Knowledge Management in Support of Spacecraft Operations

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The paper provides an overview of the status of the implementation of Knowledge Management in ESOC. Since the start, KM has been driven by the ESOC core business and focused mainly on procedures and tools to capture and share the knowledge and to preserve and evolve the competencies of the centre.

Recently the ESA Corporate KM Initiative has been launched and in this context a framework of KM projects to be undertaken at different ESA sites has been drawn. The paper presents those KM projects implemented at ESOC as services offered to the community. These services are related to increasing knowledge transfer, sharing and collaboration in particular within and across projects, assessing the core competences, strengthening the lessons learned and golden rules dissemination, and reinforcing the process of tacit knowledge capture. The competence management model defined in ESOC is also presented showing the evolution from the concept of competence appraisal dedicated to single section/division to a key tool for the management. The paper concludes by presenting the way forward and an initial approach to measure the KM benefits.

An important characteristic of the ESOC´s approach is to accomplish the KM goals in a way that is non-intrusive and does not force any new procedures or habits to end-users. In fact, several examples can be found in the literature where attempts of Knowledge Management forced end users to change their habits and "do things" in a way the system could understand. This approach mostly led to failures and demonstrated that it's hard to change habits! The paper discusses the implications of the approach taken in ESOC in the way tools are developed and integrated with end users workflow in their daily activities.

Nomenclature

ADS	=	Active Directory Service
CM	=	Competence Management
CoP	=	Community of Practice
ESA	=	European Space Agency
ESOC	=	European Space Operations Centre

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HSO = Directorate of Human Spaceflight and Operations
IT = Information Technology
KA = Knowledge Area
KM = Knowledge Management
KMO = Knowledge Management Officer
NTFS = New Technology File System
SPR = Software Problem Report
TD = Technical Domain
TOGAF = The Open Group Architecture Framework

I. Introduction

ESOC is continuously developing knowledge, skills, tools and methods in the different fields of Spacecraft Operations. The necessity to keep the acquired competences at the highest level and properly manage the know-how developed in the Directorate is a crucial element requiring excellent internal communication, open attitude and cooperation. Since the debate on Knowledge Management started, major steps have been achieved. However, some outstanding issues are still not solved. Even if the importance of KM is evident, a culture of sharing and re-use it is not completely adopted in people's mind and in the business processes; knowledge can be lost with staff departure or remain segregated. Moreover, the landscape still shows a scattered picture with individual and uncoordinated experiences which need to be harmonised between each other.

KM started with the specific objectives of understand current KM situation at ESOC, identify knowledge gaps and their criticality and prepare recommendations and actions plan as input to the directorate strategy. ESOC offers today a set of Knowledge Management services which have been selected according to the corporate KM roadmap and policy. This paper defines the objectives of KM, its management structure, its processes and services.

II. ESA KM Objectives

The implementation of a Knowledge Management strategy in ESA seeks to achieve two key strategic goals. The first is to establish and entrench a "knowledge culture" within the Agency, and the second is to enhance the operational efficiency. The former requires that the Agency takes steps to evolve into an organisation where the produced knowledge can be efficiently used and shared inside the community. Enhanced operational efficiency is expected to yield more efficiently the design and implementation of space projects.

Based on the strategic goals, the objectives of the ESA Knowledge Management strategy are formulated as follows:

Objective 1 - Facilitate knowledge sharing to increase collaboration and synergies
Objective 2 - Capture, preserve and make evolve the knowledge across missions and projects in order to increase efficiency of current and future operations, minimise the risks and avoid loss of expertise;
Objective 3 - Set up methodologies and tools for staff to find, organise, and share knowledge.

The first objective focuses on facilitating the sharing of knowledge in order to increase the collaboration between individuals and teams. This heavily contributes to creating synergies and a more fertile environment for continuous learning and for the search for innovative solutions. An effective knowledge sharing depends on how efficiently and effectively the knowledge is managed internally and how quickly it capitalises on the skills and experiences gathered in the different functional areas of the organisation.

The second objective is to ensure that the core knowledge and the gathered experience (e.g. Lessons Learned, Best Practices) remain in the Agency after leaving/retirement of key staff and it is made available to the community at the appropriate place and time within work processes. This need to maintain existing knowledge also provides the foundations to evolve towards new knowledge areas needed for future endeavours. KM methodologies allow the assessment of the current knowledge coverage and support the evaluation with respect to current and future needs.

