IFAST

Accelerator Research and Innovation for European Science and Society

Horizon 2020 Research Infrastructures GA n° 101004730

MILESTONE REPORT

Collection of feedback from industrial partners and RIs participating in I.FAST

MILESTONE: MS10

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ABSTRACT

The fundamental goal of the Task 3 of WP3 of IFAST (WP3.3) is to identify how the accelerator science and technology community can improve the effectiveness of industry-research institution collaboration since early stages. In this milestone report, the workplan of WP3.3 is described, together with a description of the activities done at this period of the project. In particular, the collection of feedback from industrial partners and RIs.

For more information on IFAST, its partners and contributors please see https://ifast-project.eu/

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Delivery Slip

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Executive summary

The fundamental goal of the Task 3 of WP3 of IFAST (WP3.3) is to identify how the accelerator science and technology community can improve the effectiveness of industry-research institution collaboration. In particular, the collaboration in the developments since early stages (i.e., low TRLs) has shown great interest in previous works.

In this milestone report, the workplan of WP3.3 is described, together with a description of the activities done so far. In particular, at month 20 of work, an initial summary of the feedback collected from industrial partners and RIs participating in I-FAST is requested. The working group has arranged a series of meetings with companies, has iterated with them and compiled their feedback. Other stakeholders were consulted as well, in particular with the ILOs of a number of European countries.

During the work, it was decided to expand the range of companies to be contacted, not just limiting responses to those already associated with IFAST, but extending to other communities related to accelerator science and technology, and to other fields of Big Science.

The work has advanced according to our expectations. Only a minor delay is reported, due to larger than expected difficulties arranging meetings with some companies. The impact of this delay both for Task 3.3 and for other tasks in WP3 is negligible.

In conclusion, the work done so far is in line with the expected plans, representing a good base for completing the remaining discussions and analysis within WP3.3.

1. Introduction

Within the community of Accelerator Science and Technology (ASc&T), a continuous and increasing need for the involvement of industry has been defined as a priority. In previous projects, fluent contacts were set out between research institutions and industry. Similar approaches have been conducted by ILO (Industrial Liaison Offices) associations, Research Infrastructures (RI) and Technological Infrastructures (TI), as well as other stakeholders with links to the Science Industry[1].

From the feedback provided by companies participating in previous accelerator projects, it was determined that there exists considerable unexploited potential for industry to positively contribute to R&D activities and/or low TRL research activities, if engaged during the early stages.

The Task 3 of the IFAST work-package 3 (WP3.3) is focused specifically on providing a clear view about the following point: ***benefits of an early involvement of the industry within the accelerator research and development activities***. For such, the working group has arranged a series of meetings

[1] In this document, the term *Science Industry* is used to define the industry involved in activity related to the design, prototyping, integration, testing and series production of scientific components and instrumentation, either under commercial contracts or within collaboration on research projects.

with companies with experience in ASc&T and related fields, has iterated with them on their responses and compiled their feedback. Other stakeholders were consulted as well, in particular with the ILOs of a number of European countries.

This milestone report summarizes the aim and motivation of this work, the methodology used, the interaction with industry and ILOs, the analysis carried out and, finally, provides some considerations on this topic.

2. Analysis of the participation of industry in collaborative R&D activities at early stages

2.1 Specific aims of WP 3.3

The fundamental goal of WP 3.3 of IFAST is to identify how the accelerator science and technology community can improve the effectiveness of industry-RI collaboration and, in particular, promote the involvement of industry in its activities at the early stages of the proposals (i.e. at low TRL).

From the analysis carried out in projects such as ARIES and AMICI, and via coordinated actions by consortia such as TIARA, it has already been confirmed that an extended involvement of industry in accelerator component development cycles, usually taking place inside the RI and TI facilities, could bring significant benefits that may lead to faster, more robust products and reduction of costs, that can represent a benefit for the companies themselves.

Ideally, this approach would benefit from early common strategies between research labs and industry in order to timely define key aspects, such as reliable designs, efficient product evaluation to avoid increasing costs, adequately defining the generation of technical knowledge or fair IP rules, among others topics. But the early engagement of industry on research projects may impose several constraints to the industry partner: higher operational costs, higher risks, decisions and investments pre-market or conflicts of interest for example.

2.2 Background

This work can be considered as a continuation of reviews with wider scope previously done by our community. The material in Section 8 has been used as reference.

Among these reference documents, we highlight the work done within the AMICI project on requirements and conditions for the developing of prototyping in the industry (reference 2).

2.3 Involved actors and activity covered

The first layer of actors involved in the work addressed in this document are industries related to accelerator component development, research institutions and ILOs.

The activities covered encompasses mainly the first stages of scientific-technical development, namely: study, design, development, prototyping, integration and tests of components for research purposes. But, on a wider scope, it is also considered industrial development aspects related with the construction of systems, large instruments, facilities, first-of-a-kind industrial equipment and series production of scientific instrumentation.

2.3.1 Industry

To our best knowledge, there is not a well identified body to interact with the industry target of our study. Except in some specific cases, there are no industry associations that can play this role either, at least in a homogeneous way among the Member States (MS) represented in IFAST.

