International Astronautical Federation
International Programme / Project Management Committee

IAF-IPMC
Young Professionals
Workshop 2017

Workshop Results Report

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March 2018

Official Group Photo of the 2017 International Project Management Committee Young Professionals Workshop delegates on 24 September 2017 at Adelaide Convention Center, Australia

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1. Executive Summary

The International Programme/Project Management Committee Young Professional Workshop sought to gather ideas and recommendations from early career employees in the international space community and provide the IPMC and IAF member organizations with greater knowledge, insights, and perspectives that can help better develop and empower the next generation of space program employees. The IPMC was supported in this effort by a group of young professionals who participated in previous workshops and served as the Workshop Organizing Committee (WOC) to manage the overall process and finalize preparation of a workshop report.

The workshop itself represented the culmination of an initiative that began in the second quarter of 2017 with the nomination and selection of workshop participants who were assigned to working groups focusing on three discussion topics. Over the ensuing period these groups discussed and investigated the topics and reached preliminary conclusions. The groups then met face-to-face at the workshop, finalized their recommendations, and presented the outcome to the IPMC members, workshop delegates and guests at the IAC.
Following the workshop, the WOC prepared a final report with summary of the results and recommendations.

Topic 1: Building the case for the On The Side Projects

On the Side (OTS) projects are projects undertaken outside the bounds of predefined work responsibilities, often by highly motivated employees or individuals based on their professional and/or personal interest. OTS projects do not necessarily result in successful products or financial revenue, but may still be of great value to an organization. It can serve the purpose for spurring creativity by offering the change to creative minds to explore new domains, pursue their personal objectives, and to innovate. OTS projects thus contribute to the personal growth, motivation and company commitment, and may generate professional opportunities.

The group has performed extensive researched in the following areas;

- Success criteria for OTS projects; three principal criteria of project success were developed.
- Business Case; the primary business opportunity for an OTS project scheme lies in being able to address high risk and high return projects with a limited investment, a secondary business opportunity exists in low risk projects which do not fall within the framework of core work statements due to schedule or resource limitations.
- Schedule and Risk Analysis; OTS projects are characterized by limited time and resources for their development. Various models for this have been identified and elaborately discussed.

- Implementation and Project Management aspects; a SWOT analysis for organizations undertaking OTS projects.

Topic 2: Learning Partnership between Young Professionals and Senior / Retired Aerospace Professionals

Knowledge Transfer (KT) is key for organizations to be able to maintain their unique critical knowledge and develop for the future. Without a proper KT/Learning partnership plan, an organization may face problems; loss of key technologies, an increase in mistakes and the need for rework, more safety incidents and a loss of quality and profits.

The following elements have been researched;

- Learning partnership is a two way street; in addition to an accelerated learning process and inclusion for YP's, focusing on dual learning can unlock their full potentials whilst enriching the SP/RP's with personal development, innovative thinking and career-enhancing exposure to recent technologies and methods.
- Existing projects and successes.
- Comparing perspectives of young and senior professionals.
- Identification of the right senior/retired staff and the right YP's.
- Criteria for success; the time of the mentee/experts is the most important cost according to both the literature study and the interview feedback.
- Resulting benefits from learning partnerships for Programme and Project Management at Aerospace companies.

In addition, a process is presented for any organization wishing to put in place an effective knowledge transfer program.

Topic 3: Reshaping the Space Industry 4.0 - Young Professionals' recommendations

The application of advanced networking and data exchange technology to the manufacturing industry has been termed Industry 4.0. This fourth industrial revolution uses digitalization and digital networks to create intelligent networking of products and processes along the value chain. Similarly, Space 4.0 refers to the next generation of conducting space activities. It is driven by digital technology advances and will bring together the traditional government-led space programs and the existing and new commercial entities entering the space industry.

In the report focus will be on the following 3 subjects;

1 PM in Global Space 4.0 and the Role of Change Knowledge

- The Four Rooms of Change, the different stages that the Space Industry will encounter in the transition to Space 4.0.
- The Sigmoid Curves, mathematical curves by which the life cycles of businesses can be demonstrated and analyzed.

- Artificial Intelligence in Project Management, it aides human decision making based on quantitative analysis of ast amounts of data.

2 Communication, Collaboration, Connectivity

- knowing how, when and what to communicate will become an increasingly essential element of PM in the aerospace domain.
- utilisation of communication plans.

3 A New Era of Risk

Throughout the following report, the various topics will discuss in details their methodology and findings which ultimately resulted in recommendations to be implemented.

2. Introduction

On September 24th, 2017 a group of 25 international young professionals – working in space agencies, companies and professional organizations– met to participate in an annual workshop organized by the International Programme/Project Management Committee (IPMC) of the International Astronautical Federation (IAF). The workshop was planned and organized by a team of international young professionals working in collaboration with the IPMC. It was held at Adelaide Convention Center in conjunction with the 68th International Astronautical Congress (IAC).

The IPMC Young Professional (YP) Workshop is an annual initiative of the International Project Management Committee (IPMC) of the International Astronautical Federation (IAF). The IPMC – which brings together representatives from more than twenty IAF member space agencies, companies and professional organizations – meets semi-annually to exchange experiences, best practices and to collaborate on projects that nurture the global space workforce.
The YP Workshop is held just prior to the IAF's International Astronautical Congress (IAC). The IPMC selects a small group of young professionals who previously participated in a YP Workshop to serve as the Workshop Organizing Committee and help the IPMC organize and manage the event.The 2017 Workshop Organizing Committee (WOC) members were:

- Birgit Hartman : WOC Project Manager
- Maarten Adriaensen : WOC Technical Manager
- Marie Botha: WOC Communications Manager
- Peter Batenburg: WOC Logistics Manager
- William McMillan: Assistant WOC Project Manager

The Workshop Organizing Committee members were also asked to closely follow the development of the discussion topics, guide the discussion group deliberations, and prepare this final report. The 2017 IPMC Young Professionals Workshop attracted twenty nine early career employees from government, industry, research and professional organizations throughout the world. Each of the participants was nominated by an IAF member organization to attend the workshop in response to a call for nominations.
The workshop participants selected one of three discussion topics to continue in smaller discussion groups that met virtually during the period prior to the actual workshop session. (Please see Section 3: Virtual Session Collaboration and Pre-Workshop Activities, below.) The results of these investigations and deliberations and associated observations and recommendations are presented in this report. The ideas and views expressed herein are those of the participants as individuals and do not necessarily reflect the views or positions of the IPMC, the IAF or its member organizations.

3. Virtual Session Collaboration and Pre-Workshop Activities

Since the Young Professionals Workshop is a one-day event, the Workshop Organizing Committee (WOC) felt it was necessary to establish relationships among the delegates who would attend through virtual tools in advance of the event. With a globally distributed and diverse group, the WOC elected to encourage use of online social and collaborative tools, such as Skype, Facebook and Google Docs and the scheduling tool Doodle, to facilitate "breaking the ice" and initiate group conversations around the chosen discussion topics.

After the delegates were selected, the Organizing Committee administered a questionnaire to obtain information including individual delegate profiles for the workshops handbook, along with their preferred social networking tools and professional capabilities and personnel hobbies. This information helped establish a basis for assigning the delegates into the various topic groups. The participating Young Professionals each expressed particular interest in one of the proposed topics. In addition to their topic interest the participants could express their desire to function as either a team leader or a rapporteur.

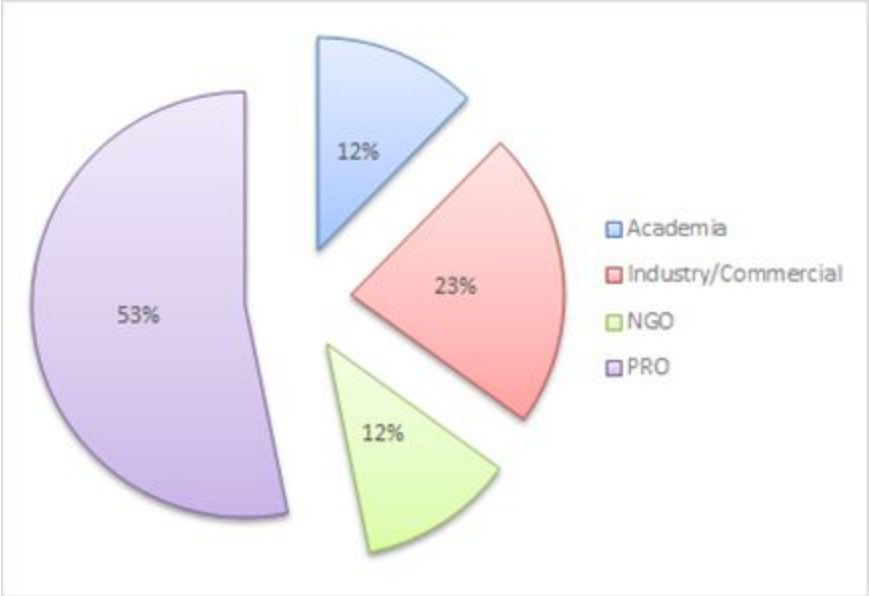
The WOC then organized a first meeting via Skype for each group to introduce the Statement of Work (SOW) and explain in detail the expectations, goals, timelines and deliverables. This was also a good time for the delegates to ask any questions, and to share their initial thoughts and ideas.

Each group selected a topic leader and a rapporteur. The topic leaders were responsible for producing requested deliverables and for managing other related discussion group tasks. The topic leaders were also the main point of contact for the WOC. The rapporteurs were asked to document the discussions and the progress made. These documents were helpful to ensure all of team members understood the status of the deliberations.

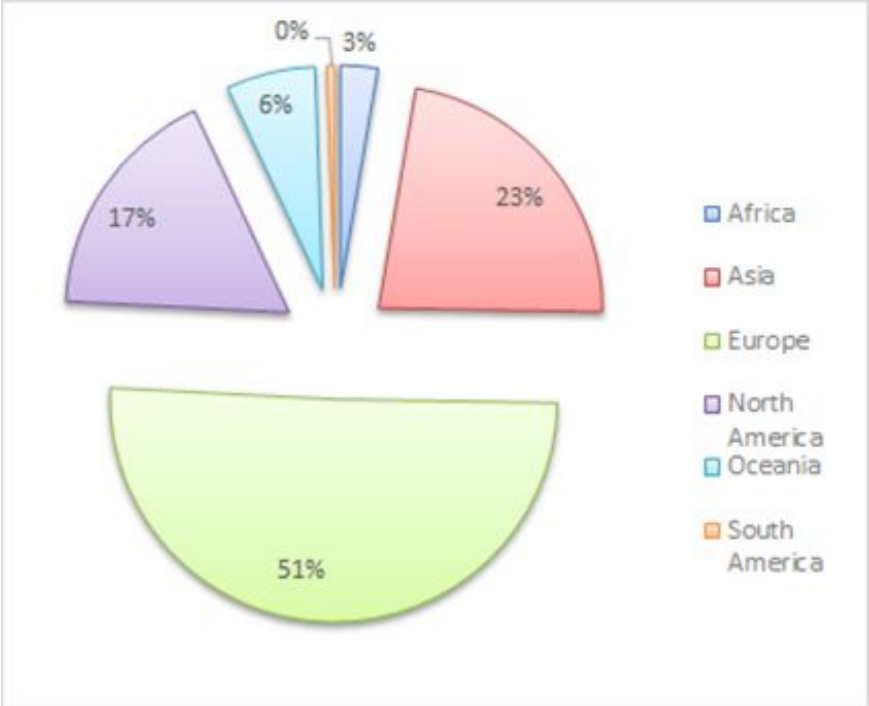
The virtual session process began in July 2017. Until the September Workshop, the delegates were asked to work on their individual topics. Discussion group meetings were facilitated via Skype and scheduled mostly through Doodle, which allowed delegates to self-organize times in line with their availability. Documents, such as mid-term reports and project execution plans were submitted as deliverables and shared under folders in Google Docs. This proved to be a very helpful and reliable tool and was easily accessible by delegates around the world. The teams then conducted in depth investigations, held various interviews, and shared their own day-to-day experiences working in the space industry as young professionals. As a tool for collaboration among thirty participants from diverse locations globally, the virtual sessions worked well as a means to bring the delegates together prior and facilitate the research prior to the Workshop.

