D4.1-CERTIFLIGHT solution verification plan

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APPLICABLE DOCUMENTS		
Ref.	File Name	Description
AD 1	Grant Agreement-101082484-CERTIFLIGHT	Project Grant Agreement
AD 2	D2.6-CONOPS and System Requirements	CERTIFLIGHT System Requirements and Conops specification.
AD 3	D3.1 - UTM Box user manual	User Manual and Specification of the UTM Box
AD 4	D3.2 - CERTIFLIGHT platform user manual	User Manual and Specification of Certiflight platform
AD 5	TN2: MAIA UTM update IF/ICD report	Update of the SW Interface of MAIA UTM with Certiflight platform.
AD 6	TN3: D-FLIGHT UTM update IF/ICD report	Update of the SW Interface of D-FLIGHT with Certiflight platform.
AD 7	TN4: e-Conspicuity SW library documentation	Technical specification of e-Conspicuity SW library for UTM Box
AD 8	TN5: DKF and Spoofing detection SW library documentation	Technical specification SW library of GNSS Algorithms for Spoofing detection for Certiflight platform.
AD 9	TN6: UNIFLY UTM update IF/ICD report	Update of the SW Interface of Unifly UTM with Certiflight platform.
AD 10	D1.2 - Project Management Plan v2.0	Project Management Plan document v2.0 with updated Risk Matrix

REFERENCE DOCUMENTS		
Ref.	File Name	Description
RD 1	https://www.cellmapper.net	Map for 3G/4G/5G Mobile base station installations, with operational frequency bands and Telecom Operators
RD 2	https://www.aerobits.pl/product/omni-directional-ground-station	ADS-B / FLARM Omnidirectional Ground Station (Rx)
RD 3	https://www.aerobits.pl/product/eval-tt-sf1/	OEM Transceiver for FLARM /ADS-B signals
RD 4	https://www.easa.europa.eu/en/document-library/general-publications/remote-identification-will-become-mandatory-drones-across	New EASA regulation regarding the Direct Remote identification for drones.

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SUMMARY

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Abstract

This document represents the contractual deliverable D4.1 – CERTIFLIGHT solution verification plan. It provides the verification plan against the most important functional chains of Certiflight platform and for the single Units / Subsystems of the related Architecture described in D2.6 document.

The verification plan will be deployed in the upcoming months after the finalization of the relevant technologies involved in Certiflight that shall be integrated and verified within WP4 timeframe. In this phase the Integration of the full solution will be therefore achieved, considering all I/Fs of the different blocks of the architecture (i.e. Devices, Certiflight Portal, USSPs).

The document provides the description of the test cases identified in chapter §4 that will be used by the Consortium to design the test environments in some cases and to implement the tests related to single units or functional chains.

Finally, a temporal plan for integration activities and the implementation of tests described is presented in §5.

1 Scope of the document

The scope of the document is to define the verification plan to fulfil the system requirements defined in the System Requirements document (D2.6). The plan includes the definition of test cases and relevant test procedures for both unit test and system tests. The system tests are related to the verification of specific functional chains.

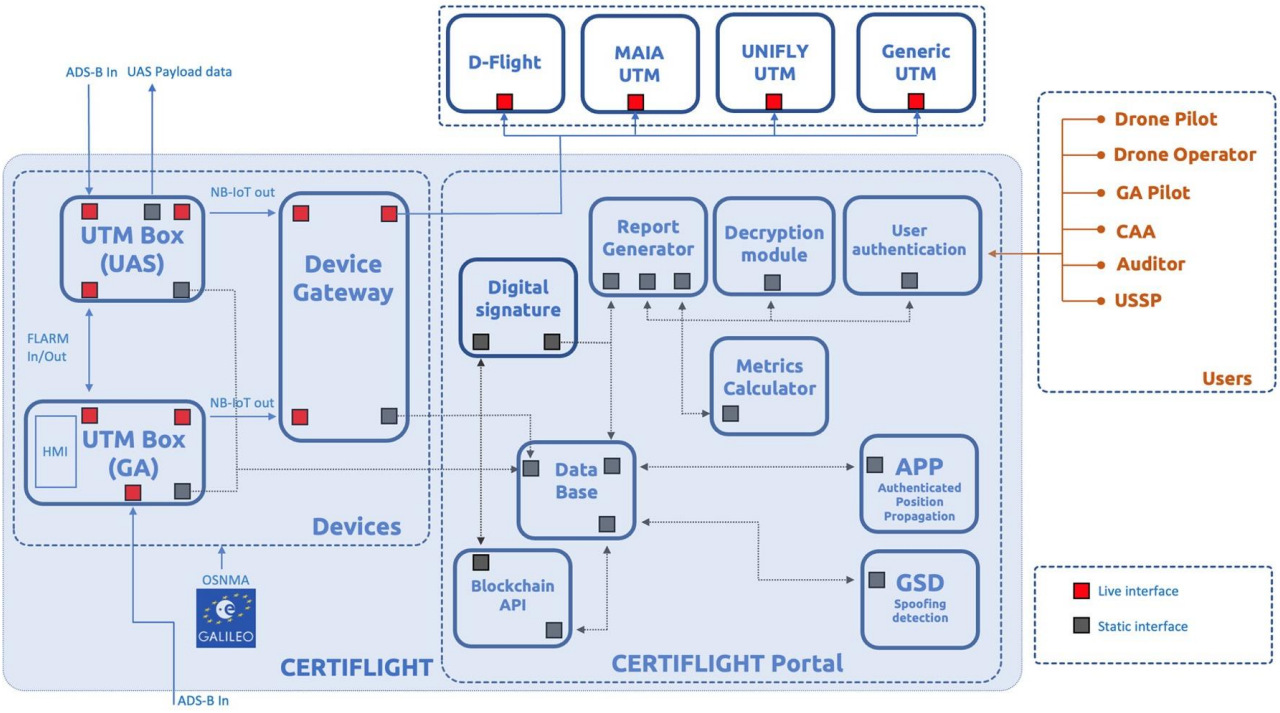

Figure 1-1 System architecture

To facilitate the reading, the Architecture of Certiflight is reproposed in the Figure 1-1, with a brief explanation of each block and the elicitation of the main I/Fs.

- **Devices:** The digital EGNSS/IoT UTM Box(s) installed on UASs and GA manned aircraft, equipped with an OSNMA Galileo/EGNOS enabled receiver, capable to guarantee the authenticity of their position information at the origin.
  - the **UTM Box** (UAS and GA) integrates GNSS and IMU sensors capable of providing information on the position, attitude, barometric and geometric altitude. Raw data of sensors are stored on board for post-processing. The chain of trust is enforced through anti-tampering mechanisms and cyphering algorithms.
  - The **Device Gateway** is the exchange node between Certiflight UTM Box and all the registered elements (CERTIFLIGHT Portal and other UTM/USSP providers) which implement tracking services relying on the authenticated information enhanced by security features, provided by the device.

- **Certiflight Portal:** it is the access point for every user to Certiflight services. Each identified stakeholder may access with his/her profile for configuration, data ingestion, retrieving, visualization and reporting features. The collected data and the final report(s) allow the user to have all the certified information for in-flight and post-flight services.

- **User Authentication:** It is the module responsible for registration and authentication of Certiflight users.
- **Digital Signature:** This module provides a signature of the data provided in input. In the case of PDF reports, documents are issued in the PAdES format, according to the specification reported in ETSI EN319142. This feature is achieved in combination with the Report Generator module.
- **Report Generator**: Certiflight system issues signed reports to the users to guarantee the integrity and authenticity of the exported data.
- **Decryption Module:** This module is used for deciphering the data transmitted by the UTM Box for real time transmission and post flight data download.
- **Metrics Calculator:** Simple metrics related to real time data provided by the UTM Box are calculated in this module for insertion in the Light Report.
- **Data base:** It is the default structure for storing and retrieving data associated to users (Real time data and post-fight data)
- **Blockchain API**: This block provides security chain based on Blockchain Service through a simplified API developed into the Certiflight system for providing long-term data integrity and storage as well as services complementary to the CERTIFLIGHT Portal (e.g. respect of contracts, unlock of payments, …)
- **Authenticated Position Propagation (APP) Module:** The APP function outcomes will be integrated in the "Full report". The input to APP algorithm, specified in the requirement CFT-SYS-0950 of D2.6 document allows the algorithm to provide the following information, in post-flight, to be included in the full report:
  - a trustable position information starting from an authenticated position
  - computation of the propagated position to reinforce the authenticity of the PVT solution and the UAS trajectory in post flight phase.
  - authenticated UAS trajectory.
  - protection of the solution from potential spoofing attacks aimed to manipulate the true position
- **Spoofing detection Module (GSD):** The GSD function outcomes will be integrated in the full report. The input to GSD algorithm is specified in the requirement CFT-SYS-0990 of D2.6 document. The purpose of the GSD algorithm is:
  - to guarantee the authenticity of data generated by the UTM Box, providing indications whether the authenticated PVT solution is genuine (Spoofing / Meaconing free).
  - To be able to indicate the level of confidence/trust of the authenticated position during all flight, providing indicators/metrics in correspondence to significant events (i.e. no OSNMA satellites present in the solution, values below threshold of defined indicator).

- **UTM/USSP Interfaces:** The UTMs/USSPs are connected to CERTIFLIGHT in two ways:
  - Through the Device Gateway for Tracking and Authenticated tracking services; in this case each UTM service provider has its own ICD I/F detailed in three specific technical notes.
  - Through direct access to Certiflight platform for post flight services retrieval. In this case, the UTM service provider logs-in as a user for retrieving the post flight Reports.

