Operational Training and Knowledge Management : Strategy and Realisation at EUMETSAT

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EUMETSAT operates Earth-observation satellites and their related ground systems in order to provide operational meteorological and climatological data services to a broad international user community. As a key element in the overall delivery of these services, EUMETSAT developed and subsequently evolved a comprehensive approach to Operations Team training in order to ensure operations engineers, analysts and shift controllers are fully prepared to perform both nominal and contingency operations in the most efficient and reliable manner possible. Operations Team training is considered a core function within EUMETSAT with resources and personnel dedicated to ensure its effective delivery. This paper discusses the approach taken to develop, implement and maintain the various aspects of Operations Team training at EUMETSAT, including initial training for new or redeployed team members, proficiency training to ensure continued competence, and preparatory training to address the introduction of new programs or major system evolutions. It describes how the specific training needs are assessed, defined and maintained; how training requirements are implemented; the certification process applied for shift controllers; and the continuous assessment of training efficacy to ensure continued quality improvement. To provide examples of this strategy, the paper reviews training activities relating to recent major projects in EUMETSAT polar and geostationary programs, and related multi-mission elements. In addition, knowledge management and knowledge transfer within EUMETSAT Operations are discussed. A brief overview of the theoretical approach is presented, leading into a discussion of how this is practically applied and continuously improved upon. Conclusions are drawn which may be useful to other satellite operators and operational service providers.

I. Introduction

EUMETSAT is tasked with the exploitation of Earth-observation satellites to support the fields of operational meteorology, climatology and oceanography. To achieve this, EUMETSAT currently operates a fleet of four satellites consisting of one Meteosat First Generation (MFG) and two Meteosat Second Generation (MSG) geostationary satellites, and one Metop polar-orbiting satellite of the EUMETSAT Polar System (EPS). Assuming no unforeseen problems, this fleet will have expanded by a further two in May and June 2012 with a third MSG satellite and a second Metop satellite placed in geostationary and polar orbits respectively. It further supports the operations of other spacecraft, providing a data processing and product dissemination capability for European users.

Due to the large financial investment required to develop and deploy satellites and their associated ground systems, these operational programs often have relatively long lifetimes in comparison to those of research or technology demonstration missions. To illustrate this, consider the Meteosat First Generation program. The first MFG satellite (Meteosat-1) was launched in 1977 and operated by the European Space Agency (ESA), while the last of the series (Meteosat-7, also known as MTP) was launched in 1997 and will likely remain in operational use by EUMETSAT until 2017, some forty years later. In the intervening years, five other MFG satellites combined to provide near-continuous services to European and global users of meteorological and climatological data, with operational responsibility transferred from ESA to EUMETSAT partway through the mission. The second generation of Meteosat geostationary satellites entered service approximately ten years ago and will, over a series comprising four satellites, span the period from 2002 until well into the third decade of the 21st century to be superseded in this mission by the Meteosat Third Generation (MTG) system.

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When dealing with programs of such scale and longevity, it is essential to capture and maintain operational knowledge in a manner that allows for continued turnover of personnel in the operational teams and academic/industrial support base. It is also necessary to ensure the operational knowledge base is sufficiently flexible and robust to support the constant evolution of systems and capabilities that are a fundamental aspect of such operational programs.

EUMETSAT has addressed this essential aspect of its operational programs by putting in place a coherent strategy to effectively identify, capture, maintain, evolve and communicate operational knowledge, as summarised below :

1) Knowledge of operational systems is identified and captured during the program development phase, where the design and function of the system – both space and ground segments – are defined, implemented and documented in the form of technical and operational baselines. In combination with the management baseline which is developed separately, and the equivalent baselines of other programs, this forms the principal components of operational knowledge of EUMETSAT.
2) This knowledge is continuously assessed and maintained to ensure that it reflects an accurate understanding of the operational system. This also includes any evolution of operational knowledge that may result from system evolutions, changes in the scope of the operational mission, and/or anomalies that have affected the execution of the mission.
3) This operational knowledge must be imparted to team members involved in supporting or executing the operational mission or a specific program. These team members must be trained to ensure their initial and continued familiarity with the operational knowledge relevant to their activities.

While each of these areas could easily warrant a number of papers on their own, this paper provides an overview of the strategy and realization of operational knowledge management at EUMETSAT.

II. The EUMETSAT Operations Team

Any discussion of the management of operational knowledge should begin with an introduction to the operations team that is both the source of the operational knowledge and the end users of the same. The Operations Team at EUMETSAT is structured in a matrix fashion along lines defined by programs, functions and levels of responsibility. The following gives a summary of how the Operations Team is structured.

A. The Operations Team and Operational Programs

Figure 1. The EUMETSAT Headquarters Building in Darmstadt, Germany

A legacy of the method whereby operational programs were initially funded at EUMETSAT, the Operations Team was divided at a technical level into discrete sub-teams each of which is allocated responsibility for the execution of individual operational programs such as MFG, MSG, EPS or Jason-2.

The Operations Team dedicated to a specific operational program consists of personnel dedicated to the operation of the space and ground segments. Satellite activities are under the leadership of the Spacecraft Operations Manager and include engineers and analysts dedicated to the satellite bus and payload, including instrument experts.

System operations are executed by engineers and analysts with detailed expertise in the design and operation of the various ground segment components that perform the ground station, communications, data processing, data and product archival, and dissemination functions. Satellite and system monitoring and control, flight dynamics, and mission planning functions straddle the divide between space and ground segment operations.

In recent years, due to the evolution of EUMETSAT's mission, this structure has also evolved to take into account the introduction of a variety of multi-mission systems that are utilized in support of multiple operational programs. For example, the EUMETSAT Data Archive and EUMETCast dissemination system are used to store and distribute operational data acquired by all of EUMETSAT's operational programs and the Operations Team members that support these functions therefore support multiple operational missions.

