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OVERALL ATM/CNS TARGET ARCHITECTURE

WP 8.1.1 – DEFINE METHODOLOGY FOR VALIDATION WITHIN OATA

Architecture Compliance Assessment Process

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Abstract

This document presents a methodology for the assessment of the functional compliance in the OATA Architecture to the user expectations and needs.

By identification of user expectations, validation aims, and examination of the corresponding operational thread the architecture is assessed together with the Stakeholders.

Keywords

Method — Functional compliance, Operational Thread, Validation Aim

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DOCUMENT APPROVAL

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DOCUMENT CONTROL

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DOCUMENT CHANGE RECORD

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EXECUTIVE SUMMARY

The “Architecture Compliance Assessment process” is a methodology that supports the validation of the functional compliance in OATA Architecture with the users’ needs and expectations. The validation process is centred on the Stakeholders, and it is also oriented towards the provision of an increased understanding of OATA, and on the early detection of potential sources of inconsistencies and problems. The users’ needs and expectations are expressed by a selected set of Stakeholders that participate in the validation process and the Validation Team. The Stakeholders’ needs and expectations will, and OATA.

The Stakeholders expectations and needs will be reviewed and compared with the goals, knowledge and information described in the OCD and re-defined as Validation Aims. These Validation Aims are the starting point to identify architecture operational execution paths called Operational Threads. An Operational Thread is an architecture path combining several modules in the OATA into an operational sequence.

The objective of the validation is to assess the ability of the OATA to provide an execution path that correctly implements the expectations and needs represented by the Validation Aims. The Operational Thread is used to show how OATA supports the User Needs expressed in the Validation Aims and Objectives.

The validation process may be able to challenge or question some of the operational concept description or OATA information. In that case, correctness will be achieved once the information is fed back into the concept description and OATA models. The validation team will propose recommendations how OATA could be improved.

1 INTRODUCTION

1.1 Document Background

The objective of this methodology is to present a methodology that permits the validation of the functional compliance in OATA Architecture with the user needs and expectations.

The assessment of the functional requirements with respect to the logical architecture is depicted as part of the OATA validation framework represented in Figure 1.

Figure 1 Summary of the Architecture Validation Process

Figure 1 shows the framework that will guide the validation process. The figure shows the four areas included in the OATA validation model. It should be noted that even though a possible timeline is indicated, it is possible to perform them in any order. The order starts from the Operational knowledge included in the Architecture, and progresses towards the compliance with the implementation assumptions. This process is iterative; in the sense that the validation process should be repeated each time a new release of the architecture is delivered.

Figure 1 also presents a summary of the overall validation guidelines with a description of the structure of the first stage: Architecture Compliance with User Needs. Arrows indicate “impact” from one element to another. This impact could represent either information to be used as input, or that a specific item’s integrity and homogeneity takes precedence over another.

This document presents the framework that corresponds to the first stage “Architecture Compliance with User Requirements”.

1.2 Document structure

This document has the following main chapters:

- **Introduction.**

  The introduction contains description of the background of this document, definitions and terms and a list of references.

- **Methodology Overview.**

  The methodology overview contains a high level description of the validation process.

- **Processes.**

  The processes chapter details each part of the validation process and describes the activities that must be undertaken during a validation cycle.

There are also several appendices included in this document that give more detailed descriptions:

- Viability of Architecture executable models
- Example of Validation Aims
- Guidelines for brainstorming
- Example of hoe to apply the guidelines
- Operational Thread presentation

1.3 Reading guidelines

The processes in this methodology are visualised as process diagrams using standard UML Business Modelling syntax, [Eriksson, Penker 00].

The process diagram contains information about:

- **Processes and Activities.**

  A process is a set of related activities and they are drawn in the centre/middle of the process diagrams with solid arrows linking processes/activities that follow one another.

- **Resources.**

  Resources are the objects within the business, such as people, material, information, and products, which are used or produced in the business. Resources are manipulated (used, consumed, refined, or produced) through processes.

  Controlling resources control or run a process. These resources are drawn above a process with a dashed line from the resource to the process.

  Supporting resources participate in a process and are not refined or consumed. These resources are drawn below a process with a dashed line from the resource to the process.

  Input information resources are placed to the left of the process and connected to the process with a dashed line.

  Output information resources are placed to the right of the process and connected to the process with a dashed line.

- **Activity synchronization.**

  Activities can be performed in parallel. A need for synchronization is shown in the process diagram by using a vertical synchronization bar. The activities after the

synchronization bar must wait for all the activities before the bar to complete before they can start.

A detailed process diagram contains activities and their relationships.

1.4 Definitions and terms

This section presents some of the basic terms that are needed to understand this document. More acronyms can be found on the web.

http://www.eurocontrol.int/oca/public/site_preferences/display_glossary_list.html

Architecture

Architecture encompasses a *set of strategic design decisions that affect most or all of the system behaviour and performance*.

A good architecture is at least approximately optimal in terms of various often-conflicting quality characteristics of the system. A good design strikes the right balance between opposing design concerns. In fact, a good architecture design optimises the importance-weighted sum of all the desired or required quality aspects of the system. If each quality aspect is presented as an independent feature with its relative importance as a weighting factor w_i, then a good architecture design finds an optimal sum among all these independent aspects:

$$FOM = optimise\left(\sum_i Q_i \times w_i\right)$$

where FOM is the *figure of merit* metric that assesses the *architecture goodness*[1].

OATA Logical View

The reader is referred to the OATA Modelling Guide (ref [OATA Modelling Guide]) for further information on these items.

Functional and Non-Functional Requirements

Two different kinds of requirements are typically considered to drive the development of a system or system element: *functional requirements* (FR) and *non-functional requirements* (NFR) or *quality of service* (QoS) requirements ref [Douglass 02].

Functional requirements refer to *what* the system is intended to do while QoS requirements refer to *how well* the functional aspects are to be achieved. Functional requirements are then related to behaviour and QoS to system qualities.

This methodology will deal with the validation of Functional Requirements, FR.

Validation Aim

A sentence, that describes Stakeholders' expectations and needs, which shall be reflected in OATA.

Appendix B presents some Validation Aims examples.

Validation Objective

A statement of what the project team will work towards to achieve the aim. A formulation of the validation aims in measurable factors.

Validation Team

[1] This topic will be discussed in [OATA WP 8.1-02] and [OATA WP 8.1-03].

A set of roles required for the conduct of the validation methodology. Each role may be assigned to one or several resources.

Validation Team Member

A resource which has been assigned to one or more specific roles.

Operational thread

An Operational Thread is an architecture path combining several modules of the architecture into an operational sequence. The Operational Thread is used to validate that a stakeholders' expectation and need (i.d. Validation Aim) is met.

The Operational Threads can be represented using the notation proposed in ref [McMillen 04]. Appendix E includes a summary of the Operational Thread notation. An example of an Operational Thread is presented in Appendix D.

Role

A required resource with a specific responsibility and knowledge suitable for the validation. A role may be assigned to one or several resources (Validation Team Members).

1.5 Bibliography

OCD VOL1 Vision	Eurocontrol, Operational Concept Document (OCD). Volume 1 (The Vision), FCO.ETI.ST07.DE201
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OATA WP 8.1.2	Eurocontrol, H. Wagemans OATA-P2-D8.1.2-01, WP 8.1 "Define Methodology for Validation within OATA - Architecture Structure Assessment Process"
OATA WP 8.1.3	Eurocontrol, H. Wagemans OATA-P2-D8.1.3-01, WP 8.1 "Define Methodology for Validation within OATA - Architecture Non-Functional Assessment Process"
OATA WP 8.1.4	Eurocontrol, H. Wagemans

	OATA-P2-D8.1.4-01, WP 8.1 “Define Methodology for Validation within OATA - Architecture Tactics Assessment Process”

2 METHODOLOGY OVERVIEW

This document describes the validation methodology concerning the validation aspect "Architecture Compliance with User Needs". The proposed approach for the validation relies on the following assumption:

> *A system or system element is valid if it correctly provides the complete functionality required with good enough quality attributes. Thus, validation keywords are correct, complete and good.*

A system or system element will be considered to be correct if it is successful in implementing the functionality described by the requirement (behaviour). To perform the validation must correctness must be defined for each functional requirement such that there is an assessment of the correctness assertion.

A system or system element will be considered to be complete if it does not include incomplete or deficient architecture modules (either functional and/or non functional) and does not exceed what is required.

Figure 2 OATA Validation Framework presents the different elements that will be considered within the OATA validation framework. This figure relates these elements, and stresses the difference between validation and verification.

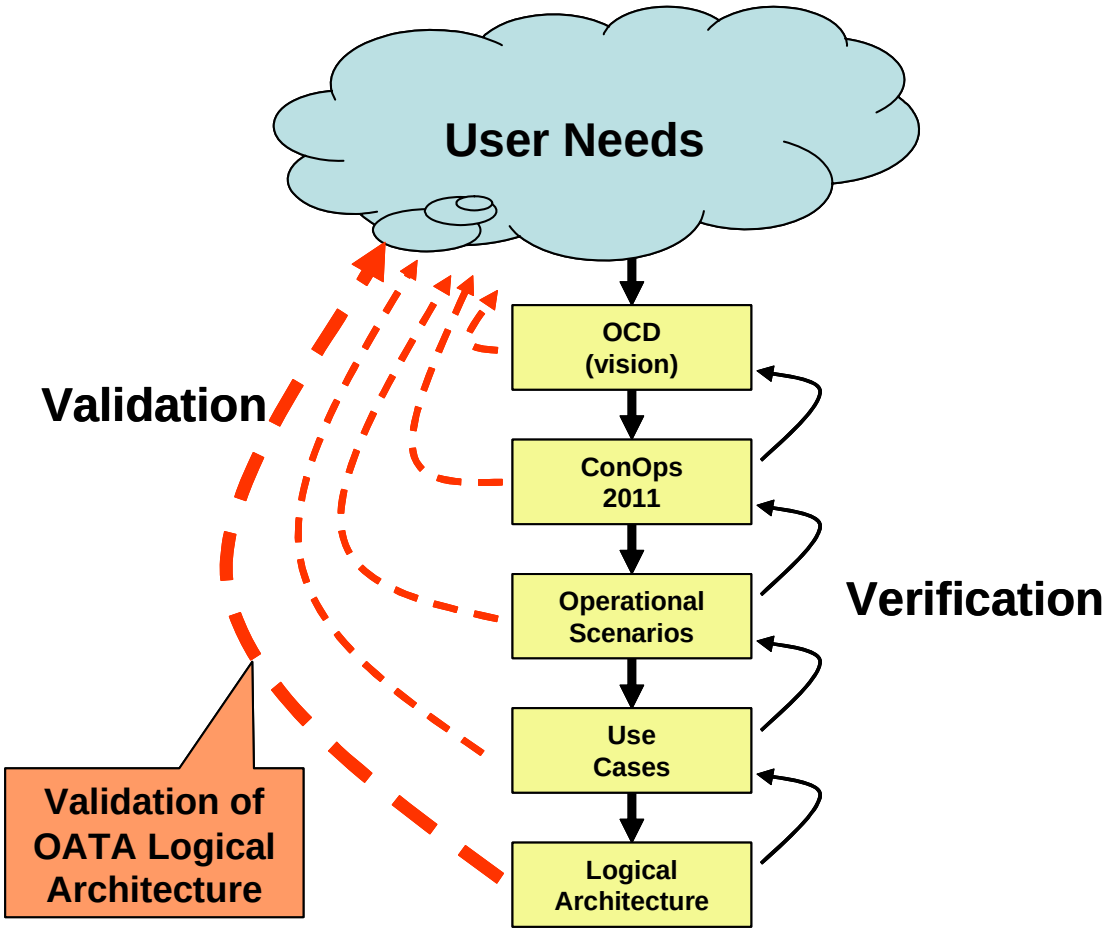


Figure 2 OATA Validation Framework

The aim of the validation of the compliance with User Requirements is to perform a comparison between User Expectations within the scope of the goals, knowledge and information contained in the OCD, and the OATA logical architecture. The architecture will be evaluated against the Validation Participant's understanding of the OCD and their observations will be used to challenge or question the OATA architecture OCD implementation. The methodology is centred on the Stakeholder, and is oriented towards the provision of an increased understanding of the system, and on the early detection of potential sources of inconsistencies and problems. The methodology is briefly summarised hereafter.

OCD User Needs are the origin of the OCD Vision and the OATA architecture is derived in a number of intermediate steps from the OCD Vision. To validate the correctness and completeness of the OATA logical architecture and to ensure that no translation errors are made in the intermediate steps, it is needed to validate that User Needs are adequately represented in the architecture. This process can be lengthy and effort consuming. Therefore, validation effort must be optimised and focused on the essential User Needs / Expectations.

The Stakeholder will define Validation Aims, which are based on their User Needs, and are prioritised. The Validation Aim will be the starting point to identify architecture execution paths that use several modules of the architecture. These paths are called Operational Threads and are used to validate that a User Need is met.

Operational Threads are thus derived from the User Needs / Expectations, and are used to validate a subset of the User Needs. Only the User Needs also identified in the OCD are the subject of validation within OATA. The subset will be selected by the users based on their expert opinion on what is most beneficial / important in 2011.