There is a large amount of knowledge generated during the day-to-day work - from formal documents, reports, presentations to the less formal knowledge, such as exchanges between colleagues that represents a significant and valuable part of the knowledge generated and accumulated within the Agency. Actually, in most of the cases this

knowledge remains in a tacit form, retained in the heads of the staff. When not formalised or made explicit, this knowledge naturally tends to be dispersed and eventually is lost for ESA and its stakeholders.

As a matter of fact and because of the long duration of ESA projects (from feasibility study to end of operations), KM is essential to maintain internal knowledge through two or even more generations. Moreover, by facilitating the creation of structured and systematic packages of training and best practices, the capabilities and flexibility of mission team members increase in addressing and solving issues or moving between mission teams. A key component of KM is also a lessons learned system, gathering and reporting on practical experiences, positive or negative, which has the potential to be beneficially used during the development and execution of existing or future projects. It can encompass anything from technical solutions to avoid a particular problem, to managerial recommendations to minimise programme risks.

The third objective focuses on helping people to access the information and resources they need to complete their tasks by providing the right KM tools, resources and methodologies.

Moreover, preparing and sustaining the technical competence of the ESA workforce is a key necessity to maintain the leading role as Europe's development agency for space programmes. Given the shortage of experienced space engineers, a continuous influx and in-house training of young engineers and scientists is essential to ensure the replenishment of the workforce. Since a few years ESA has recognised the crucial role of KM as a tool to primarily preserve and share information and know-how, but also to help guarantee its own cost-effective and qualitative evolution.

III. Current Status of KM in ESOC

The necessity to keep and properly manage the know-how developed in the Agency is recognised as a crucial element for the growth of ESA; it is also a strategic element as far as knowledge sharing/transfer to institutional partners and other Space Agencies is concerned. This has been confirmed by the various initiatives and experiences in KM developed independently by different ESA establishments in order to support their local needs.

In ESOC, the KM initiatives have been since the beginning solutions targeted and focused on specific issues related to competence maintenance and appraisal, knowledge capture and sharing.

Major steps have already been achieved in the area of Knowledge Management in ESOC:

- At a general level, managers and employees are conscious of the importance of KM, not only as a learning and development issue but as a strategic and business one as well;
- A wide set of KM and communication technologies have already been developed;
- Some important KM practices such as lessons learned are applied to missions operations;
- Operative knowledge is shared within some individual Divisions.

However, some outstanding issues are still not solved and these are in particular the aspects on which the future KM activities will concentrate upon:

- Even if the importance of KM is evident, a culture of sharing and re-use it is not completely adopted in people's mind and in business processes;
- The institutional knowledge base may shrink as individuals retire;
- New staff are immersed into new programs and expected to start working without a substantial introduction to the ESOC history and processes;
- Knowledge is often lost when staffs move to different projects/programmes without a proper knowledge hand-over process in place.

IV. KM Governance in ESOC

The KM governance introduced in ESOC to support KM consists of two levels: the TDs and the KM Core Team. Within the TDs, the specific and distinctive know-how is gathered. The roles identified here are the TD Owner, the KM Assistant, the Knowledge Area Leaders, the experts and of course the other members. The TD owner is responsible for the management of the knowledge inside the domain with the support of the KM Assistant. The KA leaders are responsible for the management of a specific knowledge area within the domain. The KM Core Team is composed of representatives of the technical domains and is in charge of designing and monitoring the overall KM in ESOC. More details about the KM governance are provided in [1].

This management set up is very important for the success of KM for the following reasons:

- Define the leading actors of the KM process and the people involved. Smart knowledge management needs structured management.
- Divide workload according to people's involvement and availability. Staff overload may limit or block knowledge sharing within the community
- Motivate and answer all questions arisen. Plan incentives and presentations whenever required.
- Ensure clear roles and responsibilities to avoid overlaps and reorganizations.

V. The Challenge of KM in Project Lifecycle and Spacecraft Operations

A complete project lifecycle from Phase A to E can span 20 years or more. The challenge to the project is how to ensure that the knowledge and data generated is transferred across phases and is accessible as a knowledge base. The challenge to mission operations is access to information/experts to create mission operations systems, and critically, to build teams of people with the right skills to execute mission operations. Mission in-orbit lifetimes may extend beyond a decade which poses problems for knowledge retention. For interplanetary missions with no "routine phase", but rather a series of special operations/encounters separated by long hibernations, good KM practice becomes essential to ensure to have right information available to the right people at the right time.

Any project will have requirements on how to structure information, whether this is requirements or design, or relating to validation or operations. Project phase reviews should not only include an assessment of completeness/correctness of project information but also ensure that maximum know-how can be extracted from the review (reasons behind design decisions, tools used, contacts, etc.) and that the information can be effectively transferred to the mission operations when needed.