B. The Operations Team and Functional Teams

In addition to the existence of multi-mission systems used to support multiple operational programs, Operations Team members with specific areas of expertise are frequently applied to more than one program where that expertise is applicable. This is particularly applicable in the ground segment where functional sub-teams have been established to provide expertise in various areas to multiple programs from a common team.

Single functional teams exist for data and image processing, data and product dissemination, communications systems, flight dynamics and mission planning, among others. A unified System Operations team supports the execution of all missions, providing oversight for system change control and the implementation of system evolutions, including updates to the technical and operational baselines.

Although less relevant on the space segment side, there are Operations Team members that support the operations of both MFG and MSG satellites due to the commonality of design and operational concepts in specific areas.

C. The Operations Team and Responsibility

The ultimate authority over EUMETSAT's mission resides in the Director-General, with responsibility for operational issues delegated to the Director of Operations as head of the Operations Department.

Day-to-day operations are the responsibility of Control Centre (CCD) and Meteorological Operations (MOD) divisions, with the user interface and EUMETSAT Data Archive under the responsibility of User Services Division (USD). System maintenance activities and evolutions are performed by Maintenance and Engineering Division (MED) in coordination with CCD, MOD and USD. Each division comprises a number of functional teams, with team members leading or supporting operational activities.

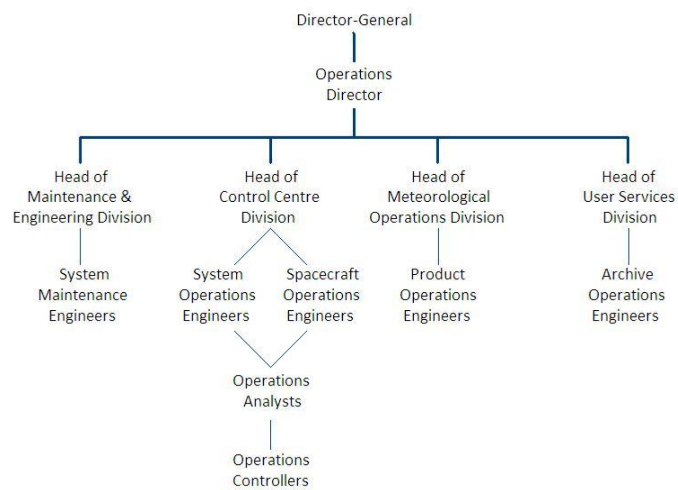

Figure 2. A subset of the EUMETSAT organisational structure, focusing on Operational Responsibility

Drawn from across the Operations Department, Operations Team members are arranged in a hierarchical structure that allows for the smooth execution of routine operations while providing an escalation path for effective decision making in the event of an anomaly. A simplified description of this structure, in order of increasing responsibility, can be summarised :

1) Operations Controllers are the 24/7 shift personnel responsible for the minute-by-minute operation of an operational system and the associated satellite(s). The Controllers have the task of executing and/or monitoring the execution of planned operations and performing the initial activities to detect, identify and respond in the event of anomalies. Where they do not have the knowledge or authority to address a contingency, they may escalate a problem to the duty Operations Analyst.
2) Operations Analysts have a more detailed level of knowledge in the operational system in comparison with the Controllers, and have dual roles. As duty Analyst on a rota basis, they perform the immediate management of the controllers within the System Operations Team. This allows them to act as a first-line operational authority for issues escalated by the Controllers. As functional Analyst for spacecraft, ground station, data processing or dissemination functions embedded in the relevant functional teams, the Analysts share on-call and reporting duties with the functional Operations Engineers.
3) Maintenance engineers have detailed knowledge of the computer systems hardware and operating systems, commercial-off-the-shelf (COTS) software, communications capabilities and system hardware that is utilized in the operational systems. They also perform routine reporting activities and provide on-call support to the Operations Engineers, Analysts and Controllers in the event of an anomaly.
4) Operations Engineers are experts in the use of the various ground and satellite systems to deliver operational services to users. As such they prepare and implement changes to the system and operations concepts in terms of hardware, application software and operational configuration. They perform routine reporting activities and provide on-call support to the Analysts and Controllers in the event of an anomaly.

5) Operations Management is performed by the Director of Operations, the various Operations Division managers, and the relevant Spacecraft and System Operations Managers. Within the System Operations Team, each operational program has a designated lead System Operations Engineer with operational authority for system issues. Operations Management ensures processes for operational scheduling, system change control and anomaly processing are performed in compliance with configuration management and quality assurance requirements.

D. Evolution of the Operations Team

During the lifetime of an operational program, the Operations Team will go through a variety of evolutions that can impact both on the need for, and resources available to, training; and on the availability of operational knowledge within the team. These are due to a variety of reasons that include :

1) the normal turnover of personnel – a factor that can be more prevalent in international organisations;
2) the contractor cycle – to ensure best value for money, contracts for the provision of personnel have durations with finite limits although usually with spans of a number of years. The periodic process to recruit under new invitations to tender can result in changes to personnel;
3) the redeployment of personnel within the Team – while working to ensure continued competency within the Operations Team, we encourage team members to progress in their careers. Several team members joined the Operations Team originally as operations controllers and have progressed to become operations analysts, operations engineers and transition from consultant to staff member, opening the possibility of taking on management roles;
4) the movement of personnel within the Organisation to support other operational programs and development activities – particularly an issue when major new programs such as EPS second generation or MTG are recruiting large numbers of personnel;
5) the reduction of overall team size that occurs when a program transitions from development and initial operations into long-term routine phase – as team competencies and system capabilities increase, and system reliability improves, the need for such an initially large team reduces and the team size is reduced through redeployment, natural contract conclusion and retirement;

The net result of these changes, except where team members relocate within the team, is to introduce a net reduction in operational knowledge which must be offset. This is achieved by capturing operational knowledge held by the Operations Team in a variety of ways.

