The Space Station Design Workshop goes digital - opportunities and challenges during pandemic-times

Markus Grass[1], *Tharshan Maheswaran*[2], *Gisela Detrell*[2]

Abstract

The Stuttgart Space Station Design Workshop, aimed at university students and young professionals, focuses on the conceptual design of a space station in an interdisciplinary and international environment within a limited timeframe. It lasts about one week and has been carried out by the Institute of Space Systems – University of Stuttgart for over 20 years. The goal of the workshop, besides its educational purpose, is to obtain creative solutions from the future generation of space experts. For the participants, the SSDW offers a unique opportunity for learning by doing and to get involved in a space project. Participants do not only need to apply their knowledge obtained during their university courses but also to put in practice and improve soft skills. The workshop starts with some lectures in relevant fields such as Project Management, Systems Engineering, as well as the different subsystems, for example Life Support. The participants are then divided into two teams. To monitor the teams' progress several milestones and reviews are planned during the week. Several tools, guides, recipes and experts are available during the workshop. Within the team, each member has a specific role, which is defined before the workshop starts, allowing preparation. The mission statement of the workshop changes every year, adapting to the current plans on human spaceflight exploration. The results of the last editions have been presented at international renowned conferences. In 2020, due to the current COVID-19 situation the workshop was cancelled. In 2021, with increasing vaccination rates in Europe, the situation had improved. However, carrying out such an international in-person workshop was still not an option. For that, the core team decided to carry out for the first time the SSDW in a digital form. Adapting the existing workshop to a digital form presented many challenges but at the same time offered many opportunities. This version has allowed to join participants and staff, that would not have been able to attend in-person, and has also opened new possibilities of communication, using currently existing tools. This paper first introduces the main characteristics of the workshop before it presents a comparison between the 2019 edition, which took place in-person, and the 2021 edition, the first digital SSDW. It summarizes the activities that took place during the one-week workshop, the tools used, and the feedback provided by the participants and staff.

Keywords

Concurrent Design, Digital vs In-person Workshop, Space Station Design

[1] Corresponding author: Institute of Space Systems, Germany, mgrass@irs.uni-stuttgart.de
[2] Institute of Space Systems, Germany

Acronyms/Abbreviations

IRS *Institute of Space Systems*

SSDW *Space Station Design Workshop*

1. Introduction

In recent years, digitalization has been advancing in many areas. Besides the digitalization and automation of monotonous office tasks new formats of knowledge transfer are also emerging. One reason is that the digital infrastructure is being expanded and more and more tools are available for digital teaching. This has a number of advantages. Based on sufficient internet access, students can for example attend lectures from any location or watch them on a time-delayed basis. This can strengthen national and international cooperation, as the respective availabilities increase when the times for transfers are eliminated. In addition, possible limitations of lecture halls due to the available seating capacity are eliminated, and the implementation of events can be guaranteed even in spite of pandemic restrictions. In light of general digitalization and the pandemic situation, a digital format was added to the already established Space Station Design Workshop (SSDW) format, described in more detail in [1]. As with previous workshops, which were held in-person, beginning in 1996, the SSDW is intended to retain its essential characteristics. Thus, the SSDW is aimed at university students and young professionals, who will be divided into two teams. Under the supervision of experts from academia and industry, these teams are to design an initial concept for a space station within a few days in an interdisciplinary, international and intercultural environment. The goal of the workshop is to obtain creative solutions from the unbiased, future generation of space experts. For the participants, the SSDW not only provides a unique opportunity to apply their theoretical knowledge acquired in university courses to a space project, but also improves their soft skills in teamwork. The workshop's task changes each year, adapting to current plans for human spaceflight exploration. The results of previous editions have been published in congresses [2-5].

2. Digital vs In-Person Workshop

The transformation of such a workshop poses some challenges to various sub-aspects, which are described and compared in detail based on the last face-to-face workshop (2019) and the first digital edition (2021). In addition to the organizational preparation and follow-up of the workshop, the two formats will also be evaluated from the participant's point of view.

