



The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Équipement de l'Aviation Civile

GUIDANCE TO ACHIEVE ATM VALIDATION PLATFORMS INTEROPERABILITY

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EUROCAE

9-23 rue Paul Lafargue
93200 Saint-Denis
France

Phone: +33 1 49 46 19 65

Email: eurocae@eurocae.net

Website: www.eurocae.net

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CHAPTER 1

INTRODUCTION

1.1 PURPOSE AND SCOPE

This document aims to provide guidance for those, who want to achieve Interoperability for their ATM Validation Platforms. It refers to EUROCAE ED-147A ATM Validation Platforms Interoperability Specification [ED-1].

The document complements ED-147A [ED-1] by proposing a common collaboration model that aims to support ATM Validation Platform stakeholders to reach their goal of working together in a collaborative way.

It provides examples and best practices from validation exercises using Interoperable ATM Validation Platforms from different ATM Domains.

As mentioned before this document is based on EUROCAE ED-147A [ED-1] but not replacing it.

1.2 DOCUMENT CONVENTIONS

Mandating and Recommending Phrases:

Even though this document provides guidance only (i.e. no requirement), the following terms are used to refer to compliance with ED-147A [ED-1] whenever a reference to the original is given:

- The use of the word "should" indicates that the criterion is regarded as the preferred option.

Recommendations provided within this document are identified by:

- The use of the word "recommend" indicates that the criterion does not refer to the specifications of ED-147A.

1.3 RELATIONSHIPS TO OTHER EUROCAE DOCUMENTS

TABLE 1.1: RELATION TO OTHER EUROCAE DOCUMENTS

LABEL	DOCUMENT TITLE	ISSUE	DATE	REFERENCE
[ED-1]	EUROCAE DOCUMENT ATM Validation Platforms Interoperability Specification	ED-147A	April 2017	n/a
[ED-2]	EUROCAE WG-81 (Interoperability of ATM Validation Platforms) Terms Of Reference	4.0	September 2015	n/a
[ED-3]	ED-147A RIM – Publish/Subscribe Matrix	ED-147A	April 2017	n/a

1.4 REFERENCES

TABLE 1.2: REFERENCES

LABEL	DOCUMENT TITLE	ISSUE	DATE	REFERENCE
[RD-1]	AIXM Aeronautical Information Exchange Model (http://www.aixm.aero)	5.1	01 Feb 2010	-
[RD-2]	Flight Object Interoperability Specification	ED-133	March 2009	

CHAPTER 2

COMMON COLLABORATION MODEL

2.1

OVERVIEW

This section describes the Common Collaboration Model comprising the basic steps that should be followed in order to achieve Interoperability among ATM Validation Platforms by means of using ED-147A.

The figure below shows the Common Collaboration Model as a V-Model for the validation of a new operational concept.

