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Impact of Remote Working on the Processes and Methodology of Training and Simulations at the Galileo Control Centre

Jasmina Brajovic[a]*, Carla García Sánchez[b]

[a] *DLR GfR mbH, Münchener Straße 20, 82234 Weßling, Germany, jasmina.brajovic@dlr-gfr.com*
[b] *LSE Space GmbH, 82205 Gilching, Germany, carla.garcia@lsespace.com*
* Corresponding Author

Abstract

The Training and Simulations Team at the Galileo Control Centre in Germany (GCC-D) is responsible for the training and certification of all operational and maintenance roles, among others, active in the Galileo project. Main tasks of the team include the definition, implementation, development, and continuous update of the training material according to the project and mission's needs; the coordination, management and, for some topics, the execution of the training lessons; the organisation, preparation, and execution of simulations, including the full operations of the Galileo Constellation Simulator (CSIM). A complete training program is a combination of classroom training, self-learning, mentorship, e-learning, practical sessions, On-the-Job Training (OJT) activities, simulations (where required) and final certification.

As per the nature of the operations activities in a Control Centre, where most activities are taking place onsite within the operational environment, most parts of the training are as well performed on-site. Trainees get assigned a mentor, an experienced and certified team member, who guides them and supports them along their training and supervises any activities assigned to them as per their training plan. Moreover, they benefit from shadowing any ongoing activities in real time and actively learn from the daily tasks that their team is responsible for.

In March 2020, the consolidated training and simulations processes and methodologies had to be unexpectedly adapted to a completely remote working environment enforced by our governments and companies. This was not an easy change and it had major impact on the team's work, but the responsibilities remained the same, to prepare the operational and maintenance personnel to ensure the Galileo service continuity and safety of the mission. Changes needed to be applied and measures taken by the Training and Simulations Team to be able to continue accomplishing their duties and meet their objectives with success. The impacts that these adjustments have had in the whole training process of the staff, the challenges that were faced and how they were overcome are discussed in this paper. It includes a summary of the lessons learned, pros and cons of remote training and simulation execution and describes which changes and measures were the most fruitful ones and have therefore been integrated into the training and simulations routine.

Keywords: Training, Simulations, Galileo, Navigation

Acronyms/Abbreviations

CSIM	Galileo Constellation Simulator
CMCF	Central Monitoring & Control Facility
DLR	German Aerospace Centre
DLR GfR mbH	DLR Gesellschaft für Raumfahrtanwendungen
EUSPA	European Union Agency for the Space Programme
FCT	Flight Control Team
FDE	Flight Dynamics Engineer
FDF	Flight Dynamics Facility
FOC	Full Operations Capability
GCC-D	Galileo Control Centre in Oberpfaffenhofen/Germany
GCC-I	Galileo Control Centre in Fucino/Italy
GCS	Ground Control Segment
GDDN	Galileo Data Dissemination Network
GMS	Ground Mission Segment
GOE	Ground Operations Engineer

GSC	GNSS Service Centre
GSOp	Galileo Service Operator
ILS	Integrated Logistics Services
IOV	In-Orbit-Validation
KPI	Key Performance Indicators
MATE	Maintenance and Troubleshooting Environment
OJT	On-the-Job
OPF	Operations Preparation Facility
OPS	Operations
PLE	Planning Engineer
SCCF	Spacecraft & Constellation Control Facility
SCPF	Spacecraft & Constellation Planning Facility
SDHS	Site Data Handling Set
SIM	Simulation
SOE	Spacecraft Operations Engineer
SPACON	Spacecraft Controller
TMS	Training Management System
TNA	Training Needs Analysis
TSO	Training and Simulation Officer
TTCF	Telemetry Tracking and Control Facility

1. Introduction

Since the first Galileo launch 2011, DLR GfR mbH is responsible for operating the Galileo Constellation at the GCC-D in Oberpfaffenhofen, Germany. Already during the operations preparation and ever since, the Training and Simulation Team has been working on developing, establishing, and maintaining training plans for all operational roles. This includes defining the necessary training and certification processes, developing training material and selecting suitable training methodologies.