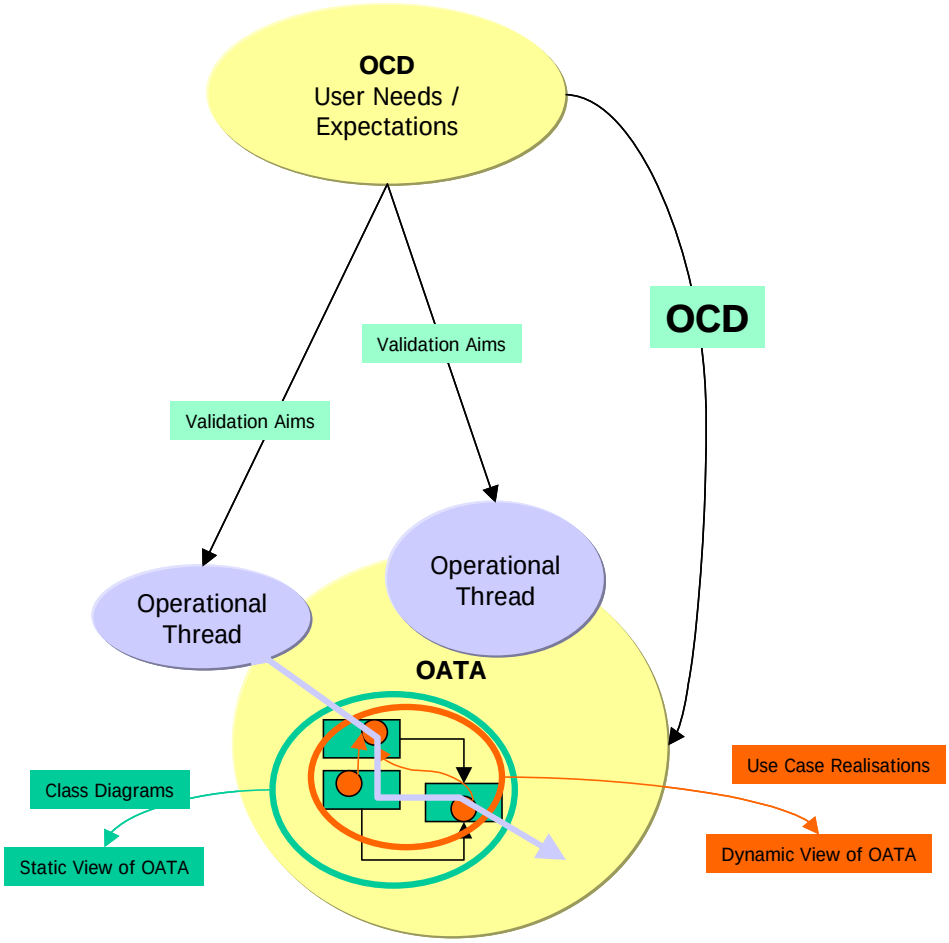


Figure 3 Validation Aims and Operational Threads in the OATA Validation Context

3 PROCESSES

3.1 Introduction

The methodology consists of three separate processes that have to be executed in a sequence since each process produces information that the following process requires.

The first process, “Preparation”, is responsible for the planning of the validation cycle and that the Validation Team is well prepared and each team member is given assigned responsibilities. The purpose of the current validation and OATA architecture version that shall be validated must also be identified. The results and other information about the validation cycle shall be documented and stored in a repository. Therefore a repository must be identified or created in the beginning of the validation cycle.

The second process, “Execution”, handles the actual assessment of the Operational Threads. The results of these assessments must be well documented and stored in the repository for later analysis.

And finally, the last process, “Analysis and Reporting”, validates the compliance of the OATA logical architecture to fulfil the Stakeholders’ expectations and needs. The validation result shall be published in one or several Validation Reports that can be distributed to the Stakeholders and the results can be used to refine the OATA architecture.

An overview of the processes and their activities are shown in Figure 4

The required information for each process is described in the process diagrams, and these diagrams also include which information that is refined or created by the processes. An overview of the information flow is shown in Figure 5.

The processes are controlled and supported by roles, information and physical resources. An overview of these resources is shown in Figure 6.

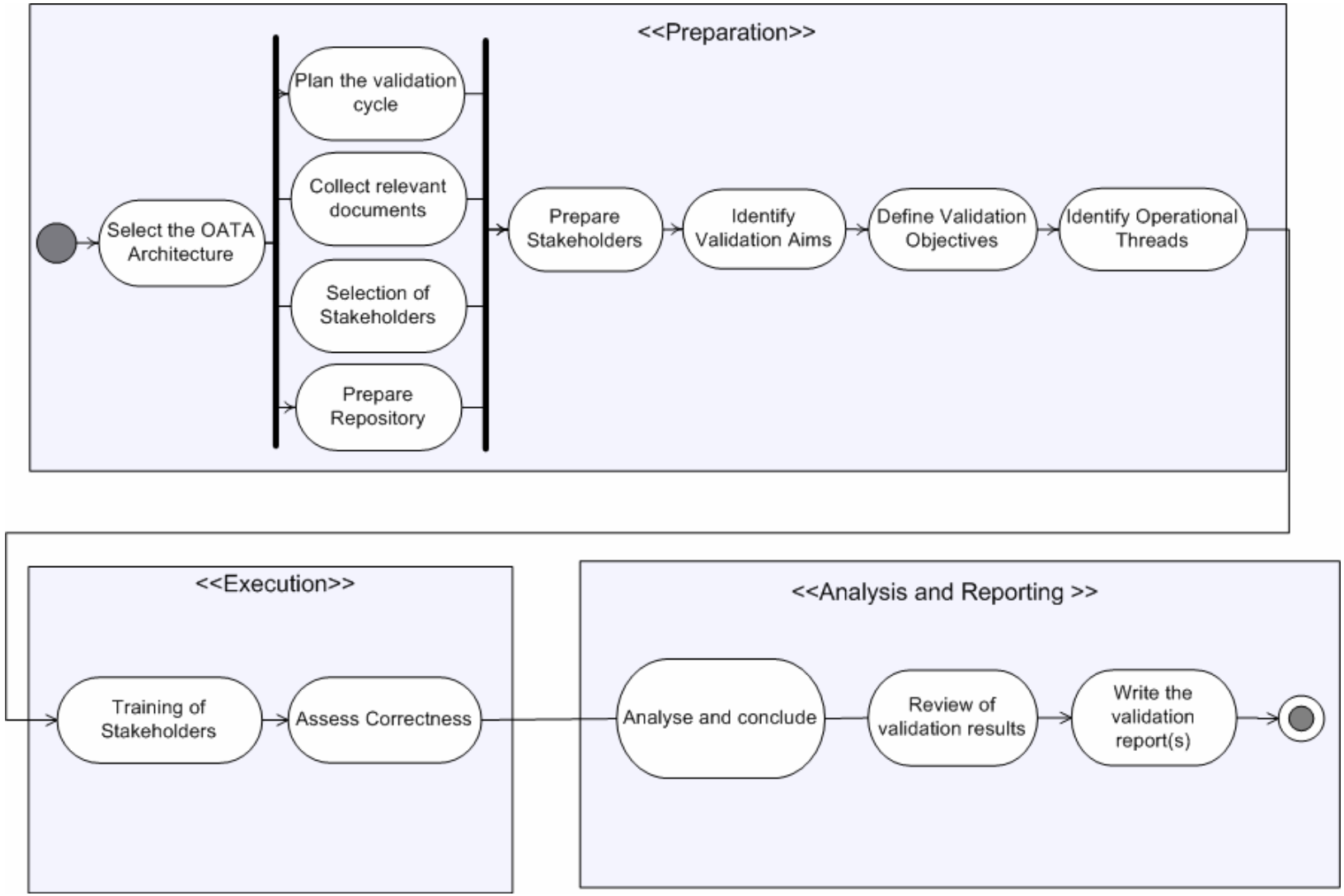


Figure 4: Process Overview

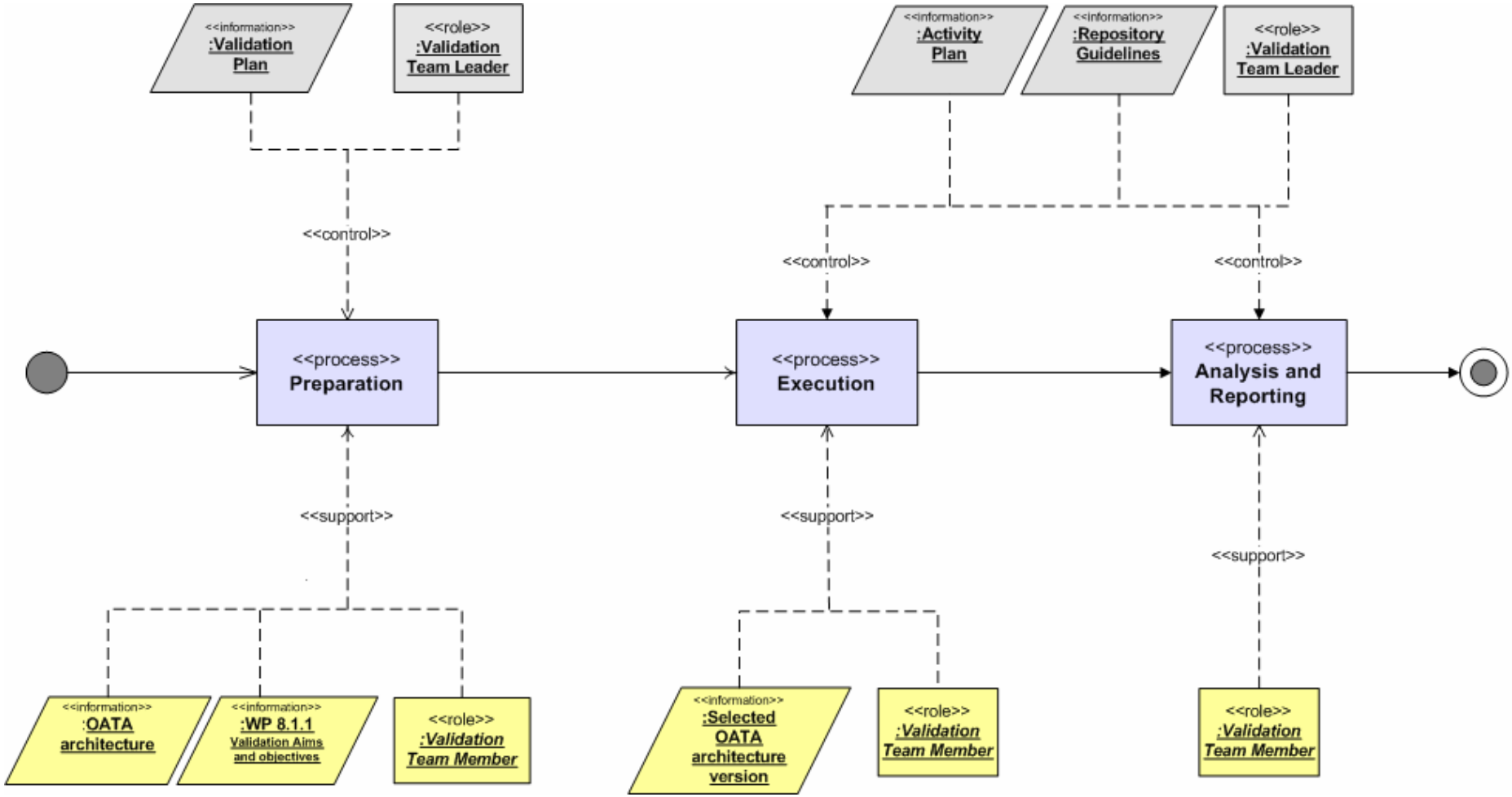


Figure 5: Resource Overview

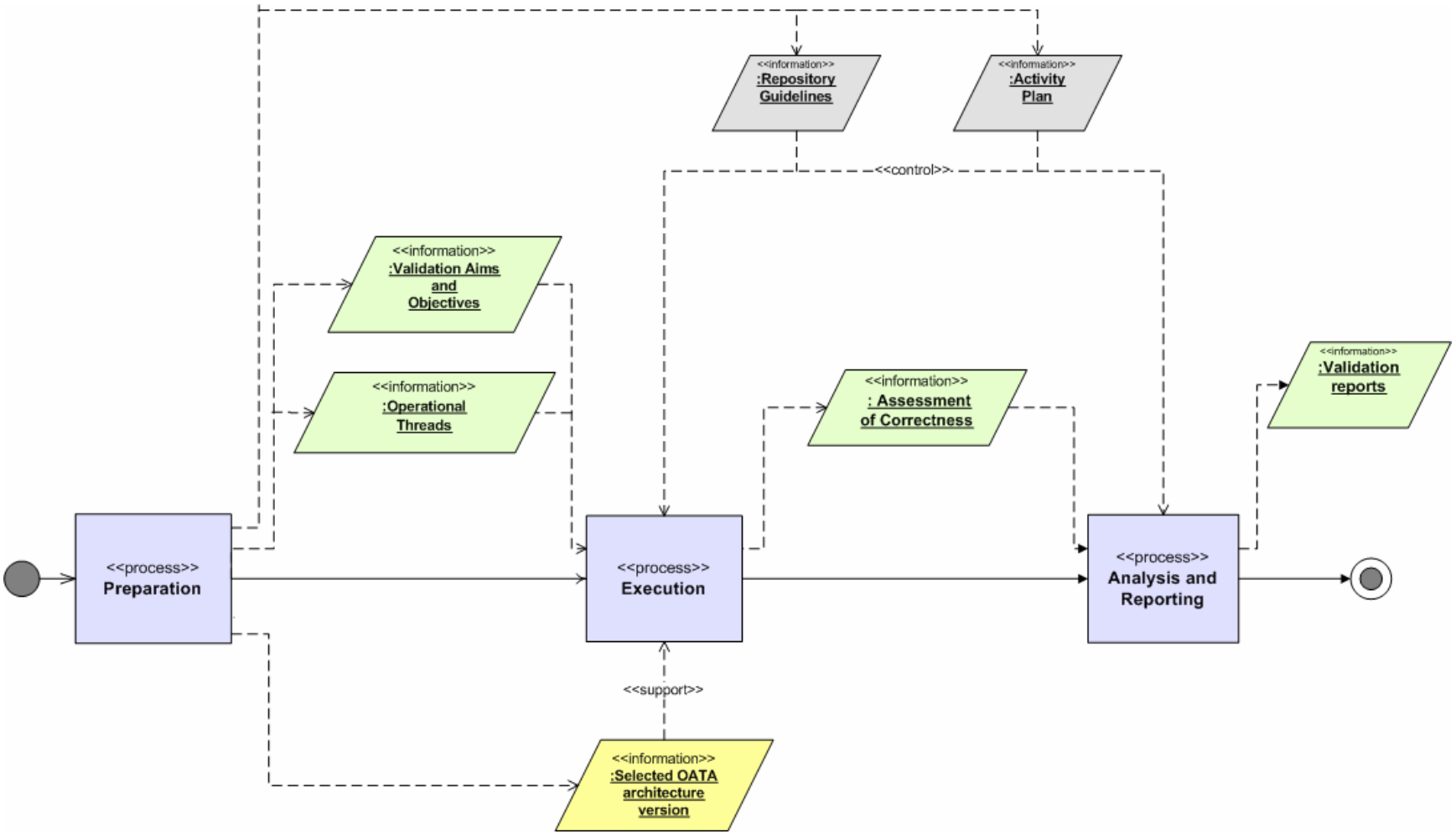


Figure 6: Information Flow Overview

3.1.1 Required roles

The table shows the different roles and their responsibility and requirements for the validation methodology. The described roles represent the Validation Team. Each role may be assigned to one or several resources and are referred to as the Validation Team Members.