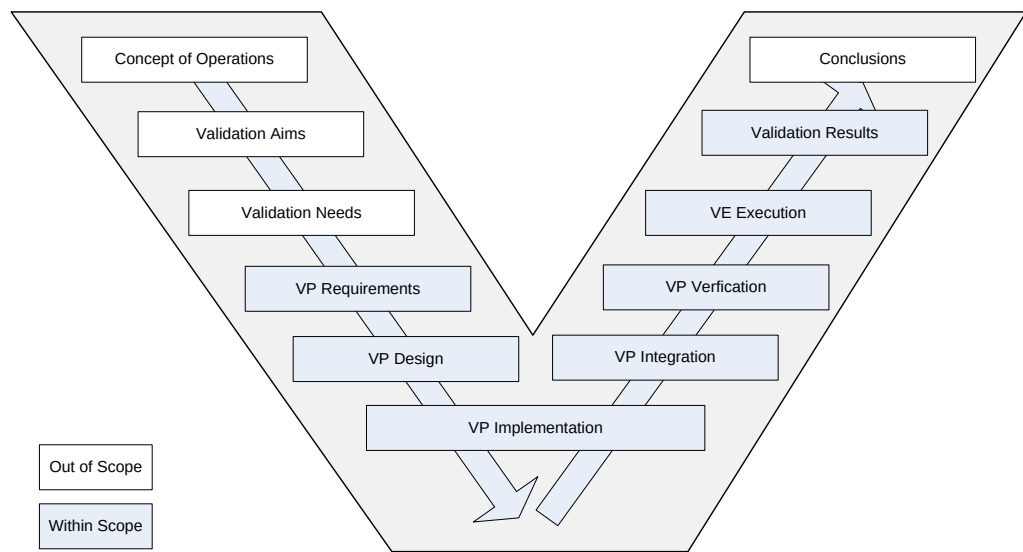


FIGURE 2.1: COMMON COLLABORATION MODEL

Validation Needs derived from Validation Aims are an important input for the engineering process of preparing an ATM Validation Platform for a Validation Exercise, because they express what the Validation Platform users expect from the Validation Platform in order to support their Validation activities.

Typical areas for Validation Needs are:

- Interoperability
- Data preparation
- Data collection
- Data post-processing and analysis
- Exercise Monitoring and Control
- Metrics
- Prototype feeding and emulation
- Validation Platform required capabilities

2.2

VALIDATION PLATFORM IOP REQUIREMENTS

The first activity within the scope of the Common Collaboration Model is the definition of Validation Platform Requirements. Validation Platform Requirements are normally defined by deriving them from existing Validation Needs. Due to the fact the nowadays validation exercises are often investigating cross domain problems, the validation platforms are composed of multiple simulators covering the domains involved.

This means that Validation Platform requirements need to take into account the complexity of the Validation Platform and the way the functionalities are distributed.

Validation Platform users and providers should commonly define and agree on Validation Platform requirements and on the criteria they need to fulfil in order to reach the users acceptance.

Validation Platform requirements should be defined for the following elements of the Experiment:

- ATM Validation Platform
 - Simulator(s)
 - ATM System(s) (optional)
- Interoperability
 - Agent
 - Common Information Model
 - Services
 - Exercise Management
- Network
- Input
 - Environmental data
 - Scenario(s)
- Output
 - Log files
 - Recording