The established training set-up was challenged in 2020 due to external constraints given by the authorities with the purpose of health safety. The training approach, its concept and execution had to be adapted. The following chapters describe the general approach for defining the training plans of specific roles at GCC-D, the challenges that were faced with working remotely and the impact it had on the existing training processes and methodology.

2. Training Process in GCC-D

The first step for establishing the training for a specific operational role in the GSOp project is a proper definition of the role and its tasks. Based on that, a Training Needs Analysis (TNA) is performed, which determines what training is required in order to get qualified to fulfil the tasks of a certain role. As next step, a Training Plan is developed, defining the exact training contents for each role, as well as the methods used and the processes that need to be followed for training and certification.

The Training process is managed through a web-based Training Management System (TMS), using the open-source learning platform Moodle. Every role in the Galileo project has a training plan defined as a scorecard that the trainee needs to process item by item, starting with general introductory courses, followed by role-specific trainings, On-the-Job trainings, and concluding with the final certification.

The scorecard training is structured in three levels. It starts with all necessary theoretical training, such as documentation, instructions, or procedures. As the trainee progresses in the training, the focus is drawn from the theoretical contents to a more practical training, such as hands-on sessions with the mentor, practical exercises in an operational training environment, shadowing of real-time operations or performing supervised operations.

2.1 Level 1 and 2

The first step that trainees start with in every role is a general introductory training containing overviews of the different project segments (Level 1), giving the trainees a broad spectrum of Galileo knowledge, which is beneficial for performing the work of their role later on. The second part of the general training (Level 2) consists of an introduction into the different tools the trainees need for their role. Table 1 gives an example of the Level 1 and 2 section of a scorecard.

Level 1 - Overview
TMS Introduction
Training and certification process
GSOp List of Acronyms and Abbreviations
GSOp Overview
Introduction to Galileo Service
GCS Overview and Operations Responsibilities
GMS Overview
GSC Overview
Introduction to Remote Sites
GSOp Planning Overview
IOV and FOC Satellite System
GDDN Service Overview
ILS and Maintenance Concept
Problem Management Training
KPI Overview
Security Awareness Training
Secure Operations
Level 2 - Tools
Document Management System
Anomaly Reporting Tool
Service Desk Interface
Configuration Management Tool
Redmine
Operational Web
MATE
Operational Log
Voice Loop Training

Table 1. Example of the Level 1 and 2 section in a scorecard

All courses within a scorecard follow a predefined structure:

- Training Course Details
    - Course Scope and Structure
    - Target Group
- Training Material
- Training Assessment (Quiz)
- Feedback

First, the course's contents, its scope and structure are defined. Then, the training material is presented. It can consist of presentations, documents, or assignments. In the end, most of the courses have a quiz where the training progress of the trainee can be assessed. As a last step, the trainees can give their feedback on the course that the training team reviews and, where applicable, implements changes on a regular basis.

2.2 Level 3

After the basic introductory courses, in Level 3, the role specific technical training starts. Also here, the most important documentation is introduced first. With this, the trainees are made familiar with the technical basics for their role. However, it is very important that the training includes practical experience as well, so mentoring sessions with the technical supervisor are introduced already at early stages of the role-specific training. Usually, the level 3 is split into 3 sub-categories (cf. Table 2):

- Level 3.1 usually contains documentation and first practical exercises on the operational elements.
- Level 3.2 covers the most important knowledge build-up with both, advanced documentation, and practical sessions.
- Level 3.3 deepens the knowledge in specific topics and contain extensive practical training, either in a simulated environment or also supervised in real operations.

Level 3.1 - Shift Lead Routine Tasks
Introduction to the Team
Introduction: Team Plan, Sequence of Events, Escalation path
Automation Introduction
Shift Handover Report
Ground System Elements Training
Procedure 001: Login/Logout
Procedure 002: Shift Handover
Procedure 003: Status Check and Monitoring
Read and understand Shift Lead Recommendations
Read and understand Ground POIs and Recommendations
Procedure 004: Setup SCCF
Practice Login and Reporting
Procedure 005: Event Handling
Procedure 006: Check Alarms
. . .
Procedure xyz: Check File Transfer System Status

