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Requirements and Conditions for Developing Prototyping in the Industry

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1. INTRODUCTION

The aim of task WP5.4 is the definition, in cooperation with interested companies, of the basic requirements and conditions that can make attractive, feasible and effective to engage companies in developing prototypes of accelerator components (or significant accelerator parts) or large superconducting magnets. Since the beginning, it has been clear that this activity, called *industrialization*, aimed at placing European Industries in position to compete in the construction of new Research Infrastructures (RI) in Europe and worldwide, helps also in making the industry skilled in technologies with application beyond the RI interests such as in medical, industrial and safety fields. In other words, the industrialization is one way for promoting the innovation, which however AMICI studied in a specific and much more articulated ecosystem industry-TI in the framework of the Work Package 4 *Innovation.*

1.1. Amici and the industries

As all the WP5 activities are based on a tight relation with industry, it was necessary to set-up a collaboration frame with the companies working in the field of accelerator and superconducting magnets. This need is in fact common to the whole AMICI project and constitutes the main objective of the Work Package 1 Task 2 (Organization of the participation of Industry). During the first three months of the project a specific workshop was organized, the 'AMICI Partner and Industry Days for Scientific Technology Infrastructure' meeting, which took place in Padua, on April 18-19, 2017. In this meeting, the goal of the AMICI project was presented to the participating companies, focusing their attention in particular on the tasks and activities in which industry is going to play an important role, and to collect their comments, suggestions and expressions of interest in order to organize their involvement in the most effective way.

Regarding the industry interest for the WP5 activities, up to 13 companies expressed their interest in being informed of the activities of the different WP5 Tasks and from 2 to 6 companies were willing to participate to WP5 working groups studying the problems and proposing solutions.

1.2. Working Method

In order to study, analyse and elaborate a proposal governing the relation industry-TI in the prototyping activities, the working group AMICI-Industry played a central role, which along the three years activities has been a permanent forum for discussing the different approaches and points of view with the aim to achieve reasonable syntheses. After the Industry Days, six companies were actively working with WP5.4: ASG Superconductors (Italy), ANTEC Magnets, S.L.U. (Spain), Babcock Noell GmbH (Germany), ELYTT (Spain), Zanon (Italy), Sigmaphi (France).

As a first step, a questionnaire was sent to these companies for defining advantages and disadvantages when dealing with the collaboration between Technological Facilities and Industry in prototype developments. The industrial partners were asked to comment the different scenarios by assigning a rank to the entity of the advantage or disadvantage (High, Medium, Low and Negligible), and possibly commenting and adding further pros or cons. The construction of prototype with industry was debated in depth in two dedicated meetings of the T5.4 Working Group: the first was held in Milano (January 25th, 2018) and the second at Bruxelles (February 6th, 2018), this latter meeting being a satellite meeting of the “Accelerator-Industry Co-Innovation Workshop” (Bruxelles, 6-7 February 2018). Other meetings took place during the annual meetings of the AMICI collaboration. Two important aspects emerged from these meetings:

1) a *Subsidiarity Principle,* strongly supported by industries, stating that if industry is interested and has the technical capacity for developing a prototype, this should be favoured; the Technological Infrastructure (TI) should be involved only if industry is not able to do it.
2) The management of the Intellectual Property (IP) in the collaborating activities between TI and Industry. This aspect was discussed in a larger frame during a dedicated workshop organized co-jointly by AMICI and ARIES at CERN on May 16th (https://indico.cern.ch/event/723985/).

However the Work Package 5.4 activities were not only restricted in the framework of the Working Group but took also advantage of the information and discussions with other AMICI WPs, in particular with the WP4, dedicated to Innovation, which performed a wide survey among a large number of Industries.

Finally, a survey was performed for understanding the present legal frameworks in the EU for the collaboration between Industry and Academia in the development of prototype. This activity received a strong support of INFN office for external funds

All these activities are reported in the present document, including also comments and conclusions.

2. INDUSTRIALIZATION AND INNOVATION

As mentioned in the Introduction, Industrialization and Innovation are strongly related. In the framework of the report D4.1 a clear definition of innovation through 4 main strands is given. In particular, two strands of Innovation have relation with Industrialization:

• *Co-innovation: co-development of products, processes or services by the TI and Industry to meet shared technology development requirements*. When this technology is dedicated is inherent to components for accelerator or superconducting magnet, it is a case of Industrialization.

• *Outward Innovation: The translation of products/ processes/ services developed within the TI out to Industry for the purposes of industrialisation/ commercialisation*. This is a typical case of technology transfer, founded on the need to make the industry able to produce on large-scale components for accelerators or superconducting magnets, having an impact on the industry market beyond the scopes of RI.

In both cases when dealing with the construction of prototype, as already remarked in the AMICI proposal, taking a leading role in the construction of prototypes for the TI, can represent for industry a very effective way to acquire first-hand knowledge of cutting-edge technologies and to provide feedback on engineering aspects that are important for the following industrialization process.

3. THE FORMATION OF THE WP5.4 WORKING GROUP WITH INDUSTRIES

At first, the working group with the known industries involved in any kind of past or ongoing collaboration with INFN has been constituted. This was done during the industry meeting held in Padua 17-18/April/2017, attended by 83 participants, including 44 delegates from industries

Many industries and research institute showed interest in investigating problems and advantages in the industrialization and prototyping process. In particular, 13 companies expressed interest in being actively involved in a WP5.4 working group. Later these companies were asked to confirm their interest and to indicate the name of a contact person who can actively work. Eight companies confirmed their participation and consequently joined in the AMICI-Industry working group: ANTEC Magnets, ASG Superconductors, Babcock Noell, Elytt Energy, Ettore Zanon, OCEM, Oxford Instruments, Thales Communications and Security. Later on, six companies among these were actually active in the WP5.4 activities.