4. IPMC YP Workshop reaching YP's worldwide

In the 6 editions of the workshop since 2012 the workshop has had 186 participants. Below you will find two graphs providing a breakdown of the background of the participants.



Professional background of the IPMC YP Workshop participants



Division per country of companies represented at the IPMC YP Workshop

5. Group topic results

During the 2017 IPMC Young Professionals Workshop the three discussion groups met face-to-face for the first time, finalized the results of their discussions and presented their findings to the other groups along with several IPMC representatives. The topic reports prepared by the three groups, along with each group's concluding observations and recommendations, are presented below. Due to the amount of information gathered, this report is a concise compilation of the results.

5.1. Topic 1: Building the case for the On The Side Projects

5.1.1. Introduction

In the frame of this study, On The Side (OTS) projects are projects undertaken outside the bounds of predefined work responsibilities, often by highly motivated employees or individuals based on their professional and/or personal interest. The development of a side project by employees may emerge from an initiative supported by the organization, such as "hackathons" or internal competitions, or directly from personal initiatives. Some side projects have previously led to very successful products or services such as Gmail, AdSense and Uber (Lui, 2016).

OTS projects do not necessarily result in successful products or financial revenue, but may still be of great value to an organization. Even when OTS projects do not lead to a product or service, the undertaking of a side project can serve the purpose of spurring creativity by offering the chance to creative minds to explore new domains, pursue their personal objectives, and to innovate. OTS projects thus contribute to the personal growth, motivation and company commitment, and may generate professional opportunities.

In Linkedin's "InCubator" program, employees may spend up to three months full time on a project unrelated to their daily tasks if they can demonstrate the value at intermediate approval checkpoints (Tate, 2012); Spotify organizes weeklong "hackathons" where the best ideas coming forward receive further resources (First Round Review, 2014). Also smaller initiatives, like the "AAUSAT" projects at the University of Aalborg in Denmark, are noteworthy: here the university makes laboratory and resources available, and students and professors can spend their free time to develop, launch and operate small satellites, contributing to students' knowledge, increased motivation and experience.

While OTS projects may also be undertaken by individuals at their own initiative, this report focuses on side projects that are undertaken through the initiative of organizations that offer a framework to support employees to engage in projects besides their general work duties. The amount of management oversight and company resources that can be dedicated may vary and are intrinsically different when comparing large organizations' funded programs with small start-ups organizing hack-days or hack-weeks. The commonality to successful OTS project schemes is that the organization recognizes the need for their talented employees to have time and possibly resources to explore topics they are interested in, to innovate and improve where they see opportunities.

This research topic aims to offer insights in the potential benefits and success criteria for the implementation of OTS projects in the aerospace sector. Feasibility and business case, advantages and risks are analyzed both at project level and from the perspective of the organization, and recommendations for the implementation of successful OTS projects are provided.

5.1.2. Methodology

The framework for this report is built on the Report on OTS Projects prepared during the 2013 IAF IPMC Young Professionals Workshop (IPMC Young Professionals Workshop, 2013). Further analysis within this report is based on literature review of existing side programs as well as interviews performed with managers and other employees with practical experience in the undertaking or overseeing OTS projects. In this report the authors identify six different models for the implementation of OTS projects in which the allocation of time and other resources (funding, laboratory availability, etc.) are considered key factors to characterize them. The present research uses those models and key factors as a basis for a schedule and risk analysis, and provides recommendations on the efficient management of time, financial and other resources. Also the follow-up of project progress and the size and characteristics of the organizations are considered, and for this reason organizations have been grouped under Academia, Small & Medium Organizations and Large Organizations. The 2013 YP Workshop report had identified potential benefits and offers a set of recommendations on elements for success when aiming to pursue OTS projects. Those include management support, evaluation of achievements, funds, hardware and recognition of the objectives. In this report several of those recommendations are further deepened: a SWOT analysis focusing on each of the three groups mentioned above is performed to establish recommendations on the practical implementation, project management and possible barriers that may impact the successful execution of OTS projects.

5.1.3. Our research

5.1.3.1. Success criteria for OTS projects

According to research conducted by Alashwal et al. (2017), three principal criteria of project success were developed: Management Success, Functional Success, and Organizational Success. The main components of success factors include Team Power and Skills, Resource Availability, External Environment, organization Capability, Project Support, and Project organization. In our research, success criteria for implementing and executing OTS projects are categorized into four areas, as shown in Table 1 here below.

Area	Success criteria
Implementation and execution of OTS project	1. Funding available 2. Schedule (*was the project completed on time?*) 3. Tools and resources available 4. Recognition of success
Organization of project	1. Project management roles established 2. Delegation of roles and responsibilities 3. Clearly stated goals and deliverables established 4. Project timeline established 5. Recruiting of participants
Benefit to organizers and participants	1. Skills development/enhancement of participants 2. Organizations able to utilize new skills of employees for their projects
OTS project success	1. Project completed 2. Deliverables achieved/submitted 3. Quality of project

Table 1: Success criteria for implementing and executing OTS projects

Quantitative, qualitative or a combination of both metrics can be applied for measuring the success criteria above. Generating feedback, for example, via a survey at the beginning and end of the project would also help evaluate the success of the project for both the employer (in case of organizations) and the participants.

We recommend to state the success criteria for an OTS project at the very beginning of the project itself, for example by listing them in the Statement of Work agreed between the initiator of the project and the Management. Success criteria should be linked to the nature of the project, which may also: improve the overall knowledge of the initiator; give appreciation of how different disciplines interact at a larger scale; enable to learn how to interact with others in multidisciplinary teams; improve communications between peers and time management. All these aspects can be associated with success factors, and therefore measured in a qualitative and/or quantitative way to assess outcome and impact of the project.

5.1.3.2. Business case

The primary business opportunity for an OTS project scheme lies in being able to address high risk and high return projects, with a limited investment (IPMC Young Professionals Workshop, 2013). Alignment of such projects with organizational strategy provides a pathway for both new business and increased scope of existing business. A secondary business opportunity of an OTS project scheme exists in low risk projects which do not fall within the framework of core work statements due to schedule or resource limitations. With investment, these projects can provide incremental improvement of an organization's internal products, processes and services. The value of these business opportunities in shaping an organization is demonstrated in the following section, by establishing quantifiable and non-quantifiable aspects of an OTS projects, and considering metrics of success.

Type	OTS Project Quantifiable Aspects	Quantity Metric/s
Monetary investment	Human resources	Human resource hours and corresponding cost, including collateral organizational support
	Other resources	Non-recurring costs e.g. equipment Recurring costs e.g. facility maintenance
Performance outcome	Profit – either directly through, or indirectly due to savings resulting from, a product, process or service	Expected (risk considerate), actual and worst case ROI/ROE
	Intellectual property generation	Design/utility patent net value
	New/increased business	Revenue
	Workforce development	Employee and skill set retention rate Employee productivity, performance and satisfaction

Table 2: Quantifiable aspects of an OTS project and/or an OTS project scheme

The quantifiable aspects associated with an OTS project and/or an OTS project scheme, are listed in Table 2 above. In general, these are attributed to financial metrics. The non-quantifiable aspects of relate to the development of an individual which is afforded through involvement in an OTS project. These in turn translate to organizational level aspects; and are illustrated in Table 3 below.

Individual Level Aspects	Organizational Level Aspects
Project, risk and time management skills that might not be otherwise gained, for example, in larger projects or where the management structure permits less influence from the individual.	Individual is able to first master project, risk and time management skills on smaller project before applying them to larger projects, as well as, providing individuals with practical, outcome-oriented training.
Interdisciplinary learning for an individual OTS project contributor, which aligns with STEM industry trends of increasingly multi-disciplinary and complex projects and skill set requirements	Cross-pollination of ideas and technical skills between team members, due to multi-disciplinary nature of projects.
Scope for an individual to: exercise innovation, with fewer bounds than perhaps a core project; be involved in the generation of patentable IP; and, make significant contributions to and shape the internal products, processes and services of an organization	Providing a pathway for an organization to harness creativeness and undergo incremental innovation in regards to its internal products, processes and services Breakthrough or disruptive innovations, including patentable and licensable material, improves market competitiveness for an organization by increasing either the depth or breadth of its portfolio Possible impacts to employee satisfaction and hence retention, both positively or negatively Fostering an "innovative culture"

Table 3 Non-quantifiable aspects of an OTS project and/or an OTS project scheme

The benefits of partaking in an OTS project for an individual, as described in Table 2 above, are self-evident and ubiquitous regardless of the level of investment from an organization. These benefits manifest at an organizational level and outweigh the risks and costs of an OTS project scheme when two key requirements are considered: firstly, the need to ensure that projects of an OTS scheme are strategically aligned with the vision/mission of the organization; and secondly, the need for a financial metric for measuring project success, as for any core or like project:

It is possible in the implementation of an OTS project, to remove limitations a core project might have; hence, aligning OTS projects with a long term organizational mission and providing some structure for innovation ensures the maximum benefit can be gained from them. Ultimately, the adoption of an OTS project scheme thereby becomes a stepping stone to fostering an innovative and agile organizational culture.

ROI - Return on investment (Profit/Assets) and ROE - return on equity ((Profit/Assets) × (Assets/Shareholder Equity) = Profit/(Assets-Liabilities)) metrics are both typical measures of project management success. Both are. indicators of how effectively a project manages its available resources; ROI measures directly compares resources and the generated income, while ROE also considers the financial leverage of a shareholder invested in the project (Investopedia, 2017). The ability to predict ROI/ROE varies over the lifetime of a project and is illustrated in Figure 1.

ROI with	Data Collection Timing (Relative to Project)	Credibility	Accuracy	Cost to Develop	Difficulty
1. Pre-project data	Before project	Not very credible	Not very accurate	Inexpensive	Not difficult
2. Reaction data	During project				
3. Learning data	During project				
4. Application data	After project				
5. Business impact data	After project	Very credible	Very accurate	Expensive	Very difficult

Figure 1. Attributes of ROI/ROE at varying project development stages (Phillips & Phillips, 2007)

In the context of OTS projects, ROI/ROE might be considerably difficult to develop for example where an OTS project is relatively open-ended; however, defining these is a necessary part of mitigating organizational risk. In addition to ROI/ROE, it is necessary to define the time period over which a return on the investment is expected. In order for an OTS project scheme to remain viable for an organization, the ROI/ROE period should be considered with respect to the standard thresholds set for core projects.

5.1.3.3. Schedule and Risk Analysis

OTS projects are characterized by limited time and resources (funding, infrastructures, manpower, etc.) for their development; could be partially of fully independent from the core business of the organization in which they are led; and could be fully, partially or not supported by the management. Given these characteristics, it is necessary to plan the distribution of resources and to manage the time available through efficient scheduling. The planning phase should also take into account possible risks that may affect OTS projects, both internally (risks related to the OTS project itself) and externally (from the organization, stakeholders, market, etc.).

The amount of time available depends on the model used by the organization for implementing and developing OTS projects. According to the 2013 IPMC YP Workshop report, models that take into account time as one of the fundamental criteria are the following:

- 120% (Overtime / Personal Unsupported Project): Good for short periods of time or for defining the initial phase of a project.
- 80%/20% (Time availability): Good for software or feasibility work, presents limited possibilities of working with hardware without additional resources.

- Funded Resources but not time (e.g. business incubation centres, supercomputer time availability, antenna/instrument time availability): Good for creativity with respect to a particular domain.
- Time limited funds: Projects of opportunity, there are times when resources are available for short periods of time and need to be taken advantage of during these periods.

