH sector, universities of applied sciences, other public sector)					
Other organisations, please describe: … … … …					
TOTAL					

5. How will access to the center be guaranteed for customers from the outside not pertaining to its partners or sponsors?

Klicken oder tippen Sie hier, um Text einzugeben.

Theme B: Services of the center

6. Please estimate how many different projects or collaborations (of companies, research partners, etc.) can be accommodated in the center and use the infrastructure planned for 2021 and 2024 over a period of one month at full capacity.

… … … … estimated number of projects per month in **2021**

… … … … estimated number of projects per month in **2024**

7. What will be the main limiting factors?
Multiple answers are possible.

	In 2021	In 2024
Staff of the centre	☐1	☐2
Own infrastructure of the centre (including equipment, buildings etc.)	☐1	☐2
Staff of affiliated and partner institutions	☐1	☐2
Infrastructure of affiliated and partner institutions	☐1	☐2
Demand from customers	☐1	☐2
Competition from other service providers	☐1	☐2
Other limiting factors, please describe briefly: Klicken oder tippen Sie hier, um Text einzugeben.	☐1	☐2

8. Please indicate the expected importance of each output in your center's portfolio (in terms of delivery to future clients and result of joint projects conducted in the center).
Please check one box per line.

Possible outputs, i.e. results of projects conducted with your future customers	Very high importance	High importance	Medium importance	Low importance	Very low or no importance
1. Materials (ceramics, glasses, metals, polymers, hybrids etc.) created as input into manufacturing processes	☐1	☐2	☐3	☐4	☐5
2. Equipment (machines, instruments, tools, fixtures etc.) for manufacturing processes	☐1	☐2	☐3	☐4	☐5
3. Manufacturing and other processes to be implemented by the customers	☐1	☐2	☐3	☐4	☐5
4. Computer software	☐1	☐2	☐3	☐4	☐5
5. Research results (proof-of-concepts, validations etc.)	☐1	☐2	☐3	☐4	☐5
6. Results of technological services (testing, analytics, design, modelling, simulation etc.)	☐1	☐2	☐3	☐4	☐5
7. Results of technology and systems development (prototypes, demonstrators etc.)	☐1	☐2	☐3	☐4	☐5
8. Other intangible goods (intellectual property etc.)	☐1	☐2	☐3	☐4	☐5
9. Physical goods (products, objects, hardware, artefacts etc.) that result from manufacturing processes	☐1	☐2	☐3	☐4	☐5
10. Other outputs, please describe … … … …	☐1	☐2	☐3	☐4	☐5

9. Please describe the main implementation risks of the service provision through the center and how the center plans to deal with them in the process (risk management).

Klicken oder tippen Sie hier, um Text einzugeben.

Theme C: Center funding

10. Please provide reasons for the necessity of the Art. 15 RIPA funding contribution to the center for 2021-24?

Klicken oder tippen Sie hier, um Text einzugeben.

11. Please explain in detail the revenue model of the center, i.e. how revenues are generated from the use of the infrastructure and the provision of services.

Klicken oder tippen Sie hier, um Text einzugeben.

12. Please describe the services which could be provided without the Art. 15 RIPA contribution with the funds contributed by the center's partners and other 3rd party funding (e.g. service fees raised from customers)?

Klicken oder tippen Sie hier, um Text einzugeben.

Theme D: Relationship with other Swiss service providers

13. Will the Centre offer services which are complements or substitutes of services provided by (groups and institutes of) any of the following Swiss organizations?

Complement: services relate to each other, complete each other, are additional
Substitute: services replace each other, are mutually exclusive
Please check one box per line.

	Complement	Substitute	Neither complement nor substitute
ETH sector			
ETH Zürich (ETHZ)	☐1	☐2	☐3
Ecole Polytechnique Fédérale de Lausanne (EPFL)	☐1	☐2	☐3
Paul Scherrer Institut (PSI)	☐1	☐2	☐3
Eidg. Anstalt für Wasserversorgung, Abwasserreinigung und Gewässerschutz (Eawag)	☐1	☐2	☐3
Eidg. Materialprüfungs- und Forschungsanstalt (Empa)	☐1	☐2	☐3
Eidg. Forschungsanstalt für Wald, Schnee und Landschaft (WSL)	☐1	☐2	☐3
Universities			
Universität Bern	☐1	☐2	☐3
Universität Basel	☐1	☐2	☐3
Université de Fribourg	☐1	☐2	☐3
Université de Genève	☐1	☐2	☐3
Université de Lausanne	☐1	☐2	☐3
Université de Neuchâtel	☐1	☐2	☐3
Universität St. Gallen	☐1	☐2	☐3
Università della Svizzera Italiana	☐1	☐2	☐3
Universität Zürich	☐1	☐2	☐3
Universities of Applied Sciences			
Berner Fachhochschule (BFH)	☐1	☐2	☐3
Fachhochschule Nordwestschweiz (FHNW)	☐1	☐2	☐3
Fachhochschule Ostschweiz (FHO)	☐1	☐2	☐3
Fachhochschule Zentralschweiz (FHZ)	☐1	☐2	☐3
Haute école spécialisée de Suisse occidentale (HES-SO)	☐1	☐2	☐3
Scuola universitaria professionale della Svizzera Italiana (SUPSI)	☐1	☐2	☐3
Zürcher Fachhochschule (ZFH)	☐1	☐2	☐3
Others			
Centre Suisse d'Electronique et de Microtechnique (CSEM)	☐1	☐2	☐3
Inspire AG	☐1	☐2	☐3
Private companies in Switzerland providing relevant services	☐1	☐2	☐3
Others, please provide the name: Klicken oder tippen Sie hier, um Text einzugeben.	☐1	☐2	☐3

