ECHO 2

Echo 2 – Dissemination WS
WP 2 “HAPS Integration”

Echo 2 – Dissemination WS, Capua, 7th of November 2024

SUPPORTED BY sesar JOINT UNDERTAKING

Co-funded by the European Union

Echo 2 – Dissemination WS, WP 2 “HAPS Integration”

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Agenda

- Overall presentation on WP 2 (Timeline, partners, main topics) (DFS)
- Presentation of the OSED (main topics, scenarios, solution) (DFS)
- Presentation VALP (overall view RTS, flight trials) –(CIRA)
  - RTS April 2025 (maybe ECTRL)
  - Flight trials AALTO 2025 (maybe AALTO)
  - Flight trials Skydweller 2025 (Skydweller)
- Standardization, Regulation – experience by AALTO with permit to fly in 2024
- Discussion

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Overall presentation on WP 2

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Overall presentation on WP 2 (1/5)

- Overview Work package 2
  - WP 2: Integration of HAPS operations in European ATM
  - Duration: Month 1 to 36 (01/09/2023 – 31/08/2026)
- Partners:
  - EUROCONTROL
  - CIRA
  - LEONARDO
  - DFS
  - ENAIRE
  - INECO
  - ENAC (FR)
  - ENAC (IT)
  - ENAV
  - AOSL
  - DSNA
  - LFV
  - LIU
  - CAI
  - SKYDWELLER
  - THALES LAS
  - NAV PORTUGAL
  - THALES SPACE
  - AALTO
  - NATS

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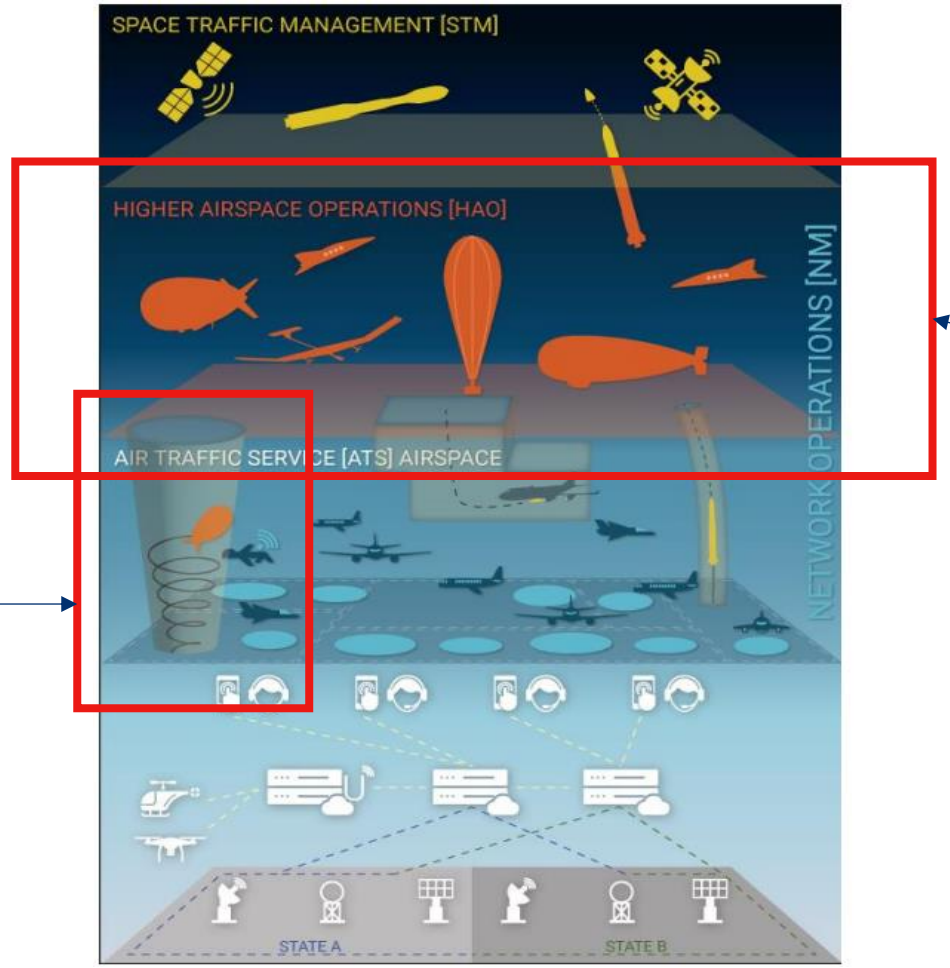
Overall presentation on WP 2 (2/5)

Content of WP 2



WP 2 Content:
High altitude operations

WP 2 Content:
Transition phase to controlled airspace

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Overall presentation on WP 2 (3/5)

Aim of WP 2:

- Development and validation of specific elements of the European High Altitude Operations ConOps related to the integration of High-Altitude Platform Systems (HAPS) in Air Traffic Management (ATM).
  - Procedures based on performance of the HAPS
  - Weather Impact (especially during take-off, climb and descent phase)
  - Network Impact (effects on overall capacity)
  - CNS Requirements (e.g. ADS-B, Mode N, separation)
  - Datalink Infrastructure (Datalink requirements, Lost Command and Control Link)
  - Ground handling of HAPS on airports
- Based on the “ECHO target concept”, the 4d trajectory of the HAPS is the central part of the development. The concept will be applied to both individual vehicles, flying according to their agreed trajectories, and to operating volumes defined as 4d zones. Elements are:
  - dynamic airspace reservation, where size and duration determined through a CDM process.
  - 4D operational zones