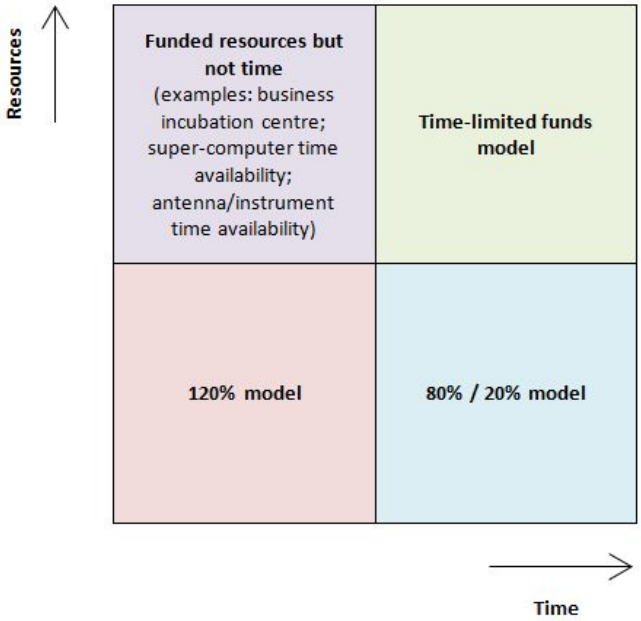


Figure 2. Models identified by 2013 IPMC Workshop Delegates, and sorted according to availability of time and resources

In accordance with the models portrayed in Figure 2, time is limited because deduced from employee spare time (*120% and funded resources but not time* models) or from daily core time (*80%/20%* and *time limited funds* models). Therefore, time shall be managed efficiently. Here follow some recommendations (Yablonski, 2016):

- Break the project down into smaller tasks. This should help creating an overview, and at the same time defining the resources to be allocated for each task and project phase. An execution time shall also be identified for each task.
- Prioritize tasks and focus on essentials. Through prioritization it is possible to avoid workloads and focus on the really important tasks first.
- Make the most out of the time available. In some cases, the model adopted by the organization does not allow enough time to work on an OTS project. Therefore, the employee should be able to productively use the time available, which could vary depending on everyday workload. The ideal condition would be to complete a task every time that the employee focus on the OTS project, and when time is short, e.g. only 30 minutes available, he or she should focus only on tasks that require an effort of 30 minutes to be completed. This condition would also give a sense of accomplishment and progress.
- Trying to develop an idea in a single project can ultimately lead to failure. Consider phasing the project with iterations to promote the maturation of ideas. Successive smaller or less scoped projects can lead to success as iterations can find what works and what doesn't. This is particularly useful for complex ideas as they can be broken down into manageable pieces.

Also resources can be limited, therefore their usage should be managed in an effective way. Ideally, resources should be allocated to the development of those tasks defined as essentials for the project. Following the PRINCE2 Methodology for managing successful projects, the allocation of resources should be interrupted whenever the desired results are not achieved, or not achieved in a timely manner (PRINCE2 & AXELOS Global Best Practice, 2009).
Progress should be assessed constantly when working on OTS projects, for example by scheduling periodic meetings. During these meetings one should analyze achieved and future milestones, plan for change (if required), and plan next steps towards project goals. Risks, both internal and external, should be taken into account when planning for future actions. External risks associated to OTS projects (as some of them were also identified by the 2013 IPMC YP Delegates) are: lack of management support; lack and/or bad management of resources; lack of access to required skill sets; delays due to bureaucracy, which could also lead to decreased motivation and passion; lack of mentorship or access to expertise; project complexity greater than expected; perceived negative career impact as a result of failure (IPMC Young Professionals Workshop, 2013).

Each OTS project has also its own set of internal risks, meaning risks directly associated with the nature of the project itself. Therefore, a risk analysis should be performed in order to: identify the risks and the context in which they may develop; assess the risks, both in a qualitative and quantitative way; plan specific management responses to decrease impacts of threats and to maximize opportunities for improvement; implement actions for reducing/removing risks, and for continuously monitoring the status over the project; communicate threats and opportunities faced by the project both within the project and externally to the stakeholders (PRINCE2 & AXELOS Global Best Practice, 2009).
The size and characteristics of the organization implementing OTS projects may influence scheduling and risk analysis. For example, in Academia time is managed differently than in companies, since OTS projects are assigned to students that have to follow classes, take exams, and work on other projects related to their main academic career. This may result in projects with very long developing time, also influenced by limited resources. At the same time, risks are different for academic projects. It may happen that more than one person work on the same OTS project, and that the team members change over time, thus influencing the homogeneity of progress. Similarly, there are differences between small/medium companies and large companies that should be taken into account when planning for time and resources, and when analyzing risks connected to OTS projects. Generally large companies have more resources to invest on OTS projects, but bureaucracy may slow down projects along their development, hence resulting in a scarce management support. Small/medium companies have fewer resources, but may be willing to invest on high-risk OTS projects anyway, also considering the benefits of possible, large returns (IPMC Young Professionals Workshop, 2013).

5.1.3.4. Implementation and Project Management aspects

The size of the organization impacts the manner in which OTS projects can be implemented. This section describes the differences identified by the team, and the following figure 3 summarizes strengths, opportunities, weaknesses and threats (SWOT analysis) for organizations undertaking OTS projects.

	Strengths	Weaknesses	Opportunities	Threats
Academia	• Easy to implement • Flexibility • Involvement of students	• Scarce funds • Limited resources	• Students' professional development • Publications of research results	• Limited student commitment
Small/Medium Organisation	• Encourage creativity • Enhancement of employees' core expertise	• Resources and funding limited to smaller employee communities	• "Hackathons" • Small investment and large returns • Generation of patents	• Losing corporate knowledge
Large Organisation	• Willingness to support employees' personal and professional development	• Difficulties in supporting vision of creativity	• Access to more funding and resources • New business	• Bureaucracy

Figure 3. SWOT analysis based on size and characteristics of organizations undertaking OTS projects

Academia

Implementation

OTS projects are relatively flexible and easy to implement within academia. A university can leverage student organizations and existing research labs to enable students to explore and foster new ideas. Goals, budget, schedule, and participating student selection can be left to the authority of the funding department. Flexibility also exists to invite students to work on unfunded projects. Students would be able to publish research results in several open conferences and journals based on the quality of OTS project results.

Project Management

There should be a standard method for documenting the proposal that clearly identifies the scope of work. Requiring the participant to complete a Project Management Plan (PMP) similar to what is used in industry can serve as professional development for the student. This PMP can be the basis for assessing progress and project success.

Relation between core work and responsibilities vs. OTS projects

In Academia, it is ideal to use OTS projects to supplement the participant's education, therefore using the project to reinforce the student's core degree or to enhance complementary skills is recommended.

Overcoming internal barriers for implementation of OTS projects

Scarcity of funding, limited resources and facilities, and student commitment can be major challenges. To overcome this, projects can be made available as volunteering opportunities before any funding is committed. Similarly, the scope and goals of the project can be based on accessible resources and student availability.

Small/Medium Companies

Implementation

Small/Medium size organizations can use the availability of OTS projects to encourage creativity as part of their core value. 120% time can be made accessible to all, however, 80/20% opportunities and funding can be limited to smaller employee communities. Limiting participation to vetted employees (not necessarily more experienced employees) will reduce the risk of a mismanaged effort. Developing a company wide culture that seeks new ideas can be created through slogans and routine activities such as hackathons and small innovation idea budgets, and with a consistent vision for innovation by management.

Project Management

Small/Medium size organizations will benefit from maintaining a low level of overhead. Templates can be used for proposals to be able to more accurately compare impacts and benefits. A committee composed of senior technical personnel that is not responsible for funding, can be used to review and grade proposals based on a scale that reflects the values of the company. Ideally, this committee can also evaluate the path and future goals that can lead to full funding. Project selection and duration could be limited to one year to protect for variability of funding, although allowing for extensions to be made for exemplary projects with track results that prove the necessity. Once selected, the project should operate with requirements for documentation and storing of data only, technical objectives should be treated as goals and scoped based on the maturity of the technology (example: Phase 1 – feasibility/project plan, Phase 2 – prototype, Phase 3 – research and development).

Relation between core work and responsibilities vs. OTS projects

Small/Medium companies will benefit by promoting ideas that are within an employee's core expertise. OTS projects unrelated to their core work could still be proposed, however, the employee should describe the project's relation to professional development or additional needed resources (other experts) to fulfill the needs of the project. Performance awards should not include a criteria for participation in OTS projects to not penalize highly performing employees that choose not to participate. However, an OTS project that matures to be fully or partially funded as a core activity certainly merits recognition as determined by the company.

Overcoming internal barriers for implementation of OTS projects

Losing corporate knowledge and new ideas as well as reallocating resources can impact a small/medium company significantly, therefore, any project that utilizes company funding, resources, and facilities, should be approved legally binding any intellectual data gained as a property of the company. However, patents shared with the employee should be encouraged to provide a give and take relationship. Investing in a 'sandbox' facility that makes hardware, basic tools, software, 3D printing, etc., accessible to participating employees will go a long way in making OTS projects more attainable.

Large Companies/Government Entities

Implementation

In a large organization, it will be difficult to reach a global and consistent vision of creativity due to the subcultures, large footprint, and varying functions across multiple regional locations. However, a global support and resources can be allocated to the various regional locations in the form of discretionary OTS project funds. In this form, the headquarters requirements to the regional entities should be focused only on the accountability for utilization of the funds and promotion of the program. At the regional entity level, implementation can be the same as in what is described for small/medium companies. One major difference is that since large companies have higher budgets, they are more capable and less impacted by supporting personal and professional development for employees seeking to enhance core skills or develop complementary skills that are in line with their core duty or career goals.

Project Management

Bureaucracy and existing policies will dictate the higher level management of funds between headquarters and the regional locations. At the regional entity level, every effort should be made to maintain a focus on value and limit the overhead from managing the OTS projects. The organization's requirements and policies should be tailored down by the local OTS project governing organization to meet minimum criteria, including requirements for documentation and the storing of data. Selection process should also be made by a local committee. Allowing individual departments to select their OTS projects may open the possibility of misappropriating OTS project funds to complete core work. As with small/medium companies, project selection and duration could be limited to one year to protect for variability of funding, but also allow extensions. Once selected, the project should operate under the requirements levied by the OTS projects local governing organization to meet the regional entity's policies for operations and safety. Technical objectives should be treated as goals and scoped based on the maturity of the technology (example: Phase 1 – feasibility/project plan, Phase 2 – prototype, Phase 3 – research and development) or professional development.

Relation between core work and responsibilities vs. OTS projects

As mentioned earlier, a large company is more capable and less impacted by supporting professional development for employees seeking to enhance core skills or develop complementary skills that are in line with their core duty or career goals. Therefore, OTS projects should not be limited to core tasks. Performance awards should not include participation in OTS projects as a criterion to not penalize highly performing employees that choose not to participate. However, an OTS project that matures to be fully or partially funded as a core activity certainly merits recognition as determined by the company.

Overcoming internal barriers for implementation of OTS projects

Bureaucracy and the tendency to create complicated implementation processes must be addressed upfront by the local governing organization to not create barriers to employees submitting a proposal for an OTS project. Proper communication and support from the regional entity's top leadership needs to reach the employee directly to bypass sub-organization cultures in which negative perception and lack of support from lower level management may be a barrier. Establishing a 'sandbox' facility that makes hardware, basic tools, software, 3D printing, etc., accessible to participating employees will go a long way in making OTS projects more attainable. This facility should have strict rules that prevent core work from being performed in it.