4. WP5.4 WORKING GROUP ACTIVITIES

4.1. Definitions

The development of a component for an accelerator could require a long R&D activity moving from feasibility studies to the construction of models and prototypes. A possible definition of the constructive phases of the R&D is the following:

Model: A device based on first development of conceptual ideas with a scaled (and many times progressive) approach. Usually tooling is not (fully) available yet. Many models could be necessary before moving to the next step of prototyping. In terms of Technology Readiness Level, a model stays in the range TRL4-TRL5.

Prototype: An almost mature component, for final assessing and training of tools and manufacturing methods. In principle, it could be used in an accelerator. In addition, in this case more than one prototype could be required before moving to the following step of component production. A prototype can range between TRL6 and TRL8.

Mass Production: Mature components. No more changes applied with respect to the last prototype (TRL9)

<u>In this report, actually, what is called prototyping in fact covers both real prototypes and most mature models.</u>

4.2. The questionnaire

Before organising the first meeting of the working group, a questionnaire was prepared to better understand the degree of interest and organise the discussion.

The questionnaire was intended to envisage and understand the problem of prototyping in case the activities are performed in collaboration between the Technology Infrastructure and the Industry.

Given the nature of this questionnaire as preliminary information for the future work, it was submitted to the only eight companies of the WP5.4 working group. At that stage, this number of companies was considered acceptable considering that about 20 companies were actively collaborating with AMICI activities (33 companies were participating to the Padua meeting). For a complete information we must say that, according the survey done in the framework of WP4.1 activities (see report on ACCELERATOR MARKET STUDY DELIVERABLE: D4.1), there about 130 different companies involved at various levels in the accelerator and superconducting magnet technologies.

Five answers were received, so a good interest in the questionnaire was shown. In appendix A of this report a more detailed description of the questionnaire is reported with a synthesis of the answers received. A series of advantages and disadvantages were envisaged regarding various possibilities for TI-Industry collaboration in prototype developments. The industrial partners were asked to comment the different scenarios by assigning a rank to the entity of the advantage or disadvantage (**H**igh, **M**edium, **L**ow and **N**egligible) and possibly commenting. In synthesis, the advantages of TI-Industry collaboration are considered higher than the dis-advantages especially if the prototype is constructed in the industry.

The results of the questionnaire and the main problems for this kind of collaboration were pointed out and discussed in a meeting held at CEA-Saclay on 19/12/2017 and in a meeting at LASA, with streaming connection on 25/1/2018.

The main points that have been highlighted are listed here:

- It is generally recognised the advantage for both TI and industries of keeping in operation tooling or big infrastructures developed for previous projects (see sub-section 4.3).
- Insurance problems are envisaged for workers hosted by the collaborating structure (the construction of prototype may require the presence of TI personnel in industry and vice versa).
- Different procedures adopted in TI and industry may constitute an obstacle (see sub-section 4.4).
- Cost sharing is a matter to be discussed case by case (see sub-section 4.5)..
- The Intellectual Property was identified as a critical point.
- Legal framework setting constraints, when selecting the collaborating industry, could limit the degree of collaboration. (see sub-section 4.6).

In the following sections, the main points and conclusions of the discussion are reported.

4.3. Efficient use of existing construction and testing infrastructure

In general a large project involving accelerator or superconducting magnets requires that both TI and Industry set-up dedicated infrastructures composed of special tooling, equipment, services and personnel, requiring investments in the order of several M€.

Many Technical Platforms of AMICI were realised for the constructing or testing aims of some specific project: as an example almost all the TPs of CEA, DESY and INFN for cryogenic radiofrequency test of cavities or module were installed for the Tesla Test Facility and soon after the XFEL projects in DESY.

At the same time for the mass production (or large scale production) of accelerator components or superconducting magnets for large projects the industry must install and put in operation expensive tooling constituting by themselves an infrastructure requiring a large initial investment and maintenance costs. An example is the complex and structured equipment needed for the construction of the superconducting dipoles and quadrupoles of the Large Hadron Colliders and for the large superconducting magnets involved in the experimental areas of LHC. Many European companies were involved in this enterprise (Ansaldo Superconduttori, Babcock-Noell, Alstom, Tesla Ltd, ..) requiring parallel production lines operating at a high production rate for being able to fulfil the LHC schedule.

In both cases once the project has been completed these *ad hoc* infrastructure are no more needed unless they can be revamped for being used in a new projects. This can be partly done for the TI infrastructures. In particular AMICI members are managing not only to keep their Technical Platforms up-to-date but also to put available, in organised way (see http://eu-amici.eu/technology_infrastructure), these high cost tooling/technologies to the industry for their scopes in the external market (i.e. the marked not explicitly related to accelerator or superconducting magnets). It is more difficult that industry can maintain for long time their infrastructures, which in many cases were dismantled; precious tools were dismissed and scraped, while the skilled personnel dispersed or lost (when hired with fixed term contracts).

Though it is unavoidable that all technical infrastructure dedicated to a specific project cannot be kept, as is, for a long time when the project is completed, many of these infrastructure can be kept alive if better integrated in the ecosystem proposed by AMICI and centred on the AMICI TPs and, in the next future, on industrial infrastructures constituting all together a solid network providing in coordinated way services (aimed to test or manufacture) for R&D projects, construction of new RI and industrial market.

4.4. Working methods in TI and Industry

Joint developments of prototypes of accelerator components and superconducting magnets have to suitably homogenise the technical and managing approaches of TI and Industry. To this aim a very basic aspect is constituted by the common knowledge, background and use of material and components properties, a specific matter studied by the Task 2 of WP5 and reported in DEFINITION OF THE POSSIBLE STRUCTURE AND CONTENT OF A DATABASE FOR MATERIALS AND COMPONENTS DELIVERABLE: 5.1). A further important aspect is related to the quality assurance plan, in particular the qualification of construction and testing methods and the management of non-conformities are crucial. A further aspect is related to the organization set-up of the industry and TI. Companies usually approaches the construction of a prototype not very differently than the mass production involving as central figure a product manager acting as unique industrial interface counting on the support of a main engineer, a tooling engineer, a responsible for the construction (often responsible of the whole workshop) and a quality manager, all working according an industrial quality standard focussed on mass production. On the other side (the TI) there is a group of scientists and technicians strongly integrated and following different quality standards focussed on the achievement of optimal performances. In order to suitably perform a co-joint activity a reasonable and practical common organization shall be found. To this aim it is fundamental the experience gained both in the past when standard contracts have been awarded from TI to Industry and (mainly) in the present time having available legal tools for innovation contract such as the Pre Commercial Procurements or the Partnership for Innovation.