To overcome this limitation, we have decided to interact with two different actors related with the Science Industry:

- A representative number of companies via an individual approach. The IFAST project is a suitable framework to make such interactions, since a significant representation of the industries involved on ASc&T are partners or associated partners of the project. Although, as mentioned afterwards, in a second consideration it was decided not to limit this work to the range of IFAST.
- The ILOs themselves, apart from facilitating the contact with the industry, can provide a valuable view to this study. A number of ILOs from different MS have been consulted.

2.3.2 Research institutions and accelerator users

Institutions involved in accelerators, both developers and users, are organized and coordinated via well-known consortia. Apart from the research and technological institutions individually, the most relevant consortia for WP3.3 are:

- For ASc&T institutions, TIARA is a suitable consortium to consult.
- For the specific needs of research and technological infrastructures of accelerators, the AMICI collaboration can provide a wide view. This collaboration is represented on IFAST, in particular in Task 13.1.

2.4 METHODOLOGY IN THIS WORK

The profile of the companies related to ASc&T is not homogeneous. They differ in aspects such as dimension, commercial approaches, proportion of business targeted to scientific applications versus general market, or collaboration experience with academia. In most cases, the information they have from our community is partial and selective, limited to the projects and contracts they have specifically encountered.

Under these circumstances, in order to gather their opinion on interaction with research institutions at early stages, we thought that it would not be efficient to submit a general questionnaire. Instead, we have opted for bi-lateral meetings in order to tailor the interactions to the actual experience and aims of each company. For such, we have selected a number of representative industries. On the other hand, the number of interactions with industry on issues related to the topics of interest for ASc&T must be optimized, in order to keep an adequate level of interest of the contacted actors.

Similarly, we have held bi-lateral meetings with ILOs from a selected number of MS, those considered as the most active in our field.

Finally, we have not limited our contacts to industries involved in IFAST, nor to industries related to the ASc&T fields. We have also contacted industry with experience in other sectors of Big Science, such as space, fusion, astrophysics or medical applications, among others.

2.5 Work plan

The workplan initially designed for WP3.3 was split in 4 steps, namely:

Step 1:

1.1. Background. Previous information of interest
1.2. Private iteration with related industries. Preliminary feedback.
1.3. Inform WP Leaders and Project Leader.

Step 2:

2.1. Internal iteration
2.2. Definition of key questions
2.3. Definition of IFAST companies, and TI, RI, others.

Step 3

3.1. Define the contact network (under iterative basis).
3.2. B2B meetings with companies in IFAST.
3.3. Presence at workshops scheduled in IFAST.

Step 4

4.1. Second iteration with selected companies
4.2. Iteration with TI, RI
4.3. Discussion with representative parties (industry, RI/TI)
4.4. Deliverable D3.1. drafting

The time line of the work is presented in Table 1.

		2021				2022						2023						2024	
		May	July	Sept	Nov	Jan	March	May	July	Sept	Nov	Jan	March	May	July	Sept	Nov	Jan	March
		Year 1						Year 2						Year 3					
		M0	**M2**	**M4**	**M8**	**M10**	**M12**	**M14**	**M16**	**M18**	**M20**	**M22**	**M24**	**M26**	**M28**	**M30**	**M32**	**M34**	**M36**
Step 1	Background. Previous information of interest																		
	Private iteration with related industries. Preliminary feedback.																		
	Inform WP leaders and Project leader for an eventual help																		
Step 2	Internal iteration																		
	Definition of key questions																		
	Definition of IFAST companies, and TI, RI, others																		
Step 3	Define the contact network (under iterative basis)																		
	B2B meetings with companies in IFAST																		
	Workshops programmed in IFAST						Indust. Event					WP13 (TBC)							
Step 4	Second iteration with selected companies																		
	Iteration with TI, RI																		
	Discussion with representative parties (Industry, RI/TI)																		
	Deliverable D3.1. drafting																		
	Milestone: M3.3: Collection of feedback from industrial partners and RIs participating in I-FAST. ***Delivery date: M 15***																		
	Deliverable 3.3: *Report on extended industrial contributions in R&D activities.* ***Delivery date: month 36***																		
	** (In black: completed; in blue: pending)	May	July	Sept	Dec	Jan	March	May	July	Sept	Nov	Jan	March	May	July	Sept	Nov	Jan	March
		2021				2022						2023						2024	

Table 1. Timeline of the activities in WP3.3

At the date of delivering this report, Steps 1 and 2 are completed.

In Step 3, actions 3.1 and 3.2 are also finished. Regarding action 3.3, WP3.3 has presented its preliminary outcome at the IFAST industry co-innovation workshop, on May 3, 2022. Since it is the only general industrial workshop organized in IFAST until January 2023, this action can be also considered as concluded.

In Step 4, according to the wide feedback received from the companies, we have decided that the second iteration foreseen in 4.1 is no longer needed, merging this second iteration to the actions to be done in in 4.3. Regarding 4.2, feedback from three RI has been collected.

3. The key questions

The actual success of a collaboration with industry depends on a proper definition of the goals and conditions. Other factors significantly affect the outcome, such as the previous information of interests shared with the industry, the viability to set out an efficient strategy of collaboration or the merging of common interests, among others. In the case of early engagement and collaborations at early stages of the development, these points must be specifically addressed as well as other issues such as commercial constraints of working far from an established market, more complex funding tools, timing aspects, singular IP issues etc.

We have compiled a list of points related to the aspects discussed in the paragraph above. This list has been the basis of our contacts with industry and other stakeholders. The list of questions compiled, so-called *key-questions* in this document, is outlined in Annex I.