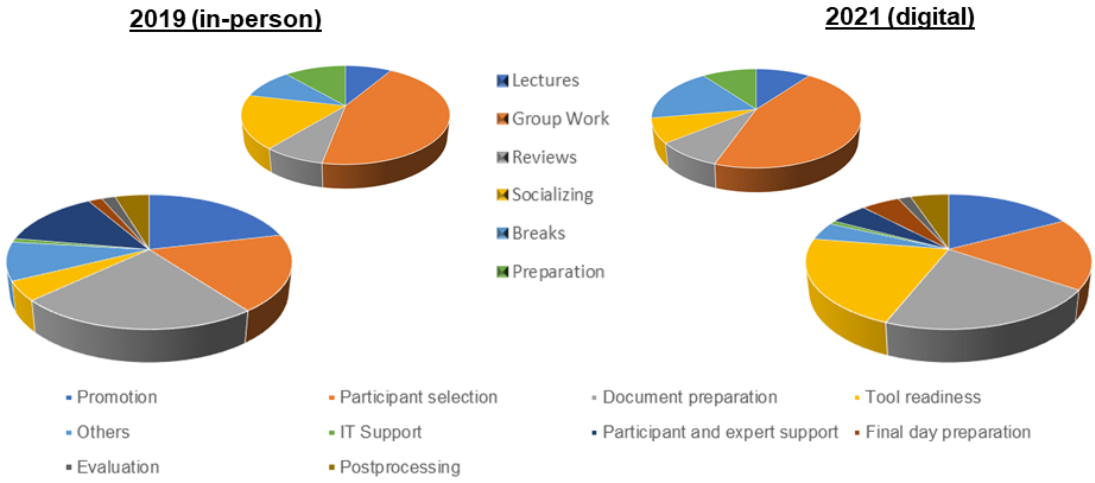
2.1. Preparations

Promotion:
The SSDW is characterized by its high professional standard based on many years of experience as well as the integration of expert knowledge, which is why it has continuously gained in popularity. The enthusiasm of the annual alumni supports the high visibility by their verbal promotion. Additionally, the posters on site and a successful web presence, both on the SSDW website [6] and in social media increases the level of awareness and consequently the application rate. Due to the prevalence of digital teaching in 2021 and the resulting low number of students on campus, posters were not used for promotion in 2021.

Participant selection:
The participants of the SSDW are selected from a three-digit number of applicants. Since the number of participants can be handled more flexible in a digital format, 50 instead of the usual 40 participants were accepted to participate in 2021. For example, additional positions in team management as well as visualization were established to accommodate the expected difficulties in the communication between participants in the digital format.

Document preparation:
To prepare the participants in the best possible way for their tasks in the team during the workshop, so-called *work packages* are created for each position. These contain various tasks with which the participant must familiarize himself with the topics. To enable the participants to get started as quickly as possible, additional help is distributed at the beginning of the workshop. The preparation of the respective documents was the same for both workshops.

Tool readiness:
Figure 1 summarizes the tools used during 2019 and/or 2021. The main difference is the integration of additional tools for the digital version of the workshop. With *Gather* [7], a virtual 2D world was created simulating the main rooms of the in-person workshop. *WebEx* [8] was used as a back-up and during the



Tools	Pre-Work		Workshop-Week-Organization		Workshop-Week – Teaching		Post-Processing	
	2019	2021	2019	2021	2019	2021	2019	2021
Gather		✓✓		✓		✓✓		
MS Office	✓✓	✓✓	✓✓	✓✓	✓✓		✓✓	✓✓
Slack		✓✓		✓✓		✓✓		✓
Webex		✓✓		✓✓		✓✓		✓✓
ASTOS	✓	✓			✓✓	✓✓		
Valispace	✓	✓			✓✓	✓✓		
LSS-Tool					✓✓	✓✓		
EDL-Tool					✓✓	✓✓		
Documentation-Tool					✓✓	✓✓		
Visualization-Tools					✓✓	✓✓		
Video / Image-Editing-Tool	✓	✓✓		✓✓	✓✓	✓✓		✓✓
Cost/Risk-Tool					✓✓	✓✓		
Kahoot				✓✓		✓✓		✓
Evaluation-Tool							✓✓	✓✓

Figure 1: Comparison of the in-person and digital SSDW format with respect to time management and tools

preparation. In addition, *Slack* [9] was introduced as a written communication tool. These programs were completed with *Kahoot* [10] as quiz tool.

