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Assessment of Effectiveness of NAVISP Phase 1 and Recommendations for Phase 2

A report by the NAVISP Advisory Committee (NAVAC)

Assessment of Effectiveness of NAVISP Phase 1 and Recommendations for Phase 2

Navigation Innovation and Support Programme Advisory Committee (NAVAC)

June 2019

Executive Summary

It is as important to take stock of successful programmes which appear to be running to schedule and delivering their intended benefits as it is to critically review programmes which are failing. This – by and large – has been the pleasant task undertaken by the NAVAC. By all measures, the NAVISP programme is doing well. In three years, most of the Element 1 budget has been consumed and Elements 2 and 3 are progressing to plan.

In this context of apparent success, our report has had to be as creative as it has had to be analytical. Rather than addressing failure, we have had to ask ourselves what could be done better or what new activities could be brought within the scope of the programme. In undertaking this endeavor, the Committee has been as much concerned with missed opportunities as it has been with assessing the performance of the current programme.

This is not to say that the report is not critical in certain areas. Many of the recommendations could and should be interpreted as criticisms, but hopefully constructive ones. However, the overall mood of the report is up-beat.

If there is an overarching message, it is that the barriers to innovation lie as much in our own minds – as individuals and as institutions – as in technological limitations. We are overeager to think in terms of industries and sectors whereas in reality the underlying physics knows of no such constraints. We have unintentional biases, ranking the creative activities of individuals and small companies before those of large corporations and global markets. In practice, all these things matter, the value of the programme lying not just in pockets of innovation but also in the wiring which brings these disparate elements together to form mature and transformational products and services.

A fundamental precept of the NAVISP programme was to take the spotlight on GNSS and broaden it into a floodlight on a much wider gamut of positioning, navigation and timing (PNT) technologies. We believe that the programme has been very successful in this respect.

However, this quest for breadth needs to be directed at more than the technology alone.

- The scope of the programme must continue to be broadened to address the application, not just the creation, of new technologies; to address users as well as developers.
- The “wiring” is as important as the component parts. Market risks, regulatory risks, and integration risks are as real and as obstructive to progress as the more obvious technical uncertainties. The programme must encourage activities in these non-technical areas.
- With the broadening of the scope comes the need for new players. Some of these companies, already active in PNT markets, are too busy to address new opportunities. The programme must appeal more to these players, and ESA should continue to simplify its procurement processes and make itself easier to do business with.
- There is a wealth of relevant expertise outside of the PNT domain, notably in large prime contractors and integrators. The involvement of these companies is essential and more must be done in outreach activities to attract them.

Not one of these observations – which incidentally – merely paraphrase the 16 detailed recommendations made in the report – concerns activities which are not already underway. The real message is therefore “maintain momentum and continue to do even more”.

Successful programmes are more than a sum of their parts. NAVISP should not only be a programme of challenges but also a programme which is in its very nature challenging. It must continue to challenge research organisations; businesses of all size, governments, regulators and ESA itself. Given the progress made to date, there is no reason to believe it will not.

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1. Introduction

1.1 The NAVISP Advisory Committee (NAVAC)

The Navigation Innovation and Support Programme Advisory Committee (NAVAC) is a committee of senior external experts established in October 2018 by the European Space Agency Director of Navigation to advice on the objectives, strategy and relevant technological priorities of NAVISP.

The members of NAVAC participate in their individual capacity and on their own time. ESA only supports the meeting travel costs. In case that a potential conflict of interest arises, the members have agreed to abstain from the discussion of the relevant topic. This allows the Committee to preserve its independence and impartiality regarding the contents of its advice.

Members have been appointed for an initial period of 2 years. The current members of NAVAC are:

- Roger McKinlay Chair
- Stefano Debei Member
- Bernd Eisfeller Member
- Peter Grognard Member
- Luis Mayo Member

The main tasks of the Committee are to advise and/or make recommendations on:

- thematic areas for the development of NAVISP activities;
- proposals for the development in NAVISP Element 1;
- support required to enhance the Programme effectiveness.

More specifically, on request, these tasks include to:

- provide recommendations as to which broad areas of interest have the greatest potential for the development of NAVISP activities and how this potential may best be realized;
- make a preliminary assessment of ideas and proposals made by the Agency on NAVISP Element 1 Workplans, in order to assist NAVISP management in setting priorities;
- provide ad-hoc advice on the results and value of individual projects;
- make an overall assessment of the Programme effectiveness at the end of each phase and make recommendations for the following one.

In line with the above, and in view of the preparation of the Programme Proposal for NAVISP Phase 2 to be presented at Space19+, the Committee has been requested to make an overall assessment of NAVISP Phase 1. The Committee has also been invited to issue recommendations for Phase 2.

1.2 Scope and Contents of the Document

The scope of this document is to present the results of the NAVAC assessment of NAVISP Phase 1 and the recommendations for Phase 2.

The status of NAVISP is briefly recalled in Section 2. This is followed in Section 3 by a description of the approach adopted by NAVAC for that assessment, that is based on a review of the scope of the close to 100 different activities (Section 4) undertaken within the Progamme, a survey of the views of the industrial participants (Section 5) and a report by ESA on efficiency of the implementation of NAVISP (Section 6). The key findings and recommendations of the Committee after assessing all these elements are presented in Section 7. Finally, the conclusions are presented in Section 8.

The report is complemented with a number of annexes detailing the contents of the industry survey and a summary of the lists of the key findings and recommendations.

2. NAVISP Status

2.1 Recall of NAVISP Objectives

The main NAVISP objective is to facilitate the generation of Satellite Navigation/PNT innovative propositions with participating States and their industry, in coordination with EU and its institutions.

NAVISP is an important element for the overall European GNSS landscape, capable of leveraging both ESA expertise gained through the Galileo, EGNOS and other related navigation programmes and the existing industrial base of the European Navigation sector.

It aims to support European industry in succeeding in the highly competitive and rapidly-evolving global market for Satellite Navigation, and more broadly PNT technologies and services, while supporting participating States in achieving their national objectives and enhancing their capabilities in the sector. The following is the understanding by NAVAC of the NAVISP objectives:

1. Addressing the end-to-end PNT value chain with a view to enhancing Member States industrial capabilities in Satellite Navigation while stimulating jobs and growth in the space sector;

2. Supporting the industry of the participating states to mature the technology readiness of the products from established companies and also encourage new entrants into the PNT market;

3. Mitigating the relevant risks, namely:

   - Technology risks including technology readiness; performance levels and/or QoS (Quality of Service); ability to compete long-term; and ability to integrate with non-space technologies

   - Market and Business risks including barriers to commercial success; the maturity of new business models with high-risk/high-potential returns; and the ability of companies to implement such models

   - Regulatory risks including regulations as barriers to market entry; regulations as barriers to new suppliers; and regulations favouring incumbent suppliers

4. Supporting PNT national programmes and relevant institutional activities following ad hoc participant Member States' requests.

NAVISP does not duplicate nor change the basis on which the strategy and approach to R&D related to the evolution of the Galileo and EGNOS systems is defined. This is determined and controlled through well-established mechanisms in the EU.

2.2 Programme Implementation Status

This report is based on the status of the implementation of NAVISP as per January 2019 (Ref.2), summarized below:

- all Element 1 activities defined under the scope of WP2017 were on-going (Ref. 3) The majority of those under the scope of WP2018 and its Addendum had been already launched ((Ref. 4) and (Ref. 5)). Procurement had also started for WP2019 (Ref. 6). With the Workplans for these three years, almost the totality of the currently available budget for Element 1 activities was being engaged;
- the processing of Element 2 proposals had resulted in 47 activities representing 55% of the total Element 2 available envelope for industrial activities;
- the Call for Proposals of Element 3, issued in May 2018, had generated six activities, resulting in more than 42% of the total Element 3 available envelope for industrial activities.

The first NAVISP Industry Days event (Ref. 7) was held in January 2019 at ESTEC to take stock of the progress of the Programme with all involved stakeholders. More than 140 people attended the two days event. Objectives, status of implementation and way forward for the Programme were presented at the event. A selection of on-going NAVISP activities was presented by companies which illustrated the diversity and broad scope of the Programme.

Based on these results and with 65% of the available funds already allocated after only two years, the ESA Director General announced that a second phase of the Programme was being proposed for next Ministerial Council 2019 (Space 19+).

3. Approach to Assess NAVISP Effectiveness

3.1 Overview

NAVISP was approved in 2016 and the first activities were contracted in 2017. Intermediate results of a selection of the first activities were presented at the First NAVISP Industry Days, which took place on the 17th January 2019 at ESTEC. However, this was only a limited set because results were not yet available for the majority of them. Therefore, the Committee was aware that a complete evaluation of the NAVISP output was not yet possible. In addition, it was too early to assess the achievement some of the NAVISP objectives, such as whether NAVISP support has made industry more competitive or whether an initiative by a participating State has attained the intended objectives.

Nonetheless, the Committee still considered worthwhile to assess what are the prospects of meeting the NAVISP objectives by analyzing the scope of the different NAVISP activities.

The Committee started its task by receiving a detailed debriefing by the NAVISP management on the objectives of the Programme and the way the Programme operates, in relation to other programmes of the Agency and also those of the EC and GSA.

Having reached a good understanding of the Programme objectives, the next step was to define the questions which the assessment would attempt to answer, i.e.:

- Are the activities targeting the right objectives?
- Is the balance of effort in the Workplans adequate?
- What is the perception of NAVISP from the point of view of the industry participants?
- Is NAVISP supporting industry in an effective way?
- Is NAVISP fostering the participation of new entrants?
- Which areas can still be improved to better support industry?

For addressing the first two questions, the NAVAC members decided to review the contents of the activities of the three NAVISP Elements and to characterize each of the activities according to a set of criteria related with the objectives of that element. While this was done for Elements 1 and 2, for Element 3, it was considered sufficient to make a qualitative assessment on how well the activities matched the Element objectives.

The majority of the remaining questions were considered more relevant to NAVISP Element 2 and the best actors that could answer those questions were the industry participants. Therefore, NAVAC prepared a questionnaire which was issued to all industry participants on that Element.

An additional source of information used by NAVAC to evaluate Element 2 were the KPI's monitored by ESA at different points in the procurement process.

3.2 Element 1 Criteria

Element 1 activities were characterized using the following criteria:

- Type of activity in relation with Element 1 objectives
- Innovation Category
- Type of risk being mitigated

3.2.1 Type of Activity

Three types of Element 1 activity were considered:

- Feasibility studies for the emergence of new PNT concepts;
- Contributions to PNT technology innovation;
- Proof-of-Concept and demonstrations of promising PNT-based services and solutions.

3.2.2 Innovation Category

The "Innovation Category" was the key indicator used by the Committee to characterize the level of innovation of the Programme. It was used to characterize both Element 1 and Element 2 activities (while it was considered not directly relevant for Element 3).

The "Innovation Category" indicator can take four values: 1, 2, 3, or 4, depending on whether an activity addresses a new technology, a new market, or both (see Figure 1).