These questions have further evolved through discussion with the companies. Some of the questions have been tuned according to the contacts with the companies, for the sake of effectiveness.

It is pointed out that this key-question document was offered to the industries as a guide for our conversation. In some cases, it was revealed to be too exhaustive and broad. In others, we started our talks on the specific points in the list but, during the conversation, we focused on issues based on the experiences of the company and, in frequent cases, the meeting evolved outside the guide proposed.

4. List of contacts

4.1 The contact with the companies

At the current development of the work, the first set of contacts with industry and ILOs can be considered as completed.

We want to highlight that the interaction of ILOs has been essential for the success of the industry feedback in the corresponding countries. Without their support, this work would not have been feasible.

It is noteworthy that only two companies refused to reply to our contacts, out of 20.

4.2 List of companies and ILOs contacted

Table 2 below shows the list of companies and ILOs contacted, together with the meeting date scheduled.

	Company	Contact	Meeting status	
France	**ILO**	**Nicolas Breton**	**24/2/22**	**09:30**
	SEF-Technologies	Eric Fanio	9/3/22	09:30
	SODITECH	Adrien Deverre	18/3/22	17:00
Netherlands	**ILO**	**Jan Visser**	**4/3/22**	**13:00**
	CRYOWORLD	Marcel Keezer	31/3/22	13:00
	HIT	Cock Heemskerk		
Italy	**ILO**	**Mauro Morandin**	**18/2/22**	**15:30**
	OCEM Power Electronics	Miguel Pretelli	3/3/22	10:10
	CAEN	Ferdinando Giordano	3/3/22	12:00
	ASG	Antonio Pellecchia	22/3/22	14:00

	SAES	Paolo Manini	9/3/22	16:00
	KYMA	Rafaella Geometrante	28/6/21	15:00
Germany	**ILO**	**Friedrich Haug**	**2/3/22**	**16:00**
	Billfinger Noell	Michael Gehring	1/7/21	13:30
	Trumpf	Marcus Lau	21/4/22	16:00
	Bevatech	Holger Höltermann		
	Research Instruments	Michael Pekeler	21/4/22	14:00
Spain	**ILO**	**Manuel Moreno** (*)		
	Spanish Science Industry Association	Erik Fernández (*)		
	AVS	M. Angel Carrera	20/10/21	15:00
	ELYTT	Aitor Echandía	8/10/21	09:00
	BTESA	Juan Lluch	2/6/21	09:15
Sweden	**ILO**	**Fredrik Engelmark**	**27/4/22**	**13:30**
	Qamcom	Otto Lilja	5/5/22	13:00
	Scandinova Systems	Mikael Lindholm		
	Quantum group			
Denmark	**ILO**	**Jonas Okkels Birk Herik**	**8/4/22**	**14:00**
	Mark-wedell	Torven Ekval	21/4/22	10:00

Table 2. List of companies and ILOs contacted. (*) WP3.3 members

4.3 LIST OF INSTITUTIONS CONTACTED

A selection of institutions has been contacted to discuss the feedback obtained from the industries. These were: DESY, CERN and INFN.

The contacts were scheduled in the following dates:

- **CERN**: 07-11-2022 and 28-11-2022;
- **INFN**: 20-12-2022;
- **DESY**: 04-01-2023.

Beside the institutions above, the consortia AMICI and TIARA have been informed of the outcome of this analysis via their representatives in CEA, INFN and CIEMAT.

5. Compilation of discussions with the industry

A compilation of points addressed and discussed within the iteration with the companies is attached in Annex II.

6. Discussion with the Research/Technological Institutions

A summary of the compilation provided in Annex II was shared with the institutions and discussed with them in specific meetings. The main outcome of such discussions is presented in Annex III.

In general terms, the institutions agreed that the work done was very complete, being their views very much aligned with most of the messages received from the companies, whilst there remained some difference of opinion in specific points related to:

- the concept of outsourcing technological capability to the industry;
- the feasibility to increase the flexibility in R&D procurements;
- the IP policy suitable for an early collaboration with the industry;
- the viability and interest of directly funding to industries for carrying out pure research activities;
- the viability to merge our technical needs with the ones of other Big Science fields.

7. Summary of the main topics identified for further analysis

From the discussions held with companies, ILOs and institutions, it has identified a set of aspects that become a very suitable base for the activities foreseen in action 4.3 (see Section 2.5).

We outline below a table of topics compiled from the work done in Task 3.3 of WP3 affecting the early engagement of industry on accelerator R&D activities. It is presented in a SWOT format. The factors below can guide a second discussion with representative parties, mainly with industry and research organizations.

Analysis of factors affecting the early engagement of industry in activities promoted by the ASc&T community		
Internal factors	**Strengths**	**Weaknesses**
Small potential market size; limited number of suppliers		Labs forced to keep internal know-how and may be interested on limiting the engagement of companies
Labs own significant technical human and material resources. They want to keep the competences of prototyping in house		There is less incentive to engage industry. Academia may become a competitor to industry
R&D service providing	More chances of industry engagement may be originated from the possibility of considering companies not only as suppliers but also as R&D service providers	
Industry owns specific complementary competences	Production aspects can be taken into consideration from the beginning; risk of sub-optimal design (that may imply higher costs at production phase or poor quality of the final products) can be minimized.	
Scientific environment characterized by general openness of the results	May facilitate the transfer of background knowledge from academia to industry	May reduce appeal for companies interested in getting exclusive ownership of the IP produced in the R&D phase
Highly specialized developments, industry personnel may not have sufficient technical knowledge	E&T actions with Labs is an efficient tool to incorporate technical knowledge. R&D activities may attract external resources to support training activities.	Transfer of knowledge to industry may be difficult or too expensive. Training actions attractive for industry should be carried out with a common plan and take place also in industry
Strong interest of some companies in getting exclusive ownership of the IP produced in the R&D phase		May produce a lock-in situation.