4.5. Cost sharing

A question has been asked by AMICI about "*To what extent, and under which conditions is industry open to sharing the costs of a prototype with the Technology Infrastructure?"*

The comments from industries pointed out that in fact the cost is not the most relevant parameter. The interest of the industry is to participate from the beginning to the design of a prototype rather than having a limited role in the manufacturing of the prototype. Industry is available to invest a significant amount of money on R&D if there is large enough business potential. It was often remarked that the *built-to-print* approach, many times used by TI, also when awarding contracts for components with a significant R&D, constitutes a limit to the potential capabilities of Industry in learning and understanding the technological aspects in view of further developments.

4.6. From prototype to mass production

Many times the development of a prototype is precursor of some contract for mass production. *Is the Industry interested in a prototype development in view of the future contracts?* The answer from industry seems not to be "*yes in any case*" but rather "*yes, depending on the objects to be manufactured*". In other words, the economical value of a contract is not the unique parameter. Again, Industry is much more interested in learning and developing technologies to be used in a wider field.

4.6.1. The lock-in

A further consideration is related to the transition from prototyping to mass production: the companies of the WP5 working group reported examples of public contract in Europe for which the development of a prototype in Industry has prevented the particular company be involved later in the tender for mass production. In general, the national laws for public contracts are trying to avoid the so-called *lock-in* (in this case, it means that a company developing a prototype has an advantage with respect other competitors and the TI should be forced not to award contract to this particular company). Of course, the possible exclusion from a bid, due to a previous involvement in the R&D phase, could constitute one of the main obstacle to TI-Industry collaboration for prototyping, especially in domains in which only a very small number of companies are able to satisfy to the required high technical standards.

In general the problem of the vendor lock-in appears critical in the Information & Communication Technology, requiring legislative interventions at national laws under indications of the European Commission, who stated that ("Against lock-in: building open ICT systems by making better use of standards in public procurement" , Com (2013) 455 final of 25 June 2013") *lock-in occurs when the administration cannot easily* *change supplier when the contractual period expires because the essential information on the system is not available which would allow a new supplier to take over the previous one efficiently.* The lock-in is therefore propitiated by the possession of confidential information, by the exclusive that the supplier can boast on the spare parts or on the consumables related to the hardware technology provided, by the in-depth knowledge of the customer's needs, from the high costs that would derive to the latter from the migration of data from one system to another and so on. Different solutions are envisaged in the above EC document for avoiding the lock-in, not easily applicable when moving from ITC technology to accelerator and superconducting magnet technology:

1) The first tool to be used is the proper organization of the awarding procedure to minimize the risk of being trapped by the selected supplier, for example by choosing to base the technical specifications on standards. For accelerator components or superconducting magnets requiring specific developments the use of standard (meaning standard component) is applicable in a few cases. This solution does not appear really effective or applicable.
2) The approach based on the life cycle cost, which allows to take into account not only the initial cost of the service or supply, but also the future costs of the maintenance of the solution, introducing in the tender documents the appropriate clauses. In addition, this solution is tightly related to the ICT world and does not seem appropriate for the AMICI field of interest.
3) Interesting tools, in case there is a need to develop new products and services, are the pre-commercial procurement (PCP) and the Partnership for Innovation (presented and discussed in next section). Given the natural competitiveness of the tools and the possibility of directing research and development towards solutions able to avoid or minimize the risk of lock-in, the PCP and the Partnership for Innovation could be well suitable for accelerator and sc magnets
4) Another potentially very useful tool, also to verify how true it is that the maintenance of the bond with the original supplier represents an obligatory choice or, in any case, in actual advantage for the public administration, is that of the preliminary market consultation.

We will come back on the lock-in issue and the ways to avoid it after presenting and discussing the legal frameworks for public contracts involving a high degree of innovation.

4.7. Prototype in industry or in TI?

A further question asked to companies was about the preferable location for the prototype development. It was concluded that it depends on the case and the manufacturing equipment could be a decisive aspect. The companies expressed their preference to develop the prototype in their facilities rather than moving personnel in

TI laboratories. The main reason seems to be a better and more synergic use of the personnel with their facility (better allocation of human resources).

4.8. The subsidiarity principle

Most companies formulated a principle of general nature to be followed in the TI-Industry relations*, the 'subsidiarity principle*' according to which '*if industry is interested and has the technical capacity for developing a prototype, this should be favoured; TI should be involved only if industry is not able to do it*".

It was generally agreed that in case of a very innovative object it is very difficult to involve the industry in the conceptual design phase for two reasons: a) in an early stage the operating characteristics of the component are not well defined yet and need iterations through preliminary studies and specific developments (early model stage in our vocabulary); b) if some critical developments are made only in industry, there is the risk to of losing high tech tools and/or expertise in the TI. Only once the object characteristics have been defined and a preliminary concept developed (Late model or prototype stages), the Industry can be suitably involved. In case of less innovative objects, industry can be involved in an earlier stage and the subsidiarity principle be applied.

5. THE MANAGEMENT OF THE INTELLECTUAL PROPERTY (IP)

5.1. IP categories

<u>IP in Academia</u>. Academia's requirements for IP generated in a project are primarily to publish results of research and show the impact of the establishment's research in tangible terms; this can be through licensing IP for royalty income or sale of know-how through consultancy.