1.1 Acronyms

Acronyms	Description
APP	Authenticated Position Propagation
AuTRS	Authenticated Tracking Service
BVLOS	Beyond Visual Line of Sight
COTS	Commercial Off-The-Shelf
EGNSS	European Global Navigation Satellite System
GA	General Aviation
GNSS	Global Navigation Satellite System
GSD	GNSS Spoofing Detection
I/F	Interface
NM	Nautical Miles
OSNMA	Open Service Navigation Message Authentication
TRS	Tracking Service
UAS	Unmanned Aerial System
USSP	U-space Service Provider
UTM	Unmanned Traffic Management
VLL	Very-Low-Level

Table 1-1 Acronyms list

2 Verification strategy

The verification strategy related to WP4 (Integration and verification activities) follows a System Engineering approach (V diagram) through a classical waterfall methodology.
The specific tailoring with respect to WP4 deliverables and relevant information is hereafter explained, through the following main steps:

- The Concept of Operations and the System Requirements are specified in D2.6 document – CONOPS and System Requirements. This document provides the list of Requirements that will be used in this phase for the verification plan.
- The Most critical requirements (typically those which verification method is via “test” in the System Requirement document) will be the focus of the verification plan. The approach for the verification is included in D4.1 (this document). The verification plan includes unit tests related to single blocks/units and test for the functional chains that involve more than one Subsystem, respectively:
  - Devices
  - Certiflight Portal
  - USSP/UTM

  with respect to Certiflight architecture presented in Figure 1-1.
- The Unit tests are grouped in three main typologies of tests related to EGNSS Algorithms, UTM Box and Certiflight Platform. The Test Results of such tests will be reported in the respective technical notes:
  - D4.2 - TN7: EGNSS functional test report for all tests regarding innovative Spoofing detection algorithms (GSD / APP).
  - D4.3 - TN8: UTM Box functional test report, for tests concerning the UTM box for UAS and GA version
  - D4.4 – TN9: CERTIFLIGHT Software test report, concerning the verification tests for the Certiflight Software-In-Cloud platform
- All test results will be included in the D4.5 document – Certiflight solution integration and verification report tests, that will wrap the unit test outcomes implemented in the technical notes and the test concerning the functional chains. The main functional chains concern the following aspects:
  - communication chain with the UTM BOX
  - Data security
  - Data retrieving in the Blockchain infrastructure for permanent, unalterable storing
  - Light Report generation
  - Full Report generation
  - Interface with UTM Service Providers for tracking and authenticated tracking
- According to System Engineering methodology, the D4.5 document will also contain the verification Matrix covering all the requirements specified in D2.6, including those which verification method is other than “TEST” (i.e. Analysis, Inspection or Review of Design) and the results of alpha testing for which the full integrated solution is needed.
- Finally, after the completion of the verification phase, the final stakeholders will be invited for the validation phase (i.e. beta testing with UAS and GA pilots supporting associations and Consortium partners). A similar approach will be followed in WP5, through the validation plan

and validation report for the fulfilment of Users' needs identified, having this time also the final stakeholders in the validation loop.

The verification plan therefore identifies a series of test cases aimed to address specific System requirements. A specification of each test case is provided with the relevant high level test procedure. When needed the procedures of tests and the testing environment will be detailed respectively in the Technical Notes D4.2, D4.3, D4.4 and in the Test Results document (D4.5).

3 Verification process

The verification process is reported below, according with the verification strategy described in the previous section.

Starting from the System Requirements [AD 2], namely from the requirements whose verification method is "TEST", specific test cases are designed in order to cover one or more requirement.
As said above, test cases are designed to verify single units, but can also address functional chains.
In the case that the identified verification method for a specific requirement is "Analysis", it is evaluated if a Specific Test case, involving for instance simulation activities, is needed to support such analysis.

Naturally, the full System Requirements matrix will cover al System Requirements, including also those requirements whose verification method is different from "TEST".
The following possibilities are considered:

- Verification by RoD/I: in this case a short description is provided in correspondence of each requirement to justify how the requirement is fulfilled. Each requirement, with respect to Certiflight Architecture specification, will exhibit therefore one of the following possibiltiies:
    - Compliant – "C": No actions needed;
    - Partially Compliant – "PC": Some actions might be needed for fixing the non-compliance points. A Remark will be included to better specify the non-compliant points
    - Non-Compliant – "NC": Some activities are needed for fixing the non-compliance. In case of activities that require disruptive actions or that can have substantial effects on the final service, the convocation of the Consortium General Assembly and / or the Advisory Board shall be considered for verification with final stakeholders and Certiflight Users, whether the effect is still acceptable or other mitigation mechanisms must be put in place.

  The justification is included in the Verification Control Matrix (D4.5)

- Verification by T: in this case the following activities will be performed:
    - Test cases specification: Test cases are defined, and a description of the test activity is given. The Test case is linked to the relevant requirements in order to verify the final fulfilment and to facilitate the overall verification process when working on the Verification Control Matrix (D4.5)
    - Test procedures specifications: Test cases are detailed with test procedures explaining how to execute the relevant test case step by step. If needed, additional instructions

for the test procedures can be detailed in the respective technical notes (where also outcomes of the tests are reported).

- Test execution: the realization of tests including output data collecting and data analysis when relevant.
- Test report preparation: Finally, a test report is prepared. The report will respect the fail/pass criteria defined in the test case specification. In case a test fails, or partial fulfilment of the test is registered, specific corrective actions shall be put in place on the target unit or subsystem.

The Verification Control Matrix, including compliance and the traceability for all requirements, will be specified in the D4.5 document.

3.1 Requirements classification

In this section a brief explanation of each typology of System Requirement is provided since the full explanation has been already provided in D2.6 [RD 1].

Name	Description
General	This kind of system requirements identifies the general requirements applicable to all CERTIFLIGHT ecosystem.
Functional	This kind of system requirements identify the functionalities to be implemented by CERTIFLIGHT platform
Interface	This kind of system requirements identifies the main logical and physical Interfaces of CERTIFLIGHT platform to internal and external Subsystems/modules/elements as the interface to external USSPs.
Performance	It identifies the performance that CERTIFLIGHT services shall guarantee
Security	It specifies the security requirements to be implemented by CERTIFLIGHT platform (i.e. chain of Trust, OSNMA, anti-tampering mechanisms of UTM Box, Blockchain node)
Operational	It specifies the Operational and usability requirements in good part to be collected by final users' feedback (i.e. Survey, Advisory Board) and UAS Operators, considering installation constraints of the UTM Box on GA and UAS, environmental requirements as temperature range, CERTIFLIGHT platform access.
Regulatory	It specifies any requirement applicable to CERTIFLIGHT platform derived from applicable regulations or Standard recommendation. For the implementation of Digital Logbook and Legal Recording Service it is mandatory to specify the requirements that standardization bodies or regulation impose
Business	It specifies any requirement applicable to CERTIFLIGHT platform derived from market analysis (i.e. competitor survey of any model of business to be followed/ implemented) that cause an impact on the UTM Box, Certiflight Services or to the architecture in general.

Table 3-1 Description of requirements typologies

3.2 Methods

This section briefly outlines the various verification methods employed to ensure the accuracy, completeness, and consistency of the System Requirements, to facilitate the verification and validation phases. In fact, verification is a critical step in the system development lifecycle that validates whether the requirements are well-defined, achievable, and aligned with stakeholder needs.
The following verification methods have been considered:

Verification Methods	Description
Test (T)	Test cases are designed to assess whether the system, as implemented, satisfies the specified requirements. Test methods can include functional testing, performance testing, usability testing, and other relevant techniques
Analysis (A)	Analysis is a verification method that involves the use of mathematical models, simulations, or other analytical techniques to assess the system requirements.
Review of Design (RoD)	The review of design is another verification method that assesses the system requirements against the proposed design solution. This method involves evaluating how well the requirements align with the overall system design, architectural choices, and technical constraints
Inspection (I)	Inspection is a verification method that involves a systematic and detailed examination of the system requirements. It typically involves a team of experts who meticulously review the requirements to identify any inconsistencies, ambiguities, or omissions

Table 3-2 Verification Methods

Starting from the verification methods identified for System Requirements defined in D2.6 [RD 1], the verification plan will maintain the traceability from the System Requirements to be verified by “Test” (T) and some of the System Requirements to be verified by “Analysis” (A), in particular those that needs the development of specific test environments for simulations.

The abovementioned traceability will be kept through the definition of specific Test Cases. Each Test case may cover more than one System requirement as showed in the specification of the Test Cases (chapter §4).

At the same time, the Test Result document (D4.5) will keep the traceability with all the System Requirements.

3.3 Process and naming convention

In the following paragraphs, some operational details about the process and naming convention of Test Cases and System Requirements are provided.

3.3.1 System requirements

CERTIFLIGHT requirements are built according to the following identification format: CFT-SYS-<NNNN> Where <NNNN> is a progressive number i.e. CFT-SYS-0100.
Additional information on requirements can be found in the D2.6 document.

Req ID	Req Title	Type	Verification Method
CFT-SYS-0100	UTM Box for UAS features	Functional	A

3.3.2 Test cases identification format

CERTIFLIGHT test cases name follows this identification format TEST_<ITEM>.<NNNN>, where:

- <ITEM> indicates the activity. Possible values are:
  - "EGNSS", functional and performance tests related to EGNSS Algorithms and target receiver.
  - "CERTISW", functional and performance test on Certiflight portal and its features.
  - "UTMBOX", in case of test activity regards the Devices for UAS and GA.
  - "FUNCHAIN", in case that test activities involve more Subsystems.
- <NNNN> is the progressive number (E.g. TEST_EGNSS.0010)

Moreover, the test cases contain the following sections:

- ID, according to the naming convention;
- Objective, indicating which is the aim of the test;
- Description, indicating a short explanation;
- Required data indicating if contingent data are preventively needed;
- Pass/Fail Criteria, indicating the condition to be evaluated;
- Parent Requirement, indicating the system requirements which are intended to be fulfilled in case of successfully execution;
- Remark, free text if needed for further explanation.

3.3.3 Verification Matrix

The verification matrix will be included in the D4.5 document (CERTIFLIGHT solution integration and verification report), built according to the following format:

ReqID	ReqTitle	ReqText	Type	Verification	D,A,I Justification	Status of compliance	Close-out Status
Requirement Identification	Requirement title	Requirement text	General, functional, perfor-mance …	A, I, RoD, T	Comment to be fulfilled only in case of a requirement verified by A, I, RoD	<C>, <NC> or <PC> depending on the verification outcome	Requirement Identification

In the verification matrix the following abbreviation will be used for all Requriments.
For verification:

- A = Analysis
- I = inspection
- RoD = Review of design
- T = Test

For assessing the status of compliance:

- C= Compliant
- NC = non-compliant
- PC = Partially compliant

4 Test Cases

This section presents the test cases divided according to the items described in paragraph §3.3.2. Each test case has an owner, which is the responsible Beneficiary, that may involve or require support from other Beneficiaries for the implementation of the test.
The target System Requirements subject to verification via “test” and “analysis” are listed in the following paragraphs. The Tests results will be reported in the document D4.5 and in the technical notes D4.2, D4.3, D4.4

Finally, the complete Verification matrix, including all System Requirements will be included in D4.5.