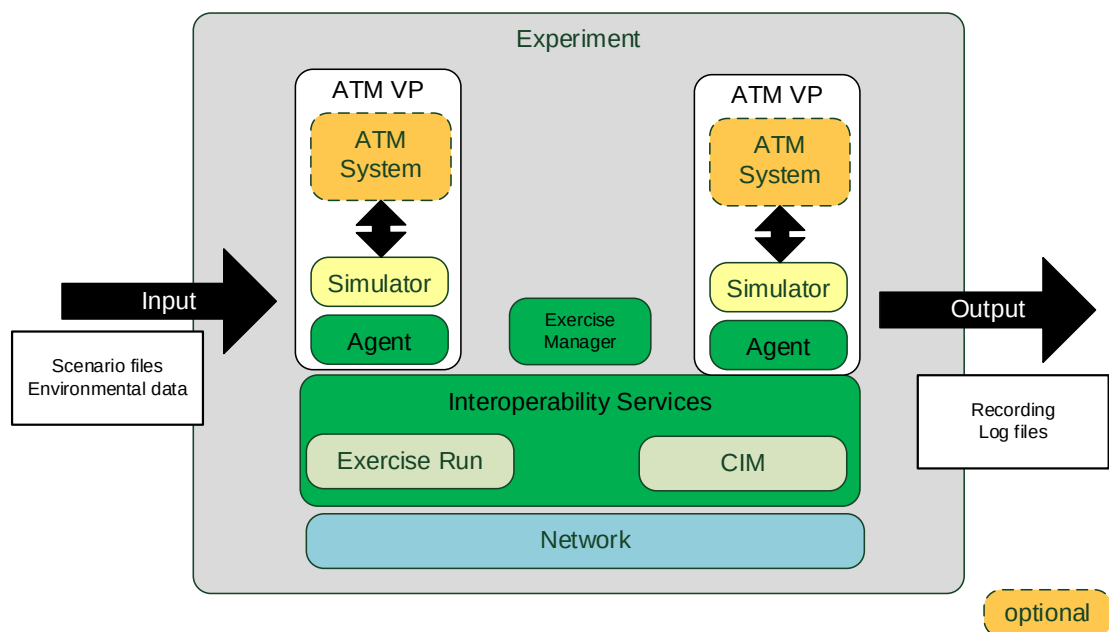


FIGURE 2.2: EXPERIMENT

2.2.1

Experiment Requirements

2.2.1.1

ATM Validation Platform Requirements

ATM Validation Platform Requirements are a relevant part for the fulfilment of the Validation Aims. They cover the requirements for the simulators and, if relevant for the experiment, the ATM systems connected within the same ATM VP. They are mentioned in this document for the sake of completeness, but they are neither in the scope ED-147A nor of this document. They are subject to the VP owner and users and do not need to be shared.

2.2.1.2 Interoperability Requirements

Whenever two or more Validation Platforms have to exchange information, interoperability requirements need to be defined in order to fulfil the validation needs. It needs to be described how the connected simulators are going to interact and which kind of information they have to exchange.

Agent gateways that translate the information from the exercise run to the participating simulators and vice versa are mandatory means to reach interoperability between VP. They are implementing the Interoperability services as described in ED-147A ([ED-1], chapter 3) and connect the VP with the Exercise Management tool that controls and monitors the exercise run.

Another important part of the interoperability requirements deals with the creation of the Common Information Model (CIM), because the CIM reflects the information exchange between the ATM Validation Platforms. The CIM is derived from the Reference Information Model (RIM) ([ED-1], Appendix A) by means of a tailoring process that is explained in ED-147A ([ED-1], chapter 2.4.2) and should be understood as a contract between participating organisations.

Validation Platform capabilities and constraints need to be taken into account for the creation of the CIM as well. Especially constraints from participating Validation Platforms, such as simulators or ATM Systems, need to be shared in this early phase, because they will limit later the capabilities of the Experiment and may eventually jeopardise the Validation Aims.

2.2.1.3 Common Input Requirements

Beside the capability of Validation Platforms to communicate with each other and to interpret correctly the data exchanged at runtime, there is a need to share the same view on the common environment. In case information about, for example, a published waypoint is exchanged, it needs to be ensured before an exercise run that all participating Validation Platforms know this waypoint.

ED-147A [ED-1] describes in chapter 4.3 how Validation exercise participants can commonly agree on standardised formats for environmental and scenario data.

2.2.1.4 Common Output Requirements

In order to ease the analysis of validation exercise results, it is helpful to exchange the collected data from the different VP in a commonly agreed format. The requirements for output data can be found in ED-147A [ED-1], Chapter 4.4.

2.2.1.5 Common Network Infrastructure Requirements

Whenever an experiment is composed of more than one Validation Platform there is a need to connect them via a common network. Even though it is transparent for a Validation Platform whether it is connected with another one by means of a Local Area Network or a Wide Area Network, there is a huge difference with regard to the preparation and implementation of the latter connection.

Wide Area Networks that connect VP from different partners located at different premises are much more challenging, because each partner needs to open his own network in order to establish the communication with the other platforms, which implies potential threats of external network attacks.

As a consequence an agreement of all VE partners on how a common network infrastructure can be built in the most secure way needs to be reached, which may be very time consuming in the phase of planning and implementing.

2.2.1.5.1 Network Security

In order to create a common network infrastructure it is a prerequisite that all partners network security requirements are going to be fulfilled.