<u>IP in Industry</u>. The organisational goals will be to gain a competitive edge from future new products and processes. Industry requirements for the IP generated in a project will be to give a company freedom to operate, to make and sell the new products, services in the future.

<u>IP in R.I. or T.I.</u> A government-funded laboratory's IP requirement for IP generated in a project is generally a hybrid of industry and academia; primarily it requires its IP in order to efficiently operate the laboratories through publication or patenting. Another strategic goal of R.I.s is to transfer their IP to industrial partners for industrial application outside their research field through licensing or selling IP that is not critical.

In cooperative developments, the different interests for the IP shall be merged through suitable IP agreements.

5.2. IP agreements

The Research Institutions working in accelerator and superconducting magnets fields are extremely open to cooperating with industries and negotiating appropriate agreements on a case by case basis. TI through KT (Knowledge Transfer) offices are willing to bring their knowledge and technologies to the market: the companies play a key role in this process. Companies can exploit their engagement in the industrialization phase in order to develop expertise and become more competitive.

5.3. Approaching an IP agreement: some rules.

- For the first contacts, confidentiality should be assumed if no confidentiality agreement is in place ('*presumed confidentiality*'), as a point of mutual respect for each other's IP.
- As soon as the ideas take shape and the relations become more formal a retrospective agreement can be put in place, so all parties can speak freely without jeopardising their or partner organisation's procedures.
- Back office support, finance, legal and IP management should be brought into discussions early on, to support the technical teams. The IP manager and legal teams should take the lead in contractual discussions to protect the technical teams working relationships.
- When it comes to bidding all the IP to be used in the project should be listed as background IP and provisions should be made for the addition of background IP throughout the project.
- The hard decisions need to be made at the beginning and communicated in a clear and consistent way in order to manage expectations; be fair, be reasonable, and endeavour to understand partner perspective and motivations.

5.4. Industry remark

Companies involved in the knowledge transfer activities ask for more confidentiality on trade secrets, direct access to the know-how needed to exploit any licensed patent and exclusive advantages with respect to their competitors: all these requests can be met by means of specific agreements (licenses, research contracts, partnership, etc).

5.5. Possible scheme for IP managing between TI and Industry

On the basis of the current experience, it is commonly believed that possible schemes for managing the IP in the TI-Industry collaborative developments can be found case by case.

The IP can be in general subdivided into three categories: 1) Open access, 2) Limited access under Non-disclosure agreements, 3) Not accessible documents. An example of subdivision for the development of superconducting magnets has been proposed by companies, which were also participating to the UE Project FUSuMaTech.

Access	IP	Comment
Open Access	Magnet functional characteristics: Field Intensity DSV dimensions and homogeneity Fringe Field Footprint, Warm bore size, Magnet size	Available on web page or information to prospective clients
Commercial access	Top level mechanical drawings, Top level electromagnetic design	
Limited Access	Force distribution Mechanical Interface	Only under Non-Discosure Agreements
No Access	Cooling solutions Top level protection strategy Design, manufacturing and process IP	Never disclosed and only owned by industry

When performing innovative activities the IPs should be further subdivided into two main parts:

Background knowledge: Each party keeps the ownership of IPR related to pre-existing knowledge/ patents.

Foreground knowledge: there are alternative provisions:

- In case of collaborative research IP may be jointly owned; shares are based on the importance of respective contributions
- In case of research contract IR may be jointly owned or exclusively owned by the customer (if so, contract value increases)

6. A SURVEY OF THE LEGAL FRAMEWORKS

6.1. EU Guidance on Innovation Procurement

The developments of accelerator component or superconducting magnet prototypes in collaboration between Industry and the Technology Infrastructure or, in general, with Academia, can only be performed in a well-defined legal framework. The Industry-TI common developments can be considered as falling in the innovation procurements, for which, being the TI mostly assimilated to public administrations, specific directives were given in the last years by EU. A *Guidance on Innovation Procurement* has been issued by the European Commission in May 2018 with the possible administrative public procedures for innovation (some regulated by the directives on procurement, others under conditional exemption):

- Innovation Partnership
- Pre-commercial procurement (PCP)
- Competitive procedure with negotiation
- Competitive dialogue

Furthermore, the European Union promotes innovation in public procurements, including through public procurements for innovative solutions (Public Procurement of Innovative Solutions or PPI), for the purchase of existing innovations that have not yet reached widespread commercialization even though they do not require new research and development activities

For the components of interest for AMICI, the innovation partnership and the pre-commercial procurements look the most interesting framework for an Industry-TI collaboration aimed at developing prototypes

<u>It is important to stress that in all cases a public selection of the industry shall be done.</u>

6.2. Pre-commercial procurement: PCP

Pre-Commercial Procurement (PCP) is the procurement of research and development of new innovative solutions before they are commercially available. PCP involves different suppliers competing through different phases of development. The risks and benefits are shared between the procurers and the suppliers under market conditions (EU Guidance).

The spirit of the PCP scheme is to fund companies to perform R&D in a competitive environment. The business case is to engage small/medium industries to work on edge technologies, even if no large market volumes are expected.

SMEs are reluctant to investigate advanced solutions that are still at an immature level of development. A “conventional” tender instrument cannot address the purpose of the R&D challenge. The effort needed is not matched by a potential large volume of products to attract large companies and technological risk is too high for small companies.

PCP instrument serves the purpose of enlarging the market basis (by reducing financial barrier for SMEs), to attract SMEs (by sharing the technological risk of committing into difficult R&D), to mitigate risk of over or under specifications, by engaging industries at the early stage. The financial risks are reduced for companies by gradually committing into the scope. The technical risks are mitigated by splitting the scope in phases and operating technology transfer by the laboratories. For the buyers the advantages are to pool resources to implement the project, to shorten the time to R&D completion and to reduce the cost. Companies can acquire potentially transferable know-how in markets other than research infrastructure. They can also increase their industrial capabilities by deploying usable tools for similar manufacturing, thus expand the market, and encourage innovation and novelty.