4.1 Target System Requirements

The following table reports the System Requirements extracted from the full list of Requirements in D2.6. the list includes those whose verification method is “TEST”.

ReqID	ReqTitle	Traceability vs User needs	Type	Owner	System, S/S or Module Reference	Remark
CFT-SYS-0060	UTM Box Interoperability	UN-REQ_06 UN-REQ_09	general	TOP	UTM Box; Device Gateway	
CFT-SYS-0120	CERTIFLIGHT Portal: data inserted by the User in the report	UN-REQ_09 UN-REQ_10 UN-REQ_11	functional	TSP	CERTIFLIGHT Portal	
CFT-SYS-0130	Device Gateway and UTM Box Authentication	UN-REQ_09	functional	TOP	Device Gateway; UTM Box	
CFT-SYS-0170	CERTIFLIGHT Portal front end responsiveness	UN-REQ_10 UN-REQ_15	Functional	TSP	CERTIFLIGHT Portal	
CFT-SYS-0180	CERTIFLIGHT Platform registration/ profiling/login	UN-REQ_10 UN-REQ_15	Functional	TSP	CERTIFLIGHT Portal	
CFT-SYS-0190	UTM Box secure binding with user profile	UN-REQ_09 UN-REQ_10	Functional	TSP	CERTIFLIGHT Portal	
CFT-SYS-0200	CERTIFLIGHT Platform configuration - profiling	UN-REQ_10	Functional	TSP	CERTIFLIGHT Portal	
CFT-SYS-0210	CERTIFLIGHT Platform configuration - Home Dashboard	UN-REQ_10 UN-REQ_15	Functional	TSP	CERTIFLIGHT Portal	Packets exceeding 1 second of delay shall be flagged by Device Gateway

CFT-SYS-0220	CERTIFLIGHT Platform - UTM box configuration	UN-REQ_03 UN-REQ_15	Functional	TSP	CERTIFLIGHT Portal	
CFT-SYS-0230	CERTIFLIGHT Portal - UTM box real time data acquisition	UN-REQ_16	Functional	TSP	CERTIFLIGHT Portal	
CFT-SYS-0240	CERTIFLIGHT Portal - UTM box real time data visualisation	UN-REQ_15 UN-REQ_16	Functional	TSP	CERTIFLIGHT Portal	
CFT-SYS-0250	CERTIFLIGHT Portal- UTM box real time monitoring	UN-REQ_16	Functional	TSP	CERTIFLIGHT Portal	
CFT-SYS-0260	CERTIFLIGHT Platform configuration - Light Report	UN-REQ_16 UN-REQ_02	Functional	TSP	CERTIFLIGHT Portal UTM Box	
CFT-SYS-0270	CERTIFLIGHT Platform - Light Report generation	UN-REQ_16 UN-REQ_02	Functional	TSP	CERTIFLIGHT Portal	
CFT-SYS-0280	CERTIFLIGHT Platform - offline full data ingestion	UN-REQ_16	Functional	TSP	CERTIFLIGHT Portal	
CFT-SYS-0290	CERTIFLIGHT Platform - offline full data processing	UN-REQ_10	Functional	TSP	CERTIFLIGHT Portal	
CFT-SYS-0300	CERTIFLIGHT Platform configuration - Full Report	UN-REQ_16 UN-REQ_02	Functional	TOP	CERTIFLIGHT Portal UTM Box	
CFT-SYS-0320	CERTIFLIGHT Platform Proof of Delivery	UN-REQ_05	functional	TSP	CERTIFLIGHT Portal	
CFT-SYS-0340	UTM Box to USSP Interface UTM I/F - Scalability	UN-REQ_06	functional	TU Delft	CERTIFLIGHT	
CFT-SYS-0360	Feature for notification regarding the UTM Box power management	UN-REQ_08 UN-REQ_13	functional	TOP	UTM Box	

CFT-SYS-0370	Feature for notification regarding the UTM Box data management	UN-REQ_08	functional	TOP	UTM Box	
CFT-SYS-0380	APP function	UN-REQ_01 UN-REQ_09	functional	W4W	CERTIFLIGHT Portal	After registration and authentication of user, specific privileges can be granted
CFT-SYS-0390	APP function state vector	UN-REQ_01 UN-REQ_09	functional	W4W	CERTIFLIGHT Portal	
CFT-SYS-0400	GNSS raw measurements database	UN-REQ_01 UN-REQ_09	functional	W4W	CERTIFLIGHT Portal	
CFT-SYS-0410	GNSS navigation database	UN-REQ_01 UN-REQ_09	functional	W4W	CERTIFLIGHT Portal	
CFT-SYS-0420	GNSS Aiding database	UN-REQ_01 UN-REQ_09	functional	W4W	CERTIFLIGHT Portal	
CFT-SYS-0430	IMU raw measurements database	UN-REQ_01 UN-REQ_09	functional	W4W	CERTIFLIGHT Portal	
CFT-SYS-0440	GNSS data frequency	UN-REQ_01 UN-REQ_09 UN-REQ_16	functional	W4W	CERTIFLIGHT Portal	
CFT-SYS-0450	IMU data frequency	UN-REQ_01 UN-REQ_09 UN-REQ_16	functional	W4W	CERTIFLIGHT Portal	
CFT-SYS-0460	APP solution frequency	UN-REQ_01 UN-REQ_16	functional	W4W	CERTIFLIGHT Portal	

CFT-SYS-0470	APP function with GNSS outages	UN-REQ_09	functional	W4W	CERTIFLIGHT Portal	
CFT-SYS-0480	GSD function	UN-REQ_01 UN-REQ_17	Functional	W4W	CERTIFLIGHT Portal	
CFT-SYS-0490	GSD solution time tag	UN-REQ_01	functional	W4W	CERTIFLIGHT Portal	
CFT-SYS-0500	UTM Box 4G/5G Handover	UN-REQ_01	Performance	TOP	UTM Box	
CFT-SYS-0510	UTM Box endurance (UAS)	UN-REQ_13	Performance	TOP	UTM Box	
CFT-SYS-0520	UTM Box endurance (GA version)	UN-REQ_13	Performance	TOP	UTM Box	
CFT-SYS-0530	UTM Box Transmission rate	UN-REQ_01 UN-REQ_20	Performance	TOP	CERTIFLIGHT Portal	
CFT-SYS-0570	APP function Horizontal position accuracy	UN-REQ_01	Performance	W4W	CERTIFLIGHT Portal	
CFT-SYS-0580	APP function Vertical Position accuracy	UN-REQ_01	Performance	W4W	CERTIFLIGHT Portal	
CFT-SYS-0590	APP function Velocity accuracy	UN-REQ_01	Performance	W4W	CERTIFLIGHT Portal	
CFT-SYS-0600	App function heading accuracy	UN-REQ_01	Performance	W4W	CERTIFLIGHT Portal	
CFT-SYS-0610	GSD spoofing detection capability	UN-REQ_01 UN-REQ_17	Performance	W4W	CERTIFLIGHT Portal	Novel technique, with just a few proof-of-concept studies available on simulated data. The approach has never been tested for real-

						world applications and no standardized approach exists. The work is still in an exploratory phase
CFT-SYS-0650	UTM Box Factory key	UN-REQ_09	security	TOP	UTM Box	
CFT-SYS-0660	UTM Box - Aircraft (UAS) pairing	UN-REQ_09 UN-REQ_16	security	TOP	UTM Box	Serial Number of UAS Flight Controller and Drone Model cab be paired with the UTM BOX serial number
CFT-SYS-0690	Accounts' data segmentation and non-interference	UN-REQ_02	security	ARIA	UTM Box	
CFT-SYS-0830	Conditioning the use of the platform by the existence and validity of a subscription	UN-REQ_10 UN-REQ_14	business	ARIA	CERTIFLIGHT Portal	
CFT-SYS-0860	UTM Box IF to Drone data bus	UN-REQ_09	Interface	TOP	UTM Box	CAN BUS or MAVLINK protocol to be built on top of UART port specification in accordance with the target drone
CFT-SYS-0870	UTM Box IF to Payload data	UN-REQ_11	Interface	TOP	UTM Box	The traceability chain shall be guaranteed for the

						way the information is generated, but not for the content of information that will remain out of scope, being a feature postponed to the industrialization phase
CFT-SYS-0880	Authenticated Tracking service Transmission	UN-REQ_20	Interface	TOP	UTM Box	
CFT-SYS-0890	Authenticated Tracking service visualization on USSP	UN-REQ_06 UN-REQ_20	Interface	TOP	USSP; CERTIFLIGHT Platform	different colors for tracking and Authenticated tracking are considered a good strategy
CFT-SYS-0910	UTM Box to USSP Interface: Connectivity	UN-REQ_03 UN-REQ_06	Interface	TOP	USSP Device Gateway UTM Box	
CFT-SYS-0920	UTM Box to USSP Interface - Tracking device monitoring	UN-REQ_06	Interface	TOP	USSP Device Gateway UTM Box	
CFT-SYS-0950	APP required input parameters	UN-REQ_01	Interface	W4W	CERTIFLIGHT Portal	

Table 4-1 System Requirements filtered by verification method “Test”

Moreover, some of the System requirements whose Verification Method is "A" shall need the execution of simulation tests. The following table lists such subset of requirements. For the full description of each System Requirement, please refer to D2.6 document.

ReqID	ReqTitle	Traceability vs User needs	Type	Owner	System, S/S or Module Reference	Remark	Simulated tests in support of Analysis
CFT-SYS-0070	UTM Box UAS / aircraft association	UN-REQ_09	general	TOP	UTM Box		Covered by TEST_FUNCHAIN.0040
CFT-SYS-0110	UTM Box for GA features	UN-REQ_07 UN-REQ_08 UN-REQ_13 UN-REQ_18	Functional	TOP	UTM Box		Covered by TEST_UTMBOX.0090
CFT-SYS-0310	CERTIFLIGHT Platform Spoofing Report	UN-REQ_17	functional	TSP	CERTIFLIGHT Portal		Example of a simulated Report with possible presence of spoofed data. Covered by TEST_FUNCHAIN.0040
CFT-SYS-0330	UTM Box to USSP Interface - Scalability	UN-REQ_03	functional	Unifly	CERTIFLIGHT		simulation test on target UTM platform (i.e. simulation of multiple tracks or stress test). Covered by TEST_UTMBOX.0060.
CFT-SYS-0540	UTM Box minimum transmission Rate	UN-REQ_16	Performance	TOP	UTM Box		analysis of flight logs from other real tests flights. Covered by TEST_UTMBOX.0070.