Typical security concerns for network requirements are for instance:

- Only outgoing network connections are allowed by the firewall
- Only a single network connection to a certified IOP Service Provider is allowed, which needs to dispatch information between the connected VP and the VPs of the other VE partners, avoiding multilateral network connections
- Only unicast connections are supported, allowing the traceability of network traffic
- All network traffic must be transferred using encryption
- Multicast traffic is prohibited
- Incoming network connections are only allowed from known IP addresses on specific ports enabled by firewall rules

2.2.1.5.2 Network Topology

The set-up of a common network infrastructure may use a network with a **Star Topology** involving a VP Interoperability Service Provider providing a bilateral secured network access between all VE partners and himself. This eases the firewall configuration of the VE partner because the connection to the IOP SP needs to be configured only once. If new VE partners appear they have to be integrated into the common network infrastructure by the IOP SP only.

The creation of a Virtual Private Network (VPN) between all VE partners is another solution that allows multilateral network connections between all VE participants. Composing VP elements by means of a VPN allows the creation of a **Mesh Topology** enabling the balancing of network traffic in a more efficient way than star topologies, which work with a dispatching node in the middle of the star that may lead to bottleneck effects.

The drawback of this solution is the increased configuration effort. Actually, each time a new VE partner needs to be integrated in a VP; all the other participating VE partners have to reconfigure accordingly their firewalls in order to make the common network infrastructure work.

Network connections can be achieved by means of:

- Virtual Private Networks over Internet
- Virtual Private Cloud over Internet
- Customer Dedicated Networks

2.2.1.5.3 Quality requirements

The Overall Network Quality of an Exercise Run is constrained by the Network Quality of each Exercise Participant. Therefore, the weakest Network Quality of an Exercise Participant could impact the Overall Network Quality.

The final result of any Exercise Run could also be directly impacted by the Network Quality of the Exercise Run.

The Overall Network of an Exercise Run will support the exchange of any data objects & messages, and supervision services.

Depending on the Exercise Run requirements, it could also support voice communications, which increases the Quality of Service required through prioritisation of voice packages on the network infrastructure.

In regards of their Exercise Run requirements, it is a best practice that each Exercise Participant checks meticulously its respective Network Quality by the evaluation of the following criteria, as a non-exhaustive list:

- Capacity,
 - e.g. Inbound/Outbound Bandwidth...
- Performance,
 - e.g. Latency, Jitter...
- Consistency,
 - Reliability,
 - Recovery,
- ...

Concerning bandwidth criteria, the Network bandwidth available at an Exercise Participant should depend on the inbound/outbound volume of data necessary to satisfy given Exercise Participant needs.

The associated upload/download bandwidths have to be specified, tailored, and validated in this regard. If not, bottleneck issues may be discovered later in the Validation Exercise runs.

As an example:

- One participant, an Air Traffic Generator, is foreseen to publish the complete traffic for a VE, which leads to a significant outbound data stream that requires a certain upload bandwidth. The participant needs to verify that its network connection supports uploads with the required bandwidth
- All other participants, which consume the traffic, generated by the ATG, need to verify that their download bandwidth is able to support the associated amount of inbound data

2.3 VALIDATION PLATFORM IOP DESIGN

During the design phase it is necessary to decide on the functional breakdown of the Experiment. This means that the participating organisations need to decide, how the required functionality is going to be distributed over the participating Validation Platforms.

Another important aspect of VP IOP Design are the capabilities of Validation Platforms to comply with key architectural concepts for ATM VP Interoperability as described in ED-147A [ED-1] in chapter 3.

It needs to be pointed out that ED-147A does not specify Interoperability of ATM Validation Platforms down to the wire protocol. This means that different implementations of ED-147A are not necessarily interoperable.

This implies that organisations participating to a distributed experiment need to agree on a common Technology Mapping during the planning phase in order to reach Interoperability of their ATM Validation Platforms.

Technology mappings are going to be defined in ED-147B and will describe how a specific technology is going to implement the IOP services.

Even though communication Infrastructures of existing ED-147A implementations are not compatible, bridging them together should be easy to achieve, as long as they are all referring to the same CIM derived from the Reference Information Model (RIM) that can be found in ED-147A ([ED-1], APPENDIX A) and comply with ED-147A ([ED-1], chapter 3).

