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Single Aircraft Turnaround Model Verification Test Report

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EXECUTIVE SUMMARY

This document presents the verification tests performed over the Single Aircraft Turnaround Model. First the technique used is introduced and justified, and then the tests ordered by its associated high level verification objectives are listed. For each high level verification objective, the performed tests are shown in tables. These tables show the inputs used in each test, the hypothesis made and the measures done. Finally the results of the tests are presented together with some notes when the tests were not passed or passed with conditions.

1. INTRODUCTION

1.1 Purpose

The main objective of the present document is to describe the verification test reports used to assess that the Single Aircraft Turnaround Model has been built correctly. Since verification is based in determining if the operational logic of the model corresponds to the logic design, the purpose of these tests will be to find mistakes in the model. This document describes the results of the tests performed over the Single Aircraft Turnaround Model last version 0.0.450.

1.2 Document Structure

This document is structured in four parts:

- The first section is this introduction which presents the purpose, structure, audience, references and abbreviations and acronyms of the document.
- The second section introduces the technique used for the verification.
- The third section contains the verification test reports.
- The last section includes some conclusions on the verification activities.

1.3 Intended Audience

This document may be distributed freely within the TITAN consortium, both to those who are involved in the use of the model as well as stakeholders to check consistency in the model.

1.4 Associated Documentation

[1] Laurie Williams, Testing Overview and Black-Box Testing Techniques, 2006

[2] TITAN D1.4 “Operational Concept Document (Issue 1)”, INECO, Version 1.0, October 2010

[3] TITAN D2.1 “Technical Requirements Document”, CRIDA, Version 1.0, July 2011

[4] TITAN D3.2 “Validation Exercise Plan”, ISDEFE, Version 0.6, October 2011

[5] Single Aircraft Turnaround Model version 0.0.450

1.5 Abbreviations and Acronyms

AOBT	Actual Off Block Time
AST	Actual Start Time
ECT	Estimated Completion Time
EIBT	Estimated In Block Time
EOBT	Estimated Off Block Time
SIBT	Scheduled In Block Time
SOBT	Scheduled Off Block Time
STTT	Scheduled Turnaround Time
TITAN	Turnaround Integration in Trajectory and Network
V&V	Validation and Verification

2. VERIFICATION

Verification is the process of evaluating a system or component to determine whether the products of a given development phase satisfy the conditions imposed at the start of the development phase.

Verification can be done in development, scale-up, or production phase of the product. It is often an internal process contrary to validation process which acts as an external process ensuring that the system is built to satisfy the customer requirements.

Whereas verification can be expressed by the question 'Are we building the **system** right?' validation is expressed by the query 'Are we building the **right** system?'

With the purpose of checking that the specifications are correctly implemented by the system, verification activities include testing and reviews.

2.1 The Logic model

When a model is verified, the aim is to determine if its logic has been correctly implemented. Therefore, next questions should be answered throughout this document:

- Are model events correctly processed?
- Are the relationships included in the model valid?

2.2 Software testing

Software testing, which is one of the software practices included in the V&V activities, is an important technique for assessing the quality of a software product.

This process analyzes a software item to detect the differences between existing and required conditions (that is, bugs) and to evaluate the features of the software item. Software testing is an activity that should be done throughout the whole development process.

2.2.1 Black box testing technique

This technique, also called functional testing, ignores the internal mechanism of a system or component and focuses solely on the outputs generated in response to selected inputs and execution conditions.

This will be the technique used to evaluate the Single Aircraft Turnaround Model since the code is considered as a "big black box" where the information is an input to the black box, and the black box produces other information as output. Based on the requirements knowledge, we know what to expect the black box to send out and test the model to make sure the black box sends out what is expected.

3. VERIFICATION OF THE SINGLE AIRCRAFT TURNAROUND MODEL

The verification tests are presented in the tables below. They describe the hypothesis, measures and consequently the problems encountered when verifying the model. Verification criteria

The Single Aircraft Turnaround model has been verified with several tests which consider the technical requirements established in [3] that should be fulfilled by this model.

The verification tests have been grouped according to their High Level Objective. These are classified into four categories which have been established depending on the type of verification they do. A brief explanation about each High Level Objective is now presented in order to clarify the tables below:

- Data Input Verification: It refers to the information introduced into the model which serves as an input and allows the simulation.
- Data Output Verification: It refers to the information provided by the model after the simulation.
- Simulation Verification: It includes all the elements (processes, resources...) contributing to the simulation. It explicitly verifies the simulation.
- Verification of the consistency of the results: The results obtained after the simulation are analyzed.