CFT-SYS-0560	Automated Separation resolution	UN-REQ_07	Performance	TU Delft	CERTIFLIGHT	This functionality shall be Simulated. The UTM Box shall report only warning messages for constraints related to HW capability and Power consumption	simulation test (ref. TEST_UTMBOX.0080)
CFT-SYS-0730	Automated Separation advisory	UN-REQ_18 UN-REQ_07	Operational	TU Delft	UTM Box	This functionality shall be Simulated. The UTM Box shall report only warning messages for constraints related to HW capability and Power consumption	simulation test (ref. TEST_UTMBOX.0080)
CFT-SYS-0990	GSD required input parameters	UN-REQ_01	Interface	W4W	CERTIFLIGHT Portal		Already included in TEST_EGNSS.0010

Table 4-2 System Requirements filtered by verification method “Analysis” (subset)

4.2 Test Cases

The Test cases to be performed against the Target System Requirements (Ref. §4.1) are identified in the following table.

Test ID	Title	Owner	Parent Requirement(s)
TEST_EGNSS.0010	APP/GSD Input verification	W4W	CFT-SYS-0400 CFT-SYS-0410 CFT-SYS-0420 CFT-SYS-0430 CFT-SYS-0440 CFT-SYS-0450 CFT-SYS-0950 CTF-SYS-0990
TEST_EGNSS.0020	APP Performance Verification	W4W	CFT-SYS-0380 CFT-SYS-0390 CFT-SYS-0460 CFT-SYS-0570 CFT-SYS-0580 CFT-SYS-0590 CFT-SYS-0600
TEST_EGNSS.0030	GNSS outages verification	W4W	CFT-SYS-0470
TEST_EGNSS.0040	GSD performance verification	W4W	CTF-SYS-0610 CTF-SYS-0480 CTF-SYS-0490
TEST_CERTISW.0010	CERTIFLIGHT Platform configuration – Data Entry	TSP	CFT-SYS-0180 CFT-SYS-0200
TEST_CERTISW.0020	CERTIFLIGHT Platform configuration – UTM box registration	TSP	CFT-SYS-0190 CFT-SYS-0220
TEST_CERTISW.0030	Real-Time Data Acquisition and Visualization	TSP	CFT-SYS-0170 CFT-SYS-0210 CFT-SYS-0230 CFT-SYS-0240 CFT-SYS-0250
TEST_CERTISW.0040	Activities statistics	TSP	CFT-SYS-0290
TEST_CERTISW.0050	Light Report generation	TSP	CFT-SYS-0120 CFT-SYS-0260 CFT-SYS-0270
TEST_CERTISW.0060	Data Acquisition	TSP	CFT-SYS-0280
TEST_CERTISW.0070	Full Report Generation	TSP	CFT-SYS-0120 CFT-SYS-0290
TEST_CERTISW.0080	Integrity of CERTIFLIGHT data – Valid data set	TSP	CFT-SYS-0320

TEST_CERTISW.0090	Integrity of CERTIFLIGHT data – Invalid data set	TSP	CFT-SYS-0320
TEST_UTMBOX.0010	Device configuration	TOP	CFT-SYS-0060 CFT-SYS-0920
TEST_UTMBOX.0020	Security chain in device configuration	TOP	CFT-SYS-0690 CFT-SYS-0130 CFT-SYS-0650
TEST_UTMBOX.0030	Device Installation and Notification Features	TOP	CFT-SYS-0360 CFT-SYS-0370
TEST_UTMBOX.0040	Device operative performance	TOP	CFT-SYS-0500 CFT-SYS-0510 CFT-SYS-0520
TEST_UTMBOX.0050	Device payload I/F function	TOP	CFT-SYS-0860 CFT-SYS-0870
TEST_UTMBOX.0060	Device Gateway – USSPs Connectivity test	TOP	CFT-SYS-0330 CFT-SYS-0910
TEST_UTMBOX.0070	Device Gateway - Transmission Rate Performance	TOP	CFT-SYS-0530 CFT-SYS-0540
TEST_UTMBOX.0080	Simulation of Velocity Obstacle-based methods	TU Delft	CFT-SYS-0560 CFT-SYS-0720 CFT-SYS-0730
TEST_UTMBOX.0090	E-Conspicuity broadcasting functions verification	TOP	CFT-SYS-0110
TEST_FUNCHAIN.0010	Inflight Services	TOP	CFT-SYS-0530 CFT-SYS-0880 CFT-SYS-0890 CFT-SYS-0910 CFT-SYS-0920
TEST_FUNCHAIN.0020	Inflight features for GA	TOP	CFT-SYS-0560 CFT-SYS-0730
TEST_FUNCHAIN.0030	Post Flight Services: Light Report	TSP	CFT-SYS-0660 CFT-SYS-0690 CFT-SYS-0830 CFT-SYS-0120 CFT-SYS-0260 CFT-SYS-0270
TEST_FUNCHAIN.0040	Post Flight Services: Full Report	TSP	CFT-SYS-0660 CFT-SYS-0690 CFT-SYS-0830 CFT-SYS-0120 CFT-SYS-0290 CFT-SYS-0300 CFT-SYS-0310

Table 4-3 Test cases catalogue

4.3 EGNSS RECEIVER

The EGNSS subset of tests will be led by W4W, and the results will be reported in TN7 (D4.2). These tests are aimed to prove the compliance of the EGNSS Algorithms (GSD/APP) according to the functionalities and the performance envisioned in the specific System Requirements and in the D3.6 Technical Note [AD 8]. TOP will be involved in the test activities for the generation of flight data through the UTM Box and for UAS Operations.

APP/GSD Input Verification	
ID	TEST_EGNSS.0010
Objective	Verify if the GNSS and IMU input data are compliant with the required input
Description	The Septentrio receiver will be configured in order to log all the packages required in the document D3.6. A twenty minutes long record will be performed in order to collect IMU and GNSS datasets. The **"APP_lib"** will be called with "GNSS_dataset.sbf" and "IMU_dataset.csv" as input. The **"Data Parsing and Organization"** module of the library will process the data and organize it in matrices/arrays/variables to be easily recovered by the Feeder. Errors will be raised in case of anomalies detected in the datasets. The same procedure will be considered for the "**GSD_Lib**" without the use of IMU data
Required data	Septentrio sbf binary file, csv file for IMU data
Pass/Fail Criteria	The test is considered passed if the following Errors code are not triggered for GSD and APP Libraries: • Error Code 100: File not found • Error Code 101: Unsupported File format • Error Code 200: Invalid Data • Error Code 201: Missing Data • Error Code 300: Data Analysis Error
Related Requirements	CFT-SYS-0400 CFT-SYS-0410 CFT-SYS-0420 CFT-SYS-0430 CFT-SYS-0440 CFT-SYS-0450 CFT-SYS-0950 CTF-SYS-0990
Remark	-

APP Performance Verification	
ID	TEST_EGNSS.0020
Objective	Verify the APP_lib correctly provides the expected output in terms of format, frequency, and accuracy

Description	A preliminary free flight of 20 minutes with drone equipped with UTM box shall be performed in order to let the onboard receiver to download the full navigation message for GPS and Galileo satellites. Once the drone is ready a test flight with the following characteristic will be performed: 1. The drone will be fixed on the ground for 2 minutes with the GNSS receiver switched on (in order to allow the computation of the PVT fix). 2. The drone will take off and follow a straight-line path for 5 minutes. 3. The drone will perform a circular path with constant radius and different altitude (i.e. helicoidal trajectory). 4. The total path shall be at least 20min long to increase the probability of the acquisition and tracking of at least 4 authenticated GAL satellites. The reference drone trajectory is computed using RTK technique to guarantee a 10cm accuracy in position, according to the applicable procedure envisioned by the UAS User manual. The recorded GNSS and IMU dataset are then processed by the APP_lib, whose provided solution will be analysed to check the format of the output data (csv table), the frequency (1Hz) and compared with the reference trajectory to compute the accuracy
Required data	Septentrio sbf binary file, IMU_csv, RTK_reference_trajectory
Pass/Fail Criteria	The test is considered passed if satisfies the Parent requirements
Parent Requirement	CFT-SYS-0380 CFT-SYS-0390 CFT-SYS-0460 CFT-SYS-0570 CFT-SYS-0580 CFT-SYS-0590 CFT-SYS-0600
Remark	As a precondition for the test execution, a complete dataset of a real flight with drone equipped with UTM box is required before the APP_lib performance verification, in order to perform the tuning of the internal Kalman filter. The flight path and conditions shall be as much as possible similar to the ones presented in the test condition

GNSS Outages Verification	
ID	TEST_EGNSS.0030
Objective	Verify the APP_lib correctly provides the expected output in terms of format, frequency
Description	Starting from the data collected for TEST.EGNSS.0020, the Feeder module of the APP_lib will simulate the absence of measurements for 10, 30, 60 seconds. The output solution will be checked to verify the capability of solution delivery at 1Hz even in absence of measurements.
Required data	Septentrio sbf binary file, IMU_csv, RTK_reference_trajectory

Pass/Fail Criteria	The test is considered passed if the APP_lib demonstrates to be able to provide the solution even in no visibility condition.
Related Requirement	CFT-SYS-0470
Remark	As a **precondition** for the test execution, a complete dataset of a real flight with drone equipped with UTM box is required, in order to perform the tuning of the internal Kalman filter. The flight path and conditions shall be the same as presented in the test condition

GSD Performance Verification	
ID	TEST_EGNSS.0040
Objective	To verify that GSD function provides a time-tagged signal classification (authentic/spoofed) in a CSV format, as outlined in the D3.6 document. The spoofing detection probability should be at least 80% (1 sigma confidence level) when at least 6 satellites are tracked.
Description	The test set will be created using data from the JRC acquisition campaigns, incorporating unused data from the training phase. It will encompass six distinct scenarios, comprising authentic signals and five different types of spoofing cases, to be utilized in the verification protocol. The function, referred to as "**GSD_lib**" is expected to generate an output file named "GSD_solution.csv," which will include the time parameter (GPStime) and a flag indicating if a spoofing attack have been detected (Spoofing_flag). The function is required to achieve a minimum spoofing attack detection probability (Recall) of 80% within a 1 sigma confidence level
Required data	The test set will include one 30-minute acquisition for each type of spoofing attack: meaconing (100 ms delay), meaconing (100 ns delay), advanced, synchronized and SCER. Each acquisition will consist of 5 minutes of authentic signals followed by 25 minutes of attacks on both GPS and Galileo constellations (6+6 satellites). The data must be stored in SBF format and contain all necessary features.
Pass/Fail Criteria	The test will be considered passed if the "**GSD_lib**" generates the output file in the correct format and if the spoofing detection capacity meets the minimum detection probability required.
Related Requirements	CTF-SYS-610 CTF-SYS-480 CTF-SYS-490
Remark	-

4.4 CERTIFLIGHT PORTAL

This subset of testing activities is led by TSP, and the results will be reported in TN9-D4.4. These tests aim to demonstrate the compliance to the System Requirements involving the CERTIFLIGHT Portal functionalities and performance in terms of communication with UTM Box, data security and authentication features, blockchain infrastructure, flight report generation (light and full report), and interface with USSPs platforms.