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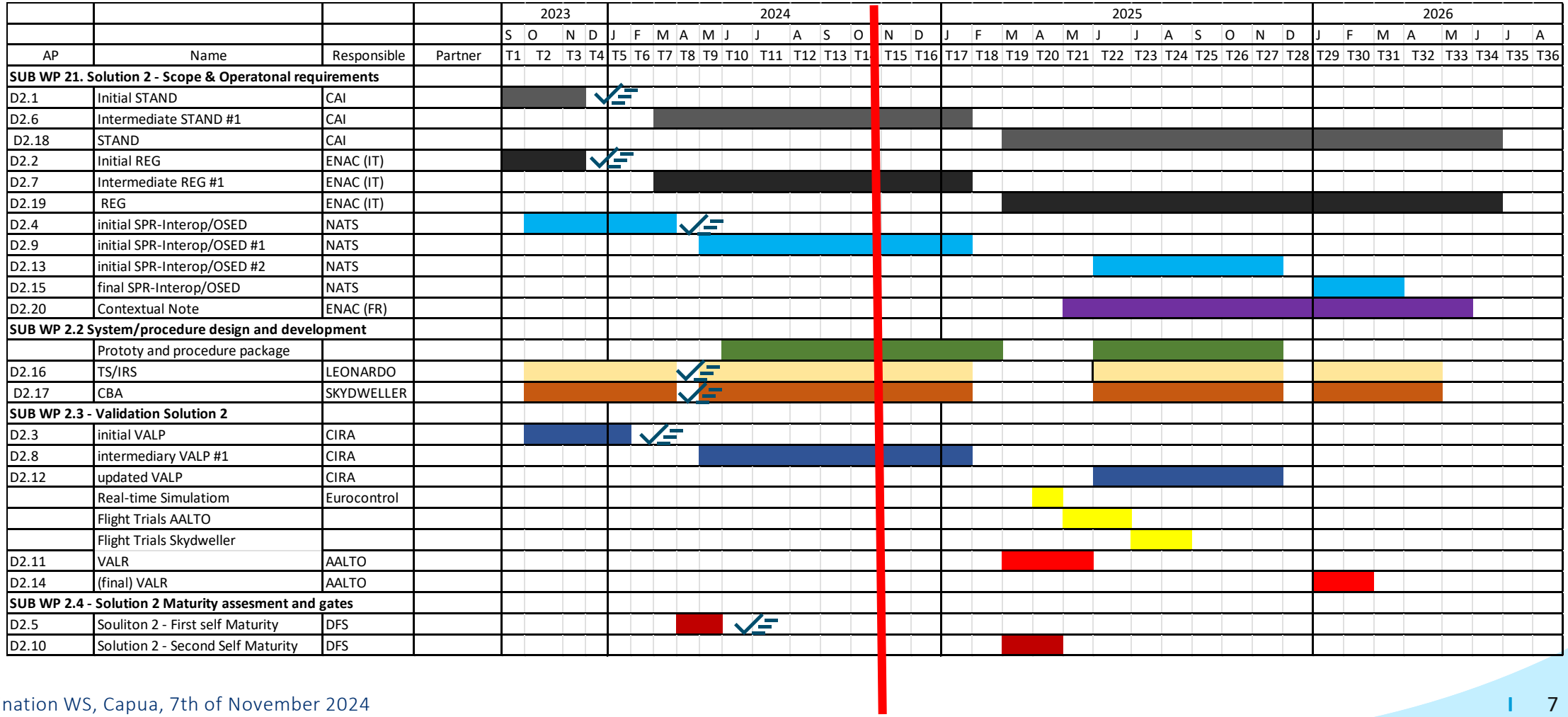
Overall presentation on WP 2 (4/5)

- Time schedule

AP	Name	Responsible	Partner
SUB WP 21. Solution 2 - Scope & Operatonal requirements			
D2.1	Initial STAND	CAI	
D2.6	Intermediate STAND #1	CAI	
D2.18	STAND	CAI	
D2.2	Initial REG	ENAC (IT)	
D2.7	Intermediate REG #1	ENAC (IT)	
D2.19	REG	ENAC (IT)	
D2.4	initial SPR-Interop/OSED	NATS	
D2.9	initial SPR-Interop/OSED #1	NATS	
D2.13	initial SPR-Interop/OSED #2	NATS	
D2.15	final SPR-Interop/OSED	NATS	
D2.20	Contextual Note	ENAC (FR)	
SUB WP 2.2 System/procedure design and development			
	Prototy and procedure package		
D2.16	TS/IRS	LEONARDO	
D2.17	CBA	SKYDWELLER	
SUB WP 2.3 - Validation Solution 2			
D2.3	initial VALP	CIRA	
D2.8	intermediary VALP #1	CIRA	
D2.12	updated VALP	CIRA	
	Real-time Simulatiom	Eurocontrol	
	Flight Trials AALTO		
	Flight Trials Skydweller		
D2.11	VALR	AALTO	
D2.14	(final) VALR	AALTO	
SUB WP 2.4 - Solution 2 Maturity assesment and gates			
D2.5	Souliton 2 - First self Maturity	DFS	
D2.10	Solution 2 - Second Self Maturity	DFS	



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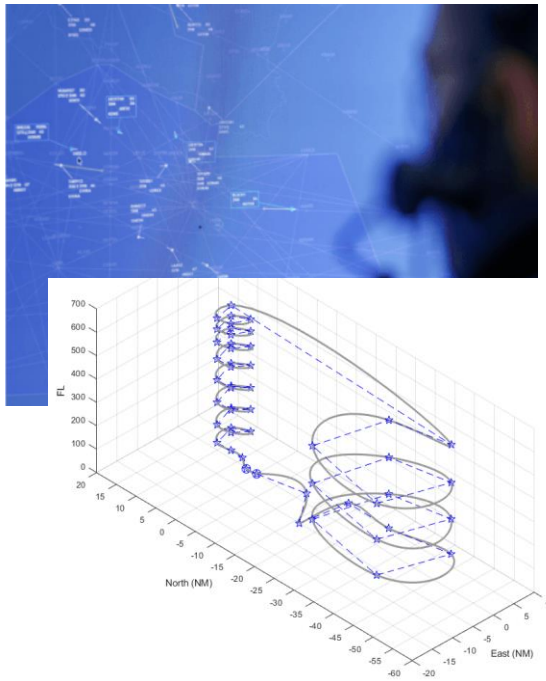
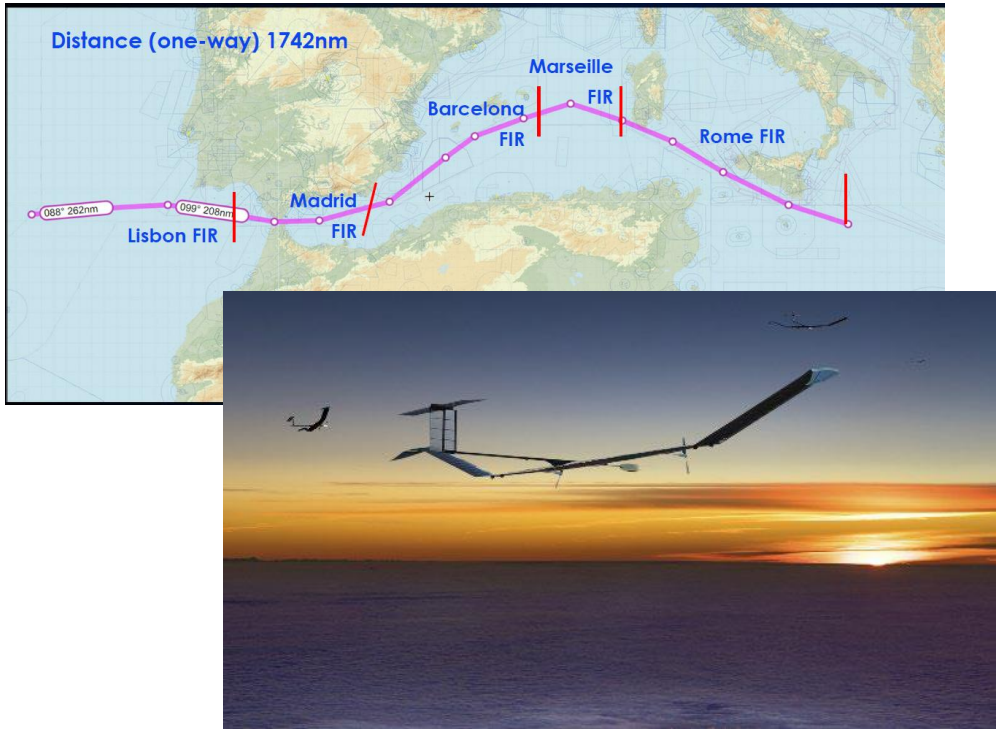
Overall presentation on WP 2 (5/5)