Validation Team		
Role	**Responsibilities**	**Requirements**
Validation Team Leader	Is responsible for the control of the validation process and team management. Is responsible of the information flow. Is responsible for the Activity Plan. Is responsible for the validation reports.	Good knowledge of the OATA project and organisation. Good knowledge of the validation methodology described in this document.
Validation Expert	Is responsible for the Validation Aims and objectives. Is responsible for the performance of workshops.	Expert knowledge about validation and the OATA Validation Methodologies.
OATA Architecture Expert	Is responsible for the OATA architecture. Is responsible for the Operational Threads.	Expert knowledge about the OATA architecture. Full access to the OATA architecture. Mandate to select version to validate.
Stakeholder	Is involved in the identification of Validation Aims. Is involved in the validation of the correctness of Operational Threads. Represent the Stakeholders interests.	Expert knowledge about user needs and expectations.
Documentation Expert	Is responsible for the documentation of the workshops.	Expert knowledge about documentation and knowledge about the methodology and the repository.
Repository Expert	Is responsible for the Repository and the Repository guidelines	Expert knowledge about the OATA Repository

3.2 Preparation

3.2.1 Introduction

The purpose of the first process is to identify and prepare all the information that will be needed to perform the validation. It must be noted that even though all the information is already available, it must be adequately prepared.
The activities included in this step comprise the collection of relevant documentation, the selection of the Stakeholders that will participate in the validation, their training and the identification, description, and selection of the Stakeholder validation aims. The following sections describe in detail each one of these activities.

The Preparation process consists of the following activities:

- Select the OATA Architecture.

  Select a specific OATA architecture version and the subset to validate.

- Plan the validation cycle.

  Create an activity plan, assign responsibilities and prepare the team members.

- Collect relevant documents

  Collect and distribute all necessary documentation for the assessment.

- Selection of Stakeholders

  Identify and select necessary Stakeholders with the expertise knowledge needed for the selected subset of the OATA Architecture.

- Prepare the repository

  A suitable repository to store the validation results shall be created (or identified) and prepared.

- Prepare Stakeholders

  Train and prepare the Stakeholders for the workshop regarding the activity “Identify Validation Aims”.

- Identify Validation Aims

  Identify Validation Aims (user expectations) from the Stakeholders on workshops.

- Define Validation Objectives.

  Define practical Validation Objectives based on the Validation Aims that facilitates the identification of Operational Threads and the analysis.

- Identify Operational Threads

  Identify Operational Thread for each Validation Aim or Objective.

The ordering of the activities, the information flow and the required resources are shown in Figure “Preparation”.

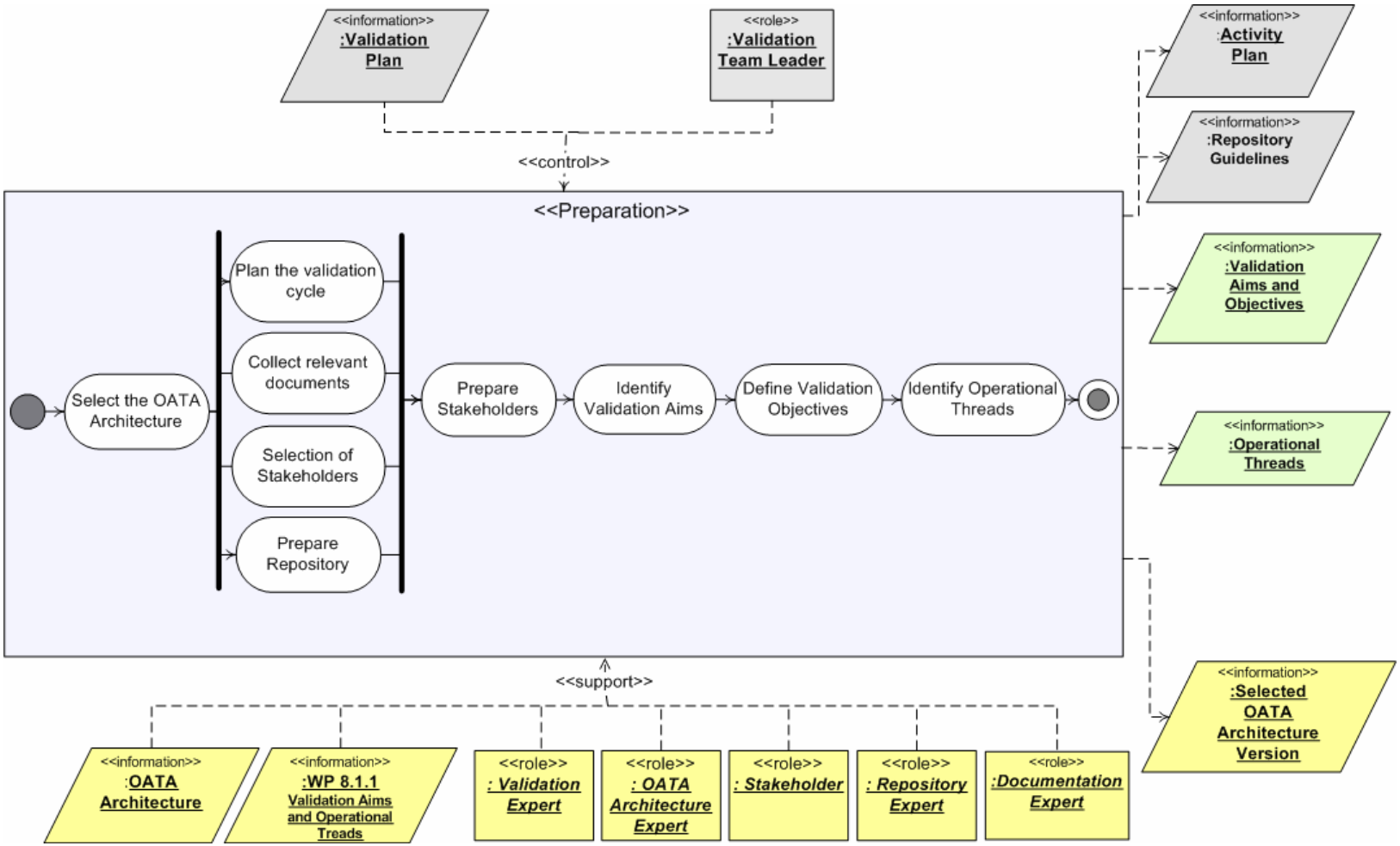


Figure 7: Preparation

3.2.2 Required resources

The table shows the planned resources for the activities in “Preparation”.

The main responsible role for each activity is highlighted in the table.

Activities	Roles						
	Validation Team Leader	Validation Expert	OATA Architecture Expert	Stakeholders	Repository Expert	OCD Expert	Documentation Expert
Select the OATA Architecture			**X**				
Plan the validation cycle.	**X**	X					
Collect relevant documentation		X	**X**				
Selection of Stakeholders	**X**	X	X				
Prepare the repository		X			**X**		
Prepare the Stakeholders		**X**	X	X		X	
Identify Validation Aims		**X**	X	X		X	X
Define Validation Objectives		**X**	X				X
Identify Operational Threads.		**X**	X				X

3.2.3 Activity: Select the OATA Architecture

3.2.3.1 Objective

The objective of this activity is to select the OATA architecture version and subset for the current validation cycle.

3.2.3.2 Rationale and Context

The development of the OATA architecture is an iterative work process with regular version releases. To ensure that the OATA architecture is not changed during the validation cycle, one specific release version must be selected. This is also necessary for maintaining the traceability to the validated version for future analysis and comparisons. A subset of the OATA Architecture can also be selected when a validation will not be performed of the whole model.

3.2.3.3 Description

The OATA Architecture Expert shall select and document the OATA architecture version that shall be validated. The selected version must be clearly identified and accessible for the Validation Team. When the OATA architecture shall be validated partly, the OATA Architecture Expert shall select and document a relevant subset of the OATA architecture. The OATA Architecture Expert shall also document the reason why certain parts have been selected for the current validation cycle.

3.2.3.4 Examples and recommendations

The selected architecture version will refer to a specific OATA baseline, for example: OATA Architecture iteration 7.

The subset can be either all clusters or a set of clusters in the OATA Architecture.

3.2.3.5 Product

The result of this activity is a selected version of the OATA architecture for the current validation cycle and the subset to validate.

3.2.3.6 Resources

The required resources for this activity are shown in the table below.

Role	Responsible	Executor	Input Information	Output Information
OATA Architecture Expert	**X**	X	OATA architecture.	Selected OATA architecture version.
				The selected OATA architecture subset

3.2.4 Activity: Plan the validation cycle

3.2.4.1 Objective

The objectives of this activity are to ensure that required resources are available and properly trained for the assignment and that all necessary documentation is available to all team members.

3.2.4.2 Rationale and Context

To have effective use of the validation team members, the Validation Team Leader should prepare a relatively detailed activity plan.

Before the validation process can be initiated it is important that the Validation Team Leader ensures that the validation team members are available and well prepared for the validation.

It is important that all validation participants, including the Stakeholders, have a good understanding of the OCD and OATA processes in order to carry out a useful and professional validation. However, since only a reduced set of information will be required and to avoid making preparations unnecessarily lengthy and cumbersome, it is essential that only relevant documentation is collected and compiled.

3.2.4.3 Description

The Validation Team Leader shall perform the following tasks:

1. Plan the activities in the current validation process.
   The planning shall contain fairly detailed resource planning and schedule for the validation cycle. Important milestones shall be identified and the workshops shall be fairly detailed planned.
2. Introduce the validation methodology to the team members.
   Each validation team member shall understand the processes and their activities.

3. Assign responsibilities to each validation team member.

3.2.4.4 Examples and recommendations

An estimation of the number of Operational Threads should be done and planned for. It may be necessary to update the Activity Plan when the exact amount of Operational Threads is known.

One major important planning issue are the detailed planning of the workshops, especially those including stakeholders. The stakeholders must be noticed well in time and also receive proper documentation. They should also be properly trained and prepared for the workshop that they shall participate in.

3.2.4.5 Product

The expected result of this activity is:

- Well prepared validation team members with assigned responsibilities.
- An activity plan for the current validation cycle.

3.2.4.6 Resources

The required resources for this activity are shown in the table below.

Role	Responsible	Executor	Input Information	Output Information
Validation Team Leader	**X**	X	Validation Plan	Activity Plan
Validation Expert		X		

3.2.5 Activity: Collection of Relevant Documents

3.2.5.1 Objective

Collect and structure the OATA information to facilitate its usage during the validation process.

3.2.5.2 Rationale and Context

It is important that all validation participants, including the Stakeholders, have a good understanding of the OCD and OATA processes in order to carry out a useful and professional validation.

However, since only a reduced set of information will be required and to avoid making preparations unnecessarily lengthy and cumbersome, it is essential that only relevant documentation is collected and compiled.

3.2.5.3 Description

This activity results in a set of documents that will be the basis for the validation cycle.

The **first task** is performed by the Validation Expert which prepares an initial list with the documents that are estimated to be necessary for the performance of the validation.

The OATA Architecture Expert, which reviews the document list, performs **the second task** and after adding his/her suggestions will deliver the documents in electronic format to the Validation Expert. The Validation Expert will then either prepare a CD for the distribution of documentation, or upload them into an appropriate website.

The **third task** is the preparation of a five-page summary of the OATA validation process using the collected information. Aside from a brief description of OATA and the identification of the validation objectives, the summary should include a definition of Validation Aims and Operational Threads, some examples, and an outline of the mechanisms and rules that will be applicable during the validation. Additionally the document should include the list of documentation available to the users. Some of the documents that will be included in the information set are e.g.:

- OATA UML Model
- OCD Volume 1.
- OCD Volume 2 (ConOps) E.g. ConOps for 2011

3.2.5.4 Examples and recommendations

The collected documents should be based only on approved versions.

3.2.5.5 Product

The product of this activity will be a set of documents which will form the basis for the validation process. This set of documents includes an OATA Validation Summary.

3.2.5.6 Resources

The required resources for this activity are shown in the table below.

Role	Responsible	Executor	Input Information	Output Information
Validation Expert	**X**	X		A set of relevant documentation
OATA Architecture Expert		X		A summary of the documentation

3.2.6 Activity: Selection of Stakeholders

3.2.6.1 Objective

The objective of this activity is to identify, select and invite Stakeholders.

3.2.6.2 Rationale and Context

The quality and confidence of the validation result relies on the selection, interest and engagement of the participating Stakeholders. It is therefore essential that the selection process is carried out thoughtfully and carefully to ensure that the participants not only cover all users, but that they also are seriously involved in the validation process.

3.2.6.3 Description

The **first task** is to identify and select Stakeholder that shall be invited to participate in the validation: The selection process should include the following Stakeholder types:

- Operational Concept Experts (from the OCD development team).
- Aircraft Operator.
- Ground Service Providers (e.g. Airspace Managers, Airspace Designers, Flow Managers).
- Controllers.
- Pilots.
- Airport Operators.
- OATA Architecture Experts.
- Validation Experts.

The **second task** is to contact and invite the selected stakeholders. The stakeholders should be contacted by e-mail attached with the OATA summary. The Validation Expert should call each one of the selected stakeholders and confirm their assistance. The stakeholders will also have an opportunity to ask questions and receive answers from the Validation Expert. As a result of this task, the Validation Expert will produce a list of Validation Participants. The invitations have to be correlated with the schedule from the activity “Planning the validation cycle”.