Others:
In addition to the planning and coordination with the invited SSDW experts, additional aspects must be considered, especially for the in-person workshop. For example, accommodation for the participants must be arranged as early as possible. Furthermore, catering must be organized for the workshop days. In the digital version of the workshop, special focus was put on designing and sending the SSDW T-shirts to the participants early on and involving them in a puzzle quiz as team challenge to get them connected before the workshop and initialize the creation of a team spirit.

2.2. Workshop execution

The workshop week was divided into the work of the organization team and the time allocation for the participants.

2.2.1. Organizational Framework

IT support:
Technical issues can occur in any project involving different digital tools. Therefore, it is important to recognize possible problems at an early stage in order to avoid them if possible or to be able to solve them quickly. While the Institute of Space Systems (IRS) provides usually the IT infrastructure during the in-person workshop, the digital format required the participants' to use their own hardware, which could not be tested in advance. Due to the reliable preparation work of all participants, there were no significant issues in both years.

Participant and expert support:
With regard to the supervision of the participants, care must be taken to ensure that they are provided with sufficient catering during their group phases, which was not required during the digital workshop. Furthermore, it must be ensured that the schedule is followed,

i.e. that the deadlines specified in the weekly schedule, e.g. for submissions, are met, but also that socializing events take place on time. It also makes sense to observe the internal organization of the teams, whereby it was difficult to capture the team dynamics.

Final day preparation:
On the last day of the workshop, a final presentation takes place, which is broadcasted live via web in order to enable the presentation of the results to a broad audience. The presentations will be followed by a closing event at which the winner of this year's SSDW will be announced. While the certificates are handed over personally at the in-person workshop, and the team spirit is more evident, a digital version poses new challenges. Through the digital footages, gathered during the workshop week, however, it was possible the create a euphoric community atmosphere by editing special highlights of the workshop week into a final closing video. Thanks to the personal avatars used in *Gather*, traditional events like a team picture could also be realized.

2.2.2. Educational / Teaching Framework

Time Management:
Figure 1 shows what proportion of the workshop's time is taken up by the respective categories. It can be seen that approximately 50 percent of the time is allocated to group work. The lectures and reviews receive a similarly large share in both years. Nevertheless, the ratio between socializing and the breaks has changed significantly, which can be explained, by the fact that the evening program in the in-person workshop served socializing purposes and had to be dropped in 2021. In addition, the breaks in the online event were extended, which provided the participants for example with enough time to prepare their meal.

Lectures:
Expert presentations on various aspects, such as project management or space station subsystems, serve to provide each participant with certain basic knowledge from the current state of research in all fields. This is also intended to raise awareness of any concerns other team members may have based on their individual academic background. While the experts have always been on site or reachable by phone in the past workshops, this time they were mainly connected digitally. Thanks to the virtual representation of a lecture hall (see Fig. 2), the participants fell into typical patterns of an in-person event. For example, a crowd was formed in front of the microphone, as seen in Fig. 2, from which questions could be posed to the lecturer.

