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## Key factors for an effective and successful LEOP SPACON crash training

Carla García Sánchez<sup>a\*</sup>, Nuria Meneses Ruíz<sup>b</sup>

<sup>a</sup> Galileo Training Officer, LSE Space GmbH, [carla.garcia@lspacespace.com](mailto:carla.garcia@lspacespace.com)

<sup>b</sup> Galileo SPACON Training Officer, LSE Space GmbH, [nuria.meneses-ruiz@lspacespace.com](mailto:nuria.meneses-ruiz@lspacespace.com)

\* Corresponding Author

### Abstract

The original LEOP team training approach at the Galileo Control Centre in Germany (GCC-D) considered that all LEOP personnel would be composed of already experienced and certified personnel working for Galileo routine operations. This approach capitalizes on the operational experience of the GCC-D teams and significantly reduces the cost and time for training in comparison to a completely new LEOP team. Additionally, it provides flexibility for the selection of the team members supporting the next LEOP in a relatively short period of time before the LEOP simulation campaign.

However, this approach could not be applied to the LEOP SPACON role. The routine SPACON team at GCC-D is required to support the 24/7 operations of the already flying satellites and could not be tasked with additional LEOP activities, so a completely new team of LEOP SPACONs had to be trained and certified in the same timeframe as the rest of experienced teams.

As defined by the very well-known project management triangle, the quality of any project will be directly affected by three main constraints: scope, cost, and time. The scope of the LEOP SPACON role was clearly outlined as part of the training needs analysis done for the LEOP team training; the cost and time were pre-defined without much margin left; and quality reduction was not an option. Considering these constraints, the first LEOP SPACON crash training was developed and delivered at GCC-D. The outcome was a fully trained and qualified LEOP SPACON team in less than three months ready to perform LEOP operations in an effective and reliable manner.

This paper describes the key factors for the effectiveness and success of such training and outlines the LEOP SPACON training plan and training schedule. Those determining key factors are:

- **Training Plan:** evolved from a reliable and consolidated SPACON training applied over 10 years. The training plan was tailored for the LEOP SPACON scope and focused on practical hands-on sessions and simulations, reducing the theoretical parts to the minimum necessary.
- **Team Composition:** very motivated and hard-working trainees who were lacking the experience and operational background compared to the rest of their LEOP teammates but showed once more how the human factor plays a determining role in the success of a training program.
- **Training resources:** dedicated and well-prepared trainers providing strong and individual mentoring to the new-to-be LEOP SPACON, closely following their training progress and providing them with continuous feedback and assessment on their performance to ensure the effectiveness of the training.

## Acronyms/Abbreviations

<b>AOS</b>	Acquisition Of Signal
<b>DBA</b>	Database Analyst
<b>FDE</b>	Flight Dynamics Engineer
<b>FOP</b>	Flight Operations Procedure
<b>GCC-D</b>	Galileo Control Centre in Germany
<b>GOM</b>	Ground Operations Manager
<b>GSOp</b>	Galileo Service Operator
<b>L11</b>	Launch 11
<b>LEOP</b>	Launch and Early Orbit Phase
<b>LOS</b>	Loss Of Signal
<b>MD</b>	Mission Director
<b>OBE</b>	On-Board Event
<b>OJT</b>	On-the-Job Training
<b>OM</b>	Operations Manager
<b>OOL</b>	Out Of Limits
<b>PA</b>	Product Assurance
<b>PLE</b>	Planning Engineer
<b>Q&amp;A</b>	Question and Answer
<b>SCCF</b>	Spacecraft and Constellation Control Facility
<b>SECOE</b>	Secure Operations Engineer
<b>SOE</b>	Spacecraft Operations Engineer
<b>SOM</b>	Spacecraft Operations Manager
<b>SPACON</b>	Spacecraft Controller
<b>SWC</b>	Software Coordinator
<b>TNA</b>	Training Needs Analysis
<b>TC</b>	Telecommand
<b>TM</b>	Telemetry