IP management	Addressing IP management at early stage meets expectations from industry	May require additional efforts on both sides. IP management not addressed in a proper way: discourage, delays, conflicts.
Limited companies liability	Engaging the companies at low TRL mitigates their risks	
Lack of clear market perspectives		Companies may not be willing to participate in the R&D activities
R&D early steps developed with no input from the industry sector	May free the developments from too stringent conservative approaches driven by industry	May hinder a synergistic approach in which both academia and industry capabilities are effectively exploited
Industry needs to make long-term planning		May be frustrated by the common uncertainties of early stage scientific developments
Specification documents not mature for production	Identification of outstanding R&D activities can create opportunities for the involvement of companies with fair remuneration	Companies may be forced to modify the design by using internal resources with no recognition of the work done
External factors	**Opportunities**	**Threats**
Procurement legislation	Initial analysis performed in AMICI seems to indicate that, at European level, new instruments like PCP and Innovation Partnerships can overcome the lock-in related constraints. This conclusion holds in the analysis carried out in this work	Provisions to avoid lock-in may discourage a company from participating to both the R&D and production phases, thus jeopardizing the possible industrial interest
Procurement contractual terms	PCP and Innovation procurements can provide additional flexibility. Some BSO seem to have ways of adapting, under fair and legal terms, the contractual conditions during the execution of the	Not sufficient flexibility to cope with uncertainties and risk that are inherent in the R&D work

	tender, thus increasing the flexibility.	
Practical implementation of innovative instruments	The representative example of QUACO. This successful PCP can encourage further implementations	Limited experience so far may discourage implementations. Large administrative complexity. May require modifications of the rules in International Organizations.
Current trend in enhancing cooperation among BSO (Big Science Organizations and communities)	Experience in one BSO can be exploited in others; there are concrete indications that experience in other sectors like space and fusion might be useful. Coordinated planning of R&D activities in common sectors may enhance the industry participation	Significant difficulties to find resources for such expansion of capabilities. It cannot be done with marginal resources.
ASc&T community aims to organize its strategy at long-term	A more suitable scenario to encourage industry to define innovation capability and resources	
Poor or non-existing cooperation among industrial companies		Companies may not be able to bring their needs to the attention of the ASc&T community with the necessary efficacy
Emphasis on governments and EC to support the R&D activities in the companies	Participation in R&D activities is considered an import enabling factor for the development of the industrial innovation potential	A clear integral strategy is mandatory for the success of R&D funding programs in industry. Significant resources and a solid managerial structure needed. Risk of reduction of technology diversity.

Table 3. SWOT analysis of early engagement of industry in R&D activities promoted by the ASc&T community

8. References

1. Deliverable report 3.2 *Strategy for innovation and industry-RI cooperation*. ENRIITC. The European Network of Research Infrastructures and Industry for Collaboration H2020 INFRAINNOV-02-2019 Grant Agreement Number: 871112. *Date:01/01/2022*

2. Deliverable report D5.5 *Requirements and Conditions for Developing Prototyping in the Industry*. AMICI. Accelerator and Magnet Infrastructure for Cooperation and Innovation. Horizon 2020 / Coordination and Support Action (CSA) Grant Agreement No: 731086. *Date:30/06/2019*

3. Deliverable report D4.3 *Report in Best Practice Collaboration between Industry and Technological Infrastructures*. AMICI. Accelerator and Magnet Infrastructure for Cooperation and Innovation. Horizon 2020 / Coordination and Support Action (CSA) Grant Agreement No: 731086. *Date:30/06/2019*

4. *Summary report of the II AMICI-Industry forum*. Held in Brussels on Sep. 17-18, 2019. Aim of the meeting: discussing the results of the AMICI project activities, and the short and medium-term strategies proposed by the AMICI collaboration, with the contribution of a qualified sample of companies. Author: AMICI Collaboration.

5. *Summary report of the Accelerator-Industry Co-Innovation Workshop*: Tools and strategies to enhance industry-academia cooperation in the particle accelerator community. Brussels, 6-8 February, 2018. Author: Maurizio Vretenar

6. *Infrastructure Survey Report TIARA-REP-WP3-2012-004*. TIARA Work Package 3: R&D Infrastructures. Test Infrastructure and Accelerator Research Area. FP7-INFRASTRUCTURES-2010-1/INFRA-2010-2.2.11 project TIARA (CNI-PP). Grant agreement no 261905. Bordais, L. (CNRS) *et al* 23 February 2012

Annex I. List of key questions

IFAST Project. WP3, Task 3. Industry-Academia approach at early stages.