Level 3.2 - Flight Operations Tasks
Automated Procedure 001
Automated Procedure 002
Follow Automated Routine Contact
Manual Procedure 003
Manual Procedure 004
Follow Manual Contact Execution
Read and understand documentation for Routine Housekeeping
Execute Routine Housekeeping contact
. . .
Routine Operations Priority Guidelines
Read and understand anomaly handling procedure
Recurring Planning Requests
Spacon procedures
Procedure xyz: Check File Transfer System Status
Spacecraft Configuration check
Automation Contingency

Level 3.3 - Ground Operations Tasks
Practice Procedure 001
Practice Procedure 002
Read and understand Workarounds
Practice Automated Procedure 003
. . .
Evaluation – Routine Contact
Evaluation – Automated Contact

Evaluation – On console
OJT Tracker

Table 2. Example of a Level 3 section of a scorecard

As explained above, the aim is always to have practical sessions in parallel to the theoretical training, however, as the trainees advance in their training plan, the amount of practical session versus theoretical increases. At first, during Level 3.1 they will mainly be conducted as mentoring sessions, where the mentor, an experienced team member assigned to the trainee at the beginning of the training, gives the trainee first introductions on the operational systems in a training environment, usually on the validation chain in a control room dedicated to validation and training.

In Level 3.2 the trainees deepen their theoretical training with practical exercises they perform on their own in the validation chain. They get acquainted with running operational procedures against the CSIM. Also, in case of the Spacecraft Operations Engineer (SOE) role, the trainees start participating in simulations, performed also in the validation chain, where they start collecting experience in a near-real operational environment. If not already started in Level 3.2, depending on the role, latest in Level 3.3 the trainees start shadowing real operations which is followed by performing supervised operations themselves in the operational environment. Each scorecard contains the minimum number of OJTs that a given role needs in order to fulfil the requirements of the training plan.

2.3 Certification Process

The process of certification depends on the definition of the training plan for each role. Still, they all have practical sessions that serve as a practical exam, e.g. simulations or supervised operations. The final certification is conducted as a certification board where the theoretical knowledge is tested by the mentor and an expert of the same or a related role. Many roles also have intermediate checkpoints where both practical and theoretical knowledge are tested throughout the training.

To complete the certification, the following criteria need to be fulfilled:
- Completion of the Scorecard
- Pass all intermediate Checkpoints
- Completion of all necessary OJTs
- Pass final Checkpoints (such as supervised operations)
- Pass Certification Board

3. The Remote-Working Challenge

In March 2020 the Training and Simulation Team in GCC-D, like all teams throughout the world, faced a unique challenge, when, for reasons of health safety, they had to adapt to the restrictions enforced by the governments and the company. All personal interaction with physical presence had to be reduced to a minimum and everything that did not necessarily need to be done on-site at the GCC-D premises, had to be performed remotely. Of course, the highest priority had to be given to the service provision, i.e. the 24/7 operations of the Galileo Constellation and all related activities that were necessary to ensure that routine operations could be continued undisturbed.

3.1 Impact on the theoretical training

For the training team in GCC-D it meant that all classroom trainings and evaluations needed to be "brought" to the homes of the trainees. Videoconferences replaced classroom trainings and online evaluations replaced paper evaluations. Where possible, online training sessions were recorded and made available to the trainees on the TMS.

The complete Level 1 and Level 2 stages of the training (cf. chapter 2.1) were changed into self-learning courses with PowerPoint presentations, documentations, and recorded trainings. Some of them were usually given as classroom training on a regular basis, those continued as online video conferences.

Course evaluations were entered into the TMS as Moodle online quizzes, that the trainees took digitally at the end of each course.

3.2 Impact on practical training

This biggest challenge was to find a solution for the practical trainings which had to be done on the operational systems that were not available from remote. The access to all operational rooms, including the training and validation room, that were regularly used by 7-8 people at the same time were restricted to maximum 2-3 people.

In practice, it meant for training, that the validation room, that was already overbooked under normal conditions due to many ongoing activities at the same time, now was even less available. Working under these restrictions would have caused massive delays in the training of many operational roles that urgently needed their trainees available for operations.

