

A Quality Approach to Knowledge Management - the experience of Telespazio Germany in GSOC

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Abstract

The Services and Satellite Operations (SSO) Department of Telespazio Germany (TPZG), with its Gilching division, provides L1 support services to its customer DLR at the German Space Operation Centre (GSOC), for both flight and ground operations.

Based on TPZG assessment and experience, the two main project resources for this kind of services are the team and project knowledge. The team comprises the personnel, with the added value of their qualification, skills and experience, which they bring to the project. Project knowledge is all the necessary know-how, documentation and procedures required for effective project execution.

In the last years, two main factors affected Telespazio's services and have highlighted the necessity of an update and standardization in knowledge management:

- Market change. Increased job hopping has led to higher team turnover, resulting in extra training costs and loss of know-how when experienced team members leave.
- Optimization of L1 support in operations. GSOC started a process of resources optimization, creating synergies across different projects and developing automation technologies. One of the ultimate goals of this effort is the reduction of the workload of operators working in a 24/7 shift pattern and therefore merge existing L1 support teams into a flexible Multi-Mission operations setup.

TPZG strategy to address these challenges is to build a reliable project knowledge, not dependent on team members experience, and therefore keep delivering safe and high-quality operations, no matter team fluctuation.

At the same time, team remains essential to create expertise and know-how and to incorporate necessary skills into the new setups. For this reason, is important to foster team strengths and tackle weaknesses, giving them proper tools and guidance.

To achieve that, Telespazio adopted a quality approach to knowledge management, by integrating key elements of EN ISO 9001:2015 - Continuous improvement and Documented information - into the main processes of knowledge management - Training plan and Documentation Management.

This paper details Telespazio approach and focus on its impact on two L1 operations support teams in the Communication und Ground Station (KOB) department of GSOC - Systems and Multi-Mission Weilheim – and their merging into a single ground operations Multi-Mission team.

One of the main results achieved is a reduced training time, which has decreased by an average of 40% for a single project and up to 50% for the combined training of the merged Multi-Mission team. Additionally, the paper discusses other important effects of this approach, such as the creation of an ownership and growth mindset in the team and an overall increased service quality.

Keywords: (Quality, Training, Knowledge Transfer)

Acronyms/Abbreviations

Dedicated Training Session (DTS)
German Space Operations Center (GSOC)
Ground Operations Centre (GOC)
Level 1 (L1)
On-Job Training (OJT)
Plan Do Check Act (PCDA)
Self-Study Training (SST)
Services and Satellite Operations (SSO)

1. Introduction

Handling knowledge is a crucial topic in space operations. Thanks to its extensive experience as service provider in operations, Telespazio Germany has a clear understanding of the importance of properly handling know-how, documentation and procedures, as well as what are the related challenges.

The goal of this work is to present a response to the challenges of knowledge management, using a quality approach derived from ISO 9001 pillars. After presenting the method, its effectiveness is assessed, via the case study of two Level 1 (L1) teams, supporting ground operations at the German Space Operations Centre (GSOC).

Since more than twenty years, GSOC is one of the main customers of the Gilching division of Telespazio Germany. The services provided cover different kind of projects, from human spaceflight to flight and ground operations for GEO and LEO satellites. In this context, L1 teams are first level support operators, in charge of monitoring a system and reacting to anomalies following procedures. In the specific case of ground operations, L1 team members handle the monitoring and control of ground stations, antennas, network, data transfer and the overall ground system of a control centre.

The paper is divided in the following sections:

- Challenges of handling knowledge in space operations
- Quality approach to knowledge management
- Training Plan and Documentation Management
- Ground Operations teams' experience and results
- Conclusions

2. Challenges of handling knowledge in space operation

Operations teams must have the necessary knowledge to run smoothly routine operations, but also to react properly to anomalies and failures. Having the correct information about what to do at any time is the key of delivering operations efficiently and safely. Because of that, proper training and procedure handling are a core aspect of space operation. Structured training processes, with training logs and certifications, as well as document management systems, are already largely used by most of the organizations. Moreover, Lesson learned and logging tools are adopted to track and consolidate information and experience; otherwise the knowledge gained during troubleshooting and other non-routine activities would be easily lost.