→ Filter: If you checked any of the boxes under "complement" in the previous question.

14. Please describe how you plan to ensure a seamless provision of services and coordinate with organisations providing complementary services?

Klicken oder tippen Sie hier, um Text einzugeben.

→ Filter: If you checked any of the boxes under "substitute" in question 13.

15. Please describe how you plan to deal with substitution services (competition, cooperation)?

Klicken oder tippen Sie hier, um Text einzugeben.

16. Do you have any further comments or suggestions to be taken into account in the assessment?

Klicken oder tippen Sie hier, um Text einzugeben.

Theme E: Center-specific questions

Swiss M4M:

17. What is the status of the financing commitments by the involved cantons Berne and Solothurn?

Klicken oder tippen Sie hier, um Text einzugeben.

18. The planned centre is primarily concerned with the transfer and application of 3D technology in the medical industry. What is the significance of the research and development dimension?

Klicken oder tippen Sie hier, um Text einzugeben.

**19. The application envisages synergies with sitem Insel AG in the area of training.
Are all possible synergies with the translation center sitem Insel AG exhausted?**

Klicken oder tippen Sie hier, um Text einzugeben.

**20. Additive manufacturing is also a focus of the inspire AG (https://www.inspire.ethz.ch/de/forschung-fuer-die-industrie/additive-fertigung-3d-druck-design-for-am/). In addition, CSEM has a focus on advanced manufacturing as well as expertise in implants.
Has a cooperation with either inspire and/or CSEM been examined?**

Klicken oder tippen Sie hier, um Text einzugeben.

Anaxam:

21. What is the status of the financing commitment by the canton Aargau?

Klicken oder tippen Sie hier, um Text einzugeben.

22. The CSEM also has competences in the field of surfaces. Have synergies been examined? What is the delimitation like?

Klicken oder tippen Sie hier, um Text einzugeben.

Theme: Additional questions

23. Please list all partners of your center as of Dec. 1st, 2019.

Note: **Partners** are all organisations or individuals who own your organisation (e.g. shareholders), are members of the association and/or have a formal and long-term relationship that entails a significant contribution to your center's service offering. They do **neither** include the recipients of your services or customers **nor** suppliers at arm's length.

Please use the level of the organization and not sublevels, e.g. different chairs at ETHZ count as one organization (i.e. ETHZ), different chairs at ETHZ and EPFL count as two organizations (i.e. ETHZ and EPFL).

	Owner/member	Name	Canton	City
Research				
ETH sector	Yes ☐1 No ☐2			
Universities	Yes ☐1 No ☐2			
UAS	Yes ☐1 No ☐2			
Others	Yes ☐1 No ☐2			
Industry				
Application community	Yes ☐1 No ☐2			
Suppliers & consultants	Yes ☐1 No ☐2			
Government				
Federal	Yes ☐1 No ☐2			
Cantonal	Yes ☐1 No ☐2			
Community	Yes ☐1 No ☐2			
NPO (associations, foundations)	Yes ☐1 No ☐2			
Others	Yes ☐1 No ☐2			

Please insert further lines as necessary.

24. Please list the measures which your center has planned to build demand (from customers) for the offered Advanced Manufacturing services, e.g. generating awareness, determining users' needs etc.

Klicken oder tippen Sie hier, um Text einzugeben.

25. Please list the measures which your center has planned to broaden the supply of Advanced Manufacturing services, which draw on your infrastructure and competencies, but go beyond your center itself, e.g. activating your partners, training consultants, or spinning-off your center's personnel.

Klicken oder tippen Sie hier, um Text einzugeben.

University of Applied Sciences and Arts Northwestern Switzerland
School of Business

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Science Council SSC

Assessment of the research facilities of national importance

Survey of the University of Applied Sciences and Arts Northwestern Switzerland, on behalf of SSC

Dear XYZ,

The Swiss Science Council (SSC) conducts with the help of the School of Business of FHNW the simplified evaluation foreseen in the application process for Art. 15 RIPA funding of the new Advanced Manufacturing Technology Transfer Centers (AM-TTC).