III. Operational Knowledge at EUMETSAT

The majority of operational knowledge at EUMETSAT is captured in the Operations Baseline and Non-Baseline Trees that define the various operational programs and projects, and the role and function of the Operations Department itself. These are subject to the rigorous development and review cycles through quality assurance, configuration management and change control processes that are an essential component of any operational agency. Indeed, these very processes themselves form part of the operational knowledge that they safeguard.

The structure of the Operations Baseline Tree (comprised of the Technical, Operational and Management Baselines) form components of operational knowledge in their own rights but the definition of operational knowledge is not limited to only these baselines. Other, in some cases less tangible, components of the overall operational knowledge at EUMETSAT also exist.

Most of this information is maintained within the EUMETSAT Documentation Management System (DMS). Within DMS, a documentation tree has been established for both Baseline and Non-Baseline items that allows easy navigation through a system containing a significant number of items from multiple operational programs and multi-mission elements. The current DMS at EUMETSAT, which holds over four hundred-thousand unique documents – many of which having multiple versions, is about to be replaced with a web-based system that will provide improved capabilities for searching, document management, sharing, and interface with external partners.

All elements of the Operations Baseline Tree are subject to strict operations configuration control processes. This is in addition to the standard documentation configuration control processes applied across the Organisation.

For each class of item in either Tree, a trade-off has been made between the need for absolute accuracy of content and format (implying strict configuration control and thorough validation), against flexibility and responsiveness (implying more targeted configuration control and stream-lined approval).

A. The Technical Baseline

The Technical Baseline is a description of the design and function of the operational system itself. This describes the core function of the operational system and its external interfaces, the design of the various facilities and internal interfaces that comprise the operational system at a high-level, the principal sub-systems that comprise each of these facilities and how they interact, down to the detailed description of the code of a given sub-system function and the format used for data exchanges at a fundamental level. The Technical Baseline therefore includes architectural design information, communications and security specifications, detailed information on the system infrastructure and the functional definitions of each individual aspect of the overall system, including any elements that are considered multi-mission in nature.

For example, the MSG System Technical Baseline describes the design, interfaces and functions of all aspects of the geostationary system ground segment. This includes an encyclopaedia of information ranging from the antenna systems in the Primary Ground Station at Usingen, Germany to the Behavioural Model Operational Test Tool used to simulate the MSG spacecraft for validation purposes, or from the Central Facility that forms the monitoring and control core of satellite operations to the External Interface Control Document that define how MSG mission data and products are delivered to the EUMETSAT Data Archive.

Developing the Technical Baseline is initially the task of the program development team. From the earliest stages of an operational program, the capabilities of the planned program are defined through requirements that are proposed, refined and matured, before being broken down into progressively more detailed factors that are later applied to create designs for the system and its components.

At each stage of the requirement definition and design processes, the understanding of the capabilities and design of the operational system deepen until a very accurate knowledge of the defined, designed and implemented system is present in the development documentation. As many components of an operational system are prepared by a variety of different vendors, each will provide a range of technical information such as design documentation, bespoke and COTS software description, equipment and software user manuals, which can be useful components of the Technical Baseline.

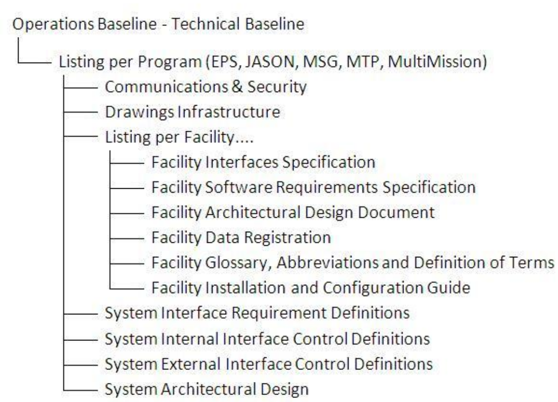

Figure 3. The Operations – Technical Baseline

Once implemented and handed over to the Operations Team for validation and operation, the development knowledge forms the core of the Technical Baseline. This must be maintained to ensure it continues to present an accurate representation of the system as it matures toward operational use, and later evolves to accommodate changing operational requirements.

The Technical Baseline may include design and interface information for Multi-mission System elements that are relevant to a given operational program, among others.

B. The Operational Baseline

The Operational Baseline describes how the system, in its current level of development and operational use, is operated to achieve the capabilities for which it was intended. In a typical operational system at EUMETSAT, this includes various forms of operational procedure, operational interface description, or operations guide ranging from system procedures that define the high-level execution of an operational task to detailed steps required to achieve a sub-system reconfiguration within a ground segment facility or spacecraft. The Flight Operations Manual provided by the prime spacecraft manufacturer is included in the Operational Baseline.

There are a number of different document types in the Operational Baseline, with formats and configuration management approaches selected according to the specific requirements of each class of document. The validation approach relevant to the various types of procedural form may vary as well.

In the EPS Operational Baseline, the validated approach to the execution of EPS and Metop operations by members of the Operations Team are defined. In this baseline, System Control Procedures (SCPs) define routine operations and specific contingency responses performed by the 24/7 shift operations controllers. SCPs are formatted for clarity and ease of use, presenting detailed operational execution information either directly or by referencing Ground Control Procedures (GCPs) and/or Flight Control Procedures (FCPs) that describe individual sub-tasks of ground or spacecraft operations in greater detail. SCPs, GCPs and FCPs are developed in MS Word and feature a preamble for configuration management and an introduction, followed by the operations procedure itself in a tabular form. Each procedure type may reference automated procedures developed in a procedural coding language such as Spacecraft Test and Operations Language (STOL).