- Validations planned in 2025

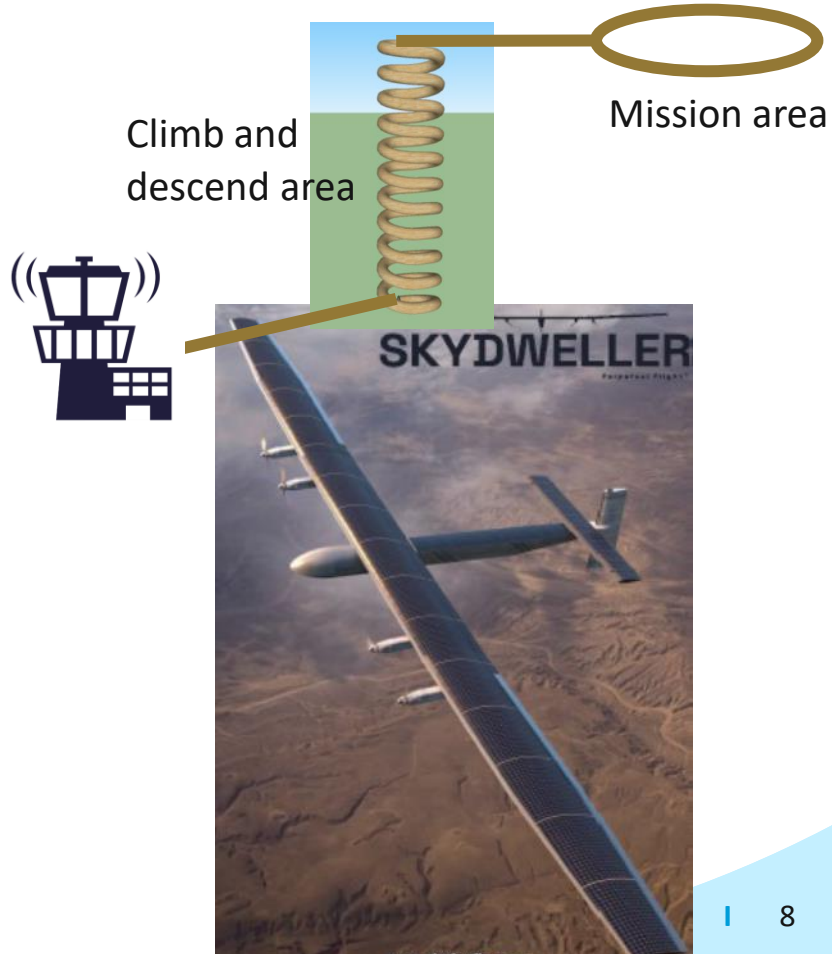
RTS Eurocontrol Brétigny



Flight trials AALTO Zephyr May/June



Flight trials Skydweller July/August



Echo 2 – Dissemination WS, WP 2 “HAPS Integration”

WP 2 Operational Service and Environment Definition (OSED)

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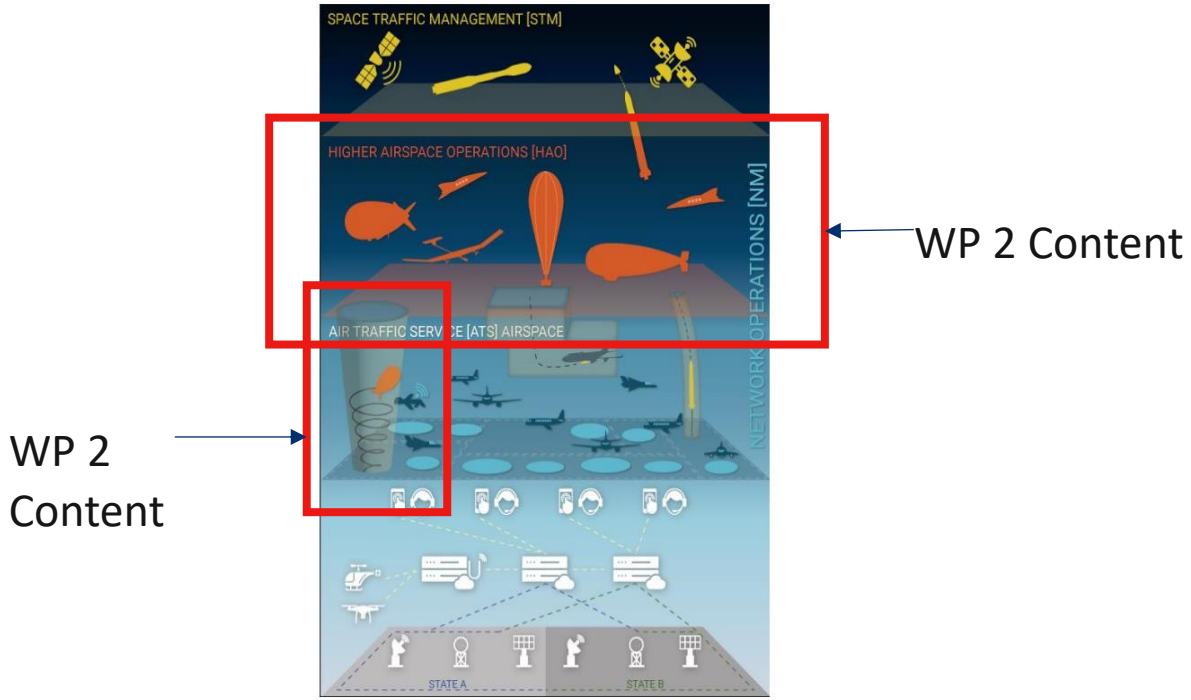
WP 2 Operational Service and Environment Definition (OSED)

- OSED split in two areas according to the two phases
  - transition phase
  - High Altitude phase
- Focus in the current OSED on the transition phase:
  - Development of procedures for safe transition to controlled airspace up to flight level 550 (16000m)
- Challenges:
  - Low performance of HAPS: (speed e.g. 25 knots, climb and descent rate below 100ft/min)
  - Drift even by low and medium wind
  - Contingency and emergency procedures
- Solution 4D operational zone
  - User centric 4D operational zone
  - Static 4D operational zone



