D4.5-CERTIFLIGHT solution integration

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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	D4.2 TN7 EGNSS functional test report	Technical Note of EGNSS tests performed with APP and GSD Algorithms
AD 11	D4.3 TN8 UTM box test report	Technical Note of UTM Box tests performed with drones and GA devices
AD 12	D4.4 TN9 CERTIFLIGHT Software test report	Technical Note of Certiflight platform unit tests
AD 13	D4.1 – Verification Plan	Verification plan

REFERENCE DOCUMENTS		
Ref.	File Name	Description
RD 1		

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SUMMARY

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Abstract

This document represents the contractual deliverable D4.5-CERTIFLIGHT solution integration.
It provides an overview of the integration and verification tests conducted to ensure seamless integration of each subsystem within the CERTIFLIGHT platform and to validate the functionality and performance of the proposed services. Emphasis is placed on End-to-End (E2E) verification tests, which assess the effectiveness of the service functional chains.

The unit tests previously detailed in technical notes D4.2, D4.3, and D4.4 are not reiterated in this document; instead, we include a compliance matrix with requirements and relevant notes where necessary.

Certiflight platform is now ready for the validation phase with minor findings related to interface and integration of its main components.

1 Scope of the document

The scope of the document is to report the results of test case described in section 4 of the verification plan (D4.1). This document reports the results of test codes TEST_FUNCHAIN_00XX.
The unit tests previously detailed in technical notes D4.2, D4.3, and D4.4 are not reiterated in this document, but only the Matrix of Compliance of each specific test cases, including relevant notes.

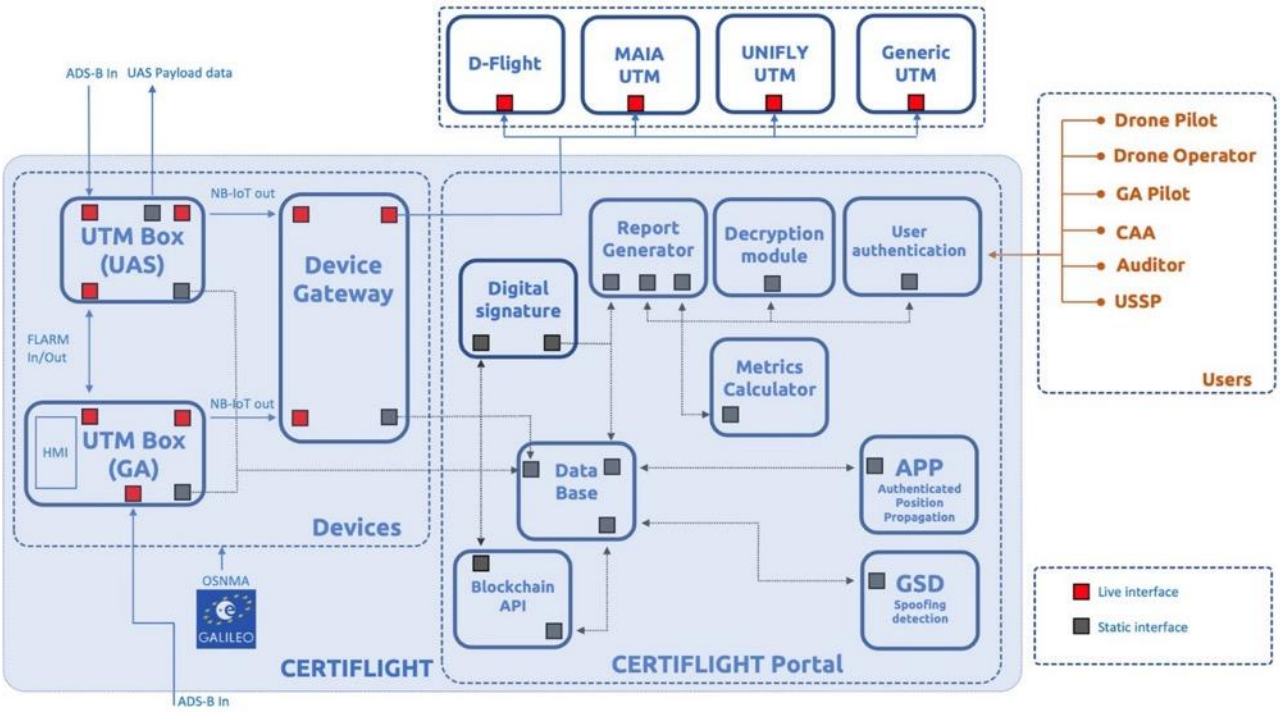

Figure 1-1 System architecture

To facilitate the reading, the Architecture of Certiflight is reproposed in the Figure 1-1, with a 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). It implements tracking services relying on the authenticated information enhanced by security features, provided by the device.

- Certiflight Portal: It is the users' access point 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.

- 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
BTS	Base Transceiver Station
E2E	End to End
GA	General Aviation
HOD	Hook on Device
ICD	Interface Control Document
NM	Nautical Miles
UAS	Unmanned Aerial System
USSP	U-space Service Provider
UTM	Unmanned Traffic Management

Table 1-1 Acronyms list

2 Units test results

2.1 REP_EGNSS

This paragraph reports tests related to EGNSS Algorithms and target receiver. The full description of the results is included in D4.2 EGNSS functional test report.

Status of the tests		
Test name	Status	Notes
TEST_EGNSS.0010 APP/GSD Input verification	Done	-
TEST_EGNSS.0020 APP Performance Verification	Done	-
TEST_EGNSS.0030 GNSS outages verification	Done	-
TEST_EGNSS.0040 GSD performance verification	Done	-

Table 2-1 Results of the EGNSS unit tests

2.2 REP_UTMBOX

This paragraph summarizes test results of the Devices for UAS and General Aviation.
This set of functional and performance test case has been closed with successful outcomes.

Status of the tests		
Test name	Status	Notes
TEST_UTMBOX.0010 Device configuration	Done	-
TEST_UTMBOX.0020 Security chain in device configuration	Done	-
TEST_UTMBOX.0030 Device Installation and Notification Features	Done	-
TEST_UTMBOX.0040 Device operative performance	Done	-
TEST_UTMBOX.0050 Device payload I/F function	Done	During the End-to-End test, the UTM Box was connected to a different M300 RTK drone with a different serial number. The interface with the payload did not show any significant performance degradation, and the “photo capture” event from the Optical Payload was recorded without issues. This recommendation emerged during the verification activities.
TEST_UTMBOX.0060 Device Gateway – USSPs Connectivity test	Done	The status of connection (TCP/IP socket) is not implemented in the ICD with D-Flight UTM and MAIA UTM.

		It is recommended to enhance D-Flight ICD and the Device Gateway ICD (used with MAIA UTM) with this feature for a better control of devices' connectivity. This recommendation is not a blocking issue.
TEST_UTMBOX.0070 Device Gateway - Transmission Rate Performance	Done	-
TEST_UTMBOX.0080 Simulation of Velocity Obstacle-based methods	Done	-
TEST_UTMBOX.0090 E-Conspicuity broadcasting functions verification	Done	-

Table 2-2 Results of the UTM box unit tests

The complete description of the results is included in the document D4.3 - TN8 UTM Box functional test report.

2.3 REP_CERTISW

This paragraph reports the output of the functional and performance test on Certiflight portal and its features.
This set of functional and performance test case on the Certiflight platform has been closed with successful outcomes.

Status of the tests		
Test name	Status	Notes
TEST_CERTISW.0010 CERTIFLIGHT Platform configuration – Data Entry	Done	-
TEST_CERTISW.0020 CERTIFLIGHT Platform configuration – UTM box registration	Done	-
TEST_CERTISW.0030 Real-Time Data Acquisition and Visualization	Done	-
TEST_CERTISW.0040 Activities statistics	Done	-
TEST_CERTISW.0050 Light Report generation	Done	Apart from the data generated by the Certiflight platform, the sections and contents of the Light report are currently under review by two independent lawyers to confirm the report's legal validity within EU jurisdictions and potential limitations.
TEST_CERTISW.0060 Data Acquisition	Done	-

TEST_CERTISW.0070 Full Report Generation	Done	Apart from the data generated by the Certiflight platform, the sections and contents of the Full report are currently under review by two independent lawyers to confirm the report's legal validity within EU jurisdictions and potential limitations.
TEST_CERTISW.0080 Integrity of CERTIFLIGHT data – Valid data set	Done	-
TEST_CERTISW.0090 Integrity of CERTIFLIGHT data – Invalid data set	Done	-

Table 2-3 Results of the CERTISW unit tests

The complete description of the results is included in the document D4.4 – TN9 CERTIFLIGHT software test report.

3 Test Procedure

CERTIFLIGHT test procedures are built according to the following identification format: PROC_UTMBOX. <NNNNx>, where <NNNN> is the progressive number (E.g. PROC_UTMBOX.0010) and x identifies the substeps of each test. The structure of the test procedure is described in the table below.

PROC_UTMBOX.NNNNx. Procedure Title			
Step	**Activity description**	**Expected Result**	**Notes**
S_NN	<Step Title> Procedure description	Test explaining what it is expected for each step of the procedure	Notes for further explanation

Table 3-1 Example of test procedure

4 Functional chains test report

CERTIFLIGHT test reports are built according to the following identification format: REP_FUNCHAIN.<NNNN>, where <NNNN> is the progressive number (E.g. REP_FUNCHAIN.0010).