Operations Guides are structured documents primarily used to describe the execution of operations by specific roles within the Operations Team. These documents detail routine tasks, responses to contingency situations and operational interfaces, and act as a dedicated repository of the information necessary for any qualified person to take on a specific engineering or analyst role. The Guides are under the ownership of the incumbent role engineer or analyst in the relevant role, and are a key training resource for new engineers. Although Operations Guides may reference SCPs, GCPs and/or FCPs, they are presented in a more flexible document format indicative of the less prescriptive nature of engineer or analyst activities relative to those of the controllers. As activities are defined and performed, the Guides are updated to reflect changes in system capabilities, operational responsibilities for the role, and to document activities of a specific role in response to contingencies. A second class of more generic Operations Guide acts as a general reference document for contingency operations, and is primarily used by the operations controllers.

Operations Interface Control Documents (OICDs) describe the operational interfaces between the EPS Operations Team and other operational teams both internal and external to EUMETSAT. This ranges from the relatively straight-forward operational interface between EUMETSAT EPS and CLS/ARGOS for the operation of the A-DCS instrument on Metop, to the highly complex operational interface between EUMETSAT EPS and NOAA for the acquisition of Metop mission data via the NASA McMurdo Sound ground station in Antarctica.

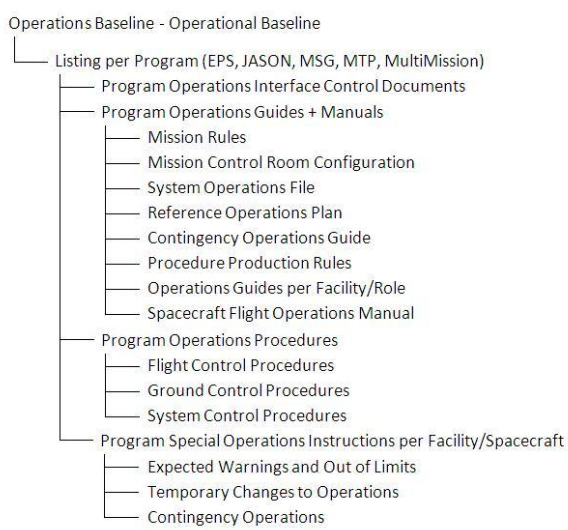

Figure 4. The Operations – Operational Baseline

Special Operations Instructions (SOIs) are a completely different type of operations procedure. Unlike the SCPs, GCPs, FCPs, OICDs and Operations Guides, SOIs are not subject to the same formal configuration control. This is a deliberate choice that allows the SOIs to be managed with a far shorter turnaround time than would otherwise be possible. SOIs provide a responsiveness that can adapt to rapidly changing circumstances and allow the quick provision of information such as expected warnings and alarms, short-term changes to nominal operations, and contingency operations. SOIs typically have limited validity periods to ensure that any information with long-term usefulness is formalised through updates to the other procedural forms.

Developing the Operational Baseline is tasked to the Operations Preparation team during the development and validation phases of an operational program. The Operations Preparation team consists of members from the system development team and the end-user Operations Team, combining detailed knowledge of the system requirements and design with operations experience to define an effective approach to operations formalized in the operational documentation. During the EPS development phase, members of the future Operations Team – already experienced in other programs both within and external to EUMETSAT – were embedded in the Operations Preparation Team to ensure the development of an operational baseline consistent with the actual system capabilities and constraints, while making best use of operational experience from other relevant programs. In the case of EPS, this meant drawing on the experience of team members that had previously participated in the operations of MTP, MSG, SPOT, ERS and ENVISAT.

The Operational Baseline may include information related to Multi-mission System elements that are relevant to a given operational program, among others.

C. The Management Baseline

The Management Baseline defines – at a high level – the operational purpose of the system in terms of services and the essential processes required to achieve this purpose. It is a combination of generic and program-specific documents and processes.

In EUMETSAT, the Management Baseline describes the high-level specifications of the operational services that a program must deliver to the user community. In order to fulfil the obligations of these services, the Management Baseline defines the high-level organisational structure and management mechanisms; the methodology for implementing operations as a process model, applicable procedures and the assignment of process responsibilities to roles. The plan for operational documentation management is detailed as is the structure of the operational documentation tree. High-level external operational interfaces, such as the relationship between EUMETSAT and NOAA, are defined in the form of Joint Operations Rules and Procedures (JORPs) that lay out the responsibilities of each cooperating partner.

It further defines the high-level processes and working practices necessary to operate, maintain and evolve the operational system in terms of operational reporting, system configuration management, the handling of anomalies and major incidents, and system change control. The Management Baseline defines the process for introducing significant system evolutions by describing the structure and lifecycle of Operations Projects.

The Management Baseline is developed during the program development phase but taking into account existing management principles taken from other existing operational programs, modified where necessary to accommodate factors that are specific to the new program. The Management Baseline draws heavily on the established quality assurance, documentation management and configuration management processes used across the Operations Department.

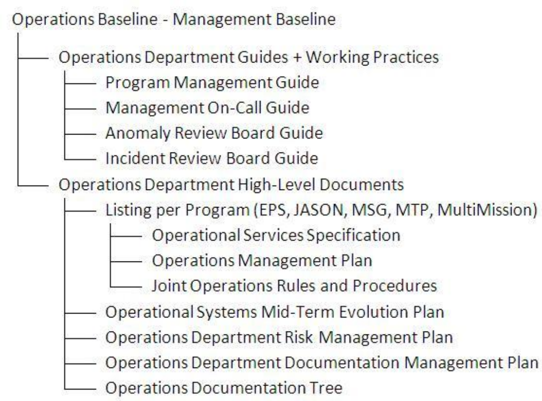

Figure 5. The Operations – Management Baseline

D. Operations Non-Baseline Components

In addition to the baseline components of operational knowledge, the Operations Team maintains the Operations Non-Baseline Tree that supports the implementation of Operations Projects, and the internal functions of the various sub-teams.