To take one example: the Rosetta mission is a long duration mission, where mission operations for final comet encounter in 2014 are now being finalized. Concerns on level of detail in instrument design information were acted upon already before launch by a KM initiative not only to create project repositories but extended to make a photographic survey of installed hardware, and conducting expert video interviews. With large documentation repositories there is always the risk of duplication, navigating to most recent document, flat structures from scanned paper copies. These weaknesses should be removed by introducing properly indexed and searchable repositories for future missions using technologies as discussed under KM services. The expert interviews are now recognized as a routine knowledge capture service and not necessarily a project specific solution and discussed later in this paper.

There are a handful of such examples where a KM plan is adopted early in the project and used specifically to map the process of knowledge transfer, but this is not the only way. As already mentioned, care should be taken not to force new processes on organizations, and there are many more examples of missions executing operations based on snapshots of design information from reviews that are kept alive by maintaining project histories of configuration changes, maintaining people directories of experts where needed, identifying peoples roles and knowledge requirements within the team and maintaining individual training and cross-training plans to cope with staff mobility and foster more tacit knowledge transfer. If there is a blueprint for a way ahead for all missions then it is to first recognize that the aforementioned processes exist and then ensure they are maintained and accessible to all: the Mars Express operations team have achieved this by introducing the living KM plan as a top level entry point, other missions use also the Intranet as the entry point. The ESOC KM team offer services to help make existing information and processes more accessible.

The above has discussed processes within a project where the push for an internal solution is a clear goal for ultimate mission success! The wider challenge for mission operations is to make more use of KM services outlined later in this paper that extend outside a single mission in particular in the areas:

- knowledge sharing - where technology now offers solutions for searching the existing knowledge base for information across missions and;
- lessons learned – where a critical point is to ensure feedback from project reviews into other projects/missions and staff training programs.

VI. KM Services

The way in which people in the organization interact with knowledge management activities is through a **service**. A service is a set of methods and tools that are supported by a team and used by staff throughout the organization. Services integrate processes, people, and systems into a cohesive support structure for how people actually do their work.

The following services are either being provided or planned to be by KM and are discussed in the following chapters:

- KM Officer
- Lessons Learned
- Competence Management
- Knowledge Capture
- Knowledge Sharing

VII. KM Officer

In the context of the projects, the creation of a new role, the KM Officer, was considered to be interesting from a strategic point of view, as he would be the KM contact point inside the projects within the organization. The objective of this pilot project is to define the roles, the responsibilities and the functioning model of the KMO that can become the pivot of the knowledge management processes inside and outside the projects. The KMO is an additional function for a project member with a limited level of effort. The role of the KM Officer will be the implementation of the goals of a knowledge management system in particular the distribution, sharing and storing of knowledge within and among projects (including reviews and Lessons Learned management and improvement). The distribution of knowledge distinguished the role of the KMO from the Product Assurance Officer which goes more in the direction of risk, problem configuration and document management plus the Lessons Learned. The KMO function is a translation of the KM governance model into the project; however, the scope of the KMO goes further compared to the KA Leader (as example). For the above reasons a dedicated pilot is envisaged.

The KMO role has to be defined also in terms of sourcing profile. Who can be the right person to cover the role, how should be the organization relationship with the other roles in the project, etc. In this project the KMO shall be engaged also in the challenge to anticipate the participation of the post launch part of the organization.

VIII. Lessons Learned

Amongst the KM pilot projects envisaged at corporate level, there is the ESA lessons learned pilot project, aiming to investigate ways to harmonize the lessons learned systems existing in the Agency and to foster the spreading and exchange of lessons learned and best practices. The pilot's objective is, from one side, to define the rules and the processes to transform the projects lesson learned in ESA golden rules; from the other side, to provide a unique access point to all different lessons learned systems present in ESA, giving people a centralized place for sharing and searching lessons learned and significantly improving the efficiency. Irrespective of the methodology, the integration of lessons learned into the overall project process is needed and should follow the scheme: project idea, review of lessons learned of past projects, project design, project execution and derivation of lessons learned from this project for future benefit.

The lessons learned process which runs in HSO aims to collect and assimilate lessons learned from the daily operational experience. The process is meant not only to improve the agreed practices within the Agency, but also to proactively interface with external entities (e.g. the customer, i.e. the spacecraft procurement entity).

