

“How to ... Lessons Learned - a Space Sector Study of Best Practice”

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Abstract: The European Space Agency is a learning organisation committed to gathering experience from its projects and activities as they progress. In setting out its internal processes and means for Lessons Learned in 2017, the Agency took reference of previous best practice of lessons learned available at that time, both from within and outside of the space sector. Now some 6 years later, the Agency is seeking to both continue to learn from others, particularly those in the space sector, and to provide its experience and expertise gained in this area to others in the space domain. The collection of experience and hence lessons include gathering experiences from other organisation through lessons learned, the exchange of experience between the Agency and other organisations and the collaboration and exchange of state-of-the-art approaches to lessons learned means and process. This is needed as the full adoption to experience sharing and learning is not simply a process change (the way we do things – climate), but also one of culture (our belief set, reinforcing why we do things). In this it is recognised that “the hard stuff is easy, and the soft stuff is hard” – meaning that building tools and documenting the process is the easy part, getting the adoption and use, and the belief that it is beneficial is the harder part. Indeed, investment in tools is generally short term, but the investment in people to create a shift in organisational culture takes much more time. This paper will take a fresh and broad look at lessons learned in the space sector, identify best practices, by gathering data from around a dozen significant space players: space agencies, major space industry and new space entities. It will then present the findings and propose the next steps, both for the European Space Agency, but also for others in the space sector to consider applying within their own organisations.

Keywords: Space sector, Lessons learned, Best practice, Culture, and Climate change

1. Introduction

The European Space Agency is a learning organisation* committed to gathering experience from its projects and activities. In setting out its internal processes and means for Lessons Learned in 2017, the Agency took reference of established lessons learned best practice available at that time, both from within and outside of the space sector.

Learning Organisation: An organization that emphasises learning that expands the skills of its employees to achieve the development of new organisational capabilities in response to evolving stakeholder needs and market-place demands (ESA 2022).

Now some 6 years later, the Agency is seeking to both continue to learn from others, particularly those in the space sector, and to provide its experience and expertise gained in this area to others in the space domain. The collection of experience and hence lessons include gathering experiences from other organisation through lessons learned, the exchange of experience between the Agency and other organisations in line with Agenda 2025 (ESA 2021) and the collaboration and exchange of state-of-the-art approaches to lessons learned means and process.

Lessons learned (LL) at ESA provides for the capture and exchange of experience from the projects and activities of the Agency, established at the corporate level through the creation of a dedicated framework (policy and process documentation), dedicated capture means and a central web-based tool. The lesson learned capability has become the “way of working” for the Agency with Directorates (of which there are 11 in the Agency) either moving to or assuring process and content compatibility with corporate process. The prime focus on achieving systematic learning outcome, is achieved through learning actions set to update or create generic or corporate processes, products, or training. In turn this has assured the lessons learned process has achieved learning at the point of use, and minimised the learning only being retained within the (now) established Lessons Learned portal.

Whilst what the Agency has established works well at ESA and continues to gather an increased level of support and participation, it cannot be assumed that this approach would work for other Agencies, or for Industry working together with the Agency, or performing the same tasks. In wanting to better understand what is considered best practice, or for those who have no experience in lessons learned, then what are the learning needs of these organisations, ESA has conducted a survey of Space Agencies and Industry. This paper reports on the outcomes of this survey, to establish what is regarded as lessons learned best practice and assess whether the Agency is best placed to share its methods and means with these organisations.

2. Research Design

The research design took the form of a survey (i.e., questionnaire) for the data gathering, sent to 2 main target groups, space industry and space agencies. As the European Space Agency, the questionnaire was focussed on industry from ESA member states countries, both the Lead Space Integrators (LSIs - large space industrial organisations, typically European multinationals), and also medium and small-sized enterprises (known as “MidCaps” and “SME’s”). As ESA has established connections with industry over the past 50 years, it was possible to use an existing network including more than 800 LSI’s, MidCaps and SME’s. For the Agencies, a survey was sent to each ESA member states with an established space agency (which amounted to 6 member states). The survey was modified slightly between the two types of groups (agency and industry), however only to the degree that the question remained relevant to that organisation, whereas the responses remained mostly the same. In this way both approaches were designed and intended to provide data to allow for cross comparison between the two target groups, to highlight similarities and differences in best practice.

Questionnaire design

The survey was designed with specific intent and covered the following data gathering need; for each of these an insight into the selection and purpose of each question topic is provided (and this relates to both Industry and Space Agency. The length of the questionnaire was limited by completion time, and this was limited to and tested to being approximately 15 minutes.