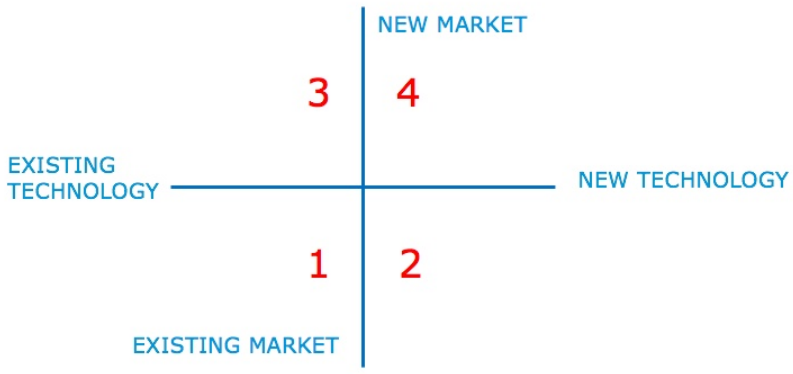

Figure 1: Innovation Category Index Definition

As an example, Category 3 represents an existing technology in a new market. Needless to say, NAVISP activities were expected to score high in innovation indexes 2, 3 and 4.

3.2.3 Risks

The risks being mitigated by the activities were classified as:

- Technical
- Regulatory
- Market

Although it was recognized that one activity could potentially address all three risks, NAVAC members made the effort to identify only one dominant risk per activity.

The risk indicator was used for both Element 1 and Element 2 activities, with the a priori expectation that Element 1 would be much more technically driven than Element 2. Then, as a way of understanding how far or close the points of view of NAVAC and industry were on this aspect, industry were also asked to identify the main risk through the survey.

3.2.4 Consistency Check

Sometimes, the Innovation Category index and the Risk index can be correlated. This was exploited to perform a sanity check during the review, i.e. an activity aiming to introduce and existing technology in an existing or a new market (innovation category type 1 or 3) can only be associated with a mitigation of the market or regulatory risks but not the mitigation of technical risks.

3.3 Element 2 Criteria

The assessment for NAVISP Element 2 was based on the following main criteria:

- the “PNT Sector” addressed by each activity, which would give a view on which areas of the market are receiving the most attention,
- the risk areas,
- the innovation category,
- the capability of Element 2 to attract new entrants and to favour SMEs,
- the implementation efficiency, e.g. the time to contract from outline proposal submission.

Contribution to growth is also an important evaluation criterion, however an assessment of this is not possible till a sufficient number of activities have been completed. On the other hand, some elements were gathered through the answers to the industry survey (Section 5).

The assessment of the PNT sector, innovation category and type of risks of each activity was done on the basis of a review of the scope of the activities and reported in Section 4. The rest of the criteria were assessed based on the results of the industry survey and complementary information provided by ESA (Sections 5 and 6).

3.4 Element 3 Criteria

For Element 3, only a qualitative assessment of the prospect of the activity meeting the intended national objectives was agreed to be done.

4. Assessment of NAVISP Activities

4.1 Element 1

NAVAC members have assessed the contents of the activities contained in the Element 1 Workplans 2017, 2018 and 2019 against the criteria defined in Section 3.2. A total of 39 activities have been considered representing a total budget of 14310 K€. The results are presented in the following sections.

4.1.1 Funding by Element 1 Objectives

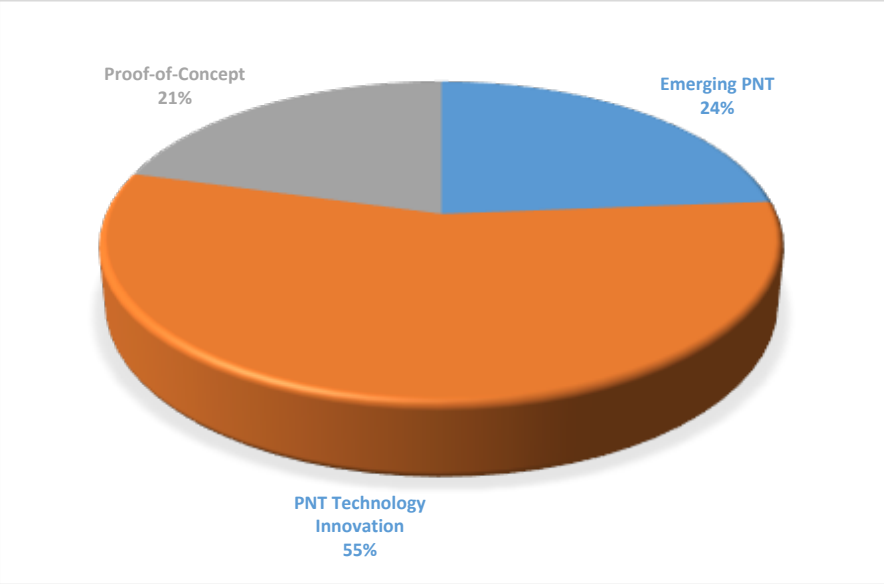

Figure 2: Distribution of Funding per Element 1 Objective

A little over half of the budget has been devoted to “PNT Technology Innovation”; “Proof-of-Concept” and “Emerging PNT”, make up the rest in approximately equal measure.

4.1.2 Funding by Innovation Category

The majority of the investment of the Element 1 budget is in activities with a high level of technological innovation (Categories 2 and 4) with more than 80% of the budget being devoted to the introduction of a new technique or technology in an existing or new market or both (Categories 2, 3 and 4).

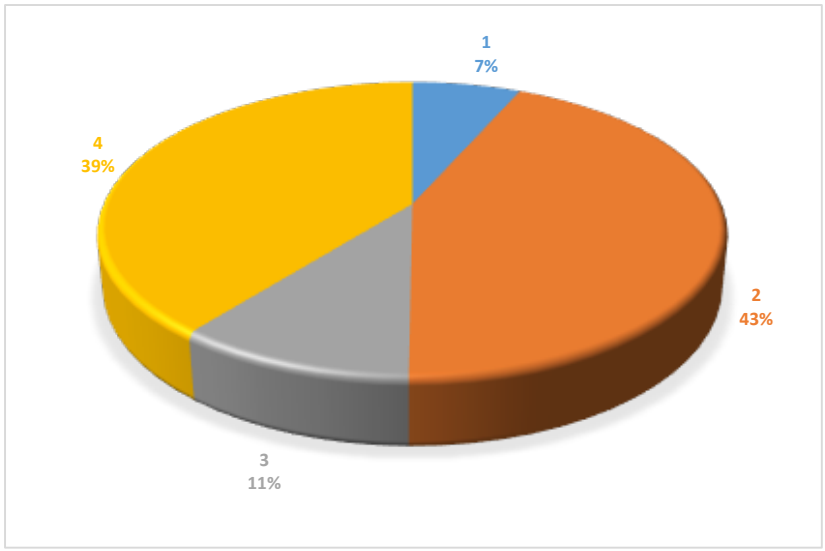

Figure 3: Distribution of Funding per Innovation Category

4.1.3 Funding by Risk Area

The majority of the funding of Element 1 has been devoted to mitigate technical risks in the projects.

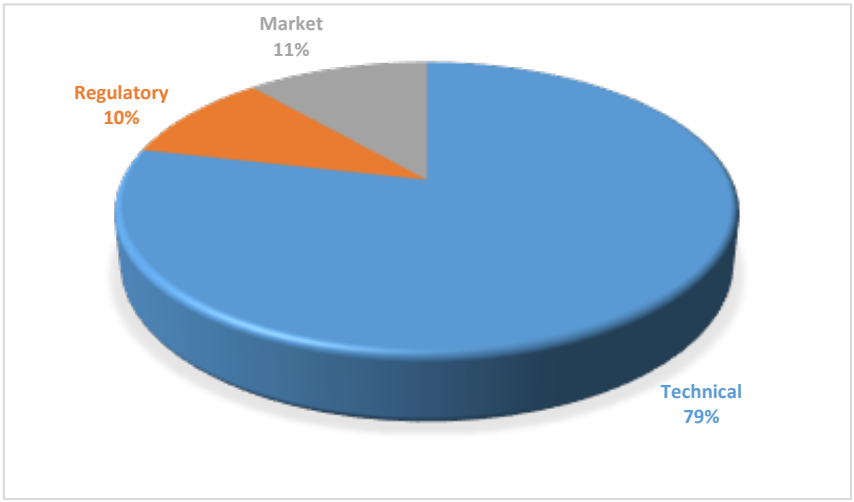

Figure 4: Distribution of Funding per Risk Area

4.2 Element 2

NAVAC members have assessed the contents of the activities contained in the Element 2 (Ref. 2) against the criteria defined in Section 3.3. A total of 47 activities were considered, representing a total budget of 40222 K€ out of which 23994 K€ co-funded by ESA.

In terms of the type of companies involved in Element 2, ESA reported that of the total of 83 companies involved at that time, 46 (55 %) are SME's. Of the total of 47 activities, 60% of the Prime Contractors are SME.

4.2.1 Funding by PNT Sector

The PNT Sectors considered were:

- Agriculture
- Aviation
- Location-Based Services
- Maritime
- Rail
- Road Transport
- Robotics
- Space & Science
- Surveying
- Timing & Synchronization

The above sectors are along the lines of the PNT market segments used in the GSA market analyses (Ref. 8) with the exception of the addition of the "Robotics" and "Space & Science" segments. Both of these areas are very relevant to PNT and the NAVAC felt it important to include them. In addition, of course, both areas are very relevant to the Agency.

With the exception of the Agriculture sector, all the other sectors considered by NAVAC are being addressed one way or another in Element 2. Before entering into the quantitative assessment of the level of support on each sector, below it can be found some highlights of the different activities.

The activities in the Aviation sector focus on the enhancement of the integrity and robustness of GNSS for this application. This includes an activity to improve an existing tool to predict the performance of RAIM, the development of a tool to assess user integrity based on SBAS/EGNOS messages, support to the certification of a GBAS station and development of advanced antennas to cope with multipath and interference.

The LBS sector activities cover three main areas:

- user equipment technology,
- applications,
- cross-sectorial activities aimed to enhance PNT performance, security and robustness.

User technology activities namely focus on antennas and GNSS chips with enhanced features, e.g low power for IoT. The application activities include several projects addressing the monitoring of vehicles and persons in different environment including in-door by integration with uWB. One of the application activities addresses PVT authentication with a novel server-based technique. The activities addressing PNT security and robustness include the development of devices and networks to identify interference, jamming and spoofing. A couple of activities propose centralized centers to support users via informing them on the identified threats to GNSS and possible countermeasures. In one activity it is planned to disseminate GNSS corrections via Iridium to augment the PNT performance.

The main activity in the Maritime sector is the support to the development of the commercial product of a Search and Rescue Second Generation Beacon. This is considered an activity with high commercial interest due to the upcoming need by the user community of replacing outdated first-generation beacons with more modern equipment and at the same time, able to use the Galileo return link service. Another activity is the development of a buoy to support positioning in coastal areas based on tropospheric/ionospheric corrections.

In the Rail sector, NAVISP is supporting the development of a combined video-GNSS location system with the potential to reach the high-accuracy and high integrity requirement of virtual balises.