CERTIFLIGHT Platform Configuration – Data Entry	
ID	TEST_CERTISW.0010
Objective	To fill in the platform with information related to the pilots and drones' fleet and to check registration and login processes
Description	Step1. Platform Operator (PlaO) • A user is accessing as PlaO performing registration and login following guided steps; • After logging in, the PlaO performs the data entry in "configuration" section entering the information about authorised pilot(s) and the fleet of drone(s) Step2. Pilot Operator (PilO) • A user is accessing as PilO performing registration and login following guided steps; Step3. Expert Operator (ExpO) • A user is accessing as PilO performing registration and login following guided steps;
Required data	N.A.
Pass/Fail Criteria	All information entered are correctly stored in the database. The full check could be performed entering the platform with PlaO profile having the complete visibility of the sections where the data entry is performed.
Related Requirements	CFT-SYS-0180 CFT-SYS-0200
Remark	-

CERTIFLIGHT Platform Configuration – UTM Box Registration	
ID	TEST_CERTISW.0020
Objective	To associate the UTM box with the CERTIFLIGHT platform
Description	• A user is accessing either as PlaO or PilO performing login following guided steps; • The user is accessing configuration => UTM box area • The user scans the QR code present in the UTM box by clicking on the "scan" button and activating the camera of the device (pc or mobile) to get the QR code image
Required data	Correct QR code installed in the UTM box
Pass/Fail Criteria	After the scan all data are entered in the platform and notification of correct acquisition appears. The check could be performed entering the platform with PlaO or PilO profiles.
Related Requirements	CFT-SYS-0190 CFT-SYS-0220
Remark	Before doing this test, the authenticity of the device must be verified on the Device Gateway according to TEST_UTMBOX.0020

Real-Time Data Acquisition and Visualization	
ID	TEST_CERTISW.0030

Objective	To verify the real-time data acquisition and visualization from UTM Box in a dedicated activity
Description	Step 1 • The UTM box (configured in TEST.CERTISW.0020) is switched-on. • An activity relevant to the current date is created (if it is the first switching-On of the day) or updated (in case the UTM box was previously switched on in the same day). • Data are visualised in a dedicated card, also showing a green light (switched ON). • Data are visualised in a map (position + tooltip with ancillary data) • Log window is showing details about incoming messages. • The PlaO user is able to navigate the map in option "Magnet enabled" or "Magnet disabled". Step 2 • The UTM box (configured in TEST_CERTISW.0020) is switched-off • Data are no more visualised in a dedicated card, also showing a red light (switched OFF)
Required data	UTM box correctly configured and switched On/Off and data are ingested in the platform in real time. The check could be performed entering the platform with PlaO or PilO profiles.
Pass/Fail Criteria	When UTM box is switched ON, the data are ingested in the platform in real time with correct visualisation in card (indicating green light) and map. The check could be performed entering the platform with PlaO or PilO profiles. When UTM box is switched OFF, no more data is retrieved and the card indicates red light. The check could be performed entering the platform with PlaO or PilO profiles.
Related Requirements	CFT-SYS-0170 CFT-SYS-0210 CFT-SYS-0230 CFT-SYS-0240 CFT-SYS-0250
Remark	-

Activities Statistics	
ID	**TEST_CERTISW.0040**
Objective	Visualise the statistic after a flight
Description	• A user is accessing the "Activities" section and configures the filter (date and UTM box selection) and click on "Apply" button
Required data	Execution of test TEST_CERTISW.0030
Pass/Fail Criteria	A graphic is generated reporting used satellites (total versus authenticated with OSNMA) in each minute of the flight
Related Requirement	CFT-SYS-0290

Remark	The generated graphic contains for each minute a mean value using all the received position in the minute interval

Light Report Generation	
ID	TEST_CERTISW.0050
Objective	To configure and generate (pdf) the Light report
Description	• PlaO user accesses the report section of an activity • Plao user click on "create" button to generate the report structure • PlaO user select "Light Report" • PlaO user checks introduction and responsibilities sections • PlaO user selects the image of the certified trajectory to be included in the report • PlaO user adds a text in the Remark section • PlaO user clicks on "Generate" button
Required data	Execution of test TEST_CERTISW.0030
Pass/Fail Criteria	The report pdf is created according to the structure reported in the CERTIFLIGHT platform user manual
Related Requirements	CFT-SYS-0120 CFT-SYS-0260 CFT-SYS-0270
Remark	-

Data Acquisition	
ID	TEST_CERTISW.0060
Objective	To ingest in the platform data both from UTM box and elaborated by expert user
Description	Step1 • PilO user accesses the acquisition section of an activity • PilO user click on "Upload" and selects from the filesystem the data downloaded from the UTM box • PilO user confirms upload Step2 • ExpO user accesses the acquisition section of an activity • ExpO user downloads raws data and performs an elaboration using third party SW • PilO user click on "Upload" and selects from the filesystem the data elaborated data as final product • PilO user confirms upload
Required data	Execution of test TEST_CERTISW.0030
Pass/Fail Criteria	All data are correctly ingested and visualised in tabular and map visualizations
Related Requirement	CFT-SYS-0280
Remark	Data in Step 1 are both final products and raw data used by the expert user to provide final products in Step2

Full Report Generation	
ID	TEST_CERTISW.0070
Objective	To configure and generate (pdf) the Full report
Description	• PlaO user accesses the report section of an activity • Plao user click on "create" button to generate the report structure • PlaO user select "Full Report" • PlaO user checks introduction and responsibilities sections • PlaO user checks acquired data section • PlaO user selects the image of the certified trajectory to be included in the report • PlaO user adds a text in the Remark section • PlaO user clicks on "Generate" button
Required data	Execution of test TEST_CERTISW.0030
Pass/Fail Criteria	The report pdf is created according to the structure reported in the CERTIFLIGHT platform user manual
Related Requirements	CFT-SYS-0120 CFT-SYS-0290 CFT-SYS-0300
Remark	

Integrity of CERTIFLIGHT data – Valid data set	
ID	TEST_CERTISW.0080
Objective	To perform integrity check of the data in the reports
Description	Step1 • Any person willing to test the integrity of CERTIFLIGHT report is scanning any of the QR codes and he is redirected on the CERTIFLIGHT public page; Step 2 • The person is entering using PilO credentials and accesses to the dataset
Required data	Certiflight report available after test TEST_CERTISW.0050 or TEST_CERTISW.0060
Pass/Fail Criteria	Step 1. The CERTIFLIGHT public page is showing that the QR code is genuine. Step2. Only allowed users can access to the dataset and check that data are the same as in the report.
Parent Requirements	CFT-SYS-0320
Remark	-

Integrity of CERTIFLIGHT data – Invalid data set	
ID	TEST_CERTISW.0090
Objective	To perform integrity check of the data in the reports
Description	Step1

	• Any person willing to test the integrity of CERTIFLIGHT report is scanning any of the QR codes and he is redirected on the CERTIFLIGHT public page;
Required data	Certiflight report available after test TEST_CERTISW.0050 or TEST_CERTISW.0060
Pass/Fail Criteria	Either the user is redirected on an external public page or to the CERTIFLIGHT public page showing that the QR code is not genuine
Parent Requirements	CFT-SYS-0320
Remark	The result reported in this procedure can only happen if data included in a report are furtherly modified in the CERTIFLGHT platform.

4.5 DEVICES FOR UAS AND GA

This subset of tests will be led by TOP, that will report the results in the TN8 – D4.3. The tests will include real flight operations with UAS for UTM Box Data generation. TOP will also handle and manage UAS operations. UTM Box for GA will be involved for tests in in real flight operations exploiting drones in this phase. In fact, data will be generated by embarking the UTM Box (GA) on a suitable drone. This step is due before providing the UTM Box to local GA aircraft communities for the validation phase. The tests aim to provide the compliance to the applicable System Requirements for the UTM Box.

Device Configuration	
ID	TEST_UTMBOX.0010
Objective	Verify the device configuration possibilities on Device Gateway
Description	This test case verifies the options available to the user for the UTM box management and configuration after the registration in the Device Gateway. Step 1 CERTIFLIGHT User (UAS and GA Operator) follows the configuration steps on the Device Gateway, as described in the section 5 of D3.1 – UTM Box User manual [AD 3] and selects all the USSPs. Step 2 Turn on the device and wait for Green Light on the LED "Status". Step 3 Verify that the device location is properly visualized on the Map section of the Device Gateway and that the serial number of the UTM Box corresponds to the serial number on the bottom of the Physical device. The Non authenticated position is flagged by a red icon. The Authenticated position is flagged by a blue icon. Step 4 The device location, the Authenticated and Non authenticated position are visualized on each USSP's interface, when selected by the Device Gateway USSP slider.