As a result of the selection process, the Validation Team will also be identified. This Validation Team will include the following roles:

- Operational Concept Experts (from the OCD development team).
- OATA Architecture experts.
- Validation Experts.

3.2.6.4 Examples and recommendations

The selection of Stakeholders should be done in close relation and coordination with the activity “Planning the validation cycle”.

It is recommended to avoid candidates that have a high-level management position (e.g. Transport Ministers should not be selected).

3.2.6.5 Product

The product from this activity is a list of Stakeholders that are invited to participate in the validation.

3.2.6.6 Resources

The required resources for this activity are shown in the table below.

Role	Responsible	Executor	Input Information	Output Information
Validation Team Leader	**X**	X	OATA Architecture subset	A set of relevant documentation
Validation Expert		X		A summary of the documentation
OATA Architecture Expert		X		

3.2.7 Activity: Prepare the repository

3.2.7.1 Objective

The objective of this activity is to prepare a suitable repository for information storage. All information gathered during the validation shall be stored in the repository.

3.2.7.2 Rationale and Context

A repository shall be selected or created to be used for documenting of the validation cycle. Guidelines for its usages should also be prepared and made available for the validation team members.

3.2.7.3 Description

The validation repository can be either a set of Word or Excel templates or it can be a database. It is important that the repository is coordinated with the other validation methodologies in order to be able to establish common search criteria.

The **first task** is to identify existing repositories from other validation cycles (e.g. Pilot Validation). If none exists the repository has to be created. Identify suitable type of repository and collect type of information that shall be stored in the repository by examining the results from the validation.

The **second task** is to create (or identify) repository guidelines to show how it shall be used.

3.2.7.4 Examples and Recommendations

A repository should be a well-structured place to store the documentation of identified architectural tactics and other important information produced during a validation cycle. It can be for example an Excel-sheet, database or a folder in a file system (or a combination).

Following criteria should be considered:

- The results must be easy to identify.
- Common information like Validation Aim shall be stored in the same way as Validation Aims from other validation aspects, e.g. functional and non-functional Validation Aims.
- The documentation of identified architectural tactics should be stored in the repository in order to facilitate analysis.

If a repository is already available (for example from previous validation iterations) for storing validation data, then this should be used. It is essential that the validation data is fully identifiable and traceable.

The possibility to search information about validation results and different validation aspects (like Validation Aims, Conclusions, Recommendations from Functional, Non Functional and Tactics) is more important than how effective the validation repository is to use during a validation cycle.

3.2.7.5 Product

The expected result from this activity is:

- A prepared repository for storage of the validation data results
- Repository guidelines

3.2.7.6 Resources

The required resources for this activity are shown in the table below.

The highlighted markings are the role responsible for the activity.

Role	Responsible	Executor	Input Information	Output Information
Repository Expert	**X**	X		Repository guidelines
Validation Expert		X		Repository

3.2.8 Activity: Prepare Stakeholders

3.2.8.1 Objective

The objective is to prepare the Stakeholders for the workshop “Identify Validation Aims”.

3.2.8.2 Rationale and Context

The Stakeholders must be given a fair chance to carry out the tasks in a good and useful way, thus thorough preparation training is required.

3.2.8.3 Description

The **first task** in the activity “Stakeholder Training” is the preparation and planning of a stakeholder training course. To ensure that an adequate and useful training is provided the Validation Expert will prepare a training plan. The validation participants will have a working knowledge of the OCD and OATA, as well as being experts in the ATM field, before taking part in a preparatory training course.

The Validation Expert shall prepare and plan a training package, based on the collected and prepared documentation from the activity “Collection of Relevant Documents”. Information material to achieve a basic understanding of the OCD and OATA processes shall be compiled and distributed to the Stakeholders, who will be expected to study it before attending the course. Stakeholder training course be focused on the specific OATA validation process. The Validation Expert shall also prepare a presentation, which covers the following issues:

- OATA Logical Architecture.

  - Main constructs and their use.
  - Possible uses of the Architecture.
- OCD ConOps e.g. for 2011.
  - Main areas.
  - Brief description of key concepts and enablers behind the ConOps.
- OATA Validation.
  - Description of each activity.
  - Guidelines and Rules applicable to the validation process.
- Questions and Answers.

The **second task** is to perform the stakeholder training using the training package and the presentation material which have been prepared.

3.2.8.4 Examples and Recommendations

Only the issues included in the proposed curricula should be included. Avoid addressing additional issues.

Limit the training to a recommended maximum of 1 day.

3.2.8.5 Product

The products from this activity is a Training Plan with Training Material including a set of documentation from activity “Collection of Relevant Documents” and trained Stakeholders ready to participate on a workshop regarding Identify Validation Aims.

3.2.8.6 Resources

The required resources for this activity are shown in the table below.

The highlighted markings are the role responsible for the activity.

Role	Responsible	Executor	Input Information	Output Information
Validation Expert	**X**	X	Collected documents	Training material
OATA Architecture Expert		X	OATA Architecture subset	Prepared Stakeholders
OCD Expert		X		
Stakeholders		X		

3.2.9 Activity: Identify Validation Aims

3.2.9.1 Objective

The objective is to identify the Stakeholder Validation Aims, which describe what the participating Stakeholders expect to see reflected in OATA.

3.2.9.2 Rationale and Context

It is important that the selection of validation aims adequately reflect Users' needs and expectations in order to ensure high quality and confidence of the validation results.

Since the possible validation aims may include many aims, it will be necessary to review and identify a prioritised subset to be addressed further in the validation process, taking account of available resources. The Validation Aims must also be in scope of the selection criteria.

3.2.9.3 Description

The Validations Aims will be identified, described and selected during this activity by the Validation Team. This section presents a set of practical guidelines and their objective is to facilitate the identification and selection of the most representative Validation Aims. Finally, remember that even though structure is necessary, people will need some time to think, sometimes thinking outside the topic (only a little) and be creative.

A brainstorming session that will be structured around the following tasks will contribute the identification of validation aims:

- Identification of Validation Aims.
- Clustering of Validation Aims. (grouping of validation aims that are related to each other)
- Elaboration of (a common) understanding of each Validation Aim. Each validation aim shall have a short associated description.
- Establishing criteria for selection.
- Performing the selection of the Validation Aims.

The reader is referred to "APPENDIX C – Guidelines for Brainstorming" to obtain a set of guidelines that should be applied to the validation aim identification brainstorms.

The **first task** is to perform a brainstorm session to identify and collect validation aims from the stakeholders. The brainstorming session performed by the Validation Team is recommended to follow these five steps:

1. Present key questions to focus on.

   The key questions should represent an operational area to focus on that is easy for the stakeholders to understand. These areas shall be selected and tailored to the participating stakeholder's expertise knowledge and in line with the selected of OATA Architecture.

2. Have each stakeholder write as many ideas (expectations and needs) as possible.

   The phrasing of the validation aims shall be described with examples and is also part of the activity "Stakeholder Training". The stakeholders should write the ideas post-it notes and tag the note with their identity. This will be useful for the traceability of the origin of the expectation. Each idea will be presented and rephrased, when necessary, into a validation aim. This can be done by putting all post-it notes on the wall one-by-one.

The **second task** is to cluster the identified validation aims. Putting all post-it notes on the wall and group them together until all belong to a group can do this. Each cluster of validation aims shall be given a unique and descriptive name. The clustering of validation aims makes it possible to "remove" redundant validation aims. The clusters make the coverage of the Stakeholders' expectations and needs visible.

The **third task** is to establish the criteria for the prioritising and selection of validation aims. When the set of validation aims is established, the Validation Team will have to decide and agree which Validation Aims will be used to validate the OATA logical architecture. This should be done following these criteria:

1. Interest to the Stakeholder.
2. Representativiness[2] of the Validation Aim.
3. In scope of the concept operations.
4. In scope of the selected OATA Architecture
5. Prioritisation of the Validation Aims by each Stakeholder.

Each Validation Aim should then be reviewed according to the selection criteria and decided whether to continue validating the aim or put it aside in a separate list for the future.

The **fourth task** is to vote for a set of validation aims that shall be validated in the current validation cycle. The number of votes per Stakeholder type shall be associated with the planned number of operational threads for the validation cycle (Activity Plan). It is here assumed that each validation aim will have one corresponding operational thread.

The proposal in the table below is to assign a number of votes per Stakeholder type. This will ensure that a specific Stakeholder type is not over-represented.

Stakeholder type	Number of votes
Aircraft Operator.	10
Ground Service Providers.	10
Controllers.	10
Pilots.	10
Flow Managers.	10
Airport Operators.	10
OATA Architecture experts.	5
Domain Expert	5
Validation Experts.	1

Each Stakeholder type will decide how to place their vote during the voting procedure.

3.2.9.4 Examples and Recommendations

Only those Validation Aims supported by the selected release of the Architecture should be addressed. Those Validation Aims that are not supported by the selected release of the architecture should be stored for future use.

3.2.9.5 Product

The output from this activity is a list of prioritised Validation Aims and short associated descriptions to get a common understanding of what each aim implies.

The selected validation aims should be the ones that reflect best the needs and expectations of the Stakeholders, and should have been agreed / accepted by all the validation participants.

3.2.9.6 Resources

The required resources for this activity are shown in the table below.

[2] How well it fits needs common to most Stakeholder types.

The highlighted marking shows the role main responsible for the activity.

Role	Responsible	Executor	Input Information	Output Information
Validation Expert	**X**	X		List of Validation Aims with associated short description
OATA Architecture Expert		X		
OCD Expert		X		
Stakeholders		X		
Documentation Expert		X		

3.2.10 Activity: Define Validation Objectives

3.2.10.1 Objective

The objective is to define suitable and practical Validation Objectives for each Validation Aim. The Validation Objectives shall still express a user expectation but phrased in such way that makes it possible to identify a unique Operational Thread and make conclusions.

3.2.10.2 Rationale and Context

Since each Stakeholder expresses the Validation Aims they are not equally phrased a rephrasing and decomposing may be necessary.

3.2.10.3 Description

The task is to inspect and analyse the Validation Aims and to define separate Validation Objectives. The Validation Objectives shall be phrased to facilitate the identification of Operational Threads and the analysis and conclusions based on the Validation Objectives.

3.2.10.4 Examples and Recommendations

The recommendation is to perform this activity as soon as possible after the identification of Stakeholder Validation Aims. The Validation Aims should be decomposed into smaller Validation Objectives when possible to facilitate the analysis.

3.2.10.5 Product

The output is a set of Validation Aims decomposed into Validation Objectives.

3.2.10.6 Resources

The required resources for this activity are shown in the table below.

The highlighted marking shows the role main responsible for the activity.

Role	Responsible	Executor	Input Information	Output Information
Validation Expert	**X**	X	Validation Aims	List of Validation Objectives

Role	Responsible	Executor	Input Information	Output Information
OATA Architecture Expert		X		with associated short description
Documentation Expert		X		

3.2.11 Activity: Identify Operational Threads

3.2.11.1 Objective

The objective is to identify Operational Threads that visualises how OATA complies with a specific Validation Aim or objective.

3.2.11.2 Rationale and Context

The validation process is based around the idea of comparing the user needs to the way OATA implements them. The validation aims incorporate the user needs whilst the operational threads present how OATA implements them.

3.2.11.3 Description

Once all Validation Aims have been identified, described and reviewed, the identification of Operational Threads will take place. The purpose is to identify Operational Threads showing how the OATA architecture maps onto the Validation Aims and hence how it contributes towards fulfilling them. To perform the identification of Operational Threads the following tasks will take place:

1. **Selection and presentation of the Validation Aims and Objective**
   Use the priority of the Validation Aims done by the Stakeholders.
2. **Identification of Operational Threads.**
   This is done by searching for items in Architecture Use Case Realisations that are related to the Validation Aim. Based on the findings the Operational Thread will be created, defined and documented. The process will be performed as follows:

   Map the Validation Aims onto the OATA architecture to obtain the Operational Threads:

   a) ***Find Use Cases related to the Validation Aim***.
   OATA experts will identify which use cases are used. Operational and OCD experts will ask questions about how the use cases are used. The Validation expert will document the discussion.

   If there are no possible mappings to a Use Case or a Use Case realisation, the team will look at the Logical Architecture classes, to find out classes that are used by the Validation Aims in OATA. The OATA experts will identify which classes are used, while the Operational and OCD experts will ask questions about how the classes are used. The Validation expert will document the discussions.

   b) ***Create the Operational Threads***
   Create the Operational Thread showing how the elements of the OATA architecture are used to meet a user need as expressed in a Validation Aim. See Appendix E for a notation that could be used. The Validation expert will document the discussions.
3. **Identification and documentation of potential risks, sensitivities and potential trade-off points**

The identification of Operational Threads should result in a discussion that addresses potential risks, sensitivities and potential trade-offs. The level of analysis is meant to be commensurate with the level of detail of the architecture specification.

A risk is a potentially problematic architectural decision. A non-risk is a good decision that relies on assumptions that are frequently implicit in the architecture. Risks and non-risks should be understood and explicitly recorded by the validation team.

A sensitivity point is a property of one or more architecture components (and/or a component relationship) that is critical for implementing a particular Operational Thread.

A trade-off point is a property that affects more than one Operational Thread and is a sensitivity point for more than one Operational Thread.

The documentation of risks and non-risks, sensitivities points and potential trade-of points should consist of:

- An architectural decision or a decision that has not been made.
- A specific Operational Thread that is being addressed by that decision along with the consequences of the predicted response.
- A rationale for the positive or negative effect that the decision has on implementing the required Operational Thread.

3.2.11.4 Examples and Recommendations

It is very important that the prepared Operational Thread is rebuilt together with the Stakeholders to increase their understanding and the quality of the validation. Be careful and precise with the documentation.

3.2.11.5 Product

The output product is Operational Threads and their description and possibly a list of Validation Aims that do not have an associated Operational Thread.

3.2.11.6 Resources

The required resources for this activity are shown in the table below.

