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THE FAIRY HUMAN TOUCH OF A CONCURRENT DESIGN TEAM LEADER

Gwendolyn L. Kolfschoten[(1)], Ilaria Roma[(2)]

*[(1)]**Starion Group***
Schuttersveld 2, 2316 ZA, Leiden, The Netherlands
Email: g.kolfschoten@stariongroup.eu

*[(2)] **ESTEC – European Space Research & Technology Centre***
Keplerlaan 1, 2200 AG Noordwijk, Netherlands
Email: Ilaria.Roma@esa.int

INTRODUCTION

Concurrent Design is an approach developed by the European Space Agency to support early phase design teams in creating a first assessment of the feasibility of a mission. Concurrent Design nowadays heavily focusses on Model Based System Engineering and rigorous fact-based analysis and simulation. However, in the end, the magic of Concurrent Design is created by team collaboration, and therefore, team dynamics are at the heart of a successful study. This paper will zoom in on the role of the Team Leader in building a team, creating effective team dynamics, and supporting the team not just in 'doing the work' but especially also in creating shared understanding, inspiring creativity and thinking about the design challenges from multiple perspectives and navigating challenges and disagreements. Although such challenges happen in any team, and are subject to any leadership role, they are enlarged and emphasized in the pressure-cooker of concurrent design environment. In CD studies, 8-10 sessions is all the team has to create a full scale assessment of the design challenge, leaving little time to 'let things pass' or to 'grow into it'. The team needs to collaborate effectively from day one, and issues need to be resolved as soon as possible in order to keep the team happy and effective.

When done well, Concurrent Design is fun, participants enjoy the sessions an get energy from their progress and achievements. The role of the Team Lead is to unleash this collaborative environment, without being given too much time for teambuilding and group processes as the focus is on the mission.

In this paper we describe and compare the case studies from two seasoned Team Leads working in different domains: the ESA Concurrent Design Facility and the Dutch Ministry of Defence. They each describe a case in which their teams were successful in a challenging design task, and how they supported the team, nudging them to come up with creative solutions and well-analysed decisions, while at the same time building the team. This requires creating an effective atmosphere, with psychological safety, inclusiveness, shared understanding and ownership to help the team creating a state of 'flow', with high motivation that leads to productivity and creativity.

THE CASES

Case 1 the Ice Giants – Team Lead Ilaria Roma

This Concurrent Design study was performed at the ESA CDF. The objective of the study was to investigate the feasibility of a mission to explore of the two 'ice giants': Neptune and Uranus. The study is a typical example of an ESA CDF endeavor and resulted in a key ambition listed in the Voyage 2050 long-term planning of the ESA Science Program [1]. The team explored the feasibility of five different options for an orbiter, a probe, both targeted to either Neptune or Uranus, and a moon lander targeted to Triton (Neptune moon). The objective of the mission was to gain knowledge about the structure and composition of the celestial bodies.
The Ice giants are on a very far distance from Earth resulting in high technical challenges with respect to power and data transmission. Furthermore, radiation harnessing, long lifetime - and therewith reliability of equipment - are among the key challenges of the design.

Case 2 the new maintenance concept – Team Lead Gwendolyn Kolfschoten

This concurrent Design study was performed at the Dutch Ministry of Defense as part of the CD pilot phase [2]. It concerned the introduction of a new weapon system, that would be used by different departments. (e.g. more than 1 end user). The design of the system was modular, which was for these departments a new way of working. It entails that the system can be repaired during operation in a matter of hours. Repair in this case requires the exchange of components. The objective of the study was to write a plan for the Integrated Logistic Support of the system; everything that needs to be organized to start using the system, ranging from a place to store them to proper training and maintenance facilities, and many other aspects.
Many of these things have to be in place before the system arrives from the factory, so a planning is also part of the deliverables.

INVOLVING THE TEAM

Question
In your experience as Team Leader, can you observe the same performance of teams across all studies? Or is there any variation?
What makes a study attractive for a team to perform?

Answers
For the Ice giants, the study objective stretched beyond what is currently possible with space technology and was therefore exciting and inspiring from a research perspective. Feasibility of missions is by no means a given and thus the focus of the study was to assess its boundaries, from a technical programmatic and risk point of view, encompassing technology readiness and budget management.

For the maintenance concept, also an innovative challenge was presented to the team, but there was more resistance. Not everyone understood the concept at first, and its implications were not clear to all team members, neither accepted as a fact. For instance, the concept meant that less preventive maintenance would be required, but this was questioned by the experts.

Lesson Learned
The Team Lead shall create the attractive element for people to feel inspired and to feel ‘part of the team’ and responsible for the task. This is not always a given, even when the task is challenging and innovative. Team Leaders do this by highlighting the challenge and its importance, as well as the individual role that each team member has to play, and how that is critical to the success.

TEAM BOND

Question
How can a Team Leader make sure that large teams, gathering people that normally do not work together, actually become a team within the setting of a CDF Study?
What are the additional challenges of leading disperse teams, with different cultures, values, priorities?
Why is it important to feel safe in a CDF Study setting?