Status of the tests		
Test name	Status	Notes
TEST_FUNCHAIN.0010 - Inflight Services	Done	-
TEST_FUNCHAIN.0020 - Inflight features for GA	Done	-
TEST_FUNCHAIN.0030 - Post Flight Services: Light Report	Done	-
TEST_FUNCHAIN.0040 - Post Flight Services: Full Report	Done	-

4.1 REP_FUNCHAIN.0010 Inflight Services

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 was implemented with real flight operations with UAS with the devices on board. During this test the user has followed the Section 7 “Inflight” of the D3.1 UTM Box User Manual [AD 3].

This test was performed following the steps described in the table below.

PROC_FUNCHAIN.0010 Inflight Services			
Step	Activity description	Expected Result	Notes
S_01	**Turn on the device and wait for component preparation** The user turns on the device and checks the battery level as indicated in section 3.1 of the user manual	When all components of the device are ready the Status LED flashes green	-
S_02	**OSNMA features check** The user checks the proper functioning of OSNMA authenticated feature by monitoring the LEDs on the UTM Box device.	The OSNMA LED flashes to notify the position authentication	-
S_03	**Check visualization on USP** The user checks the correct visualization of the position information broadcasted by the	The parameters are displayed correctly	-

	UTM Box and network identification parameters.		
S_04	**Perform a 10-minute flight** The pilot carries out 10 minutes flight, monitoring that the authenticated flight tracking information correctly appear in all three USSPs and Certiflight Portal	The flight track is displayed correctly	The device for GA was displayed on Certiflight platform with an icon of a drone. This minor issue was solved with a dedicated field in the message, specifying the aircraft type. The Heading and other parameters were showed with decimal values. The minor issues was solved, rounding to Integer values. Measurements units were converted from m/s to knots for pilots' usability
	Repeat the test with the Device for GA properly installed on drone.	The Device for GA behaves as expected	-

Table 4-1 Test procedure FUNCHAIN.0010

4.1.1 Test execution and results

Date	9th of October
Tester	Francesco Russo
Place	TopView premises
Hardware used	Device for UAS, Device for GA, DJI M300 RTK
Notes	-

This test was performed in the same day, installing the devices on the DJI M300.
We executed a 10-minute flight for each device, monitoring the track on Certiflight Portal and integrated USSPs. The first flight was conducted with the Device for UAS, named **Certibox1** for this purpose. As shown in Figure 4-1 both OSNMA and STATUS LED worked properly during the test.

Figure 4-1 Device for UAS installed on the drone

During the flight the authenticated track was visible on the Certiflight Portal (Figure 4-2), d-flight (Figure 4-3), Unifly UTM (Figure 4-4) and MAIA UTM (Figure 4-5)

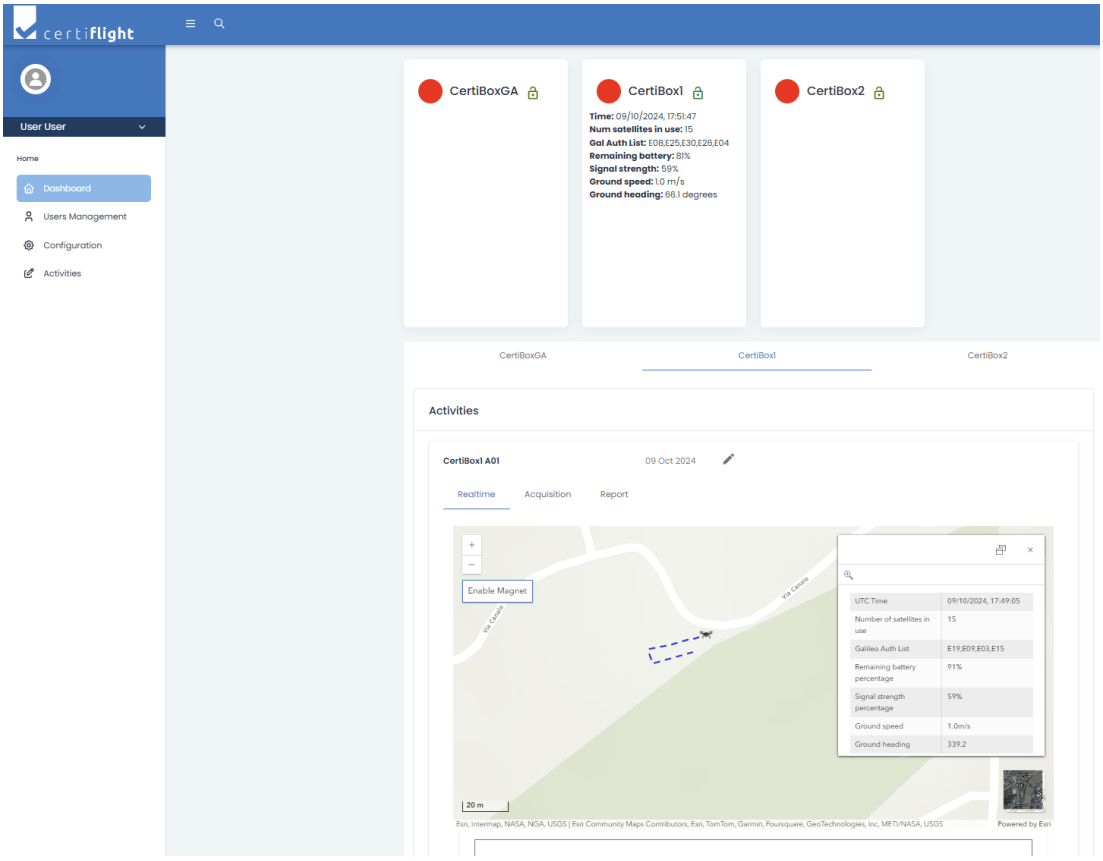

Figure 4-2 Authenticated position of Device for UAS on Certiflight Portal

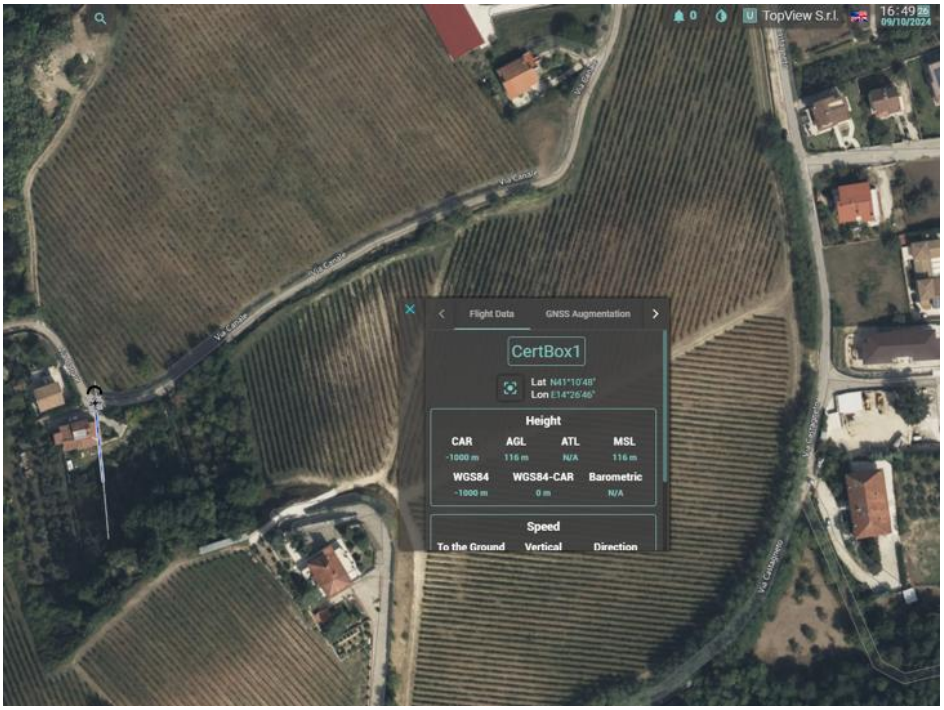

Figure 4-3 Authenticated position of Device for UAS on on d-flight

Figure 4-4 Authenticated position of Device for UAS on Unifly UTM

Since MAIA UTM platform is accessible by TopView in Italy, we executed with support of Upvision the verification tests in Italy, before the first missions of the validation campaign in Czechia.

Figure 4-5 Authenticated position of Device for UAS on MAIA UTM

The same test flight was conducted with the Device for GA installed on DJI M300, named **CertiboxGA** for this purpose.

Figure 4-6 Device for GA installed on the drone

As shown in the figures below, the Device for GA transmitted the authenticated position correctly. The plane is currently displayed with a drone icon. A dedicated “aircraft type” field was included in the message to solve this issue, after the testing activity.