The highlighted markings are the role responsible for the activity.

Role	Responsible	Executor	Input Information	Output Information
Validation Expert	**X**	X	Validation Aims and Objectives	Operational Threads
OATA Architecture Expert		X		Optional: List of Validation Aims without Operational Thread
Documentation Expert		X		

3.3 Execution

3.3.1 Introduction

The validation of OATA compliance is based on the identification and assessment of Operational Threads. Once all information has been adequately prepared, the assessment of the OATA correctness will be performed.

The correctness is assessed by a mapping of validation aims onto OATA. If the validation aim can be mapped the OATA is assessed as correct.

The validation Execution process has two activities to assess if the OATA logical model meets the user needs. These activities are:

- Training of Stakeholders.

  In this activity the Stakeholders will be informed and trained for the assessment workshops “Assess Correctness”.

- Assess OATA Correctness.
  In this activity the Operational Threads is presented and re-built together with the Stakeholders and then assessed if OATA can implement the Validation Aims through Operational Threads.

The ordering of the activities, the information flow and the required resources are shown in Figure “Execution”.

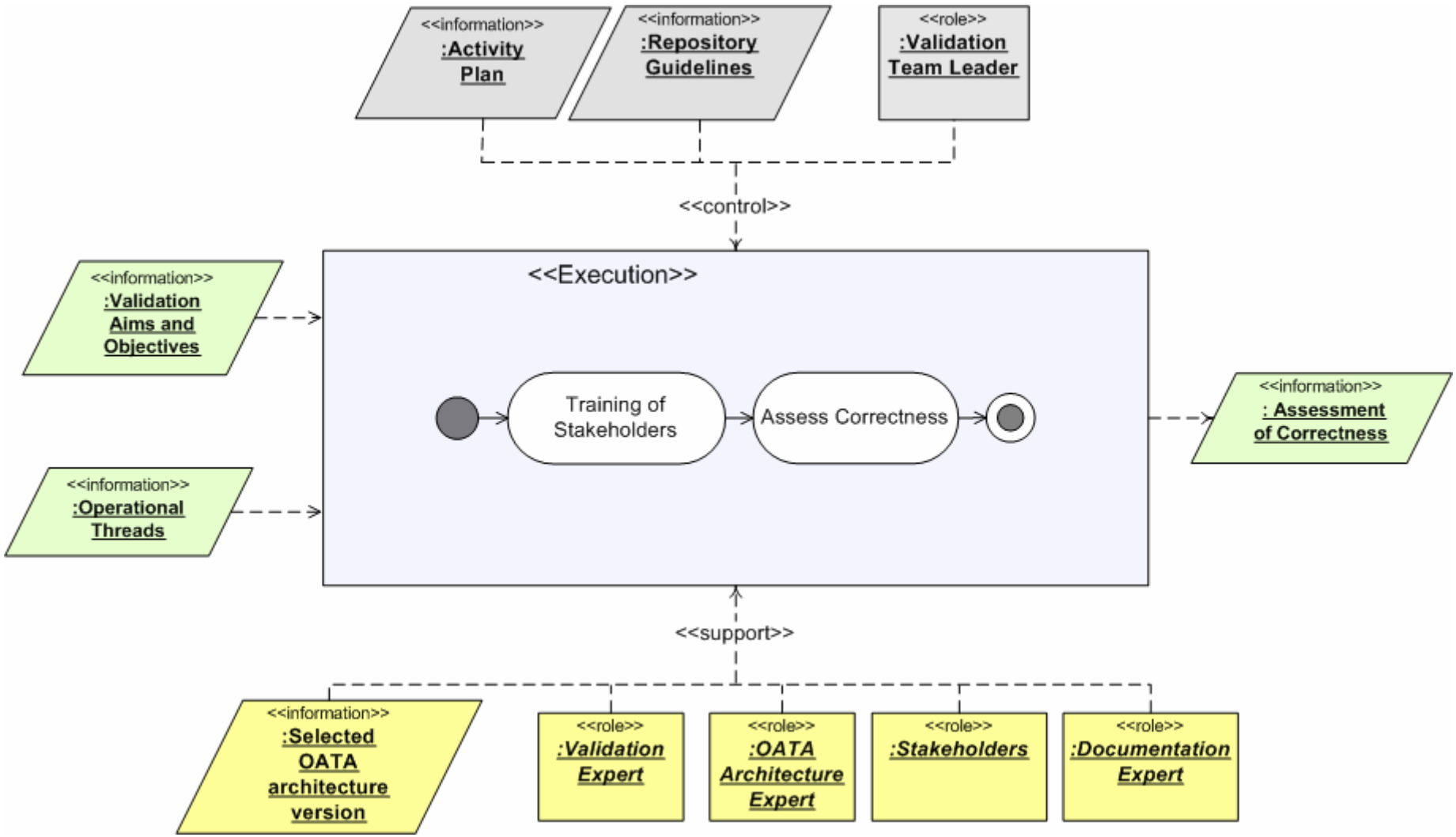


Figure 8: Execution

3.3.2 Required resources

The table shows the planned resources for the activities in “Execution”.

The main responsible roles for each activity are highlighted in the table.

Activities	Roles				
	Validation Expert	OATA Architecture Expert	Stakeholders	OCD Expert	Documentation Expert
Training of Stakeholders	**X**	X	X	X	
Assessing Correctness	**X**	X	X	X	X

3.3.3 Activity: Training of Stakeholders

3.3.3.1 Objective

The objective is to prepare and train the Stakeholders that shall participate on the workshop “Assess the correctness”.

3.3.3.2 Rationale and Context

It is very important that the Stakeholders participating in the workshop “Assess the OATA correctness” are well prepared and informed about the objectives and layout of the workshop.

3.3.3.3 Description

The **first task** is to prepare the training material. The material should include an overall presentation of :

- The methodology for Compliance Assessment.
- The process for Compliance Assessment
- The OATA Architecture and the subset to validate
- The operational concept description
- The identified Validation Aims and the defined Validation Objectives.
- Training material and examples on Operational Threads

The **second task** is to perform the training of the Stakeholders. This activity should be planned early and in close connection with the workshop “Assess the Correctness”.

3.3.3.4 Examples and Recommendations

This activity should not be underestimated. Well prepared and trained Stakeholders will increase the quality and efficiency of the workshop. The training material from the activity

"Prepare Stakeholders" should be used and updated for this activity. The training of the Stakeholders is recommended to be conducted close in time before the actual workshop for the assessments. The amount of training has to be adapted to the participating Stakeholders.

3.3.3.5 Product

The output from this activity is a training material for the workshops and well-prepared Stakeholders.

3.3.3.6 Resources

The required resources for this activity are shown in the table below.

The highlighted marking shows the role main responsible for the activity.

Role	Responsible	Executor	Input Information	Output Information
Validation Expert	**X**	X	Operational Threads	Well prepared Stakeholders
OATA Architecture Expert		X		
OCD Expert		X	Training material from activity Prepare Stakeholders	
Stakeholders		X		

3.3.4 Activity: Assess the Correctness

3.3.4.1 Objective

The objective of this activity is to assess the ability of the architecture to provide an execution path (Operational Thread) that correctly implements the User Needs (represented by Validation Aims and Objectives).

3.3.4.2 Rationale and Context

To assess that the architecture is correct, it is necessary to show that it supports the User Needs expressed in the Validation Aims and Objectives. The validation process may be able to challenge or question some of the operational concept description or OATA information. In that case, correctness will be achieved once the information is fed back into the concept description and OATA models.

3.3.4.3 Description

The following tasks shall be iterated for the assessment of each selected Operational Thread:

The **first task** to be performed is to present the Operational Thread. It is important that all participating members understand the Operational Thread. An efficient way to increase the understanding is to re-build the prepared Operational Thread on the whiteboard together with the Stakeholders so they can follow the thread from the initiation to the end result. During the presentation of the Operational Thread there will be questions and the presentation will glide into the validation task. This means that it is important to document all raised questions and answers that will contribute to the analysis and conclusion regarding the correctness of the Validation Aim and Objective.

The **second task** to be performed is the assessment of the correctness of the Operational Thread and thereby the OATA Architecture. The following actions need to be performed:

1. ***Review the mapping***.

   The team will ask themselves the following questions:

   a) Does the Operational Thread need additional classes?

   b) Are the existing classes defined correctly?

   c) Does the Operational Thread need additional Use Cases?

   d) Are the existing Use Cases defined correctly?

   e) Is the flow of interaction as expected?

   This action will identify elements that the architecture already supports, thus providing additional support regarding the compliance of the OATA architecture with the operational concept description.

2. ***Analyse the mapping to identify possible problems found in the Operational Thread.***

   Two types of situations are expected to arise:

   a) The architecture is able to implement it without changes or

   b) A change in the architecture is necessary to cover the Operational Thread.

   The Operational Threads represent additional components and services that the architecture must satisfy. For each Operational Thread the review should identify the changes[3] needed to implement the Operational Thread and estimate the cost of performing them.

After the correctness assessments are performed, all the identified Validation Aims should have at least one associated Operational Thread linking the user needs to the OATA Logical Architecture elements.

3.3.4.4 Examples and Recommendations

To actually be able to document the discussions and conclusions there needs to be well prepared tables for the results. The recommendation is also to assign the documentation responsibility to a separate role on the workshop. The documentation is very important for the analysis activities and should be well prepared before start of the workshop.

3.3.4.5 Product

A conclusive document including a matrix of validation aims, related Operational Threads and an assessment of their correctness.

Templates for the documentation must be well prepared and coordinated with the Repository. The documentation should also be coordinated with the template for the Validation Report.

An example of a table is shown below to assist the documentation on the workshop.

Validation Aim	Operational Thread	Correctness Assessment	Completeness Assessment #1	Completeness Assessment #2

[3] Modifying the architecture means introducing new components or connections, or changing the specification of a component or a connection.

3.3.4.6 Resources

The required resources for this activity are shown in the table below.

The highlighted marking shows the role main responsible for the activity.

Role	Responsible	Executor	Input Information	Output Information
Validation Expert	**X**	X	OATA Architecture	Assessment of the OATA correctness per Operational Thread
OATA Architecture Expert		X	Validation Aims and Objectives	
OCD Expert		X	Operational Threads	
Stakeholders		X		
Documentation Expert		X		

3.4 Analysis and Reporting

3.4.1 Introduction

The purpose of the process “Analysis and Reporting” is to study the different elements resulting from the validation and their interrelationships to gain confidence on the results and on the validity of OATA.

The activities included in this process comprise the Analysis of the different Validation Results, their review by the Stakeholders, and the elaboration of the validation report. The following sections describe in detail each one of these activities.

The description of the activities presented in this section assumes that they are all performed for the first time.

The ordering of the activities, the information flow and the required resources are shown in Figure “Analysis and Reporting”.

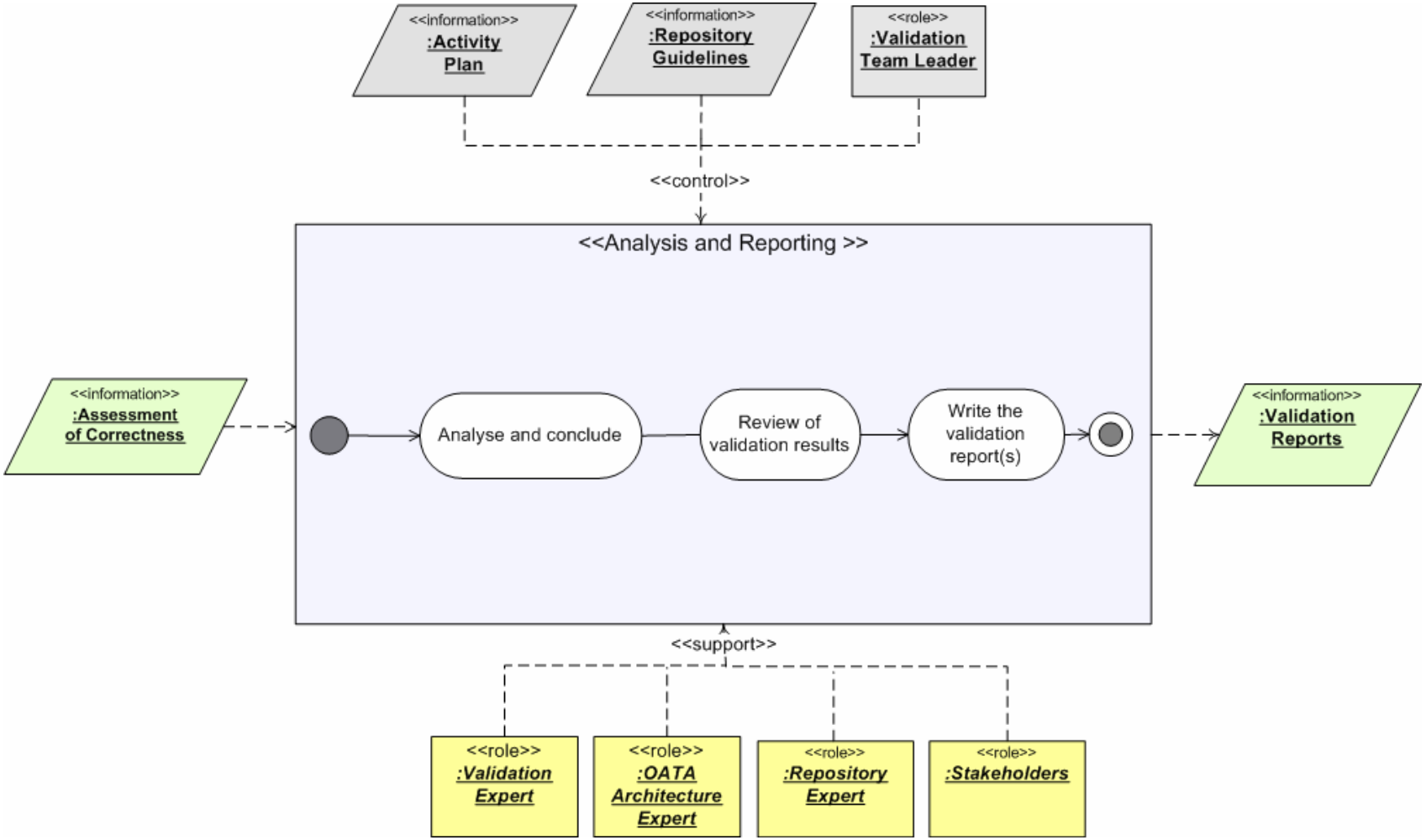


Figure 9: Analysis and Reporting

3.4.2 Required resources

The table shows the planned resources for the activities in “Analysis and Reporting”.