The documents contained in the Operations Non-Baseline Tree are not subject to the strict operational configuration control that is in place for the Operations Baseline Tree, but remain subject to normal EUMETSAT documentation standards for format, change control, review and publication.

Operations Project areas are central locations used as a repository for all documentation related to the planning, management and technical implementation of an Operations Project. Recent examples of such projects include the introduction of an Antarctic Data Acquisition capability for EPS, or the preparing to process and disseminate data from the Suomi/NPP program.

Operations Team areas provide for a common area where teams can record information such as contact information, scheduling of on-call support provision, shift planning for the controller team, rotas for specific duties such as duty analyst, reporting of team activities, team minutes of meetings, working practices, and many others.

The Operations Non-Baseline Tree allows for improved consistency and commonality of approach across multiple operations programs.

E. Other Operational Knowledge Components

There are a number of other elements, not included in the various baselines described above, which contribute to the operational knowledge of EUMETSAT. It is not possible to give anything more than a cursory introduction to there here :

1) Knowledgebase – an XML/HTML-based repository of operational knowledge maintained under the ownership of the Operations Analysts and Controllers, and is for their own use. The Knowledgebase holds detailed information regarding system alarm messages and the associated appropriate response. The

structure of the Knowledgebase reflects the structure of the Generic Event Monitoring System (GEMS) application to which it refers. The Knowledgebase is exempted from strict configuration control to allow a rapid turnaround for updates which are frequently required due to the sheer volume of messages it contains;

2) Wiki – an "online" resource only accessible via the EUMETSAT intranet, the Wiki is repository of operational knowledge that concentrates on areas of interest common to many members of the Operations Team. This is excludes detailed technical information on operational systems but rather concentrates on support functions such as the BlackBerry devices for use by on-call support engineers, the office computing environment and associated applications, the documentation management system, the operational configuration management application, and so on;
3) Intranet – a purely internal online environment for access to a wide variety of information across EUMETSAT relating to organisational, financial and administrative functions, the intranet provides access to the Wiki, internal directories, as well as social information resources;
4) Extranet – an externally-accessible secure environment for permitted users to access working information on the system status, operational plans and schedules, on-call support scheduling and contact information, and includes links to system remote-access telemetry functions;
5) Anomaly Reports – held on the Anomaly Processing Tool (APT), anomaly reports detail problems that have arisen with system software, hardware, interfaces or operational documentation, and the progression of these towards resolution through investigative activities and, where appropriate, system changes;
6) Engineering Change Proposals and Engineering Tasks – created and maintained in the Configuration Management application, Serena Dimensions, any changes to the configuration-controlled operational system are initiated by an engineering task which defines the activities to be performed along with assigning team responsibilities, due dates and exact details of the software, hardware or configuration change to be made. Engineering tasks are triggered by change proposals to evolve or maintain the system, or in response to anomaly reports;
7) Training materials archive – a collection of materials used in the planning and, preparation for, and implementation and assessment of, operational training at EUMETSAT, this archive contributed to the operational knowledge primarily in how it describes the performance of training itself rather than the subject matter of the training, which is a representation of information found elsewhere. Of principal relevance here are the descriptions of the training schedules, how training is implemented for various roles, and the assessment of training effectiveness.

Operational knowledge is, in itself, of little benefit unless it is put to effective use. There is no point in amassing large volumes of operational knowledge if it is not maintained and made easily accessible to those that require it. The following sections describe how specific aspects of the above operational knowledge are applied to preparing and supporting a core aspect of the Operations Team structure at EUMETSAT – the operations controllers.

IV. Operations Team Training

A. Training Needs Analysis

The purpose of training is to impart operational knowledge to trainees in an effective manner, thereby enabling them to perform an operational role against specific capability and expertise requirements. It is essential to identify the exact information that a trainee must acquire in order to achieve the required level of capability. This is achieved by determining the requirements of the role for which the trainee is being prepared, and assessing the level of knowledge they may already have to determine the actual gap in their knowledge and experience compared with the desired profile. Failing to perform this analysis in an effective manner could result in the trainee being partially unprepared for their intended role, thereby introducing a risk to the operational system.

The outcome of the first component of the training needs analysis is an Operations Training Plan. This is then tailored for the individual trainees through the definition of a Training Schedule that is unique to each trainee while derived from the relevant Operations Training Plan.

Over the lifetimes of EUMETSAT's operational programs, Operations Training Officers have developed a series of Operations Training Plans to define the training required to impart the operational knowledge for a given program.

For EPS, this is covered by the LEO Programs Operations Training Plan, which combines the training requirements of the EPS and JASON programs into one document. This is currently supplemented by the EPS/Metop-B Preparatory Training Plan, to be later joined by the in-development Sentinel-3, SARAL and Jason-3 Preparatory Training Plans. As each of these developments become operational over the next few years, the preparatory training activities will be incorporated into the training baseline identified in the LEO Programs

Operations Training Plan. A GEO Programs Operations Training Plan addresses MFG and MSG training, with an MSG-3 Preparatory Training Plan currently in effect.

B. Induction Training

The first form of training any Operations Team member encounters is induction training where new members of the team are familiarised with the system design and operational concepts, and how these are implemented in practical terms. New team members being redeployed from other aspects of EUMETSAT Operations will be familiar with many of the multi-mission systems used by their new program, while others that are entirely new to the EUMETSAT organisation will require training in all aspects of the operational systems as well as the basic organisational logistics of controlled access, office computing, communications and, most importantly, access to the on-site catering facilities.

Induction training can take a significant period to complete, depending on the nature of the role the new team member will assume, and be bound by a gradual transition to operational readiness in the case of engineers and analysts, or a specific certification milestone in the case of operations controllers. Induction training is handled as a combination of formalised training implemented by the Operations Training Officer, and informally within the relevant sub-team of the overall Operations Team.