- Do you consider your organisation as a learning organisation?
 - It was important to have a comparable indicator of the perception of the individual of their organisations approach to learning from experience. Whilst this question is subjective, it is important to establish your culture and climate regarding learning – which is the fundamental basis of lessons learned. The open questions allow you to provide us some insight in to the way you think and act in your organisation in the area of learning, and provides us your unique perspective of how you view and implement this.
- Please indicate the level of priority, difficulty and benefit for the following aspects (people, process, technology and organisation) for successful Lessons Learned in an organisation
 - When implementing change in an organisation, “best practice” states that you should consider the aspects of “people, process and technology”. These are needed to assure the desired change (in the case of lessons learned an improved learning from experience) is embedded in the everyday work of an organisation. In understanding the industry perspective, on the importance of these issue and the challenges and benefits associated with them, the Agency can then focus its efforts on what is perceived as important by industry. In addition, it has been proposed that the organisation itself also directly impacts successful change implementation, and hence this is also included over and above the three establish criteria from change management theory.
- Please indicate the level of importance of the pre-requisites for establishing Lessons Learned in your organisation
 - When establishing a change within an organisation, it is important to consider what needs to already be in place in order to promote the adoption of the change applied. Results of a previous ESA research activity (Herd 2022) as given in Figure1, determined a number of key prerequisites that were needed when implementing lessons learned at the Agency as a vehicle for change in learning from experience. Recognising that industry and the Agency are somewhat different in structure and business goals, it was important to test the Agency’s best practice against the perceptions of industry to establish any similarities or differences in these 6 key areas.
 - *Identify key stakeholders*
 - *Communication means*
 - *Training means*
 - *Process for publishing documents*
 - *Technology / Infrastructure (IT and Tools)*
 - *Predefined terminology*