The role main responsible for each activity is highlighted in the table.

Activities	Roles				
	Validation Team Leader	OATA Architecture Expert	Validation Expert	Stakeholders	Repository Expert
Analyse and Conclude	X	X	**X**		X
Review of validation results	X	X	**X**	X	
Write validation report(s)	X	X	**X**		

3.4.3 Activity: Analyse and Conclude

3.4.3.1 Objective

The objective is to analyse the results from the Execution and show how OATA supports the operational concepts.

3.4.3.2 Rationale and Context

The reasons to perform an analysis of the results are the following:

- A better understanding of the relationships identified in the Validation Aim and in the associated Operational Thread(s).
- An understanding of what is behind a specific Validation Aim and its related Operational Thread(s).
- Determining the problems and resources associated with addressing Validation Aims and related Operational Thread(s).

The Validation Team needs to identify, describe and understand clearly the implications of the obtained results.

The level of the analysis is not meant to be comprehensive and detailed, but rather commensurate with the existing level of detail of OATA. Its purpose is to establish a link between the architectural decisions that have been made and the OCD requirements (through the Validation Aims and the Operational Threads).

3.4.3.3 Description

The **first task** is to analyse the validation results. The validation team addresses each one of the Operational Threads by asking a set of approach-specific and OCD related questions. These questions might come out from documented knowledge (e.g. ATM 2000+ Strategy document), or from prior experience of the Stakeholders. The questions are a starting point for discussion, and for the determination of potential risks, sensitivity points, or tradeoffs.

The validation team should have a clear understanding of how OATA fulfils and implements the OCD requirements. The purpose of the analysis is to identify areas of potential concern within the architecture. These areas can be made the focus of future effort in terms of prototyping, design, and analysis. The validation team should give specific attention to:

- Important architectural important decisions that have not been made.
- Highly correlated architectural components.
- Architectural trade-offs.

To perform the actual analysis the following questions (based on the previous results) are suggested for each Validation Aim:

	Validation Process
• **What is the Validation Aim?** Describe the Validation Aim and its understanding.	Preparation
• **Why is the Validation Aim important to the Stakeholder?** The purpose is to understand the reasoning behind the selection of a specific Validation Aim (criteria, votes, etc.)	Preparation
• **When does the Validation Aim / Operational Thread occur, or when does it become significant?** **How critical to the Stakeholder is this Validation Aim / Operational Thread**.	Execution
• **Which Operational Thread(s) address the Validation Aim?**	Execution
• **How is the Operational Thread described?** Aside from the recommended Operational Thread presentation, the Validation Report should include the classes, the relations, the responsibilities and the use cases associated to each Operational Thread. For the purpose of efficiency and to avoid redundancy, it is suggested to use references to the actual OATA documentation (when possible).	Execution
• **Is the OATA correct?** Is the architecture able to implement the Operational Thread?	Execution
• Is OATA complete? Are there gaps (Operational Threads that need non-existing architectural components)? Is it related to new architectural modules or to existing one?	Execution

The results of the analysis will be documented in the Validation Report.

The **second task** is to update the Repository with the validation results.

3.4.3.4 Examples and Recommendations

The following metric is suggested to measure the coverage of the Validation Efforts:

$$OperationalThreadCoverage = \frac{\sum Number\ Different\ Architectural\ Components\ Affected}{Total\ Number\ Architecture\ Components}$$

This metric is strongly coupled with the validation scope, and its purpose is to be used as a way to compare the different validation processes that will be performed during the lifetime of OATA.

The validation report must address only the information related to the validation aims and operational threads that have been identified.

The validation report must include only facts obtained from the validation process.

3.4.3.5 Product

The output is a Validation Report.

3.4.3.6 Resources

The required resources for this activity are shown in the table below.

The highlighted marking shows the role main responsible for the activity.

Role	Responsible	Executor	Input Information	Output Information
Validation Expert	**X**	X	Assessment of correctness	Analysis and conclusions
Validation Team Leader		X		Updated Repository
OATA Architecture Expert		X		
OCD Expert		X		
Repository Expert		X		

3.4.4 Activity: Review of validation results

3.4.4.1 Objective

The objective is to brief the Stakeholders about the validation results. This is an opportunity for Stakeholders to review, and support/confirm the results.

3.4.4.2 Rationale and Context

The whole purpose of the validation process described in this document is to ensure that the User (Stakeholder) Needs are reflected and adequately modelled in OATA. Once all the information has been prepared for delivery, but prior to its formal acceptance, the Stakeholders are given an opportunity to review and comment the Validation Report.

3.4.4.3 Description

The Validation Expert will deliver (after approval of the OATA Architecture Expert) the validation results to the Stakeholders. The Stakeholders will have a reasonable amount of time (1 month) to review and comment the results. The Stakeholder comments will be sent to the Validation Expert who will collate and distribute them to the involved OATA experts. Once the comments are approved, the validation expert will update the Validation Report.

3.4.4.4 Examples and Recommendations

The validation results should be taken from the updated Repository.

3.4.4.5 Product

The output is a set of comments on the assessments, which is the base for the Validation Report.

3.4.4.6 Resources

The required resources for this activity are shown in the table below.

The highlighted marking shows the role main responsible for the activity.

Role	Responsible	Executor	Input Information	Output Information
Validation Expert	**X**	X	Validation Results	Review comments from Stakeholders
Validation Team Leader		X		
OATA Architecture Expert		X		
OCD Expert		X		
Stakeholders		X		

3.4.5 Activity: Write validation report(s)

3.4.5.1 Objective

The collected information and recommendations from the performed OATA validation cycle needs to be summarized and prepared for presentation to the OATA Stakeholders.

3.4.5.2 Rationale and Context

The information produced during the previous steps and activities must be structured in such a way that it is easily accessible and interpreted. Documenting and distributing the validation results precipitates two effects. First, it results in a closure of the validation by relating the final results to the initial presentation. Second, it elevates the risks that were uncovered to the attention of the management. What might otherwise have seemed to a manager like a complicated technical issue is now unambiguously identified as a threat to system qualities.

3.4.5.3 Description

The validation report should be prepared during the planning phase and continuously updated to make this activity easier and more efficient. When the validation report is ready it should be sent to the validation team including Stakeholders for review. The validation report shall be updated and the reviewers should be reflected in the document history.

The following paragraphs present and describe the different areas that should be addressed by a validation report. Each one of the following items corresponds to a section of the Validation Report template used in the Pilot Validation.

Report Section	Comment	Validation Process
1. Introduction and Document Background.	Establish the information needed to understand the report. Project background, glossary, definition of terms, references, etc.	Preparation
2. Summary of validation strategy and planning	Describe the overall planning and strategy of the validation	
3. Conduct of validation exercise	Describe deviations, the overall schedule and validation team	
4. Validation results	Describe the results: • Validation Aims • Validation Objectives • Operational Threads • Specific validation results	Execution
5. Analysis of the validation result	Document the analysis based on the validation aims and objectives	Analysis & Reporting
6. Conclusions and Recommendations	Document conclusions and recommendations from the validation team.	
7. APPENDIX A: Detailed Validation Results and summary matrices	Synchronized with the Repository	Execution
		Analysis & Reporting

3.4.5.4 Examples and Recommendations

It is also recommended to generate a lessons-learned report, to record the main conclusions on the validation methodology itself, regardless of the concrete data obtained in the assessment process.

3.4.5.5 Product

The output from this activity and the validation cycle is the Validation Report and optionally a Lessons Learned Report.

3.4.5.6 Responsibilities

The required resources for this activity are shown in the table below.

The highlighted marking shows the role main responsible for the activity.

Role	Responsible	Executor	Input Information	Output Information
Validation Expert	**X**	X	Validation results	Validation Report
				Optional:
Validation Team Leader		X		

OATA Architecture Expert		X		Lessons Learned Report

4 APPENDIX A - VIABILITY OF ARCHITECTURE EXECUTABLE MODELS

4.1 Introduction

What is considered an executable model? An Executable Model is a model complete enough to be executed and that can also be augmented by custom code, but only at the behaviour level. The Executable Model defines a structure of classes and their behaviour. It also shows the interface to external systems.

The use of an executable model based on OATA should provide an answer or insight to the following questions:

- Does a class actually produce the service/product it is supposed to?
- Do later steps in a process actually produced by earlier steps consume intermediate services/products?
- Does the flow of resources through a process match the flow of control?
- Does the flow of resources suggest opportunities for improving the process, for example by increasing parallelism or assigning tasks to different roles?

4.2 Identify the Characteristics of an Executable Model

4.2.1 Objective

Identify the characteristics of an executable model that verifies the compliance of the OATA UML constructs with the OATA development guidelines.

4.2.2 Rationale and Context

There are several possible reasons for using an executable model of the architecture. Amongst them the most relevant are:

- Removing Ambiguity
  - The Executable model forces semantics to be defined
  - The Executable model makes behaviour more visible
- Providing a medium for Communication
  - The Executable model highlights general process flow over details

4.2.3 Responsibilities

Actor	Role	Responsibilities
OATA expert.	Lead the implementation of the executable model.	Provide knowledge about the information contained in OATA. Identify additional information needed.
Validation Expert.	Identify traces needed to be included in the model.	Identify the areas of the architecture that need to be tracked and implement the traces needed to assess their validity.

4.2.4 Description

The specific steps and inputs needed to construct an executable model are strongly dependant in the type of tool used. The following steps and inputs represent a generic process that should be followed to obtain an executable model from a UML specification:

- Add missing semantics (related to expected behaviour).
  - Define concrete semantics between state machine and their context.
    - How are state machines started?
    - Can an instance have multiple active state machines?
    - How is an incoming message converted to an event?
    - How is a generated event converted to an outgoing message?
    - Synchronisations.
- Clarify Variations.
  - Resolve transitions.
  - Identify concurrency.
  - Map UML structure models to database.
  - Select action semantics and the concrete syntax for actions.
  - Select primitive actions, functions and data types.
  - Implement custom code.
- Generate database from structure model.
- Execute.

The resulting Executable Model would be used to:

- Ensure the completeness and correctness of the UML constructs.
- Ensure that the functionality is defined and allocated in some way.
- Ensure that the interactions are completed and carry all the information that is needed.

4.2.5 Product

Executable model of the OATA logical architecture.

4.2.6 Product Quality

Quality	Description	Evaluation
Specific.	The executable model must have the level of definition that allows to identify the creation / destruction of objects, and to follow the flow of control.	

4.3 Available Tools

There are several tools available in the market. Even though all have different capabilities, they all require the same types of inputs (as shown in 6.2.4). The following sections do not make an assessment of their performance or their adequacy to the task.

4.3.1 Rational Rose Technical Developer

The information contained in this section has been extracted from:

http://www.ibm.com/software/awdtools/developer/technical

The following list presents the key features of the product:

- Targeted for commercial software products and systems, including real-time and embedded applications.
- Most robust model-driven development solution.
- Fully-automated design-to-code translation for Java, C and C++.
- Runtime model execution, fully executable code generation and visual debugging.
- Automatically builds drivers, stubs, test harnesses and actual test scripts.
- Optimized for event-driven, concurrent and distributed applications.
- Advanced modelling constructs for meeting stringent requirements for latency, throughput, and dependability.
- Designed for the most technologically challenging applications.
- Includes IBM Rational Rose® RealTime for full-scale model-driven development with Java, C and C++.
- Includes IBM Rational Rose® for UNIX/Linux for design-level integration with Java, C++, and Ada.

The use of a tool such as this implies that the architecture has to have a level of detail sufficient for the elaboration of the stubs. As reflected by tool requirements, the level of detail needs to include classes, use cases, and in some instances state diagrams (especially in those cases where messages are used to initiate some action.

4.3.2 Telelogic TAU/Architect

The information contained in this section has been extracted from:

http://www.telelogic.com/products/tau/Architect/features.cfm

The following list presents the key features of the product related to the Dynamic Model Verification feature of the tool:

- Advanced dynamic model verification.
- Live generation of sequence diagram of real-time behaviour.

- 'Abstract' UML - simulation and sequence diagram trace of 'abstract' UML, e.g. informal decisions and informal tasks.
- Graphical trace in state diagrams during model verification.
- Replay scenarios - steps taken in model execution can be saved and later replayed.

4.3.3 I-Logix Statemate

The information contained in this section has been extracted from

http://www.ilogix.com/products/magnum/index.cfm

The following list presents the key features of the product related to the Dynamic Model Verification feature of the tool:

- Combines traditional graphical design notations and Unified Modelling Language (UML) diagrams.
- Direct and formal link between user requirements and software implementation by allowing the user to create a complete, executable specification.
- Scenarios can be captured and included in Test Plans which are later run on the embedded system to ensure that what gets built meets what was specified.
- State of the art, advanced technologies including formal verification. This type of analysis can be performed so engineers can validate their Statemate graphical specifications, to ensure that they follow good design practices, and prove that they meet user defined critical properties, such as safety.

4.4 Estimation of the effort needed to develop an executable UML model

As it has been seen previously it is very difficult to identify precisely the actions that are needed to implement an executable model. This difficulty is caused by the different requirements of the tools on the UML model detail level. Nevertheless, it must be noted that once the adequate UML model detail is attained, the creation of the executable model is rather simple and straightforward.

Thus rather than providing the effort needed to bring the UML model up to the desired detail, this section presents the minimum set of UML constructs that would be needed to generate an executable model. Please note that the minimum set of constructs is also heavily dependant on the selected tool:

- Use Cases.
- Class Diagrams.
- Activity Diagrams.

If the user wants to obtain full use of all the executable benefits then the UML model should also include:

- State charts.