Interview with companies. Key Questions

General points

- From your experience of collaboration with research institutes, please, comment on your vision about an efficient industry-research center interaction. In particular, the added value of a collaboration at early stages.
- Please, comment on the key drivers for the pros and cons of an early stage collaboration with research institutes.
- Please, comment if you see any possibility to really get the common competences and capabilities (both of the industry and academia) exploited better

Specific subjects

1. Funding tools for a better industry-academia approach at early stages.

1.1. CE/National Program calls:

- Examples of call formats benefiting this approach
- Examples of call formats not benefiting this approach
- Please, define your ideal CE-MS funding programs for such approach.

1.2. Type of procurement/contracting rules.

- Procurement contracts at national level. Drawbacks
- Focused tenders. Pros and cons
- Collaboration vs procurement
- The ideal tender processes

2. Timing

2.1. Which is the right moment to initiate the industry-academia contacts?

- On development projects. From existing prototypes to series
- On R&D projects. From the starting of the initiative
- Risk and advantages of early contacts

3. Research Strategy

3.1. From the point of view of the interest of the industry,

- How do you see the dissemination of the overall strategy of the projects, from the H2020 projects, communities, task force groups ...?

3.2. More in detail about the access to information of new projects

- Preliminary Meetings.
- User/Suppliers project meeting in advance to CDR.

3.3. In a similar focus. Please, comment on your vision about how industry can find the right information for a suitable collaboration on the projects. In two scenarios:

- Large collaboration projects, like IFAST
- Bilateral actions, few partners projects, directly led or supported by a research institution

4. Market and competition issues

4.1. Pros and cons about early contacts from the commercial point of view.

4.2. How to handle fair competition at early stages

4.3. How to handle the risk of an early engagement.

4.4. How to pin focus on market since the early beginning.

5. Education, training, outreach

5.1. Tools to get access to the suitable knowledge. Needed further tools?

5.2. Tools for personnel interchange: EU projects, infrastructures programs, collaborations with Academia ... Needed further tools?

6. IP.

6.1. Patent model:

- Previous patents and owned by one single party
- Co-generated patents

6.2. Alternatives to the patent model

7. ILO / TT Offices / Industrial Associations

7.1. The roles of ILO/TT Offices / Industrial Associations. Feedback

7.2. The roles of the Framework projects (ARIES). Feedback

7.3. The roles of the Community collaborations (TIARA, LEAPS). Feedback

9. Network and links

8.1. To the eye of the industry: is the network of research institutions in Europe efficient?

8.2. Is it there a clearly identifiable unique body Industry/Lab to Brussels?

8.3. How do you see the existing links with other communities such as LEAPS, detectors?

8.4. How do you see the existing links among different fields (Space, PP, Fusion, medical, ...)?

Annex II. Interaction with Industry. Preliminary considerations

IFAST Project. WP3.3. Considerations about early engagement of the industry on Accelerator Activities

II.1. Key aspects

Points to consider to promote an industry-Research Institutions interaction at low TRL within the ASc&T sector

Specific considerations

- Involve the industry on research activity from the design stage.
- Separate the design stage from the production stage.
- Involve the final user since the very early beginning.
- The good relationship with research institutions is considered as a strong added value. A work program based on the trust, on solid relations, is a base for success. This simplifies tremendously the IP concerns.
- A limitation: the involvement of the industry in a collaboration with the research institution before placing the contract can generate conflict of interests. Providing support to the research institutions at early stages is in some cases considered as a non-equity advantage for applying to the tender.
- Early engagement is good for an adequate IP management. The IP generation, when addressed at high TRL models, is not ideal to the industry.
- Some companies declare as critical point to have limited liability. Liability cannot be unlimited; it is a blocking point to the companies. Engaging at low TRL can facilitate this point

Strategy

- Pursue well defined research and development programs, with integrated aims.
- A strategy coordinated with the industry: the objectives defined according with the resources of the research institutions and the resources and capability of the industry, put in common. The growing plan defined together. Joining strategies.
- Prepare the industrial ecosystem at longer terms. Face the "peaks and valleys" on the demands for research developments.
- Revision of the IP strategy.
- Explore synergies with other fields: expand the demands from ASc&T in coordination with other Big Science fields.
- A better internal organization among the industrial community, helping to create a coordinated strategy. It is not only the academia the ones who has to mobilize towards a common direction.

Education and training

- Support for training of young expert engineers and scientists. Sharing training personnel between research institutions and industry. Sharing the costs
- It is important the training personnel to be in the industry, at least partially.

Procurement procedures

- Among the options available on procurements, only innovative procurements such as PCP are mentioned as a model well suited to work at low TRL.
- Use and expand innovation procurement procedures.
- Follow successful examples in other fields, more advanced: Space in particular. Fusion in some aspects.

I.2. Actions to analyze for promoting collaboration at low TRL

Research institutions

- Research Institutions have to avoid prototyping internally in some aspects or, at least, not alone.
- IP must be shared since the early beginning. Tender processes must be adapted to this strategy.
- Leverage our internal technological capacity in line with the existing industry.
- Insisting on promoting efficient E&T programs, making them visible to industry with lower experience and contacts via ILO.
- Assuring long-term development plans.
- Related to the previous point: guarantee the access to the information on new initiatives, calls, projects, infrastructure upgrades, etc, under a coordinated scheme.
- Include the industry on the ASc&T strategy: the objectives defined according with the resources of the research institutions and the resources and capability of the industry, put in common.
- Promote the integration of roadmaps within synergetic communities. Join strategies specifically on ASc&T.
- Promote synergies with other Big Science fields. In particular, Fusion and Space, that might help to avoid peak-valley activity gaps. (*)
- Promote flexible conditions in the procurement contracts.
- Use and expand innovation procurement procedures. Relevant examples in other fields.