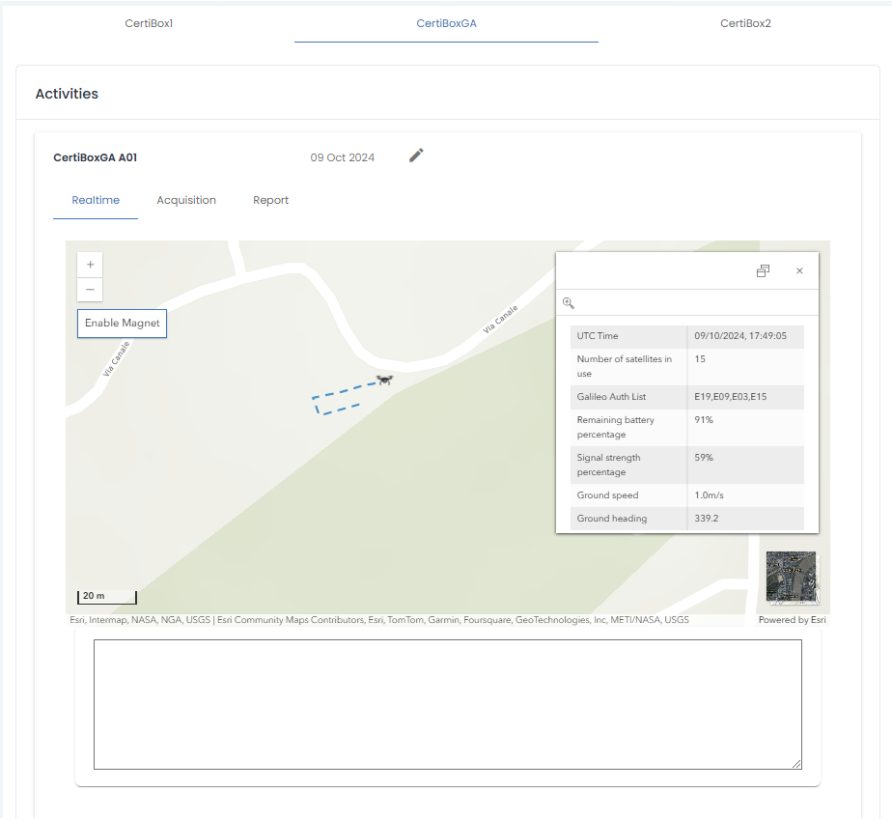

Figure 4-7 Authenticated position of Device for GA on Certiflight Portal

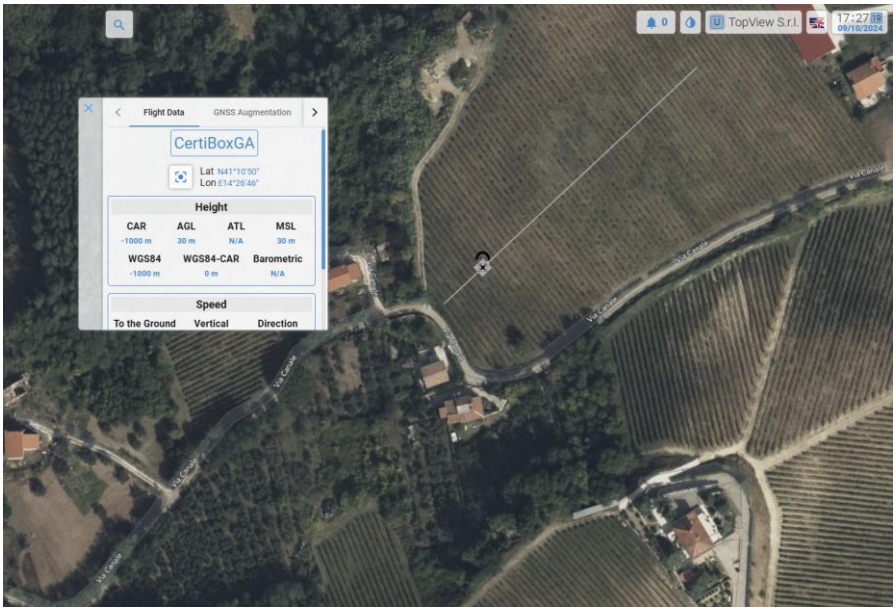

Figure 4-8 Authenticated position of Device for GA on d-flight

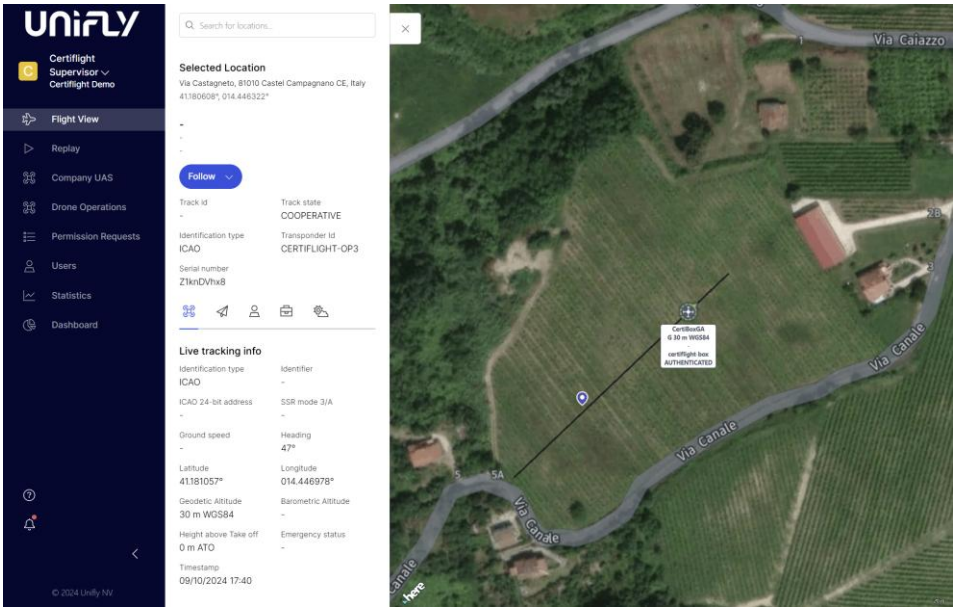

Figure 4-9 Authenticated position of Device for GA on Unifly UTM

The test was successfully passed.

4.1.2 Implementation of Direct Remote ID feature

As discussed during the TRR meeting, the direct remote identification functionality was developed in the Certiflight Device for UAS, considering new regulations and evolving market demands. In fact, according to EU Regulation 2019/947, starting from 1 January 2024, all drones operated in the "Specific" category must be equipped with a remote identification system. Such opportunity has been identified early this year and it's been proposed as an additional in-flight service to enhance the appeal of the device for UAS. (reference D4.1, TRR meeting MoM).

The new functionality was integrated on the actual UTM Box (and also on the Commercial TopView Product Pollicino™, soon available on the market with the new functionality). DRI has been implemented in the past 4 months through Bluetooth technology, following the standards UNI-EN 4709-02 and ASTM 3411-22. As expected and verified, this implementation had no impact on the previously existing interfaces of Certiflight System. Once turned on the device transmits via Bluetooth all the data requested by the regulation and the standards, such as:

- ✓ UAS position and timestamp
- ✓ UAS ID
- ✓ EASA Operator Code
- ✓ Pilot position

This data can be visualized on dedicated and freely downloadable apps. In our test we used the App Drone Scanner.

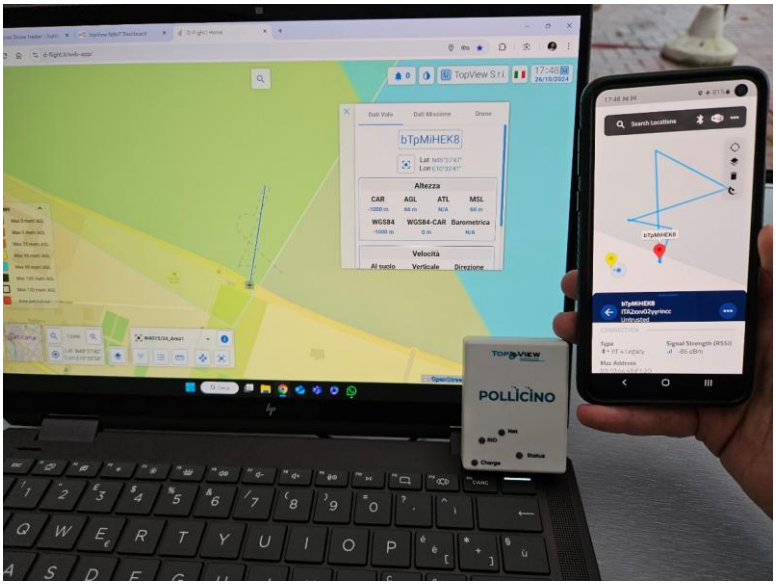

Figure 4-10 DRI Implementation tested on Drone Scanner APP

4.2 REP_FUNCHAIN.0020 Inflight features for GA

The test verifies the inflight features of The UTM Box device for GA. For this purpose, two UASs were 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 advisory conflict resolution algorithm was verified despite the technology used (4G/5G and or FLARM / ADS-B)

PROC_FUNCHAIN.0020 Inflight features for GA			
Step	**Activity description**	**Expected Result**	**Notes**
S_01	**Design the flight trajectory for Drone 1** 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.	Trajectory exported as .KML file to be upload on the Ground Control Station.	
S_02	**Define reference point for Drone 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.	The position of Drone 2 triggers the algorithm for conflict resolution.	