Most of companies collaborating with AMICI appreciated this approach, which was tested by some of AMICI members with the project QUACO, as discussed in detail in next section.

6.2.1. An example of PCP: QUACO

A Pre-Commercial Procurement (PCP) initiative was funded by EU under the name QUACO (H2020 PCP - Grant Agreement no.689359). The project run in collaborative effort among four partners of AMICI, CERN, CEA, CIEMAT, NBCJ coordinated by CERN, around the development of the Q4-MQYY full scale quadrupole magnet prototypes for HL LHC project.

In the case of the QUACO PCP, the starting point is the functional specification of the MQYY magnet. QUACO is organized in three competitive phases: conceptual design (4 months), engineering design and mock-ups (13 months), prototype-manufacturing phase (18 months). Four firms started the project. From one phase to the next, one firm is eliminated based on technical, quality assurance and project management evaluations. At the end of Phase 3 scheduled in June 2020, two firms will remain and deliver a MQYY prototype ready for test.

The phase I and II of the project concluded successfully. 4 companies (3 SMEs) were engaged in phase I and in phase II, 3 of those have produced extended analysis, engineering designs and mock-ups to demonstrate viability for a final manufacturing of the Q4. Companies were engaged into innovative, and in some cases, unprecedented technologies routes for this type of magnets. Examples of innovation solutions investigated as spin-off from QUACO are described below:

- Shrink-fit solution for magnet collaring. Azimuthal pre-stress of the coil is obtained with an oversize spacer and with the thermal shrinkage of Al collars. It is the first time this method is used for a 2-1 quadrupole manufacturing.

- Bladder & Keys for magnet assembly: an outer Al shell contains the forces during operation and provides additional compressive stress to the magnet after cooling down. It is again the first time Bladder & Keys technology is used for a quadrupole manufacturing.

- Modular tools: Modular tooling concepts, which can easily be adapted to different size of similar magnets: a relevant cost reduction strategy for manufacturing and time to market.

The studied solutions are all very interesting for accelerator technology but only 2 companies have accessed the last phase of the project because PCP does not allow to proceed with 3 companies.

After manufacture completion of the two prototypes in June 2020, the tests of the prototypes are expected to take place at CEA Saclay in a test cryostat.

Different lessons were learned from QUACO experience. The tendering in Phases is well-appreciated by suppliers. No crucial legal point were raised until the award and the signature of the Framework agreement and the Work Order. The PCP allowed to reduce the risks as several suppliers are competing simultaneously in Phases. The PCP triggers innovation from SMEs through an early engagement in the tendering process. In QUACO smaller SMEs were attracted (to get tooling and infrastructure) for the developments of MQYY magnets and after the PCP an increased competition from SMEs can be expected. The buyers and bidders conference is important in the whole PCP process to create credibility and trust between both the supplier and the Buyers Group. PCP increase also “the team up together” between Research Centres..

Nevertheless, the obligation to publish the maximum budget for each Phase and for each contractor reduces the competition (small variation in the financial offers). The effect of price criterion is so reduced to almost 0, except in Phase I. The fact that no technical negotiations is permitted is a burden for R&D-developments and IPR remain a critical aspect of PCP (Contractors have their own internal rules).

6.3. Innovation Partnership

Unlike in the case of Pre-Commercial Procurement, the Partnerships for Innovation are concerned with developing solutions with a reasonable marketing perspective.

The Partnership for Innovation combines the research and development phase and the purchase phase of the developed product (innovative solutions subject to the PPI, as shown in the next section) in one tender procedure and may involve the involvement of one or more operators in every phase (with the possibility, after each phase, to conclude the partnership or reduce the number of partners involved, provided that the client has indicated these conditions in the documentation related to the contract).

6.4. Competitive procedure with negotiation and competitive dialogue

Further possibility in innovative contract is using a negotiated procedure for public procurement which requires the adaptation of readily available solutions of a particularly complex nature or in which the technical specifications cannot be established with sufficient precision. In these circumstances, the EU rules offer public contractors a choice between two similar procedures: competitive procedure with negotiation and competitive dialogue.

The main difference between the competitive procedure with negotiation and the competitive dialogue lies in the degree of clarity that the public purchaser has of the project. In the first case, the public purchaser has a more precise idea of the nature and object of the public procurement contract, while in the second case choices are still to be made upstream.

The European Union also promotes innovation in public procurement through Public Procurement of Innovative solutions (PPI), for the purchase of existing innovations that have not yet reached widespread commercialization while not requiring new research and development activities. PCP and PPI therefore represent the two possible approaches to innovation.

In the procurement of innovative solutions (PPI) public purchasers do not purchase research and development services but act as "launch customers" also called early adopters or first buyers) of innovative works, services and supplies that are not yet widespread on a large-scale commercial basis (or already present on the market on a small scale), including solutions based on already existing technologies and used in an innovative way to improve the quality and efficiency of public services, ensuring the quality of public spending. The PPI can be the next step of the PCP.

6.5. European country laws for innovative industrial contracts

In this section some examples about the ways the indications of EU Commission have been included into the national laws for innovative public contracts.

6.5.1. France

- Innovation partnerships developed by the EU to bridge the gap between R&D and procurement of innovative solutions are transposed in the French public procurement code, art. L. 2172-3. Going further, decree N°2018-1225 sets the stage for a three-year experimentation to bypass art. L. 2172-3 for contracts under 100k€. No competitive tendering process is required and no proof has to be provided regarding the need for an innovative solution.

- Following Directive 2014/24/UE, R&D procurements (PCPs and direct contracts) are excluded from the scope of French rules on public procurement if they respect the following criteria :
  - The private contractor must contribute to the financial effort.
  - The resulting IP must be shared.
  - The contract must be limited to R&D actions and should not entail any direct industrial follow-up.

- PPIs remain covered by the general dispositions of the public procurement code regarding competitive tenders (art. R. 2123-4 and L. 2124-3). The regulator has produced guidance to better use the usual procurement procedures in the context of research and innovation.