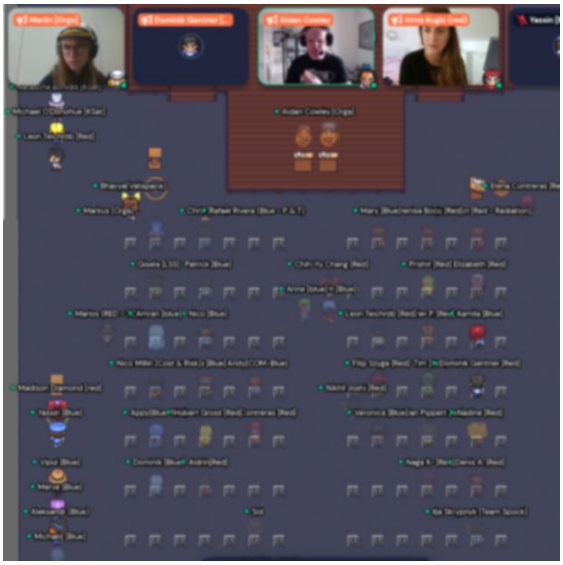


Figure 2: Virtual lecture hall

Group work:
As in the in-person workshop, both groups were given their own team rooms. Since one can move freely with one's avatar in the virtual world, the expected problem of communication difficulties between persons was significantly mitigated. Often subgroups met in the prepared compartments with whiteboards to participate in brainstorming sessions or discussions regarding implemented values. Furthermore, participants could go to the expert room to get their advice. If they were not present, they could be contacted via the messenger tool (Slack). This tool was also used for general advice from the organization, but also within different groups, so that the working meetings of individual subgroups did not have to be disturbed.

Reviews:
A side room in the respective team room was used as a presentation forum for the reviews. After the presentation of the team's current status, the experts posed follow-up questions to understand the depth of detail of the ideas or to provide new inputs. Afterwards, there was also an opportunity for students to raise specific questions to the experts. These reviews were mostly similar in 2019 and 2021 apart from an

additional review during the digital workshop. The reviews also served as practice for their public final presentation of the results. Based on this final presentation and the project report of each team, an evaluation committee decides which team wins the current edition of the SSDW. Figure 3 shows the winning concept from 2021.

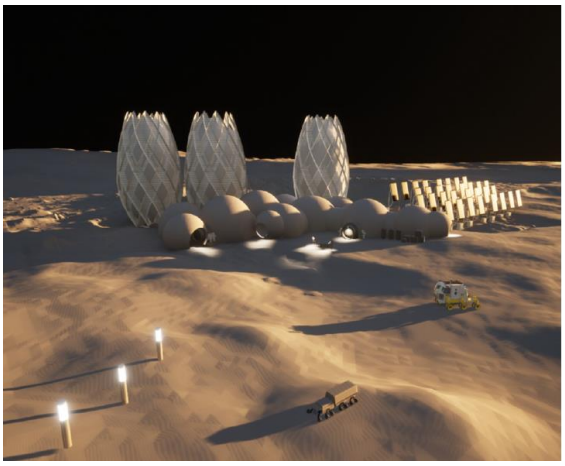


Figure 3: Winning concept 2021

Social Events:
Together with the adjustments to group work, the necessary changes for adequate digital socializing represent the greatest challenges. For example, the team spirit should also be created during SSDW 2021, although personal contact between participants was unfortunately not possible. Since evening activities such as a joint dinner at a typical local restaurant or a tour to the local planetarium were not possible, these were substituted, for example, by video contributions by the organization team produced especially for the SSDW. In addition to a video tour through the planetarium, participants were also able to attend on a virtual tour through Stuttgart and have a look at various working groups at the IRS. While the 2019 participants built and launched water rockets in small groups, the 2021 students participated in a treasure hunt through the virtual map. To break up the intense group work after a few hours of work a social event was integrated. Hereby the panel discussion of the in-person workshop was substituted by a *PowerPoint* karaoke (Fig. 4) in the digital format. The euphoria of the participants was clearly visible from the emojis shared. A new addition to the digital version is a short quiz after each lecture block to keep the attention and to review what has just been learned.

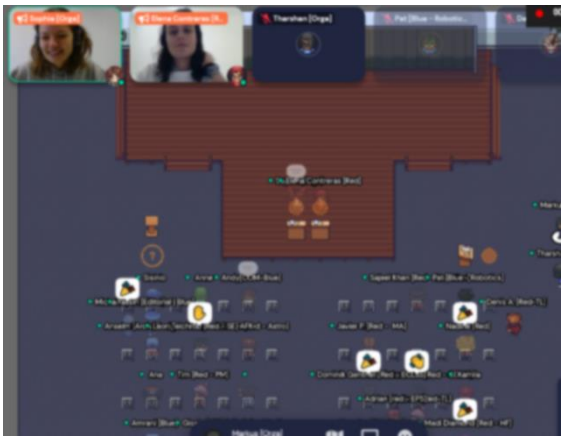


Figure 4: PowerPoint karaoke in Gather

Breaks:
While the breaks in the in-person workshop offered another opportunity for networking, these were used in a variety of ways in the digital version enabling a flexible networking process.

