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Analysis of the knowledge transfer efficiency within the Galileo project training system from the trainee’s perspective
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Abstract

Galileo is a European Union project which provides worldwide geolocation and precise time synchronization services. It is composed by a constellation of 24 satellites in medium earth orbit (MEO) at an altitude of approximately 23000 km. The constellation is a 24/3/1 walker constellation which orbital planes are equally distributed with an inclination of 56 degrees. In December 2016 the service was declared operational by the European Commission.

The entire constellation is controlled by two operation centres. The first one is the Galileo Control Centre in Oberpfaffenhofen (GCC-D) and operated by the Gesellschaft für Raumfahrtanwendungen (DLR-GfR) while the second is the Galileo Control Centre located in Fucino (GCC-I) and operated by Telespazio. Between the two sites, the roles and the responsibilities are split. The GCC-D is the prime responsible for the whole ground segment and the constellation routine operations, while GCC-I acts as the backup centre. On the other hand, GCC-I is the prime responsible for the mission and the classified segment, while GCC-D supports as backup.

Numerous teams are necessary to control and monitor the constellation and the infrastructure to ensure the coverage of all the aspects of the ground and flight segments. This means that the newcomers joining the company or switching teams must be professionally trained and certified for the new role before they can safely operate and contribute efficiently to the project. To guarantee a continuous coverage for all the roles, the training process must be efficiently and clearly organized to maximize the know-how transfer to the newcomers. Among the biggest challenges in this field, we find:

- the number of distinct positions that must be covered by the training;
- the difference in responsibilities of the two GCCs;
- the different geographical location of the two GCCs;
- the continuously evolving infrastructure, which requires constant updates of the training material.

Other factors also indirectly affect the training efficiency e.g. busy launch phases, intensive system validation periods, simulation campaigns, off routine or non-nominal conditions of the operations, governmental restrictions due to the pandemic etc.

In this paper we want to present and qualitatively analyse the training system by sharing the knowledge transfer experience as seen from the trainee’s point of view. Considerations will be made about its strengths and its weak points and possible improvements will be presented.

To do this, the GCC-D’s training programmes for the following teams are analysed:

- Ground Operations Engineer (GOE)
- Mission Operations Engineer (MOE)

Keywords: (Galileo, GNSS, Training, Knowledge Transfer)

Acronyms/Abbreviations

DLR-GfR	Gesellschaft für Raumfahrtanwendungen
GCC	Galileo Control Centre
GCC-D	Galileo Control Centre in Oberpfaffenhofen
GCC-I	Galileo Control Centre in Fucino
GNSS	Global Navigation Satellite System
GOE	Ground Operations Engineer
GOM	Ground Operation Manager
GSS	Galileo Sensor Station
MATE	Maintenance and Troubleshooting Environment
MEO	Medium Earth Orbit
MOE	Mission Operations Engineer
OJT	On the Job training
OPE	Operational Chain
SECOE	Secure Operations Engineer
SIS	Signal In Space
SOPS	Special Operations
TMS	Training Management System
TTCF	Telemetry Tracking and Command Facility
ULS	Uplink Station
VAL	Validation Chain

1. Introduction

The aim of this paper is to provide an insight of the training processes of the ground team in the frame of the Galileo project. Galileo is Europe’s program for a global navigation satellite system (GNSS) with the goal to provide accurate global positioning and timing service. The constellation is composed by 24 operative satellites (and 6 spare) in MEO at an altitude of 23222km and distributed on three planes with an inclination of 56° [1]. To guarantee the service provision the mission relies on the continuous coordination and synchronization of many different elements and specialized facilities which cover the necessary functions to provide a reliable and precise signal.

Contractually, Spaceopal GmbH is the prime contractor for the Galileo operational services, with its subcontractors DLR-GfR and Telespazio providing the monitoring and control of the constellation and all its mission relevant infrastructure respectively.

After an extensive testing and validation period in December 2016, the navigation service was declared operational by the European Commission [2]. The provided services are:

- Open service;
- Commercial service;
- Public regulated service;
- Search and rescue service.

To be able to manage a such a complex infrastructure highly qualified operators are needed. This leads to a complex and demanding training scenario for all the new team members which are evaluated by a certification board to be certified to operate. The training plan is divided in levels. After each level there is a certification board which assesses and provides feedback of the trainee’s knowledge. After a general introduction to the system, the training plan goes deeper into detail of the individual roles, tasks and infrastructure. Therefore, for each role in the Galileo operations team there is a specific tailored training plan. The main objectives of the training are:

- Ensure that every trainee gets the proper knowledge to operate safely and autonomously and gets positively assessed by the certification board;
- Keep track of the system evolution and changes in order to be an up-to-date reference for the team members;
- Consolidate the knowledge of the team by means of recurrent and delta-trainings.