The content of induction training is documented the operational program's Operations Training Plan and in associated presentations and training summaries.

C. Proficiency Training

Once a team member has completed their induction training, they will take their place in the Operations Team. From that point on, a comprehensive program of proficiency training activities provide the team member with periodic refresher training on key areas of operational knowledge. This type of training is most frequently applied to the operations controllers where familiarisation with evolving operations procedures and system design changes is essential and so the provision of adequate training opportunities is defined in the Controller Team contract.

Typically, proficiency training focuses on a single aspect of operations, such as ground stations, satellite eclipse operations, or data dissemination, to give trainees a targeted review of material previously covered by induction training. Proficiency training is usually handled informally within the relevant sub-team of the overall Operations Team.

The range of proficiency training topics is documented the operational program's Operations Training Plan and in associated presentations and training summaries. Proficiency training providers draw on relevant induction training materials.

D. Preparatory Training

When a significant evolution to the operational system is planned, preparatory training is introduced to prepare the Operations Team for the new system baseline. Evolutions can include transitions to a new hardware system, adding major new capabilities to the operational system, adding a recurrent satellite to an existing program[1], or introducing significant new operational services. Preparatory training is a significant training effort focussed on the specific changes to the system but applied across the whole Operations Team, and typically is an integral part of the operations project associated with the system evolution.

Recent examples of preparatory training at EUMETSAT include : 1) the introduction of an Antarctic Data Acquisition capability for the EPS/Metop system where significant modifications were made to spacecraft operations, communications, data processing systems, and an entirely new operational interface with an international partner was defined; and 2) preparations for the launch of a third MSG satellite utilising a system originally only intended to support two in-orbit spacecraft.

Preparatory training is not defined as a part of the operational program's Operations Training Plan. However, once completed, the content of the Preparatory Training is used as the basis for an update to the Operations Training Plan, establishing a new baseline for future Induction and Proficiency Training activities.

E. Training Delivery

Induction and preparatory training for Operations Team members is often delivered initially as formalised presentations in a classroom environment. Subject matter experts from the Development, Operations and Maintenance Teams are drawn upon to prepare and present such training, with support from the Operations Training Officer to ensure consistency and to handle logistical arrangements. Classroom training is a useful way of communicating information to a large group of people, but should be balanced with closer interactions on a one-to-few or one-to-one basis as it is not always easy for the trainer to determine how well the trainees have assimilated the information presented. The effectiveness of classroom training is also highly dependent upon the nature of the trainer, where the need to capture and retain the concentration of the trainees becomes an essential element that contributes to the overall training outcome.

After completing initial classroom training, the focus of induction and preparatory training expands to include practical activities in a simulation or development environment. Here, trainees can achieve familiarity and hands-on experience without presenting a risk to the prime operational system or services. Finally, trainees are positioned to shadow the subject matter experts as they perform the activities for which they are being trained, eventually to take over responsibility for these operational activities.

Where other alternatives are not available, external training resources may be utilised, although this is often an expensive option and impractical for extended or repeated use, or when dealing with larger groups of trainees. However, there have been occasions where this was the preferred option as the training referred to externally produced COTS products, or where the number of trainers involved was similar to the number of trainees. During the preparations for the launch of the first MSG satellite, spacecraft engineers were trained by a variety of system and sub-system experts at the satellite manufacturer site in Cannes, France. Similarly, key members of the Operations Team were trained in the use and maintenance of the EPS monitoring and control COTS software at an site in the USA. These key team members then returned to EUMETSAT as subject matter experts and were able to take over the training duties for other team members.

Proficiency training generally is handled in a more informal manner, where a subject matter expert tutors a group of team members to draw out their understanding of the subject matter and clarifies or reinforces their knowledge where appropriate.

For new programs being brought to operational readiness, and for the completion of preparatory training in circumstances such as adding a recurrent spacecraft to an existing system, a phase of operational rehearsals provides an opportunity to complete the hands-on component of training and allows for a clear assessment of the Operations Team readiness to assume responsibility for the new program or major system evolution involved. Clear objectives for the rehearsals are assessed against the achievement of specific criteria to determine team readiness, or identify areas where additional focussed training may be required. Such activities also overlap with the final verification and validation of the operational system – both human and machine elements – giving an overall view of readiness.

F. Assessing Training for Continuous Improvement

Training the Operations Team is not a static activity. It is constantly evolving to accommodate the frequent changes in the availability of training resources, the range of operational knowledge to be imparted, the profiles of the trainees, and the timeframe available for training.

As a result, a process of continuous re-assessment and review is an essential element of the training regime. The training needs of different roles, programs and individual trainees must be continually assessed to ensure that the training is delivering the desired level of capability and expertise in the personnel.

To address this, the effectiveness of training is reassessed as an integral part of the delivery of that training, by gathering feedback from the trainees, trainers, and relevant team leaders on content, presentation, and the balance between classroom and hands-on activities.

Assessment of the capabilities and expertise of trainees after the completion of the training also gives a key insight into the effectiveness of the training. For engineering and analyst roles, this is usually performed informally within the team, with feedback provided by the team members themselves and the relevant team leader. For operations controllers, this is accomplished in a formal certification assessment.

In addition, periodic reviews of the Operations Training Plan are conducted to assess the scope of the overall training regime and to plan for future evolutions, such as the integration of now completed preparatory training activities into the training baseline, or the development of new preparatory training activities in parallel with forthcoming operations projects. This review includes a cycle to ensure that the training regime remains in line with high-level operations management objectives and the specification of operational services.