However, despite the efforts in managing it in a structured way, knowledge in space operations remains very project specific and tied to individuals' experiences. This makes it highly affected by personnel turnover and not efficient in sharing resources between projects.

2.1 Turnover

In the last years, job hopping has increased in the whole market, particularly accelerating during COVID-19 pandemic [1]. This change of attitude regarding career progression, with younger generations seeking flexibility and fast growth, has brought huge impact in service provision. Especially for entry level positions, such as L1 teams, it has become an important cost factor in terms of reoccurring training and onboarding. On the other hand, when experienced personnel are leaving, it may create a know-how gap which takes even longer to recover, causing loss of time and resources.

To mitigate this issue, it is crucial to make knowledge less dependent as possible from the individuals. In parallel, an effort should be made to reduce the high turnovers with retention strategies, targeting team morale, belonging, ownership, and fostering a culture of constructive feedback between teams and leadership.

2.2 Sharing resources

Not only turnover has ramped up. Recently, it has been observed in the space industry an effort in resources optimization, with large use of automation in routine processes and the introduction of Artificial Intelligence and Machine Learning in operations [2]. Having repetitive tasks and monitoring activities automated is of course reducing the manpower needed, especially operators, and together with the general pursuit of optimizing resources, a lot of organizations started restructuring, with teams being shared or merged.

This is happening also in GSOC. In the flight operations department, both spacecraft controller and spacecraft operations engineers are facing changes in their work setup, with several projects combined and resources shared. The same process is ongoing in the ground operations department, with operators' teams combined in a new multi-mission environment.

With these changes, a single individual may have to gain knowledge for several projects and even roles. The amount of training activities can rapidly become challenging and time consuming. Because of that, the approach cannot be using the same project-related training as before, but it should transition to a layered training, with increasing level of details. As first the training should consider the operational setup of the department and provide all the necessary information to give a correct background understanding, no matter what the trainee previous experience is. Then the training should focus on the role specifics and only at the very end add the project related information and activities. This can maximise the flexibility of the training and therefore of the personnel.

3. Quality approach to knowledge management

From the analysed challenges and implications, it is clear the need of an improved approach to knowledge management, able to tackle the issues of fast team fluctuation and challenging training requirements.

The starting point is to understand how the knowledge management process interacts with the two main project resources in space operations services: team and project knowledge.

The team comprises the personnel, with the added value of their qualification, skills and experience, which they bring to the project. Project knowledge is all the necessary know-how, documentation and procedures required for effective project execution. As described in Fig. 1, these two resources are continuously interacting.