5.1.4. Conclusions

OTS projects are often creative/innovation spurring projects, initiated by highly motivated employees outside their daily core work, with the purpose of pursuing personal objectives, enriching their professional skills and generating professional opportunities. Therefore OTS projects may still be of great value to an organization, even when they do not necessarily result in successful products or financial revenue. Success criteria and factors are usually linked to the nature of the OTS project, and shall be stated at the beginning of the project itself (e.g. in the Statement of Work) to justify its feasibility and show the business opportunity to the Management - small investments in high-risk projects with the possibility of large returns. Time and resources allocated to OTS projects can be limited, therefore it is recommended to prioritize tasks and focus on essentials through efficient planning. Early project management of such OTS projects also helps manage potential internal and external risks and helps maximize opportunities for improvement. Size and characteristics of the organization (academia, small/medium companies, and large companies) may: influence the way OTS projects are implemented and resources allocated; define boundaries between core work and responsibilities; help overcoming and/or create additional internal barriers for the implementation of OTS projects. Recommendations for successful implementation of OTS projects are provided through our research, thus allowing us to justify the undertaking of OTS projects by organizations with different size and characteristics.

5.2. Topic 2: Learning partnership between young professionals and senior/retired aerospace professionals

5.2.1. Introduction

Knowledge Transfer (KT) is key for organizations to be able to maintain their unique critical knowledge and develop for the future. Globally, the number of older people is growing faster than any other age group (United Nations, 2015). Without a proper KT/learning partnership plan, an organization may face problems: loss of key technologies, an increase in mistakes and the need for rework, more safety incidents and a loss of quality and profits.

Although many advantages of KT are known, there is no one single solution for a learning partnership plan which fits all demands from the aerospace community. There are a variety of motivations for an organization to invest in KT. For example, the motivation may be for an employee to become more productive, for employee retention, to keep critical skills in an organization, to inform project management, plus many more besides. There are various different knowledge types that can be transferred, for instance explicit or tacit knowledge, and individual or social knowledge (Osterloh and Frey, 2000). Thus, it is not realistic to concentrate on a single learning partnership plan suitable for all organizations.

The objective of this report is to identify a clear process which can be followed to put in place a learning partnership plan between young professionals (YPs) and senior/retired professionals (SP/RPs). Since there is no "one size fits all" solution, the deliverable focuses on providing the elements of a process for implementing a learning partnership plan focussing on KT, a foundation which different organizations can adapt to their specific needs.

In section 5.2.3, the following research elements are summarized. These elements have informed the process for implementing a learning partnership plan focussing on transfer of knowledge:

- Learning partnership as a two way street;
- Existing projects and successes;
- Comparing perspectives of young and senior professionals;
- Identification of the right senior/retired staff and the right YPs;
- Criteria for success;
- Resulting benefits from learning partnerships for Programme and Project management at aerospace companies.

In section 5.2.4, the practical process for implementing a learning partnership plan focussing on Knowledge Transfer is described.

The analysis contained within this report spans both public and private institutions, but focuses more on larger organizations. Small organizations naturally transfer their knowledge informally and have less knowledge transfer issues. Both senior professionals (SPs) and retired professionals (RPs) are considered in the analysis. RPs are assumed to be retired from organizations but still remaining active in their sector and with an intensive role in their organizations, for example via alumni networks. The deliverable focuses on the space sector; however, the research field is not limited. Knowledge transfer issues are not only relevant to the space sector, but also to other industrial areas (e.g. IT, finance), where the suggestions of the analysis could be equally applicable.

5.2.2. Methodology

After group deliberation, it was decided that the scope of this report should be clarified from 'develop a learning partnership plan between young and senior and/or retired aerospace professionals, with a focus on knowledge transfer' to 'identify a clear process which can be followed to put in place a learning partnership plan between young professionals (YPs) and senior/retired professionals (SP/RPs)' to allow for the plan to be easily adapted to suit many different organisations. In the process of clarifying the topic several components of the study were further defined, including the general purpose, applicable organizations, timeframe, target age ranges, applicable industries, and tools to be utilized to collect information.

An initial literature review was conducted to collect background information on the topic and its elements, as well as to ensure that other studies undertaken by IAF project groups were not duplicated. Upon completion of the literature review and discussion of its products, the group members explored existing partnership programs within their respective organizations and consulted senior professionals and industry experts to collect knowledge gathered over the course of their careers. The interviews conducted were based on questions and topics of discussion that were identified as being most useful and impactful, then used to further support the research and direct the outputs of this research topic. The working group's final product is an easily implementable process that can be utilized by a wide range of organizations within differing industries, sizes and stages of development.

5.2.3. Research and Analysis of Topic Elements

5.2.3.1. Learning partnership as a two way street

While a classical mentorship scheme has clear benefits for the protégée, there is a similar gain for both the mentor and organization if the learning partnership becomes symbiotic. In addition to an accelerated learning process and inclusion for YPs, focusing on dual learning can unlock their full potentials whilst enriching the SPs/RPs with personal development, innovative thinking and career-enhancing exposure to recent technologies and methods.

The importance of KT strategies and mentorship programs has been the topic of countless studies, including past IPMC YP Workshop Reports (2012-2016). The literature typically identifies benefits for the YPs and highlights them as the receiving part. As demonstrated by the Return of Investment study in the 2015 IPMC YP Workshop Report, mentoring - even as a one way scheme - is a good investment for organizations.

In a dual learning partnership the SPs/RPs take an active role as the receiving part, benefitting from the collaboration with YPs. What YPs lack in experience and performance is made up for by a strong desire to learn, personal drive, ambition, and willingness to experiment. We refer to the work of past IPMC YP Workshop Reports for a study of KT and learning partnership from the perspective of the YP and focus on the following in our findings for learning partnerships as a two way street.

Interviews conducted with experienced professionals show they support the idea of a dual learning process with YPs. Important benefits identified include:

- Gain perspective and challenge routines by exposure to new ideas and methods
- Reflect on existing processes through YPs' different approach to tackling tasks, handling documentation, delivering presentations, searching for information, etc.
- Develop leadership skills and improve the ability to communicate and promote STEM
- Stay connected to the developing frontline of the field, including the most recent technology, methods, software/tools and theory
- Improve proficiency in assets of modern society that the YPs' generation grew up with, such as an internationalized mind-set, global awareness and use of social media
- Foster innovation induced by diversity in experience, as inventive approaches are increasingly important in a competitive space community

In addition, a dual learning partnership and KT plan has the following important implications for organizations and their YPs:

- Ensures continuity of projects and prepares the organization for the future
- Boosts innovation and performance by combining existing expertise and new ideas
- High mobility of YPs gives them the ability to take a role in knowledge management strategies as liaisons between different establishments

Both within and beyond the space sector, the benefits of mentorship programs are widely recognized. To enhance the classical one-way mentorship relationship into a dual learning partnership we suggest the following:

- Increase the inclusion and visibility of YPs and their contribution to the organization's missions. The objective is to improve overall collaboration, expose senior staff to the YPs' ideas and methods, and motivate YPs to stay in the organization post training
- Create a framework and atmosphere where KT from YPs to their senior colleagues is enabled and encouraged. Allow both formal and informal relationships to develop
- The YPs can provide access to their network and provide valuable feedback and suggestions to improve a company's or agency's recruitment process and entry level programs. In the increasing global competition this has the additional advantage of improving the cost efficiency as well as attracting the most talented recruits.

5.2.3.2. Existing projects and successes

Most organizations implement knowledge transfer programs of some sort. These programs mostly fall under the classification of a typical 'mentoring' scheme. However, there are instances of organizations facilitating the transfer of knowledge in other ways. A summary of the relevant schemes encountered during the course of this study is given below, grouped by focus:

Mentoring programs

NASA has formal mentoring programs in place for almost all of its centers, focused mainly on technical areas. There are also Young Professional groups at NASA centers, and many take part in reverse-mentoring programs or organise informal guest speakers from upper management to speak at events (IPMC YP Workshop Report Topic 5, 2014).

At Airbus, there are many different 'classical' mentoring schemes in place which target both the general mentoring of less-experienced personnel, as well as mentoring aimed at developing a person for a specific future role. Reverse mentoring schemes have also been trialled in recent years. In one such scheme, the younger person was encouraged to bring their perspectives and competences specifically on the topic of digitalization, to the mentoring session.
ESA has a mentoring initiative for newly appointed staff and for employees changing ESA sites to aid their transition into the organization. The relationship is relatively formal, and is linked to training.
A similar scheme is in place at OHB. An internal mentoring scheme pairs young professionals as well as new employees with more senior employees during their first 6 months after joining the company. The more senior mentor is responsible for introducing their mentee to the company's processes and culture, and also serves as a useful mechanism for intercultural exchange due to the diverse mix of nationalities of employees.

Knowledge Management programs

NASA has a large and well-established lessons learned system, LLIS (Lessons Learned Information System). Each lesson learned within the database describes the original driving event and provides recommendations that feed into NASA's continual improvement via training, best practices, policies, and procedures (Bell, 2017).
Similarly, JAXA has the LINKS (Lessons, INtelligence and Knowledge Sharing System) database for capturing lessons learned. The database is used in the spacecraft design review process where it is mandatory to cover lessons learned. JAXA aims to keep this tacit knowledge by organizing an independent evaluation team consisting of retired professionals using a reemployment system. The team serves as an advisory board for spacecraft design reviews and makes suggestions to young professionals based on their experiences.
Airbus has official, as well as more ad-hoc knowledge sharing initiatives in place. One element of the official Knowledge Sharing scheme consists of a dedicated facilitator meet with an outgoing employee and their successor, and facilitating the transfer of knowledge using dedicated tools. The scheme is versatile, and can be adapted to a number of different situations, for example, documenting project-specific lessons learned, or capturing knowledge and experience from a retiring employee.
ESA has a very well-developed Knowledge Management Strategy, details of which are presented in the 2016 IPMC YP Workshop Report (Topic 2). A dedicated Knowledge Management Office is responsible for the "identification, preservation and evolution of knowledge." One aspect of this Knowledge Management program is the "capturing of personal experiences and tacit knowledge" from a leaving or retiring member of staff so that it can be passed on and shared with the rest of the organization.
Knowledge Transfer takes many forms, and most organizations have some sort of program in place to facilitate knowledge transfer. These programs range from simple mentoring, or 'buddying' schemes, to complex Knowledge Management strategies.

From the analysis of previous KT projects, the following can be remarked:

- A mentoring, or 'buddying' scheme for new employees is a good way of introducing that person to the culture, values and working practices of an organization, and need not be overly-formalized.
- Reverse mentoring schemes allow for both parties to benefit from a mentoring relationship. It may be beneficial to have a specific focus for the mentoring, for example, to allow competences and ideas around digitalization to be transferred from the younger generation to the older generation.
- Knowledge Management can be complex and require significant effort and resources to maintain effectively.

5.2.3.3. Comparing perspectives of young and senior professionals

The literature review included several instances of IAF IPMC YP reports, highlighting early-career decision factors, the mindset of a young professional in the aerospace industry, and factors affecting their decisions, preferred methods of engagement, and knowledge exchange. These findings were supplemented by industry-specific reports and an interview with space historian Dr. John Logsdon.

Newly hired staff bring new ideas to the organization and the processes in place- an infusion of insight, which can prove extremely useful to the future of any team. Young professionals generally pursue aerospace as a passion, yet matriculate in relatively small numbers with a high dropout rate, especially when compared to fields such as informational technology. Early career aerospace professionals have shown a specific interest in prestige and seek to engage in the excitement that is inherent in the aerospace industry, as opposed to other fields. However, as millennials are significantly more likely than previous generations to switch careers more than once, as they are often frustrated by static organizations with a lack of upward mobility. Young professionals appreciate mentorship through social events and tend to display interest in organizations that feature a culture of engagement, and unique experiences, such as exchange programs. However, while specific young graduate programs and internships are beneficial for entry-level employment, they are often very competitive and only a few with experience can obtain them. Volunteer organizations such as the Space Generation Advisory Council (SGAC), which can offer networking opportunities with senior professionals and foster industry involvement, are very important for development.
Young professional training is very different today compared to how senior personnel was trained in the past, especially in larger and older organizations. Informal interviews may be preferred to sponsored training and orientations. However, secure environments may prevent informal off-the-record discussions. When considering intra-office dynamics, development of young professionals can potentially give rise to complications as young professionals may be viewed by superiors as an incoming replacement. Cultural compatibility, hierarchy and silos may also limit effective mentorship. One significant challenge for senior professionals and young professionals is the different frames of reference through which they operate given differing types of experience over their careers.