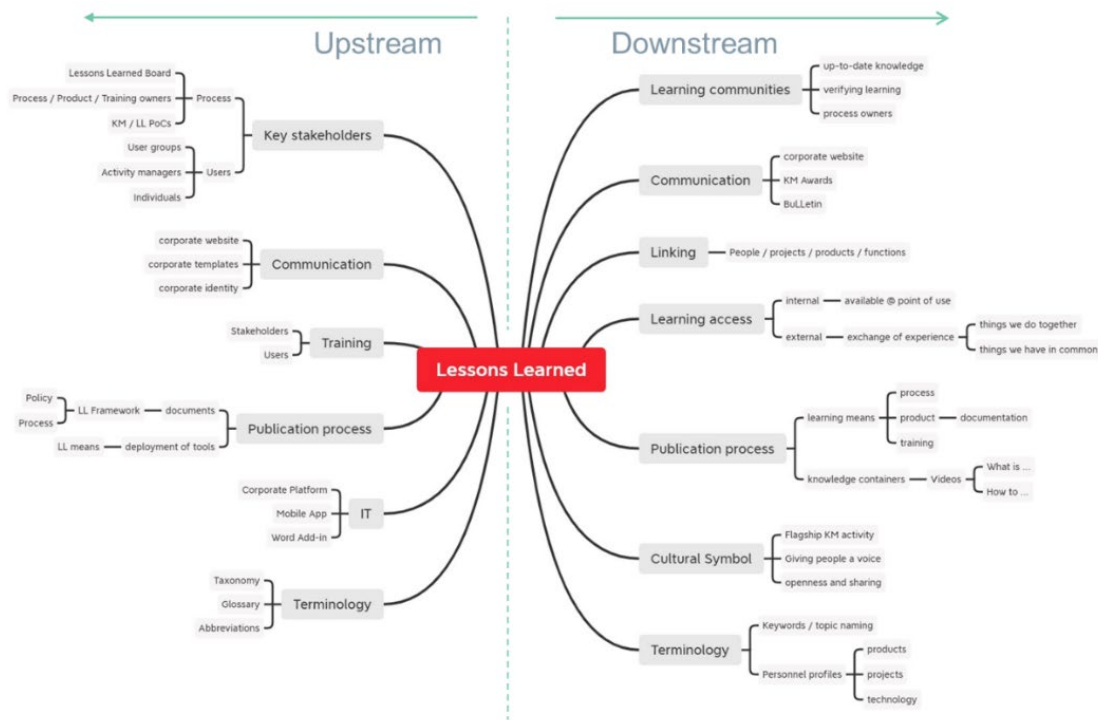


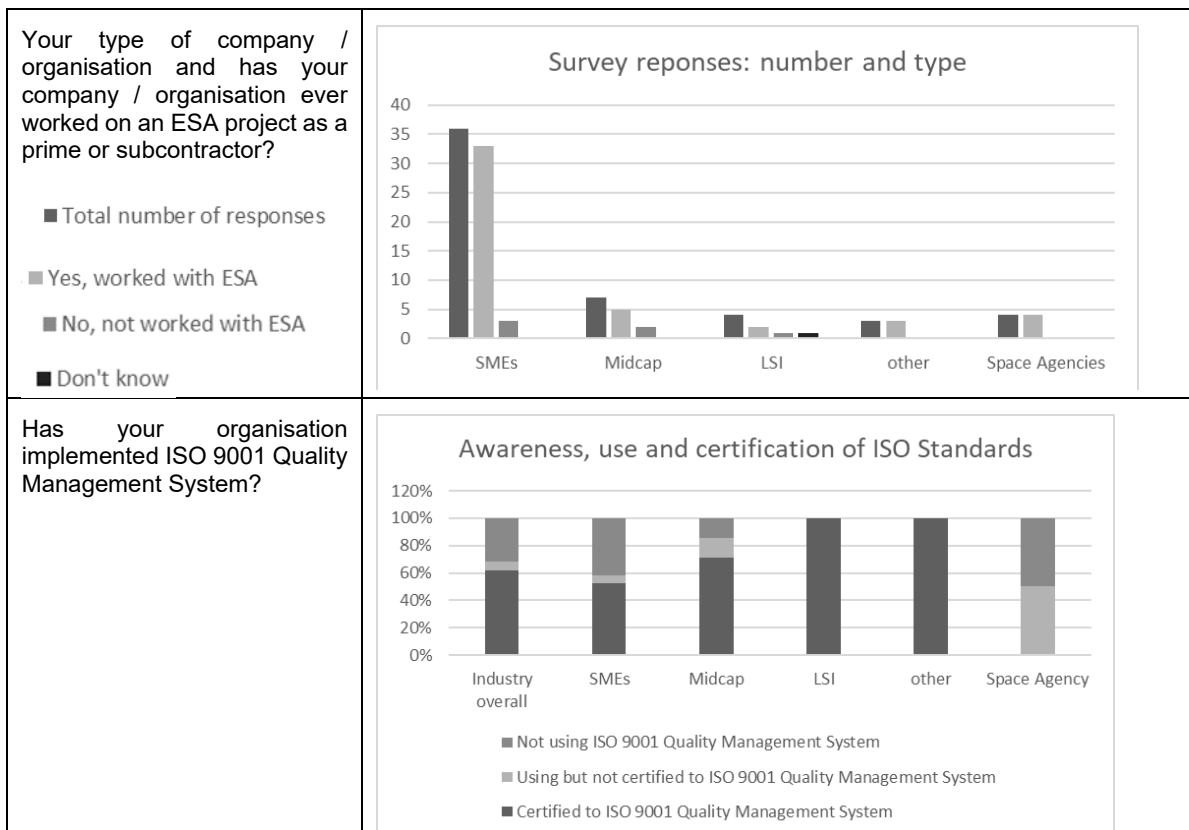
Figure 1: Upstream and Downstream Considerations for Establishing Lessons Learned Process (Herd 2022)

- Please indicate the level of benefits to be gained in establishing (or in running) Lessons Learned in your organisation
 - Also from the Agency research (Herd 2022), as given in Figure 1, we looked at the benefits realised and needed to check these 7 categories of potential benefit against industry experience or expectation of learning from experience.
 - Establishing communities of practice
 - Communication of learning and benefits
 - Creating a learning dialogue and exchange of experience
 - Creating greater access to learning
 - Capturing new processes and learning means
 - Creating cultural change / symbol of learning
 - Improved terminology
- Please indicate your organisation’s level of interest in topics where capturing experience could provide learning
 - When examining the ESA lessons learned database, we find there are 6 main areas of learning. Whilst the Agency’s lessons learned is relatively new, in that it has been actively as a corporate activity for the last 6 years, these 6 themes are repeated and reinforced with each capture event, and therefore are identified by the Agency as being our main areas of learning.
 - Management
 - Engineering
 - Quality
 - Launch / Operations
 - Procurement
 - Information Technology / Human Resources / Communication
- What other areas of learning are important to your organisation
 - To support industry best in learning from experience the Agency is seeking to better understand where industry needs are (for each of these areas) and also to allow for other areas of learning to be identified of which the Agency was not aware.
- Please state your agreement that Lessons Learned provides discussion a) topics b) content, c) justification and d) taking action

- At ESA we have evidence of lessons supporting and creating communication between experts, by providing topics and content of that interaction and exchange of knowledge. It is seen that lessons are the sole reason for the dialogue to be set-up and engaged in, and in addition has provided the justification for taking action to create the identified learning needed to address the lesson (i.e., assuring the repetition of a positive experience or the prevention of a negative one).
- How far do you agree that Lessons Learned can be applied to capture experience and learning from the following: project, activity, function, technology, product.
 - Lessons learned can be applied to many areas within an organisation, and at ESA it is primarily apply it to major space development projects. However, it has also been applied to activities, functions, technologies and also products to gather experience and determine the most beneficial learning needed (for the processes, the documentation recording those processes and the training for needed skills). This question then allows the feedback from industry of what topics are thought to be most suitable for lessons learned.
- ESA is considering whether to develop a Lessons Learned tool for use outside of the Agency; would your company be interested to use this tool and what would you use it for?
 - The Agency is committed to make a difference by supporting industry directly through the capture and exchange of experience. By requesting feedback on industry interest in a direct intervention (the provision of a on-line tool to support lessons learned) ESA then be more effective in supporting industry in this area.
- What would be the main reason(s) for using Lessons Learned in your organisation: improvement in business, product, quality (product), quality (process), lower costs.
 - Understanding the reasons for industry to engage in lessons learned, and the areas in which industry believes it can improve also provide the Agency with both the mandate and direction in which this support can be directed. This question can also highlight the expected benefits to gained both by the Agency and industry alike when exchanging experience.