6.5.2. Germany

- Partnership for Innovation

This legal tool is governed in Germany under the "Regulations on the award of public contracts, Paragraph 19", last issued in July 2017, which in turn is governed by the National Law "Act against Restraints of Competition, Part 4, Paragraph 119 (7)" last issued in July 2016. Here are the stipulations for the awarding of contracts for which there is currently no solution available on the market for the products (or services or construction) required.

- Pre-commercial procurement (PCP)

It is covered under a variety of procurement laws and regulations in Germany including the 2 mentioned above. These cover the pre-commercial award of contracts as an approach to the award of contracts public contracts for research and development. The services supplied for the R&D and their results may not exclusively be property of the contracting authority. Prerequisite is that the costs for such services not be completely covered by public funding and that the contract(s), do not constitute State aid (as determined by the EU Commission).

- Competitive procedure with negotiation

This tool is also covered under "Regulations on the award of public contracts, Paragraph 17", which in turn is governed by the National Law "Act against Restraints of Competition, Part 4, Paragraph 119 (5)" and the requirements are:

- the needs of the contracting authority cannot be fulfilled without the adaptation of already available solutions or,
- the contract cannot be placed without prior negotiation due to the nature, complexity or the legal or financial framework of the requirements the order or,
- the requirements of the order cannot be accurately described by referencing common technical standards or specifications.

- Competitive dialogue

It is covered under "Regulations on the award of public contracts, Paragraph 18", which in turn is governed by the National Law "Act against Restraints of Competition, Part 4, Paragraph 119 (6)" and encompasses the same requirements as those for the "Competitive procedure with negotiations". The contracting organization is free to choose between the two procedures.

6.5.3. Italy

In Italy the Pre-Commercial public contract (incorporated into Italian law in Article 158 of Legislative Decree 50/2016 for Procurement Code) and the partnership for innovation (incorporated with the art. 65 of the Procurement Code that governs them in the chapter relating to the procedures for the selection of the contractor for the ordinary sectors.) are born as tools to promote applied research in resolving issues of primary importance public interest for which there is not a (satisfactory) solution on the market. <u>The R&D activities covered by the pre-commercial contract do not include commercial development activities in any way</u>.

Jointly with the R&D services contract, a limited supply is possible, consisting solely of the products resulting from the research activities, with condition that these products have a minority value (not exceeding 49% of the total contract value) and that the production is intended to incorporate the results of field tests and to demonstrate that the product or service is suitable for mass production or supply in compliance with acceptable quality standards.

Furthermore, in pre-commercial procurement the contracting authority does not have itself the exclusive exploitation (for its own purposes) of the R&D results and benefits arising from the procurement (such as intellectual and/or industrial property rights), but with other parties, allowing companies to make profits from the marketing of new products/services resulting from R&D and obtaining, in return, to remunerate research less than the hypothesis of exclusive development.

7. POST-R&D PHASE

In the section 4.6, the problem of the lock-in has been mentioned and the possibility to avoid it through the PCP or the Innovation Partnership introduced. Both the legal tools are relatively recent and a consolidated experience with their use is not available yet in the AMICI community. However, some preliminary consideration can be done.

7.1. After PCP

According to the European guidance, once the pre-commercial phase is over, the product or service that constitutes the result of the R&D activity must be found by TI on the market through the use of ordinary public procurement procedures. For this reason, at the end of the predefined research phases and in the event that the TI deems the resulting solutions to be satisfactory and really better than those available on the market , the supply contract through which the TI decides to procure the technological solution must be open to the entire market and governed by the rules of the Code of public contracts. In other words, third parties must be in a position to make an offer for commercial production and must not be put in place discriminatory conditions against potential suppliers.

If the TI has the availability of the free user license obtained as a result of the pre-commercial contract, the obligation for calling a public procedure for the procurement of the solution, in order to identify the best bidder able to carry out the project based on technical specification, in principle meets no particular issues. In this circumstance, there are no restrictions on the fact that the TI expresses its need in terms of detailed technical specifications and makes the executive project available to any third party awarded, as developed by the pre-commercial contractor.

The situation is different if the TI does not hold a free use license and there is no company, despite the patents have been made available on fair terms and reasonable conditions, interested in making an industrial production of the good. In this circumstance, it should be possible to have recourse to the "Single supplier"; the uniqueness of the supplier must be certain before to come to private negotiation through a market survey, which can have the sole purpose of acquiring the certainty of such uniqueness or to exclude it.

As conclusion, we can state that involving the PCP the lock-in could be avoided if there are no restrictions on the Intellectual Property. On the other hand, the lock-in is unavoidable, but justified if the TI does not hold a free use license.

7.2. Involving the Innovation Partnership

Innovation partnership is a relatively new type of public procurement procedure (2014/24/EU) to be used only in cases where no solution for a public buyer's needs is available on the market. This is the case of accelerator components and superconducting magnets requiring a prototype phase before the mass production.

According he EU guidance: *The main feature of the innovative partnership is that the innovation occurs during the performance of the contract, so that the public buyer is entering into a contract with the best potential supplier(s) of innovation. The supplier(s) is (are) expected to create the innovative solution and ensure its real-scale implementation for the public buyer*.

Operatively the industrial partner(s) develop the models and/or the prototype in collaboration with the TI. In fact, the Innovation Partnership allows *that the research and development phase can be further divided into several stages designated for evaluating concepts, developing prototypes and/or testing performance. During each stage, the number of partners may be reduced on the basis of predetermined criteria*. In the following mass production phase, the partner(s) provide the final results.

Even if there are not examples yet within the AMICI community<u>, this tool looks to be optimal for developing prototypes having as mandatory following step the mass production. The lock-in issue is intrinsically excluded by the nature of the tool based on the choice of the best potential users since the R&D phase</u>.