V. Operations Controller Training and Assessment

A. Role and Profile of Operations Controllers

At EUMETSAT, operations controllers are the “front-line” operators of an operational system and are required to maintain a broad knowledge of all aspects of the operational system in order to monitor and perform the routine operations required to keep the system running smoothly. Additionally, they must be able to detect, isolate and perform an initial response in the event that an anomaly occurs, drawing on the support of operations analysts and engineers as necessary. Furthermore, EUMETSAT operates comprehensive operational systems that begin with the acquisition of data by the satellites and ends with the delivery of the resulting mission products to the end users. The same operations controllers operate the spacecraft, ground stations, monitoring and control functions, data processing and product generation functions, and the dissemination of data to the users. They are also the first point of contact for operational partners such as NOAA, CLS/ARGOS, CNES and others.

The training requirements for operations controllers are therefore unique within the Operations Team, similar only to the operations analysts and system operations engineers in breadth, although not to the same depth. A dedicated approach to operations controller training and certification has been developed in response.

Operations controllers at EUMETSAT are typically drawn from one of two background profiles. The first set of operations controllers at EUMETSAT for MFG were qualified technician-level personnel, often drawn from military backgrounds in electronic systems and communications. Starting with MSG and now found across all operational programs, a second profile of controller emerged in the form of recent graduates in sciences, engineering and computing disciplines. A balance of personnel between these two profiles within the controller team has been found to be the most beneficial in terms of team stability, maintaining operational knowledge, and as a source of experienced personnel for redeployment to other roles. While some operations controllers have been satisfied to remain in this role for many years, others have moved to become operations analysts and engineers.

Figure 6. Operations Controllers operate EUMETSAT systems 24 hours a day, 365 days a year

B. Executing Controller Training

When a new controller is recruited into the team, a custom training schedule is developed from a standard template that addresses the training required to take them from their current level of experience and capability to the desired level required for certification. As you might expect, this can vary significantly from one candidate to the next. Generally, a training period of approximately thirteen weeks is required for a trainee to attain a level of competence in the operations concepts, mission-specific systems, and multi-mission systems necessary to proceed to certification.

The training schedule for a new recruit begins with an introduction to the organisation followed by overviews of the operational system and operations concept. However, a conscious effort is taken to expose the trainee to the Mission Control Room (MCR) environment from the very start, observing experienced controllers on shift. As the trainee progresses, the balance between classroom activities and shadowing controllers in the MCR changes from the former to the latter, with periods of self-study and interim assessment by the Operations Training Officer and Controller Team Leader. The level of detail involved in classroom studies increases as the trainee's familiarity with the system and operations concept improves, allowing for study of contingency cases and details of instrument design and production operations.

The trainee is provided with a considerable amount of training materials, including the entire operational, technical and management baseline, and the presentation materials from classroom training. Key amongst the operational baseline as far as the controllers are concerned is the Reference Operations Plan (ROP) which is the entry point for controller-level operations, mapping operational activities to system procedures such as SCPs. From this starting point, the trainee can progress through the operational baseline to any activity that the controller is expected to perform.

Several factors can impact on the detailed scheduling of controller training. A trainee from a background without operational experience or exposure to real-time satellite and ground systems has, at first glance, the largest amount of new information to absorb. For prospective controllers with experience of operational missions at other operational agencies, the fundamentals of operations will not be new to them but many differences in operational approach and detailed systems knowledge will be unavoidable.

Take the example of a controller moving from ESA's European Space Operations Centre (ESOC) to EUMETSAT EPS. These two agencies are both located in Darmstadt, with much of EUMETSAT's heritage originating in ESOC. However, the systems used for EPS at EUMETSAT have little or no similarity to those used for similar missions at ESOC, such as ERS or ENVISAT. Operating systems, bespoke and COTS software applications, and multi-mission systems are very different at the two agencies. In addition, the operations concept for operations at ESOC separates spacecraft and ground segment operations entirely, while at EUMETSAT the space and ground segments are operated as a single System.

Trainee controllers redeploying from within EUMETSAT will have similar issues, although multi-mission aspects and end-to-end operations approach will be common. Therefore the training schedule for an experienced controller joining an operational program will be close to that of an entirely new trainee. The only exception is where a controller is being redeployed between two very similar systems, in which case the transition period and associated training may be shorter, such as from MFG to MSG.

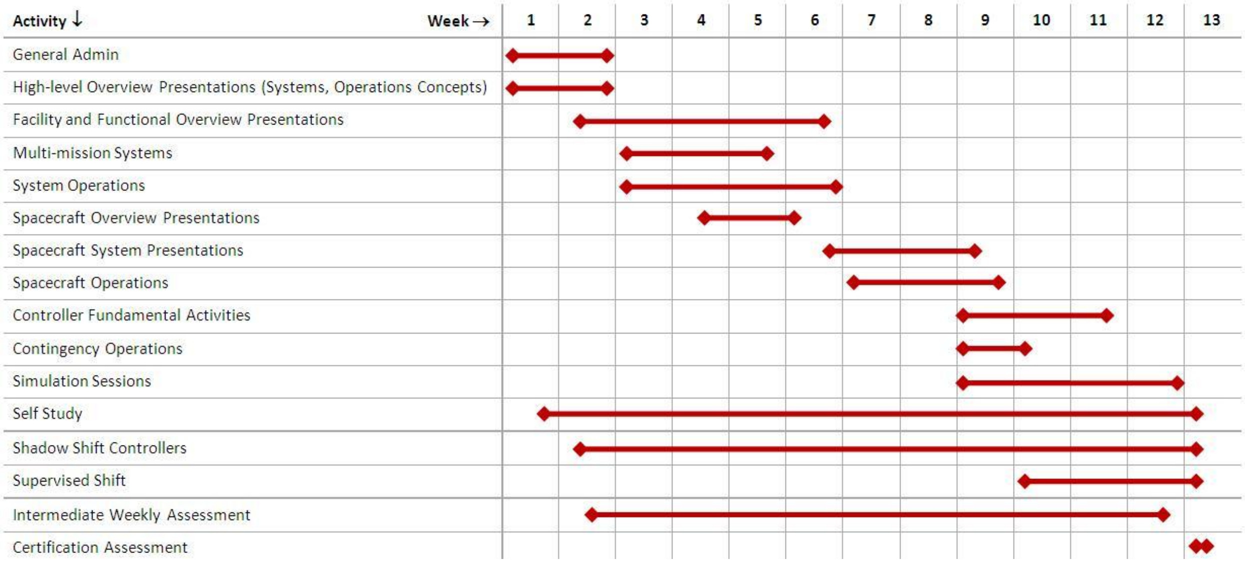

Figure 7. A high-level summary of the Induction Training program for an EPS Operations Controller