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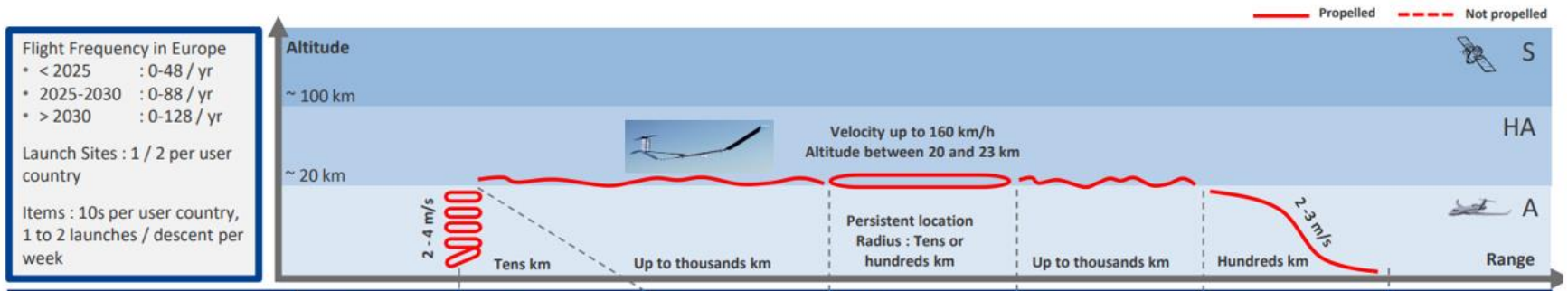
WP 2 Operational Service and Environment Definition (OSED) (2/6)

- Use Cases:
  - Motorized Heavier Than Air (HTA) Fixed Wing operations
  - Lighter Than Air (LTA) Free Balloon operations
  - Lighter Than Air (LTA) Manoeuvring Balloon operations
  - Motorized Lighter Than Air(LTA) Airship operations



UC_HAPS_FW1		Pre-flight (Ground)	Take off + Ascent (A + HA)	Transit (HA)	Mission (HA)	Transit (HA)	Descent (HA + A)	Pre-flight (Ground)
Vehicle & Operator capabilities	Duration	Days	8-10 hours (diurnal)	Hours	Up to several months	Hours	Up to 18 hours for diurnal landing	Hours to days
	Motion type	N/A	Powered climb with limited ascent rate	Propulsion / Control-Gliding	Propulsion / Control-Gliding	Propulsion / Control-Gliding	Propulsion / Control-Gliding	N/A
	Maneuverability	N/A	Spiral ascension or En-route climb segments	En-route climb/descent segments	En-route climb/descent segments / Horizontal waypoint tracking with limited pan	En-route climb/descent segments	En-route descent segments	N/A
	Fly over area	N/A	Close to launch site, depending on weather conditions Vertical transition: up to 75 NM radius	Worldwide (limited latitudes) Corridor : 20 NM width (FL550-FL700)	Persistent location (circles) with 10s / 100s km radius (limited latitudes)	Worldwide (limited latitudes) Corridor : 20 NM width (FL550-FL700)	Close to recovery site, depending on weather conditions Corridor : 20 NM width	N/A

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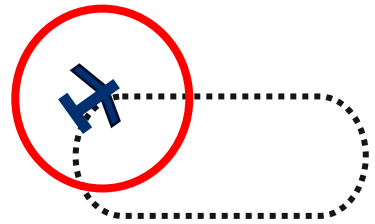
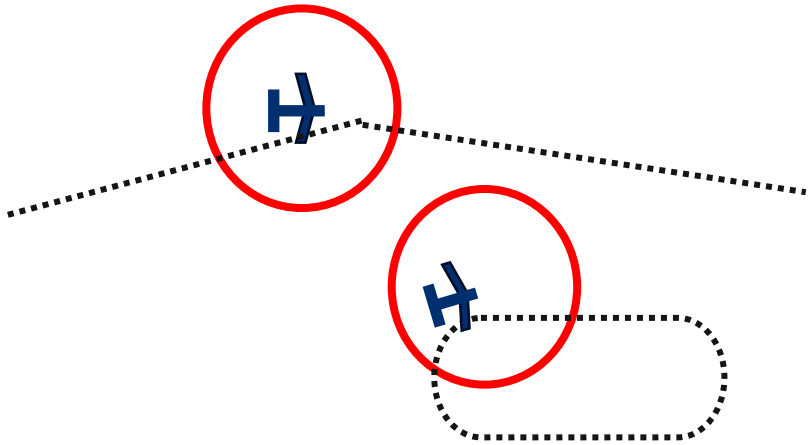
WP 2 Operational Service and Environment Definition (OSED) (3/6)

Discussion example:

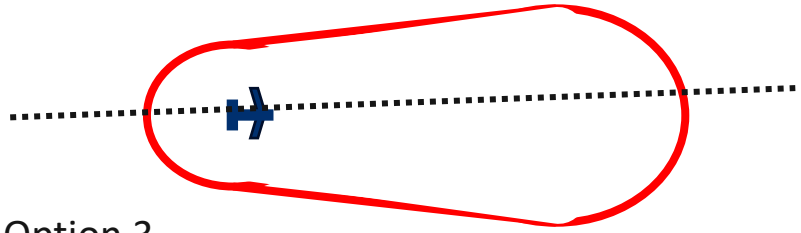
- Volumes provide ATCO with additional separation volume to account for limited HAPS manoeuvrability and maximum possible wind deviation
- Additional separation could be FBZ sep inside volume as ‘safety buffer’?
  - Pro:
    - small volume
    - Less complex geometry (option 1)
  - Con:
    - Dynamic ‘jittery’ nature may decrease ability for ATCO to plan traffic around HAPS
- **Result:** Two types of 4DOZ in development for validation in WP2:
  - ‘Laterally Static 4D OZ’
  - ‘Vehicle Centred 4D OZ’