2.4 VALIDATION PLATFORM IOP IMPLEMENTATION

Once the analysis of the Validation Platform IOP Requirements is completed and it is clear that all participating Validation Platforms are able to fulfil the requirements, a decision needs to be taken on which Technology should be used to implement ED-147A.

Beside technical matters, the financial aspects need to be taken into account as well. Depending on the chosen technology used to implement ED-147A, there may be some costs associated to software licenses and to a common IOP infrastructure delivered by an IOP Service Provider.

2.4.1 Develop Common Information Model

ED-147A ([ED-1], chapter 2.4.3) describes the requirements related to the definition of the Common Information Model (CIM), which is derived from the Reference Information Model (RIM).

In the course of defining the CIM, users are free to extend the RIM with information elements that are not available yet in order to achieve the Validation Platform requirements.

Changes that have been applied to the CIM during a Validation Exercise preparation may be proposed to WG-81 as a change to the existing RIM.

Once the CIM is defined and agreed among the partners, it is recommended to create a Mapping Document that describes the relations between the Agent Gateway and the ATM Validation Platform it connects. The Mapping Document reveals the relations between the Data Transfer Objects and Messages on one hand and the data items of the ATM Validation Platform on the other hand.

These Mapping documents are created for each ATM Validation Platform and do not need to be shared.

The ATM Platform/Adaptation Layer, as part of each Agent, implements this mapping in order to exchange information between the ATM Validation Platform and the Agent Gateway that connects the Validation Platform to the Exercise Run.

It is a best practice to create a Microsoft[®] Excel file from the RIM that can be used as a working paper for reaching an agreement on the CIM. Once the partners have agreed on all attributes to be exchanged the result is taken over in the UML model.

Moreover this Excel file may also contain the publish/subscribe matrix (see chapter 3.3.2) the publication frequency, event type (event vs cyclic) and a default value in case one simulator is unable to deliver a specific value that is mandatory for another one.

2.4.2 Develop Agent

In order to achieve Interoperability of Validation Platforms, Agents need to be developed. Agents are establishing a link between ATM Validation Platforms and the implementation of Runtime Interoperability Services of ED-147A. The details are described in ED-147A chapter 3.3.2.

2.4.2.1 How to implement DTO Ownership Transfer

The Agent owning an Aircraft Object usually initiates the DTO Ownership Transfer by sending an AirHandoverRequest Message. The AirHandoverRequest Message contains the AirHandoverRequestKey, which describes the criteria that needs to be analysed by the receiving Agents.

It is a best practice to use the AirHandoverRequestKey „AHRKT_Frequency“, because this is in-line with operational procedures that send an aircraft to the next sector on a frequency and assuming there is an unambiguous relation between sector and frequency.

For further details refer to ED-147A 3.4.2 Data Transfer Objects and 3.4.5 Object Ownership Transfer and also ED-148 3.2.2 General Ownership Strategy.

2.4.3 Develop Exercise Management

Exercise Management Services (EMS) provide the means to create, monitor and control an Exercise Run.

Create Exercise Run

The only application that is able to create an Exercise Run is the Exercise Manager (EM) by means of an Exercise Manager Gateway. The EM uses the EMS to

instantiate an Exercise Run, which is the basis for all expected Validation Platforms to get connected.

Exercise Monitoring and Control

Once connected the VP sends its current state by means of its Agent Gateway to the Exercise Manager Gateway.

Receiving the Agent state from all participating VPs allows the Exercise Manager to compute the Exercise Run State, which is a prerequisite for the EM to enable the Exercise Run Start Button and for the Supervisor to start the Exercise Run.

In case an Agent Gateway reports a malfunction of its connected VP to the Exercise Run the Exercise Manager is going to change the Exercise Run State accordingly and is thus informing the Supervisor about the degraded mode of the Exercise Run.

There should be only one instance of the Exercise Manager per Exercise Run.