S_03	**Install the device for GA on the Drone 1** The Device for GA is installed by Testing team on a suitable drone 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 Box for GA, to playback the video in post processing and monitoring the advisory messages provided to the Pilot.	The device is installed correctly and is framed by the action cam	
S_04	**Drone 1 with UTM Box executes predefined flight paths** to intersect the companion UAS (drone 2), triggering the separation algorithm.	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	

Table 4-2 Test procedure FUNCHAIN.0020

4.2.1 Test execution and results

Date	24th of October 2024
Tester	Francesco Russo
Place	TopView premises in Castel Campagnano
Hardware used	Device for GA, Windows PC
Notes	-

This test was executed in Castel Campagnano. A specific trajectory was drawn on Google Earth and then exported as KML file on the drone ground control station.

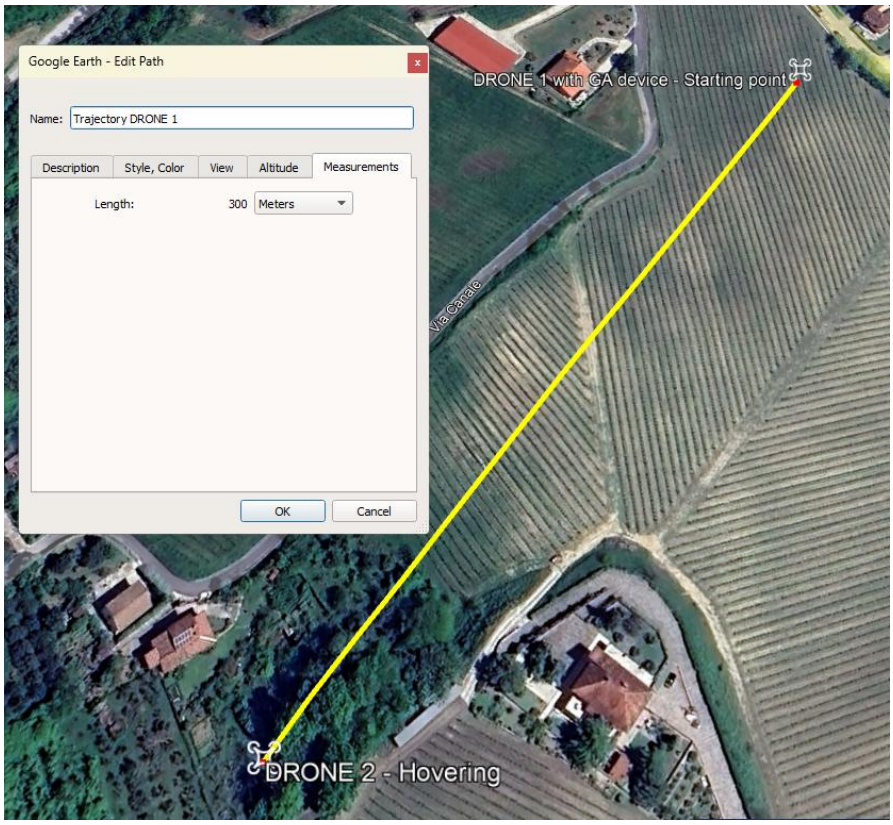

Figure 4-11 Trajectory of Drone 1

We performed two in-flight tests to verify the feature of the Device for GA.
To test them, we mounted the device for GA on the Drone 1, DJI M300, using a dedicated 3D printed adapter. This adapter featured an action-cam holder also, aiming to record the behaviour of the device during the flights.

Figure 4-12 The device for GA and the Action Cam onboard of Drone 1

For the test we used a second drone: DJI M200 with the COTS **Aerobits HOD Flarm transceiver** on-board. This second drone was lifted and left in hovering right above our premises, aiming to transmit the signal to the first drone with Device for GA on-board.

Figure 4-13 The drones used for the test with the devices onboard

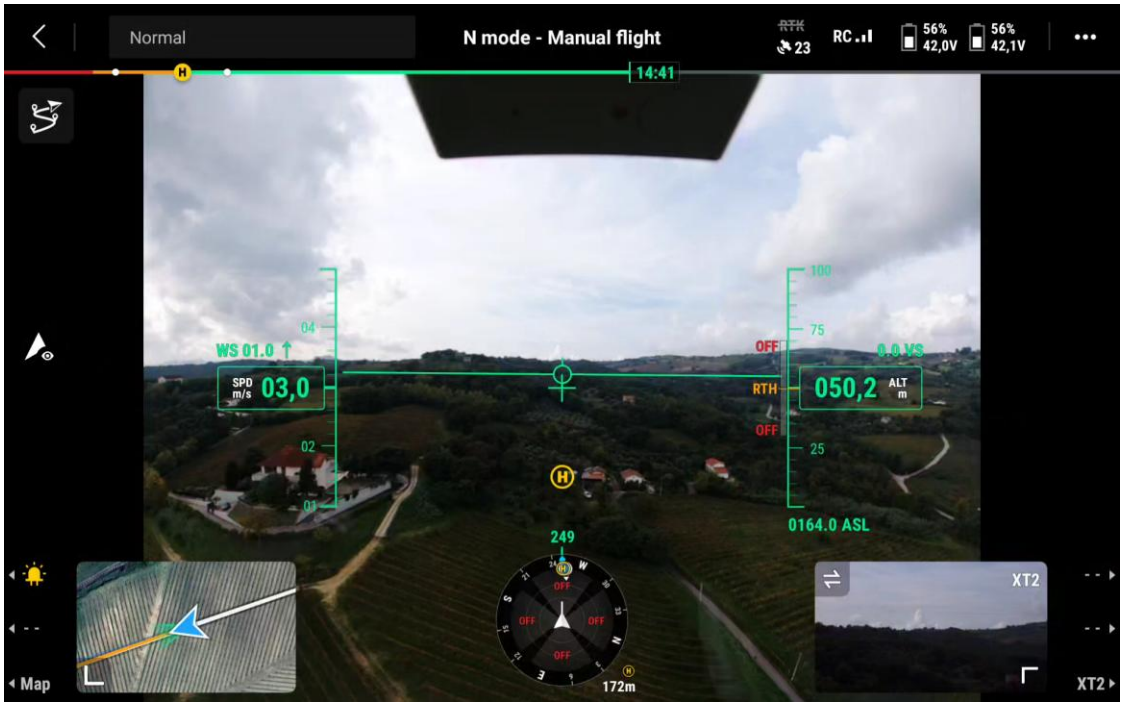

Figure 4-14 Screen capture from the ground control station of drone 1

The drone 2 was lifted up and standed in hovering at 50 meters above ground level, after that we gradually flew the Drone 1 to the Drone 2 at 3 m/s.

Figure 4-15 The Drone 1 with GA device during the flight

The algorithm snapped at 36 seconds before the conflict. In Figure 4-16 the output of the algorithm shows “Time to conflict = 36,72883411957616 s”

```
2024-10-24 13:04:26,944 INFO Horizontal conflict.
My data= {'LAT': 41.18043, 'LON': 14.44915, 'ALT': 200.7, 'DIR': 254.1, 'GS': 6.481439999999999, 'VS': -0.01}
Aircraft= {'ID': '300247', 'LAT': 41.17945, 'LON': 14.44613, 'ALT': 190, 'DIR': 0, 'GS': 0, 'VS': 0.0, 'TS': 1729767859.5707362}
Time to conflict= 36.72883411957616s
```

Figure 4-16 Algorithm activation on the log of the Device for GA

This activation was captured by the action cam also.