The process is divided in self-learning modules, simulations-, mentorship- and on the job training (OJT) activities. It usually takes about 6 months and ends with the full certification of the trainee.

1.1 Importance of the training and the knowledge transfer in Galileo

The training and the knowledge transfer is a key element within the Galileo project. It is extremely important to offer a continuous coverage of the operational roles by training people in their field of competence. Galileo is a continuously growing and developing project which brings a lot of dynamism to the positions. New roles are common and new or existing teams are created or expanded respectively, to deal with the Galileo system evolution. As a result, there is a constant need to train new people in a fast and efficient way, as well as addressing changes in the team, with people changing company, job or role, and thus need to be substituted by new members. This implies that the knowledge from the experienced people, must be transferred directly to the trainees as not to be lost. To mitigate this situation, DLR-GfR has come up with solutions to put in direct contact the trainees with the experts in the working team.

1.2 Introduction to the ground infrastructure

To better understand the ground infrastructure the teams are working with, a brief introduction is provided covering the core of the Galileo system and the control centres. There are two centres located in Europe: one is in Oberpfaffenhofen, Germany and is known as GCC-D while the other is in Fucino, Italy and is known as GCC-I. From these two centres the ground, space and mission segments are controlled. For the sake of redundancy, a dual site concept has been established assigning prime and backup roles among the two control centres, as shown in Table 1[3]Table 1. To guarantee business continuity, the dual site concept includes procedures in the case of a planned or an unplanned handover. Therefore, the team members must be trained and prepared at any time to allow a smooth transition in case of need. This requires that people, who cover a backup role, on the backup site must get continuous refresher trainings, which are nominally carried out on the primary site.

Table 1. Segment distribution among sites [3]

Segment	GCC-D	GCC-I
Space	Prime	Backup
Ground	Prime	Backup
Mission	Backup	Prime
Secure operations	Mixed	Mixed

To ensure uninterrupted operation of the constellation, the antennas have been spread at remote sites around the globe. Galileo has 6 S-band antennas called telemetry tracking and command facilities (TTCF) [4]. These antennas are used for the routine command and control of the satellites. They provide the RF up- and downlink to the satellites, and are primarily operated from GCC-D. Additionally, Galileo has 20 C-band uplink stations (ULS) located around the globe [5], which are used by the mission segment to upload the navigation message to the satellites. These antennas are mainly operated from GCC-I since it is the mission prime site. Furthermore, the mission segment also possesses 30 precisely time synchronised omnidirectional Galileo sensor stations (GSS), which are required to determine the satellite position by receiving the signal in space (SIS) of each satellite. The distribution of the elements within the different sites can be seen in Table 2 [4,5,6] and visualised in a contextual map in Figure 1 [7].

Table 2. Galileo sites [4,5,6]

Site	Control Centre	TTCF	ULS	GSS
Oberpfaffenhofen, Germany	X			X
Fucino, Italy	X			X
Kiruna, Sweden		X		X
Kourou, overseas department of France		X	X	X
Noumea, overseas department of France		X	X	X
La Réunion, overseas department of France		X	X	X
Redu, Belgium		X		X
Papeete, overseas department of France		X	X	X
Svalbard, Norway			X	X
Azores, Portugal				X
Troll, Norway (Antarctica)				X

Kerguelen, oversea department of France	X
Jan Mayen, Norway	X
Saint Pierre and Miquelon, oversea department of France	X

In Figure 1[7] it is seen that the distribution of the sites with TTCF and GSS antennas is quite uniform around the globe to guarantee a full global coverage. Nevertheless, new sites and antennas are planned and in continuous evolution to respond to the demand of the increasing number of satellites and redundancy.



Figure 1. Galileo sites and ground stations [7]

1.3 Introduction to the groups and organisation

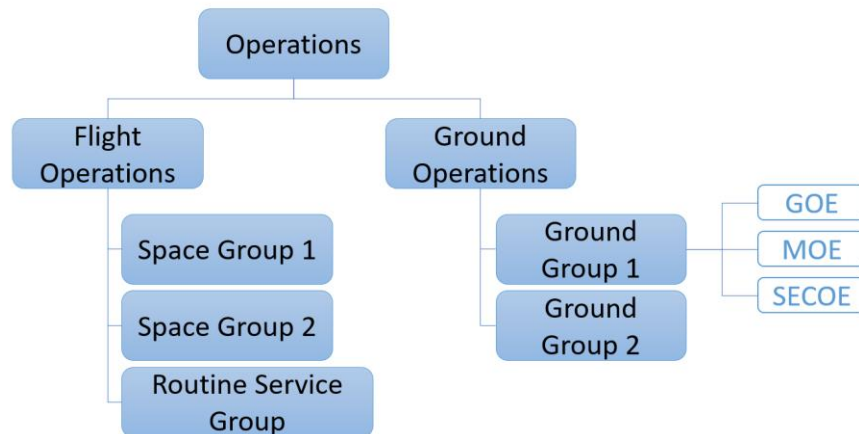


Figure 2. Operations organisational structure

To understand the complexity of the training system, the operations team structure is represented schematically in Figure 2. The high-level separation is done first by dividing the operations department between ground and flight operations. Within the flight department there are the space group 1, space group 2 and the routine service group. This paper focuses on the training programmes of the ground operations department, which consists of ground group 1 and ground group 2. Ground group 1 is responsible for ground segment operations as well as ensuring that the system is available 24/7 by intervening whenever there is a problem. Ground group 2 is focused on level 2 support and