3. Results

Table 1: Characteristics of Responding Organisations



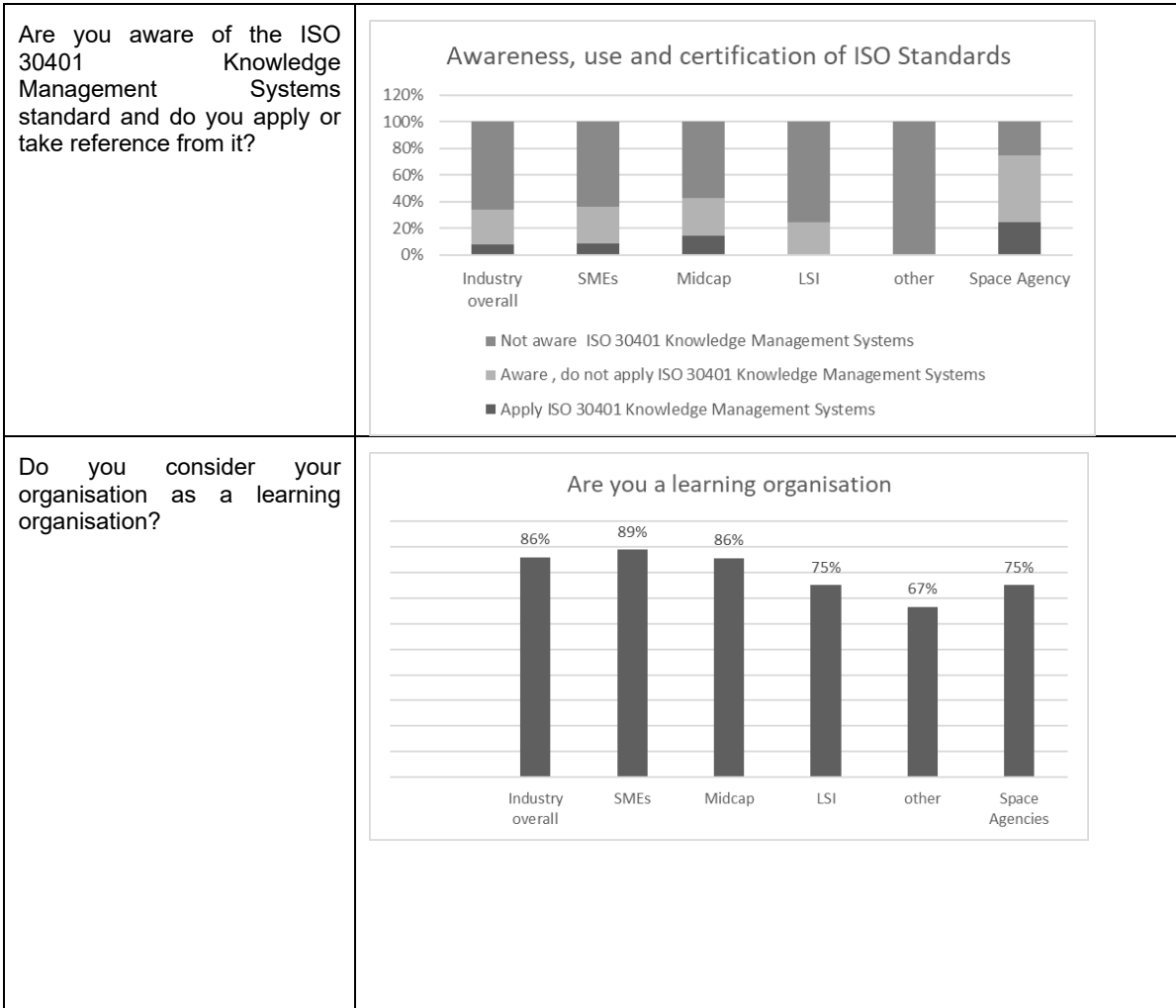