From approximately three-quarters of the way through the training schedule, the trainees begin acting as day-shift controllers although under the supervision of an experienced controller. Towards the end of the training schedule, the trainee is predominantly performing real operations under supervision, and undergoing regular informal assessment. Once the Operations Training Officer and Controller Team Leader concur that the trainee is ready, a formal assessment takes place to certify the trainee as a qualified operations controller.

C. Controller Formal Certification

Controller certification is the final step of induction training. Here the candidate controller is interviewed by an assessment board, led by the staff System Operations Engineer and supported by a Spacecraft Operations Engineer and a Quality Assurance Engineer, to assess their readiness to begin unsupervised shift operations. The formal assessment is in two distinct parts – theoretical and practical – and generally completed in half a day.

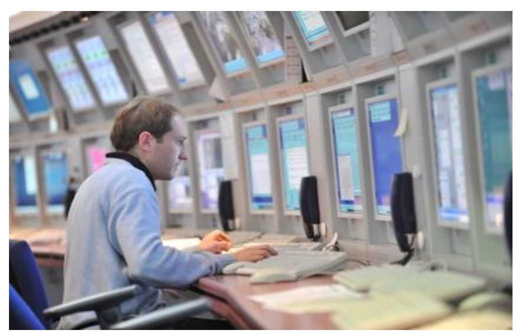

Figure 8. Operations Controllers are certified for shift operations during a thorough practical and theoretical assessment

The practical assessment is divided between spacecraft operations and system (ground) operations. The candidate is followed through a typical series of spacecraft operations – pass-based for LEO missions – and asked to explain each activity as they progress. A similar assessment is performed for system operations covering topics such as monitoring and control, ground stations, data processing, mission planning and dissemination. Their performance is assessed for competence and effectiveness, against operations procedures for accuracy. During the execution of these activities, the candidate is asked detailed questions on the satellite and its operation, as well as the correct response to contingency situations that may arise.

Between or after the two sections of the practical assessment, the candidate controller is interviewed to assess their theoretical knowledge. They are asked a series of questions designed to reveal the depth of their knowledge on the mission objectives, system design, operational processes, contingency scenarios and fault diagnosis, and operational partner interfaces.

After the interview, the assessment board meets to discuss and agree on their assessment of the candidate. A certification report is generated which declares whether or not the candidate is certified for unsupervised shift operations. Although not normally the case, the report may also indicate if specific additional training is required where that is felt necessary by the assessment board. The candidate is informed of the outcome of their assessment. As the controller team are employed as consultants via a contracting company, this is performed via their employer.

To date, no candidate controller at EUMETSAT has failed to pass their certification assessment, although a small number of trainees failed to achieve a level of competence necessary for them to be put forward for certification and subsequently left the organisation.

VI. Conclusion

EUMETSAT has developed and maintained a comprehensive approach to training members of the Operations Team responsible for the routine delivery of mission products within strict timeliness and availability requirements that comprise operational services to its user community. The complex nature of EUMETSAT's activities in support of these services has generated a large volume of applicable operational knowledge that has been captured and is now utilised for the training of new and redeployed personnel.

This operational knowledge was, and continues to be, captured through a variety of processes associated with developing, validating, and operating EUMETSAT's operational systems. This operational knowledge is maintained through a process of continuous review and is captured in a range of documentation and electronic formats, based on the nature of the information and how it is utilised.

The broad and detailed training regime that resulted is based on a standardised training suite customisable as appropriate to address the needs of specific trainees and roles. In particular, training implemented to prepare, assess and maintain the operations controller team has proven a highly-effective tool to ready candidate controllers from a variety of backgrounds and profiles for the unique challenges associated with the day-to-day operation of complex and geographically-distributed operational systems with stringent availability and timeliness constraints.

Appendix A
Acronym List

APT	Anomaly Processing Tool
CCD	Control Centre Division (in EUMETSAT Operations Department)
COTS	Commercial Off The Shelf
DMS	Documentation Management System
EPS	EUMETSAT Polar System
ESA	European Space Agency
ESOC	European Space Operations Centre (of ESA)
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FCP	Flight Control Procedure
GCP	Ground Control Procedure
GEMS	Generic Event Monitoring System
MCR	Mission Control Room
MED	Maintenance and Engineering Division (in EUMETSAT Operations Department)
MFG	Meteosat First Generation (geostationary satellite system)
MOD	Meteorological Operations Division (in EUMETSAT Operations Department)
MSG	Meteosat Second Generation (geostationary satellite system)
MTG	Meteosat Third Generation (geostationary satellite system)
MTP	Meteosat Transition Program (MFG satellite)
OICD	Operational Interface Control Document
ROP	Reference Operations Plan
SCP	System Control Procedure
SOI	Special Operations Instruction
STOL	Spacecraft Test and Operations Language
USD	User Services Division (in EUMETSAT Operations Department)

Appendix B
Glossary

Metop	Meteorological Operational (satellite of the EUMETSAT Polar System)
Dimensions	A Configuration Management tool from Serena used by EUMETSAT Operations

Acknowledgments

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