maintenance for the overall ground infrastructure involving antennas, software and hardware. For the scope of this paper the only ground group 1 is taken further into consideration and analysed in detail. Within this group we can distinguish 3 sub-groups: GOE, MOE and secure operations engineers (SECOE). Each of these sub-groups are taking care of a portion of the system either as a prime or as a backup role. GOEs are responsible for the ground control segment including antenna, hardware and software failures and ensure availability of the ground segment on a 24/7 basis. Since GCC-D is the prime responsible for the ground segment, this is a primary role in the GCC-D. MOEs are responsible for the availability of the ground mission segment, which generates the Galileo navigation messages. For this role the control centre in Fucino is the primary responsible. This means that in GCC-D the MOE is predominantly a backup role to GCC-I, however, is also covered on a 24/7 basis as with the GOE role. As a result, part of the main and the refresher training of the GCC-D MOEs must be performed locally in GCC-I. The SECOE team is responsible for operating the secure payload and the secure ground segment. For the secure operations the responsibilities are shared between GCC-I and GCC-D. Being that all these roles quite different and dependent on a specific control centre, it results clear that the training program must be tailored and managed independently for each single role.

2. Certification process and Scorecards

The GOE role is one of the primary roles in GCC-D, therefore, it is strongly recommended in ground operations to start the training of all newcomers as a GOE first, before moving to be cross-trained as a MOE or a SECOE. Apart from a few exceptions, every person will eventually be double certified as a GOE plus a second role. This has the advantage of creating a more flexible team, but at the expense of an overall longer training time. To keep track of the certification progress, the training team uses a tool called the training management system (TMS), in which the scorecards for the different roles are managed. The scorecards are like “to do lists” in which the trainee can find the details and the material related to the self-learning modules, the mentorship- and the OJT activities to be completed in order to be admitted to the certification exam.

2.1 The GOE scorecard

The GOE certification is divided into 3 levels: CL0, CL1 and CL2. These levels contain the modules, tasks and material related to the topics to study.

- In CL0, the main aim is to gain a general introduction to all the systems, the GNSS infrastructure, an insight of the other teams, the data exchange flows and an introduction to the tools/processes which are used within the Galileo project to keep the system up and running. At the end of CL0 there is a briefing planned with a GOE mentor to assess and approve the knowledge of the trainee.
- In CL1, the aim is to start to perform operations on console under the supervision of a fully certified GOE. The list of self-learning activities starts to reduce and the number of OJTs start to increase. The trainee will be included in the assignment of the routine special operation tasks (SOPS), which they will be shadowing or carrying out under strict supervision. After the scorecard has been completed the trainee needs to pass an internal board assessment to obtain the CL1 certification.
- In CL2, the level of self-studying activities decreases further in favour of practical activities. The trainee is involved in non-routine SOPS and supports the local internal processes. To do this, the future GOE will receive their own credentials for the operational chain (OPE) and the validation chain (VAL). To complete the training, the trainee must perform a minimum of 2 weeks shadowing of on-call in which they will be in charge of the 24/7 troubleshooting, the monitoring of the OPE chain, and performing the daily checks. During this period, an experienced GOE is assigned to shadow the trainee’s 24/7 on-call duties in case of need. The final board is composed by an internal team member, the ground operation manager (GOM) and a member of the training team responsible for the certification. During the examination the trainee is confronted with open questions simulating real life on-call scenarios. After this, the board discusses and evaluates the trainee and come to a joint conclusion which can be a “success”, a “partial success” or a “failure”.

A success means that the GOE is fully certified and can perform operations independently; a partial success means that the GOE is lacking knowledge or experience in some areas and will have to consider a delta training and delta examination; while a failure means that the trainee will have to repeat the whole examination. In Table 3 the number of modules contained in the different levels is shown. It must be kept in mind that the number of modules is not representative of the time spent on a certain topic/level because the workload of a module can range from 10 min to weeks. The timeline and effort estimation will be discussed in the next chapters.