Required data	UTM Box Serial code, User configuration data, User's account email and password
Pass/Fail Criteria	All parameters from the system requirement (CFT-SYS-0060) are displayed on the selected USSPs. Tracking and Authenticated Tracking information of the same flight log are visible simultaneously on the three USSPs' platforms.
Related Requirements	CFT-SYS-0060 CFT-SYS-0920
Remark	-

Security Chain In Device Configuration	
ID	TEST_UTMBOX.0020
Objective	Verify the security mechanisms of the device
Description	Check the multiple security mechanisms during the device initialization and first configuration procedure. Step 1 CERTIFLIGHT User executes the first initialization procedure as described in the section §5.1 of D3.1 – UTM Box User manual [AD 3]. Step 2 The device gateway recognizes the serial number of the device as authentic and implements the binding mechanism for ensuring the first tract of the security chain. Step 3 The user receives a confirmation message on the Device Gateway 5.1 of D3.1 – UTM Box User manual [AD 3]. The device is now uniquely associated to the User's account.
Required data	UTM Box Serial code, User configuration data, User's account email and password
Pass/Fail Criteria	The pairing sequences are correctly performed.
Related Requirements	CFT-SYS-0690 CFT-SYS-0130 CFT-SYS-0650
Remark	-

Device Installation And Notification Features	
ID	TEST_UTMBOX.0030
Objective	Verify how the devices notify the users
Description	To test the entire procedure of installation of the UTM BOX and proper functioning of the LED notification as explained in the user manual. Step 1

	Once turned on the Device for UAS and the Device for GA, the LED "Status" must be visible and inform the user about battery charging status, as described respectively in the sections §3.3 and §4.2 of D3.1 – UTM Box User manual [AD 3]. All these sub steps shall be verified according to the User Manual for both UTM Box versions. Step 2 To physically connect the UAS Device to the drone by means of USB Type C. To verify that the LED "Charge" shows that the box is properly powered by the drone via the USB-C connection. Step 3 On the Device for UAS, to remove the Micro SD from the slot (see. Figure 3.3 in D3.1 – UTM Box User manual [AD 3]). To turn on the Device and verify that the Status LED notifies the SD error see. Table 3.1 in D3.1 – UTM Box User manual [AD 3]) Step 4 On the Device for UAS, to insert the Micro SD card fully loaded in the Micro SD slot (see. Figure 3.3 in D3.1 – UTM Box User manual [AD 3]). To turn on the Device and verify that the Status LED notifies the SD error see. Table 3.1 in D3.1 – UTM Box User manual [AD 3]).
Required data	User's account email and password Device Gateway Screenshots and Device Gateway log file
Pass/Fail Criteria	Led Status and Charge show the respective charging and powering information (according to User Manual); Error status is signalled according to the User Manual, error messages on the Device Gateway are readable.
Related Requirements	CFT-SYS-0360 CFT-SYS-0370
Remark	-

Device Operational Performance	
ID	TEST_UTMBOX.0040
Objective	This test verifies the most challenging operational performance of the device as network handover and battery usage.
Description	This test case verifies the 4G/5G Base Stations' handover capabilities and battery endurance of both devices. This test will be performed by car to allow multiple cell handover situations. As precondition for this test a suitable trajectory shall be identified with the support of applications as https://www.cellmapper.net [RD 1]

	The identified trajectory shall guarantee at least 3 cell handovers by design. Both GA and UAS UTM Boxes can be used for the same test. Step 1 To verify that the 2 UTM Boxes are operational and paired to the tester's account as per TEST_UTMBOX.0010. To turn on the Device (UAS and GA) with fully charged battery Step 2 To execute the identified trajectory by car there and back again, checking the behaviour of LEDs as per UTM Box User Manual, in particular in the places where the cell-handover handover is expected. Step 3 After the test, keep the devices turned on and download the flight log by logging on the Device Gateway to verify how many cell handovers happened. If any, to verify if the handover lasted more than 10 seconds. If this condition is verified, to check if the warning message has been generated on the device gateway (and through video footage of the LEDS of the UTM Box, collected by the tester). Step 4 After having downloaded the data, keep the devices on and place them back in the car until it enters the "in sleep" mode (sections 3.3 and 4.2 of D3.1 – UTM Box User manual [AD 3]). This can happen after some hours. Step 5 To collect the flight logs from previous steps, together with the ones from the previous test cases and measure the battery endurance (from turning on to "in sleep" mode), by counting the effective " flight time" in the internal telemetry message.
Required data	User's account email and password Device Gateway Screenshots and Device Gateway log file(s) Flight time (UTM Box internal telemetry) and n. of reconnections (UTM Box Internal Modem message) Predefined trajectory (kml) Positions of 4G/5G cells (kml)
Pass/Fail Criteria	Seamless reconnection after handover < 10 seconds. All the "network handover Delays ">10 seconds of one flight log are signalled by a warning message in the device gateway. The average value of Battery endurance of the UTM Box (UAS) logs complies with the endurance requirement of 3 hours. The average value of Battery endurance of the UTM Box (GA) logs complies with the endurance requirement of 8 hours.
Related Requirement	CFT-SYS-0500

	CFT-SYS-0510 CFT-SYS-0520
Remark	-

Device Payload I/F Function	
ID	TEST_UTMBOX.0050
Objective	Verify the payload I/F capabilities of the device
Description	To verifiy as prerequisite that the TEST_UTMBOX.0030 has passed with no issues. Step 1 To enter the device in payload mode according with subparagraph §6.1.2 of D3.1 – UTM Box User manual [AD 3]: Step 2 To check that the LED Status flashes Blue and then Green. Step 3 To prepare the drone and the drone's payload to operations. To execute a flight (or bench test) where the Device is in Payload Mode and the UAS payload is capable to generate some products like RGB photos of thermal pictures. To execute some Thermal and RGB Shots manually by the tester. To switch off drone and UTM Box. Step 4 To verify on the UTM Box telemetry data through data logs that the event "picture shot" has been registered by the UTM Box telemetry and the event is tagged with epoch and position.
Required data	GNSS signal in Open sky conditions for test
Pass/Fail Criteria	Payload mode is signalled by the LED Status according to User Manual. UTM Box Telemetry includes the list of tagged events with epoch and position.
Related Requirements	CFT-SYS-0860 CFT-SYS-0870
Remark	-

Device Gateway – USSPs Connectivity test	
ID	TEST_UTMBOX.0060
Objective	Verify the interface between Device Gateway and USSPs
Description	To verify the integration between the UTM Box and the USSP according to the interface explained in: • D3.3 TN2: MAIA UTM update IF/ICD report [AD 5] • D3.4 TN3: D-FLIGHT UTM update IF/ICD report [AD 6] • D3.7 TN6: UNIFLY UTM update IF/ICD report [AD 9]

	The test foresees the injection of multiple simulated tracks to each USSP according to the parameters described in the technical notes. As prerequisite, TEST_UTMBOX.0010 shall be executed with no issue. Step 1 The user connects with their user and password to the Device Gateway and turns on the UTM Box device. Step 2 On the Device Gateway "USSP section" enables all three UTM/USSPs provider, thus enabling the broadcast of the UTM Box track on all interfaced systems. Step 3 The user verifies though API logs that no error was generated after connectivity for both authenticated and non-authenticated tracks.
Required data	User's account email and password on Device Gateway Screenshots and Device Gateway log file(s) UTM /USSP APIs testing account and password.
Pass/Fail Criteria	The device gateway receives a connectivity confirmation from the USSPs with no issues for both authenticated and non-authenticated tracking information. No data injection issues are reported.
Related Requirements	CFT-SYS-0330 CFT-SYS-0910
Remark	-

Device Gateway- Transmission Rate Performance	
ID	**TEST_UTMBOX.0070**
Objective	To Verify the device transmission rate performance and notify any temporary transmission outage
Description	As prerequisite, TEST_UTMBOX.0010 shall be executed with no issue. Step 1 To execute one or more flight sessions with the Device (UAS or GA). Step 2 To collect the flight logs and verify: • From the timestamps and epoch information, how many tracking and authenticated tracking messages (data packets) were sent with a delay of more than 1s; • To measure if any packet is sent with a rate of over than 5 seconds (i.e. every 6 seconds); • How many delayed messages result flagged according to the req. CFT-SYS-0530.

Required data	UTM Box internal log with timestamp. Device Gateway internal log with timestamp
Pass/Fail Criteria	100% of messages with delay over 1 s are flagged by the Device Gateway. This condition applies to Device Gateway, USSPs and CERTIFLIGHT Portal.
Related Requirements	CFT-SYS-0530 CFT-SYS-0540
Remark	Packet lost are not counted.

Simulation of Velocity Obstacle-based methods	
ID	TEST_UTMBOX.0080
Objective	Analysis and Simulation of Velocity Obstacle-based algorithms
Description	TopView supported by TU Delft simulates potential conflict situations where the User shall be advised to change heading and speed (one or both) and with enough time span to verify if the message is provided at least 15 seconds before the potential collision. These conflict situations will be generated by simulations and the tracks will be injected in the Device Gateway, so that the real UTM Box will recognize it as real traffic. The UTM Box will act as a “Hardware in the loop”. The potential interfering traffic will be simulated. Step 1 The Device Gateway generates a simulated traffic and transmits it to the UTM Box GA via 4G/5G network. Step 2 Once received the simulated tracks, the Velocity-obstacle method algorithm detects potential traffic interference and generates a warning message. The message is displayed on the HMI display of the UTM Box (GA version). The warning messages are also collected on the log file of the device. Step 3 Verify that the warning messages generated from the algorithm include advise for heading and speed (one or both) and measures if the message is provided at least 15 seconds before the potential traffic interference
Required data	Simulated traffic with interfering trajectories with respect to the real position of the UTM Box. UTM Box in open sky for best performance. Device position logs (.csv), including conflict resolution messages.
Pass/Fail Criteria	Advisory messages correctly generated by the UTM Box. Heading and Speed are included in the message.