Each High Level Objective is split into several Low Level Verification Objectives which provide a more specific description about the verification done. These Low Level Verification Objectives will be verified with different tests.

Each test contains its own Hypothesis about the expected results. The Measures column explains what should be tested and the way of executing the tests. The Severity column defines the degree of need for the developers to correct the problems. The severity level is expressed as follows (in descending order of severity):

5- As soon as possible

4- Almost as soon as possible

3- When possible

2- Needed

1- If possible

3.1 Scenario dataset

According to the Validation Scenario data defined in [4], the data inputs to be considered by the model are listed below:

- Number of flights, Number of passengers for flight, special passenger rate, number of passengers to perform the check-in for any flight, number of passengers to perform the passport control for any flight SIBT, EIBT, SOBT, EOBT, AOBT.
- Flight type, stand type, aircraft type.
- Total check-in desks, security and passport control desks in the airport, total number of gates and its associated airlines and properties.

- Passenger travel distances in the airport (i.e. from check in desk to security control, from security control to boarding gate, etc.), mobile resources medium travel distances, estimated average time per passenger for boarding/de-boarding.
- Standard planned duration of the aircraft handling processes, standard processes planned duration, standard elapsed time.
- External delays, forced delay in all the processes, possible forced delay in % of the turnaround processes, STTT of any flight.
- Is de-icing scheduled?, standard required resources.
- Total number and type of boarding/de-boarding facilities and their availability for the airport, Total number and type of handling processes facilities and their availability for the airport, Total number of Airport safety facilities and their availability, Total number of de-icing facilities in the airport, Total number of Fuelling facilities and their availability.
- % of gate reallocation at short notice, % of passenger arriving late XX minutes, % of unavailability of a service.

A simplified current turnaround scenario has been used to test the Single Aircraft Model. This turnaround is composed by one departure flight and one arrival flight. Each flight has ten passengers. Flight, passengers, processes and gate properties, as well as the number and kind of resources available, change according to the tests hypothesis and goals.

For the verification tests, these properties vary by means of giving different values to the data inputs presented above.

3.2 High Level Objective: Data input verification

Low Level Verification Objective	Test Id.	Measures	Expected results	Notes	Severity	Results
The model allows introducing the data inputs.	**DI-001**	Check if the inputs reflected in the validation scenarios can be introduced in the model.	The listed inputs in the Validation Scenarios can be introduced in the model.			Passed.
The model allows modifying the data inputs.	**DI-002**	Check if all the introduced inputs can be modified.	Once the data input are introduced, they may be modified whenever it is needed.			Passed.
The model allows saving the data inputs.	**DI-003**	After introducing the inputs, the scenario is saved and then closed. After opening the saved Scenario, it is checked that the changes have been saved.	Once the scenario dataset is saved, the model is able to read and implement the scenario dataset.			Passed
The range of values of the data input parameters are consistent to the validation objectives.	**DI-004**	Check that the required range of values set in the validation objectives may be introduced in the model (e.g. number of passenger of an aircraft between 1 and 600 passengers, number of check in desks between 1 and 1000).	Data input can be introduced within a range of values coherent with the validation exercise objectives.			Passed.
The model does not accept any data input parameters out of the boundaries of the defined range of	**DI-005**	Check that it is not possible to introduce data input parameters which are not consistent with the validation objectives (e.g. number of	Data input cannot be introduced out of a range of values coherent with the validation exercise objectives.	All the values that we are going to use can be introduced. An error alarm appears when trying to introduce values out of the		Passed.

Low Level Verification Objective	Test Id.	Measures	Expected results	Notes	Severity	Results
values.		passengers smaller than 1).		defined value range.		
The model does not accept invalid values.	**DI-006**	Check the model behaviour when introducing data inputs with invalid values (e.g. end time before start time, character instead of integer).	Data input with invalid values are not accepted by the model.			Passed.