As an example, a senior with military background may find difficult training civilians. A persisting industry trend is a low presence of women and non-Asian minorities, especially in leadership roles. This industry characteristic may cause some difficulty for mentorship matches based on common culture, but the bonding of individuals within those groups may be stronger due to a shared experience.
Intra-generational knowledge exchange is difficult often requiring time and the development of close relationships. Process flows can simplify this phase. Ideally, the process should follow a cascading dynamic that includes both mid and top-level professionals. It is important to identify the goals of all stakeholders and establish the relationships on both the organization and individuals' ideal outcome. Senior mentorship, combined with other forms of training and support, help retaining young talent, increase job satisfaction, and improve workplace effectiveness. Professional mentorship must become a priority, and young professionals should actively seek it. The success of mentorship and exchange programs depends greatly on the capacity of the senior mentor to be open, available, willing, communicative, and patient.

5.2.3.4. Identification of the right senior/retired staff and the right YP

Building partnerships where the right senior/retired staff and young professional come together can be challenging, as mentioned above. The task of how to identify and connect two suitable partners depends firstly on the mentoring approach. As mentioned in the former YP workshops reports, the mentoring approach depends on the characteristics of the organization. An informal approach may be better suited for smaller organisations, but could also work in large companies/agencies provided they have an established culture of mentorship.

Formal vs. informal mentoring approaches
From the interviews conducted for this workshop we found that most big and well established companies of the space industry such as OHB, ESA, Airbus, have already implemented formal mentorship approaches. A shared point of view during the interviews regarding the mentoring approach is the importance of setting a clear framework. This framework should include among others clear objectives, a meeting schedule, meeting duration, confidentiality, rules, etc. A starting point for a formal mentorship could be a contract, where these points are outlined and in which the expectation and goals are clarified from the beginning. These agreements should leave nevertheless a certain freedom on self-organisation to mentor a Mentee. Depending on the mentoring approach the identification of the right senior and young professional staff differentiates. For informal approaches the identification, as well as the coming-together of mentor and mentee, happen in a more natural way. For formal approaches the need to identify certain matching criteria arises in order to establish a process.

Matching criteria
As interests differ depending on the type of mentorship a matching principle based on multiple criteria is necessary. From the interviews conducted one of the most important criteria when identifying mentoring partners is the willingness and motivation to teach and learn of the mentor and mentee, as well as a common interest in the job. When pairing mentors and mentees, some degree of personality and lifestyle matching is important as sensitivity to personality and differences is a worthwhile consideration. Some aspects to observe may include personal values, political affiliation, religiousness, style, hobbies. Additionally, a genuine interest, openness and trust are mentioned as important characteristics from both sides. Furthermore, it was also proposed to put one mentee with a team/multiple mentors in order to cover the broad interest of the mentee.

Mentoring networks
Connecting YP and senior professionals to an internal network of an organization is certainly easier than keeping connected to RPs. Therefore, RP alumni organizations should be integrated into a successful knowledge transfer program. Retired professional alumni leagues are often connected to organizations. Among other things, they have helped with orientation and training of employees. An organization shall ensure they maintain good relationships with retirees by, for example, inviting them regularly to company events. They should be valued and utilized as much as possible.
In conclusion, identifying key interests of senior professionals as well as young professionals will allow a successful pairing of mentor and mentees. Nevertheless, one of the most important criteria is a mutual interest to teach and learn.

5.2.3.5. Criteria for success

The defining of success criteria for a knowledge transfer plan from the start of its development is very important. This becomes the indicator for the evaluation of the KT plan, and enables feedback to be obtained and to improve the plan for the next iteration. KM, KT and mentorship have been discussed in previous YP workshops with limited discussion about the criteria of success. In the 2015 IPMC YP Report Topic 1, the group focuses on quantitative evidence for the mentoring program. They reviewed and analyzed the past YP reports and existing mentoring programs. Cost-Benefit Analysis (CBA) and Return of Investment (ROI) are introduced and the items to be considered as costs and benefit/return are specified. Several benefits are discussed and evaluated, with measurable improvements of important parameters such as the retention rate or satisfaction rate.
From a literature survey, CBA is recommended to be included in KT plans (Trautman 2013). It is important to make informed decisions about knowledge transfer investments and ROI is used as an indicator of the CBA to evaluate quantitatively (McGovern, 2001). Since ROI is the ratio of the benefit and the cost of the KT plan, it is important to define the measurable benefit and cost. Since the benefit is emphasized in the other sections, the cost of KT is investigated here.

KT is not free, and the cost is an unavoidable factor to be considered. In many cases costs can be measured easier than benefits. Typical examples of costs are: fees for external coaches/mentors, training costs of internal coaches, lost working time while individual KT is undertaken, and so on. In particular, many studies (e.g. Trautman 2013) emphasize the consideration of the time experts (SP or mentee) will spend on transferring knowledge.
In the interview research, most of the interviewees were concerned about the time of the SP used for KT. This fact is compatible with the literature research. SPs are usually busy with their day-to-day jobs and will need to specifically dedicate time to mentoring. The value of the SPs' time needs to be taken into consideration when constructing a knowledge transfer plan. There was no opinion from interviewees about the operational or development cost of a knowledge transfer system. However, it is known that many of the knowledge transfer/management systems currently in place use IT (web-based) services and therefore require operation/maintenance.
In summary, it is very important to set success criteria to evaluate a KT plan. A cost-benefit analysis can assist in making decisions about KT investment. It is important to define the measurable benefit in order to evaluate the KT plan; the cost is often easy to measure. The time of the mentee/experts is the most important cost according to both literature study and interview feedback.

5.2.3.6. Resulting benefits from learning partnerships for Programme and Project management at aerospace companies

The topic of resulting benefits from learning partnerships for program and project management at aerospace companies can be seen as a compilation of the successes and learning opportunities of the five elements discussed above. Previous IPMC YP workshops have included many reactions, both positive and negative, toward mentorship programs in the workplace. However, they did not cover the resulting benefits from learning partnerships to the same extent as the topics discussed above.

Our current understanding of these benefits derives from prior IPMC YP workshops, and the past and current literature on knowledge transfer and learning partnerships of aerospace corporations. In addition, our team conducted interviews with senior-level/retired aerospace professionals who could effectively speak to this topic and therefore see where our interviewers agreed and disagreed with the available literature.
Prior IPMC YP workshop reports have argued that 30% of people who left their company did so due to lack of mentorship programs, while others have revealed that adequate planning creates the most effective mentorship programs with the strongest results. Variables such as employee retention and time/cost constraints can have a great impact on the resulting benefits of an organization. Also, many of these benefits depend on what the company is seeking to gain. Larger companies may be more interested in obtaining effective knowledge transfer programs, while medium companies may be seeking other objectives. The results vary from organization to organization, but a commonly trending theme among the past reports shows that the more time and dedication the organization places into a mentorship program, the stronger and more effective the overall outcome is.

Throughout the interviews conducted by the delegates, questions on the resulting benefits of learning partnerships at aerospace companies focused on two main points:

- What balance of informal and formal partnerships were best, in order to help the Young Professional sector succeed?
- Have learning partnerships between senior-level/retired professionals and young professionals helped aerospace companies over the long-term?

With these two questions in mind, we gained first-hand knowledge on what senior level professionals find critical to successful learning partnerships, and insights into their own experiences throughout the years. The first question addresses a common debate that has occurred throughout mentorship programs – what balance (if any) between formal and informal learning partnerships was successful? From interview responses shared with the delegates, the majority believed that a combination of both is important and beneficial. Some responses believed that formal mentoring partnerships may outweigh the informal for many reasons. Formal partnerships may be more beneficial when an individual may not have the ability to instigate a mentoring relationship on their own, and that well-defined formal relationships can be very useful. Many interviewees agreed that aerospace companies have generally benefited from the broad range of mentorship programs that are available to them.

Benefits from learning partnerships and knowledge transfer programs are not limited to internal YP and SP professionals within a company. Much of the literature that is readily available on this topic, provides cross-cutting benefits from learning partnerships between companies and universities, government organizations who are and are not experienced with aerospace programs, along with many others.

What was also evident in the interview responses was that knowledge transfer/management and learning partnerships needed to be included from the very beginning. The benefits resulting from the programs therefore significantly outweigh the associated costs.

Overall, the resulting benefits of an effective knowledge transfer/learning partnership program depend on many variables. Also, it is important to continually acknowledge that what is a suitable program for one aerospace company may not be an effective approach for another. Therefore, the approach needs to take into consideration the broader requirements for the development of a knowledge transfer program. This is particularly evident in the aerospace sector where technical and operational knowledge transfer can save an aerospace corporation a lot of costs.

The benefits of these programs are therefore more or less dependent on the resources and time the aerospace company is able to dedicate over any given timeframe. Also, the learning partnerships are not vertical, but horizontal. We have heard from many interviewees that the most successful partnerships are those where not only knowledge is transferred to the YP, but the senior-level professionals are also able to gain new insights. These resulting benefits needs to provide a platform where senior-level professional, the YP, and the company overall are able to move forward in way that is helpful to all.

5.2.4. Development of Learning Partnership Plan

In this section a generalized process is presented that can be employed by, and adapted by, any organization wishing to put in a place an effective knowledge transfer program.

STEP 1 - Definition of Objectives

It has become clear throughout this study that a knowledge transfer program must have a clear direction and clear objectives. The overall direction and the specific aims of the knowledge transfer plan should be well-defined and made clear to all participants in the scheme prior to the knowledge transfer taking place. This allows expectations to be set, and will maximize the benefit to all participants. By defining objectives in this way, a set of measurables will be a natural by-product. Measurables are vital to ensure that the scheme can be monitored, and effectiveness quantified (see Steps 7 and 9).

STEP 2 - Identification of participants

Before any knowledge transfer program can begin, it is essential to identify the potential participants. Care must be taken to select those to whom knowledge transfer will benefit the most, and who can offer the most in terms of knowledge to be shared. The engagement of retired professionals shall also be considered by organizations. It is important to ensure a proper match in the process of pairing mentors and mentees for effective KT. While exact compatibility is not feasible, there are several consideration that will impact the success of the plan, such as ensuring physical proximity of mentor and mentee, and making sure all parties have sufficient time to commit to the scheme.

STEP 3 - Cost benefit analysis

Cost (financial and time) constraints must be taken into account before any knowledge transfer program begins. It is expected that any knowledge transfer program will require, at minimum, a small amount of resources to set-up and maintain. However, it is important to establish in advance whether the program will require any additional resources, such as a budget for implementing activities or for implementing significant improvements along the way. The time of participants is another important consideration. A knowledge transfer program which allows for participants to take part during working hours and without detriment to project booking codes will be arguably more successful than one which does not.

The program is only worth pursuing if the costs do not outweigh the benefits. At the start of the program, the benefits must be assumed, and a cost benefit analysis estimated. Once the program is underway, feedback should be collected and analysed to allow for the program benefits to be quantified and for a more accurate cost benefit analysis to be determined. Program benefits may be difficult to quantify, but in the case of the KT plan having the aim of improving the management of a particular project, the benefits may be quantified in terms of the cost savings as a result of an increased utilisation of lessons learnt. The cost benefit analysis process should be repeated throughout the lifetime cycle of the program to ensure that the knowledge transfer program is always of value.