4.5 Conclusions regarding the viability of the development of an executable UML model

The use of an executable model provides automatic UML construct verification. The level of information that can be extracted from an executable model ranges from the verification of the correct implementation of the UML constructs, to the identification of potential synchronisation problems.

If the UML model information is available, then the generation of the executable model – using the appropriate tool- is straightforward.

5 APPENDIX B - EXAMPLE OF VALIDATION AIMS

The following examples show different Validation Aims:

- Delegate sequencing responsibility to the pilot. *Ability of OATA to meet ASAS requirements.*
- Ensure the implementation of planned solutions through entry/exit conditions by ensuring the handover of a flight while meeting the respective condition. *Ability to perform MSP.*
- As soon as an aircraft enters an en-route sector, enable its insertion in the arrival sequence as soon as flight detection (e.g. activation of flight plan by the FDPS) is facilitated by an ABI message (Advanced Boundary Information). *Ability to provide synchronisation over several sectors. This is an enabler for concepts such as the Extended TMA or and advanced AMAN.*
- Negotiation of a safe trajectory by an autonomous aircraft that is in a potential conflict (single) situation. *Ability to implement ASAS.*

The following figure shows how an Operational Thread would be used to validate OATA:

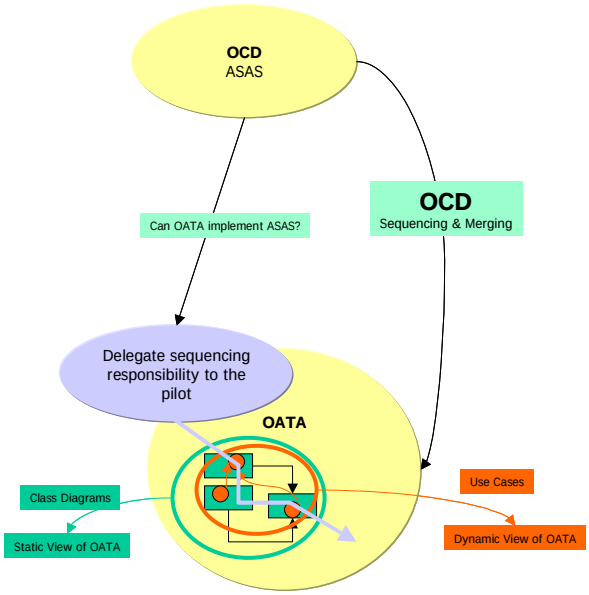


Figure 5-1 Use of Validation Aims and Operational Threads

6 APPENDIX C - GUIDELINES FOR BRAINSTORMING

6.1 Introduction

The following guidelines have been written to assist in the identification of the Validation Aims and on the Operational Thread elaboration. In the following text the word “idea” has been chosen to reflect either a Validation Aims or an Operational Thread.

Before describing the main steps that should be followed to obtain the maximum number of ideas, the reader must take note of the following statements that will ensure the adequacy of the results:

- Strive for quantity not for quality.
- Defer judgement of ideas.
- Wild ideas are welcomed.
- Do not react or discuss on any ideas.

6.2 Identification of Ideas

The following five steps are typical of brainstorm sessions geared towards the identification of possible solutions. In our case, the steps have been adapted towards the identification of Validation Aims / Operational Threads.

1. Give people a question or problem to focus on.

To start the brainstormsession post the key question that has to be addressed. For example, “Which Validation Aims would you think represents best the Air Traffic Management Operations?“ how will OATA implement the ASAS Package 1 Sequencing?”

The OATA, OCD and Validation Experts should have prepared these questions in advance.

2. ***Have each person write as many Ideas[4] as he/she can***.

It is important to allow people to think privately. Once the brainstorm session starts, other people might influence their thinking. The “any Idea goes” attitude must be encouraged. People should not criticise or censor anybody’s ideas. A maximum time of ten minutes is recommended.

3. Record and post all ideas without discussing or evaluating them.

Proceed all around the room, person by person, until everybody has run out of ideas. Record all ideas and assign each one of them a number (it will be useful for reference and for grouping). If an idea seems similar to another one, check with both authors to see if it is so; if they are similar, do not record them a second time.

4. ***Encourage people to build on each other Ideas***.

Ask whether someone has an Idea that builds on the existing ones.

5. ***Clarify the Ideas***.

After all ideas have been identified, allow people to ask questions about them. Remember that the group’s goal is to understand and clarify the ideas, not to discuss it in detail.

[4] In the Operational Thread case, the process should be geared towards identifying how OATA could implement the Validation Aim. Please note that some of the results will not be necessarily correct, but that in general they will contribute towards the understanding of the OATA logical model.

6.3 Clustering of Ideas

The activity of clustering is grouping the identified ideas into categories to help organise the evaluation process. Clustering will allow people to discuss and assess all ideas in the same category at once. It also permits to assign specific categories to specific teams for the purpose of assessment and selection. The process to perform the clustering should be as follows:

1. Ask the group which Ideas are related. Label the ideas using letters (or colours, or post-its or …). If a group member prefers not to have the idea related, honour their reasoning and move on.
2. Label each idea group with an appropriate title (e.g. airport operations, aircraft responsibility, sequencing and metering).

6.4 Establish Criteria for Selection

At this stage, the brainstorming group should agree on the selection criteria. It is interesting to distinguish between essential criteria that the identified idea must meet (e.g. it must be part of the OCD) and desirable criteria that it would be nice to meet (e.g. address local needs).

6.5 Selecting the Identified Ideas

Identified ideas that do not meet the essential criteria are discarded. If the ideas seem very promising, but it is not contained in the essential criteria, it should be recorded as a possible shortcoming.

Ideas that sound interesting or creative, but that everybody knows that they are not feasible should be discarded.

Discuss the merits of each Idea. How will the Idea help to assess if OATA meets the OCD requirements? Is this the best way to implement the Idea onto OATA? Push the group to scrutinise each Idea thoroughly.

The group must reach a consensus regarding the Idea that are selected. To do so, the voting mechanism presented in the main text should be used. Remember: *it is not possible to assess all* Ideas *at once.*

6.6 Managing the Brainstorming Process

6.6.1 Keeping People on Track

The facilitator is responsible for keeping the group on track. To begin with, the facilitator must provide clear guidelines about how to carry each step. The facilitator must also steer the group back on the track when they wander.

6.6.2 Handling Difficult individuals

From time-to-time any member of a group can become difficult. Even though all situations are different, the facilitator can follow some simple guidelines to handle this type of situation:

- Handle the problem before it gets out of hand.
- Do not embarrass people. Protect everybody's self esteem throughout the process.
- Take Control in a positive, constructive way. Be direct, factual and sincere. Avoid opinion-based comments, and use instead observation-based statements that are focused on the issues.
- Assume that the other person means well.

If the problem can be handled in a positive, constructive way in front of the group, do so. If not, wait until the next break and discuss the problem with the individual. If needed, setup a meeting with the other person, put the issue over the table and work out a solution together. This three-step approach will be useful when meeting with the other person:

1. Describe your concern or the problem as you see it.
2. Together, work out a solution.
3. Recap the agreement that you have reached.

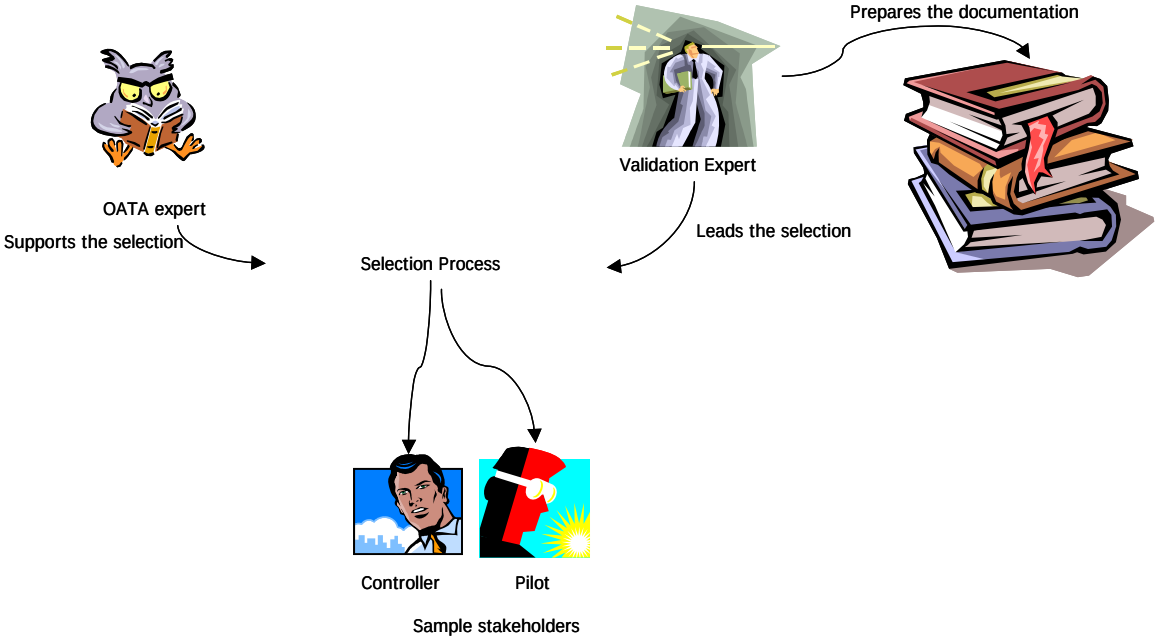
In any case, do not allow yourself to resolve all the conflicts, if you do so, you will become the place where all group members come to complain, and you will eventually become the source of many group conflicts.

7 APPENDIX D – EXAMPLE OF HOW TO APPLY THE GUIDELINES

This example presents a possible validation of the compliance of the architecture with the OCD. The example is not exhaustive, and its purpose is to illustrate how the different items of the guideline are used to perform the validation. This example does not cover all activities; it focuses mainly in the activities related to the preparation and the execution of the validation.

Although this example only deals with one Validation Aim (*Runway Incursion)*, several aims will be required to accomplish the validation with good quality.

The first stages of the guidelines are geared towards the preparation of the validation. Initial activities ensure that all information is prepared and made available, and that there is a group of Stakeholders ready and willing to participate.



3	PREPARATION OF THE VALIDATION
3.1	Introduction
3.2	Activity 1: Collection of Relevant Documents
3.3	Activity 2: Selection of Stakeholders
3.4	Activity 3: Stakeholders Training
3.5	Activity 4: Identification of Stakeholder Validation Aims
3.6	Activity 5: Selection of a Set of Stakeholder Validation Aims

Figure 7-1 Preparation of the Validation: preparing the Information and the Stakeholders

Once the participating Stakeholders are prepared for the task, identification of what aspects of the OCD will be validated. To this end, a series of brainstorms are carried to identify the validation interests of the selected Stakeholders.

As a result of this process one of the Validation Aims identified and selected is *"Show how OATA takes care of Runway Incursion"*.

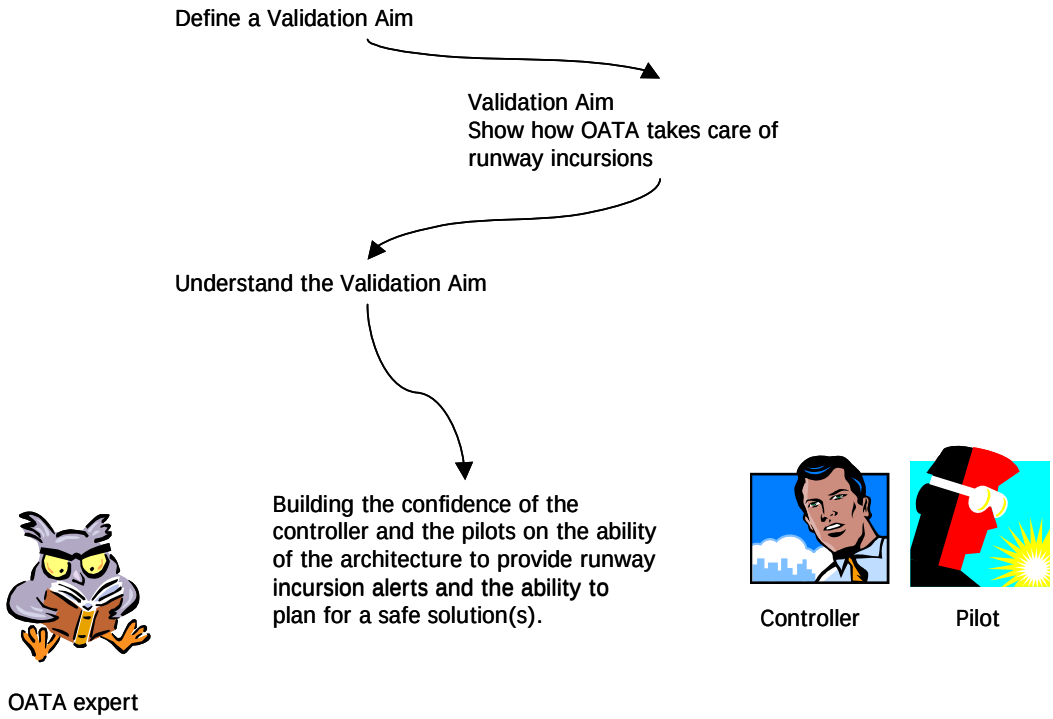


Figure 7-2 Preparation of the Validation: Identification of Validation Aims

With all the information and the Stakeholders adequately prepared, the validation process performs the activities needed to identify the Operational Thread and to assess correctness and completeness. The first activity identifies the Operational Threads.

This example assumes that only one operational thread is related to the selected validation aim.