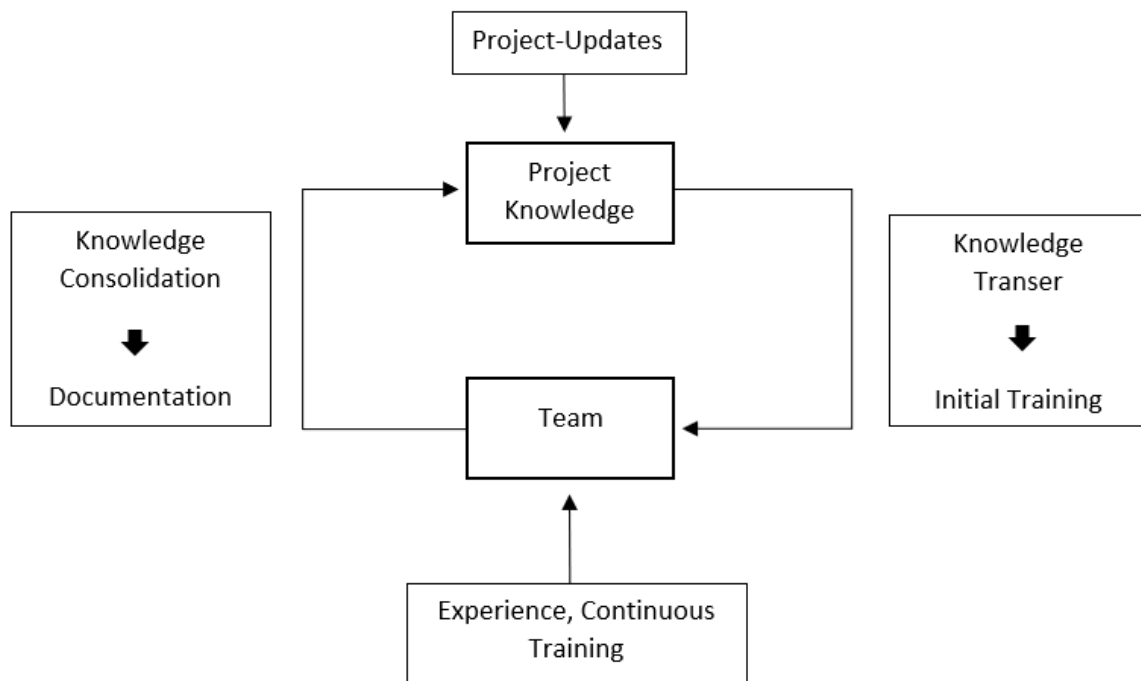


Fig. 1. Interaction of project resources with knowledge management processes

Project knowledge is regularly updated, for example with the introduction of new internal or external constraints, system improvements, concept changes. This project knowledge needs to be transferred to the team via the knowledge transfer process. The team enrich the received knowledge with their experience and this enrichment should be brought back into the project knowledge via the knowledge consolidation process.

Knowledge transfer is usually regulated by the training plan in place, while the knowledge consolidation is mainly obtained via documentation management.

Therefore, training plan and documentation management are the key elements of knowledge management which we need to work on. To properly restructure these elements, the idea is to incorporate the quality approach from the International Standard [3] in our processes of knowledge management. Specifically, using the Plan Do Check Act (PDCA) cycle and the Continuous Improvement and Documented Information concepts.

3.1 Quality approach – ISO 9001

The main reason why the ISO 9001 has been picked as reference approach for the knowledge management restructuring is stated in its Introduction: “This International Standard employs the process approach, which incorporates the Plan-Do-Check-Act (PDCA) cycle and risk-based thinking. The process approach enables an organization to plan its processes and their interactions.” [3]
Properly handling project resources and their interaction, using the knowledge management processes, is exactly our goal and therefore, the quality approach is the selected tool to achieve an improved setup.
In fact, “this approach enables the organization to control the interrelationships and interdependencies among the processes of the system, so that the overall performance of the organization can be enhanced.” [3]

The next step to properly implement this approach is to clarify what are and how we want to use the PDCA, the Continuous Improvement and the Documented Information.

3.1.1 PDCA

The PDCA cycle is a management method largely used, and it’s defined as a tool which “enables an organization to ensure that its processes are adequately resourced and managed, and that opportunities for improvement are determined and acted on.” [3]

The four step of this method are described as follow [3]:

- Plan – establish the objectives of the system and its processes, and the resources needed to deliver results in accordance with customers’ requirements and the organization’s policies and identify and address risks and opportunities. Set goals and derived actions.
- Do - implement what was planned.
- Check – monitor and (where applicable) measure processes and the resulting products and services against policies, objectives, requirements and planned activities, and report the results.
- Act - take actions to improve performance, as necessary.

The system and its processes are identified as per Fig.1 and the risk and opportunity analysis has been already presented in Section 2. The derived goal is to achieve an efficient knowledge transfer and consolidation and therefore a solid training plan e documentation management are needed.

The training plan in place should be as generic as possible, responding to the need of having flexible training and should be well structure and monitored. In this way we can monitor the results and correct what is not working.

The documentation management should be able to track the experience gained by the team and integrate it in the project documents. Once there, it can be transferred again into the training plan.

3.1.2 Continuous Improvement

The PDCA cycle is already highly focused on improvement, through the Check and Act steps. However, the improvement concept is discussed in even more details in ISO 9001, as it’s one of the principles of quality. Improvement and development should be driving values of each organization, which shall aim to [3], [4]:

- Improving its products/services not only to meet requirements but also to address future needs and expectations.
- Correcting, preventing or mitigate issues.
- Improving the performance and effectiveness of the processes.

Regular analysis and evaluation should be able to identify needs and opportunities and therefore the corrective actions, changes and re-organization which may bring benefit.

Regarding knowledge management, the continuous improvement can be applied in several aspects. One is in the training plan, which should be reviewed and improved after each training experience/exercise and used to maintain the knowledge level of the team always updated and possibly developed depending on future needs identified.