STEP 4 - Initiating the Knowledge Transfer Partnership

The expectations and the goals of the KT plan shall be determined and shared with all the participants at the initiation of the scheme. The main objective of the KT plan should be stated in a few words so that everyone can keep it in mind. Sharing of not only the final goal but also the key milestones is an efficient way of driving the KT plan. The historical record of KT in the organization is also important information to be shared with mentors at the start of the KT partnership. In addition to this, the generational gap between YPs and SPs needs to be addressed at the start of the partnership as there may be potential differences in backgrounds and styles which may affect the KT. Sharing the overall background and objectives of the KT plan makes the direction and priority of the program clear to all participants.

STEP 5 - Nourishing the Knowledge Transfer Program

Once the KT program has been established it is vital to promote and nourish it. Publicizing the scheme and its benefits will ensure that it gathers momentum and keeps on going over the years, and can in addition serve as a selling point to attract new talent to the organization. Both at the startup phase and during the course of the KT program it is important to provide the participants with the necessary support and facilities to monitor progress and promote fulfillment of the objectives. In addition to the procedure of the formal KT program it is advantageous to encourage informal KT and mentorship bonding in order to improve the overall transfer outcome. Creating a framework and a colloquial atmosphere where discussion and exchange of experience and ideas between young professionals and senior colleagues and institution overall is enabled and encouraged will allow for both formal and informal relations to develop. Examples of methods to achieve this are given in the Annex to this report.

STEP 6 - Monitoring the Knowledge Transfer Program

As KT can be complex and require significant effort and resources to maintain effectively, a continuous and frequent monitoring shall be implemented and defined as checkpoints along the KT management plan. At these checkpoints, which could follow, for example, a standardized procedure, the KT plan manager can check in on participants to see that all the aims/objectives are being met, and that everyone is benefitting from the exchange as agreed on Step 4. Based on the outcome of this monitoring, the KT plan manager can define whether the mentoring agreement is proceeding as planned, or if a loop through Step 4 is necessary to further nourish the relationship or if an intervention is necessary through Step 7.

STEP 7 - Interventions

The success of a KT/mentoring program also depends on the relationship the mentor and mentee are able to create. Finding a good fit is key and both parties should not be afraid to say when things are not working out between them. Mentors and/or mentees should not feel that they are stuck with their KT partner. If the relationship is not fruitful, the KT plan manager or the Line Manager of the mentee should intervene as soon as possible to avoid wasting time and resources.

STEP 8 - Analysis/Feedback

When developing an effective learning partnership plan, it is important to provide analysis and feedback throughout. The program shall be analysed in terms of whether the knowledge transfer program is benefiting a particular project/program or the organization as a whole, whether the costs associated with the knowledge transfer are sustainable in the long-term, and whether the organization has the tools/personnel to continue the knowledge transfer program. The measurables identified in Step 1 will help with the analysis. In addition to this, it is important to ascertain the successes and failures of the program, as well as to identify areas for improvement in future KT programs. The outcome of the analysis may inform a redefining of objectives, subsequent cost benefit analysis, or ideas for improving the scheme.

STEP 9 - Improving the Scheme

Any feedback received from participants must be acted upon, with the aim of continually improving the knowledge transfer program. If the transfer of knowledge between YP and SP is not efficient with the current program setup, then measures must be in place to rectify this. Since improvements to the scheme may incur additional costs, CBA should be repeated.

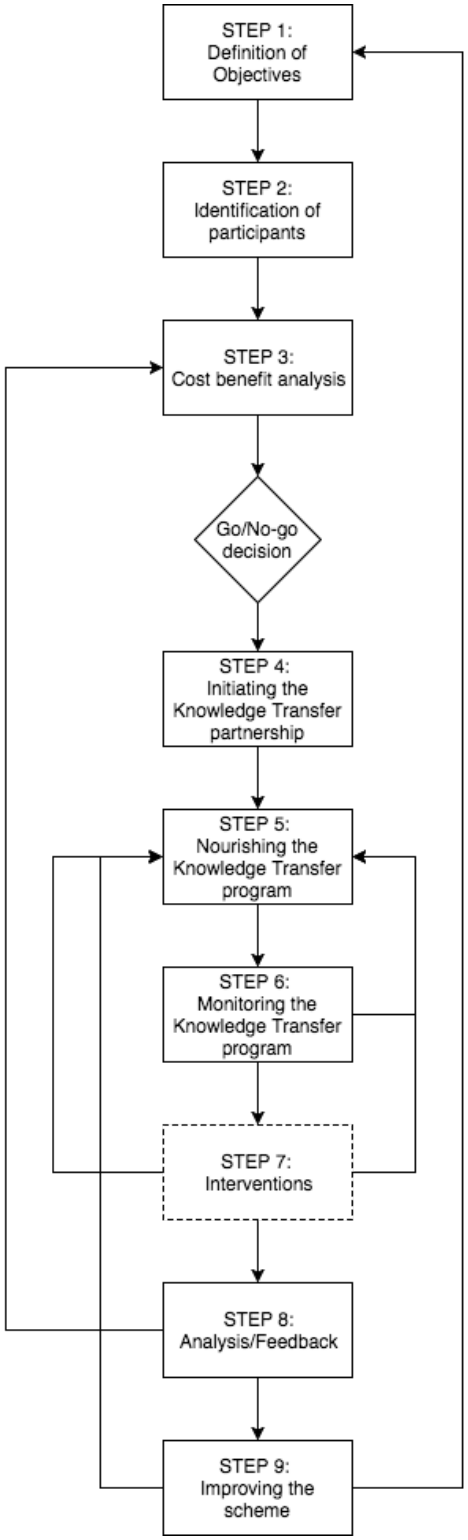


Figure 1: Nine Steps of the Learning Partnership Development Plan

5.2.5. Concluding remarks

This research topic has summarized the fundamentals of learning partnership plans involving both young professionals and senior/retired professionals, and has presented a clear design flow that can be followed in order to implement a knowledge transfer plan within an organisation. A design flow for a learning partnership plan has been presented in place of a rigid structure as there are a variety of demands from the aerospace company and no single, optimum plan suits all. An owner or sponsor of a knowledge transfer plan may follow the flow and construct a learning partnership plan which is optimum and efficient for its demand.
The following key points have been identified:

- There are clear benefits of enhancing the classical one-way mentorship relationship into becoming a symbiotic dual learning partnership
- KT can take many forms, e.g. formal or informal, depending on an organization's resources and demands
- It is essential to identify the goals of both sides (YP and SP/RP) participating in the KT program
- It is important to pair participants in the KT program in way that is most beneficial for the program
- CBA in the early development phase of the KT plan is important for developing a successful KT plan and for monitoring and assessment of the plan after deployment
- It is important to nurture the KT program and provide an appropriate set-up/environment to encourage effective KT
- It is important to continually monitor and improve the KT program to ensure that it remains effective and of maximum benefit to the organization

The benefits of a learning partnership are clear, both qualitatively and quantitatively, but it is not simple to conduct an optimum learning partnership plan. In this report, a straightforward way to tailor a learning partnership plan to an organization's demand is presented. This process may accelerate KT in organizations and sustain their advantages for future growth.

5.3. Topic 3: Reshaping the Space Industry 4.0 - Young Professionals' recommendations

5.3.1. Introduction

Recent times have been marked by a proliferation of entrepreneurship alongside increasingly rapid developments in digital technology. The application of advanced networking and data exchange technology to the manufacturing industry has been termed Industry 4.0. This fourth industrial revolution uses digitalization and digital networks to create intelligent networking of products and processes along the value chain. Similarly, Space 4.0 refers to the next generation of conducting space activities.

Following on from the eras of astronomy study, the Mercury, Gemini, and Apollo missions, and the International Space Station (ISS) (European Space Agency, 2016), Space 4.0 is driven by, but not entirely focused on, digital technology advances. Space 4.0 will bring together the traditional government-led space programs and the existing and new commercial entities entering the space industry. Hence, the space industry is facing a period of adjustment, including how to handle currently-funded projects, how to invest in new private ventures, and how to manage these new interactions. In response, the European Space Agency (ESA) has pledged itself to evolving to Space 4.0 by committing to innovate, inform, inspire, and interact (European Space Agency, 2016). This indicates that Space 4.0 will be realized through changes to business practices—project and program management (PM)—rather than changes to technology alone.

The aim of this report is to:

- define Space 4.0 in a context useful for the International Astronautical Federation's International Project/Program Management Committee (IPMC);
- assess the ways in which the space industry can evolve into Space 4.0, including identifying challenges, opportunities, and new approaches; and
- recommend how PM at aerospace companies can benefit from and adapt to Space 4.0.

Space 4.0 is a broad topic and has many different associations depending on region and industry. For the purposes of this report, it was important to focus on aspects of Space 4.0 that could translate to useful recommendations for the IPMC. Group 3 researched, brainstormed, and mind-mapped Space 4.0 to identify the most relevant aspects. The resulting mind-maps are shown in Appendix A. The initial mind-map explored the influences affecting Space 4.0, PM aspects, different understandings of Space 4.0, potential benefits, and ideas around how to achieve Space 4.0 in practice. The second mind-map then identified and linked the key elements from the first in order to define Space 4.0.

Using this mind-map, Group 3 defined Space 4.0 as finding the balance between government and commercial space programs, specifically:

- the changes required to facilitate the shift from regional space efforts to global collaborations;
- enhanced communication resulting from Industry 4.0's affordance of connectivity; and an increase in risk appetite resulting from the competition of commercialization.

The following discussion focuses on each of these Space 4.0 elements in turn to provide observations on how they help the space industry evolve to Space 4.0 and recommendations for project management.

5.3.2. Project Management in Global Space 4.0 and the Role of Change Knowledge

5.3.2.1. The Four Rooms of Change

Space 4.0 is a rapidly changing environment. There has been a steady shift from 'governments providing over 80 per cent of the revenue in 1973, to commercial industry, in 2015, generating three quarters of the revenue for the sector (Australia's Space Industry Capability, 2017). To approach global Space 4.0, a change in the space industry's culture and mindset is essential.

The Four Rooms of Change Theory by Claes Janssen can be applied to describe the different stages that the space industry will encounter in the transition to Space 4.0 as it is expected to occur in many of the different aspects. The four rooms—or psychological states of mind—are Contentment, Self-Censorship and Denial, Confusion and Conflict, and Inspiration and Renewal (Janssen, 2017). It could be argued that some areas of the space industry were in the Contentment Room; relaxed and in control of the situation, verging on stagnant (Musk, n.d.). Bringing the commercial sector into the space industry during recent years has resulted in some of the larger, more established Agencies and companies to enter the Denial or Confusion and Conflict Rooms. Certain mindsets, as well as competing commitments, can be resistant to change and prevent the industry from moving forward into the Inspiration and Renewal Room. It is important to identify the hidden influencers and address the hidden competing commitments in the industry in order to bring forth the change to Space 4.0.

NASA is an example of an established space agency that is now moving towards the Inspiration and Renewal room. Since 2005, NASA has been working successfully with commercial companies to form partnerships, some of which have transitioned to full contracts (Hackler & Wright, 2014). SpaceX (USA) and Orbital Services Corp. (Orbital ATK, USA) were two such companies under the Commercial Orbital Transportation Services (COTS) program which has ultimately led to two new US medium class launch vehicles and two new automated cargo spacecraft (Hackler & Wright, 2014).

Traditionally, NASA has developed an internal design before approving it to be contracted out. However, COTS was the first of its kind at NASA that enabled private companies and startups to retain their intellectual property (IP) (Abbany, 2016). Alan Lindenmoyer, the Program Manager who created COTS, explained how NASA had to redefine the original Space Act Agreements (SAA) and change the way NASA interacted with commercial companies (see Appendix B). By becoming an investor in commercial companies as opposed to a service purchaser and by minimizing the requirements to open trade space, NASA has enabled commercial companies to form part of the Space 4.0 solution and 'give private commercial industry a chance to prove that systems could be developed more quickly and cost effectively' (A. Lindenmoyer, personal communication, 2017).