The activities included in the Road Transport sector target the area of driverless cars and autonomous vehicles in general, focusing on:

- components for the in-vehicle GNSS PNT elements
- tools for assessment and testing of PNT solutions, and
- complementary non-GNSS PNT solutions

This includes advanced antennas developed specifically for this application, customized S/W of GNSS receivers to meet stringent safety and regulatory requirements, the upgrade of a commercial simulator to provide a testing framework allowing the rendering of complex multi-sensor scenarios, and the development and breadboarding of elements of a non-GNSS smart infrastructure supporting high accuracy based on in-vehicle radar and local road-side elements.

The sector of Robotics includes a couple of activities to support the development of robust positioning and navigation solutions for high-end drones. One of them involves the integration of a ground-based location system using pseudoranges to complement the navigation solution of a drone used for airborne wind energy applications. Another, the use of GNSS for improving the robustness of remotely piloted aircraft in the Arctic region.

The sector of Space and Science includes quite a number of activities addressing the development of GNSS receivers to be used by space users with increasing emphasis on the use of COTS to reduce cost, and with focus on use in micro-launchers and micro-satellites, in line with the trends of new space. Within this sector an activity addressing the use of GNSS for attitude determinations of High Altitude PseudoSatellites (HAPS) has been considered due to the similarity of HAPS with space platforms. In addition to these activities, there a couple

of them addressing the development of tools to support testing by simulation or to develop advanced orbit restitution algorithms.

The sector of Surveying does not contain at the moment, too many activities since high accuracy, previously a specificity of the products of this domain and subject to many R&D activities in the past, is now also being investigated in other sectors, e.g. autonomous vehicle, robotics. The activity included in NAVISP involves the support to the development of a receiver to reach high accuracy and reliability in machine control in forest environment (high masking angle). For this purpose, advanced algorithms, multiple antennas and the integration of GNSS with MEMS is planned.

The Timing and Synchronization sector includes one activity to generate and disseminate UTC Time-as-a-Service (TaaS) to external users based on the use of atomic clocks. Its first user will be the stock market of an important European city. Another supported activity is the development and industrialization of an existing ground clock based on laser cooled atoms (Muclock). The improvements planned to be introduced are expected to allow this clock to compete with the current commercial technologies. Finally, a third activity deals with the development of a timing module to be used in the tools to maintain the power distribution networks. This module will integrate GNSS with eLoran and be able to operate inside substations and underground ducts.

The following figure presents the distribution of funding per PNT sector. Both the total budget of the activities and the total budget considering only the NAVISP funding is considered.

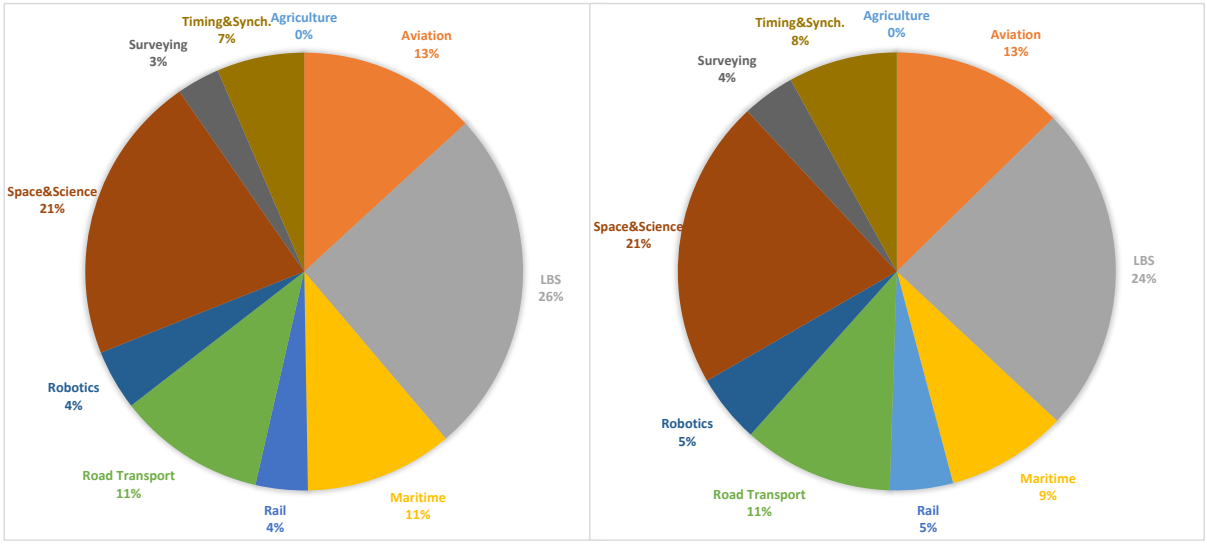

Figure 5: Distribution of Funding per PNT sector. Total (left), NAVISP-only (right)

It can be observed that with the exception of "Agriculture", e.g. precision farming PNT applications, all the PNT sectors received some attention within the Element 2. The predominant sectors are "LBS", "Space &Science", "Aviation" and "Road Transport" which in total concentrate about 70% of the NAVISP budget

The funding distribution picture is largely unaffected by the addition of co-funding. It is to be noted that level of co-funding is related with the type of companies making up the consortia

implementing the activities[1]. Therefore, it is difficult to draw conclusions using the level of co-funding as an indicator of for e.g. the industrial interest in a certain sector, or the level of involvement of SMEs and primes on that sector. The most factual data is that averaging across all the sectors, the level of industry co-funding was 38% which shows the positive effect of the injection of public funding in the overall mobilization of funds for PNT activities.

4.2.2 Funding by Innovation Category

The results of the innovation category analysis are presented in Figure 6.

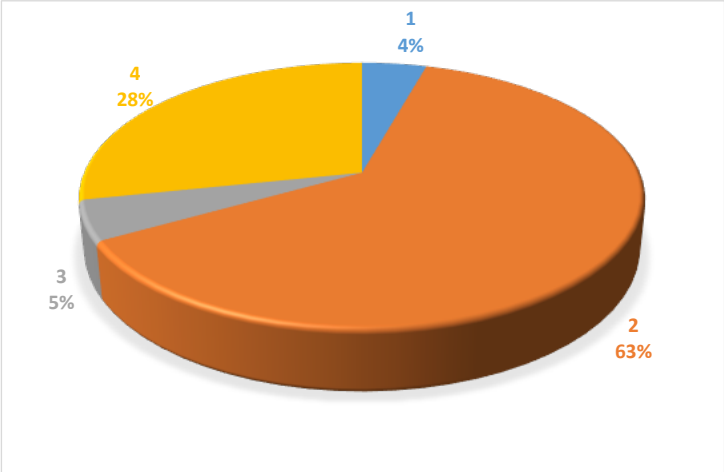

Figure 6: Distribution of Funding per Innovation Category Index

It is observed that the majority of the funding is invested in activities leading to the introduction of a new technology in an existing market (category index 2). It is also noted that the funding in the introduction of an existing technology in a new market is somehow low (5%). The total funding devoted to the introduction of a new technique or technology in an existing or new market is as for Element 1, very high (91%).

4.2.3 Funding by Innovation Category and PNT Sector

In Figure 7 is shown the funding by sector further broken down by innovation category.

It is noted that the sector where more focus has been on a new market or application have been: “Robotics” and “Road Transport” followed by “Space&Science” and “LBS”. On the other hand, the sectors where more focus has been on existing markets or applications have been “Surveying”, “Maritime” and “Aviation” followed by “Timing & Synchronization” and “Rail”.

[1] As per NAVISP Programme regulations, large companies can only be supported up to 50% of the project budget by the Programme while SME’s can be supported up to 80%.

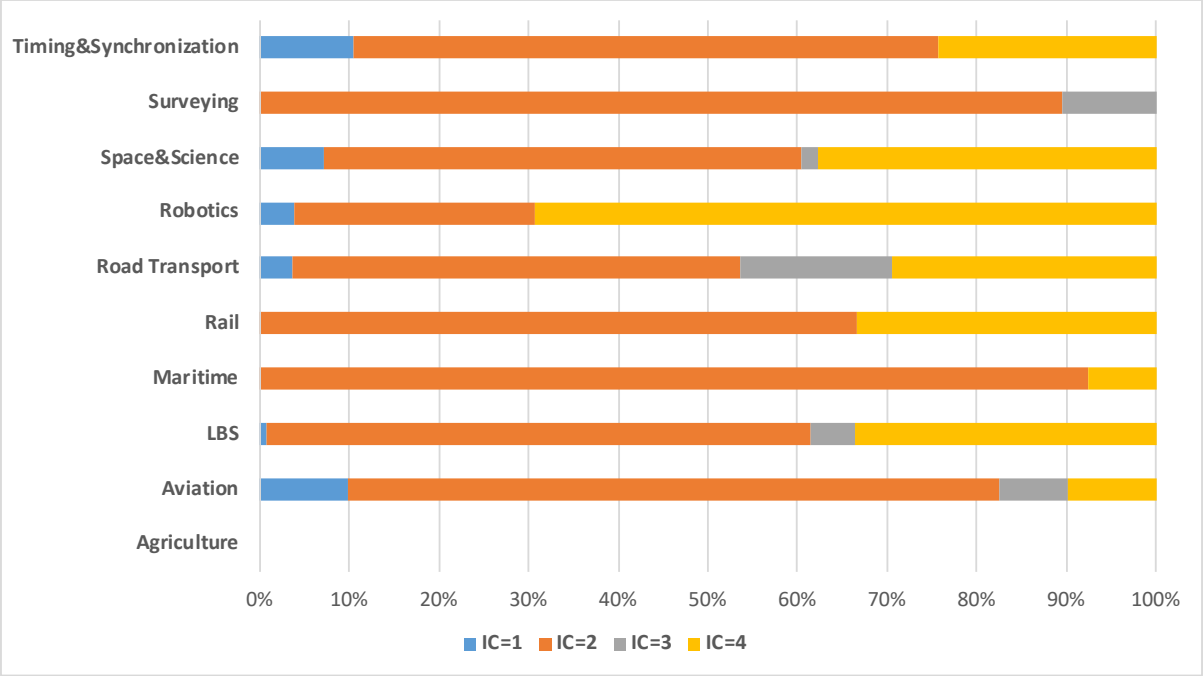

Figure 7: Distribution of Funding per Innovation Category Index and PNT Sector

4.2.4 Funding by Risk Area

The distribution of funding per risk area is presented in Figure 8. It can be observed that the majority of the funding is devoted to reduce the technical risk.

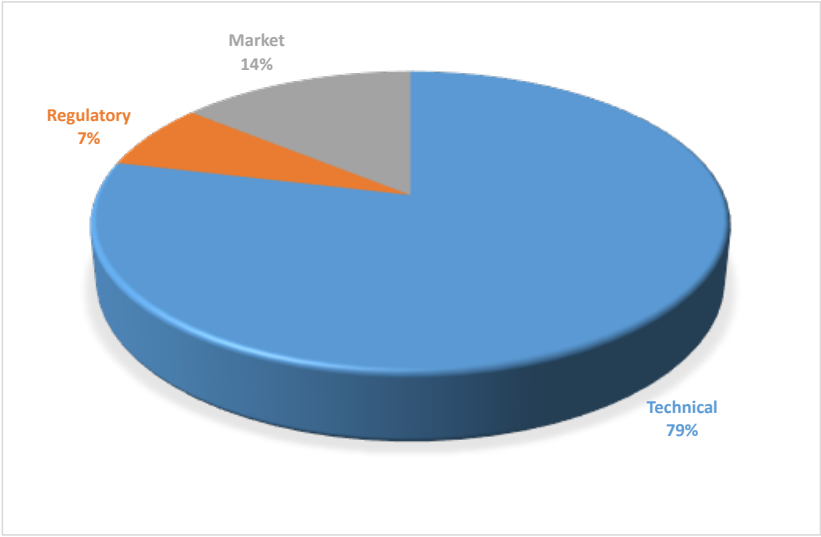

Figure 8: Distribution of Funding per Risk Area

4.3 Element 3

NAVAC members have assessed the contents of the activities contained in the Element 3 against objectives of the Programmne Declaration. In total, 6 activities have been assessed for a budget of 3723 K€.