At the same time, with the tracking of anomalies and relative corrective actions, the team can expand the project knowledge. Moreover, gaining experience, the team can also identify corrections to the project knowledge itself or its processes, giving a huge contribution to the knowledge consolidation process. In this sense the knowledge consolidation is not only consolidation of the experience achieved, but also enrichment.

3.1.3 Documented Information

The only way to retain knowledge and not having to completely rely on individuals to access information, is keeping Documented Information. The information which should be documented are not only the knowledge itself, but all the processes required for the project execution, to ensure that also this crucial information is consistently controlled and managed. This approach ensures consistency and standardization in processes, provides evidence and facilitate communication and knowledge transfer.

As first step, the needed information for an organization or project should be identified and the related documentation should be properly created. Policies, procedures, manuals, reports are just some examples of the standard kind of documentation which can be used for the purpose. This Documented Information should be properly described, e.g via reference numbers, author, date, format [3], and should be regularly reviewed and updated.

Another important topic is the control of Documented Information, to ensure information is available, suitable for use and adequately protected [3]. This can be achieved via clear control of the versioning, how information is distributed, accessed, used and stored. Documentation in its latest version should be easily accessible to who needs it and available in a specific storage space, with the necessary backups.

Documentation management should be able to address all these aspects and respond to the specific requirements of an organization. A continuous effort should be in place to identify what needs to be converted in documented information and in which form. All the project documentation and the training plan itself should be created and maintained with regular reviews and tracked updates.

4. Training Plan and Documentation Management

A revisited training plan and documentation management process, developed via the quality approach, are presented here. In this specific context, the training plan and documentation management are detailed for a service providing L1 team (team members + Group leader) supporting space operations, but it can be easily generalized and applied in a different setup.

4.1 Training plan

This training plan is a self-sustaining process of knowledge development and consolidation, which builds and maintains the necessary expertise in all the team members, through all the project phases.

4.1.1 Initial Training

A crucial element of handling project knowledge is to efficiently transfer it to new team members. A successful knowledge transfer is ensured by the initial training and certification processes.

The goal of initial training is to give the trainee the necessary knowledge to perform routine and non-routine activities with confidence, following the procedures, and a good understanding of the system to properly initiate the troubleshooting process in case of anomalies.

The first introduction day is held by the Group Leader, then a mentor is assigned to monitor the training status. However, all the team members are involved in the training. This rotating trainer concept results in a continuous review of training topics for all team members and the possibility of repeating and see different perspective for the trainee.

Different training categories are used, to optimize the time available:

- SST: Self-study training
- OJT: On-job training
- DTS: Dedicated training session

The trainee is on site as much as possible, during office hours, to participate operations and get hands on experience of the system. When no activities are planned, the trainee follows the training schedule and proceed step by step to get knowledge of the subsystems and activities, with the help of the team member on shift and self-study sessions.

For activities that are critical or not common, a dedicated training session is scheduled, to properly train these.

The training schedule and content follows an approach which increase the level of details with time, going from a general description of the ground operations environment to the most specific task and activities of the project:

- General introduction to satellite communication: space and ground segment, kind of orbits, steps of contact with the satellite, RF basics, mission phases.
- Introduction to the specific work environment: department, teams, projects.
- Operational training: procedures, logging and reporting, control room environment, accounts.
- System and subsystems
- Tasks and activities

The reference documents used for the training are, when possible, project dedicated training documents, together with procedures and user manuals.

A Scorecard, with the training schedule and lists, ensure that all the topics are covered. It contains:

- Schedule and record of training activities.
- List of documentation to be read.
- List of procedures to be trained.
- List of activities to be trained.

The Scorecard is kept on console and updated by the trainee with the record of training activities and checked regularly by the mentor. The lists of documentation, procedures and all the activities to be trained are a reference for who's performing the training and give also an overview of the training status. Regularly, the Scorecard is sent to the group leader. With this regular update, the training pace and process is monitored and can be reported to stakeholders if needed.

When all the training content is covered, all documentation, procedures and activities from the lists are trained and the candidate is comfortable with all the topics, a certification takes place.