## 1. Introduction

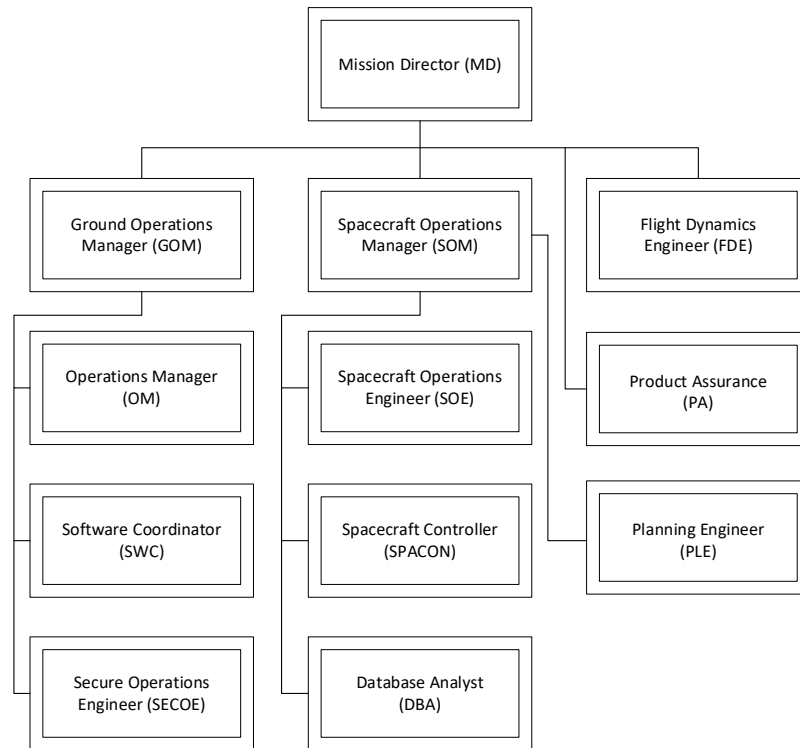
For the first LEOP operations at the Galileo Control Centre in Germany (GCC-D), the GSOp Training Team was responsible for the definition, preparation and management of the training and qualification plan for the LEOP operations team as well as the preparation, planning and execution of the LEOP Simulation Campaign. The scope of the LEOP training was to assure that the LEOP team could perform safe and efficient operations from the launch until completion of full handover to the routine operations team. The complete LEOP operations team under the responsibility of the GSOp Training Team is shown in Figure 1.

The LEOP training concept at GCC-D follows the methodology and training processes described in the GSOp Training Plan and adds a dedicated LEOP delta training to the baseline knowledge of the existing operational roles. This concept is based on the assumption that all LEOP personnel is composed of already experienced and certified personnel working for Galileo routine operations. Such approach capitalizes on the operational experience of the GCC-D teams and significantly reduces the cost and time for training and readiness in comparison to a completely new LEOP team, since every certified operations team member at GCC-D could perform LEOP activities pending only the completion of the LEOP delta training and the participation to the LEOP sim campaign. Additionally, it provides flexibility for the selection of the team members supporting the next LEOP in a relatively short period of time.

At the end of the LEOP Simulation Campaign and before going on console for LEOP operations, the Training Team performs an assessment of the LEOP readiness of each LEOP trainee by reviewing their:

- Completion of the LEOP delta training
- Participation and performance during the LEOP Simulation Campaign

After a positive assessment, the team member receives the LEOP operations' readiness.



**Figure 1: LEOP team organisation**

This LEOP training concept could not be applied to the LEOP SPACON role because the routine SPACON team at GCC-D is required to conduct 24/7 routine operations for the already in-orbit satellites and cannot be tasked with additional LEOP activities. The routine SPACON team is usually manned with 6 team members and the LEOP SPACON team requires a minimum of 5 team members to be able to cover LEOP operations in a 24/7 shift pattern. Increasing the routine SPACON team size to be able to cover routine and LEOP operations simultaneously was not a meaningful solution, given the related high increase in the required personnel and the fact that the LEOP SPACON role is not permanently needed, as the Galileo LEOP schedule was foreseeing approximately one LEOP per year in the upcoming years. All other operational roles had to additionally ensure the service continuity of the Galileo constellation during LEOP preparation and LEOP execution and therefore did not count with enough resources to support the LEOP SPACON operations either.

Considering these limitations, it was decided to create a completely new team of LEOP SPACONs composed of personnel from other GCC-D teams, who did not necessarily have previous experience in operations, but had to undergo a short, yet comprehensive training and certification program in order to be ready to perform LEOP operations in an effective and reliable manner. This paper describes the LEOP SPACON crash training course developed and delivered at GCC-D to train the LEOP SPACON team for the Galileo L11 launch (first LEOP at GCC-D) with a focus on the key factors for its effectiveness and success: training plan, team composition and training resources.