Answers
The Ice Giants study was conducted in the ESA CDF facility, with the involvement of several NASA colleagues. The sessions were live, despite the time difference across the teams. The team had a shared drive for presentations and an action log driving the overall design process. They worked with OCDT (predecessor of CDP4-COMET) as the Integrated Design Model to share data and information. A total of 36 participants were involved representing different space engineering domains. The core team consisted of a Team Leader, a System Engineer, an Assistant System Engineer and – on the ‘’customer’’ side – a he Study manager and a team of study Scientists.

The maintenance study was part of the early CD studies where a facility was improvised. It took place during covid, which meant that some participants were always joining design sessions online, and some other were occasionally online. The study had to bridge two worlds: physical and digital. The project team was responsible for the overall integrated logistic plan, while the end users as well as their supporting divisions were used to ‘receive and approve’ such plan. In the study they were invited to collaborate jointly to create the plan, which in the view of the end users, was outside the normal scope of their tasks. One of the divisions even indicated they were not able to participate and got a representative to replace them. Their attitude was quite skeptical, but they were willing to participate.

In the ice giants study, particular effort was devoted to ensure a fail-safe environment, conducting focused but informal sessions with cakes and even chocolates sent to the remote participants, in order to create a sense of connectedness. This is very important to unleash creativity and ensure that people feel their instrumental role within the study.

In the maintenance concept study, a key challenge for the Team Lead was to create the 'team' feeling, which was clearly absent, and - even worse - some participants had encountered each other in previous projects and were still dissatisfied with the outcomes of those projects. Although the informal breaks did help, part of the end-user group left the room during the breaks. At some point the Team Lead joined them outside to have a chat about the situation, emphasizing the importance of their participation and leaving the past behind, which helped to improve the team atmosphere.

Lessons learned
Collaboration and creativity requires the feeling of being safe to fail, so to ''dare'' and share information that is not yet complete evaluated.
It is the role of the Team Lead to create a sense of belonging, making the team feel safe to fail, create an informal setting for creativity to ''flourish''. Treating each person as an individual, understanding their motivational drivers and leveraging on them to make every single contribution unique and invaluable is instrumental. This sometimes requires addressing and putting down resentment in the group.

BRINGING STRUCTURE

Question
What is the role of the TL in deciding how to structure the sessions?
How does he act for a baseline getting selected among several design alternatives?
What is the risk of not having a good IFP?

Answers
The Ice Giant study was organized in a total of 9 sessions. The Kick-off session explained the study objectives, mission requirements, drivers, trade-offs and logistics matters. The 2nd to 4th sessions zoomed in on the Neptune probe and orbiter design and the 5th to 7th sessions focused on the Uranus probe and orbiter. Each design sequence started with initial sizing based on mission requirements and key assumptions followed by plenary trade-off analysis, a baseline selection and a session to finalize the design iteration. The sessions were divided in two parts, one focusing on the orbiter, the other on the probe. Session 8 was focused on checking and harmonizing any loose ends from each of the four options, and Session 9 was devoted to the ''Internal Final Presentation'': a session giving to the team the opportunity to check on their own design all together. In total, each option was addressed in several iterations. In parallel, within this specific study, the moon lander was addressed at high level and partially off-line, due to the limited amount of time within the plenary sessions.

The study about the maintenance concept started with the 'Concept of Operations' the military setting in which it would be used. Next, sessions focused on different aspects of the maintenance concept, ranging from housing to maintenance cycles, to education, to documentation, to administrative processes and spare parts. Finally, the team focused on the planning and the timeline to ensure that all is ready in time for operation. For instance, the documentation of the system has to be available to develop the training, which in turn needs to take place before the first systems arrive. These dependencies were sometimes hidden. Furthermore, a concept of operations for in-mission maintenance had to be devised. Finally, the team had to create a cost balance and compare maintenance options. This revealed that the cost difference between options was much more limited than expected, and the operationally most preferred option could be selected.

Lessons Learned
The trade-offs in the design are not always obvious, and sometimes key choices are revealed during the study. Vice versa, some design choices seem difficult, but when analyzed in a clear balance, the choice becomes obvious.
Structure is key in focusing the sessions and prioritizing critical design challenges. Even when the team thinks that a choice is obvious, it is important to approach it in a fact based manner, to ensure that it is justified by evidence. The Team Lead shall collect factual data to justify the baseline selection involving the perspective of all team members. A Team Lead may have to insist on such rigor when the team is inclined to choose based on heuristics, given the time available.

CLOSING THE LOOP

Question
Why is an early mission design iterative and when does the Team Leader know it is ''good enough'' to stop?
How does the Team Leader control the good conduct of the study? What are the KPIs?