	The message is triggered at least 15 seconds before the potential traffic interference.
Related Requirements	CFT-SYS-0560 CFT-SYS-0730
Remark	-

E-Conspicuity broadcasting functions verification	
ID	TEST_UTMBOX.0090
Objective	Verify the FLARM and ADS-B broadcasting functions for e-Conspicuity
Description	This test aims to verify the e-Conspicuity features related to the capability of the UTM Box (GA version) to transmit and receive the position information from surrounding aircraft, without the use of the 4G/5G telephony network. For this test, a The UTM Box will be mounted on a drone and it will be flown at incremental distances at a suitable altitude from a dedicated VHF ADS-B/FLARM omnidirectional Ground Station [RD 2], to evaluate the maximum range. A second drone equipped with ADS-B/FLARM Device [RD 3] will used to transmit ADS-B/FLARM signals. Step 1 Identify a suitable area for testing with no ground obstacles (i.e. trees, slopes and buildings) in a Class G airspace where drones are allowed to fly up to at least at 50 meters (up to 120 meters). Design a trajectory on some digital cartography (i.e. google Earth) where it will be possible to measure the distance on the horizontal plane, having also the vertical profile of the area. Step 2 Place on the Map the reference point of the Ground Control station and the trajectory of the drone 1, staring from 100 metres horizontally and 50 meters vertically outbound from the VHF Ground station. Step 3 The UTM Box for GA is installed by Testing team on a suitable drone (1) capable to transport the device, with enough space for a clean installation of the FLARM / ADS-B and GNSS Antennas. Specific adapters (i.e. 3D printed) would likely be needed. The second drone will be equipped with the ADS-B/FLARM Device [RD 3] for transmit ADS-B/FLARM signals. This drone will be flown 50 meters on the zenith of the VHF Ground station.

	Step 4 Start the test by flying the drones. Drone 1 will fly outbound from the VHF Ground station from the defined starting point. Drone 2 will be in hovering above the VHF Ground station. During the fly, the testing team will control the reception of the signal on the VHF Ground Station from Drone 1. The Reception of the VHF signal from Drone 2 to Drone 1 will be verified in post processing on the UTM box log. The pilot will make several flights by positioning the UAS at increasing distances from the starting point, at different heights.
Required data	Logs of the UTM Box (GA); logs of the ADS-B/FLARM device [RD 3]; logs of the VHF Ground Station [RD 2]
Pass/Fail Criteria	The measured distance between drone 1 and VHF Station is at least 1 km (Tx performance) The measured distance between drone 1 and drone 2 is at least 1 km and (Rx performance)
Related Requirements	CFT-SYS-0110 CFT-SYS-0560
Remark	There are no system requirements for the e-Conspicuity range considering that FLARM technology is integrated as a COTS technology, however 1 km is the minimum expected to allow the Separation Algorithm to provide warning according to CFT-SYS-0560, in absence of 4G/5G network.

4.6 FUNCTIONAL CHAINS

These tests aim to verify the functionalities of Certiflight platform that involve more than one subsystem, stimulating the implemented interfaces. Functional chains tests will be led by TOP, with support of TSP, W4W, TU-Delft and USSPs. The results will be reported in the D4.5 document.

Inflight services	
ID	TEST_FUNCHAIN.0010
Objective	Verify the inflight services for both UAS and GA: Network ID, tracking and authenticated tracking
Description	This test involves the UTM Box devices in both versions (UAS and GA), the Device Gateway and the three USSPs with their respective interfaces. The test will be implemented with real flight operations with UAS with the devices on board. During this test the user follows the Section 7 “Inflight” of the D3.1 UTM Box User Manual [AD 2]. Step 1 The user turns on the device, check the battery level as indicated in section 3.1 of the user manual and wait until all components of the device are ready (Status LED flashing green) Step 2 The user checks the proper functioning of OSNMA authenticated feature by monitoring the LEDs on the UTM Box device. Step 3 The user checks the correct visualization of the position information broadcasted by the UTM Box and network identification parameters of all three USSPs according to sections §7.2, §7.3, §7.4 of the user manual of the UTM Box and on the Certiflight Portal with real time information. Step 4 The testing pilot carries out 10 minutes flight, monitoring that the authenticated flight tracking information correctly appear in all three USSPs as described in section §7.2.1, §7.3.1 and §7.4.1 of the UTM Box user manual and on the Certiflight Portal. The test will be repeated with the UTM Box (GA) properly installed on drone.
Required data	Execution of tests: TEST_CERTISW.0010 TEST_CERTISW.0020 TEST_CERTISW.0030 TEST_UTMBOX.0010 TEST_UTMBOX.0020

	TEST_UTMBOX.0030 TEST_UTMBOX.0040 TEST_UTMBOX.0060 TEST_UTMBOX.0070
Pass/Fail Criteria	Visualization of authenticated tracking over all USSPs and Certiflight platform in real time as described in UTM Box Manual and Certiflight platform User Manual.
Related Requirements	CFT-SYS-0060 CFT-SYS-0130 CFT-SYS-0500 CFT-SYS-0510 CFT-SYS-0520 CFT-SYS-0530 CFT-SYS-0650 CFT-SYS-0660 CFT-SYS-0690 CFT-SYS-0830 CFT-SYS-0880 CFT-SYS-0890 CFT-SYS-0910 CFT-SYS-0920
Remark	

Inflight features for GA	
ID	TEST_FUNCHAIN.0020
Objective	Verify the inflight features for GA (FLARM, ADS-B, Separation Algorithm and warning message).
Description	The test verifies the inflight features of The UTM Box device for GA. For this purpose, two UAS will be involved for tests in real flight operations. Drone 1 is equipped with the UTM Box for GA while drone 2 acts as companion aircraft for the test purposes as previously done in Unit test TEST_UMTBOX.0090. In this case the full inflight service, including the behaviour of Separation Algorithm will be verified despite the technology used (4G/5G and or FLARM / ADS-B) Step 1 Identify a suitable area for testing with no ground obstacles (i.e. trees, slopes and buildings) in a Class G airspace where drones are allowed to fly up to at least at 50 meters (up to 120 meters). Design a trajectory on some digital cartography (i.e. google Earth) where it will be possible to measure the distance on the horizontal plane at defined reporting points. Make sure the trajectory can be exported to the Ground Control Station of the Drone 1.

	Step 2 Place on the Map the reference point of the Drone 2 (in hovering) and the trajectory of the drone 1. The trajectory should be designed to engage the separation algorithm approximately in specific points. Step 3 The UTM Box for GA is installed by Testing team on a suitable drone (1) capable to transport the device, with enough space for a clean installation of the FLARM / ADS-B and GNSS Antennas. Specific adapters (i.e. 3D printed) would likely be needed. An action-cam will be also installed to record the HMI display of the UTM Boc for GA, in order to playback the video in post processing and monitoring the advisory messages provided to the Pilot. The drone 2 will be equipped with a UTM Box (UAS version) Step 4 Drone 1 with UTM Box executes predefined flight paths to intersect the companion UAS (drone 2), triggering the separation algorithm. The messages displayed on the device are captured by the dedicated camera.
Required data	Execution of tests: TEST_CERTISW.0010 TEST_CERTISW.0020 TEST_CERTISW.0030 TEST_UTMBOX.0010 TEST_UTMBOX.0020 TEST_UTMBOX.0030 TEST_UTMBOX.0040 TEST_UTMBOX.0060 TEST_UTMBOX.0070 TEST_UTMBOX.0080 TEST_UTMBOX.0090 Video footage of action camera, UTM Box (GA) log, UTM Box (UAS) log
Pass/Fail Criteria	Event triggered correctly and displayed on the HMI of the UTM Box. The UTM Box (GA) detects potential collisions and displays the advisory message. The message is provided at least 15s before the potential traffic interference. The UTM Box (UAS) correctly displays the UTM Box (GA) traffic on USSPs and Certiflight Portal
Related Requirements	CFT-SYS-0520 CFT-SYS-0660 CFT-SYS-0110 CFT-SYS-0560 CFT-SYS-0730
Remark	-

Post Flight Services: Light Report	
ID	TEST_FUNCHAIN.0030
Objective	Verify The functionality of the Light Report from pre-flight to post-flight report generation. The test stimulates all the required interfaces among the different Certiflight Architecture subsystems.
Description	This functional chain test verifies all the steps to generate the light report from an operational perspective. The units involved in this test are the UTM Box for UAS, the Device Gateway and the CERTIFLIGHT Portal. The APP and GSD blocks of Certiflight Portal are not part of this test, since they are not required in the light report generation. The following steps shell be followed: 1. The UAS Pilot installs the UTM Box on the drone and configure the account on the Device Gateway, according to the UTM Box user manual and on the Certiflight Platform according to the Certiflight Portal user manual guidelines. 2. The pilot follows all the steps for the association of the UTM Box with their account on the Device Gateway as per TEST_UTMBOX.0010 and TEST_UTMBOX.0020, ensuring that the first tract of chain of trust is enforced. 3. The pilot follows all the steps on the Certiflight Platform as per TEST_CERTISW.0010, TEST_CERTISW.0020 and TEST_UTMBOX.0030, ensuring that the second tract of chain of trust is enforced. 4. On The UTM Box Once Status LED is green and OSNMA LED is flashing, the UTM Box automatically starts to log data onboard and transmit data to Device Gateway and Certiflight Platform. 5. The pilot performs a 10 minutes flight operation. 6. Once the mission is completed, the pilot follows the steps of TEST_CERTISW.0050 - Light Report generation. 7. The Report is signed electronically by the digital Signature module and it is downloaded after flight.
Required data	Execution of tests: TEST_CERTISW.0010 TEST_CERTISW.0020 TEST_CERTISW.0030 TEST_CERTISW.0040 TEST_CERTISW.0050 TEST_CERTISW.0050 TEST_CERTISW.0060 TEST_CERTISW.0080 TEST_CERTISW.0090 TEST_UTMBOX.0010

	TEST_UTMBOX.0020 TEST_UTMBOX.0030 TEST_UTMBOX.0040 TEST_UTMBOX.0060 TEST_UTMBOX.0070 TEST_UTMBOX.0080 TEST_UTMBOX.0090
Pass/Fail Criteria	The full operation from configuration of UTM Box, to Light Report download is performed as described on the UTM Box and Certiflight Platform User manuals. The light report, with basic metrics including information regarding OSNMA satellites is included in the Light Report. The authenticity of the information shall be verified by stakeholders with verification of the QR codes included in the Light Report downloaded.
Related Requirements	CFT-SYS-0120 CFT-SYS-0130 CFT-SYS-0180 CFT-SYS-0190 CFT-SYS-0200 CFT-SYS-0220 CFT-SYS-0230 CFT-SYS-0240 CFT-SYS-0250 CFT-SYS-0260 CFT-SYS-0270 CFT-SYS-0500 CFT-SYS-0510 CFT-SYS-0520 CFT-SYS-0530 CFT-SYS-0650 CFT-SYS-0660 CFT-SYS-0690 CFT-SYS-0830 CFT-SYS-0880
Remark	-

Post Flight Services: Full Report	
ID	TEST_FUNCHAIN.0040
Objective	Verify The functionality of the Full Report from pre-flight to post-flight Full Report generation. The test stimulates all the required interfaces among the different Certiflight Architecture subsystems.
Description	This functional chain test verifies all the steps to generate the Full report from an operational perspective. The units involved in this test are the UTM Box for UAS, the Device Gateway and the CERTIFLIGHT Portal, including APP and GSD components.