Table 3. GOE scorecard modules

Level	Activity	Number of modules
CL0	Self-Study	58
	Mentorship	30
	OJT	0
CL1	Self-Study	26
	Mentorship	25
	OJT	14
CL2	Self-Study	20
	Mentorship	11
	OJT	6

2.2 The MOE Scorecard

The MOE role is primarily a backup role in GCC-D. This means that all the activities, checks and actions performed on OPE chain must be strictly coordinated and guided from the prime site (GCC-I) if required. Therefore, part of the training shall be performed at the prime site to understand the primary system and meet the engineers working from there. The scorecard in this case is divided in two sections, CL0 and CL1:

- In CL0, the main objective is to give a general introduction to the trainee to get an overall understanding of the Galileo project. This section is derived from a subset of the CL0 modules of the GOE scorecard. In general, as people who are to be trained as a MOE have already been certified as a GOE, this part can be skipped and marked as completed.
- In CL1, the scorecard mixes practical and self-learning experience together. The trainee must study to understand each element function and in parallel performing basic operations, whilst shadowing the MOE on call on the backup site. One of the most consistent parts of the training are the OJTs planned at the main site. This means that a business trip to GCC-I must be organised, coordinated and scheduled between the two sites. Nominally, it lasts a whole week and consists of shadowing and performing operations under supervision of the prime MOE colleagues in GCC-I. Additionally, the trainee has the opportunity to get to know personally the colleagues at GCC-I and gain further knowledge on the functioning and management of the system. To complete the MOE scorecard there is an online test. Based on the results of the test and based on the assessment that the colleagues in GCC-I have done during the OJT week, the training team responsible confirms the success or the rejection of the trainee in completing the MOE certification.

To get a better overview, the number of modules for the MOE scorecard levels is listed in Table 4. Due to the different workloads of the modules, the quantity is not representative of the time spent for the different levels. The timeline will be discussed in the next chapters.

Table 4. MOE scorecard modules

Level	Activity	Number of modules
CL0	Self-Study	33
	Mentorship	12
	OJT	0
CL1	Self-Study	20
	Mentorship	7
	OJT	10

3. Training timeline

The duration of the training is influenced by many factors. These factors can be grouped in the following categories:

- Project related factors: launch phase, system software upgrade, hardware upgrade, validation phase, handover to backup site;
- Company related factors: recruiting in batches or single people, organizational restructuring;

- External factors: restrictions due to the pandemic, conflicts between member states and partners;
- Personal factors: personality, practice oriented, theory oriented, proactivity, learning method;
- Team factors: availability for mentorships, competence, teaching skills.

To predict the duration of the complete certification process, estimations are made considering a nominal situation in which the team is available for shadowing and mentorship activities and there are no busy project phases going on. The trainee should in any case be proactive and claim support from the assigned mentor whenever needed.

Table 5. Certification times

Role	Level	Weeks
GOE	CL0	5
	CL1	8
	CL2	9
MOE	CL0	5
	CL1	9

In Table 5 you can see the currently estimated times for the GOE and the MOE certifications. In overall 22 weeks are planned for the full GOE and 14 weeks for the full MOE certification.

3.1 GOE certification timeline

In Figure 3 an estimated timeline for the GOE certification is shown. Starting with the CL0, the first 5 weeks it is seen that almost all the time is spent in self-study modules while, towards the end, the time dedicated to the mentorship modules is increasing.

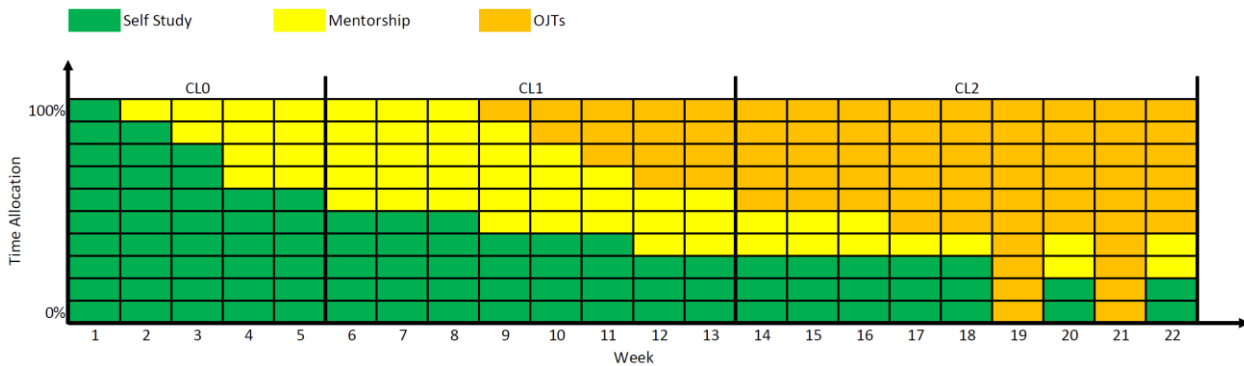


Figure 3. GOE training plan time allocation estimation

During CL1 the mentorship and the OJT modules are increasing, with a subsequent reduction of the time that the trainee must spend on self-study modules. At the end of the CL1, the amount of time spent on self-study-, mentorship- and OJT modules should be nearly the same. In CL2, most of the time is spent working under supervision of an experienced GOE in the control room or helping in the internal processes. Therefore, more than 50% of the time is spent on OJT activities to get the trainee ready for operations. Towards the end of the CL2, two shadowed on-call weeks need to be performed by the trainee as per OJT modules. These two weeks, represented in Figure 3 on week 19 and 21, will take 100% of the time, during which the trainee will have to be on-call on a 24/7 basis.