2.5 VALIDATION PLATFORM INTEGRATION

One key enabler for the integration of the Experiment beside the choice of the ED-147A [ED-1] technical mapping is the network infrastructure. The network infrastructure is an important topic because it builds the backbone of any net centric architecture. Depending on the physical architecture of an Exercise Run the participating validation platforms need to communicate either via a Local Area Network (LAN) or a Wide Area Network (WAN).

Especially WAN configurations imply connectivity between different sites and thus have to use external networks like the Internet. Opening validation platforms network to the external world always affects cyber security. A common approach needs to be discussed and organised in an early phase of the validation exercise organisation in order to find a common network setup that complies with the network security requirements of all participating organisations. An early start is necessary because of the time consuming nature of finding an agreement and the extremely long implementation times for setting up such a network configuration.

2.5.1.1 Local VP Integration

It is a best practice to integrate and test the Interoperability of ATM Validation Platforms locally first – if possible. The reason is that problems that might occur during integration tests can be commonly discussed and resolved by the involved teams. Further, with this approach the Integration Teams are able to sort out problems that are typically introduced by Wide Area Network connections.

2.5.1.2 Distributed VP Integration

After successful local integration testing, the validation platforms can be connected via a WAN connection. Integration tests should be re-executed in order to confirm that the Validation Platforms still work together correctly.

2.6 VALIDATION PLATFORM VERIFICATION

Executing validation exercises with humans in the loop is a very costly undertaking, especially when ATCOs are involved. Therefore, it is a prerequisite to verify whether all involved Validation Platforms are working as specified before handing them over to the team executing the validation exercises.

Moreover, it is necessary to test whether the validation platform performance requirements can be met or not. Early measurements testing the network performance help to have enough time to find an alternative solution in case of problems.

2.7 VALIDATION EXERCISE EXECUTION

The execution of a validation exercise is supported by ED-147A by means of the exercise run concept, see [ED-1] chapter 3.3.1.

The exercise run is the overall logical container of runtime operations that supports the execution of the exercise.

The exercise run is created by the exercise manager application and all participating agents are connecting themselves to it once it is created.

The agents communicate with the exercise management application and exchange information concerning the command & control of the exercise run.

The exercise run follows a state based concept that allows the exercise manager to synchronise the connected validation platforms by means of their agents and their current states. The exercise state represents the overall status, which depends on the state of each connected validation platform.

Synchronisation points, the so called exercise run states as defined in ED-1, chapter 3.5.1 exercise run state management, are used to coordinate the connected validation platforms throughout the life cycle of the exercise run.

Once the exercise run has reached the state “Initialized” the start command can be given. It is assumed that all connected validation platforms are running at the same pace thus a desynchronization should not appear during the exercise run lifetime.

After completion of an Exercise Run, or in case a failure is reported by one or more agents, the exercise manager destroys the exercise run.

2.8 VALIDATION RESULTS

Validation results are gathered during the various validation exercise runs that are executed on the participating validation platforms. In order to collect them in a meaningful way it is a prerequisite to agree on common output data formats during the planning phase of an experiment.

Common output data formats allow the people conducting and analysing validation exercises to get a common view on the data collected during a validation exercise and ease the way towards validation tools chains.

2.9 MANAGEMENT

2.9.1 Organisation

The Common Collaboration Model (CCM) proposed in this document is derived from a V-Model. It is intended to help the participants to reach a mutual understanding of both the activities that need to be executed and the deliverables that should be delivered.

Validation exercise milestones (Mx) should help the participants to align their internal processes to the CCM. The figure below shows the processes as a waterfall model of the VP development lifecycle.