Table 1: Data Input Verification Tests

3.3 High level Objective: Data Output Verification

Low Level Verification Objective	Test Id.	Measures	Expected results	Notes	Severity	Results
The model provides the data outputs in graphical and text formats.	**DO-001**	After introducing the data input, the simulation is run and the data output are analysed.	The model provides graphical information during the simulation about the status of the turnaround processes. The file obtained after the simulation shows the data outputs in text format.			Passed.
The data outputs obtained are consistent with the data inputs.	**DO-002**	After introducing the data input, the simulation is run and the data output are analysed.	The model reacts as it is expected according to the data input introduced.	Capacity property for resources (e.g.: to set up a maximum number of passengers using the bus) did not work as expected. The 'Batch node' has been created to solve this issue. This node batches entities is a container. The entities packed pass through the following node of the network (normally a resource node) as a unique entity (container).	1	Passed with conditions
				Resource node did not work as expected, taking one resource for each entity. It was solved by creating 'One Time Node' When a 'One Time Node' is included within a process, this process uses this resource	1	

Low Level Verification Objective	Test Id.	Measures	Expected results	Notes	Severity	Results
				since the start of the process until the end. This way, all the entities of the same flight use the same resource. However, entities do not spend time when passing through 'one time node'. (passengers or other entities using the resource). A workaround has been used to simulate the time per passenger using the resource. It creates a queue before the 'One time Node'.		
Data outputs are provided at the precise moment and with the frequency required to monitor and analyse the results.	**DO-003**	After introducing the data inputs, the simulation is run and the data outputs are analysed at the time they appear.	The data output are obtained when expected.			Passed
Data output files contain validation metrics.	**DO-004**	After running a simulation, the data output files are opened and their content is analysed.	Validation objectives can be assessed using the output files if following qualitative and quantitative information is available: - Start and end of each process. - Register of the used resources. - Register of flights.			Passed

Low Level Verification Objective	Test Id.	Measures	Expected results	Notes	Severity	Results
			- Register of disruptions or unexpected events.			
Data output files can be used easily for the output analysis.	**DO-005**	After running a simulation, the data output files are opened and analysed. The data are inserted in excel tables and filtered upon several criteria.	Validation objectives can be assessed in a user-friendly way by using the output files.	An entity filter was created to configure the data output presentation. Data outputs are not always obtained in appropriate way in the following cases: High lack of resources or high traffic density (30% increment). In those cases data regarding last flight processes of the traffic sample is not provided sometimes. Therefore, more number of simulation runs is needed to obtain valid results.	1	Passed with conditions.

Table 2: Data Output Verification Tests

3.4 High level Objective: Simulation Verification

Low Level Verification Objective	Test Id.	Measures	Expected results	Notes	Severity	Results
The process editor works as expected.	**SV-001**	Define each one of the node types in the process editor by changing its properties.	The model allows adding and deleting nodes as well as editing their properties.			Passed.
	SV-002	Define the interaction between nodes (network) by modelling several turnaround processes (e.g. check-in, security, boarding...).	The model allows establishing several links between nodes. Each node, depending on its type, can be linked to one or two subsequent nodes.			Passed.
	SV-003	After defining several node types and the network relating to them, the model is run and the entity output file is analysed. Several entities with different properties are filtered and its flow through the nodes is analysed.	The entities flow through the nodes during the simulation. The path followed depends on the rules applied in each node as well as the network defined.			Passed.
The nodes work adequately.	**SV-004**	After defining several node types and the network relating to them, the model is run and the entity output file is analysed. The time spent for each entity in each node is observed.	The time spent by the entities in the nodes obeys node criteria according to entity properties.			Passed.
	SV-005	After defining several node types and the network relating to them, the model is run and the entity output file is analysed. Specific rules corresponding to each node type (e.g. resource booking, conditionals, queues...) are checked.	Node rules are followed according to the nature of each node type.	Some parameters do not work in resource node such as time to aircraft, time at aircraft and time to gate. However new	1	Passed with conditions.

Low Level Verification Objective	Test Id.	Measures	Expected results	Notes	Severity	Results
				solutions/ workarounds were implemented to allow modelling these scenario parameters (e.g. new kind of resource nodes).		
Process relationships work properly.	**SV-006**	After defining several node types and the network relating to them, the model is run and the process and entity output files are analysed. The start and end times of processes are observed and compared to the first and last entity passing through the concerned process.	Time constraints between processes are carried out.			Passed.
	SV-007	After defining several node types and the network relating to them, the model is run and the process and entity output files are analysed. Processes times (start and end times) are observed to check if the process rules are being carried out.	Rules about processes are obeyed (e.g. close a process when all the entities have passed or wait until the last entity passes).			Passed.
Process durations are coherent with the data input introduced.	**SV-008**	After defining several node types and the network relating to them, the model is run and the process output file is analysed. Processes durations are observed and compared to the data input time defined.	Processes last according to data input durations introduced.			Passed.
Resource Management works	**SV-009**	After defining several node types and the network relating to them, the model is run and the resource output file is	Fixed resource management is carried out as expected.			Passed