The compilation of the lessons learned occurs at the major project milestones or at calendar intervals for continuous services. Every staff has the opportunity to assess the work done so far with respect to the plan or to the usual practices. Any positive or negative deviation may suggest a recommendation for the future. The second step consists of the public presentation of the proposed lessons learned. After the presentation, a pool of domain experts nominated by ESOC management analyses the proposed lessons meant for the improvement of the organization. When the expert agrees with the recommendation, he validates the lesson and escalates it to the ESOC management for disposition. Then, this management board decides on the validated lessons. If the recommendation is considered useful for the organization, the ESOC management board assigns an action to implement it.

The outcome of the process is then a modification to either:
- Procedures in the Quality Management System
- Localized management instructions
- Training given to staff.

With this approach, the process of lessons learned in HSO transforms valid recommendations in concrete modification of the methods to perform the day-to-day job for the benefit of the whole organization.

A second stream of the process extracts the lessons to be dispatched to the customer: from HSO directorate to Science and Earth Observation Programme directorates via the Technological Support directorate. In this case the HSO directorate plays as supplier that reports to the customer lessons (in terms of suggested recommendations) to be assimilated for the next space missions. The main areas addressed by this stream of lessons are the spacecraft design, the timely provision of required inputs to ground and the overall organization and management of the partners involved in the mission (mission/programme management).

The provision of these lessons learned aims at stimulating improvements on the space segment side for the upcoming satellite missions, to avoid the repetition of the same "mistakes" (as seen from Operations) and to increase the efficiency and the effectiveness of the ground support and the entire system for the overall satisfaction of the mission data end users.

IX. Competence Management

ESA is a knowledge intensive organisation. To ensure a continued success, it is crucial the transfer of these knowledge between employees in order to maintain a high level of competence. Individual competence is formed as coexistence of knowledge, skills and attitudes relevant for functions that individual executes within the role assigned.

Moreover, the need for competencies can change over time as well as the availability of the competent personnel. Investing in competencies has to be performed in such way that it swiftly benefits delivery of current and future organisational capabilities and services. For the above reasons ESA decides to invest time in analysing and formalising the management of competences.

Some years ago, the ESOC Knowledge Management performed a categorisation of current status of knowledge, defining technical domains and within them knowledge areas and fields. A knowledge area is an aggregate of knowledge fields with a good homogeneity inside, whether a knowledge field represents a specific academic discipline or application. The analysis revealed the need of matching each different area and field with the individual level of know-how and later the need of assessing the criticality of them. These preliminary steps have been the basis of the recent competence management. Making use of the TOGAF methodology, the activity is regulated by formal phases, started from the Requirements and the System Architecture is moving now towards the Migration and Implementation
The first phases have been instrumental in the determination at one side of the scope and at the other side, the identification of the stakeholders involved in this process.

CM must ensure	main CM stakeholders
Awareness **of the current and future competencies needs with respect to the ESA functional roles that realize ESA's (critical) strategic capabilities and services**	Managers from the ***Section Head up to the higher level management*** (i.e. Division and Department heads) that need to be aware of type and level of competencies present in the Agency
Preservation **of competencies acquired in long-term missions/projects/operations**	***Department and Division heads*** that gives strategic direction to the Section Heads based on Directorate Roadmap for the future competencies
Evolution **of competencies to the need of new programs/projects**	***Project and Ground Segment Managers*** who need to be aware of competence level of current resources in relation to current and future execution of project related activities
Regular *link* of the *staff competencies* to Program/Project requirements and strategy roadmaps	***Section head*** that shall interpret and align higher-level ESA competence requirements with the staff in line with the CM implementation plan
Structured decision making for identifying *competence gaps* or unbalance, training opportunities and development plans on either short or long-term	***Human Resources*** unit to assists Section Heads in choice of training programs, to forecast and monitor ESA-wide competency requirements, to guide career management.
Efficient *competence maintenance* and up-to date overview, i.e. shape competences to cope with future directions and changes in technology	***Individual*** that comes with initiative (e.g. self-identified competence training and development needs) and when requested by Section Head, can provide self-competence assessment

Table 1 – Competence management scope and stakeholders

The different purposes of Competence Management (CM) have the consequence of involving stakeholders of different nature with different needs, tasks and responsibilities. For this reason, it was not trivial to formalise the CM in the following sub-processes:

- ***Competence Requirements Definition*** – this process defines a collection of strategic and operational competence requirements related to the ESA's current and/or future (predicted) competence needs.
- ***Management of Competence Requirements*** – this process is responsible of understand, structure and give priorities to the competence requirements. This can be derived from produced plans or by interviewing key stakeholders. Different drivers can contribute to this process, the main ones being movement or change in personnel (retirement, new employment, move of function) and technology evolution. During this process, roles are assigned a satisfying level of competence, keeping in mind that competencies are not equally critical for execution of work related functions.
- ***Competence Assessment*** - this process is responsible of assessing the individual competencies and measure them against the competence requirements identified for the role assigned. This process is the most important in the overall and contains two parts:
  - Part I – mapping desired/required competence level in relation to the role. This is achieved by defining and implementing a Competence Measurement Set
  - Part II – mapping individual competence to the role(s) it possesses. This is achieved by filling in relevant part of competence measurement set and review, confirm and aggregate the data

- ***Competence Gap Analysis and Action Proposal*** – this process is using the outcome of the Competence Assessment containing the individuals competence and their corresponding roles in the organization; this process shall produce a report of potential discrepancy (gap) between required level of competence for a certain role and actual competence of the individual executing the role. In addition to this, it should also propose actions and plans to mitigate the identified competence gaps.

- ***Mitigation Approval and Execution*** – this process shall involve relevant stakeholders to plan and activate individual (or group) development plan and/or competence elevation measure. This step include dialog with individuals and Human Resources unit, although actions shall not be limited to training.

- ***Competence Management Improvement*** – this final process shall ensure that suggestions for improving the CM are addressed and implemented in collaboration with relevant stakeholders (e.g. Management or Knowledge Area leaders).

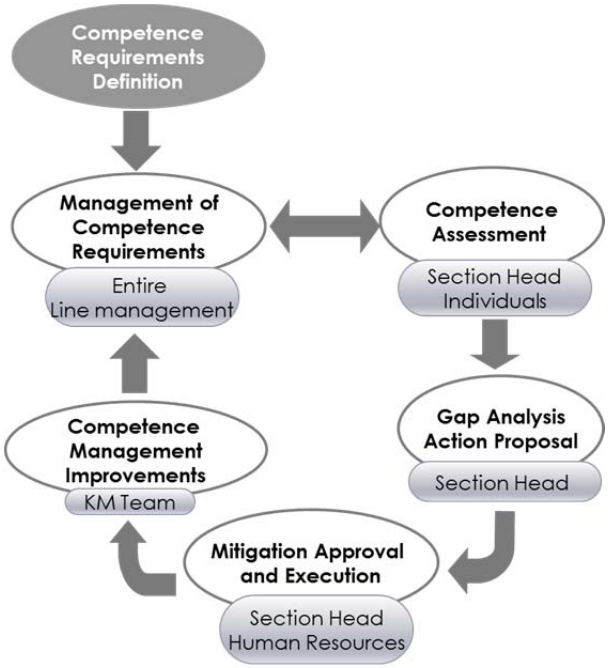

Figure 1 – Competence Management and Main Stakeholders

Due to the number of different stakeholders involved with different needs, particular attention has been given at identifying a data model and the set of requirements for a tool that shall support the CM. It is expected that the information collected by the CM will need to be centrally stored and remotely accessible (e.g. Web interface). The system shall support access roles in order to preserve the correct level of confidentiality and at the same time, the requested level of data aggregation in the reports. A previously implemented prototype has been instrumental at identify limit and requirement for the tool that shall be developed in the future.

X. Knowledge Capture

The term 'Knowledge Capture' is normally used for two types of processes. On one hand there is the continuous knowledge capture and transfer during the course of a project, where methods like communities of practice, mentoring, master-student, project tandems, lessons learned or documentation standards are used. On the other hand there is the knowledge capture and transfer at specific points in time when staff members are leaving their posts such as change of position within organization, leaving the organization or retirement. The latter case is the subject of this chapter.

For most of the methods listed above it can be seen that this process requires verbal communication. The transfer of experience in a verbal form should be preferred compared to the written one. Verbal communication creates contact and nearness which are essential for the passing on of experience. Experiences are best exchanged in the personal conversation.

Looking through the literature most of the references either propose a kind of workshop (called expert debriefing) or recommend interviews (moderated or un-moderated). For completeness some further explanations are added for the comparison of both methods:

- The expert debriefing is a kind of forum/ workshop in order to allow the expert to explain his specialized knowledge for a selected range of topics to a larger group of participants. Of course, the assistance of a moderator would help to facilitate to express the underlying expertise. In essence, the goal of the expert

debriefing is twofold, the expression of the underlying expertise in a verbal interaction with the audience and the recognition of the expert's merits (a sign of appreciation of the achievements of the leaving expert).

- The interview is better applied for the description of complex subjects. Obviously they have to be video-recorded. The participation of the interviews would be very limited, i.e. the expert, the moderator and the IT member.