The industry

- A major effort on self-organization. Industry associations must be encouraged.
- Being proactive in the information about projects and tenders. Via conferences, sharing research projects (in particular the transversal work packages of integration projects, or via ILOs, among others.
- Help to co-fund the needed investment, at a fair balance, depending on the distance to the market.
- Proactivity on Education and Training programs (interdisciplinary interchanges, industrial PhD programs, ...)
- Further resources since earlier stages to orientate the vision of development and singular equipment with higher market impact.
- Be ready to share risk.
- Simplify and speed-up the internal communication process and the flux of information (catalogs, list of contacts, ...)

II.2. Summary on main aspects addressed

1. Facts affecting the analysis

The industry working on the production of components or solutions for the Accelerator sector is very heterogeneous. For this reason, we should not expect a unified message from this community.

There are two main reasons why the industry gets involved in the technologies needed by the accelerator sector (ASc&T). They could aim for:

- series productions to reach the general market and/or
- the production of specific products for the Scientific Infrastructures (one-shot).

There are also two relation mechanisms:

- Procurement via contracts and
- collaboration in projects.

In both cases, not all industries accept or get motivated by both options.

Differences are not only related to the relation the industry has with the research institutions but also to the intrinsic nature of the companies, their involvement in the sector or the resources available. Here are some of these differences:

- **ASc&T activity rate**: From 20% to 80-100%.
- **Knowledge of the field**: Some companies are just informed via closer institutions, while others invest heavily in collecting information via conferences and face-to-face meetings among others.
- **Funding rate required versus potential benefit**: A combination of factors, related to the added value in terms of intellectual return to the company or the distance to the market or the availability of resources, among others that is not the same in every company.

Finally, the industry involved in ASc&T seems not to be a very consolidated, well-organized community.

2. The global opinion of the industry on a deeper involvement on Low TRL

Most interviewed companies are in strong favor of being involved at low TRL. They think that it is beneficial for both sides. However:

- The concept of early engagement **is not perfectly agreed upon by all companies**. In most cases, it is understood that "involvement in Low TRL" means starting a contractual relationship with the research institution from the conceptual design phase.
- Companies with wider experience indicate that **adequate information on the future needs of the product is required** as they can/have to build a business plan that will be based on this information.
- A number of companies with longer experience in the field **criticize strongly the current model**, claiming that a different approach closer to the "*old times*" is required.
- Smaller industries, limit their interest to some aspects, mainly due to a **lack of resources** and not being open to investing significant resources for their involvement in low TRL projects.

As a co-lateral remark, we received two messages

- It is a good praxis involving to the final buyer early on the industry/academia collaboration, when this is not the research institution in charge of the development.
- Companies find big difficulties on the last steps to the market. Regulation and legal aspects are a severe burden to them, with a reduced help from institutions and specialized companies.

3. The ideal industry-research labs interaction model within the ASc&T sector

From the feedback of the industries, we identify that, in the fields in which the research institutions could work with industry at low TRL and the institution decide not to do it, somehow, the research institution becomes a competitor of the industry. **The procurer can become a competitor**.

If going to a higher level of integration of the industry at low TRL, the model demanded by the most experienced industry would suit the following points:

- Involve the company **from the design stage**.
- **Involve the final user** from the very early beginning.
- Pursue **well-defined research and development programs**, with integrated aims and long-term objectives.
- **Separate the design stage from the production stage**.
- Have a work program based on **trust and on a solid relationship**. This simplifies tremendously the IP concerns.

Some other crucial points beyond the interaction model:

- **A strategy coordinated with the industry**: the objectives defined according with the resources of the research institutions and the resources and capability of the industry, put in common. A growing plan defined together. Joining strategies.
- **Prepare the industrial ecosystem at longer terms**. Face the "peaks and valleys" of the demands for research developments.
- **Support for the training of young expert engineers and scientists**. Sharing training personnel between research institutions and industry. Sharing the costs
- On this last issue, it is important that the **personnel involved in the training can work in the industry**, at least partially.
- Use and expand **innovation procurement procedures**. Relevant examples in other fields.

4. The case of not working at low TRL

Some relevant companies declare cases in which the research institutions in the ASc&T field keep the policy of covering by themselves the first stages of the technological research, developing its own first prototypes. When this is the case:

- **Technical Suboptimization**: The result is not optimum from the final technical outcome viewpoint; the industry claims that prototypes developed in this format, in many cases, are subject to foregoing improvements as they are not industrialized, and the techniques used are not always the ones that industry will use.
- **Cost suboptimization**: Procurements based on prototypes developed by the research institutions alone are subject to limitations that can affect the contract development itself. Prototypes subject to improvements mean modification of specifications, longer delivery terms and larger costs. Technologies can also be more costly or difficult to use for mass production.
- **Risk moved to the industry**: Using techniques that are not the optimal ones for industrialization will have a cost. Industries will face the dilemma of quoting what it is requesting knowing that will fail and that then they will have to face potential over costs or risk of losing the tender. In some cases, the conclusion is that the company decides to accept the contract without a budget for contingencies for changes that are, in the end, needed.
- **Conflict of interest**. Providing support to the research institutions at early stages was considered a non-equity advantage for applying to the tender.
- Early engagement is good for **an adequate IP management**. The IP generation, when engaged at high TRL models, is not ideal to the industry.