Answers
In the Ice giants study, and in all feasibility assessments, the design approach was both top down (functional decomposition of requirements) as bottom up, (key requirements and product tree design from each of the sub-systems). These are confronted to explore if they 'fit' together. Misalignments at this point were addressed and resolved with the team, in the classical design iterations that can be well described by the sol called ''spiral model''. The sessions were designed with a clear focus on action points and missing information, this was tracked with an action tracker and reminders of the status of the design at the beginning and end of each session. The team involved in the Ice Giants CDF Study adopted the Integrated Design Model and used the sessions to actively describe the system with the model parameters, instead of giving information to the System Engineer via other unstructured channels (email/messages…).

For the maintenance concept the team didn't work on an integrated design model. However, they did create a joint budget model and a joint planning. These were presented early in the study and refined based on the insights of each session. While one stakeholder was responsible for this, actions were assigned to many stakeholders to find out cost aspects as well as planning aspects. Presenting some of this information was tricky as for instance the duration of a maintenance practice was longer than expected or even acceptable. However, process improvements were out of scope and the team agreed to calculate based on realistic estimates. The openness of some stakeholders with this respect was refreshing and helped the rest of the team to accept the reality of some challenges.

Lessons Learned
The TL shall ''design the design process'', time is part of the performance and having clear design process is fundamental for leading the team and have it performing.
he Team Leader shall organize an IFP actively engaging team members in checking and aligning assumptions and data in order to have an homogeneous design, useful to possibly evolve throughout the following phases. The Team Leader has the crucial role to explore sensitivity of the design iterations using the information provided by the team members and can thus assess when the convergence of the spiral model is sufficient to have a baseline design.
KPIs are often related to the design drivers, and - as ancillary tools - the Team Lead has the process and actions trackers that ensure that all aspects are addressed with documented justification. This ensures traceability for the follow-up.

DRIVING RIGOUR

Question
How does the TL ensure the use of the model, why is that element important in the study?

Answers

In the Ice Giants study, the entire team worked on the integrated design model. An introduction training to the use of the modelling environment is always made available for new participants. The integrated design model was set up to contain key sub-systems and equipment parameters. The model was particularly focused on the information required to create budgets such as mass, power and data, etc. Normally, the team works with the Delta V budget, deriving the propellant required to change orbit, the dissipation budget to understand the overall heat balance given the extreme external environment. The design iterations for each option involve collecting data from the domain experts to assess whether the budgets comply with the allowances (mass shall match the launcher performance or any given envelope, power shall match with solar array areas or any other energy source available, etc.)

In the maintenance concept study, the team did not use an integrated design model, but instead kept a budget sheet and planning as the central focus point. Later, the project manager indicated regretting the decision not to use such central model, mainly because in a later phase, it would have been useful to keep the budgets up to date and accurate.

Lessons Learned
Modelling makes design iterations easier and faster. Traceability and readiness for follow up phases is enabled.

SUSTAINING RESULTS

Question
What are the tangible artefacts deriving from a CDF Study? How are results reported today and how will that evolve in the future, with the novel technology available? What are intangible results, and how are they recognized?

Answers
In the ice giant study, The results were collected in a final study report that included clear conclusions on the feasibility of each of the options. The recommendations included pointers for further research and the technologies requiring further

development for the mission to succeed. The study informed the Voyage 2050 roadmap, addressing the long-term planning of the ESA Science Program. The study was completed in the allotted time, both in time allocations for the specialists as well as throughput time. The resulting report can be found at the ESA website [3].

The maintenance concept study showed that there was invaluable feedback from the end-user team. Not only they enabled a 'reality check' on many aspects, indicating that solutions on paper would not work in the day-to-day practice, let alone in an operational setting, but they also provided key insights in challenges that were not even on the radar of the project team. For instance, while a modular design would be very practical when at a home base, it would bring significant additional challenges in operation, where large sized spare parts had to be brought along which meant a lot of additional cargo. These unexpected problems were called 'gifts' for the project manager. Although they seemed annoying when discovered, their impact would have been much worse if discovered later. An intangible result was the relation between the different groups involved. While there was still some skepticism, the collaboration had much improved, and the project manager kept his word and updated the team every month about progress. This proved to be much more effective in the long run.

Lessons Learned

The Team Lead shall emphasize not only the results 'on paper' but also the effects that are less tangible.
The Team Leader has to celebrate finding the design problems and trade-offs, even, or especially when they are disturbing. Spotting them early is always better than finding them later. Of course, finding solutions for them is cause for even more celebration. However, identifying the issues early, even if they thwart feasibility, is always better then identifying them later.

CONCLUSIONS

For the ice giants, the key lesson was the powerful beneficial effect of the inspiring and challenging task given to the team. Once the Team Lead was able to inspire and engage the team with a vision, with the importance of the mission and the excitement of being part of something new, they were much more engaged, and this created room for creativity and new ideas. A success …for the space endeavors and for the people working in space missions: like you!

For the maintenance study, the key lesson was the importance of the relationships between the team members. Despite a perfect sense of responsibility, the study would run in a more effective manner when the team members get along well. It is always worth investing in this aspect.

More lessons and ideas will be inspired by the future challenging applications of concurrent design that the community of practitioners is and will be working on.

To be continued!

REFERENCES

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