2.3. Post-Processing

Evaluation:
In order to further optimize the workshop, an evaluation was carried out among the participants and experts. The highly positive feedback from the last evaluations was also reflected in the efficient verbal promotion mentioned at the beginning. The choice of additional tools for digital implementation was particularly emphasized in the last evaluation. Despite the successful coverage of many aspects through the integration of digital tools, both experts and participants favored an in-person workshop, since the evening socializing events could not be fully implemented digitally.

Further Work:
In addition to the usual final documents which need to be sent to various institutions, this digital edition was followed up by sending out the certificates of participation by mail. In order to enable further international networking of the participants with the SSDW team, they are integrated into the SSDW alumni network.

3. Results and Discussion

The results delivered by both teams at the end of the digital SSDW are equal to those of the in-person workshop, which is why the implementation of the first digital workshop must be considered as a success. In both workshops, thanks to the many socializing

events, a team spirit was created, which led to final results of the workshop serving as a basis for further work in both editions [11]. The preparation of this new concept was more challenging than the organization of previous years, as new tools had to be tested and implemented. The workload during the workshop week was similar, as essential aspects such as the provision of catering were not required, but balanced by additional digital aspects as the video editing.

4. Conclusions

With the successful implementation of the SSDW 2021, a digital version of the already established SSDW in-person format was created. The concept established in this way is decoupled from the previous constraints and is now available as a location-independent version, enabling a more flexible response to unforeseeable global impairments in the future. A hybrid edition of the SSDW might be able to combine the positive aspects of both workshop formats and might be an additional concept considered worth testing.

Acknowledgements

The authors would like to thank everyone that made the first digital workshop edition possible. Without such great staff and experts and their ideas and knowledge shared before and during the workshop it would have not been such a successful experience. As the workshop always needs to be funded, the authors gratefully appreciate the supporters assistance, namely the DAAD, TESAT, Airbus, Price Systems, Astos, Valispace, HE Space, the Institute of Space Systems, the University of Stuttgart and many more!

References

[1] G. Detrell, M. Schwinning, R. Ewald, An international and interdisciplinary approach on learning how to design a space station, *Acta Astronautica*, 157, 489-499, 2019

[2] M. Grass, M. Schwinning, R. Ewald, Conceptual design of a crewed platform in the Venusian Atmosphere, *Journal of the British Interplanetary Society*, Vol. 73, 115-125, 2020

[3] M. Schwinning, J. Skalden, R. Ewald, Conceptual design of a permanent Lunar surface base, *69th International Astronautical Congress*, Bremen, Germany, 2018

[4] M. Schwinning, G. Detrell, R. Ewald, Conceptual design of a manned platform in the Martian system, *68th International Astronautical Congress*, Adelaide, Australia, 2017

[5] M. Schwinning, R. Ewald, Conceptual Design of a Human Spaceflight Platform as ISS successor, *67th International Astronautical Congress*. Guadalajara, Mexico 2016

[6] SSDW: https://ssdw.irs.uni-stuttgart.de, last visited: 20.03.2022

[7] Gather: https://www.gather.town, last visited: 20.03.2022

[8] WebEx: https://www.webex.com, last visited: 20.03.2022

[9] Slack: https://slack.com, last visited: 20.03.2022

[10] Kahoot: https://kahoot.com, last visited: 20.03.2022

[11] A. Joshi, C. Korn, M. Magkos et al., AMORE - Mission concept overview for a progressively independent and self-sustainable lunar habitat, *4th Symposium on Space Educational Activities,* Barcelona, Spain, 2022