## 2. LEOP SPACON role

The LEOP SPACON role was defined and implemented to fulfil the LEOP SPACON tasks as described in the LEOP Operations Concept Document, where it is declared that the LEOP SPACON is in charge of the following tasks:

- Managing the commanding function of the Spacecraft and Constellation Control Facility (SCCF)

- Sending telecommands under supervision of SOM/SOEs
- Reporting to the SOM about any issue concerning TC function, spacecraft or system performance issues

The LEOP SPACON is continuously supporting the SOM on-console, who is in charge of all spacecraft operations activities and the responsible for the spacecraft monitoring and for flight operations procedures' scheduling and execution.

The Table 1 compares the LEOP SPACON and the routine SPACON roles:

<b>Routine SPACON</b>	<b>LEOP SPACON</b>
works autonomously on-console in accordance with the scheduled operations plan and with the established flight operations procedures	mainly follows the instructions received by the SOM and is never performing operations alone on-console
performs daily routine operations for the whole Galileo constellation	operates maximum two spacecrafts at the same time
takes corrective actions as necessary, applying contingency and emergency procedures approved for the mission	only executes autonomously the two Flight Operations Procedures (FOPs) to initiate and close a contact

**Table 1: Routine SPACON vs. LEOP SPACON**

Although this table does not show in detail all the tasks and responsibilities of these both teams, it is meant to illustrate the differences in training requirements in the scope of this LEOP SPACON crash training.

### 2.1 Training Needs Analysis (TNA)

The Training Needs Analysis (TNA) is the foundation for any training development and implementation in the GSOp Training Team. The GSOp TNA has been designed to analyse the Galileo training needs and requirements for the GCC-D operational roles. Additionally, a delta Training Needs Analysis (TNA) was developed to assess the LEOP delta training needs for the existing operational roles involved in LEOP activities. These training needs are built up after identification of the core tasks of a given role which are then linked with the required knowledge and skills that each trainee must acquire.

The main objective of the TNA for the LEOP SPACON role is to provide the inputs for the LEOP SPACON training development. The first step consists of identifying the main tasks requiring a training and qualification plan as in Table 2 below:

<b>Role</b>	<b>Core Tasks</b>
LEOP SPACON	<ul style="list-style-type: none"> <li>- Preparation and configuration of LEOP SPACON workstation</li> <li>- Proficient usage of SCCF</li> <li>- Monitoring and control of all TM and TC applications</li> <li>- Following SOM instructions</li> <li>- Execution of AOS/LOS procedure autonomously</li> <li>- Informing SOM about any OOLs, OBEs or any other anomalies</li> <li>- Logging and reporting of OOLs, OBEs or any other anomalies</li> </ul>

**Table 2: LEOP SPACON core tasks**

Once the core tasks of the LEOP SPACON role are identified, it is necessary to define the corresponding training needs to fulfil those tasks and prepare the LEOP SPACON training plan. These are:

- Training and certification process
- Operational tools
- Voice communication protocol
- LEOP roles and responsibilities
- LEOP setup and operational concept
- LEOP infrastructure
- SCCF introduction
- Introduction to TM & TC standards
- SCCF TM & TC applications
- TM & TC anomalies
- AOS/LOS FOPs
- Logging and reporting
- Introduction to LEOP simulation environment
- Secure Operations

The TNA and the training plan are complementary and consistent to each other. While the TNA describes the training required for a role, the training plan describes the training processes, methods, and certification process.

### **3. LEOP SPACON training approach**

The main constraints and challenges for the preparation of the LEOP SPACON training were the following:

- The full LEOP SPACON training and certification had to be completed in the same timeframe as the rest of experienced teams, who only needed to complete the LEOP delta training (timeframe given was 3 months)
- The LEOP SPACON trainees were not dedicated 100% to the training
- Each LEOP SPACON trainee had completely different backgrounds, technical skills, and knowledge of the Galileo project
- Most of them did not have any solid background in spacecraft operations

The scope of the LEOP SPACON role, as previously described, was clearly outlined as part of the Training Needs Analysis (TNA) and the cost and time were pre-defined without much margin left. Therefore, the standard GSOp training approach had to be reviewed to cope with these constraints, providing dedicated resources to this training and adapting the training process and methodology to ensure that the quality and results of this training would not be affected.