Two types of activities can be distinguished according to their objectives:

- Activities addressing the topic of PNT resilience, either within a particular domain (maritime, in-land waterway) or in general by making a national survey of the criticality of the topic for all domains, or by developing tools and facilities to detect events impacting PNT resilience (e.g. interference).
- Activities addressing the implementation of test-beds to support the development of PNT solutions in specific domains (maritime, UAV's).

The topic of PNT resilience, concentrates 66% of the budget while 33% is devoted to PNT test-beds. As expected, the resilience of PNT is a topic which appears to rank high on the national priorities, modulated somehow by the relevance of specific PNT sectors for each country.

In quite a number of activities, the consortia are made of a mix of public institutions and private companies which is in-line with the objective of Element 3 to set up the processes to identify and federate institutional demands.

All of the activities are proposed by single countries although aspects addressed, i.e.PNT resilience are of multi-national interest This is further discussed in the section of key findings (Section 7).

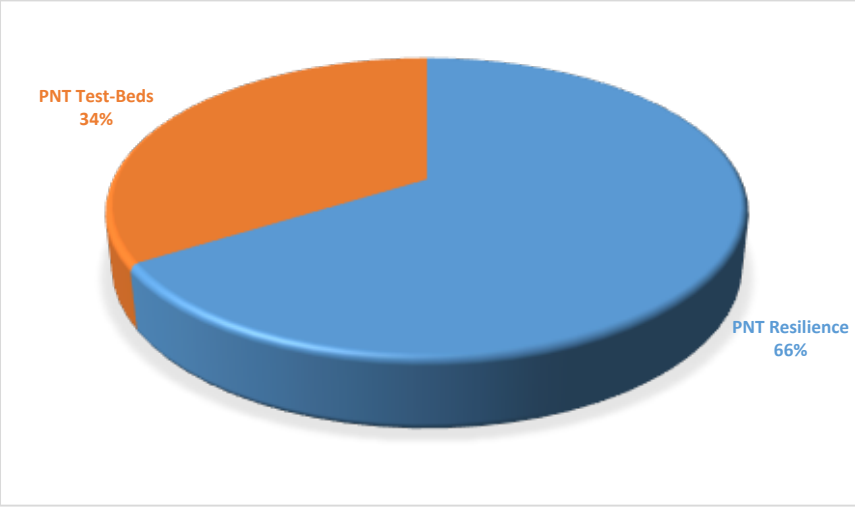

Figure 9: Distribution of Funding in Element 3

5. NAVISP Element 2 Industry Survey

5.1 Overview

Survey: On the 19th of February 2019 a questionnaire aimed at collecting the feedback of the companies participating in NAVISP Element 2 was sent out (see Annex A).

The questionnaire was the basis to derive NAVAC recommendations on possible actions to improve the effectiveness of Element 2 to support the competitiveness of the Industry.

The objectives of the questionnaire were twofold:

- comments/suggestions on the efficiency of the procurement cycle and,
- assessment of the role of Element 2 as a tool to increase the competitiveness of industry.

The survey was addressed to all actors that were part of an on-going NAVISP Element 2 activity at that time, i.e. it was sent to 25 prime contractors and 15 sub-contractors.

Extended Survey: On the 15th of March 2019 the survey was sent to the points of contact of the remaining 22 primes for activities that were not yet contracted, for a total 62 questionnaires sent

In total 20 responses to the survey were received, out of which 16 were primes for on-going activities and the remaining 4 were from primes of not yet on-going activities. Out of the 20 responses, 11 corresponded to SMEs.

5.2 Results

Q1: Overall Assessment of NAVISP Experience

Under this question, the companies were asked to express what was their experience of applying and implementing an activity through NAVISP. The questions were similar to the ones contained in a recent European Investment Bank report (Ref. 9) analyzing the experience of European space companies with public sector financing. The results of the NAVISP and the EIB surveys are reported in
Figure 10. The results are presented in terms of percentage of respondents[2].

[2] In NAVISP, the number of respondents were 20. In the EIB report (Ref.9) the number of companies consulted were 40.

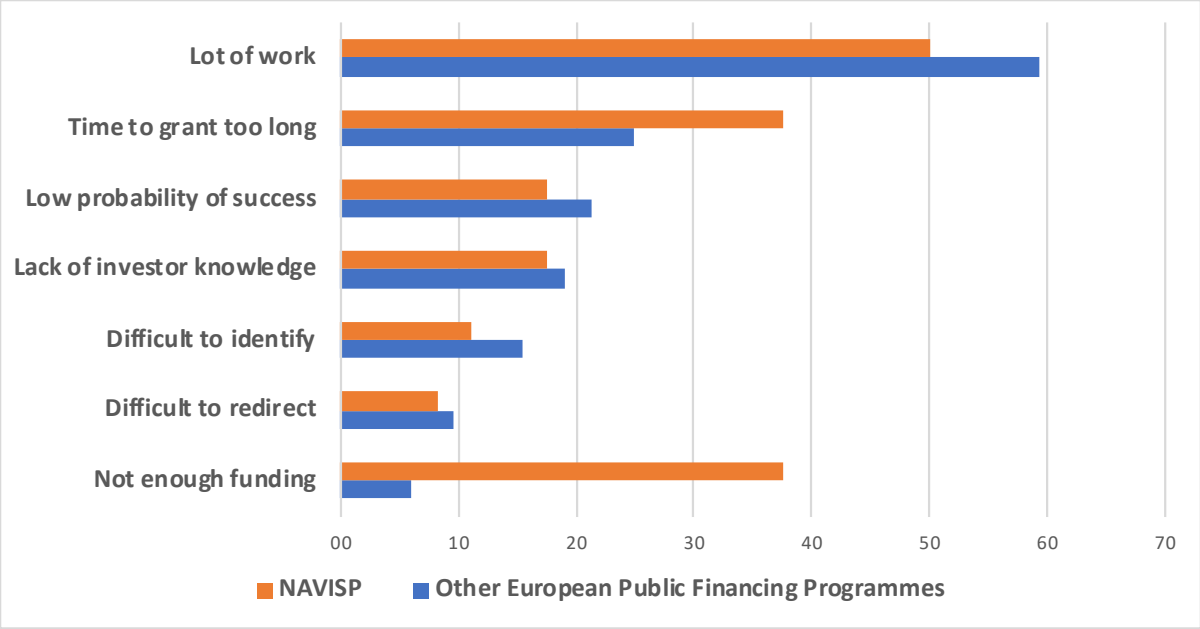

Figure 10: Experiences of Companies with Public Financing Programmes

The most remarkable difference is that the companies participating in NAVISP found funding limitation as a strong source of frustration. This is understandable, since the financing instruments considered in the EIB report included the whole variety of ESA and EC instruments (e.g. H2020 space-related calls) which in general are able to mobilize larger amounts of funding compared to NAVISP. Below a quote from one of the respondents.

> *"I think it is a quite well optimized program. Funding vs.objectives is small, as it is costly to really develop a viable product",*
>
> NAVISP participant

As in the EIB report, the amount of work is also an important element of concern. A remark to be made on this, is that this amount of effort is expected to be related with the preparation of the proposal and the administrative part of preparing the contract. The effort related with the actual implementation of the project cannot appear in the survey yet since most of the activities are just being initiated.

Finally, although one of the objectives of NAVISP is to reduce the time-to-grant, this aspect is still an important source of dissatisfaction for the companies, although as indicated in section 6, the main reason for the delays came from the time it took to the companies to prepare the proposals.

Q2: Procurement Process

Under this point, the companies were asked a number of questions to determine the effectiveness/efficiency of the procurement process. Results are given in Figure 11.

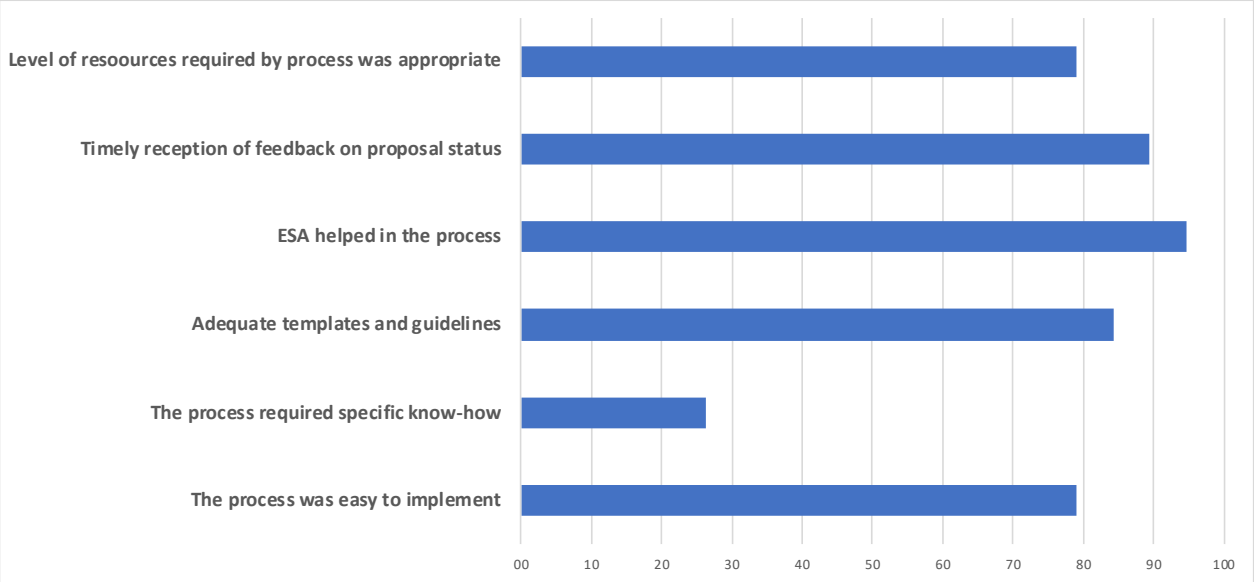

Figure 11: Views (% of Respondents) of NAVISP Participants on Several Aspects of the Procurement Process

Overall, the NAVISP participants appeared to be quite satisfied with the procurement process. However, through some of the quotes of the companies provided with the answer it is perceived that there is still room for improving and simplifying the process even further, even if the help of ESA has been appreciated.

> *"We believe a simplified single volume proposal would fit much better with the agility goal",*
>
> NAVISP participant

The perception above was supported by the answer to Q1, were the companies expressed their concern with the amount of work required to prepare the proposals.