Option 1
Circle centred on current position



Option 2
Circle offset to account for HAPS velocity



Option 3
Cone of uncertainty based on HAPS velocity

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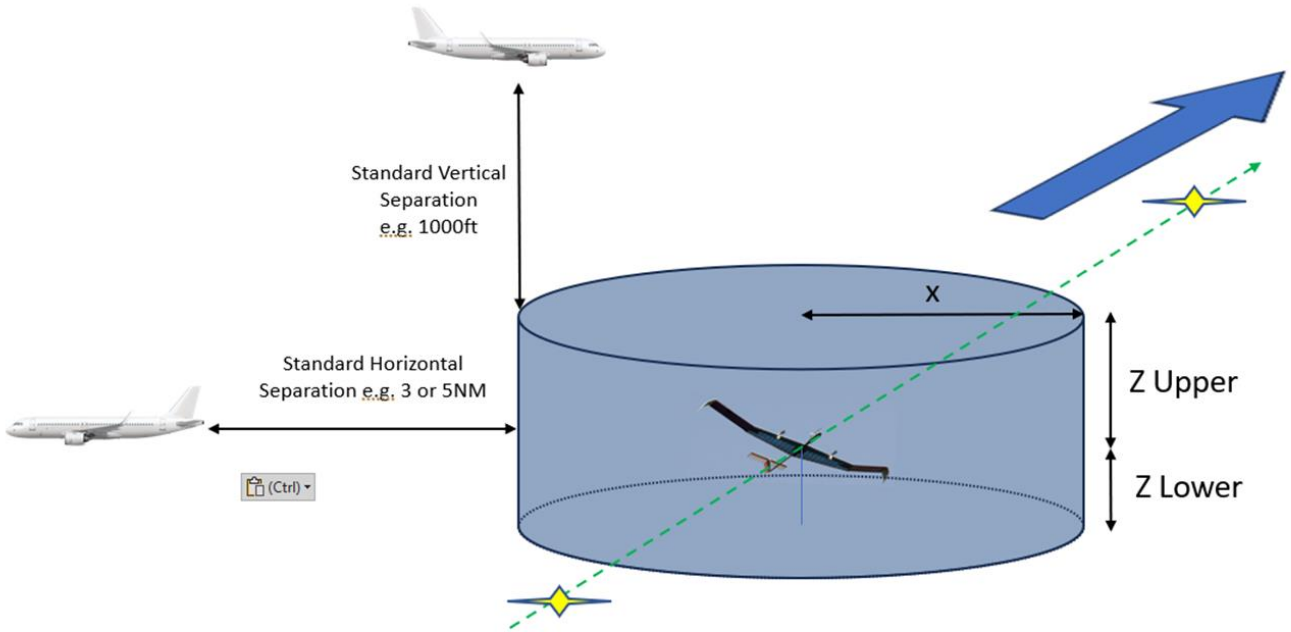
WP 2 Operational Service and Environment Definition (OSED)

- Vehicle Centred 4D operational zone
  - Zone centered on surveillance position of HAPS (follows HAPS trajectory)
  - Intended to support all transit profiles
  - Dimension of the 4D zone (x and z) is depending on the performance of the HAPS and on a safety analysis
  - ATCo is separating against the 4D zone, separation minima the same as for traditional aircraft
  - If special separation buffer is needed, e.g. for overflights of HAPS due to wake turbulence, this buffer will be included in the dimension of the 4D zone
  - Dynamic display to ATCOs



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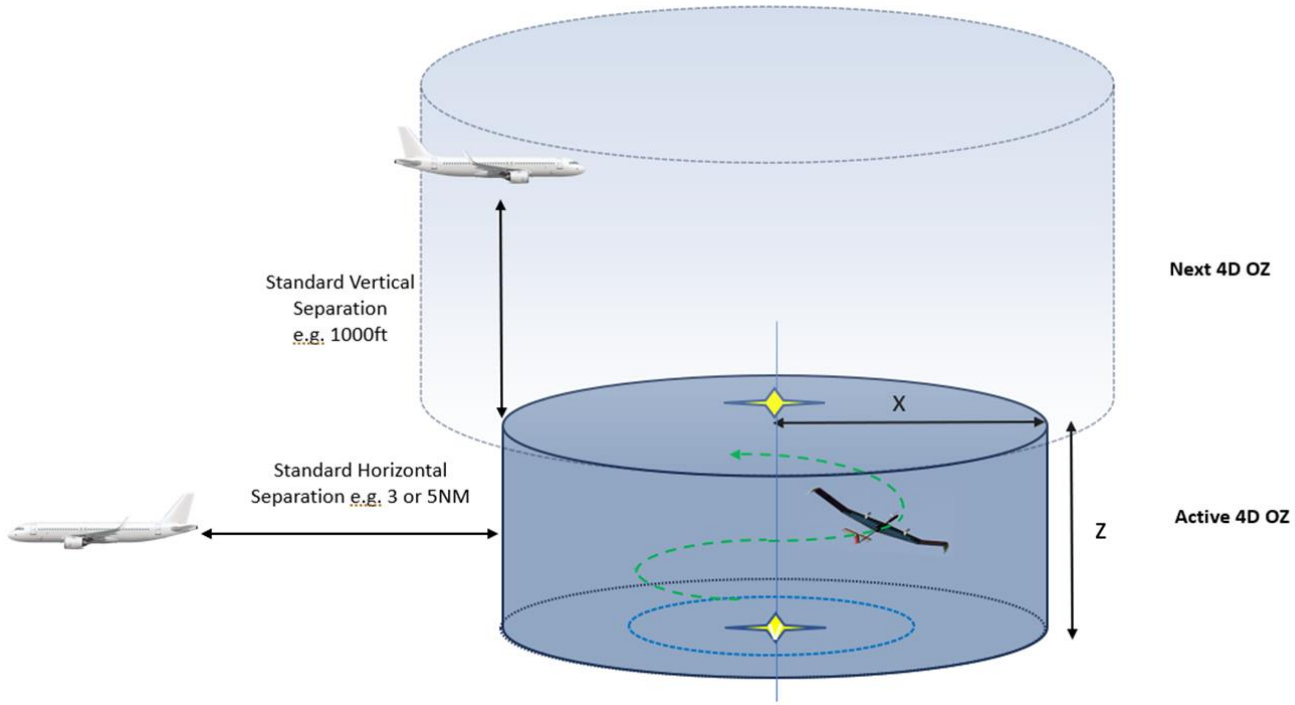
WP 2 Operational Service and Environment Definition (OSED)

- Laterally Static 4D operational zone
  - By activating one 4D zone after another the HAPS can climb and descend through controlled airspace (Does not move laterally)
  - Intended for spiral climb/descent only, can be smaller than SUAs
    - Radius of spiral climb/descent
    - Potential deviations
    - Safety Margin
  - dimension of the 4D zone is fixed, within the HAPS can moving
  - The operator of the HAPS is responsible to stay clear from the border of the 4D zone with additional buffer
  - ATCo is separating against the 4D zone, separation minima the same as for traditional aircraft
  - Simple display to ATCO



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WP 2 Operational Service and Environment Definition (OSED)

- Other procedures
  - Communication between ATC and HAPS operator via ground – ground communication (for the RTS)
  - Clearance by ATC to HAPS operator possible, but due to the low performance of the HAPS not meaningful
- HAO service discussed but not developed so far:
  - Separation responsibilities
  - Different traffic scenarios with supersonic flights (WP 3)
  - Technical capabilities of HAPS surveillance and communication
  - Altitude measurement (barometric, GPS)
- Potential limitations of existing CNS in Higher Airspace e.g.
  - Non-optimised and/or fully tested CNS coverage at higher altitudes e.g. VHF, DME, PSR / Mode S
  - Dual redundant surveillance coverage gaps expected
  - Pressure Altimetry reporting accuracy decrease above FL500, unviable above FL800
  - Investigation of Geometric Altimetry & ATC procedures needed
  - DME accuracy also expected to decrease above FL600