5.3.2.2. The Sigmoid Curve

Another approach to assess the space industry's pathway to Space 4.0 is by using the Sigmoid Curve (Figure 1). The Sigmoid Curves are mathematical curves by which the life cycles of businesses can be demonstrated and analyzed.

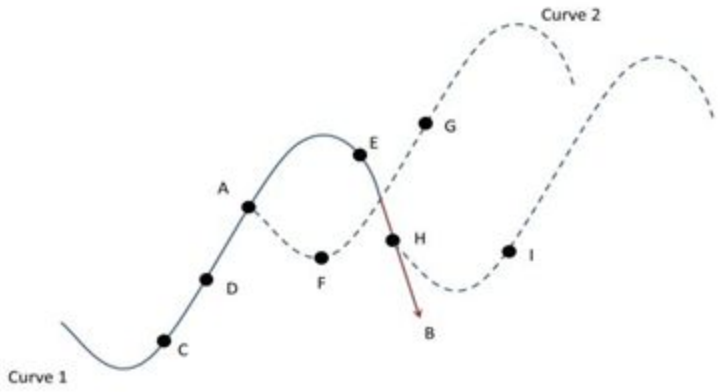


Figure 1 Sigmoid Curve depicting a classic two curve model (WLA, 2016)

These curves are intended to recognize the overall need to continually evolve and to encourage businesses to innovate even during periods of successful growth. Here the Sigmoid Curve is applied to NASA, JAXA, and ESA to see where each lies in the Curve 2 transition point for global Space 4.0.

As discussed, NASA began looking to create partnerships with the private sector with the creation of the COTS program in 2005. This occurred six years prior to the retirement of the Space Shuttle. The COTS program was revolutionary for NASA and created an agency-wide shift in how to further advance space exploration. This shift in NASA's mission was realized by the investment in private companies to make headway in the exploration of space while simultaneously maintaining NASA's dominance within the industry (Hackler, 2014). Further still, it showed their initiative to innovate during a period of stability and strong funding. This embodies what the Sigmoid curve seeks to demonstrate in terms of effective transitions; that is, the transition from Curve 1 to Curve 2 through Point A.

ESA has had a period of stability with the Ariane launch program, demonstrating more than 220 Ariane flights since 1979. In 2014, ESA contracted ArianeGroup to develop Ariane 6 for launch in 2021 ("Ariane 6", 2017). Even though ESA demonstrates tremendous stability through the Ariane launch program, it has been working towards advancing its efforts to develop more partnerships with the private sector. Another great example of ESA and private sector partnerships is the ICE Cubes Service, set to launch in 2018. This is the first commercial European opportunity to conduct research in space aboard ESA's Columbus laboratory on the ISS. Additionally, ESA currently has proposals from the private sector for current ISS missions, post-ISS missions, and lunar missions ("Partners for Space Exploration", 2017). Given ESA's continued internal development currently in parallel with their recognition of the need to development external partnerships, they would also fit near Point A of Curve 1 in the Sigmoid Curve analysis.

To date, JAXA has contributed to the completion of 11 satellite and spacecraft missions with 16 missions currently in operation and six more under development ("JAXA | Missions", 2017). In 2007, JAXA's primary launch vehicle—the H-IIA—was transferred to private ownership by Mitsubishi Heavy Industries, Ltc. (HMI). H-IIA's successor, H-III, is currently being developed by JAXA and HMI. Anticipated for a 2020 launch, H-III will be JAXA's first commercially viable launch vehicle. By transitioning the developmental work of H-IIA and H-III to HMI, JAXA and its associated companies have had capacity to offer development and manufacturing services to customers producing commercial satellites for a variety of scientific purposes (Launching Spacecraft for Customer Around the World, 2017). Given JAXA's current growth in the global space economy and their strong dependence on and support of commercial partnerships and ventures, it can be concluded that they too are considering the next phase of the future into Space 4.0 during a period of success. This too places JAXA at an optimal Point A on Curve 1 in a Sigmoid Curve analysis.

5.3.2.3. Artificial Intelligence in Project Management

Artificial Intelligence (AI) has been progressing rapidly during recent years. It helps humans' decision making based on quantitative analysis of vast amounts of data. AI will be a dependable tool for PM as the latter is a very complex process that has many dimensions and deals with large amounts of data. Many PM tools already use AI. For example, ZiveBox is a software which uses AI to determine the length of a task in order to examine the productivity of each team member. Rescoper also uses AI for automatically scheduling tasks based on workload and task duration. ClickUp is a recently developed tool which can predict the best team member for a task, automatically tags users in comments based on relevancy contexts, estimates correct task time, etcetera (Burger, 2017).

AI in PM is becoming an active area of research with new, useful methods being developed rapidly. In terms of knowledge management, an ontology-driven case-based reasoning system is proposed, which can measure the similarity between knowledge collections even though they were written in natural language (Martin, 2012). New techniques are being researched for a branch for project portfolio management. The requirement to handle independent concurrent projects is enabled by Fuzzy Inference and Artificial Neural Networks for these complex and non-linear problems (Ali & Aspen, 2014).

AI will likely progress and undertake a greater part of PM functions in near future. Nevertheless, it should be highlighted that an aspect of PM remains with the responsible project manager. Management skills such as creativity, intuitiveness, and interpersonal skills are still required (Ciklum, 2016; Janowski, 2017; Can Machines Deep Learn Project Management?). As AI technology is integrated, emotional intelligence in PM will become increasingly important.

5.3.2.4. Summary

The transition of the space industry into the global Space 4.0 environment can be modelled using the Four Rooms of Change Theory, which suggests that a move into the Inspiration and Renewal room is required to facilitate transition to Space 4.0. An understanding an organization's psychological state of mind will be required to assist progressing the transition and to counteract the barriers to change. Application of the Sigmoid Curve to the major space agencies NASA, ESA and JAXA has found that these organizations are now poised for change. The adoption of evolving PM techniques, such as artificial intelligence, have the potential to assist programs with this change; however, these powerful tools are not a substitute for the human management aspects required of the project manager. The human element of project management remains, so it is essential for project managers to believe in the global Space 4.0 transition and lead the industry through this change.

5.3.3. Communication, Collaboration, Connectivity

5.3.3.1. Background

The Space 4.0 communication environment will be one of collaboration and connectivity between government programs, private projects, and industry. Knowing how, when, and what to communicate will become an increasingly essential element of project management in the aerospace domain. Communication makes up 70 – 90% of a project manager's work (Project Management Institute, 2008), so it follows that poor communication can lead to project failure.
Table 1 provides a simple list of types of communication models and methods from which communication modes are derived. Standard communication models focus on the process of communication: transmission (linear message); transactional (a conversation); and interactional, a conversation between multiple senders and receivers (Mishra, 2017; Logan, 2001). Main project management communication methods are 'push' (whereby a sender is actively providing information to a receiver), 'pull' (in which information is essentially archived for a receiver to access), and interactive, which aligns with transactional and interactional models (Monnappa, 2017). Traditional PM communication methods are often considered as linear (Brantley, n.d.).

Models	Methods	Modes (not exhaustive)
Transmission	Push	Reporting, directed (one-way) emails, directed (one-way) phone calls
	Pull	Libraries, policies, processes
Transactional	Interactive	Phone conversations, video conferencing, meetings (but not always), instant messaging
Interactional		

Table 1 Communication Types in Project Management

Within PM, the main communication considerations are the type of process (as above), the direction of the communication flow (e.g. hierarchical), and the context in which the communication will take place (Narula, 2006). Considering these elements determines the most appropriate mode of communication at a given time. This, however, is where project managers reportedly fail (Kliem, 2007). The key issue facing project managers in this area appears to be choosing the correct mode (media/tool) and the correct information for the given context and audience. If a Space 4.0 communication environment provides even more modes and data, how are project managers to adapt?

5.3.3.2. Establishing a Baseline

A questionnaire was developed to understand how communication currently affects day-to-day space projects and programs. The questionnaire was distributed among Group 3's workplaces around the world. At the time of writing there had been 62 responses received, 55% of which were from project managers with the remainder from team members. For context, most respondents worked within project teams of 1 – 10 people, worked to produce or acquire hardware, and worked for sub-contractors or agencies. Aerospace related projects were targeted, although the respondents also had experience in mechanical engineering, academia, and the software industry.

Modes. Email was reported as the most widely used mode of communication, but also the most time consuming. More efficient ways of exchanging information quickly and informally while still being on record is required. Instant messaging was the only relatively new mode of in-team communication used often. Physical meetings, conference calls, and phone calls were also highlighted. However, these modes are ephemeral; often only a small portion of the information is recorded, potentially incorrectly. Even though these methods are valued, methods of collecting data during those meetings and phone calls should be explored. Communication modes most used within teams are also usually chosen when communicating to outside stakeholders (besides the public), although sharing information through technical reports and websites are also used for this purpose. For communicating to the public, websites, social media, and press releases are most commonly used.

Plans. Communication plans are one of the most important tools available for PM communication. Despite the majority of the respondents working in projects of 10 or fewer, project team members were largely unaware of the existence of a documented communication plan for their project, despite 44% of project managers claiming to have a documented plan.

Software and data. Software is a key aspect of Space 4.0 as it is entangled with Industry 4.0, in which connectivity and advancements such as the Internet of Things are central. However, only 60% of manager respondents used software tools (besides Microsoft Office) to aid their work. Interestingly, project members were unaware of software tools being used for project management. Software tools or software tool usage may need to be improved to adapt to Space 4.0. For example, while the amount of data that one can access is increasing rapidly, better data management is required to keep track of everything that is relevant to a project.

Complaints. Project members, but not managers, responded that they find meetings and reporting inefficient. The former is in line with a (failing) transmission communication model: the project manager is delivering one-way communication that is not well received by the members.

Misunderstandings, waiting for or chasing replies, and repetition of information were also identified as areas in which respondents lose time. Further, while respondents with experience in fields other than aerospace did not find differences in the manner of communication between industries, some did raise concern over the large number of people involved in space projects and the associated layers of management. This, too, can prohibit effective communication.

5.3.3.3. The Space 4.0 Communication Environment

Solutions to the challenges highlighted by theory and the questionnaire are required for PM to adapt to Space 4.0. The solutions will not be special new types of communication. Rather, there are many existing communication methods available that need to be better understood and used more effectively in project settings.

Application of accepted theory. Developing live communication plans is a relatively simple and highly recommended means to aid PM in adapting to Space 4.0. This requires formally recording all project stakeholders, the available and appropriate modes of communication to each, the type of information each requires, and the times at which each stakeholder requires communication. Evaluating appropriate modes of communication ('how') and the types of information required ('what' and 'why') by each stakeholder requires an understanding of fundamental communication theory. Having a documented plan allows all members of the project team to understand the project's communication requirements, facilitating a connected and collaborative communication environment.

Retention of ephemeral data. Traditional forms of communication, such as meetings and phone calls, remain important due to their human factor. However, without a way to record the data, messages can be lost or misunderstood. With the availability of the internet and the possibility to store huge amounts of data, this is no longer a futuristic idea. Universities across the world are already recording and storing lectures. Software packages such as WebEx, Skype, and Google Hangouts provide audio and video conferencing with recording options. There is also software available to record landline and mobile phone calls. However, is this legal?

Many government bodies have rules in place to protect individuals' information. However, if the rules are followed it is possible to store the video and audio data and thus record the meetings and phone calls (see Article 30 of European Union, 2016). One rule states that all stored data should have an end date attached to it, after which the data should be deleted. Since privacy rules differ per country, it is recommended to check the law when it comes to recording and storing conversations. Automated voice-recognition software that transforms the spoken word into written transcripts could provide a workaround to privacy law. Despite this, retention of personal expression to deduce meaning would still be useful.