Q3: Contribution to Growth

Under this question, the companies were asked about how the NAVISP activity has contributed to the growth of the company and whether they have hired new employees as a result of the activity.

While, the companies recognized that it was still premature to provide and assessment on this, a number of the quotes received in response to this question were encouraging.

”By covering for the de-risking of a potential key weakness, we strengthen our story line to investors and partners”

"It is a brand new activity to our company not conceivable without such support”

”the activity will be one of the major milestone in our internal programme of commercial product development”

"It gave confidence to new investors"

"It is expected to be an important contribution to our produc offering, and improve our market position significantly”

"starting a new path of the business line"

"It is helping to expand the future capability of our GNSS products which will contribute to future growth of our business”

"We were able to address a completely new market segment”

"To support has helped us to move forward a project that is very important to our future project road-map”

"This activity is fundamental to launch a development line very oriented to product. It allows setting up the process and market approach”

"The NAVISP funding covers the gap between market demands, our current capability and competitor technology”

NAVISP participants

In terms of new employees, out of the 18 companies that provided answers to this question, 11 companies have had to hire new employees as a result of the NAVISP activity

Q4: Risk Mitigation

Under this question, the companies were asked to indicate what was the risk mitigated by the NAVISP activity: technical, market & business or regulatory. The results are presented in Figure 12.

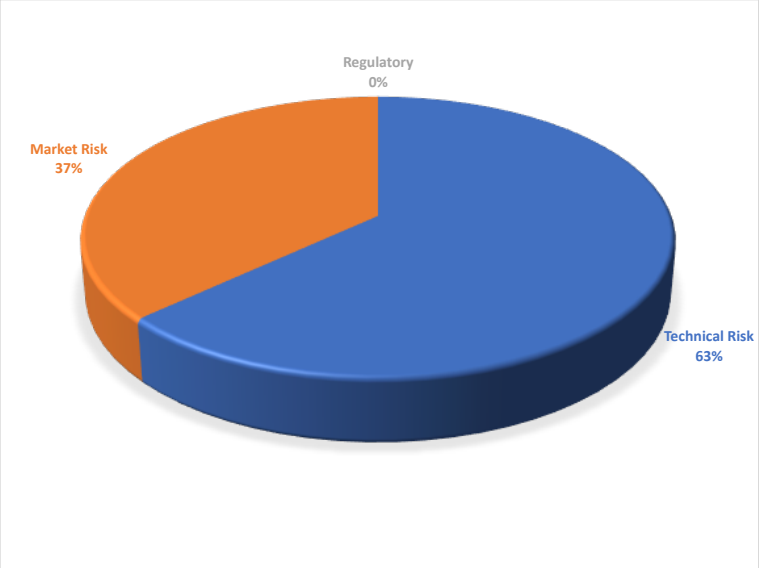

Figure 12: View of NAVISP participants of main risk mitigated in their NAVISP activity

As already identified by the NAVAC members (see Figure 8), NAVISP is considered by a majority of the respondents to the survey as an instrument to reduce the technical risks in the development of their PNT product. Although none of the companies identified the regulatory as the main risk, more than 30% of the companies considered the regulatory as the second main risk being mitigated by NAVISP.

Some of the quotes provided under this question were:

> *"The NAVISP project is contributing through the validation of the industrial process and tools"*
>
> *"We focus the project on technology, so the targeted risk is the technology risk"*
>
> *"The aim is to control the production of an important element of the product"*
>
> *"The NAVISP contribution to reduce risk was the collaboration between companies to address the market"*
>
> NAVISP participants

Q5: Fostering New Entrants

Under this question, the companies were asked whether they were new entrants to the PNT market or to ESA.

A total of 19 projects answered this question: 6 of these projects included new entrants to the PNT market (9 companies) and 8 projects included new entrants to ESA (14 companies).

7 companies were both new entrants to the PNT market and to ESA. The majority of the companies that were new entrants to the PNT market, were also new entrants to ESA (see Figure 13).

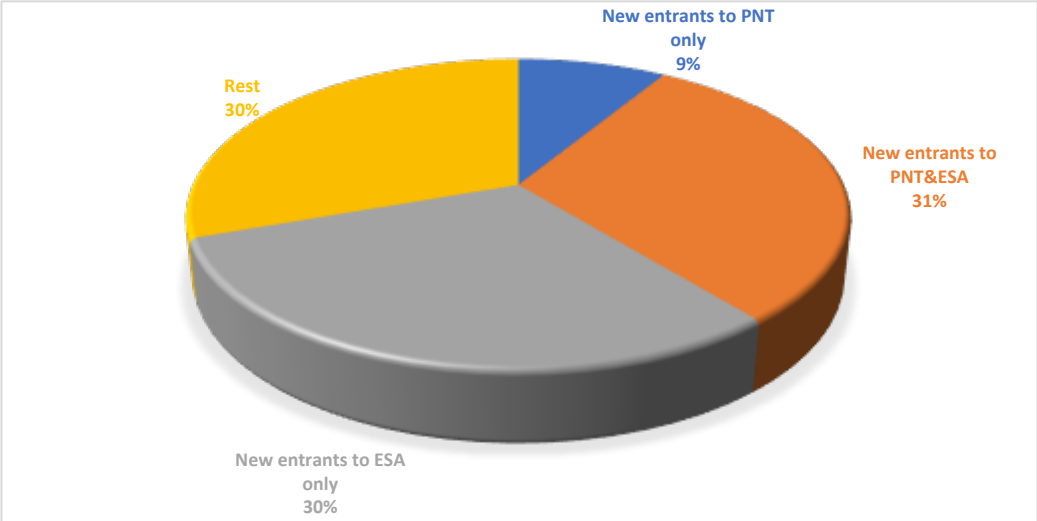

Figure 13: Distribution of New Entrants to PNT/ESA in the Survey

The result above already shows that NAVISP appears to be a good tool to attract new entrants to ESA and even to PNT. However, being aware that it represents only a distribution based on the limited set of companies that answered the survey, the results were further validated with the data available to ESA and corresponding to all the companies.

Regarding newcomers, ESA confirmed that 34 (41%) among all the companies (83 primes and subcos) were involved in ESA projects for the first time, and 16 of those new entrants to ESA, were primes in their projects, that is 34 % of all the primes in the 47 Element 2 activities considered. These two figures, more than 40% of new entrants, close to 35% of primes, are quite significant and confirm the appeal of the Programme and the effectiveness of the promotion and outreach efforts of ESA on NAVISP.

It was also reported by ESA that 11 consortia (23% of the projects) are composed by a complete mixture of public and private entities (large companies/SME/universities and research centers), therefore NAVISP appears to be also, an important instrument in the stimulation of business' networks among the different stakeholders.

Overall, the figures confirm the attractiveness of the Programme for SMEs and newcomers and the facilitation of partnerships among space and non-space actors.

Q6: Overall Assessment of the different ESA supporting tasks

Under this question, the companies were asked to provide their assessment about the utility of different ESA supporting tasks: from technical expertise support to the value of the ESA brand for their product. The results are presented in Figure 14.

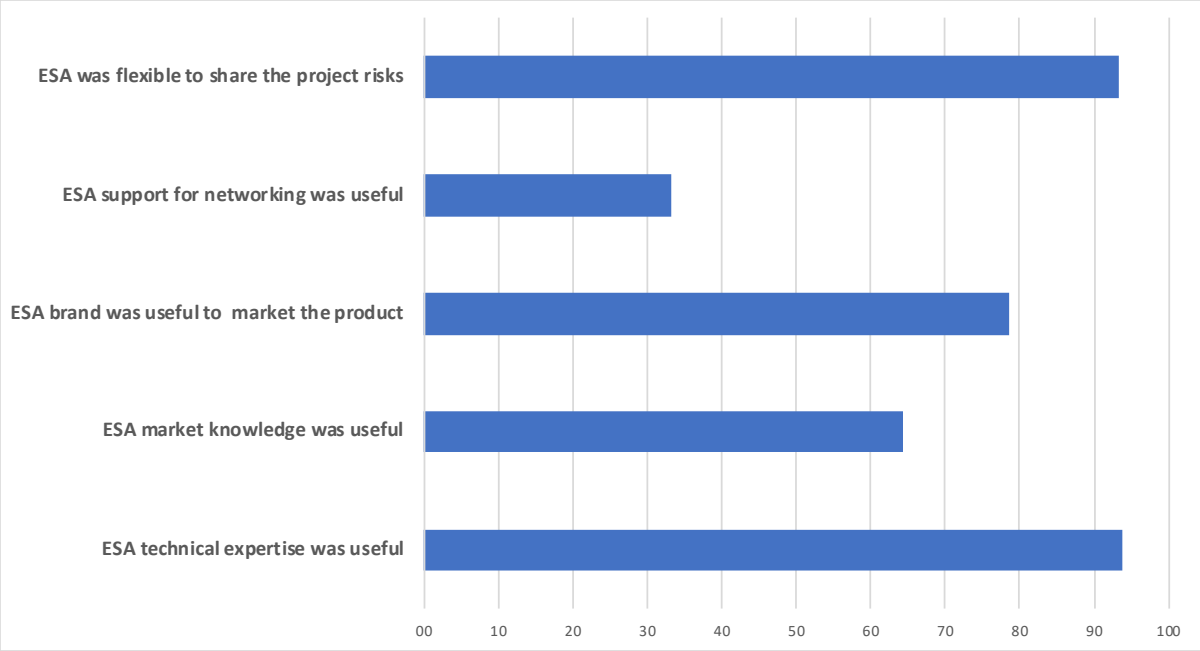

Figure 14: NAVISP Participants view on the various ESA support tasks

The answers showed strong appreciation for ESA technical expertise, flexibility of ESA to share project risks and the association with ESA brand as a value for their product (see quote below).

> *"The award of the NAVIPS contract by ESA brought a huge amount of credibility to this new company which was extremely benefitial when talking to potential business partners and investors".*
>
> NAVISP participant

The support that ESA can provide to network with other companies in the value chain and the ESA market knowledge is appreciated but at a lower level compared to others aspects of the support.

It is however to be noted that a number of companies considered that not all the questions above could be answered since their project was just starting.

6. NAVISP Implementation Efficiency

To complete the assessment of the Programme, ESA NAVISP management provided to NAVAC a detailed briefing on the procurement process with particular focus on the actions taken to monitor the achievement of the programmatic targets.

In particular, the NAVISP Implementing Rules (Ref. 10) stipulate for Element 2 that the duration between the reception of the project Outline Proposal and the award of the contract to Economic Operator should not exceed 4 months.

Due to the different nature of Element 1 and Element 3 in comparison with Element 2, it is understood that a similar target for those elements was not established.

In addition, the NAVISP Programme Declaration (Ref. 1) provides an indicative breakdown of the financial envelope of NAVISP Period 1, assuming a target figure of 15% for the ESA internal costs.

The status of achievement of the above targets is reported in sections 6.1 and 6.2 respectively, as provided by ESA Executive.