3.2.1 Usage of virtual environment

At that time a virtual environment emulating the Galileo Ground Control Segment (GCS) for maintenance and troubleshooting, MATE, was already under development and in use by the GCS Level 2 Maintenance team. For the Training and Simulation Team, in the new situation, it suddenly became a high priority to make it the main training platform for as many roles as possible. MATE is accessible through the browser on the working laptop from remote and the trainees were able to use it for their practical exercises instead of being dependent on the availability of the validation room. The trainees were performing exercises on their own, mentoring session with their mentor and during the most restricted times even Simulations were executed using MATE.

MATE is designed to contain a virtualised version of all GCS elements (cf. Fig. 1). The CSIM and the Spacecraft and Constellation Control Facility (SCCF) were the most relevant elements for training, since they are mainly used by the Flight Control Team (FCT) and their training as SOE, as well as the Shift Team for their on-console training. Those two were available for training, as well as the Spacecraft and Constellation Planning Facility (SCPF), which was also extensively used by the Planning Engineer trainees. Unfortunately, it was not possible to use the Flight Dynamics Facility (FDF) in this virtual environment at that time. Also, the CMCF and TTCF elements on MATE, that were necessary for Ground Operations Engineer trainees, were not yet available for training. For all usable elements, their environment needed to be set up and maintained in a way that it would reflect the real operational environment as good as possible, including all relevant operational data that was needed to create a realistic set-up.

As the number of MATE users suddenly increased significantly, an important organisational addition was necessary to ensure a smooth shared usage of MATE between the teams. A booking system was set up to reserve time slots for the usage of each GCS element by the different users.

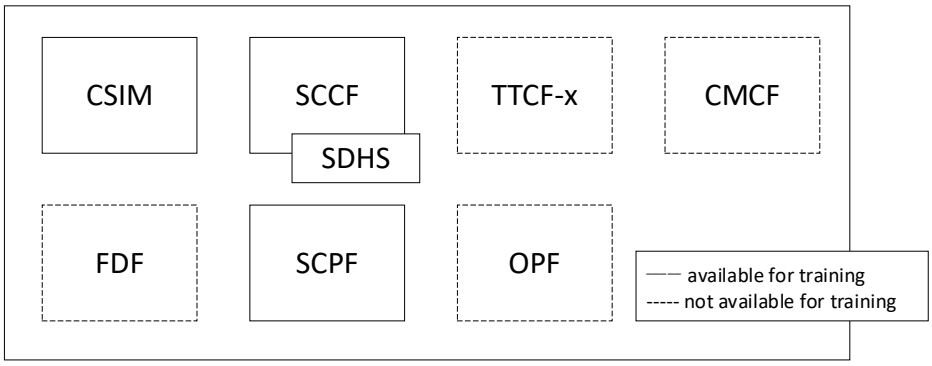

Fig. 1. GCS elements in MATE

3.2.2 Role specific impacts

As every operational role has a dedicated training plan with a specific methodology approach according to the requirements of the role, the impact of the restrictions varied for the different roles. In the following paragraphs and in Table 3 some of the main roles that were mostly trained during that period and the adaptive measures are described.

The **FCT** training, i.e., the **SOE** role, is a very extensive training, that includes a large number of theoretical instructions, but also needs a very extensive practical focus. Therefore, the use of MATE was essential. As mentioned in chapter 3.2.1, the trainees were able to use it for practicing on their own, for mentoring sessions and sometimes it was even used for Simulation. However, many aspects of that set-up are not comparable to real operations. Most critical, the voice communication only used a work-around through Microsoft Teams, which is a completely different system from the one used in real operations. The set-up of the displays in the remote environment cannot be compared with the set-up in the operational room, that has several screens for every workstation where a number of displays needed for operations can be monitored at the same time. Also, the big screens on the front wall of the control room, showing the schedule and the time display were missing at the remote working setting. Therefore, the simulations on MATE were kept to a minimum and, whenever possible, they were performed in the GCC-D on site.

The approach for the **Shift Team** Training, i.e., **SPACON**, is an efficient and to-the-point training that focusses on the well-defined everyday routine work of the 24/7 operations on console, directed at the goal to achieve the certification in a relatively short time frame. Most of their practical training activities were moved to MATE, however, they did their OJT on console with the supervising SPACON, as per training plan. Otherwise, they would not have been fit and confident enough for the work on console in the pre-defined training schedule.