8. RECOMMENDATIONS FOR FUTURE AMICI- CODE OF CONDUCT

The AMICI WP3.2 has envisaged a possible structure of the AMICI integrated Technology Infrastructure (see Report on the networking and coordination model DELIVERABLE: D3.2) having in its core a Collaboration Board (CB) which can count on an Industrial Advisory board, The Industry AB will be a body that is *asked to give advice and recommendations on strategic matters to the CB. Members of the Industry AB will be invited in person by the CB, but not as a representative of their company.* One of the first aim of the coming integrated TI based on the AMICI structure should be the definition of a Code of Conduct governing in standard way the AMICI- Industry relations both on matter of Innovation and Industrialization.

Regarding this latter aspect, the following points shall be integrated into the Code of Conduct:

1- Communication. The industry needs to access as soon as possible to the information related to new projects requiring an R&D phases and construction of models and prototype. This point has been also remarked in the framework of the WP4 (Innovation) activities.

2- The clear definition of the conditions for an early involvement of the industry in the prototyping since the design phases. As already remarked, this is difficult when the project is at a very early stage, when well-defined technical specifications are not available yet, but can be done for the prototyping phase.

3- The definition of the contract strategy for a co-joint development. Presently both PCP and Innovation Partnership looks suitable as framework legal tools
4- A standard IP agreement
5- An agreed formulation of the Subsidiary Principle, strongly supported by the industry

9. CONCLUSIONS

The AMICI-Industry working group WP5.4 about the basic requirements and conditions for setting up collaborative Industry-TI efforts aiming at prototype developments has analysed the possible issues coming from this collaboration and envisaged some possible solutions. Some basic aspects and issues were studied, and possible solutions found.

- In general, it appears that the collaboration for a prototype development should be performed within standard legal frameworks for innovation procurements such as the Innovation Partnership and/or the Pre-Commercial Procurement. In any case, the company to be involved shall be selected through an open public procedure. A direct experience of a part of AMICI partners with PCP is going on (the EU project QUACO finishing in 2020) with very encouraging results for this kind of tool. However for and R&D activity followed by a mass production the Innovation Partnership looks a better tool than PCP, but a direct experience of AMICI partner is not available yet for this specific legal tool.
- The involvement of the industry in the prototyping shall be done if possible at an early stage of the design unless the component to be developed is highly challenging and not well defined yet. The role of the industry should not simply cover manufacturing aspects but also design aspects in collaboration with TI. This is important to allow industry set the basis for future products beyond the scopes of the specific prototyping activities.
- The industry asks to be timely informed about the need for a prototype development and, if the content of the R&D is limited, industry would like to apply a principle (the subsidiary principle) to perform in first person this activity. Moreover, there is a strong preference of Industry in performing the activities at the Industry premises.
- Even if it is difficult finding general rule for the Intellectual Property, from the discussions held in meetings and workshops it appeared that some general rules can be agreed, and possible schemes exist depending on the cases.
- Moving from prototype to mass production some problems could arise due the limitations to lock-in included in the national laws for public contracts. The use of

Pre-Commercial Procurement and of Innovative Procurement (especially this latter) should limit or avoid at all the lock-in.

- The integrated Technology Infrastructure for accelerator and superconducting magnets should consider including these aspects in a Code of Conduct to be applied in its relationship with Industry in a way that does not conflict with the specific country laws.

APPENDIX A

The Questionnaire for the Industries of the working group of Task WP5.4 Prototype development with Industry

Two possibilities were taken into consideration:

1. The industry develops prototypes in the facilities of the TI in close collaboration with TI personnel.
2. The industry develops prototypes in their facilities taking advantage of existing tool or other technical infrastructure not available in the TI. This second aspect of the prototype development could contribute in taking active large general purpose tooling or facilities developed for past projects and marginally or not involved at all after the project conclusion.

A series of advantages and disadvantages were envisaged regarding various possibilities for TI-Industry collaboration in prototype developments. The industrial partners were asked to comment the different scenarios by assigning a rank to the entity of the advantage or disadvantage (**H**igh, **M**edium, **L**ow and **N**egligible) and possibly commenting and adding further pros or cons.

In both scenarios the prototype development could contribute in taking active large tooling or facilities developed for past projects and marginally or not involved at all after the project conclusion.

To be noted that the legal frameworks (constituting limitations) were not yet part of the discussion, because we were trying to preliminary understand how much appealing is the collaboration Industry TI in the prototype development.

The questionnaire:

Case 1: Industry develops prototype in the Technical Infrastructure - Advantages

Advantages for Industry	Rank (H,M,L,N)	Comments from Industries
Possibility to gain more money	**H, 3L, N**	- Main scope the Industry is to get more profit from its activities. In the case of prototype the primary scope could be different but balance of profit-cost should be always under control. - Money comes mainly from the use of the acquired knowledge into the development of new projects in different field. Access to certain production tools, which are not affordable for the firms nowadays,

		would reduce costs and, hence, allow companies a better money value distribution. - Depends on the subject and what is available from TIs. This requires people from industry to be present at TI's with an associated cost.
Growing of the knowledges	**3H, M, N**	- Working and living in a TI certainly allows more focus and information/experience interchange.
Access to first hand and extremely high quality know how	**3H, M, N**	- TI's have a high density of high quality know how and sharing time and space with fellow colleagues should be very beneficial.
Access to already available high cost tooling/technologies not available in the industry due to high cost/high risk in buying and doing investment, in particular for small and medium-sized enterprises	**3H, M, L**	- The use of the tooling should be not limited to the TI/ operators - Small companies meet large difficulties in justifying investments in expensive and very specialize tools, sometimes even before understanding the pros/cons completely. - The advantage depends on the real availability of tooling/technologies
Limited economical investment / low risk	**2H, 2M, L**	- Investment in case of prototype could not be justified. Investment is done if industry expects a fair return and use in a short-medium-long period. Single prototype could not justify investment unless it is covered and paid by the external funds. - There are several risks associated with this approach and the economical investment would vary. Specifically, the risk of letting part of the personnel leave the company in seek of more

		appealing positions should be addressed.
More updated perception of future possible markets (general and accelerator fields)	**3H, M, L**	- The industry will dispose a better access to future markets as the TI are closer to the new needs in these fields. - The market of interest for industry is generally not to be found in laboratories except for scientific market
Other …	**H**	- Relationship with other companies, especially complementary companies in order to propose system integrated instead of just products

The answers are H for 50%, M for 22%, L for 19%, and N for 9%, testifying that the advantages in this case are considered medium-high.