6.1 Element 2 Time-to-Award Contract

6.1.1 Element 2 Procurement Process

The tendering process in Element 2 follows a two-step approach:

- Submission of Outline Proposal:
  - after a positive assessment and consultation with the relevant Delegation, ESA will invite the Tenderer to submit a Full Proposal.
- Submission of Full Proposal:
  - after a positive evaluation of the Full Proposal ESA will award the contract to the Tenderer. A prerequisite for the start of the Full Proposal evaluation is the reception by ESA of the Letter of Support signed by the National Delegations of the State the Prime and Sub Contractors belong to.

To monitor and control the above procurement cycle, the overall time from “Outline Proposal to Funds committed” is broken down into four main steps.

- Step 1: Submission of Outline Proposal by Tenderer, assessment by ESA and the relevant Delegation (this step goes from the time of Outline Proposal submission to time when ESA invites Industry to submit the Full Proposal).

Responsibility for the efficiency of this step is shared between Industry (poor quality of the Outline Proposal requiring interaction with ESA for clarifications), ESA (assessment of Outline Proposal) and the relative Delegation (green light to proceed). This step goes from the time of Outline Proposal submission to time when ESA invites Industry to submit the Full Proposal.

- Step 2: Submission of the Full Proposal by Industry (including LoS by Delegation).

  After the consequent authorization to proceed, the Economic Operator is requested to submit the Full Proposal. The responsibility for this step resides in the Economic Operator and the relevant Delegation for the provision of the LoS.

- Step 3: ESA evaluation of the Full Proposal.

  Once the Full Proposal is submitted to ESA together with the LoS, ESA assesses the Full Proposal. This step is fully under ESA responsibility.

- Step 4: Negotiation process and contract award.

  Once evaluation is completed, ESA negotiates with the Economic Operator to award the Contract. Responsibility on this step is shared between ESA and the relative Economic Operator (quality and completeness of the Full Proposal implying interactions before contract award).

To each of the steps above, a target duration was assigned in order to fulfil the overall objective of four months.

These are the following:

- Step 1: 10 calendar days.
- Step 2: 30 calendar days.
- Step 3: 40 calendar days.
- Step 4: 40 calendar days.

The ideal procurement model is provided in the picture below.

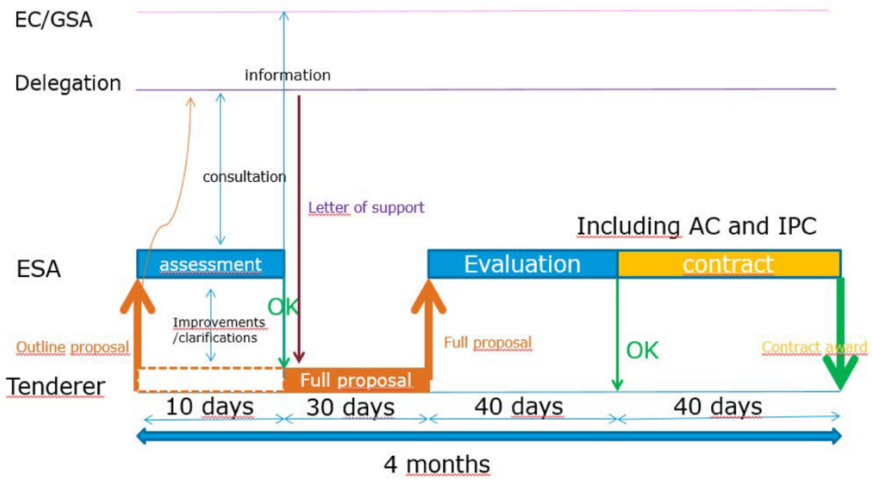

Figure 15: Model of the ideal procurement process

The objective of 4 months is a challenge within ESA environment. The efficiency of the process is impacted by different factors: These are:

- the quality and completeness of the Outline Proposal and the Full Proposal that are prepared on the basis of Guidelines and Templates provided by ESA and that can imply delays for revision/clarification/re-submission,
- the time for the Industry to prepare and submit the Full Proposal,
- the internal procedures at ESA, the availability of persons for the decision meetings (TEB and negotiation meeting),
- the availability of the Letter of Support to be provided by Delegations
- the availability of the persons for the meetings.

Some measures were taken from the beginning of the implementation to design a lean and agile procurement process:

- For the quality of Outline and Full Proposals:
  - Simplified Outline and Full Proposals structure and content with detailed guidelines and templates available on EMITS under CfP AO8927
  - Interaction with Tenderers and Delegation before submission
  - Mail address available for clarifications.
- For ESA procedures:
  - Adoption of the simplified tools available at ESA (ESA STAR, virtual meetings, etc.)
  - Simplification of the IPC papers submission since June 2018.
- For the availability of the persons:

- Optimisation of the planning of TEB (notification by the company 15 days in advance of the date of the intended submission of the Full Proposal), negotiation meetings, etc.

6.1.2 Element 2 Procurement Process KPIs

In accordance to the different steps defined for the Procurement Cycle and with the objective of monitoring and control the actual times of the different activities wrt the model the following Key Performance Indicators have been created and tools put in place to track each action and sub action of the procurement process and measure them.

KPI #1 to measure Step 1:
Calendar days between Outline Proposal reception and ESA feedback to the Tenderer.
Objective: 10 Days

KPI #2 to measure Step 2
Calendar days between ESA feedback to the tenderer and Full Proposal reception (and Letter of Support).
Objective: 30 Days

KPI #3 to measure Step 3
Calendar days between Full Proposal (and Letter of Support) and TEB report.
Objective: 40 days

KPI #4 to measure Step 4
Calendar days between TEB report and contract award.
Objective: 40 Days

KPI #5 to measure overall procurement time
Calendar days between Outline Proposal reception and contract award.
Objective: 120 Days

6.1.3 Element 2 Procurement Process KPIs Results and Analysis

The results and the analysis on KPIs refer to a total of 25 activities which have completed the Procurement Cycle.

For KPI#1, calendar days between Outline Proposal reception and ESA feedback to the Tenderer, the target of 10 days was mostly achieved. The current average is 15.9 days. The existence of a few cases with big deviations from the average is the responsible for which the KPI has not been achieved.

KPI #2, calendar days between ESA feedback to the tenderer and Full Proposal reception (and Letter of Support). The target for this indicator is not met for almost all the Full Proposals received (only 4 of them have met the target). Main reasons not to achieve the target are:

- Long Full Proposal preparation by Industry, despite the recommendation to submit it in 30 days.
- Late availability of the Letter of Support.
- Lack of quality of some of the Full Proposals that need to be resubmitted.

KPI #3, calendar days between Full Proposal reception (and Letter of Support) and TEB meeting. The objective (40 days) is largely met being the average 31.16 days.

KPI #4, calendar days between TEB report and contract award. The objective is achieved except for a few cases, which are the cause of a small deviation from the target (40 days) of the measured average of 48.28 days. Main reasons are:

- The unavailability of the participants to the negotiation meetings, both from ESA and Economic Operators.
- A poor quality of the proposal, which implies number of clarifications issued by ESA and to be responded by Industry before the negotiation meeting.

KPI #5, calendar days between Outline Proposal reception and contract award. Average measured 170.5 days. If KPI #2 is set to 30 days for those proposals that do not meet the objective, the average is 124.3 days.

Overall, the 4 months objective the Procurement cycle is almost met except for the delays in submitting a complete Full Proposal of good quality by Industry. This is reinforced by the positive trend of this KPI since the start of the Programme (Figure 16).

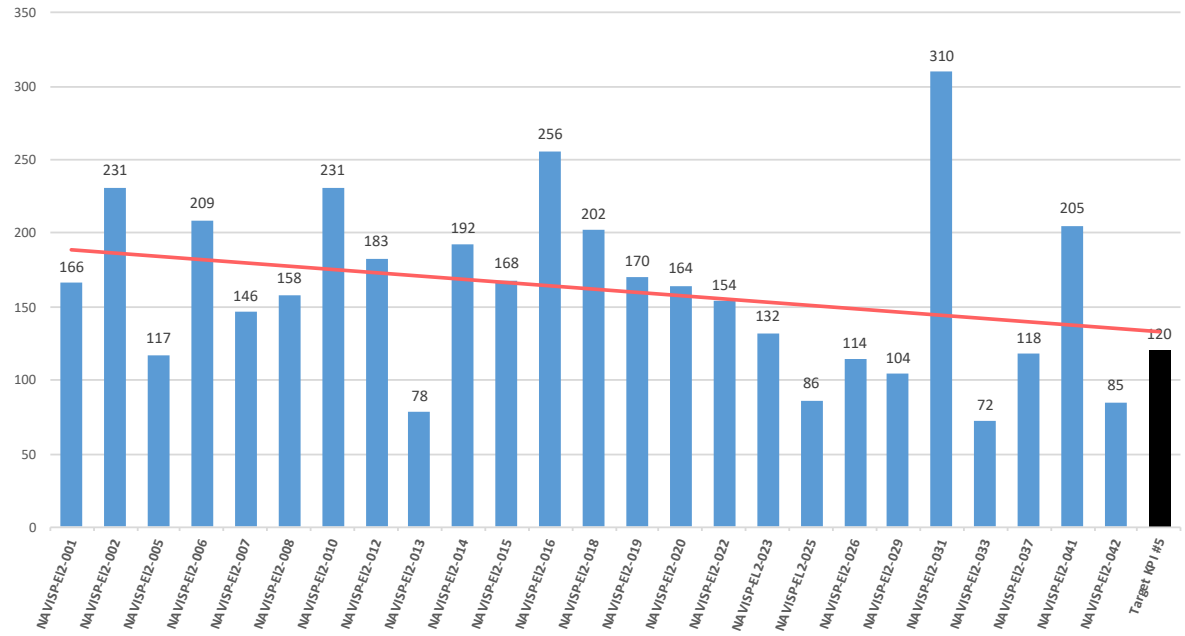

Figure 16: Number of Calendar Days between Outline Proposal Reception and Funds Committed

6.2 NAVISP ESA Internal Costs

Leaving aside small yearly deviations, the internal costs of the Agency are maintained close to the 15% target across the 3 elements of the Programme (Ref. 11). Keeping a very small management team and pulling technical competence from the relevant departments has demonstrated to the be a win-win solution both to keep ESA overhead low and to fully exploit and further develop ESA technical expertise in GNSS and PNT.

Another effort toward efficiency was the simplification of procurement procedures and the use of the available IT instruments (ESA STAR, virtual meetings, …).

The requirements for the project management by the companies were also simplified in order, especially for SMEs, to minimize the administrative burden during the execution of their awarded activities.

7. Key Findings and Recommendations

KF-1: The non-GNSS centric approach of NAVISP is one of its strongest assets and is leading the way to innovation.

A strong point of NAVISP is that it goes beyond the GNSS-centric view and towards more comprehensive real-world navigation issues and developments. During the last decades, the satellite navigation (SatNav) centric view was dominant in the R&D domain. However, we are entering now in a scenario where a fundamental threat on satellite based PNT is visible. This is coming partly from high adjacent band interference from telecommunication and amateur radio systems and other interference sources. Additionally, low-cost jammers (in future low-cost spoofers) are easily available. Therefore, to take this non-GNSS centric approach is essential for a programme supporting navigation innovation to succeed.

This is partially the case for Element 1 activities (innovation), which cover already a wide range of topics which are not purely GNSS-centric. These includes new and alternative navigation concepts and solutions, specific GNSS receiver technology developments and a wide range of space applications. Most of the activities are focused on new technology developments and consequently are falling in very strong innovation categories.