3.2 MOE certification timeline

Concerning the MOE certification, in Figure 4, a similar timeline as for the GOE training is shown. During CL0 the main time is spent on self-studying modules while moving towards the end of the level, the training gets more interactive with the mentorships. In a similar way, during CL1, the self-study time is reduced to a minimum to give space to the increasing mentorship and OJTs parts. Close to the end of the certification a whole week of training is foreseen at the mission prime site in GCC-I which will take 100% of the trainee’s time.

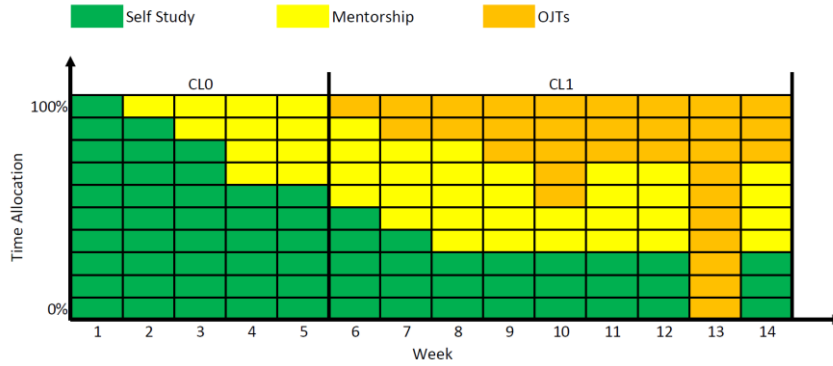


Figure 4. MOE training plan time allocation estimation

Usually, the MOE certification is performed after the GOE training, which means that the CL0 can be skipped since it has been covered already by the trainee. According to the nominal timeline of Figure 4, the CL1 should be completed in 9 weeks, after which, the new MOE will be ready to support the team. In this case, it has been observed, that the time to complete the certification does not respect these predictions at all. To further analyse this observation, it is needed to look at the boundary conditions under which the training is carried out. Realistically speaking, the MOE certification is done in parallel to the ongoing GOE activities and the on-call service making it impossible to complete the CL1 within the predicted 9 weeks. In Figure 5 this case is represented with the CL1 training time redistributed assuming 50% of GOE duties together with the on-call weeks. In this condition a MOE certification could last up to 20 weeks and this delay is strongly dependent on the rest of the teams capability to cover the additional workload caused by the missing GOE. As a matter of fact, it can be stated that in a nominal project situation a GOE can dedicate from 40% to 70% of its time to the studies. On top of this delay, also the bureaucratic time must be considered since the training activities have to be coordinated between the two sites, business travels must be organised, and additional documentation must be carried out. In this case, the certification will be delayed together with the future support capability for the MOE team.

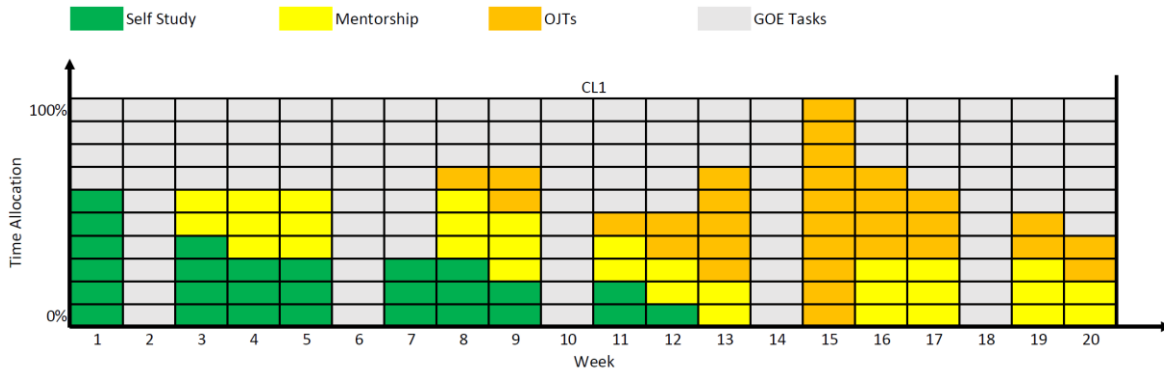


Figure 5. MOE training plan time allocation estimation for a 50% GOE

In the timeline presented in Figure 5, the on-call rotation period and the 50% availability are considered. It is clearly seen that even by skipping the CL0, the timeframe for the overall training is increased. 5 Weeks of delay are due to the on-call service, which must be done approximately every 4th week. The rest of the time, the trainee has only 50% of the available time to dedicate to the training, which is strongly dependent on the day-to-day workload of the team. Another factor delaying the schedule towards the end of the training is the different cross site approval loops needed for the account creation after the trainee is certified. This is roughly represented by the weeks 16 to 20 that pass from the OJT week in Fucino to the final certification date.