Sharing information through databases. Many projects currently rely on written reports that must be shared among and read (and understood) by project managers. The questionnaire indicated that much time is lost writing reports. Should reports need to be generated, this could be accomplished through automated programs. This concept is similar to what is often done in software engineering, where comments in code are directly translated into documentation on the code itself. Some software packages are already available that could fulfill this purpose, but since many companies work with their own reporting templates, it could be beneficial to have a distinct database linked to a special report generating tool specific to a company.

Databases alone can be used to present information in certain formats. If this happens to be an online database, non-internal stakeholders can access information directly without waiting for a report. However, direct access to information may not deliver the required or desired message to the stakeholder. Alternatively, if the same kind of information is requested by different people, or a stakeholder simply wants an overview, the information could be presented in a project wiki. Creating such an internal wiki (preferably on a company server) can take some time, given the extra effort to reproduce information in the new format, but it can be a useful and efficient way of both storing and presenting information.

Challenges. Firstly, the space industry is subject to International Traffic in Arms Regulations (ITAR) control, in which information exchanged is confidential and cannot be stored on (public) cloud-based servers. For recording meetings, WebEx provides the possibility to save files on your own computer. However, robust security measures must be in place to control both the access to the data and the storage location of the data; the data must be stored in the same country as the owner company is located. Secondly, data management will become increasingly important in the Space 4.0 communication environment, as will continuing to accurately define and maintain project baselines throughout project lifetimes. A data management team, including configuration manager, is recommended for securing and tracking data and ensuring that all applicable laws are respected.

Opportunities. The main advantage of both recording meetings and phone calls and having open access databases of information is that no information is lost and can always be retrieved. Direct access to data can be made easily accessible through a project wiki for those stakeholders who require it. Using automated reporting software, reports could still be generated if needed with all the information required drawn from the backend database. Data itself can be automatically uploaded to those databases by sensors connected to the company internet; this is where the IoT becomes highly useful. When all sensors in, for example, test equipment is connected to the same server or database, the data can be stored live and inspected while tests are happening from any location. Note, though, the potential peril of having project stakeholders view live data. Again, robust data management and access control will be important to maintain.

The theory and questionnaire results observe that there are current challenges for PM communication that Space 4.0 will affect. To reach Space 4.0, these different communication challenges should be addressed and overcome. Information will become be accessible in real-time everywhere, so communication must become more efficient. The recommendations presented in this section will help project and program managers to propel their projects into the next space revolution. Note that, driven by cost efficiencies, other industries have made faster progress in this area; best practice solutions may be found outside the space industry.

5.3.4. A New Era of Risk

5.3.4.1. Background

Risk management is here defined as the process of identifying, assessing, and mitigating risks and is a crucial element of project management. A risk is any uncertain event or condition that could cause an impact (usually negative) to the project if it occurs (Project Management Institute, 2008).

The Project Management Body of Knowledge (PMBOK) Guide states that the aim of the risk management processes is to proactively address risk throughout projects; without this approach, risks are more likely to have a higher impact and could lead to project failure (PMI, 2008).
Space projects have different or higher risks compared to other industries due to the inability to access or repair items once in space and the extreme environment of space. Human spaceflight and space debris also add factors to consider relating to the safety of people and equipment.

5.3.4.2. Risk Management: NASA and ESA

Established space agencies such as NASA and the ESA have stringent standards in place to mitigate many of the negative risks that are associated with space travel. NASA Academy of Program/Project and Engineering Leadership (Appel) Academy Director (NASA Appel, 2011) stated that 'we have highly sophisticated tools such as probabilistic risk assessments (PRA) that help us quantify and interpret risks with as much precision as possible… we have rigorous reviews that operate under a governance model that strives to give everyone a voice in making the case for or against key decisions'. Standards that have been accepted for use in the space industry include NID 8000-108, PMBOK Guide, ISO 9000, and AS9001. A NASA contractor commented, though, that different systems are used by different contractors, making standard risk management difficult. (D. Worman, personal communication, August 28, 2017). Comparatively, in the European institutional space market, the European Cooperation for Space Standardization (ECSS) is generally a requirement placed on companies (Sagath, Van Burg, Cornelissen & Giannopapa, 2017). Reviewing lessons learnt is also important in this field. The NASA Appel booklet of key mistakes made, written by interviewing successful senior managers, is an excellent example of knowledge transfer to mitigate future risks.

5.3.4.3. Risk Management: Industry 4.0

The 2016 IPMC YP Workshop Report discussed Industry 4.0 and its potential for the space industry (IAF-IPMC YP Workshop, 2016). Industry 4.0 is also referred to as 'smart manufacturing' and the main advantages are to increase performance and reduce costs on a mass market scale. The report identified that Industry 4.0 can help to reduce risks through data sharing and data mining; converting the real world into the digital world allows for easier data analysis and processing. The downside of this is that there could be increased risks related to cyber security. The most obvious application for Industry 4.0 approaches is in the production phase; however, this could also be applicable to operations and service applications.

5.3.4.4. Risk Management: Space Startups

Contacts from a small selection of startup companies provided feedback on questions relating to how the company handles risk management; particularly, whether risk averseness is a problem. They were also asked for suggestions on how to encourage future development within the aerospace industry.

Asia Pacific Region Startup: A source from a space startup company in the Asia Pacific region stated that their company had no formal risk management procedure or any risk register (Anonymous, personal communication, August 12, 2017). This company had a major focus on trying to move their market quickly and, if a problem occurred, they would work on it until solved. This source believes that the approach to risk in a startup is much different than in more established companies or government since they are generally pre-revenue and do not need to be as concerned with answering to stakeholders and making large profits. There are also constantly new developments that makes identifying and analyzing potential risks difficult.

Neumann Space: Neumann Space has a more formal approach to risk management because it needs to work with existing companies and is planning to test items on the ISS (P. Neumann, personal communication, August 13, 2017). Neumann Space works closely with their partners and uses common standards; generally, ECSS for operation and documentation. Neumann sees that risk averseness is common within the space industry and that this is understandable due to the high costs involved. Neumann Space works to reduce these concerns by following appropriate procedures and aiming to operate effectively at a lower cost and shorter time frame. Neumann identified that a potential improvement for the industry is a relaxation of insurance requirements for low-risk small payloads. Neumann suggests that either using waivers or government underwriting could help to reduce the cost and encourage development.

Dutch Startup: A startup in the Netherlands stated that financial risk was their main risk and directly impact their ability to maintain their business long term (Anonymous, personal communication, August 15, 2017). To mitigate this risk, this company is very careful about their expenses and constantly works on improving the details of their business model. For helping startups, they recommend allowing access to micro-grants and investments without the need to write 50-page proposals and having a more streamlined process. Using government grants combined with Angel investors could help to encourage investment and reduce the risk to investors.

Fleet Space Technologies: Fleet is relatively new company, founded in 2015, and they are working on putting together a quality assurance program that will include identification and mitigation of key project and business risks (A. Barton, personal communication, September 13, 2017). They do not see risk averseness as a problem since they are backed by venture capital and there are many other competing companies with similar business models. Their main concerns are to focus on aggressive self-imposed deadlines and to make progress in areas such as regulations, partnerships, and customer engagement. Fleet says that, to stimulate space startups, governments should allow for fast and cheap failures as learning opportunities and act as an anchor customer, focusing on finding solutions to meet identified needs rather than setting detailed design requirements; the NASA COTS program is a good example of this.

Feedback from space startups has identified that difficulty securing funding, acceptance of lower level technology and high costs of insurance are key issues. This may lead to an increased use of Commercial Off-The Shelves (COTS) components, with lower reliability, counterbalanced by an increased number of redundancies (e.g. mega-constellation of mini/micro satellites). Support in terms of streamlined funding processes and flexibility relating to insurance and technological readiness requirements would be beneficial. Therefore, it is recommended that the following be explored:

- common risk management standards and processes between companies;
- streamlined processes for applying for government and/or Angel investor funding; and
- flexibility with respect to insurance and technology readiness level for small scale projects.

5.3.5. Conclusion and Recommendations

Through framing Space 4.0 in the project management context, three key high-level potential benefits of Space 4.0 for PM have been identified. This report has analyzed these Space 4.0 elements - global collaborations, enhanced communication, and new approaches to risk management - and discussed the resulting suggested future developments. The following recommendations are made in the spirit of change and progression into a global, connected, and actively working space industry:

- The major space agencies are currently poised for change. Delaying change towards Space 4.0 could result in decreased innovation.
- Understanding individual space organizations' psychological state of mind is required to counteract any barriers to change.
- While the use of AI as a PM tool continues to mature, the human management aspects remain integral in leading the industry transition to Space 4.0.
- Communication plans must become mandatory in space projects to better cope with the increased number of communication modes and types.
- Recording or automating transcriptions of otherwise ephemeral communication modes should be considered to avoid losing data and time in meetings or on phone calls.
- Developing organized databases that either feed a front-end such as a project wiki or be used to automate reports would save much time in communication.
- Data and configuration management teams must be invested in; they will be essential in Space 4.0 PM.
- Common risk management standards and processes between companies must be appointed.
- Streamlined processes for applying for funding must be sought.
- Flexibility in terms of insurance and technology readiness level must be considered for smaller scale projects.

6. Concluding Observations

Every year the IPMC YP workshop topics are carefully chosen in close collaboration with the committee members. The topics represent the interest and challenges that aerospace industry and organisations face on a daily basis.

2017 Marks the first year that a few selected IPMC Committee members have supported the Workshop Delegates throughout their discussions and research to come to the most optimal conclusions and recommendations. We have seen that this collaboration was very much appreciated by both the delegates and the Committee Members. We thank them again for their effort.

We invite the IAF's IPMC committee members and the Young Professionals to further discuss the findings of these topics and find a way to implement the recommendations in their respective organisations. The recommendations are evident, well thought out and based on the examples, experiences and input from today's way of conducting and developing business.

7. List of Workshop delegates

Organisation	First Name	Last Name
SGAC	Roberto	Aguilar
UAE Space Agency	Mohammed	Alameri
UAE Space Agency	Heyam	Alblooshi
UAE Space Agency	Abdulla	Alshehhi
NASA	Ivan	Anchondo
NASA	Elizabeth	Barrios
SGAC	Chris	Beauregard
Airbus	Julie	Blond
Boeing	Alexander	Bowen-Rotsaert
US National Academy of Sciences	Mia	Brown
ESA	Noella	Cacciotti
Nova Systems	Fiona	Carter
Airbus	Sian	Cleaver
SGAC	Carmen Victoria	Felix Chaidez
Nova Systems	Dominic	Hardy
Beihang University	Chongwen	Jiang
ESA	Amanda	Kiilerich
JAXA	Masaru	Koga
Nova Systems	Emma	Kohlhagen
Nova Systems	Erin	Madden
SGAC	Kavya	Manyapu
Space Cooperative Inc	Yalda	Mousavinia
ESA	Johanna	Pardo
NVR	Stacha	Petrovic
University Amsterdam	Daniel	Sagath
ESA	Joost	Vanreusel
Boeing	Parekh	Viha
NASA	Alexander	Walts
JAXA	Tomohiro	Yamaguchi

8. Previous Workshop Reports

2012 IPMC YP Workshop Report

2013 IPMC YP Workshop report

2014 IPMC YP Workshop report

2015 IPMC YP Workshop report

2016 IPMC YP Workshop report

9. Acknowledgements

The 2017 IPMC Young Professional Workshop has greatly appreciated the support of Boeing, JAXA, MBRSC, Arianegroup and SAS. The WOC would like to warmly thank the sponsors continued support to the Young Professionals Workshop.

The WOC is looking forward to the future with the preparation of the next workshops and the continuation of the implementation of previously presented recommendations. The WOC, in close collaboration with the IPMC, strives to advance on the development and empowerment of the next generation space workforce.

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