The Expert debriefing as well as the Interviews are implemented at ESOC. Since October 2009 when the method was implemented first about a dozen events took place with a clear majority for the Expert Debriefing. However, it goes without saying that they are applied in addition to the ordinary hand-over techniques between the leaving staff and his successor. The goal of these methods is to spread the gained experience over a larger group of colleagues, also with the intention to initiate further discussions and transfer of knowledge.

	Expert Debriefing	Interview
Type	Guided workshop	Script followed
Audience	Members of enhanced KA	Interview team only
Interaction	Face-to-face interaction	No direct interaction
Moderation	Required	Depending on subject
Expert recognition	Directly in public	Indirect

Table 2 - Different methods for Knowledge Capture

Irrespective of the method (Expert debriefing or Interview) there is no basic difference for the overall structure of the procedure with respect to the preparation and its conduct. The knowledge capture procedure consists of:

- Step 1: Review of status with an inquiry. The objective is to assess the important knowledge subjects of the leaving staff as well as the knowledge demand required by the group and the successor. For the identification of the essential knowledge items to be captured different viewpoints should be adopted in addition to the chronological review of the projects supported. The quality aspects could be the other viewpoints such as best and worst practices, contribution of the success and mistakes leading to a possible failure.
- Step 2: Plan for debriefing and interview. This includes the sequence of knowledge subjects for the debriefing / interviews and its structure.
- Step 3: Conduct of Debriefing / Interviews with the goal to capture the tacit knowledge and to facilitate its documentation. The various viewpoints mentioned for the first step above has to be adopted for the conduct of the expert debriefing and the interviews as well.
- Step 4: Documentation of tacit knowledge with the help of video-recording. Audio-visual means are a valuable complement within the preservation methods for knowledge as more senses are involved for the explanation and the understanding of the complex subject.
- Step 5: In addition to the previous step, there is an ongoing work to facilitate the contents of the video in text format. This is to say, there is the intention to offer for every video a transcription of the speech, being both of them synchronized in a way that any user can search the terms of interest and skip directly to that part in the video. This is a big leap forward in the scope of knowledge capture, since once the videos are in text format, they can be indexed by any search engine and their contents can be retrieved in such an easy way never before experienced in ESA in the realm of video capture.

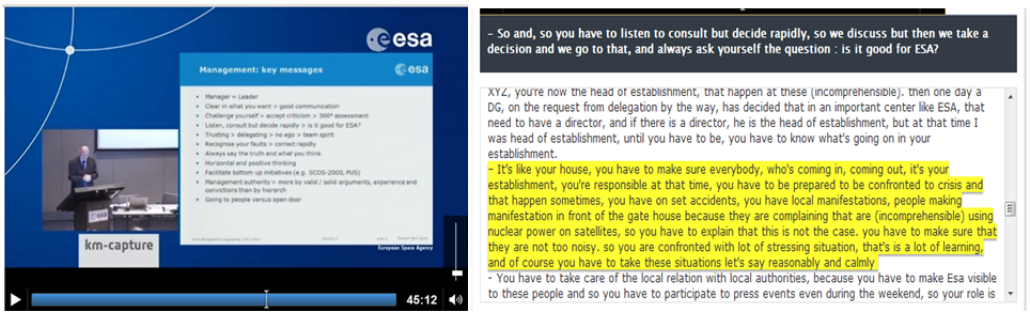

Figure 2 - Captured Video with Transcriptions

Currently the procedure is enhanced by narrative methods, also called Story Telling. They play a significant role in the capturing of experience. Narrative methods do not only consist of telling of occurrences, events or episodes but they also include the usage of pictures, metaphors and analogies.

XI. Knowledge Sharing

As knowledge and experience is mostly in the heads of the people knowledge sharing has primarily to take place between people supported by procedures and IT tools. It is obvious IT tools alone would not be able to maintain knowledge sharing. The knowledge sharing in ESOC takes place with the following means:

- Supporting the Communities of Practice. Knowledge sharing can be facilitated through the creation of knowledge networks which are not necessarily aligned with the vertical hierarchy. Communities of practice are informal groups who organize themselves. They meet on a voluntary basis in order to discuss various topics, to exchange views and to look for solutions. The members could belong to different domains and hierarchical sections. Very often Communities of practice are described by the elements density (strong or weak ties), duration and range (one department or entire organisation). Most of the communities of practice are characterized by strong and long-term liaison.
- Sharing Best practices repositories. The sharing of Best/Worst Practices could improve the efficiency of a company significantly.
- Using KM Portal to share knowledge .