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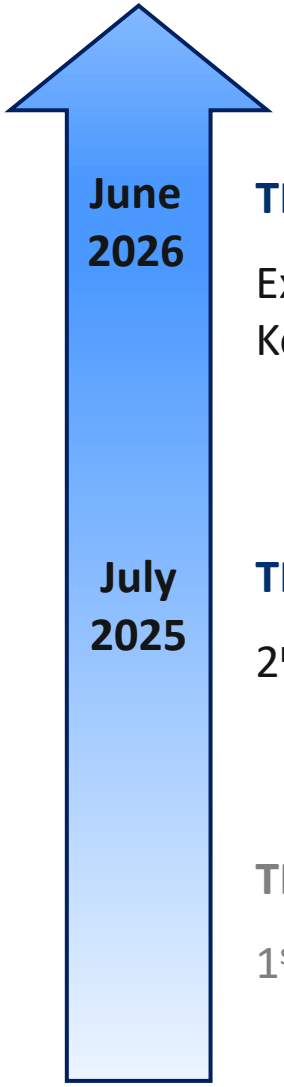
WP 2 Validation plan (VALP) - Overview

TRL progress of the WP2 Solution (0438)



TRL 6 *"Prototype Demonstration in a Relevant end-to-end Environment"* *(end of Industrial Research & Validation)*

Exit maturity gate achieved by means of AALTO and Skydweller Flight Trials from May to September 2025 from Kenya, Fuerteventura or Grottaglie (TBD). ECHO2 project nominally should end on August 2026.

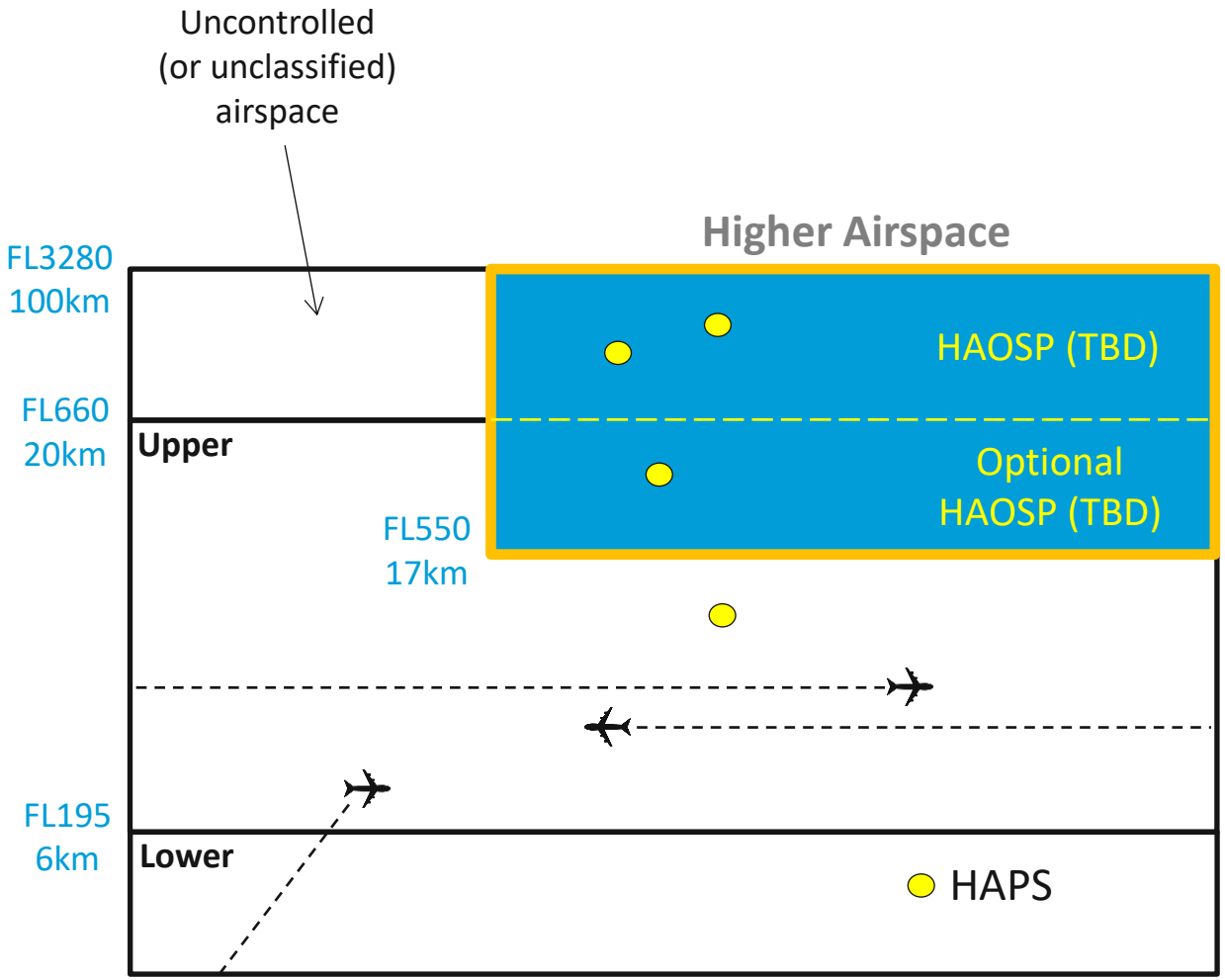
TRL 4 *"Subsystem Validation in Laboratory environment"* *(mid of Industrial Research & Validation)*

2nd self-maturity assessment to be achieved by means of RTS on April 2025 in EUROCONTROL Innovation Hub.

TRL 2 *"Formulation of Technology concept"* *(end of Exploratory Research)*

1st self-maturity assessment previously achieved by means ECHO and OBELISK (DFS) projects.

OSED Use Cases



Covered by RTS

UC-01 & UC-02: Transit in controlled airspace of ATC *managed* and *non-managed* HAPS.

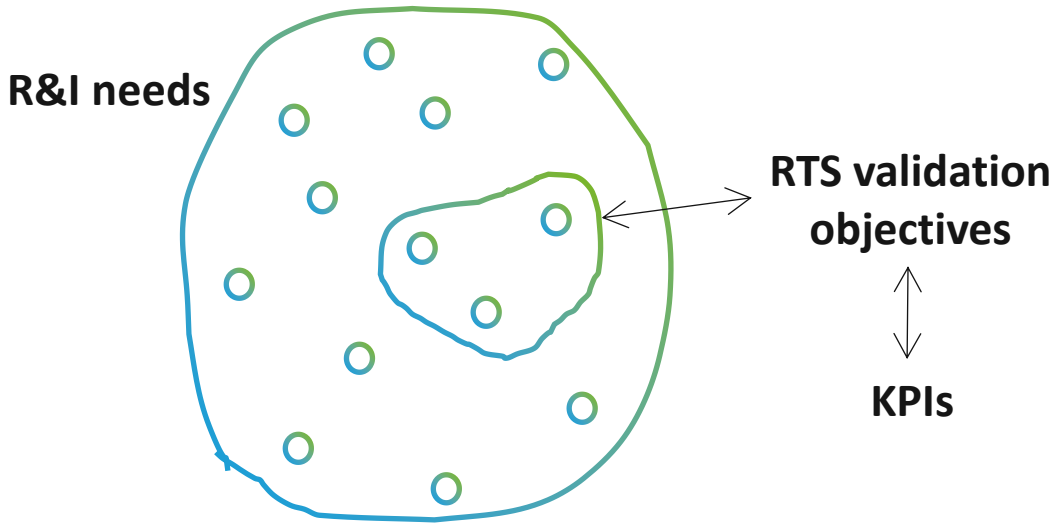
UC-03: HAPS crossing the interface controlled/uncontrolled airspace.