The LEOP SPACON training was therefore prepared according to the following principles:

- Dedicated trainers from the Training and Simulations team at GCC-D to prepare, coordinate, implement and supervise the training day to day
- Minimize the self-study and maximize mentored sessions
- Expert training courses given by experienced ops personnel
- Practical ops training to be provided on-site in a simulated LEOP operations environment
- Specific hands-on exercises on the LEOP SPACON tasks to be executed together with their trainers
- Repetition of hands-on exercises as many times as needed to allow the trainee to get proficient in their duties and the LEOP operations environment
- Participation to On-the-Job activities and internal LEOP simulations from the beginning of the training
- Continuous feedback sessions with the trainers and other LEOP experts to identify any possible knowledge gaps and performance issues at an early stage
- Intermediate checkpoints to evaluate and assess the trainee's progress

According to the identified training needs and following the training principles described above, we developed and delivered the first LEOP SPACON training at GCC-D. The Table 3 below shows the estimated effort invested by the GCC-D Training Team in the preparation and execution of this training:

<b>Effort estimation for the LEOP SPACON training</b>		
<b>Training module</b>	<b>Theoretical training [h]</b>	<b>Hands-on training [h]</b>
LEOP operations concept	12	
LEOP Infrastructure	12	
Voice communications protocol	6	9
SCCF	24	42
TM/TC standards	24	
Flight Operations Procedures	18	60
Ops tools, logging and reporting	12	24
Hands-on exercises		72
TM & TC anomalies	9	9
Secure Operations	12	18
Q&A, feedback and assessment sessions	36	
Intermediate evaluation and final certification	60	
<b>Sub-total estimated effort [h]</b>	<b>225</b>	<b>234</b>
<b>Total estimated training effort [h]</b>	<b>459</b>	

**Table 3: GCC-D Training Team effort estimation**

It must be understood that this effort and dedication from the Training and Simulations Team is not provided to the training of any other operational or maintenance roles at GCC-D. The resources from the Training Team are also limited and the preparation and execution of such intense and personal training meant that at least one Training and Simulations Officer was mainly dedicated to these activities, sometimes even two of them. Furthermore, it must be underlined that the LEOP SPACON trainees had additional responsibilities in parallel of this training, what meant that not all of them could attend the training sessions at the same time. For this reason, the trainers had to continuously adapt the schedule of the training and additional sessions were needed on some occasions.

#### **4. Training Key factors**

The key differentiator to other training programs is the capacity of adjustment from the original LEOP team training approach to the new concept for the LEOP SPACON training in a very limited amount of time and with a group of trainees without operations background. The key factors for this effective and successful LEOP SPACON training are:

- A well-defined Training Plan
- Motivated and hard-working team members
- Dedicated training resources

##### *4.1 Training Plan*

The LEOP SPACON training plan was based on the already existing training plan for the routine SPACON team at GCC-D. This was one of the first training plans elaborated for the Galileo operations teams and has been in place for over 10 years. It is a reliable and solid training plan in constant development and improvement to cope with the

new project and mission needs and still fulfil the training and certification schedule to ensure 24/7 operations service continuity.

As previously explained in chapter 3, the tasks and responsibilities from the LEOP SPACON role are limited in comparison to the ones from the routine SPACON, therefore the LEOP SPACON training plan was tailored for the LEOP SPACON role needs. Following the same approach as in the routine SPACON training, the LEOP SPACON training was focused on practical training sessions and simulations, reducing the theoretical training sessions to the minimum necessary. All training modules contained hands-on exercises specifically developed for this training in order to maximise the time on-console for the trainee and get used to the LEOP operations environment. Those exercises were repeated several times to allow the trainees to get proficient with their duties and improve their reaction time when working on console.

#### *4.2 Team composition*

The selected LEOP SPACON trainees were a group of 5 people working for the Galileo project for several years, with different backgrounds and expertise who were not dedicated 100% to this role. This allowed building a highly motivated cross-functional team coming from different disciplines within the company.

The LEOP SPACON trainees went through an intense training while they were working in parallel for their main position; they had to face several unexpected and stressful situations as part of their training exercises and LEOP simulations; and they had to get familiar to work in operations and strictly follow instructions. In addition to the gained technical knowledge during the training and the LEOP execution, the multi-disciplinary aspect of the LEOP SPACON team became a big benefit for the project since it improved the working communication and information exchange when handling other topics outside the LEOP perimeter.

The good set of personal and soft skills from the LEOP SPACON trainees played a determining role in the success of their training and certification. Despite their lack of operations experience, they counted with the following very important qualities:

- Extremely motivated
- Hard-working
- Quick learners
- Flexible
- Able to quickly adapt to the LEOP operations environment

Their attitude and commitment with this training were crucial for the effectiveness of their training and their certification for LEOP operations.