5. What else we can do to promote a low TRL approach

In order to deploy an advanced low TRL research institutions-industry collaboration program in ASc&T, some actions can be foreseen to carry on from the research institutions and industry.

Actions from the research institutions

In the topics in which we decide start working at low TRL, **changes must be done within the research institutions to adapt our activity to this model**:

- **Avoid prototyping internally when the feasibility** of the component/equipment **is not put in doubt by the industry**.
- **Share IP since the early beginning**. The IP generation, when engaged at high TRL models, is not ideal for the industry.
- **Adapt the tender processes** so as to be able to buy R&D produced with the industry and not just components.

Actions from both:

The following general concepts are more relevant at low TRL:

- A strategy coordinated with the industry: the objectives must be defined according with the resources of the research institutions and the resources and capability of the industry, put in common.
- Well defined research and development programs, with integrated aims and long term.
- More proactivity on setting a long-term strategy with the industry.
- Proactivity on Education and Training programs for stays both at research labs and industry.
- Avoid peak-valley activity gaps. Increase the dimension range. Create integrated industrial plans. Trying to find synergies with other fields. In particular, Fusion and Space.
- The growing plan defined together. Joining strategies.
- A better internal organization among the industrial community, helping to create a coordinated strategy. It is not only the academia the ones who has to mobilize towards a common direction.

6. About tendering and partnership tools to promote low TRL

Current procurements and project partnership models

As previously indicated, there are two relation mechanisms:

- Procurement via contracts and
- collaboration in projects.

Procurements in the ASc&T sector are not a strong source of revenue.

Collaborations and Partnerships on research projects are seen mainly as a method to:

- **gain expertise;**
- **gain a recognized reference**;
- **establish close links** with research institutions, and
- invest in **know-how**.

They consider it as an investment and, for such, they accept the co-fund that this partnership implies.

Specific messages received

- Separate the tender in steps.
- A good tendering strategy: the institution places an order for a preliminary study and then, to avoid problem of the competition during the tender, the institution owns the intellectual property produced.
- The rules must be clear. Avoid too many options, it is limiting, in term of costs. More options mean that the company has to look for protections.

Having said that, they highlight that there are no golden rules.

Limitations reported

Often research institutions request **quotations for a concept based on schematic drawings**. This can be misleading as many times the design must be adapted before the development stage towards industrial specifications. It also consumes industrial resources.

Before the contract, the risk for the company is that the discussions with the institution are started in many cases providing know-how in advance, modifying the design, with no guarantee of being awarded. The company may invest its time and know-how to improve a design that other company may win. From the industrial point of view, this procedure discourages from sharing information with the research projects. They report that this happens quite frequently.

In many cases, accelerators, synchrotrons and other related facilities provides designs not completely finalized. And, from this step, budget quotations are requested. Some companies do not just offer their help for improving the specifications; they simply go to the tender. But, in the tender, the design is frozen and, if not optimized, the product is less reliable, more expensive.

Most of the times, research institutions want to have the most modern instrumentation for their experiments. Sometimes this goes against the reliability of the final product: the most advance instrument cannot be the most reliable. It can turn into a product that cannot be reliable.

Liability

Some companies declare as critical point to have limited liability. Liability cannot be unlimited; it is a blocking point to the companies, to the limit that, sometimes, they have been excluded from some tenders due to this aspect.

Comparison with other regions

Very experienced companies report that, if we compare the contract procedures in Europe with those in ASIA, Canada, USA, they do not find too much difference; they are very much comparable. Same level of specifications, rules bit different (USA: easier best value for money), but not significantly.

From this message, they infer that, regarding standard procurement contracts, there is no much room for improvement in Europe; not much if compared with other countries.

Regarding collaboration and not tendering, the USA has the SBIR2 and STTR programs that target among others “Foster technology transfer through cooperative R&D between small businesses and research institutions”. These programs target common R&D between SMEs and research institutions and are fully funded by the US Government to stimulate technological innovation and multisector collaboration.

Successful tendering processes

Among the options discussed on procurements, only innovative procurements such as PCPs are mentioned as a model well suited to work at low TRL. The PCPs are procurement contracts targeting engineering services and

[2] https://www.sbir.gov/about

follow the concept of the best value for money. They also consider that material and tooling could remain with the companies if this enhances their capabilities and forces a very clear IP definition from the conceptual phase.

More advanced models in other fields

Examples of tendering processes of interest to low TRL have been found in other fields. In Space applications, ESA has specific programs for low TRL: it is the case of the former TRP, currently TDE (Technology Development Element). Their vision is to secure the competitiveness of our industry. Beyond plain business, strategy for setting industry.

ESA manages the IPR to facilitate the attractiveness to the industry. Purchasing not only to fly equipment, but to promote competition. ESA does not aim at being owners. They leave to the developers. With rights of access, free licenses for the member states.

Besides, we want to highlight that ESA has set out procurement procedures flexible enough to be adapted to modifications during the procurement phase. Procurement rules open to competition with negotiation. CCN (Contract Change Notice, ESA own regulation as International Organization): sometimes, motivated by ESA, sometimes, requested by industry.