3.3 Timeline improvement suggestions

By closely looking at the MOE timeline in Figure 5 it gets clear that one of the main time delays is due to the on-call weeks carried out in parallel to the training. A solution could be to remove the trainee from the GOE on-call plan

for the foreseen training period. This measure has a direct effect on the on-call plan and has as a prerequisite that there are enough resources available in the GOE team to be able to remove the trainee from the on-call rotation. To ensure this, a resource planning must be carried out for 4 months in the future. During this time, the trainee will still be available to carry out his nominal GOE tasks up to 50% of its time. This is possible if the GOE takes care of the assigned routine processes without getting overloaded with any other action or SOPS support assigned. With this measure it would be potentially possible to save 5 weeks. This reduces the necessary time to 15 weeks saving 25% of the certification time.

An even better result could be achieved by removing the GOE completely from the team letting him carry out the training on a full-time basis. The impact on the team workload during this period would be high but the total training period could be reduced to 9 weeks. The total certification time would drop from 20 weeks to 9 weeks by saving 55% of the time. Additional advantages of this solution are that the trainee can fully concentrate on the MOE topics increasing its learning efficiency. This also improves the consolidation of the training carried out on the prime site.

4. The GOE certification process from the trainee’s perspective

At the beginning of the training the trainee gets assigned a mentor. This mentor is a certified GOE who is part of the internal training team process. The trainee is then introduced to the TMS, familiarises himself with the different types of activity. The levels of certification are explained as well as the different types of exams which must be passed to get the full certification. To have an idea about the training schedule, the exam dates for the CL0, CL1 and CL2 are preliminarily scheduled, according to Table 5, to set a target date for the trainee. Since the number of modules in the scorecard is quite high, and the breadth of the training material wide, it is common in the first weeks that the trainee feels a bit lost and needs some additional guidance from their mentor. Due to the continuous evolution and changes to the Galileo infrastructure, it happens also that some links or material referenced in the modules can become outdated or invalid which can cause some confusion for the trainee. Therefore, the trainee is constantly invited to log and report to his mentor possible errors or misalignments in the material during his training activities allowing the training program to be kept up to date and constantly improved.

The CL0 level is mainly based on self-study activities and basic introduction mentorships. With the mentorships the trainee gets to know the system but also the team members and their different fields of expertise. In case of difficulties, it is the duty of the mentor to guide the trainee, as well as schedule the mentorships with the other team members. When all the modules of CL0 are completed, the status of the trainee is assessed by the mentor. Missing points and doubts are clarified, and the decision as whether to proceed with the CL1 section of the training is given.

During the CL1 phase, the trainee is introduced to the practical work by supporting the SOPS. Depending on how confident the person is with the system, the activity can be executed from the GOE and followed by the trainee as well as performed from the trainee itself while shadowed by the certified GOE. While performing the activity, any questions can be immediately answered and further details about the system can be shared with the trainee. Thus, the knowledge transfer is optimised, as the trainee can profit directly from the knowledge and from the personal experience of the experienced GOE. In the CL1 phase, the trainee is included actively in the team and gets to know the colleagues better. In parallel to the SOPS, the onboarding in the project processes start as well. This gives the opportunity to learn and get a deep knowledge of the processes which are necessary to maintain the effective operation of the Galileo ground segment. Towards the end of the CL1 level, the trainee attends some special preparation sessions for the upcoming exam. The CL1 exam is held in front of an internal board and consists of theoretical questions about the system and its processes, as well as mitigation of the main issues which can happen during operations. The duration is scheduled for one hour, after which if the trainee is successful, is forwarded on to the CL2 level.