Case 1: Industry develops prototype in the Technical Infrastructure – Dis-advantages

Disadvantages for Industry	Rank (H,M,L,N)	Comments from Industry
Risk for TI founding availability / reliability	**2H, M, 2L**	- Foreseen availability and reliability have to be assessed before collaboration starts and contracted.
Complicated procedure for buying / call for tender (public buying)	**2H, M, L, N**	The procedures should not be more complicated than strictly necessary. Procedures depend on each institution.
Co-working	**2M, 2L, N**	- Tasks and responsabilities should be clearly identified. Nevertheless this aspect should not affect the needed cooperation and information's exchange. Operators from industry could not be allowed to use tooling-equipments available into TI because rules and/or training limitations - Co-working itself is never a disadvantage if well organized. - Requires right/good skills and resources in due time from both sides. Foreground management will have to be addressed.
Not direct / personal management of TI personnel	**H, 2M, L, N**	- The control over the personnel should be addressed in previous arrangements. Even if, naturally the TI/RI personnel will always have to respond to their managers, these managers should have signed common goals shared with the Industry. A management team with members of both parts should be created. - Beside a formal agreement stating what will be the working perimeter for each party, it is preferable if it lays on a personal and mutual agreement between people and if there is a common interest.

Scheduling must be agreed with TI and could be not fully under industry control	**3H, 2M**	- The time to market is essential and even if not always easy to master, it shall be controlled by companies to ensure return of investment. - Scheduling can be mutually agreed provided main industrial milestones are fulfilled . Both parties have a common interest to succeed and deliver.
Limitations in participating to call for tender on the same field due to national regulation	**H, M, 2L,N**	
Other …		- It has to be taken into account the necessity to move some toolings from the Industry to the TI because in many cases, the Industry operator prefers to use his usual equipment.

The answers are H for 30%, M for 30%, L for 27%, and N for 13%, testifying that also <u>the disadvantages in this case are considered medium-high</u>.

Case 2: Industry develops prototype in their facilities with the collaboration of TI
Advantages

Advantages for Industry	Rank (H,M,L,N)	Comments from Industry
Access to up to date knowledges potentially of interest for wider market products	**3H, M, L**	- The Industry must always monitor the surrounding market environment where the main business opportunities occur. The possibility to access to TI knowledge could help..
Increased productivity of the plant/tool (used not only for production but for prototyping too).	**3M,2L**	- The increased productivity of the tool, related to the prototype, should be marginal if the projects are to be designed for medium or large size batches of components. In case of small productions instead, it could be interesting. - This could be in case of time-sharing for some people/experts working on different subjects in the company.
Development of new technologies before future mass production or for wider market products	**4H, L**	- The Industry needs the TI projects to spin-off in order to make real profit. The society would also benefit from early adoption of potentially beneficial technologies - There is a gap between a prototype and a series production. There can be a transfer in due time from TI to industry.
Sensitize TI personnel to industrial needs and methods	**H, 3M, L**	- The TI personnel would certainly grasp different point of views from the various approaches to work from the companies. Their methods, more than their needs would benefit. The Industry needs could be taken into account when development choices conflict with similar outcome expectative.
Other... Crossing together industrial methods with the scientific knowledge can favor optimization (people are more “clever” when they understand what they do).	**L**	Whatever the site chosen for the prototyping, contacts and dialogue between people from both cultures are to be fostered.

The answers are H for 38%, M for 33%, L for 29%, and no N, testifying that the advantages in this case are considered medium-high.

Case 2: Industry develops prototype in their facilities with the collaboration of TI. Dis-advantage

Disadvantages for Industry	**Rank (H,M,L,N)**	**Comments from Industry**
General business risk for the company	**H, 2M, 2L**	- It is difficult to foresee impact of prototyping activities to the "standard" industry programs - There should be no bigger risk for the companies than average. R&D activities in the industry are foreseen as a know-how source so financial risks are studied to know the capacity of the firm to select the size of the projects to invest in. - The collaboration purpose has to be defined (transfer of existing know-how, prototype feasibility using new technologies evaluation....). There is a certain level of risk to be as possible evaluated before the collaboration starts. Stop and go steps have to be planned.
Research scenario may change and the developed prototype becoming obsolete	**H, 2M, 2N**	- It is normal that during the development of prototypes changes will occur. A good project management will be necessary to foresee the evolution of the needs. Even the own project could be the source of changes. - One has to stay pragmatic. This possibility can occur whatever the location for the prototyping.
No / limited market for the developed prototypes	**2H, 2M, L**	- If market scenario ends with the prototype, all the expected costs should be covered by the prototype program - It is a problem the industry already faces today. The prototypes are designed with the only purpose of serving the serial production for the TI. Returns have to be taken into account not only from a short term point of view (invoicing) but from knowledge acquisition that lead to future projects/activities. -The market study has to be done before starting and continued in parallel. As far as a collaborative work is decided, the confidence in the

		associated market has to be sufficient.
Too rapid technology development: prototype / product is "old" for the market	**H, 3N, L**	- TI market is top-notch regarding new technology development, so this should be not an issue. It seems rather low risk since the know how arises from a laboratory supposed to offer leading edge technologies and generally aware of competing technologies. If this occurred, stop and go process can limit impacts.
Limitations in participating to call for tender on the same field due to national regulation	**M, L 2N**	-

The answers are H for 21%, M for 25%, L for 25%, and N for 29%, testifying that the dis-advantages in this case are considered relatively low.