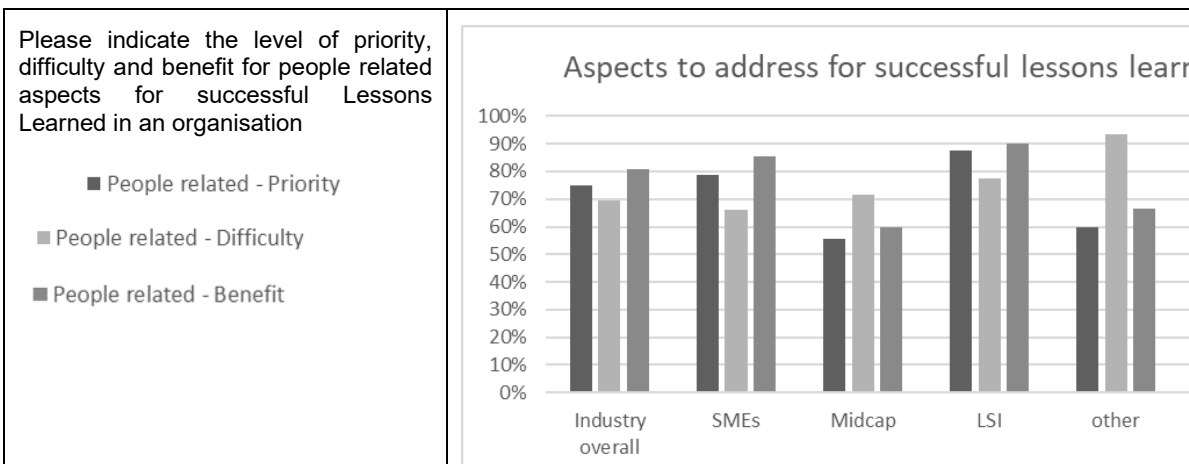
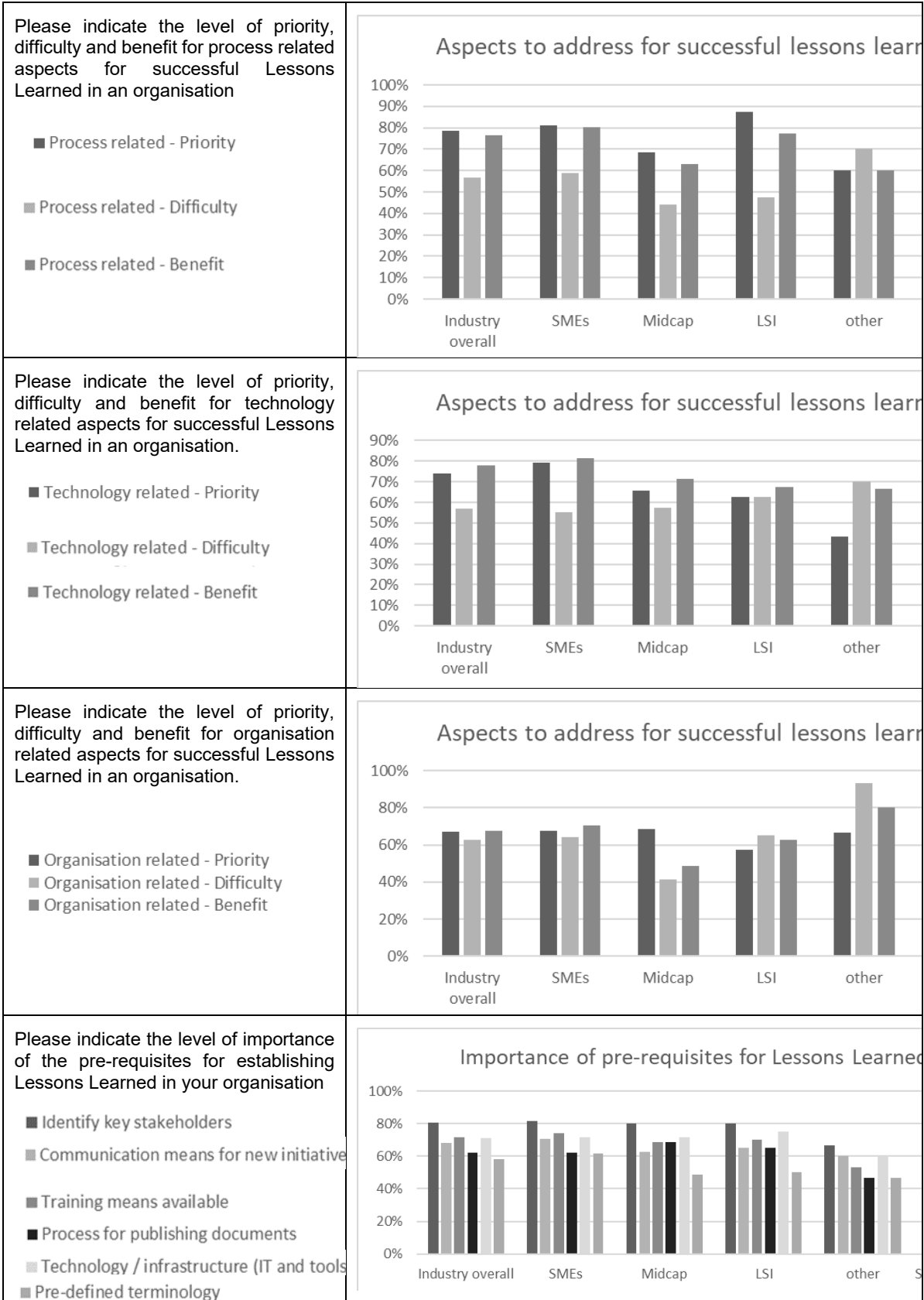