Once the CL1 certification is achieved, the mentor and the manager request the account creation on the VAL and OPE chains. The CL1 certified trainee then has more responsibility for his activities. Simple recurring activities can be performed without supervision whilst more complex or critical tasks, shall still require the supervision of a certified GOE. The focus of the self-learning part of the training is now mainly concerning contingency procedures and non-routine activities. These procedures and workarounds can be tested in VAL or on a virtualised test environment called Maintenance and Troubleshooting Environment (MATE). To prepare the trainee for the full certification, two shadowed on-call weeks are to be scheduled, in that the trainee will then be the primary on-call contact for all the ground related issues, and in charge of the daily checks on OPE. During these first 2 on-call weeks, the trainee can rely on 24/7 support from their assigned shadow. In some cases (if deemed necessary), the training mentor and the trainee can agree to perform further shadowed on-calls before of the CL2 certification. Once all the modules of the last level

are completed a few preparation sessions are organised by the mentor and the team members to simulate the CL2 exam. The official exam is then scheduled with the external training team and ground managers which form together the certification board. Questions are asked in form of simulated on-call cases. To solve these cases, the GOE is only allowed reference material nominally available to the GOEs, including procedures, workarounds and personal notes. In addition to the trainees knowledge, their behaviour is evaluated, i.e. in case of stressful situations, how they deal with pressure is observed, etc. The trainees shall be able to solve the standard on-call cases, stay calm and, if the issue is not solvable, ensure the system in safe running conditions until further support can be requested from the other teams. After the questions, the trainee is asked to leave the room until the board has discussed the performance and agreed on the final verdict. Here, different options are possible: there can be a full pass, a partial pass with some delta trainings (and further shadowed activities), or a failure with the consequence that the exam will have to be repeated. After successful certification, the new GOE is inserted in the on-call plan and provides official service within the team. He can now perform SOPS without support, investigate issues alone and get prime responsible for one or more project processes.

4.1 GOE certification improvements

- When the team workload is low, people are more able to give extensive and clearer mentorships to the trainees. In busy phases this is not always possible and generates frustration, where the trainee is not always understanding what he should do, or why certain activities are done. Unanswered questions can create even more confusion and impact the trainee’s motivation. An improvement for this is not to assign mentorships to people which are currently busy or in stressful situations. Therefore, during busy periods, the training team mentor pays more attention in helping the trainee to schedule the mentorships and avoid busy people.
- Another issue which could lead to confusion for the trainees are outdated modules, different templates and missing or corrupted links in the training program. Since different people are taking care of the update of the scorecards it is sometimes the case that the layout of the module is not always the same or that the attached documents are provided in forms of links to different platforms or databases. To avoid this, there is the necessity to agree and implement a unified template for the modules and a unified place where to store all the training material linked in the scorecards. This facilitates the retrieval of documents and presentations even after the training in case there should be the need of looking up something.
- When the SOPS are assigned to the trainee, it is essential that they fully understand the activity and the context in which the activity takes place. Often, multiple SOPS are linked together even if performed weeks apart from each other and by different people. Due to this, the trainee may lose the macroscopic context in which the activity is happening and gets confused. Therefore, it is always worth it to spend some minutes before of the start to brief the trainee and ensure that everything is well understood.

5. The MOE certification process from the trainee’s perspective

The MOE training usually is carried out as a secondary certification after the GOE one. Once the trainee begins the MOE training, he is given access to the MOE scorecards. Since he is already familiar with the training system and the project, the support needed from the assigned mentor at this time is minimal. For the MOE training, a higher level of autonomy and self-organization is requested. The trainees are responsible for the organizing and informing of their reduced availability to the GOE team. This means that in busy periods, in which the team is lacking personnel, the training must be paused, as the priority of the training is lower than for operational tasks. While the self-studying modules are straight forward, the organisation of the OJTs and the Mentorships is more difficult due to the lower amount of MOEs on the backup site. In addition, the trainee will not receive any access credentials for the validation chain upon full certification. Consequently, there is no “playground” environment to test and get confident with the system. The only way to get confident with the mission control facilities is to shadow the MOE on call and to follow the routine daily checks on the backup site. A trip to Fucino is then organised to follow the routine and the special operations from the prime site. Beforehand it is recommended that any specific or detailed questions relating to prime operations should be noted down, and then can be answered by the GCC-I MOEs experts at the prime site to clarify all the doubts about the mission segment. In GCC-I the trainee must follow specific tasks which are described on the scorecard as well as all the other relevant tasks which are ongoing. This can be a bit confusing at first, as in one week the tasks will range from routine operations to short- and medium-term planning, trouble shooting, SOPS, procedures, mission processes etc. The OJT week is also a very useful opportunity to get to know the people in GCC-I and learn which are their fields of expertise.

After this week of intense activities, the trainee returns to GCC-D and the performed tasks are filled in the OJT document and approved by the relative parties. To approve the trainee’s OJTs, the training team in GCC-I performs a briefing with the mentors to check if he has understood the modules and is able to perform operations. In the meantime, at GCC-D an online test on the TMS must be passed by the trainee and the scorecard will be updated with the latest status. Once the OJT document is signed by all the parties and sent to GCC-D, it is possible to start the requests for the creation of the OPE and VAL accounts. Before the accounts are created, the requests must be approved by the security officers in GCC-D and in GCC-I as well as from the training teams on both sides. This process is composed by many steps, which will take usually about 2 to 4 weeks. As soon as the requests are approved and the accounts have been created, the new certified MOE is inserted in the correspondent on-call plan and considered as fully operative.