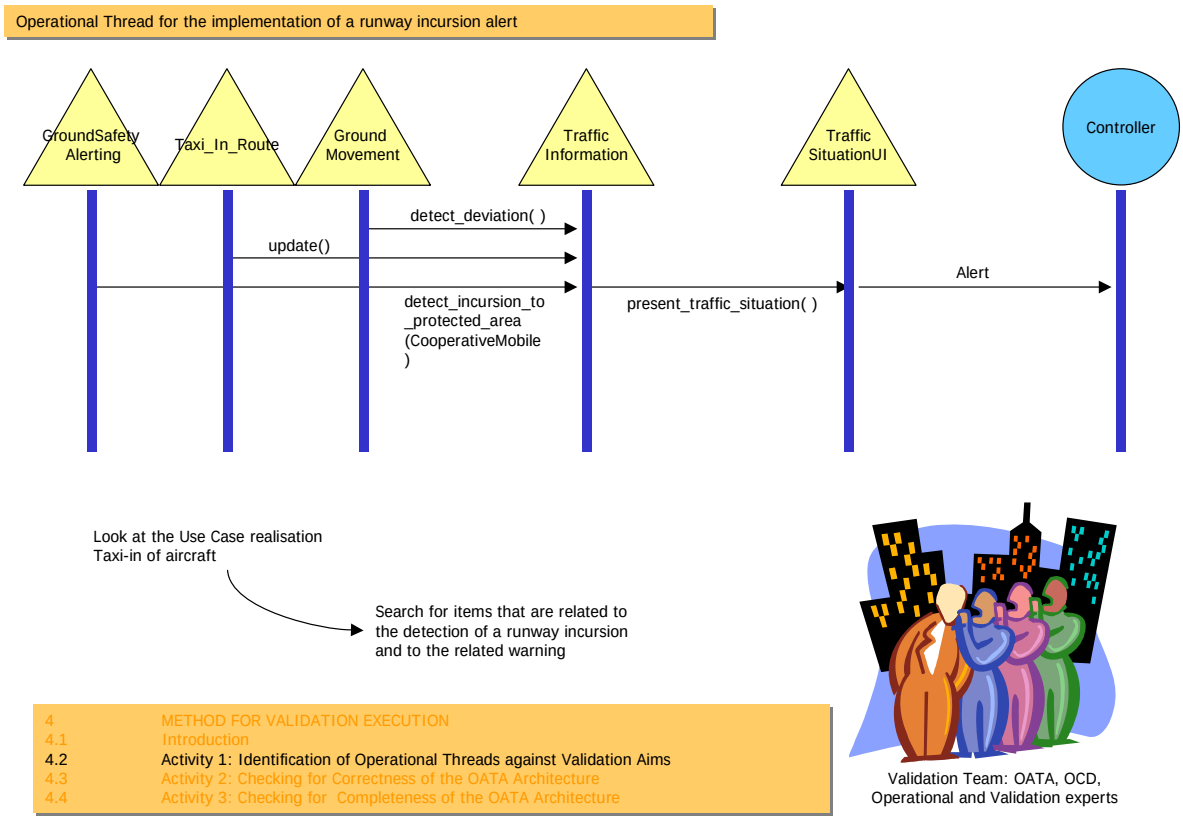


Figure 7-3 Method for Validation Execution: Identification of Operational Threads against Validation Aims. Example

The use of questioning techniques permits to identify quickly the possible errors in the implementation of the OATA Architecture. The use of this technique, allows the Validation Team to identify (in our example) the need for the use of a new class (Pilot) that would receive the alert messages from the TrafficSituationUI. The results are recorded in the table format present in the main body of this document.

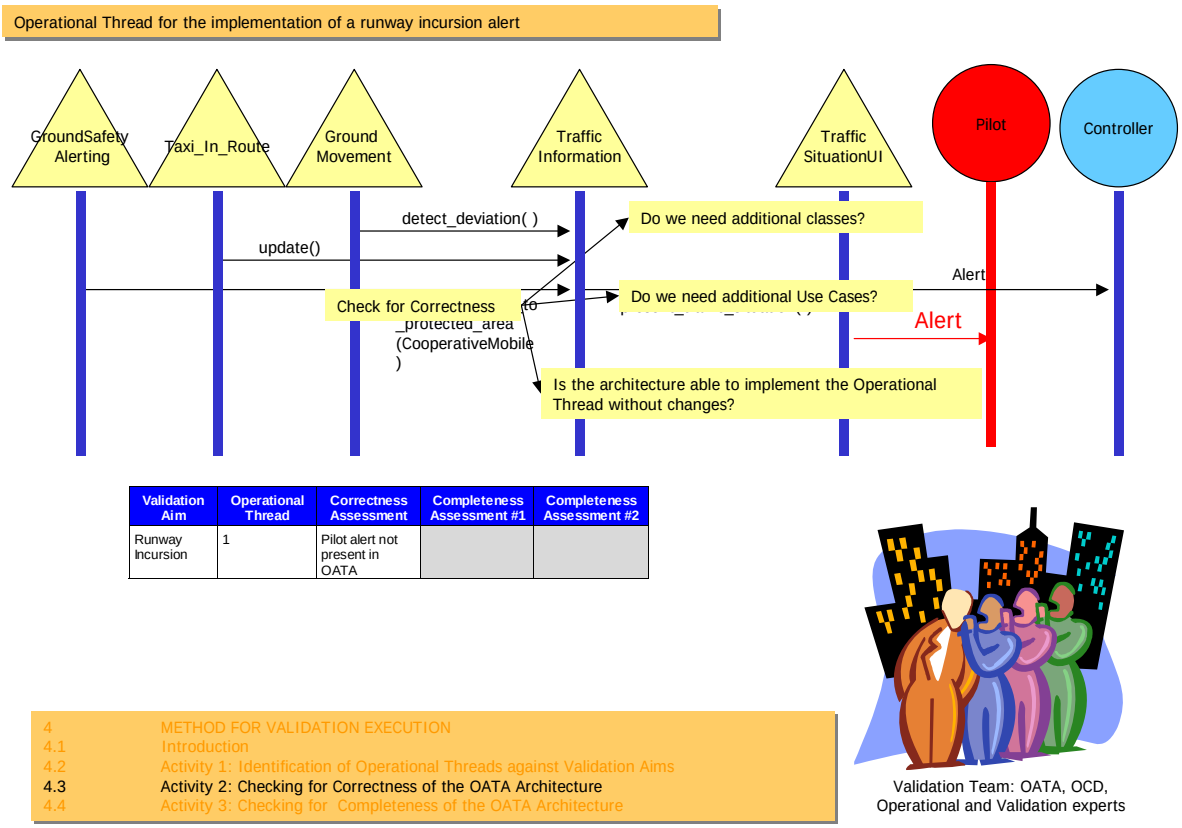
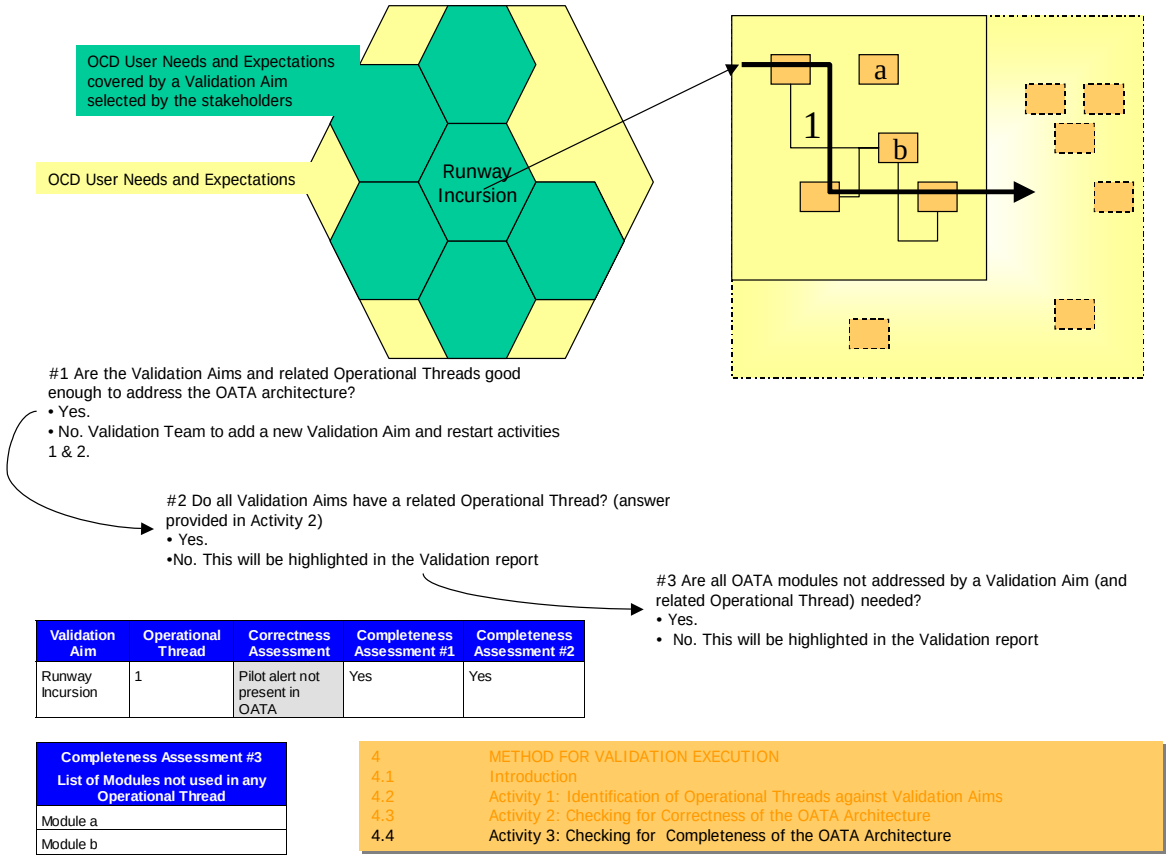


Figure 7-4 Method for Validation Execution: Checking for Correctness

Once the OATA Architecture is checked for correctness, the Validation team needs to check if it is also complete. This is done through a set of established questions. In our example, *Runway Incursion* validation aim of course does not cover all validation aims. To check the completeness, the Validation Team will need to identify and process all validation aims and related operational threads.

The example assumes that not all OATA modules (a & b) are addressed by the Validation Aim. This information is recorded in the appropriate table template presented in the main body of this document.



Validation Aim	Operational Thread	Correctness Assessment	Completeness Assessment #1	Completeness Assessment #2
Runway Incursion	1	Pilot alert not present in OATA	Yes	Yes

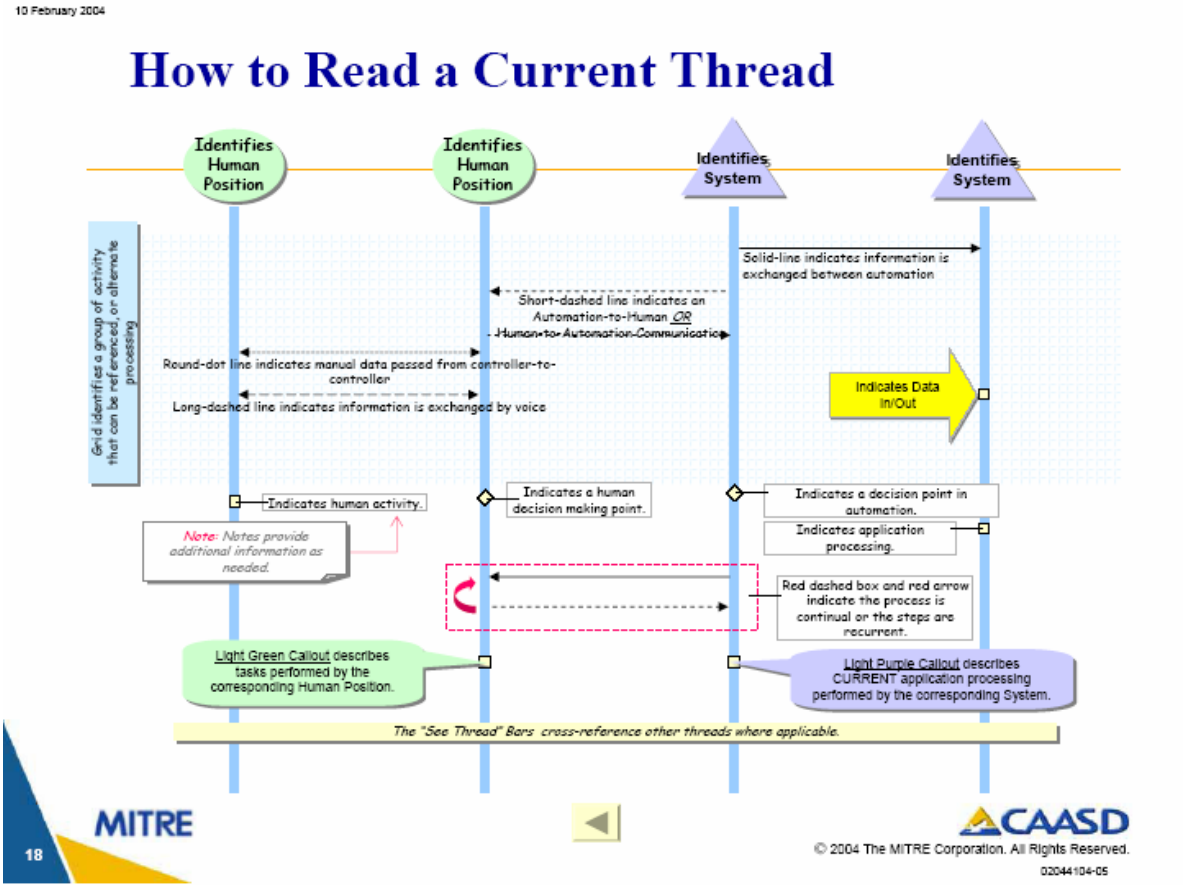
Completeness Assessment #3 List of Modules not used in any Operational Thread
Module a
Module b

Figure 7-5 Method for Validation Execution: Checking for Completeness

8 APPENDIX E - OPERATIONAL THREAD PRESENTATION

8.1 Operational Thread presentation – Example 1

The following figures have been extracted from reference [McMillen 04]. The figure presents the notation used to describe an Operational Thread.



8.2 Operational Thread presentation – Example 2

The following figure has been extracted from a Validation Report from the Pilot Validation. The figure represents an Operational Thread with UML notation for sequence diagrams as used in the OATA logical model.