Also, during the period of restricted access, a completely new team of 6 **Flight Dynamics Engineers** (FDE) needed to be trained. In the specific case of the FDE, the MATE environment did not support the FDF, yet. Furthermore, the practical training and OJT needed to be done in the same room where FD and Planning operations were performed. That imposed an even larger restriction on their training because the operational work always has priority. Therefore, it was not possible to complete the training without a significant time delay and a particularly high dedication of the mentor.

The practical training of the **Planning Engineer** (PLE) trainees was mostly performed in MATE during the two years of restrictions. Towards the end of the training, the PLE trainee needs to simulate a planning week and if successful, performs a supervised planning week in the operational environment. Only the last part, the supervised planning operations at the end of the training were performed in the operational environment.

The Ground team, and the training of their **Ground Operations Engineers** (GOE), also experienced many challenges due to the access restrictions at GCC-D. Their team went through many changes at that time and there was an elevated turnover rate. During those 2 years several new team members had to be trained in the adapted

remote training environment. The Ground operations team training covers all GCS elements, but as previously explained, not all of them were available in MATE at that time. For their training, the practical part is mainly based on mentoring sessions and shadowing activities onsite with the most experienced team members. It is particularly difficult to teach someone how to investigate and troubleshoot an incident on an element if this cannot be shown and tested "live", therefore they had to be allowed to go onsite, even if it was only for a very limited time and with only 1 additional person (the assigned mentor). The mentors had to dedicate much more time to the trainees to instruct them on all known anomalies and workarounds during online sessions and use the allocated time at GCC-D for the supervised OJTs defined in the training plan. This resulted in a significant increase in workload on the experienced team members, who had to continue fulfilling their usual tasks at the same time. I also resulted in a time delay in the final certification of those trainees.

For all roles in general it was noticeable that the remote work situation had a huge impact on the quality of the mentoring approach. Especially trainees that did not change roles within the project but were new in the company and in the Galileo project, were sometimes reluctant to contact their mentor or colleagues for help, when working remotely. For the trainees it was not always easy to find out the availability of their mentors as the established way to contact them was through a MS Teams call or an email. It was difficult to build and maintain the team spirit when people rarely met each other or even never met in person for many months after joining the project, what sometimes made them feel isolated during their training. Also, they did not experience the atmosphere of working in a real operational environment and it was then on the Training Team and the Mentors to recognise the problem and take active measures to improve the situation for the trainee by scheduling mentoring sessions on site whenever it was possible without violating the health safety regulations.

Role \ Impact	Theoretical Training online	Practical Training on MATE	OJT on MATE (SIM, OPS)	Evaluations online	Certification Board online		Difficulties in mentoring process	Time delays
Spacecraft Operations Engineer								
Shift Team								
Ground Operations Engineer								
Flight Dynamics Engineer								
Planning Engineer								

	possible						yes	
	partially						partially	
	not possible						no	

Table 3. Exemplary operational roles and the impact on their training

Table 3 shows the impacts of remote working on the roles and different part of their training. The yellow colour indicates a successful adaptation of methodology, that was considered positive. A partial adaptation (orange-yellow) means, that difficulties were encountered with adapting to the remote-working measures or where it was only partially possible, while the orange colour identifies where an adaptation was not possible. It can easily be seen, that the FDE and GOE roles were most impacted by the situation, as some adaptation measures could not or not fully be implemented for them. The second last column shows that all roles experienced difficulties with the mentoring process, while the last column reveals, that the roles which mostly could not adapt to a remote-working environment had to accept time delays in their training.

3.2.3 Impact on System Upgrade Training

During that time a major upgrade of the GCS needed to be rolled out, accompanied by extensive training (theoretical and hands-on) on all elements. With the restrictions at the time, it was impossible to have classroom trainings in person, all training sessions were held online and, taking advantage of the situation, recorded for future use. The Hands-On Sessions were organised strictly following the train-the-trainer principle because only maximum 3 people could be present. Even the trainers were in some cases not present on site due to the travel restrictions, so they presented the exercises by sharing their screen from remote while they were using their system in factory. In the GCC-D, the trainees then performed the same exercises in the validation room while having the support from the instructor via video conference.