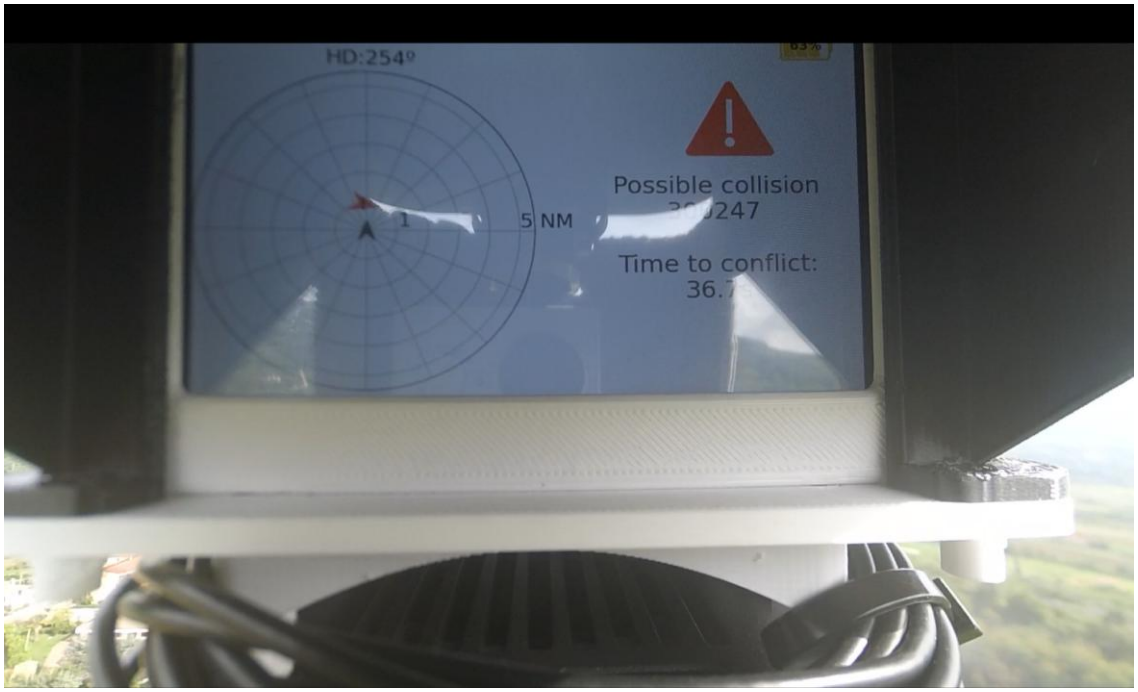

Figure 4-17 Algorithm activation captured by the action cam

As shown in Figure 4-18, the algorithm suggested the speed and direction correction to avoid the collision with Drone 2.

```
2024-10-24 13:04:52,419 INFO Vertical conflict.
My data= {'LAT': 41.18007, 'LON': 14.44746, 'ALT': 202.8, 'DIR': 245.8, 'GS': 5.09256, 'VS': -0.06}
Aircraft= {'ID': '300247', 'LAT': 41.17947, 'LON': 14.4462, 'ALT': 194, 'DIR': 90, 'GS': 0, 'VS': 0.0, 'TS': 1729767891.2784977}
2024-10-24 13:04:52,423 INFO Horizontal conflict.
My data= {'LAT': 41.18007, 'LON': 14.44746, 'ALT': 202.8, 'DIR': 245.8, 'GS': 5.09256, 'VS': -0.06}
Aircraft= {'ID': '300247', 'LAT': 41.17947, 'LON': 14.4462, 'ALT': 194, 'DIR': 90, 'GS': 0, 'VS': 0.0, 'TS': 1729767891.2784977}
Time to conflict= 15.097747191686002s
2024-10-24 13:04:52,461 INFO Speed/Heading bands:
speed_band= [9.59969295288006e-13, 1.1990076622431039e-12]
dir_band= [-145.80642771101313, -98.63764911896008]
```

Figure 4-18 Algorithm's advice on the log of the Device for GA

These advice for conflict resolution was properly displayed by the device and captured by the action cam Figure 4-19.

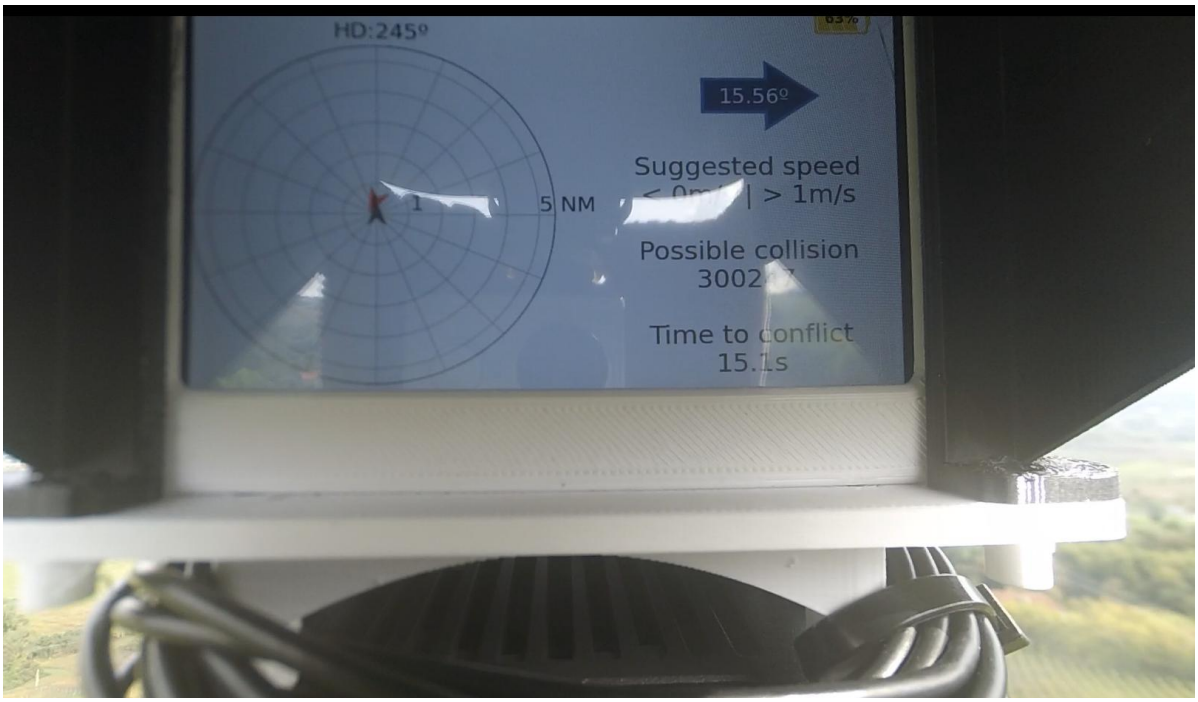

Figure 4-19 The conflict resolution advice captured by the action cam

This test was passed. Minor adjustments for the units of measurements (m/s-> knts) and rounding the information provided (i.e. heading) was implemented after the test.

4.3 REP_FUNCHAIN.0030 Post-flight Services: Light report

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.

PROC_FUNCHAIN.0030 Post-flight Services: Light report			
Step	**Activity description**	**Expected Result**	**Notes**
S_01	**Install the device on the drone** 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.		
S_02	**Association on device gateway** 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.		
S_03	**Pairing the device with Certiflight portal account** 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.		
S_04	**Turn on the device and wait for component preparation** 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.		
S_05	**Performs a 10-minute flight operation.**		
S_06	**Generate the light report** Once the mission is completed, the pilot follows the steps of TEST_CERTISW.0050 - Light Report generation.	The Report is signed electronically by the digital Signature module, and it is downloaded after flight.	

Table 4-3 Test procedure FUNCHAIN.0030

This test was already performed in D4.4 document as unit test. In this test we verified the complete functional chain, making sure that from installation of the Box on the drone, till the generation of the light report, each step was successfully achieved.

4.3.1 Test execution and results

Date	10th of October
Tester	Francesco Russo
Place	TopView premises
Hardware used	Device for UAS, Windows PC
Notes	-

The device pairing procedure has been done with a new serial number.

Figure 4-20 The device used for the test, the serial number is visible on the side