KM Portal

The KM Portal, within the ESOC intranet, is the "entry-point" for all ESOC KM related activities and also a platform providing a simple, friendly and flexible on-line environment for storing, sharing, searching and retrieval of knowledge.

The followed approach is based in the Communities of Practice, which are the crucial part of the Knowledge Management Portal. When any employee needs certain information that cannot be acquired from the existing platforms (DMS, share drives, etc.) he may need the input from his team colleagues or from other colleagues dealing with similar knowledge. Therefore, it may be necessary the creation of a community that would share useful information and best practices. The KM Portal provides the platform for this knowledge sharing, by enabling a space in which the members of every community create, store and classify the content according to their experience, giving a new approach to access information that complements the more formal ones.

This is also considered as a bottom-up approach, since the communities set-up and organization is spontaneous and motivated by people's knowledge needs. As soon as someone wants to create a community, he is able to do that without the need of further authorization. In this way, the KM Portal administrators are mere spectators providing a platform, and letting the information be structured and flow by the same people that need and use it.

After an initial period of testing, the information that can be found or shared is very varied: from tips & tricks of the day-to-day work to user manuals.

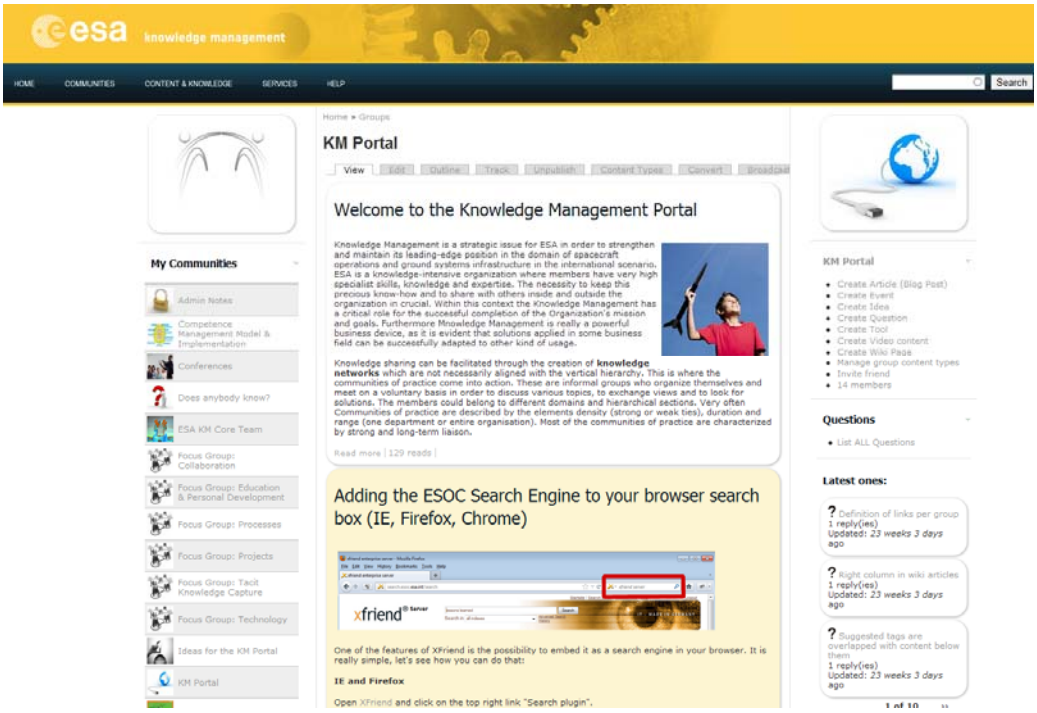

Figure 3 - ESOC KM Portal

Moreover, the KM Portal is not only a place for communities but also the entry point to other functionalities. A critical one is the Tools Catalogue, an interactive collection of tools developed, customized or simply used within ESA. This database collects tools from any department, team or individual that is willing to publish it. The inputs (link and basic description) are provided by the users, who are the ones who really knows the resources that they are going to share.