4.1.2 Certification process

The Certification is the final step of the initial training. It comprises a set of questions and activities to be performed by the candidate. The trainee is therefore motivated to pursuit a sufficient preparation and it can be verified that the required level of knowledge is reached. Before the foreseen certification a review session is held to understand the preparation level of the trainee and confirm the foreseen certification date. In this session it should be reviewed the Scorecard status, to find what are the missing topic and focalize the training on that. Moreover, some time should be used to clarify all the questions that are still unclear.

The certification is divided in a theoretical part with a questioning and a practical part where is required to perform or simulate common activities and troubleshooting.

Theoretical questioning topics follow the training content with some mandatory questions to demonstrate proper knowledge of the system.

The practical part consists in showing how to perform some activities following the related procedure, together with some questions about how to react in case of problems along the execution. The certification date should be picked in order to have some scheduled practical activity to be performed in real time, if possible.

4.1.3 Continuous Training

The continuous training process aims to consolidate and develop team knowledge, build new skills and strength team expertise.

To achieve that, it focuses on 2 aspects:

- **Training review:** all team members are involved in the initial training of a new team member. As trainers, all team members have the chance to explain the system and the activities to the trainee and therefore review themselves the training topics. This also results in a review of the procedures and training material, which can therefore be updated, if needed.
If no initial training activities take place during a year, a review of the procedures and training material is scheduled for all team members.
- **Training session:** dedicated training sessions are organized to strengthen team knowledge and technical background. Specific training goals are set during yearly reviews with each team member, based on the analysis of reoccurring issues and team weaknesses, project requirements and relevant personal interest.

3.2.4 Cross-training

The cross-training is a process providing to members of a team first a general understanding and then a complete preparation for activities delivered by another team. This kind of training can be triggered to prepare a team for new activities or merging with another team, but it has also the immediate benefit of creating redundancies within the involved teams; as well as improving the general understanding of the flight/ground operations environment.

4.2 Documentation Management

As highlighted in 3.1.3, documentation and information management are a fundamental step to maintain and improve project knowledge. Without this step, all the experience, lesson learned and processes improvements would remain in the team, while it should be consolidated in the project.

L1 teams in space operations, are usually required to handle:

- Procedures and manuals
- Training material
- Scripts and tools
- Point of contact lists

4.2.1 Documentation review

As described in the training plan, a review of the training material and procedures is planned at least yearly. This not only ensure a review of the training topic for the team, but it's also the main occasion to do the necessary updates. The Group Leader is usually the one in charge of collecting the inputs and officially release new versions of the reviewed documents.

Moreover, the Group Leader should do regular reviews of the documentation and work on necessary updates when new processes or tools are introduced, aiming to keep all documentation always up-to-date.

4.2.2 Lesson learned

Another important factor is the documentation improvement.

All relevant information is collected usually with dedicated team logs, anomaly reports, discrepancy reports, project specific logging and reporting systems, progress meeting, operational meeting and the regular exchange with client and the team.

Once issues, lack of training and non-conformities are found, the documentation needs to be updated, to implement necessary corrective actions and improve performance and effectiveness.

4.2.3 Storage and control

Not only reviews and updates are important, but also the correct storage and version control of project documents. A change log should be used in all the documents to keep track of version, authors and changes done. All procedures and relevant project documents should be stored following project requirements. In general documents should be stored in a unique place, accessible to who need it and with the latest version available.

5. Ground Operations teams' experience and results

The following case study, presented to assess quality approach effectiveness, details the experience of two L1 teams supporting ground operations for the Communication und Ground Station (KOB) department of GSOC: the Systems and the Multi-Mission Weilheim team.

The Systems team provides 24/7 support to GSOC Satellite Ground Operations, monitoring the overall status of the network and handling its configuration to properly allow offline and real time data transfer between GSOC, its Ground Station Network and other agencies/control centres. This team is composed by six operators and a ground system engineer, which acts also as Group Leader.

Multi-Mission Weilheim team is six/seven operators, with the Group Leader within the team. They support 24/7 ground station operations at the Weilheim ground station, monitoring the overall status of the ground system and operating the antennas.

These two teams experienced high turnovers of core team members, especially after the pandemic, causing a quick drop in the overall team know-how. Moreover, the teams were impacted by a restructuring process, as anticipated in 2.2, with the goal of merging the two teams in a single Ground Operation Centre (GOC) team by 2025.

Therefore, starting in 2022, in response to the team fluctuation and foreseen challenges, a single Group Leader has been appointed for both teams, to tackle the problems in knowledge management and prepare for the merging, using the quality approach.