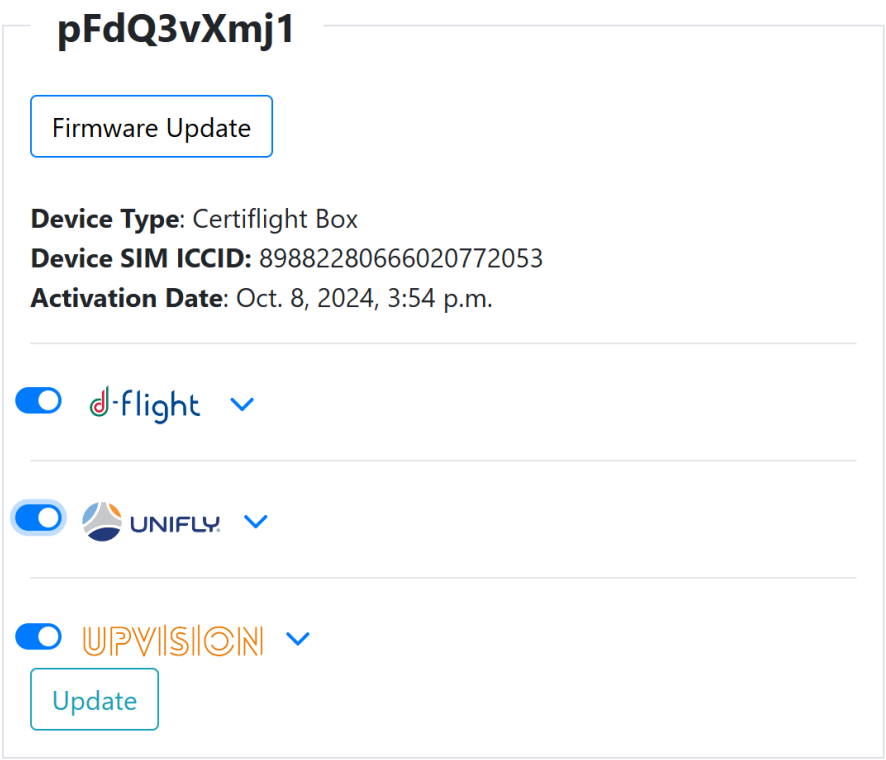

Figure 4-21 The device registered on the device gateway

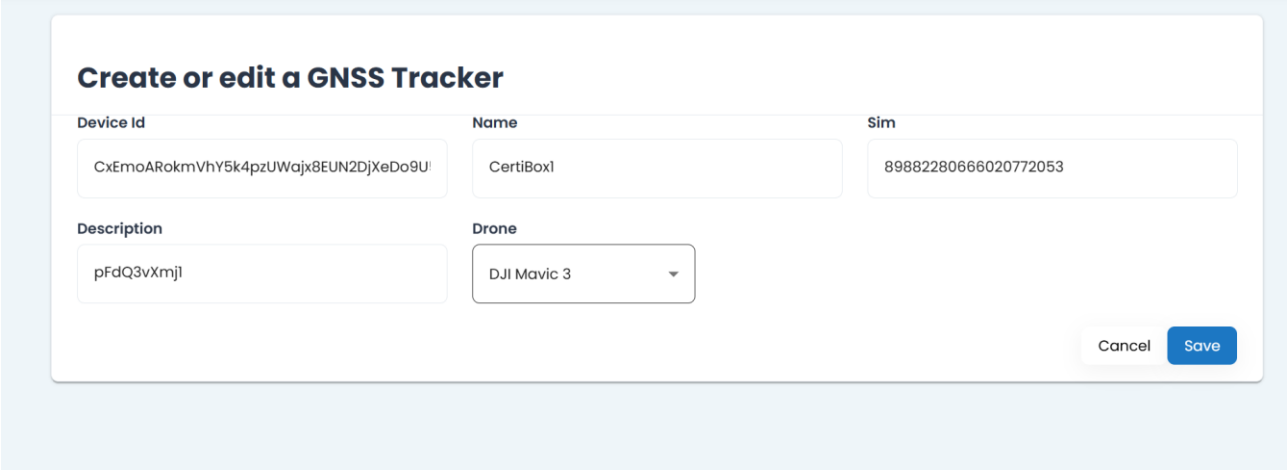

Figure 4-22 The device registered on Certiflight Portal

The flight was performed in Castel Campagnano. A grid trajectory was drawn on Google Earth and then exported as KML file on the drone ground control station.
This grid path was executed two times, flying at 2m/s.

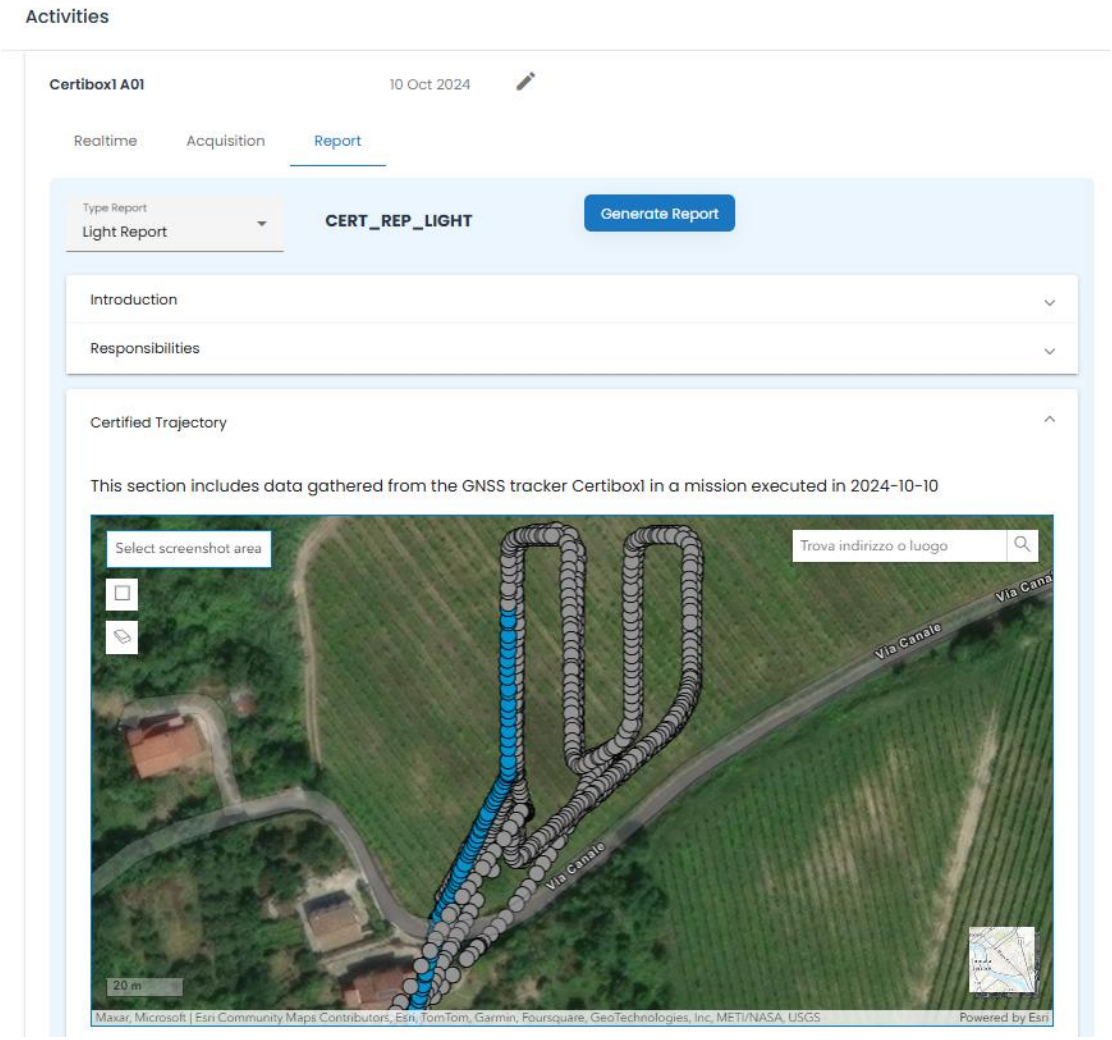

Figure 4-23 The flight trajectory in the report section of the activity

After the flight the light report has been generated.

Figure 4-24 The flight trajectory in the light report

Figure 4-25 The selected authenticated position in the light report

Figure 4-26 The flight statistics in the light report

4.4 REP_FUNCHAIN.0040 Post-flight Services: Full report

This test was performed following the steps described in the table below.
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.

PROC_FUNCHAIN.0040 Post-flight Services: Full report			
Step	**Activity description**	**Expected Result**	**Notes**
S_01	**Upload of additional data** 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).	The data is uploaded in the acquisition section	
S_02	**Generate the Full report**	Input data are processed by GSD / APP Algorithms according to the specification provided in D3.6. The Report is signed electronically by the digital Signature module.	

S_03	Download and check the report	The full report is available on Certiflight Portal to the Pilot that can download it.	

Table 4-4 Test procedure FUNCHAIN.0040

4.4.1 Test execution and results

Date	10th of October
Tester	Francesco Russo
Place	TopView premises
Hardware used	Device for UAS, Windows PC
Notes	-

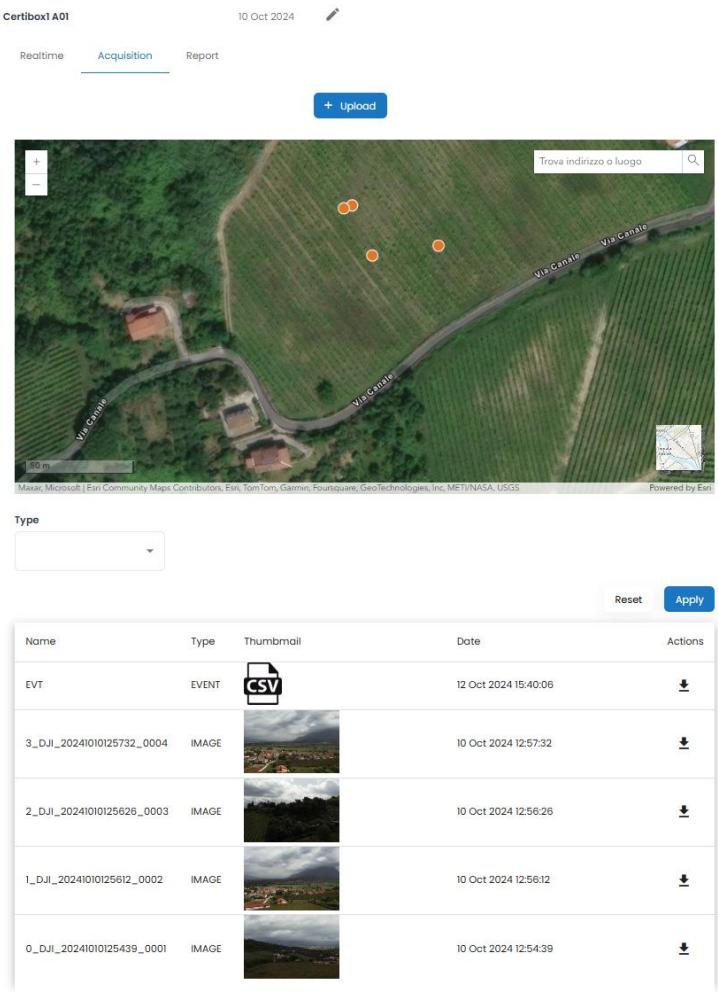

Figure 4-27 The additional data uploaded in the acquisition section

5 Verification Matrix

The verification matrix is presented according to the following format:

ReqID	ReqTitle	Type	Verification Method	D,A,I Justification	Status of compliance	Close-out Status
Requirement Identification	Requirement title	General, functional, performance …	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 Requirements.
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

Req ID	Req Title	Type	Verification Method	Test Case/ procedure ID	RoD, I, A Justification	Status of compliance	Close-out Status
CFT-SYS-0010	CERTIFLIGHT Solution	General	RoD	-	The design of Certiflight solution has been verified during the end-to-end tests	C	CLOSED
CFT-SYS-0010	CERTIFLIGHT Solution	General	RoD	-	The design of Certiflight solution has been verified during the end-to-end tests	C	CLOSED
CFT-SYS-0020	CERTIFLIGHT Services	General	RoD	-	The design of Certiflight solution has been verified during the end-to-end tests	C	CLOSED
CFT-SYS-0030	Galileo Navigation Message Authentication service	General	A	-	Requirement analysed during the end-to-end tests	C	CLOSED
CFT-SYS-0040	Permanent storage of data generated by CERTIFLIGHT devices	General	A	-	Requirement analysed during the end-to-end tests	C	CLOSED
CFT-SYS-0050	UTM Box for CERTIFLIGHT	General	A	-	Requirement analysed during the end-to-end tests	C	CLOSED
CFT-SYS-0060	UTM Box Interoperability	General	T	TEST_ UTMBOX.0010	-	C	CLOSED
CFT-SYS-0070	UTM Box UAS / aircraft association	General	A	-	Requirement analysed during the end-to-end tests	C	CLOSED
CFT-SYS-0080	UTM Box to USSP Interface UTM I/F - AuTRS visualziation	General	A	-	Requirement analysed during the end-to-end tests	C	CLOSED
CFT-SYS-0090	UTM Box status feedback to Pilot	Functional	A	-	Requirement analysed during the end-to-end tests	C	CLOSED
CFT-SYS-0100	UTM Box for UAS features	Functional	A	-	Requirement analysed during the end-to-end tests	C	CLOSED
CFT-SYS-0110	UTM Box for GA features	Functional	A	-	Requirement analysed during the end-to-end tests	C	CLOSED
CFT-SYS-0120	CERTIFLIGHT Portal: data inserted by the User in the report	Functional	T	TEST_CERTISW.0050 TEST_CERTISW.0070	-	C	CLOSED

CFT-SYS-0130	Device Gateway and UTM Box Authentication	Functional	T	TEST_ UTMBOX.0020	-	C	CLOSED
CFT-SYS-0140	i-Conspicuity message Payload	Functional	I	-	Requirement verified by code inspection (debud mode) during the end-to-end tests	C	CLOSED
CFT-SYS-0150	UTM Box Position Accuracy	Functional	A	-	Requirement analysed during the end-to-end tests	C	CLOSED
CFT-SYS-0160	UTM Box Remote Identification (NRI and DRI)	Functional	A	-	Requirement analysed during the end-to-end tests New developed functionality (DRI) was successfully tested	C	CLOSED
CFT-SYS-0170	CERTIFLIGHT Portal front end responsiveness	Functional	T	TEST_CERTISW.0030	-	C	CLOSED
CFT-SYS-0180	CERTIFLIGHT Portal registration/ profiling/login	Functional	T	TEST_CERTISW.0010	-	C	CLOSED
CFT-SYS-0190	UTM Box secure binding with user profile	Functional	T	TEST_CERTISW.0020	-	C	CLOSED
CFT-SYS-0200	CERTIFLIGHT Portal configuration - profiling	Functional	T	TEST_CERTISW.0010	-	C	CLOSED
CFT-SYS-0210	CERTIFLIGHT Portal configuration - Home Dashboard	Functional	T	TEST_CERTISW.0030	-	C	CLOSED
CFT-SYS-0220	CERTIFLIGHT Portal - UTM box configuration	Functional	T	TEST_CERTISW.0020	-	C	CLOSED
CFT-SYS-0230	CERTIFLIGHT Portal - UTM box real time data acquisition	Functional	T	TEST_CERTISW.0030	-	C	CLOSED
CFT-SYS-0240	CERTIFLIGHT Portal - UTM box real time data visualisation	Functional	T	TEST_CERTISW.0030	-	C	CLOSED
CFT-SYS-0250	CERTIFLIGHT Portal- UTM box real time monitoring	Functional	T	TEST_CERTISW.0030	-	C	CLOSED
CFT-SYS-0260	CERTIFLIGHT Portal configuration - Light Report	Functional	T	TEST_CERTISW.0050	-	C	CLOSED

CFT-SYS-0270	CERTIFLIGHT Portal - Light Report generation	Functional	T	TEST_CERTISW.0050	-	C	CLOSED
CFT-SYS-0280	CERTIFLIGHT Portal - offline full data ingestion	Functional	T	TEST_CERTISW.0060	-	C	CLOSED
CFT-SYS-0290	CERTIFLIGHT Portal - offline full data processing	Functional	T	TEST_CERTISW.0040 TEST_CERTISW.0070	-	C	CLOSED
CFT-SYS-0300	CERTIFLIGHT Portal configuration - Full Report	Functional	T	TEST_CERTISW.0070	-	C	CLOSED
CFT-SYS-0310	CERTIFLIGHT Portal Spoofing Report	Functional	A	-	Requirement analysed during the end-to-end tests	C	CLOSED
CFT-SYS-0320	CERTIFLIGHT Portal Proof of Delivery	Functional	T	TEST_CERTISW.0080 TEST_CERTISW.0090		C	CLOSED
CFT-SYS-0330	UTM Box to USSP Interface - Scalability	Functional	A	TEST_ UTMBOX.0060	Requirement analysed during the end-to-end tests	C	CLOSED
CFT-SYS-0350	Feature for UTM Box pairing with the drones	Functional	I	-	Requirement verified by inspection (UTM Box Serial number successfully paired with drone and displayed on Device Gateway portal) during the end-to-end tests	C	CLOSED
CFT-SYS-0360	Feature for notification regarding the UTM Box power management	Functional	T	TEST_ UTMBOX.0030	- Battery threshold corrected	C	CLOSED
CFT-SYS-0370	Feature for notification regarding the UTM Box data management	Functional	T	TEST_ UTMBOX.0030	-	C	CLOSED
CFT-SYS-0380	APP function	Functional	T	TEST_ EGNSS.00020	-	C	CLOSED
CFT-SYS-0390	APP function state vector	Functional	T	TEST_ EGNSS.00020	-	C	CLOSED
CFT-SYS-0400	GNSS raw measurements database	Functional	T	TEST_ EGNSS.00010	-	C	CLOSED
CFT-SYS-0410	GNSS navigation database	Functional	T	TEST_ EGNSS.00010	-	C	CLOSED
CFT-SYS-0420	GNSS Aiding database	Functional	T	TEST_ EGNSS.00010	-	C	CLOSED

CFT-SYS-0430	IMU raw measurements database	Functional	T	TEST_ EGNSS.00010	The test was partially compliant, as the noise level of the UTM Box was higher than expected. Although the noise effect was partially mitigated during testing, the industrial-grade IMU used does not achieve the performance required for the APP to be fully utilized. On the other hand, a high-end IMU would not align with market expectations for a 'low-cost' solution. This result suggests a potential split into two UTM Box hardware products: the current UTM Box, suitable for quick market adoption, and a high-end UTM Box with enhanced performance.	PC	OPEN The UTM box was not capable to provide noise information related to the IMU. The IMU measurement show frequent spikes and outliers that cannot be mitigated during the pre-processing and cannot be used by the APP without high degradation in performance.
CFT-SYS-0440	GNSS data frequency	Functional	T	TEST_ EGNSS.00010	-	C	CLOSED
CFT-SYS-0450	IMU data frequency	Functional	T	TEST_ EGNSS.00010	The result of this test further confirms the potential need to split into two hardware products. Specifically, the 10 Hz IMU frequency drops to 9 Hz when the microcontroller of the UTM Box processes the signing of telemetry data for the authenticated tracking functionality.	PC	OPEN Frequency of logging is not always stable and shows values lower than 10Hz. The time in the datasets presents sudden jumps, where the Unix time is not logged correctly and presents invalid

							values. This problem is caused by the high computational loads for the UTM box micro-controller to sign the data for authentication that affected the IMU data collection
CFT-SYS-0460	APP solution frequency	Functional	T	TEST_ EGNSS.00020	-	C	CLOSED
CFT-SYS-0470	APP function with GNSS outages	Functional	T	TEST_ EGNSS.00030	-	C	CLOSED
CFT-SYS-0480	GSD function	Functional	T	TEST_ EGNSS.00040	-	C	CLOSED
CFT-SYS-0490	GSD solution time tag	Functional	T	TEST_ EGNSS.00040	-	C	CLOSED
CFT-SYS-0500	UTM Box 4G/5G Handover	Performance	T	TEST_ UTMBOX.0040	-	C	CLOSED
CFT-SYS-0510	UTM Box endurance (UAS)	Performance	T	TEST_ UTMBOX.0040	-	C	CLOSED
CFT-SYS-0520	UTM Box endurance (GA version)	Performance	T	TEST_ UTMBOX.0040	-	C	CLOSED
CFT-SYS-0530	UTM Box Transmission rate	Performance	T	TEST_ UTMBOX.0070	-	C	CLOSED
CFT-SYS-0540	UTM Box minimum transmission Rate	Performance	A	-	Requirement analysed in TEST_ UTMBOX.0070	C	CLOSED
CFT-SYS-0560	Automated Separation resolution	Performance	A	-	Requirement analysed in TEST_ UTMBOX.0080 and TEST_FUNCHAIN	C	CLOSED
CFT-SYS-0570	APP function Horizontal position accuracy	Performance	T	TEST_ EGNSS.00020	-	PC	OPEN Tested in not complete nominal condition, the APP shows slightly higher errors