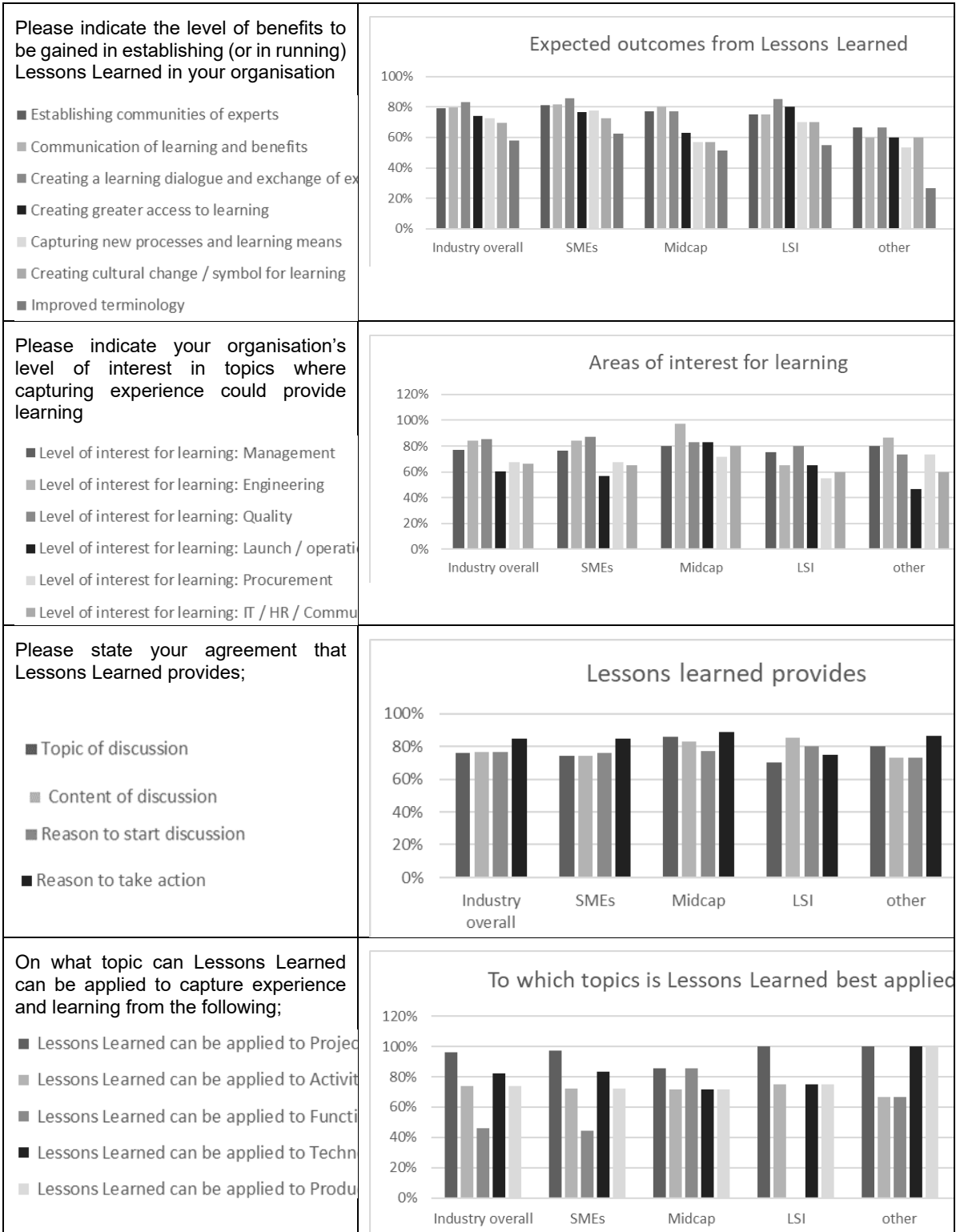
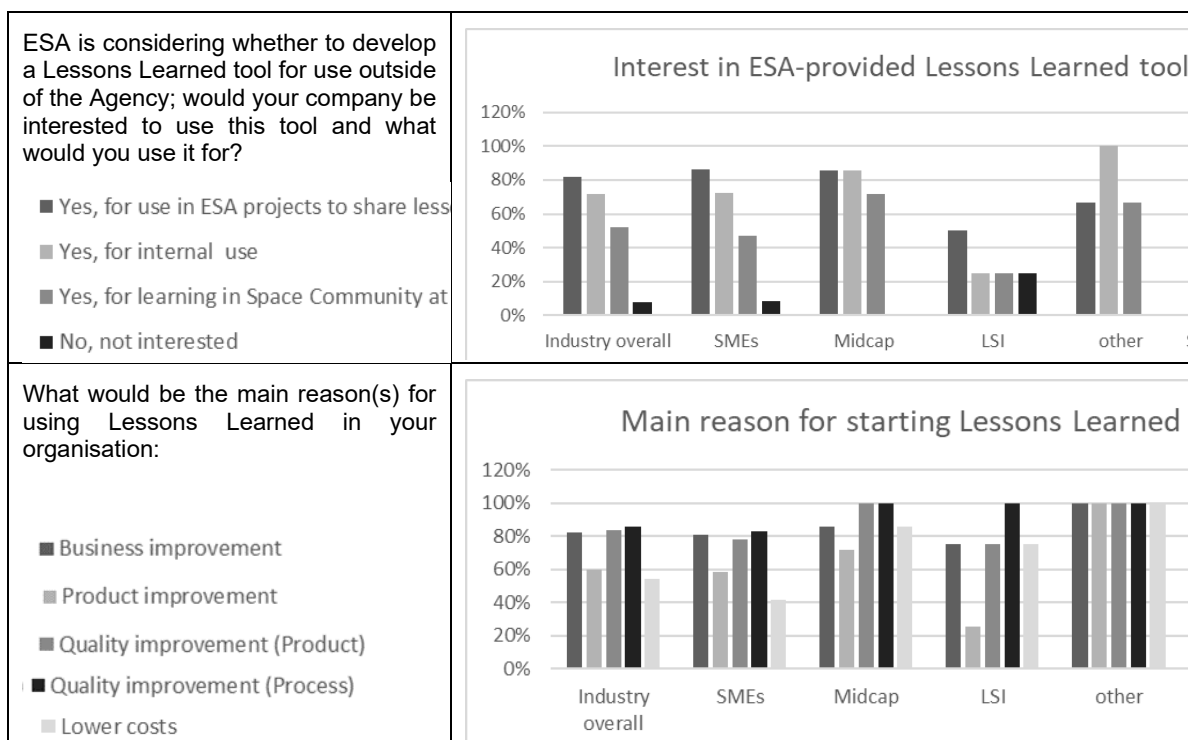