Low Level Verification Objective	Test Id.	Measures	Expected results	Notes	Severity	Results
properly.		analysed. Durations of the use of the fixed resource are observed as well as the way in which each resource is used (how it is transferred from one entity to another)				
	SV-010	After defining several node types and the network relating to them, the model is run and the resource output file is analysed. Durations of the use of the mobile resource are observed as well as the way in which each resource is used (how it is transferred from one entity to another)	Mobile resource management is carried out as expected.			Passed
The value of the data inputs is properly modelled.s.	**SV-011**	After defining several node types and the network relating to them, the model is run and the input and output files are analysed taking into account the data input values introduced. It is ensured that the distributions, data values, etc. are well interpreted by the model.	The model interprets correctly the data input values (e.g. the mobile resource capacity is coherent with the data value introduced or the number of special passengers generated by the model follow the distribution introduced)			Passed

Table 3: Simulation Verification Tests

3.5 High level objective: Verification of the consistency of the results

Low Level Verification Objective	Test Id.	Measures	Hypothesis	Notes	Severity	Results
The simulation of one generic airport delivers results similar to reality.	**RC-001**	Data input are introduced and the simulation is run.	The results obtained after the simulation (e.g. times spent in the processes, resources used...) correspond to reality.			Passed.
The model behaviour is as expected (with respect to today's operations).	**RC-002**	Data input are introduced and the simulation is run. Disruptions, lack of resources or delays are introduced and the way in which the model simulates these scenarios is analysed.	The model results maintain consistency with real reactions as it is expected according to the validation objectives data input introduced (e.g. Number of delays increase in more restrictive scenarios).	Close immediately functionality does not work as expected. If AST>ECT for a turnaround process, its duration is zero. Validation scenario definition and analysis should be performed taking into account this fact.	2	Passed with conditions
Errors are adequately reported.	**RC-003**	Data input are introduced with non valid relations between them. The simulation is run and Error file is analysed.	The model reports errors when there is no consistency between the data input or the processes involved in the turnaround.			Passed.
The sequence of the turnaround sub-processes is the established in the TITAN Operational concept [2].	**RC-004**	Data input are introduced and the simulation is run.	The sequence of the turnaround sub-processes which appears at the end of the simulation is the established one in the TITAN Operational concept (e.g. check in is realised always before boarding)			Passed.

Table 4: Consistency Verification Tests

4. CONCLUSIONS

High and low level verification objectives have been checked. Most of the results of verification are positive (22 out of 26 tests were passed); however some of them have been passed with conditions. These issues have been solved with restrictions, which have been classified in severity levels, and finally do not affect the model.

The open issues are related to three minor problems encountered:

- Some resource parameters do not work as expected but different solutions were encountered to satisfy the requirements; even though these parameters still do not work.
- When the resources available are very low (with respect to the traffic sample), sometimes the model is not able to finish the simulation (completing all the turnaround processes). This fact indicates the need to repeat these simulations more times than others to achieve the required confidence interval.
- The functionality 'close immediately' for the turnaround processes does not work as expected when the delays in the model are high (bigger than one or two hours).

The following table summarizes the issues found while verifying the Single Aircraft Turnaround Model version 0.0.450.

Test Id.	Issue	Severity
DO-002	Capacity property for resources (e.g.: to set up a maximum number of passengers using the bus) did not work as expected. The 'Batch node' has been created to solve this issue.	1
	Resource node did not work as expected, taking one entity per resource. It was solved by creating 'One Time Node'.	1
DO-005	Data outputs are not obtained in appropriate way in the following cases: High lack of resources or high traffic density (30% increment). In those cases data regarding last flight processes of the traffic sample is not provided sometimes. Therefore, a great number of simulation runs is needed to obtained valid results.	1
SV-005	Some parameters do not work in resource node such as time to aircraft, time at aircraft and time to gate. However new solutions/workarounds were implemented to allow modelling these scenario parameters (e.g. new kind of resources nodes)	1
RC-002	"Close immediately" functionality does not work as expected. If AST>ECT for a turnaround process, its duration is zero.	2

The final conclusion is that the model passes the verification test with enough accuracy to carry out the simulations.