#### *4.3 Training resources*

The LEOP SPACON training was prepared and delivered by dedicated trainers from the GCC-D Training and Simulations Team, who had previous experience in LEOP preparation and LEOP operations. They closely followed the training progress of each LEOP SPACON trainee during the regular mentoring and training sessions and organized frequent Q&A sessions where the trainees could address any open topics.

For some specific training modules, online sessions were organized by the Training Team and delivered by experts from the Ground Operations and Spacecraft Operations teams, who had been working for the Galileo project during many years and were involved in the L11 LEOP preparation since the very beginning. These courses were very useful because they provided the opportunity to the LEOP SPACON trainees to directly learn from very experienced colleagues and to get a better understanding of the Galileo operations.

An important part of the LEOP SPACON training were the practical ops training sessions in a simulated LEOP environment, like the hands-on sessions and the LEOP internal simulations. Most of them were taking place onsite in an operational control room. In addition, the trainees had the possibility to setup sessions with a simulator and an

operational LEOP SPACON workstation in a virtual training environment from their own computer for self-practice and for the execution of virtual LEOP simulations. A key success factor during the self-practice sessions was the continuous support of the Training Team, available to help the trainees solving any issue they encountered.

Additionally, after each LEOP simulation, the Training Team collected the feedback on the individual performance of each LEOP SPACON trainee and, together with the LEOP SOM and the LEOP Simulations Officer, the individual progress was assessed. The knowledge gaps for their LEOP operations readiness, if any, were identified and communicated to the trainees, who enormously benefited from the continuous feedback received on their performance. This methodology additionally allowed to introduce delta training sessions early enough and reduced the risk of delays in their final certification.

This training approach focused on hands-on activities and dedicated training resources became a key factor in the effectiveness and success of the training as it clearly proved an acceleration on the learning process and therefore allowed to achieve the training objectives in the required timeframe.

## 5. Results

If we consider the project management triangle, the three main constraints to accomplish a project are clearly defined: scope, cost, and time. A change to any of these factors will impact the result of the project. Our project was the LEOP SPACON training, and the scope, cost and time were pre-defined, so we adapted our standard training methodology to successfully accomplish our project. The result was a fully trained and qualified LEOP SPACON team in less than three months ready to perform LEOP operations in an effective and reliable manner.

The LEOP SPACON team provided amazing support to the L11 operations at GCC-D. The LEOP operations went smoothly and any non-nominal situation could be quickly identified and solved. The team had all the necessary skills to perform their tasks and supported the rest of the LEOP team as required. The feedback received on the LEOP SPACON performance was always positive and exceeding expectations.

As described by some of the LEOP SPACON team members, their participation to L11 as LEOP SPACON was a life-time experience. They gained a global vision of the Galileo project, and it helped them value and understand even more their role in it. They were truly motivated to delve into the core business of GCC-D, spacecraft operations, and the opportunity to be part of the LEOP activities allowed them to go into detail about many technical matters. This training was also decisive for their future personal career development, letting them to access to a permanent position in routine operations, which may not have been even thought of without getting insight into the operations environment.

All in all, the LEOP SPACON Training is a great example that internal job rotation and cross-functional trainings implemented in a prompt and dynamic way are possible assuming the availability of professional training personnel who is capable to present technical aspects to non-technical teams clearly, concisely, and methodically, and assuming that cross-training possibilities are given to the employees.

## 6. Conclusions

Taking into account the three key factors analysed in this paper, the followings conclusions can be taken:

- The operations environment and the LEOP boundary conditions are in continuous change. This means that the training processes and methodologies need continuous adjustments. However, the LEOP SPACON training plan can be perfectly reused and will only have to be updated to cope with the delta training needs from the upcoming LEOPs.
- In the specific case of the LEOP SPACON role, which is not permanently staffed and needed, it is not possible to predict whether the same team members will be available for several consecutive LEOPs or it will be necessary to train new LEOP SPACON trainees for each new launch. In case of a high turnover rate, the effort of the GCC-D Training and Simulations Team in the execution of this training would have to be repeatedly invested.
- If new LEOP SPACON trainees are needed, their motivation, commitment and set of personal skills will continue playing a determining role in the success of their training and certification.



- Without dedicated training resources and the regular feedback and assessment of the trainees, it will not be possible to keep the training and certification schedule nor its quality.

These last conclusions will have to be carefully considered for the preparation of the next coming LEOPs, and the sustainability of this training approach will have to be further analysed. For now, the LEOP SPACON crash training can be declared as a great success-story for the Galileo L11 operations, and as an excellent reference for the future of the Galileo LEOP operations.

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