UC-04: HAPS in Higher Airspace managed by an HAOSP. The principle of **Collaborative Decision Making (CDM)** should be applied, based on future technology to ensure self-separation where ATC is not responsible (similar to U-space but should be avoided in presence of manned aircraft).

Research & Innovation needs vs validation means

			RTS	Flight Trials
1	**Procedures for transit**	Clarify the procedures based on the 4D OZ type during HAPS climb/descent in ATM zone (e.g., release of levels in the case of Laterally Static 4D OZ, clearance to operators, etc.).	(✓)	✓
2	**Procedures for HAOs**	Clarify the procedures focusing on how an HAOSP can deconflict multiple collaborative & non-collaborative HAPS with different mission requirements.		✓
3	**4D OZ parameters**	Understand how sizing the 4D OZ to visualize it on the CWP (identify dependencies on HAPS performance, winds, number of HAPS in the area, CNS performance, off-nominal situations, ...).	✓	✓
4	**Wind impact**	Understand the wind impact on HAPS performance and trajectory predictability.	✓	(✓)
5	**New roles and responsibilities**	Clarify the stakeholders interaction mechanisms, including new phraseology and flight permission methods. For instance, define how HAPS operators present their Extended Flight Plan with planned trajectories and the tracking error threshold.	(✓)	✓
6	**CNS for HAOs**	Evaluate the CNS requirements for managing HAPS in HA, such as latency, update frequency, navigation accuracy and radar range.		✓
7	**Contingency and emergency situations**	Understand how contingency & emergency situations should be managed (unexpected wind or turbulence, power loss in cruise, loss of LOS/BLOS link, aircraft failures, ...).	✓	(✓)

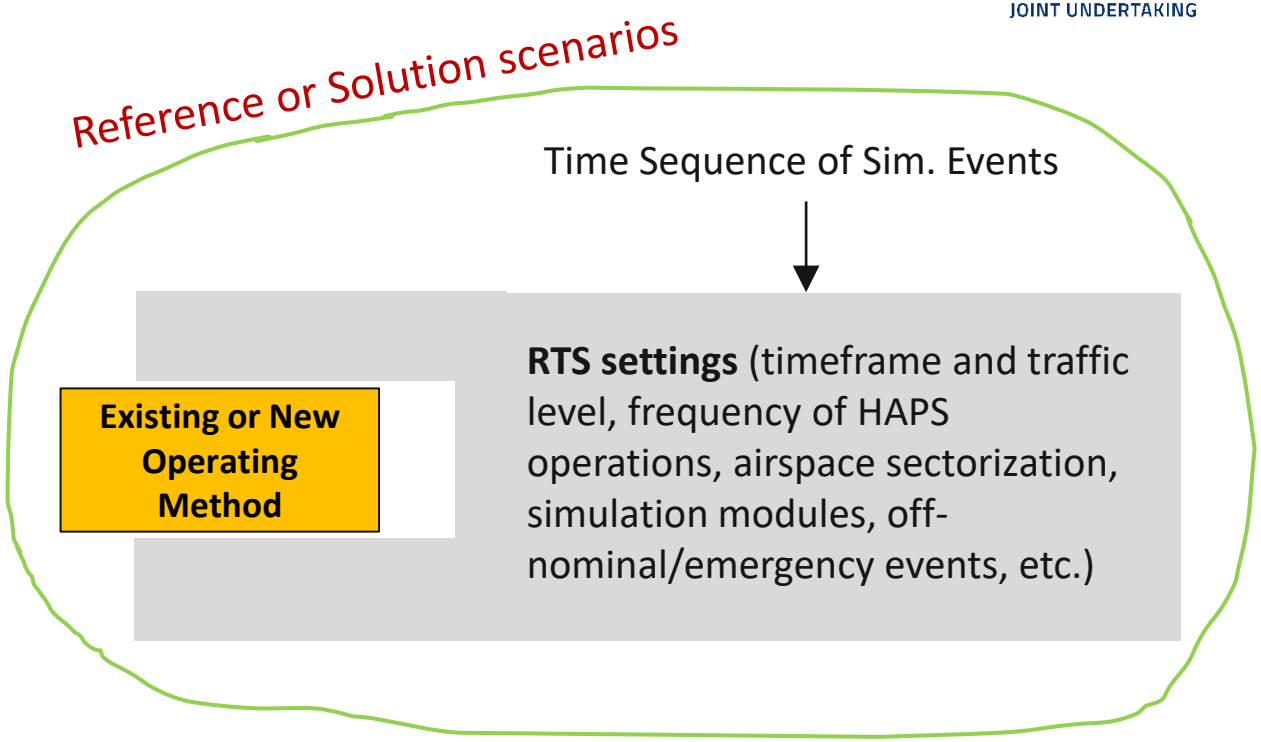
RTS validation (1/2)



PEARL project addresses some KPIs:

- **Safety**
- **Human Factor**
- Fuel Efficiency (1)
- Airspace Capacity (1)
- Predictability (1)
- G2G Air Nav Services Cost Efficiency (2)