Another remarkable feature of the KM Portal is the provision of a Search Engine, which indexes as much repositories across ESOC as needed. This was a leap forward to strengthen the position of the KM Portal as a single entry point. The criteria followed during this integration (which is still on-going) are:

- The integrated search engine should offer as much functionality from the KM portal as possible.
- The integrated search engine should permit its use minimizing the number of clicks from the user.
- The integrated search engine should avoid asking for credentials

In addition, the users are enabled to submit the repositories they want to be indexed, being once again the driver of such an application.
The implementation of the portal is based on Drupal (http://drupal.org/) an open source content management system widely used and with a large and very active user community. The Drupal system is based on a very limited number of core functionality on top of which the user community has developed a large number of plug-in modules that implement a wide variety of functions. Among others, the KM Portal supports currently the following features:

- KM Project pages: these are static web-pages that describe the KM initiatives within ESOC;
- Portal level blog: users can submit blog posts that are relevant for the entire portal audience and that are automatically displayed on the front page;
- Communities of practice: these are communities within the portal community focused on specific topics or knowledge areas;
- Community level blogs: blog posts can also be submitted targeting one or more community of practice when only relevant to those audience;
- Content pages: these are similar to blog posts but normally with a wider and richer content fully addressing a specific topic;
- Wiki-like pages: these are similar to content pages but allowing several editors contributing to provide content;

- Forums: traditional forums on specific topics or knowledge areas;
- Main navigation menu: contains links to create content, look at the most recent activities, etc.

Search Engine in the KM Portal

As mentioned before, the KM Portal will offer the functionality of an integrated search engine, following one of the recommendations from the "Advanced Knowledge Management Systems for Space Operations" study, which was *to move the concept from concept validation to actual implementation and deployment across ESA and ESOC.*
Part of that study was the creation of a demonstrator that would be a pilot of a search engine across ESOC, called Huginn. However, though the concept and the original idea were well developed, the implementation did not reach an acceptable status. So it was decided to look the available solutions in the market. Several ones where considered but after a successful test period, one stuck out from the rest, according to the criteria that we here describe:

- *Ease of use*. The test version of the software was installed in ESOC and was running in less than one hour.
- Ease of configuration. Any person that has administrator access to the application can add, modify or remove repositories to be crawled.
- *Compatibility with Active Directory Servers*. Complete support of ADS and NTFS/share rights or integrated rights administration.
- *Flexibility*. This application allows a high flexibility when indexing a variety of repositories, especially if they are web based.
- *No limit in the number of documents*. Whereas other solutions based the licence cost in the number of documents to be indexed (which is a constantly growing figure), the selected one places no limit in the amount of files crawled.
- *Price*. The total costs and the cost-benefit ratio were giving the most favorable and advantageous value for money.

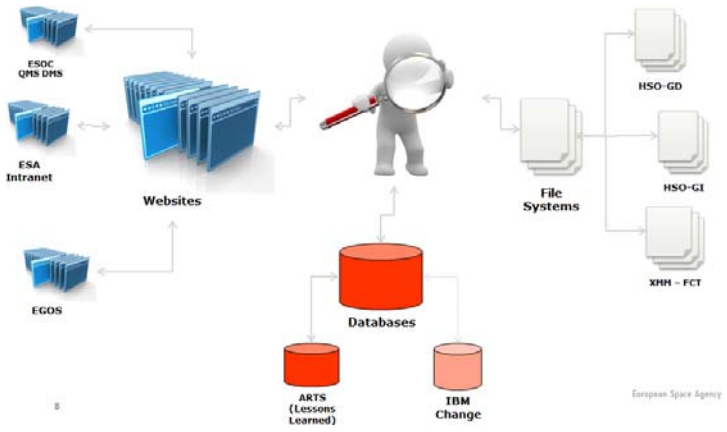

Figure 4 - Search engine schema

Custom extensions to the Search Engine

As an extension to the built-in features of the selected solution, it has been required the development of a custom interface with the current ESOC SPR database: the IBM Change platform.
Among all the repositories existing in ESOC, the IBM Change was considered one of the most important due to the huge amount of information regarding different missions, so many users could benefit from having it indexed.

Also, as mentioned above it is very important to achieve the integration with the current KM Portal. Our intention is that the user of the KM Portal could do the search through an integrated module that could make transparent (if desired) the existence of the native interface of the search engine, creating in this way, a single entry point to the information stored in ESOC.

XII. Next Steps

The paper has described the current status of the KM activities in ESOC, in particular those related to competence management, knowledge capture and sharing. Special attention has been devoted to discuss the challenges of KM with respect to ESA project lifecycle and mission operations.

The envisaged next steps are as first to consolidate the current procedures and deploy the KM IT tools throughout the centre. These activities constitute the basis for the development of an ESA KM Corporate strategy which will be supported by means of an harmonization and extension of the activities and processes existing in the different ESA sites.

In parallel, an analysis will be conducted to identify possible measurements of the impact of KM on the ESOC business or in other words what the expected payoff of KM is. This will include case studies on how different organizations have approached the problem of KM metrics, and what can be learned from their successes or mistakes.

Acknowledgments

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