CFT-SYS-0580	APP function Vertical Position accuracy	Performance	T	TEST_ EGNSS.00020	-	C	CLOSED
CFT-SYS-0590	APP function Velocity accuracy	Performance	T	TEST_ EGNSS.00020	-	C	CLOSED
CFT-SYS-0600	App function heading accuracy	Performance	T	TEST_ EGNSS.00020	-	C	CLOSED
CFT-SYS-0610	GSD spoofing detection capability	Performance	T	TEST_ EGNSS.00040	-	C	CLOSED
CFT-SYS-0620	UTM Box Cybersecurity	Security	A	-	-	C	CLOSED
CFT-SYS-0630	UTM Box Anti Tampering Mechanisms	Security	I	-	Requirement verified by inspection during the end-to-end tests	C	CLOSED
CFT-SYS-0640	Chain of Trust of Information	Security	A	-	-	C	CLOSED
CFT-SYS-0650	UTM Box Factory key	Security	T	TEST_ UTMBOX.0020	-	C	CLOSED
CFT-SYS-0660	UTM Box - Aircraft (UAS) pairing	Security	T	TEST_ FUNCHAIN.0030 TEST_ FUNCHAIN.0040	-	C	CLOSED
CFT-SYS-0670	Data Protection practices	Security	RoD	-	The design of Certiflight solution has been verified during the end-to-end tests	C	CLOSED
CFT-SYS-0680	Device Tampering	Security	RoD	-	The design of Certiflight solution has been verified during the end-to-end tests	C	CLOSED
CFT-SYS-0690	Accounts' data segmentation and non-interference	Security	T	TEST_ UTMBOX.0020	-	C	CLOSED
CFT-SYS-0700	Super-user feature available only to competent authorities	Security	I	-	-	C	CLOSED
CFT-SYS-0710	UTM Box orientation	Operational	I	-	-	C	CLOSED
CFT-SYS-0720	Vertical Position Indicator for GA	Operational	A	-		C	CLOSED

CFT-SYS-0730	Automated Separation advisory	Operational	A	-		C	CLOSED
CFT-SYS-0740	Preparedness for real-time monitoring and automation	Operational	RoD	-		C	CLOSED
CFT-SYS-0750	Smart Contract activation	Regulatory	RoD	-		C	CLOSED
CFT-SYS-0760	Legal Recording	Regulatory	RoD	-		C	CLOSED
CFT-SYS-0770	Digital Logbook	Regulatory	RoD	-		C	CLOSED
CFT-SYS-0780	Network Remote Identification	Regulatory	RoD	-		C	CLOSED
CFT-SYS-0790	Tracking	Regulatory	RoD	-		C	CLOSED
CFT-SYS-0800	Accident and Incident Reporting	Regulatory	RoD	-		C	CLOSED
CFT-SYS-0810	CERTIFLIGHT Platform Flexible and adapted licensing conditions	Business	RoD	-		C	CLOSED
CFT-SYS-0820	SWaP-C	Business	RoD	-		C	CLOSED
CFT-SYS-0830	Conditioning the use of the platform by the existence and validity of a subscription	Business	T	-	-	C	CLOSED
CFT-SYS-0840	Development of a software-based/ web-based custom subscriptions set	Business	RoD	-		C	CLOSED
CFT-SYS-0850	Preparedness for mass-production and integration in drones	Business	I	-		C	CLOSED
CFT-SYS-0860	UTM Box IF to Drone data bus	Interface	T	TEST_ UTMBOX.0050	-	C	CLOSED
CFT-SYS-0870	UTM Box IF to Payload data	Interface	T	TEST_ UTMBOX.0050	-	C	CLOSED

CFT-SYS-0880	Authenticated Tracking service Transmission	Interface	T	TEST_ FUNCHAIN.0010	-	C	CLOSED
CFT-SYS-0890	Authenticated Tracking service visualization on USSP	Interface	T	TEST_ FUNCHAIN.0010	-	C	CLOSED
CFT-SYS-0900	CERTIFLIGHT Portal Interface	Interface	RoD	-	The design of Certiflight solution has been verified during the end-to-end tests	C	CLOSED
CFT-SYS-0910	UTM Box to USSP Interface: Connectivity	Interface	T	TEST_ UTMBOX.0060 TEST_ FUNCHAIN.0010	-	C	CLOSED
CFT-SYS-0920	UTM Box to USSP Interface - Tracking device monitoring	Interface	T	TEST_ UTMBOX.0010 TEST_ FUNCHAIN.0010	-	C	CLOSED
CFT-SYS-0930	UTM Box to USSP Interface - Flight data format	Interface	A	-	Requirement analysed during the end-to-end tests	C	CLOSED
CFT-SYS-0940	UTM Box to USSP Interface - Compatibility	Interface	A	-	Requirement analysed during the end-to-end tests	C	CLOSED
CFT-SYS-0950	APP required input parameters	Interface	T	TEST_ EGNSS.0010	-	C	CLOSED
CFT-SYS-0960	UTM Box installation	Interface	I	-	Requirement verified by inspection during the end-to-end tests	C	CLOSED
CFT-SYS-0970	GNSS receiver signal bands	Interface	RoD	-	The design of Certiflight solution has been verified during the end-to-end tests	C	CLOSED
CFT-SYS-0980	GNSS receiver's antenna	Interface	I	-	Requirement verified by inspection during the end-to-end tests	C	CLOSED
CFT-SYS-0990	GSD required input parameters	Interface	A	TEST_ EGNSS.00010	Requirement analysed in unit test TEST_ EGNSS.00010	C	CLOSED
CFT-SYS-1000	Data Base format	Interface	A	-	Requirement analysed during the end-to-end tests	C	CLOSED

Table 5-1 Verification Matrix

6 Conclusions

The integration and verification phase were successfully completed, with only minor issues identified during the integration activities. Key conclusions from this phase are summarized as follows:

- ✓ Potential Fork of UTM Box Hardware Products: IMU and Microcontroller Performance
  - The testing performed indicated that the current UTM Box hardware configuration, which includes cost-effective (but still industrial-grade) components like the 32-bit Cortex®-M4 core microcontroller and the 16-bit IMU (STM LSM9DS1) with a 3-axis accelerometer, gyroscope, and magnetometer, is partially compliant for the implementation of the APP algorithm. All other components of Certiflight, including the GSD algorithm, are fully supported by the existing hardware.

  - In fact, while a high-end IMU would improve performance and address the requirements of the APP (in-depth analyzed during the testing in D4.2), it would not align with market expectations for a cost-effective solution. As a result, a two-product approach is recommended. Verification activities with W4W Marvin box demonstrated support for higher frequency rates, making the APP algorithm more effective at an expected optimal performance rate of 100 Hz, though the form factor and weight of the Box is not compliant with market expectations. However, It should be noted that the APP algorithm had an experimental nature and its functionality, limitations and performance requirements were studied throughout the project.

  - This approach would allow the **standard UTM Box** developed in the project to retain its current configuration, meeting current market demands and enabling faster market adoption while maintaining the target market price suggested by the cost-benefit analysis. In contrast, the **High-Performance UTM Box** would be a premium variant with a new architecture, incorporating dual-core microprocessors like the ARM Cortex-A9 or Qualcomm Snapdragon 410E (as examples) and a high-end IMU, such as the Analog Devices ADIS 16xxx series, to achieve improved precision and noise control for users needing enhanced performance and full applicability of APP algorithm.

- ✓ Compliance with DRI (Direct Remote Identification)
  - Although not coded as a test (but reported in par. 4.1.2, the DRI functionality on the current UTM Box has been fully implemented, meeting the ASTM 3411-22a Standard Specification for Remote ID and Tracking and ASD-STAN UNI EN 4709-002:2023 specifications. The EU Declaration of Conformity was completed and submitted to EASA last August, with publication on the EASA website pending (https://www.easa.europa.eu/en/domains/drones-air-mobility/operating-drone/specific-category-civil-drones). This ensures that the Certiflight UTM Box is compatible with recognized standards for Remote ID and tracking functionalities.

- ✓ Certiflight Light and Full Report - Legal Validity and Compliance:
  - The reports generated by the Certiflight platform are currently under review by two expert lawyers to assess the scope of their legal validity across the EU when paired with

qualified electronic signatures or seals, in accordance with the eIDAS (2.0) regulation (EU 910/2014). Data storage on certified blockchain infrastructure, such as the European Blockchain Services Infrastructure (EBSI) is aligned with best practices from the European Blockchain Partnership (EBP). The validity of report is an important activity to be discussed in the final stage of the project

Beyond these considerations, the Certiflight Platform is now ready for the validation phase.