Annex III. Discussions with Research and Technological Institutions

III. 1. General comments received about the work done

- The consulted RIs think that the information collected in this work is very compete. The points addressed are the fundamental topics to analyze. No relevant points missing.
- Some comments outlined are inconsistent [3].

III. 2. Comments about enhancing the capacity of the companies for designing and prototyping

Contradictory messages were collected in this aspect:

In favor:

- The input in the document to incorporate the industry in basic design phase to include industrialization procedures is supported by some institutions (not all).
- Example of the PCP QUACO. Industry proposed a design different to the one provided by the RI. The RI prototype resulted to be not serializable, while the industry design did.
- Industry has already resources and know how. Not needed for prototyping when the know how exists at industry. RI has to carry on with the prototyping only in the cases that the industry is unable to do it.

Against:

- The view of some RIs is that our RIs want to keep the competences of prototyping; they do not want to rely on the industry capability for its development programs.
- RIs has to secure their needs in house, because the ASc&T industry is a sector in which there are few companies, because a small market.
- There exists inherent risk if the know-how is transferred to the industry. If the company disappears, the capability is lost. Difficult to secure.
- Diversification is also a problem. No control of that.
- Developing new procedures on industry that consequently apply for a patent put a lock on the know-how.
- Early development may imply a high risk level that the industry could not afford.

III. 3. Comparison with other communities

Critical with our procedures:

- ESA procedures on industry strategy are more efficient that ours. Our RI rules are not efficient: they buy based on money. Best value for money only for services.

Protective of our procedures:

[3] This is expected since due to the diversity of opinions on the industrial representatives and that all these opinions were collected

- ESA is an agency, has no competency in house. Our RIs need to keep such competences; they cannot rely on the industry capability for its development programs. The development programs must be in-house and, when the technology ready, they should be transferred.

III. 4. Comments about merging strategy and need with other communities

Positive:

- Synergic communities: fora like BSBF were meant for that. Further synergic actions are not needed; what it is needed is more funding resources to promote co-strategies with other R&D fields in the existing fora.
- It really depends on the field. It can be identified some niches where possible, but difficult in general. Examples of possible technical sectors for merging: electronics, high speed, short pulse, power electronics. Other fields: Energy supply, with common problems,
- Artificial Intelligence is a field with specific viable options to merge.

Negative

- Room for a more integrated approach on Big Science? It should be very interesting to merge, would benefit everyone. But it is not obvious. Severe difficulties to standardize.
- Significant difficulties to find resources for such expansion of capabilities. It cannot be done with marginal resources. In the current budget situation, the chances are very limited.

III. 5. Comments on the risk

Critic with our procedures:

- We have few large companies working for ASc&T. Big companies take no risks. Big companies do not reply our tenders because they have computed the cost of a bad prototyping from RI.
- Guarantee, cash flow, liabilities: industry cannot afford an insurance for securing liabilities. If industry develop the prototype for a RI, they cannot carry the burden of operation liability.

Protective of our procedures:

- Changes on the procedures of our large RI? Some RIs do not see this point.

III. 6. Comments on IP

Critic with our procedures:

Protective of our procedures:

- IP owned by the generator. Questionable. In the start of the PCP program, IP was not supposed to remain in the companies. It was not meant like that initially by EC.
- RIs agree on that companies should have resources, and IP. But RIs cannot leave this IP: they need this IP to place procurements, under competitive basis. RIs need to have the right to spread this IP, to guarantee competitiveness.

III. 7. Comments on funding R&D in the industry

In favor

- Grants to fund R&D in industry, non-refundable, EC programs for funding research in industry (no functional development, not even prototyping): yes, it should be a good point
- DOE programs support SMES. Money to grant experience. Non-refundable. This is our missing point. We have only the contract tool, not no-refundable funding.
- USA links the money placed on big contracts with big companies to the no- refundable fund to SMEs.

Against

- In some aspects, DOE promotes limit the standardization of own technology. Example: specific control systems only accepted by DOE. We have much more freedom in Europe, what it is positive.
- The transfer of information to use broadly the results should be difficult.

III. 8. Comments on contract procedures

Specifically, RIs are not aware of any other innovation contracts apart from PCP.

About the lack of flexibility of our contracting rules, there are discrepant views. Some RIs consider that the own standard procedures rules are fair and efficient. They must keep some level of rigidity for the sake of legality and fair procurement.

Other RIs report that, for them, research contracts are living tools. Once granted, they change into collaboration. They are able to adapt specifications and prices, up to some level. This is why they actually are research contracts. In any case, they point out that any modification must be done in a fair way, by mutual agreement (procurer-companies), to avoid disputes, and to demonstrate the use funds in an efficient way. They have regulations about how to adapt the specifications and price change. In any case, information must be clear and legal discussion must be open.

Annex IV: Glossary

Acronym	Definition
AMICI	Accelerator and Magnet Infrastructure for Cooperation and Innovation. (Horizon 2020 Project GA No: 731086)
ASc&T	Accelerator Science and Technology
EC	European Commission
ILO	Industrial Liaison Office
IP	Intellectual Property
MS	Member State
RI	Research Infrastructure
TI	Technological Infrastructure
TIARA	Test Infrastructure and Accelerator Research Area Consortium
TRL	Technological Readiness Level
WP	Work-package