5.1 Changes introduced

The main changes related to the introduction of the quality approach in the training plan are:

- Update and creation of dedicated training material, with same layered structure and common sections for the two teams. In this way, even if the teams are still separate, the starting point for a common training material is already in place.
- Review, update and creation of relevant procedures, to properly consolidate knowledge from experienced team member and previous troubleshooting.
- Promote participation of team members to DLR trainings about space and ground operations, to improve and develop skills and knowledge relevant to the DLR environment and to create visibility for the team members.
- High level cross training performed for all team members, getting a first introduction on the system used and activities performed by the other team.

Moreover, specifically regarding documentation management and knowledge consolidation, the following changes have been introduced:

- Use of Issue Logs to keep track of technical and management issues within the team, create awareness and properly address risks and opportunities.
- Change Logs introduced in all documents maintained by the team.
- At least yearly review of training material and procedures performed by all team members.

Finally, to improve team ownership and growth:

- Yearly reviews between team members and Group Leader, to exchange feedback, address issues and prepare dedicated training goal.
- Use a communication management plan to have a more structured communication within team, management and all stakeholders.
- Open communication with the team regarding project steps and changes, possibly asking feedback, to improve awareness and ownership within the project.

5.2 Results

One of the main results of the method is the reduction of training time. The consolidated new training plan has reduced the initial training time of 50% for the System team and 25% for Multi-Mission Weilheim. The two trainings have been also harmonized and synergized in several iterations, creating a first draft of the future GOC training.

Specifically, in preparation for the new GOC setup further cross training activities have been organized, with all team members going through the initial training of the other team. This was 30-50% faster than a complete initial training, thanks to:

- Working on almost same multi-mission projects and having daily exchange between the teams.
- General introduction already performed, which allows to start with already a basic understanding.
- Ground segment self-study and continuous training sessions.
- Technical background and experience of GSOC operations.

With this training process, 6 operators were successfully trained before start of 2025, five from Multi-Mission Weilheim to Systems team and two from Systems to Multi-Mission Weilheim.

From this experience, we collected inputs from the operators, teams and DLR, to fine-tune the cross-training process and the GOC training itself. This refined GOC training has already been used to do some further cross training and a full training for a new team member.

The achieved timeframe of the initial training was between 5 and 7 weeks for Systems team and between 8 and 10 weeks for Multi-Mission Weilheim, depending on the previous experience of the trainee and the pace of the training. Thanks to the combined training material and the cross training experience, the timeframe for the GOC training, which covers both projects' sets of activities, is an average of 12 weeks.

Both dedicated training material and procedures have been successfully kept updated and, combined with the use of Issue logs, we achieved a reduction of reoccurrences of anomalies related to mistakes or inexpertise.

In general, we observed an improvement in team morale and performance, with team members actively reporting needs for procedures updates, providing new solutions themselves and keeping consistently the log and reporting of activities and anomalies. The overall service quality increased, resulting in an increased customer satisfaction and better cooperation in the transition to the new GOC setup.

6. Conclusions

For service delivery in space operations, especially L1 teams, a strategic quality approach to knowledge management, has proven to be a successful response to challenges posed by team fluctuations, restructuring and operational optimization.

The integration of ISO9001:2015 principles of continuous improvement and documented information has brought for the Systems and Multi-Mission teams presented in the case study, an improved training efficiency in terms of time and effectiveness. The know-how has been consolidated within project documents, making it not strictly dependent on team members' expertise and reducing mistakes coming from not tracking previous issues. At the same time team members, thanks to the introduction of more structured processes, have increased their level of ownership, switching to a mindset of growth and cooperation with management.

In conclusion, embracing a quality-based knowledge management approach is the key to a consistent increase in service quality.

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References

- [1] Eurostat, Statistics Explained, "Job vacancy statistics", 2024
- [2] SPAICE conference, <https://spaice.esa.int/>, (accessed 12.03.2025)
- [3] Technical Committee ISO/TC 176 "Quality management and quality assurance", EN ISO 9001:2015, Quality management systems – Requirements
- [4] Technical Committee ISO/TC 176 "Quality management and quality assurance", ISO 9000:2015, Quality management systems — Fundamentals and vocabulary