Table 2: Responding Organisations on “Best Practice” in Lessons Learned









4. Discussion

The survey was sent out to around 800 small and mediums-sized (space-related) enterprises that were registered as part of the space industry with the European Space Agency. This community was informed of the launch and asked to respond to the survey through ESA Learning Hub (ESA 2023) – the ESA SME web platform and e-newsletter used for holding and promoting information and training of benefit to space industry, and ESA Star (ESA 2023) the Agency’s procurement webpage and newsletter, in addition to highlighting the survey’s release via ESA Twitter feed (ESA 2023) and ESA LinkedIn (ESA 2023). These channels provided a survey response rate of around 7% (taking a target audience of 800) - which is low but within an acceptable range for questionnaire responses (typically push surveys having a response rate of around the 11%, with a range of between 6% and 16%).

In order to have a comparative set of data, other sizes of space industry were included, MIDCAPS and Lead System Integrators (LSIs), with the size / type of organisation being self-declared. As a comparator to space industry, the survey was also sent out in parallel to 8 national space agencies with 4 responses being received.

Of the responses from industry, around 70% came from the SME population and 14% from MIDCAPS, with 2% from Lead System Integrators (LSI).

The statistics taken from ISO 2021 Survey results (ISO 2022) of certification of ISO 9001 (ISO 2015) gives the number of certified businesses in the ESA member state countries as being 280,000 business against a total number of businesses of 26.3 million overall. This then gives an approximate level of 1% of all registered industry as certified, whilst the survey indicated that 60% of respondents were ISO 9001 certified. Whilst the standard ISO 9001 does contain a sub-section relevant to knowledge management (i.e., clause 7.1.6), seeking for organisations to “*determine, maintain and make available knowledge necessary for the operations of process and achieving conformity of products and services*”, the standard is used as an overall indicator for the process-based nature of an organisation. and specifically consider this relevant for lessons learned, which is highly process based. Around a third of the respondents were using or aware of the ISO 30401 Knowledge Management Systems (ISO 2018), however ISO does not publish certification numbers for this standard in order to make an industry comparison to the survey sample.

SME’s were the group to report themselves highest as being learning organisations and in the open responses as to why this was so, the justification for the response highlighted the following aspects;

- Learning by doing (21 instances)
- Learning through training (15 instances)

- Learning through processes (15 instances)
- Learning through technology (4 instances)
- Learning through recruitment (1 instances)

With regard to the industry indication of the priority, difficulty and benefit associated with people, process, technology for successful lesson learned in an organisation, an interesting result is obtained by using the following equation giving an outcome plotted below, and indicating that the survey response indicate that when assessing the motivators and barriers to adoption, they would equally address process and technology, less likely to address people related aspects, and unlikely to address organisational aspects.