We were asked by to take a closer look at the overlaps between the (planned) new centers and your organization as well. This is the main purpose of the following questions. In addition, we want to compare the scope and aim of the new centers with established organizations in the field of Advanced Manufacturing in order to understand their potential impact.

Please answer our questions and send the document back by email or regular mail as soon as possible but until **December 13th** the latest.

We apologise for the very short timeframe, but we hope that you will contribute to ensure a correct and fair evaluation of the planned new centers.

Thank you very much for your support!

Dr. Claudia Acklin, Swiss Science Council

Prof. Dr. Franz Barjak, School of Business, University of Applied Sciences and Arts Northwestern Switzerland

Prof. Dr. Fabian Heimsch, School of Business, University of Applied Sciences and Arts Northwestern Switzerland

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Theme A: Partners and locations of your organization

1. Please list all locations of your organization existing (or planned) in 2021 and the planned staff FTEs.

	Canton	City	Staff foreseen 2021 (in FTEs)
Headquarters			
Klicken oder tippen Sie hier, um Text einzugeben.			
Klicken oder tippen Sie hier, um Text einzugeben.			
Klicken oder tippen Sie hier, um Text einzugeben.			
Klicken oder tippen Sie hier, um Text einzugeben.			
TOTAL	–	–	

Please insert further lines if necessary.

2. Please list all partners of your organization.

Note: **Partners** are all organisations or individuals who own your organisation (e.g. shareholders) and/or have a formal and long-term relationship that makes a significant contribution to your organisation's service offering. They do **neither** include the recipients of your services or customers **nor** suppliers at arm's length.

Please use the level of the organization and not sublevels, e.g. different chairs at ETHZ count as one organization (i.e. ETHZ), different chairs at ETHZ and EPFL count as two organizations (i.e. ETHZ and EPFL).

	Name	**Canton**	**City**
Research			
ETH sector			
Universities			
UAS			
Others			
Industry			
Application community			
Suppliers & consultants			
Government			
Federal			
Cantonal			
Community			
NPO (associations, foundations)			
Others			
TOTAL			

Please insert further lines as necessary.

Theme B: User base of your organization

3. Please describe the minimum competencies your customers need to have in order to carry out projects with your organization.

Klicken oder tippen Sie hier, um Text einzugeben.

4. Please estimate the size of the organization's potential customer base in 2021 by type of customer.

Note: Potential customers are all organisations which are likely to request any of the services offered by the center according to its terms of reference.

Number of customers

… … … … Small- and medium sized enterprises

… … … … Large enterprises

… … … … Research institutes (from universities, ETH sector, universities of applied sciences, other public sector)

… … … … Other organisations, please describe: … … … …

… … … … TOTAL

5. **Please differentiate the potential customer base of your organization in 2021 by location.**

Number of customers

… … … … Regional customers (located in your vicinity, e.g. same canton or region)

… … … … National customers (located in other Swiss cantons)

… … … … Foreign customers (located abroad)

… … … … TOTAL

6. **Please provide an estimate for the number of customers which will be served by your organization per year (and if applicable per customer type).**

	2021	2022	2023	2024	TOTAL
Small- and medium sized enterprises					
Large enterprises					
Research institutes (from universities, ETH sector, universities of applied sciences, other public sector)					
Other organisations, please describe: … … … …					
TOTAL					

7. **How is the access to your organization guaranteed for customers from the outside (not pertaining to your owners or sponsors)?**

Klicken oder tippen Sie hier, um Text einzugeben.

8. **Please list the measures which your organization carries out to build demand for Advanced Manufacturing services, e.g. generating awareness, determining users' needs.**

Klicken oder tippen Sie hier, um Text einzugeben.

9. **Please list the measures which your organization carries out to support the development of supply of Advanced Manufacturing services, e.g. training consultants, and spinning-off your organization's personnel.**

Klicken oder tippen Sie hier, um Text einzugeben.

Theme C: Services of the center

10. **Please describe the main infrastructures which are available at your organization for Advanced Manufacturing projects.**

Advanced Manufacturing is understood as a family of activities that (a) depend on the use and coordination of information, automation, computation, software, sensing, and networking, and/or (b) make use of cutting edge materials and emerging capabilities enabled by the physical and biological sciences (e.g. nanotechnology, chemistry, and biology). This involves both, new products emerging from new advanced technologies and new ways to manufacture existing products.

Klicken oder tippen Sie hier, um Text einzugeben.

11. Do you see any complementarities or overlaps between your infrastructure and the technologies planned by the five new applications for Art. 15 RIPA funding coming from the AM-TTC initiative?