5.1 MOE certification improvements

- Perform the training in parallel to the GOE activities, where the trainee communicates his partial unavailability to the team and organises his tasks accordingly. Currently there is no process foreseen to remove the trainee from the GOE on-call plan fully, or to properly communicate its unavailability officially. Therefore, it is sometimes challenging to keep the workload under control and the trainee may feel frustrated or stressed. As a potential solution, it could be useful to report the status of the trainee at the weekly GOE meeting, stating that the person is in training and therefore should not get any further tasks assigned. Another option could be to mark the days of study as “training” days in the team plan such that everyone knows that the person would not be available at all on the planned days.
- Another mentionable point is the lack of a virtualised training environment and access to the VAL chain. This can penalise the trainee as there is sometimes no other way to access the facilities than to shadow a certified MOE in OPE chain. As a result, procedures cannot be tested, and only the daily checks can be performed under strict supervision of the certified MOE. This will be solved by the introduction of a virtual environment in a similar way it has been done for the GCS infrastructure with the MATE. An interim solution would be the creation of accounts and accesses for the VAL chain immediately after the start of the CL1 level.
- Since the OJT week is performed towards the end of the training, most of the training period the trainee does not know the experts of the different systems personally at the prime site. Due to this, the trainee has to keep track of all the questions that arise during the training for answers once he visits the primary site. This could be solved by creating a list with the contact persons in each field of expertise, to facilitate the inter-site contact and collaboration. To improve internal communication, it would be useful to integrate the Microsoft Teams environment between GCC-I and GCC-D and to execute regular checkpoint calls between the trainee on the backup site and the experts on the main site.
- The OJT week is generally quite intense, and many tasks are performed in parallel. Plans to extend the training on the main site to two weeks would be advantageous, such that in the first week the trainee can shadow the activities and get explanations, whilst in the second week he has the possibility to consolidate the tasks by executing them under the expert’s supervision.
- Another common issue is the filling and approval of the OJT documentation. To speed up this process, the formal document could be filled in immediately while the OJTs are being performed. In this way, the trainee shall have the final document ready for the signatures at the end of the training, and the verification process could be optimised.
- Concerning for the account creation, the security checks could be started earlier with the requests being prepared weeks in advance, so that, at the trainee’s final certification date, the accounts are already available and only need to be handed over to the newly certified MOE.

6. Pros and cons of the actual training process

To further assess the training system the main aspects have been listed and analysed in Table 6 by finding the respective pros and cons.

Table 6. Pros and cons of the main aspects of the training process

	Pros	Cons
Training system based on scorecards	Gives a clear structure and way forward to the trainee.	Difficult to relate to a timeline since it is in a “to do list” form.

Elevated number of modules	Covers all the aspects of each GCS element separately.	May lead to confusion and give an overwhelming feeling to the trainee.
Subdivision of modules in self-study, mentorships and OJTs	It is clear for the trainee how the module must be processed and eases the training organization.	-
Scheduling certification dates at the beginning of the training	Gives the trainee a fixed objective and timeline to complete the training levels.	The certification milestones may not be sufficient to give a proper timeline to the trainee.
Mentorships and OJTs require time and availability of the operation team members	Ideal for the direct transfer of the knowledge from experienced people to the trainees and to create a unified team spirit.	In busy and critical project phases it can be sometimes difficult to organise them. In addition, the knowledge transfer efficiency can drop heavily if the mentorships are carried out quickly, skipped or improvised.
Simulation environments	Ideal for the trainee to get confident with the system and try procedures without the risk of impacting the operational environment.	The simulation environments are limited and regularly used by many people. This requires coordination to prevent interference between users.
Early inclusion of the trainee into the project processes in parallel to the training	Includes the trainee into the project processes and the operational team. Gives support to operations.	Not all the time is dedicated to the training. May lead to confusion if the trainee is not fully aware of the assigned process and the connection to the other processes.

7. Conclusions

In conclusion, the training programmes for the ground operations teams are well organised and structured to prepare the newcomers for the ground roles. The system based on certification levels, certification boards and modules has been proven in the past years to be robust and offering a clear training plan to the trainees. With the analysis of the training timeline some weak points have been discovered, especially in the case of the double GOE-MOE certification. With the proposed measures for reducing the GOE workloads and the account requests process optimization it has been shown that up to 55% of the certification time can be saved. On the other side, the training has been analysed from the trainee’s perspective, individualising strengths and weak points which lead to motivation drops, confusion and dissatisfaction. With measures to improve communication, the introduction of detailed SOPS briefings and some organisational finetuning it has been shown that the quality of the training can be improved consistently leading to a smoother training process. All these mitigations will be further discussed and implemented in the near future. To measure the effect on the trainee’s satisfaction and performance, the plan is to proceed with interviews and direct feedback to the mentors.

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