	The following steps shell be followed: 1. The UAS Pilot installs the UTM Box on the drone and configure the account on the Device Gateway, according to the UTM Box user manual and on the Certiflight Platform according to the Certiflight Portal user manual guidelines. 2. The pilot follows all the steps for the association of the UTM Box with their account on the Device Gateway as per TEST_UTMBOX.0010 and TEST_UTMBOX.0020, ensuring that the first tract of chain of trust is enforced. 3. The pilot follows all the steps to connect the Drone with the payload as per TEST_UTMBOX.0050. 4. The pilot follows all the steps on the Certiflight Platform as per TEST_CERTISW.0010, TEST_CERTISW.0020 and TEST_UTMBOX.0030, ensuring that the second tract of chain of trust is enforced. 5. On The UTM Box Once Status LED is green and OSNMA LED is flashing, the UTM Box automatically starts to log data onboard and transmit data to Device Gateway and Certiflight Platform. 6. The pilot performs a 10 minutes flight operation. 7. Once the mission is completed, the pilot follows the steps of TEST_CERTISW.0070 - Full Report generation, involving full data download of the UTM Box after flight and invokation of GSD and APP algorithms. 8. The Report is signed electronically by the digital Signature module and it is downloaded after flight. 1. To generate the full report, the pilot connects the UTM Box to Certiflight Portal to upload the data according to D3.2 (GNSS, IMU raw data, Payload data). 2. Input data are processed by GSD / APP Algorithms according to the specification provided in D3.6. A simulated spoofed position must be included to show that the CERTIFLIGHT platform geo tags the area on the map when generating the Full Report. 3. The Report is signed electronically by the digital Signature module. 4. The full report is available on Certiflight Portal to the Pilot that can download it.
Required data	Execution of All units test TEST_EGNSS.XXXX TEST_CERTIFLIGHT.XXXX TEST_UTMBOX.XXXX
Pass/Fail Criteria	The full operation from configuration of UTM Box, to Full Report download is performed as described on the UTM Box and Certiflight Platform User manuals. The Full report, with events triggered (i.e. photo acquisition) and additional information regarding probability of Spoofing detection are included in the Full Report. The authenticity of the

	information shall be verified by stakeholders with verification of the QR codes included in the Light Report downloaded.
Related Requirements	CFT-SYS-0060 CFT-SYS-0120 CFT-SYS-0130 CFT-SYS-0180 CFT-SYS-0190 CFT-SYS-0220 CFT-SYS-0230 CFT-SYS-0280 CFT-SYS-0290 CFT-SYS-0300 CFT-SYS-0320 CFT-SYS-0380 CFT-SYS-0390 CFT-SYS-0400 CFT-SYS-0410 CFT-SYS-0420 CFT-SYS-0430 CFT-SYS-0440 CFT-SYS-0450 CFT-SYS-0460 CFT-SYS-0460 CFT-SYS-0470 CFT-SYS-0480 CFT-SYS-0490 CFT-SYS-0500 CFT-SYS-0510 CFT-SYS-0520 CFT-SYS-0530 CFT-SYS-0570 CFT-SYS-0580 CFT-SYS-0590 CFT-SYS-0600 CFT-SYS-0610 CFT-SYS-0860 CFT-SYS-0870 CFT-SYS-0880 CFT-SYS-0950
Remark	The test shall be repeated with simulated spoofed positions to providing a case of detection in the Full Report.

5 Verification plan

The results and complete reports of the tests planned in this document will generate the following deliverables:

- D4.2 – TN7: EGNSS Receiver functional test report, that will include the results of the tests of GSD and APP algorithms;
- D4.3 – TN8: UTM Box functional test report;
- D4.4 – TN9: CERTIFLIGHT Software test report;
- D4.5 – CERTIFLIGHT solution integration and verification report, that will include the functional chain tests.

D4.2, D4.3 and D4.4 will report the test results respectively for tests codes TEST_EGNSS_00XX, TEST_CERTISW_00XX, and TEST_UTMBOX_00XX.

D4.5 will report the results of the system integration and of the overall verification activities. System integration will include:

- testing activities at subsystem level;
- testing activities at system level through functional chains, either in simulated or real environment, as it follows:
    - integration and test of UTM Box (UAS and GA);
    - verification of APP and GSD algorithms capability, including EGNSS Receiver OSNMA tests (against benchmarks);
    - verification of Velocity Obstacle-based algorithm;
    - integration and test for CERTIFLIGHT SW Platform, including data traceability chain;
    - integration and test of MAIA UTM I/F vs CERTIFLIGHT platform;
    - integration and test of D-Flight I/F vs CERTIFLIGHT platform;
    - integration and test of Unifly UTM IF vs CERTIFLIGHT platform.

Considering the effort for the realization of some test equipment for some of the tests described and the new Risk / Opportunity identified (n.5 in The Risk Matrix of PMP document - AD 10), an update of the schedule is proposed in Figure 5-1.

In particular, the new Risk/Opportunity considers the possibility to integrate of a new functionality in the UTM Box for the direct remote identification, coping with the new EASA regulation [RD 4] in force since 1 Jan 2024.

This functionality regards a new interface on the UTM Box for UAS to be implemented through Bluetooth and WiFi technology that has no impact on the already provided interfaces of Certiflight System. Such new feature requires some additional effort and time for the realization and testing.

For these reasons the integration and verification activities of WP4 whose finalization was planned at Month 21 (July 2024) are proposed to be postponed to Month 24 (October 2024). This postponement will have no effect on the overall Gantt and on the Validation activities of WP5, but represent a very good opportunity for the Consortium, to make the Certiflight Solution more appealing on the market.

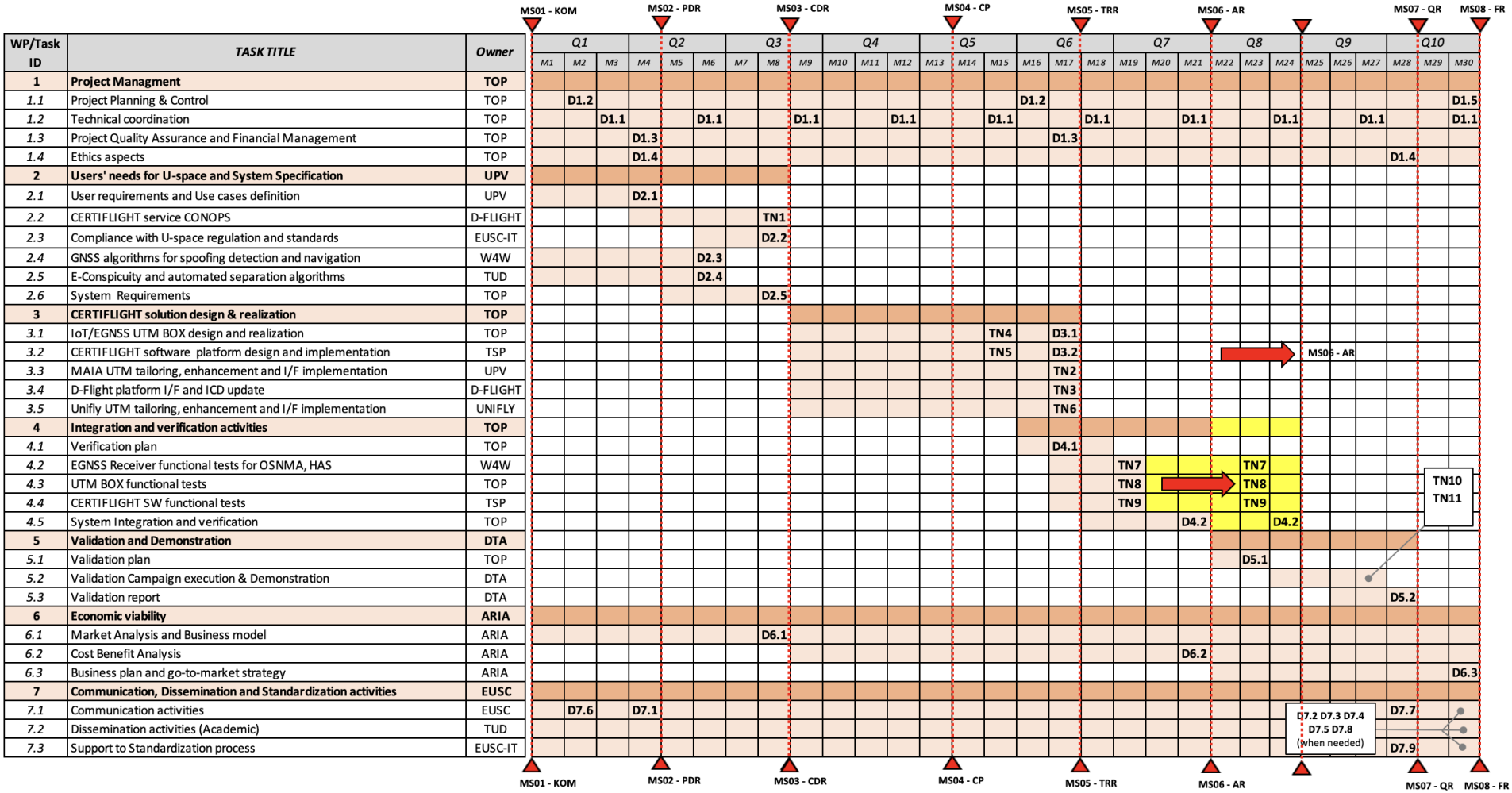

Figure 5-1 Project Gantt chart updated with AR postponed at M24 (October 2024)