Acronym	Name	Technologies	Main Contact
ANAXAM	Applied Materials Analytics with Neutron and X-Ray Radiation	Tailor-made sample environment/equipment, automated sample manipulators and detectors, to be used on SINQ, SLS and SwissFEL at PSI Supplementary infrastructure for pre-characterization (e.g. electron microscopy) and sample preparation Hardware and software for data analysis and data interpretation	Christian Grünzweig, PSI
hipC	Hot Isostatic Pressing (HIP) for Additive Manufacturing	HIP machine capable of high pressure (2000bar) and Uniform Rapid Cooling, allowing the combination of HIP and heat treatment	Felix Reinert, SIP Biel
M2C	Micro-Manufacturing Science and Technology Center	Femtosecond laser system and 3D printer for high-precision multi-material free form additive manufacturing	Bruno Studach, EPFL
M4IVD	Manufacturing for In-Vitro Diagnostics	Centralized and audited infrastructure, including up to 4 printing stations, embossing and nanoimprint station, reagents deposition by inkjet, converting and lamination station, die and laser cutting. 2nd generation line includes high precision manufacturing of microfluidics, optical structures and electrical sensors, 3rd generation line printing and assembling of active components on the disposable cartridge. Supporting manufacturing stations for calibration, labelling and pouching.	Christian Bosshard, CSEM
m4m	Manufacturing Technologies for Medical Applications	Pilot manufacturing line for 3D-printed implants using powder bed fusion technology "Selective Laser Melting" (SLM), integrated into an ISO 13485 certified quality management system (to produce medical devices of the classes I, II and III), powder handling, post processing and cleaning equipment, (probably later) coating equipment	Nicolas Bouduban, 41medical

Please add the acronym of the center, which technologies are complements or substitutes and how you evaluate this.

Klicken oder tippen Sie hier, um Text einzugeben.

12. Please estimate how many different projects or collaborations (of companies, research partners, etc.) in the field of Advanced Manufacturing can be accommodated in your organization and use the infrastructure planned for 2021 and 2024 over a period of one month at full capacity.

… … … … estimated number of projects per month in **2021**

… … … … estimated number of projects per month in **2024**

13. What will be the main limiting factors?

Multiple answers are possible.

	In 2021	**In 2024**
Staff of the centre	☐$_1$	☐$_2$
Own infrastructure of the centre (including equipment, buildings etc.)	☐$_1$	☐$_2$
Staff of affiliated and partner institutions	☐$_1$	☐$_2$
Infrastructure of affiliated and partner institutions	☐$_1$	☐$_2$
Demand from customers	☐$_1$	☐$_2$
Competition from other service providers	☐$_1$	☐$_2$
Other limiting factors, please describe briefly:	☐$_1$	☐$_2$

14. Please indicate the importance of each output in your organization’s portfolio (in terms of delivery to clients and result of joint projects conducted in the organization).
Please check one box per line.

Possible outputs, i.e. results of projects conducted with your customers	Very high importance	High importance	Medium importance	Low importance	Very low or no importance
1. Materials (ceramics, glasses, metals, polymers, hybrids etc.) created as input into manufacturing processes	☐1	☐2	☐3	☐4	☐5
2. Equipment (machines, instruments, tools, fixtures etc.) for manufacturing processes	☐1	☐2	☐3	☐4	☐5
3. Manufacturing and other processes to be implemented by the customers	☐1	☐2	☐3	☐4	☐5
4. Computer software	☐1	☐2	☐3	☐4	☐5
5. Research results (proof-of-concepts, validations etc.)	☐1	☐2	☐3	☐4	☐5
6. Results of technological services (testing, analytics, design, modelling, simulation etc.)	☐1	☐2	☐3	☐4	☐5
7. Results of technology and systems development (prototypes, demonstrators etc.)	☐1	☐2	☐3	☐4	☐5
8. Other intangible goods (intellectual property etc.)	☐1	☐2	☐3	☐4	☐5
9. Physical goods (products, objects, hardware, artefacts etc.) that result from manufacturing processes	☐1	☐2	☐3	☐4	☐5
10. Other outputs, please describe … … … …	☐1	☐2	☐3	☐4	☐5

15. Please explain in detail the revenue model of your organization, i.e. how revenues are generated from the use of the infrastructure and the provision of services.

Klicken oder tippen Sie hier, um Text einzugeben.

Theme D: Center-specific questions

CSEM:

16. Please describe at a high level what services CSEM’s customers can obtain?
Note: Please use an appropriate level that you use to distinguish the services, e.g. joint/collaborative R&D projects, contract research, (technological) consulting services, training courses, support to start-up companies etc.

Klicken oder tippen Sie hier, um Text einzugeben.

Thank you for your replies.

Please send the completed questionnaire back to us by e-mail or post:
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franz.barjak@fhnw.ch