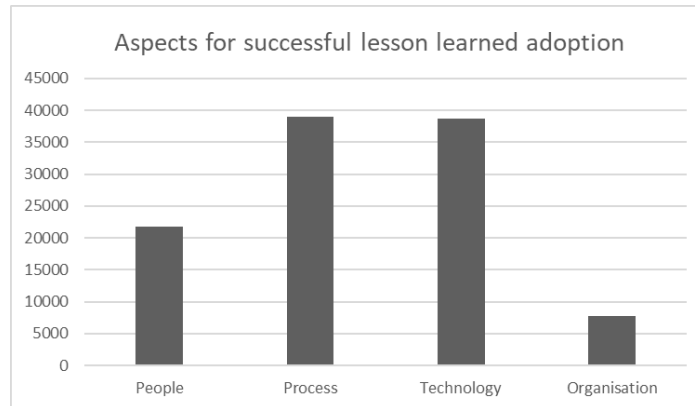


Figure 2: Plot of “Overall Likelihood of Successful Lesson Learned = Priority (Benefit -Difficulty)”

For pre-requisites needed to establish lessons learned in an organisation, identified as upstream considerations in Figure 1, across the range of survey responses the highest was “*identifying key stakeholders*”, and the least having a “*pre-defined set of terminology*”. For the outcomes, identified as downstream outcomes in Figure 1, the highest overall was “*creating a learning dialogue and exchange of experience*”, whilst the lowest was “*improved terminology*”.

For an organisation’s interest in specific topic to which lessons learned could be applied to create learning, the top (equal) were “*engineering*” and “*quality*”, with the lowest being “*launch / operations*”.

For what lessons learned provides in terms of learning, the overall highest aspect was that of giving a “*reason to take action*” with an overall equal score for “*topic of discussion*”, “*reason to start a discussion*” and “*content of discussion*”.

For the selection of best topics to apply to lessons learned, the highest was “*projects*” and the lowest being “*functions*”.

As to the interest of the respondents to use a lessons learned tool, there was an overall majority of interest to use a tool “*for use in ESA projects to share lessons with ESA*”, and also “*for internal use*” (within the responding organisation). There was a lower, but still overall positive response for sharing experience to the “*space community at large*”.

The main reasons for using a lessons learned process in an organisation was given as equally, “*business*” and “*quality (product and process)*” improvement, whilst “*lower costs*” was least likely to be a reason for use of lesson learned.

5. Conclusion

In order to identify what was considered by the European space industry was best practice the Agency undertook this survey of European space-related industry, using the network of connections within an active community. The response rate gives some credibility to the survey responses as far as being representative of the likely overall opinion of SME’s of what is lessons learned best practice. However, for MIDCAPS, LSI’s (of which there are 3 organisations that the European Space Agency engages as Lead System Integrators) and Space Agencies, a more direct data gathering approach is recommended to complement better the insights to compare to those provided by the SME community (whilst the data obtained from these smaller groups does provide some interesting comparison, this is by no means significant). In this ESA is already working with some Agencies to establish a protocol for experience exchange and that this has already been put into action between the

respective Space Agencies, and we will continue to apply this approach to other space organisations supporting this individual organisation-to-organisation exchange. The established of a tool for lessons learned may well better support this exchange to be more common practice and “every day”.

The further exploration of the differences between the SME response and the ESA proposed benchmark of best practice in terms of needed pre-requisites and also the outcomes deemed as most important will help the Agency respond in a more relevant manner when creating the dialogue with SMEs on how to realise the needed exchange of experience and to assure the identified learning.

It is recognised that in the analysis of which aspects need addressing (people, process, technology and organisation) and the benefits and barriers to doing this, that the results of the survey support the principle of “*the hard stuff being easy and the soft stuff being hard*” – however this does not negate the fact that the soft stuff identifying key stakeholders for example, is still rated as the highest key aspects for the pre-requisites of establishing lessons learned in an organisation.

For the definition of a learning organisation as proposed by ESA, in the comparison of what industry perceives, it is considered that there are no non-linearities between the two. However, SME’s seem to be even more focussed on an ability to change through learning (“*learning by doing*”), which could be as an influence of their market place demands and funding dynamics, and the size of the organisation (with their size being an enabler for change, and people as opposed to process being major influences in the climate and culture dynamic of an organisation).

Contrary to the SME consideration for importance of terminology, at ESA we have found that having a common agreed set of terminology (reported by SMEs as lowest needed pre-requisite, and lowest outcome) is essential in order to capture and communicate the learning effectively. Indeed, even the basic enabler for the initial retrieval of knowledge based on a user need for learning, which hinges only on the keywords used by that individual when performing a search of the lessons learned database. In this regard ESA will look at the application of knowledge graphs, natural language processing and understanding (NLP and NLU) (Mihaylov 2022) in order to make the proposed lessons learned capability offered to industry more flexible (for the user) but still more robust (for the data processing) – by helping the user to identify (common and agreed) keywords when initially capturing a lesson. This technology is in the early stages of being rolled out at ESA and the Agency will share its learning on this as it is further used and improved to meet user needs (mostly ease of data entry, and, ease of data retrieval).

The European Space Agency will now further engage and explore how to address the identified need for SME’s to have access to a lesson learned capability (i.e., tool) for use both within projects undertaken with the Agency but also for an SME’s internal use. For now, though, the Agency is happy to share its learning on this latest step forward in understanding best practice and through this better enabling the sharing of experience and knowledge through lessons learned, for both the space community and other communities that could benefit from this work.

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