3.3 Impact on Certification

Once the realisation of the practical part of the training was solved, the least impact was experienced in the certification process. Intermediate checkpoints, where the trainees take around 90 minutes test about their theoretical knowledge, were already performed online. The Certification Board is usually attended at least by the trainee, the mentor, the TSO and preferably 1-2 experts. That had to be changed from physically attending in a meeting room to performing it online via video conference. With that approach there were no restrictions on the number of attendees and the board could be held with the usual quality.

4. Result

Even if triggered by external circumstances, the changes that were implemented in the theoretical part of the training can be considered a progress. The trainees gained freedom at organising their training at their own pace and contacting the trainers/mentors only in case of questions. The transition to purely on-line theoretical training was beneficial for the Training and Simulation Team because less resources were necessary to support that methodology once the on-line material including the recordings was provided.

Performing the certification boards online was considered equivalent to the boards in person from the Training Team point of view. It did not affect neither the necessary effort or the efficiency from a methodology perspective, however, the set-up and circumstances of the remote office of both trainee and TSO could affect the quality of the certification board in terms of privacy and the ability of the trainee to focus and concentrate. Therefore, it is considered an advantage to keep that flexibility for all participants to pick the location that fulfils those aspects best for them.

The practical training, on the other hand, showed several disadvantages. Although the virtualised training environment was a huge achievement and without it, many practical trainings would have been almost impossible, working on MATE did lack the aspect of a real operational environment, especially for simulations. The quality of on-line practical training from remote depends much more on the trainee's self-initiative, both in picking up a session as well as contacting the mentor for support. Therefore, in many cases the online practical training did not have the same quality as on-site in person, resulting in the fact that an increased number of trainees did not feel confident as they were approaching their certification. Also, a lack of practical experience among the trainees was noticed by the Training and Simulation Team. This could only be compensated by an increased involvement of the TSO, by investing time to closely follow the progress of each trainee and support with advice and guidance, as well as encouraging the mentor to get more involved, where that lack of interaction was noticed. These difficulties caused delays of a few weeks in the training of several trainees. In some cases, the mentor was still supervising the freshly certified trainee for a couple of weeks, to compensate for the lack of confidence on console at the very beginning. For some roles where the practical activities had to be done on site, not the lack of mentoring sessions but the limited access to the operational rooms caused several weeks of delay. However, through the dedication of the TSOs, the mentors and the trainees, the GfR Training and Simulation Team successfully managed to get through the restricted times with no impact on operations, neither from a scheduling nor from a quality perspective. In 2021 even a full LEOP team was well-trained on time to perform a very successful 11th Galileo launch, that was performed completely from DLR GfR for the first time.

The significant advantage of the temporary focus on the virtual environment is that, after the operational environment was available again as before, the possibility to train in MATE, and the corresponding booking system, was kept. That means for the trainees that they have an additional platform for practicing independent of their work location, which gives them much more flexibility during their training. Only for Simulations the virtual environment is not used at the moment, as it lacks several essential aspects a trainee needs in order to become confident for the work on console.

5. Conclusions

As discussed in chapter 4, the adaptation of the training processes and their methodology, due to the restricted situation, brought advantages and disadvantages. When after two years those restrictions were starting to be removed, the Training and Simulations Team transitioned into a new process and methodology approach that made use of all advantages of remote work, especially for the theoretical training, but bringing the trainees back on site into the real operational environment for practical exercises and Q&A sessions with the mentor in person. However, having the virtualised environment available is a huge advantage as it still gives more flexibility to the trainees and increases the number of available platforms for training. That's why MATE is kept being further developed and maintained also for training purposes. In the last year the limitations of MATE have already been reduced. Almost all GCS elements have been implemented and are now available for training, and the environment is more representative of real operations. The experiences collected during the two years of remote working have inspired the teams to further work on solutions to make MATE more suitable for Simulations as well, and to work on improvements of its booking system.

The training processes that were established to work from remote are a significant advantage for the Training and Simulations Team to be able to follow the trainings at the GCC-D, as well as at the remote sites in Italy (GCC-I) and Spain (GSC) and by that lay the foundation for reliable and safe operations in the Galileo project and further improvement of the training processes and methodologies.

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