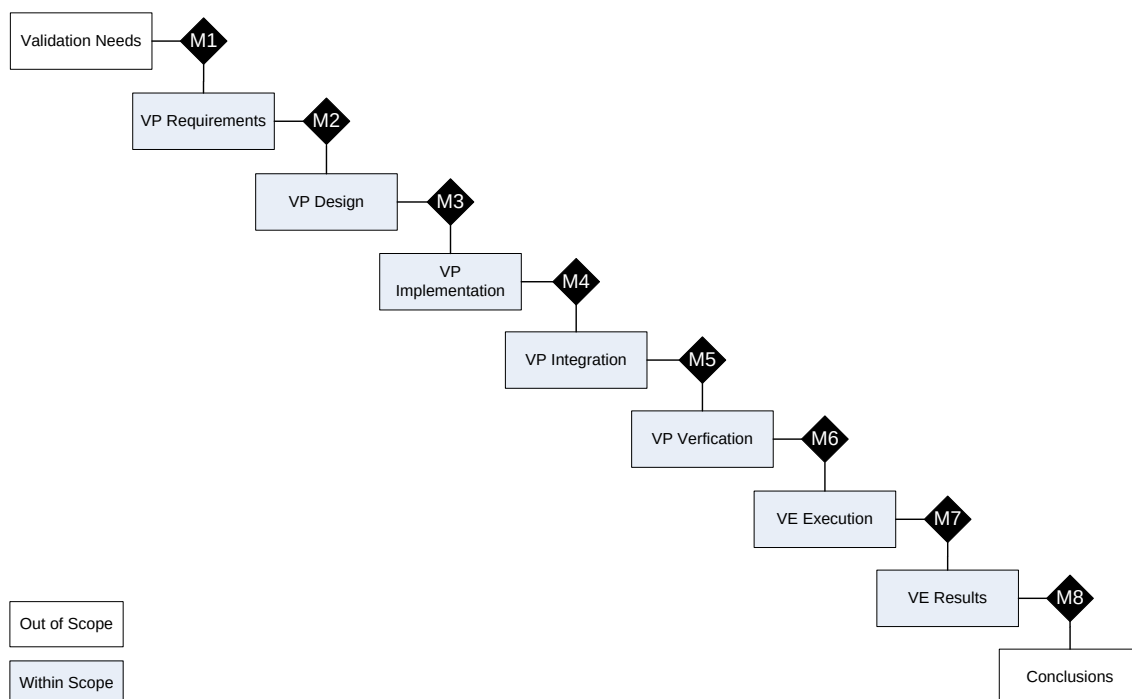


FIGURE 2.3: CCM MILESTONES

TABLE 2.1: CCM MILESTONES

Milestone	Milestone Deliverables
M1	Validation Needs Document
M2	Validation Platform Requirements Document System Requirements for the VP are defined Common Information Model is defined
M3	Validation Platform Design Document Common IOP Architecture is defined ED-147A implementation is chosen All Agent mappings are defined
M4	All Agent Gateways are implemented Common Network Infrastructure is established
M5	All Validation Platforms are configured, integrated and tested Experiment is integrated
M6	Validation Platforms is verified Experiment is ready for Validation Exercise execution
M7	Validation Exercise completed
M8	Validation Platform outputs are processed and Validation Exercise results are prepared

2.9.2

Roles and Responsibilities

For the organisation of a distributed validation exercise, the following roles should be envisaged:

- **Exercise Coordinator**
The Exercise Coordinator is responsible for the management of the overall validation exercise. He/She ensures that the validation aims and validation needs are properly defined and coordinated among all operational stakeholders. He/she further takes care, together with the validation platform coordinator, that the validation platform requirements are correctly defined and in line with the validation needs. The development and coordination of common validation scenarios and common validation environment is also under his/her responsibility.
- **Validation Platform Coordinator**
The validation platform coordinator is the interface between the validation platform users represented by the exercise coordinator and the validation platform developers. He/She ensures that the validation platform is developed in a way that it fulfils the validation platform users' needs. This means that the VP should be able to support the VE execution by means of covering all mandatory validation platform requirements in time. The VP coordinator is responsible for the planning and follow-up of the VP development and integration until the VP is successfully verified and handed over to the VP users.
- **Network Coordinator**
The role of the network coordinator is a key role because of the fact the Interoperability of ATM validation platforms is a network centric issue. This means that the various network requirements of the different participating organisations need to be aligned in order to find a network access solution supported by all the participating organisations hosting validation platform(s).