The Element 2 activities (competitiveness) show a good coverage of most of the PNT sectors. Because the primary goal is to boost the development of competitive products, the topics covered are very specific and address real-world PNT issues and developments. Many up-to-date technical challenges and trends in PNT are met, i.e. such as integrity for autonomous driving, interference detection, development of receivers and antennas, high accuracy services. It turns out that the companies who are involved in these activities have a significant interest to make use of the ESA technical expertise in PNT. This fact is correlated with the major interest of industry to mitigate technical risk. Again, beneficial innovation categories of the activities result.

REC-1: To maintain and if possible widen the non-GNSS centric view of NAVISP with the objective to enhance the robustness of the user's position, navigation and time determination.

This could be achieved by:

- Element 1: maintaining a high percentage of the work plan budget devoted to R&D on non-GNSS centric activities.
- Element 2: organizing dedicated calls to non-GNSS centric activities

Examples of non-GNSS centric activities include the development of multi-sensor PNT solutions where GNSS is not the main sensor, e.g. image and terrain-based navigation and in general any activity aiming to mitigate the vulnerability of GNSS to jamming and spoofing.

KF-2: The scope of the Programme is appealing and aligned with industry needs.

The success of Element 1 shows that the ESA vision was closely matched with industry expectations. The pace at which funding contracts have been let further supports the appeal of Element 1. It appears that the Programme is well aligned to industry's interests and needs. It is however noted that the Programme would benefit from participation of a wider number of member states to Element 1 due to the positive effect that this would have on the increase of competition for the tenders of the workplan.

REC-2: ESA to encourage the participation of a wider number of member states to Element 1 due to the positives effect on competition.

The splitting of element 1 and element 2 has given opportunities to those seeking to create new businesses and services as well as those wishing to grow market share or become more competitive. (e.g. more profitable). Both business models are needed to drive innovation. This has broadened the appeal of the funding. Element 3 is also proving to be an element to support effectively national strategies.

The total number of activities incubated (close to 100) in the first two years of the NAVISP Programme and the type of companies participating, shows not only the general appeal of the Programme but also its attractiveness to SMEs. The appeal of the Programme was also visible by the number of people that attended the industry day.

REC-3: To retain the current structure of NAVISP focusing on innovation, competitiveness and national strategies since it fits the general interest and affinities of the stakeholders in the Programme.

Although it was early to assess the potential of Element 1 to generate activities for Element 2 or other industrial initiatives, this should be considered as an important criterion of effectiveness of the Programme in the future.

REC-4: ESA is encouraged to monitor the capability of Element 1 to generate follow-on industrial initiatives in the PNT sector.

KF-3: The Programme has succeeded in putting together a broad portfolio of innovative activities with strong focus on technology push and less than desirable focus on market pull.

The activities undertaken so far within Element 1 fit well the objectives of the Programme. As per Figure 2, roughly half of budget (55%) is geared towards technology innovation, while the rest is evenly split between analysing the feasibility of new PNT concepts, with a lower technology readiness level, and developing demonstrators and proofs of concept, with a

higher TRL. Besides, NAVISP devotes slightly over 80% of the resources within this element to promoting the development of new technologies to address the requirements of either new or existing markets (see Figure 3), while the rest – a mere 18% - is spent in introducing existing technologies in new markets. This is a good balance for an Element that focuses on pushing technology to the market however the application of existing technologies in new markets is also a form of innovation that could receive more attention in the future. In this respect, it does not come as a surprise that most of the risk mitigated by Element 1 are of technical nature (Figure 4); however, Element 1 should possibly pay more attention to mitigating regulatory risks in some areas (e.g. railways or autonomous car), developing solutions in line with emerging standards or stimulating the introduction of new standards. Indeed, dealing with regulatory issues may be crucial to introducing these technologies in the market.

REC-5: ESA to include in Element 1 Workplans more activities aimed to reduce regulatory risk related with the introduction of existing PNT technologies in new markets/domains. Proof-of-Concept or demonstration activities would go in this direction.

In Element 2, a large part of the budget (more than 90%) aims at developing new technologies for either new or existing markets (Figure 6). While innovation content is high, the resulting effect is that most the resources are spent in mitigating technology risks. Only 14% of the funds under this Element go to dealing with markets risks, a surprisingly low level of funding for activities that are supposed to be at a high technology readiness level (or at least higher than for Element 1), and where, consequently, the effort should be spent on covering market and regulatory risks, rather than technical.

REC-6: ESA and participating States to encourage the submission of proposals to Element 2 aiming to reduce market risks by strengthening the requirements on industrial/product maturity of the outputs of the activities.

It appears that both in Element 1 and Element 2 there has been an assumption "in the market"[3] that ESA funding is for reducing technical risk, not regulatory nor market risks. Creating a specific element/call would test the market for such funding.

REC-7: To stress in the various outreach actions of ESA on the Programme, the opportunities that NAVISP offers to reduce market and regulatory risks and not only technical risks.

KF-4: Phase 1 of the Programme has succeeded in addressing a broad variety of PNT sectors but effort is not fully coherent with the European industry market positions.

The spread of the activities undertaken during this first Phase of the Programme can be considered as extremely successful, both because ESA has managed to capture the interest

[3] Here the term "market" refers to the community of ESA initiators of Element 1 ITT's and companies submitting proposals for Element 2.

of almost every application sector from the outset and because of the balance of the funding, that has reached most of the relevant sectors.

As concerns the distribution of budget among the different PNT application sectors, there is a clear divergence between the funding requests from the industry to NAVISP and the actual market share of the European industry in the different sectors of application. As shown in Table 1 below, the European integrators dominate the agriculture and surveying segments of the market. However, only 4% of the projects within Element 2 have to do with surveying, and not a single project has been funded for agricultural applications.

	Component manufacturers (Europe: 20%)			System integrators (Europe: 27%)		
	Europe*	North America	Asia+Russia	Europe*	North America	Asia+Russia
	6%	61%	33%	4%	36%	60%
	51%	23%	27%	30%	21%	48%
	25%	65%	10%	23%	76%	1%
	31%	46%	23%	33%	14%	53%
	43%	9%	47%	**37%**	37%	26%
	6%	63%	31%	**42%**	39%	19%
	36%	40%	24%	**37%**	34%	29%

Table 1: European industry market share in the GNSS market by application sector (Ref.8)

A potential explanation could lay in the fact that European suppliers feel comfortable with their position in these niches and prefer to concentrate their effort in catching up in other areas. But this would lead to higher requests for funding in areas like LBS or aviation, where the European industry lags behind their international competitors. This is certainly the case, but not with such intensity as to provide a suitable explanation to the distribution of the activities: LBS take a mere 24% of the funding, and aviation just 13%, fairly close to the 11% that goes to road applications where the European industry has also a competitive edge.

The apparent mismatch between the allocation of funding in the Element 2 of the Programme and the market position of the European industry in the GNSS downstream market might be due to the failure of the Programme to reach key players outside the space industry. It is self-evident that the level of awareness within the space industry about NAVISP is higher than for other application sectors; that is probably why space and science funding requests amount to 21% of the budget, while other areas – with a much larger market potential, like road applications or LBS – take a much smaller share of the funding. Another possible cause could have been the reluctance of key players to expose their IPR to ESA by participating in the Programme.

REC-8: ESA and the participating States are encouraged to discuss with non-space European key players in the GNSS/PNT markets in order to understand how to make the Programme more appealing to their participation.

In addition, to cover the current gap of activities in the sector of agriculture, the following recommendation is made:

REC-9: To organize within Element 2 a dedicated call addressed to specific PNT sectors currently underrepresented or of strategic significance.

KF-5: Exploration of new markets in Element 2 can be further enhanced

The funding allocated within Element 2 (Figure 6 and Figure 7) goes mainly to existing markets; innovation categories 1 and 2 take 67% of the total funding. Exploring new markets only receive one third of the budget and actually very few effort (5%) is devoted to explore new markets with existing technologies. This explains why most of the budget (79% as per Figure 8) focus on reducing or mitigating technology risks rather than market or regulatory risks. Addressing new markets should be an important objective for the next phase of the Programme since there may be hidden opportunities in new markets which significant contributions to growth.

The recommendation here is complementary to REC-5 but with more emphasis on the new markets.

REC-10: To encourage the exploration of new markets in Element 2 by organizing a dedicated call addressing the introduction of existing PNT technologies in new markets.

KF-6: The Programme has fostered the participation of new SME entrants, and business networks, however engaging large non-space primes is still a challenge.

As it is to be expected most of the companies and institutes currently involved in the NAVISP activities are the well-known players in satellite navigation and PNT. A few prime space companies like Thales, Airbus and GMV are active. However, the majority of the actors belong to the SME league. In particular for Element 2, 55% of the companies are SME's and 60% of the projects are led by SMEs. As a matter of fact, more than 40% of the companies are actually new entrants and close to 35% of the project are also led by those new entrants. On the other hand, 23 % of the projects are executed by consortia involving a mix of large companies, SME's, universities and research organizations.

The above numbers are all very impressive figures and confirm the attractiveness of the Programme for SMEs and newcomers as well as the role that it plays on the facilitation of partnerships among space and non-space actors.

One remaining issue however is how to motivate the participation of very relevant non-space primes in the Programme, e.g. Robert Bosch GmbH who is doing the development of a high-precision high integrity navigation system for autonomous driving.

The need to discuss with the European key players in the GNSS/PNT markets was already identified under REC-7. The recommendation here places more focus on the need to discuss with system integrators (primes) that are entering in the PNT market. In both cases, the emphasis is in companies outside the space sector and therefore not likely to be aware of the opportunities being offered by NAVISP.

REC-11: ESA and the Participating States are encouraged to discuss with system integrators (primes) that are entering in the PNT market but whose primary business is not space related, about the opportunities that NAVISP may offer to their activities.

KF-7: The management objectives of the Programme have been broadly met contributing to a positive reception by industry and a further appetite for simplification of administrative procedures.

The European industry involved in Element 2 seems to be highly satisfied with the operation of NAVISP. The main complains have to do with the amount of work required to obtain the funding and with the level of funding available (
Figure 10). As concerns the first, this complain is common with other national or international research programmes. Actually, the percentage of questionnaire respondents complaining about the amount of work required to complete the process of answering the call for proposals and negotiating the contracts is lower (roughly 50%) than for other European programs (60%). Nevertheless, the complains about the availability of funds for the program are significantly higher than for other European programs; in fact, almost 40% of the respondents consider that there is not enough funding to address the objectives of Element 2. This is possibly due to the trend among the Member States to spread their contribution over as many local companies as possible, avoiding to concentrate their funds over a limited range of activities. While this is understandable from the national standpoint, it limits the effectiveness of the Programme at European level.

REC-12: Participating States to Element 2 are encouraged to consider to increase the budget per activity in order to increase the effectiveness of the public investment allowing projects to arrive to more mature outputs from the industrial product point of view.

ESA has made a great job in reducing the time required to process the industry proposals. Unfortunately, this effort has not always been complemented by the time taken by industry and national delegations. There have been some occasions where the time required to prepare the full proposals and to obtain the required letter of support from the Member States has taken longer than expected. This is a source of frustration for all parties involved.

REC-13: ESA to consider the inclusion of mechanisms in the current Element 2 procurement process allowing to better control the time taken by companies to prepare full proposals and the time to obtain the required letter of support.

ESA support was highly valued by the participating companies (Figure 14), especially as concerns its flexibility to share risks with the industry and its technical support. However, ESA's support for networking ranked low in the view of the participants. Industry events, as the one organised in January 2019 or local events at the Member States, may eventually help to increase the effectiveness of this support. This is also paramount to getting more new entrants trying to get involved in the Programme.

REC-14: ESA is encouraged to continue its networking efforts and in particular the regular organization of NAVISP industry days were stakeholders in the programme could meet and share experiences and results.

ESA's has also managed to meet the target of an overhead under 15%, while still achieving the Programme objectives. The main risks of such a low overhead were the limited amount of effort available for the process of identification and definition of the workplans for Element 1 and the preparation of the related statement of works as well as for the assessment of industry's proposals within the target timeframe set for Element 2. Both risks have been properly dealt with, considering the pace of deployment of Element 1 and the assessment of the implementation efficiency of Element 2.

Some criticism is however possible as concerns the time required to kick-off and implement a new project within Element 2: some of the segments in the downstream market may demand much shorter time frames. For instance, the typical time scale for introducing a new LBS service for the consumer market is in the other of months rather than years; four months could be too much to reach the market on time for accepting the proposal for a new application, let alone the additional time required for its development. Some additional effort would still be required from all parties to shorten still further the proposal processing time.

REC-15: ESA to consider, within the limits of due diligence, further simplification of the procurement process to allow reducing even further the time required to place contacts in Element 2, in particular, for those activities where the main focus is to reduce the market risk.

KF-8: Element 3 has been an adequate mechanism to accommodate activities of national interest in a wider multi-national programme. This opens opportunities for cross-fertilization between activities.

Element 3 of NAVISP was proposed as a vehicle to include activities of national interest in a multi-national programme. It has been encouraging to see that participating states have taken this opportunity and a number of activities are already being implemented. This allows to address broader PNT issues (e.g. PNT resilience) from the realities of different countries, which is certainly contributing to enrich the Programme.

The opportunity is therefore there to encourage cross-fertilization between activities with similar objectives in order to optimize solutions, coordinate standardization and interoperability, promote user acceptance and to take stock of lessons learnt. If this opportunity is exploited adequately, Element 3 has the potential to be a very significant achievement of the Programme.

REC-16: ESA is encouraged to promote cross-fertilization among Element 3 activities by for example, organizing workshops on common topics.

8. Conclusions

Initiated in 2017, the NAVISP program has progressed well and has good, growing momentum. The available budgets for Elements 1, 2 and 3 appear well spread over a significant number of activities, which, given the focus on innovative concepts, hold the potential to result in sustainable economic activities, strengthening the competitive position of the Participating States' industry in the world PNT market.

Innovative concepts inevitably carry a variety of risks, and it appears that the NAVISP focus on innovative ideas is effectively well present in a large majority of the projects, with more than three quarters of all projects dealing with the introduction of new technologies and reduction of technical risk.

For these two reasons – momentum and a solid focus on novel technologies- the NAVISP program has taken a strong start, which justifies continuing and if possible expanding the program beyond 2019.

This report has presented the findings of NAVAC in assessing the effectiveness of the first phase of the programme covering roughly the first three years of the programme (2017-2019). The assessment has resulted in a total of 8 major key findings and 15 recommendations.

The key findings broadly confirm that the initial ambitions of the Programme are being realized. Areas for improvement have been also identified, namely to reinforce the addressment of new markets, to encourage more activities aiming to reduce market and regulatory risks, to involve in the programme the key European non-space PNT system integrators, to further stream-line procurement processes and to encourage cross-fertilization across national projects.

The recommendations are addressed both to ESA and the NAVISP participating states and include advice on prioritization of activities in terms of scope and budget, continuing the outreach efforts with special focus on the areas for improvement, further simplify the procurement process and use Element 3 as a forum to exchange common experiences across national projects.

In summary, NAVAC has concluded that NAVISP is a successful and valuable instrument for enhancing the competitiveness of the European industry in the PNT area. We strongly encourage the Member States to contribute to all the elements of the programme and to increase its economic envelope and to take full advantage of the agility and flexibility that it offers to achieve their national objectives.

References

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5) "Addendum to NAVISP Element 1 Workplan for 2018", ESA/PB-NAV(2018)15, 17 April 2018
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10) "Implementing Rules for the Navigation Innovation and Support Programme (NAVISP)", ESA/C(2016)128
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Annex A: NAVISP Element 2 Participant Questionnaire

Q1. Overall Assessment of your experience with NAVISP

In a scale of 1 (High) to Low (7), what were the most frustrating aspects you have found in your NAVISP activity:

It required lot of work	
The time to start the activity was long	
The probability of success for the NAVISP application was lower than in other programmes	
The knowledge of ESA of the project was low	
It was difficulty to identify the adequacy of NAVISP to my project	
It was difficult to redirect the project mid-way	
There was not enough funding	

Other. Please specify:

Q2. Procurement Process

How was the procurement process adapted to your company profile?

	Yes	**No**
The process was easy to implement		
The process was cumbersome and required some specific know-how		
Templates and guidelines for the preparation of the full proposal were adequate		
ESA Executive was supportive and helped to understand the process		
We received timely feedback of the status of our proposal		
The level of resources required by the process was appropriate		

Other, i.e. which areas of the process would you improve? (please specify)

Q3. Contribution to Growth

Have you hired any new employees to develop this activity (or to replace the resources that you are devoting to this activity)? If so, how many?

Please detail on which other way, the activity has contributed to the growth of your company.

Q4. Risk Mitigation

One of the main objectives of the Element 2 of the NAVISP Programme is to reduce the risk to your company in the introduction of PNT products or services. Please enter "1" for the highest risk mitigated through this activity and "2" for the next highest risk.

(1) <u>Technology Risk:</u> Related to technology readiness, ability to deliver the targeted performance, long-term ability to compete with other suppliers	
(2) <u>Market and Business Risk:</u> Related to the uncertainty of commercial success of the technology or business model.	
(3) <u>Regulatory:</u> Related with the difficulty in developing products or services by market regulatory barriers or dominant position of incumbent suppliers.	

Please detail on which other way (if any), the activity has contributed to reduce the risk.

Q5: Fostering New Entrants

One of the objectives of the NAVISP Programme is to foster the emergence of new entrants onto the PNT market and/or ESA.

If relevant to your activity, please indicate:

How many companies in your activity (including yourself) are new entrants to the PNT market?	
How many of those companies (including yourself) are new entrants to ESA?	

If applicable, what was the reason for involving a new entrant on PNT or to ESA in the activity?

Q6. Provide your overall assessment about the different ESA supporting aspects

	Yes	**No**
ESA technical expertise was useful		
ESA market knowledge or value chain knowledge was useful		
ESA brand was useful to market the product/technology		
ESA support in networking with other companies up or downstream in the value chain was useful		
ESA was flexible to share the project risks		

In a scale of 1 (High) to Low (7), please rank the usefulness of the ESA support:

ESA technical expertise was useful	
ESA market knowledge or value chain knowledge was useful	
ESA brand was useful to market the product/technology	
ESA support in networking with other companies up or downstream in the value chain was useful	
ESA was flexible to share the project risks	

Other comments:

Annex B: List of Key Findings

ID	Key Finding
1	The non-GNSS centric approach of NAVISP is one of its strongest assets and is leading the way to innovation.
2	The scope of the Programme is appealing and aligned with industry needs.
3	The Programme has succeeded in putting together a broad portfolio of innovative activities with strong focus on technology push and less than desirable focus on market pull.
4	Phase 1 of the Programme has succeeded in addressing a broad variety of PNT sectors but effort is not fully coherent with the European industry market positions.
5	Exploration of new markets in Element 2 can be further enhanced.
6	The Programme has fostered the participation of new SME entrants, and business networks, however engaging large non-space primes is still a challenge.
7	The management objectives of the Programme have been broadly met contributing to a positive reception by industry and a further appetite for simplification of administrative procedures.
8	Element 3 has been an adequate mechanism to accommodate activities of national interest in a wider multi-national programme. This opens opportunities for cross-fertilization between activities.

Table 2: List of Key Findings

Annex C: List of Recommendations

ID	Recommendation
1	To maintain and if possible widen the non-GNSS centric view of NAVISP with the objective to enhance the robustness of the user's position, navigation and time determination. This could be achieved by: • Element 1: maintaining a high percentage of the work plan budget devoted to R&D on non-GNSS centric activities. • Element 2: organizing dedicated calls to non-GNSS centric activities Examples of non-GNSS centric activities include the development of multi-sensor PNT solutions where GNSS is not the main sensor, e.g. image and terrain-based navigation and in general any activity aiming to mitigate the vulnerability of GNSS to jamming and spoofing.
2	ESA to encourage the participation of a wider number of member states to Element 1 due to the positives effect on competition.
3	To retain the current structure of NAVISP focusing on innovation, competitiveness and national strategies since it fits the general interest and affinities of the stakeholders in the Programme.
4	ESA is encouraged to monitor the capability of Element 1 to generate follow-on industrial initiatives in the PNT sector.
5	ESA to include in Element 1 Workplans more activities aimed to reduce regulatory risk related with the introduction of existing PNT technologies in new markets/domains. Proof-of-Concept or demonstration activities would go in this direction
6	ESA and participating states to encourage the submission of proposals to Element 2 aiming to reduce market risks by strengthening the requirements on industrial/product maturity of the outputs of the activities.
7	To stress in the various outreach actions of ESA on the Programme, the opportunities that NAVISP offers to reduce market and regulatory risks and not only technical risks.
8	ESA and the participating States are encouraged to discuss with non-space European key players in the GNSS/PNT markets in order to understand how to make the Programme more appealing to their participation.
9	To organize within Element 2 a dedicated call addressed to specific PNT sectors currently underrepresented or of strategic significance.
10	To encourage the exploration of new markets in Element 2 by organizing a dedicated call addressing the introduction of existing PNT technologies in new markets.
11	ESA and the participating States are encouraged to discuss with system integrators (primes) that are entering in the PNT market but whose primary business is not space related, about the opportunities that NAVISP may offer to their activities.

12	Participating States to Element 2 are encouraged to consider to increase the budget per activity in order to increase the effectiveness of the public investment allowing projects to arrive to more mature outputs from the industrial product point of view.
13	ESA to consider the inclusion of mechanisms in the Element 2 current procurement process allowing to better control the time taken by companies to prepare full proposals and the time to obtain the required letter of support.
14	ESA is encouraged to continue its networking efforts and in particular the regular organization of NAVISP industry days were stakeholder in the Programme could meet and share experiences and results.
15	ESA to consider, within the limits of due diligence, further simplification of the procurement process to allow reducing even further the time required to place contacts in Element 2, in particular, for those activities where the main focus is to reduce the market risk.
16	ESA is encouraged to promote cross-fertilization among Element 3 activities by for example, organizing workshops on common topics.

Table 3: List of Recommendations

European Space Agency