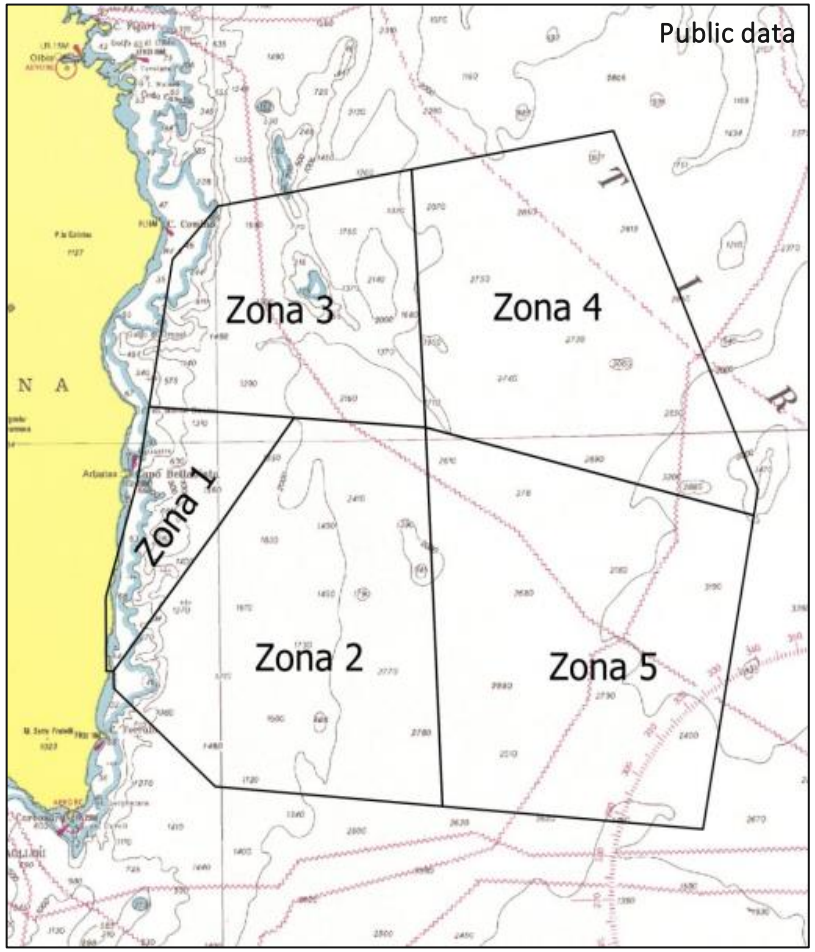
but the effectively measurable KPIs are under discussion (FTS is not planned in WP2)



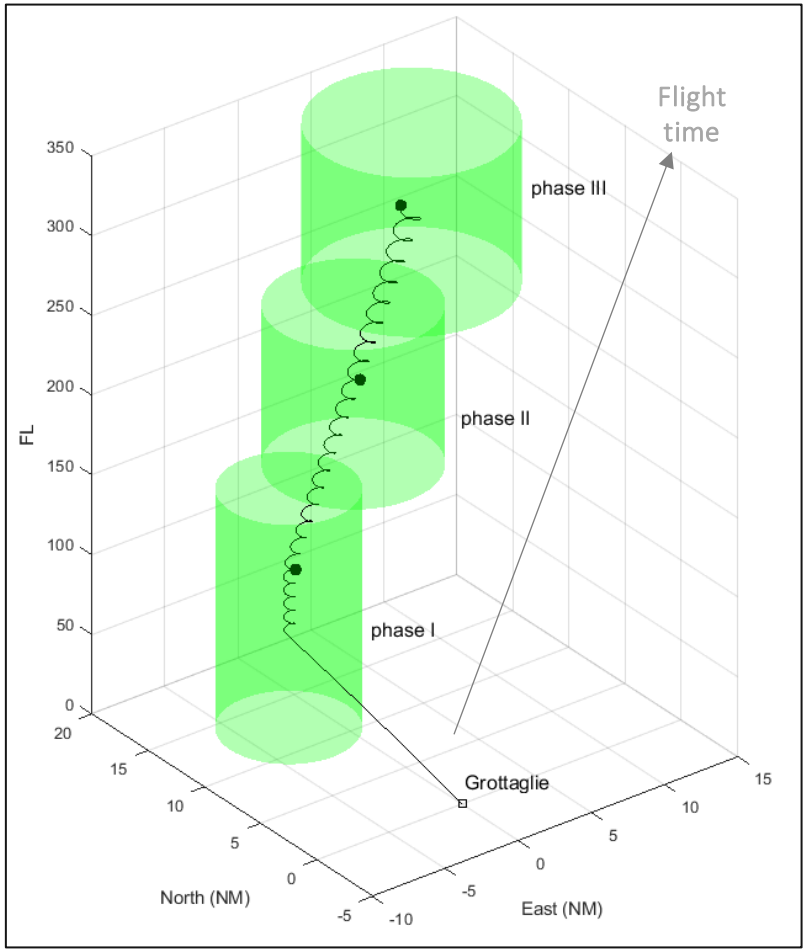
- During validations, we have “variable” and “constant” parts
- Solution scenarios must be assessed wrt Reference ones

RTS validation (2/2)

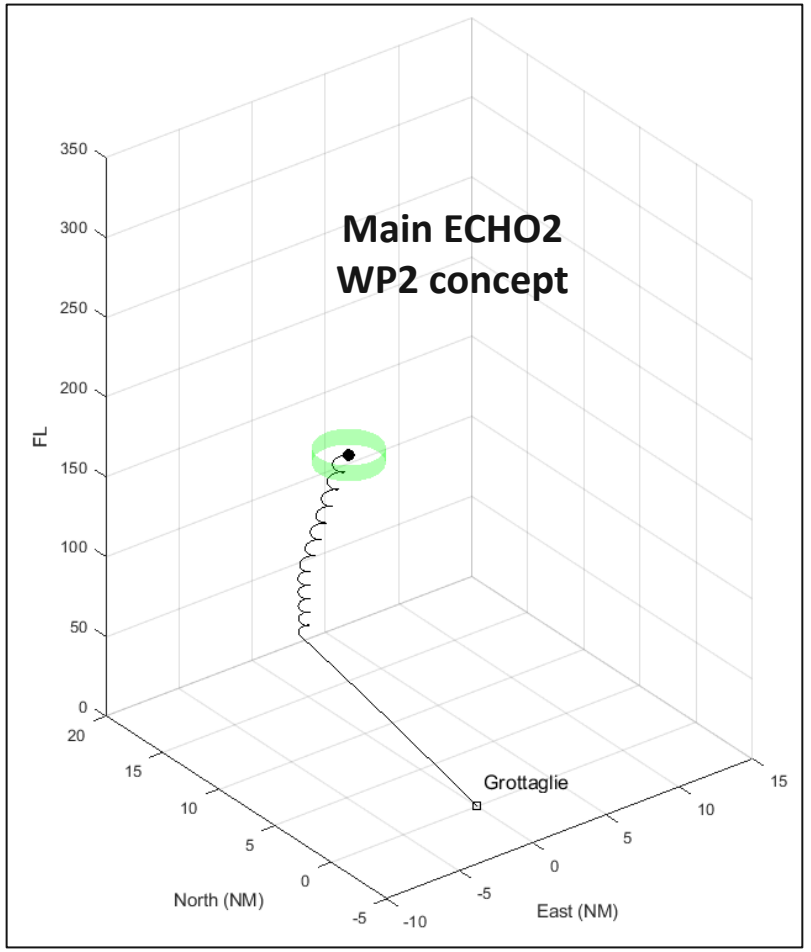
MORE SAVED AIRSPACE, MORE EFFICIENCY



Existing Operating Method
(*Temporary Reserved Area*, TRA)



New Operating Method #1
(Laterally Static 4D OZ)



New Operating Method #2
(Vehicle-Centric 4D OZ)

Flight validation

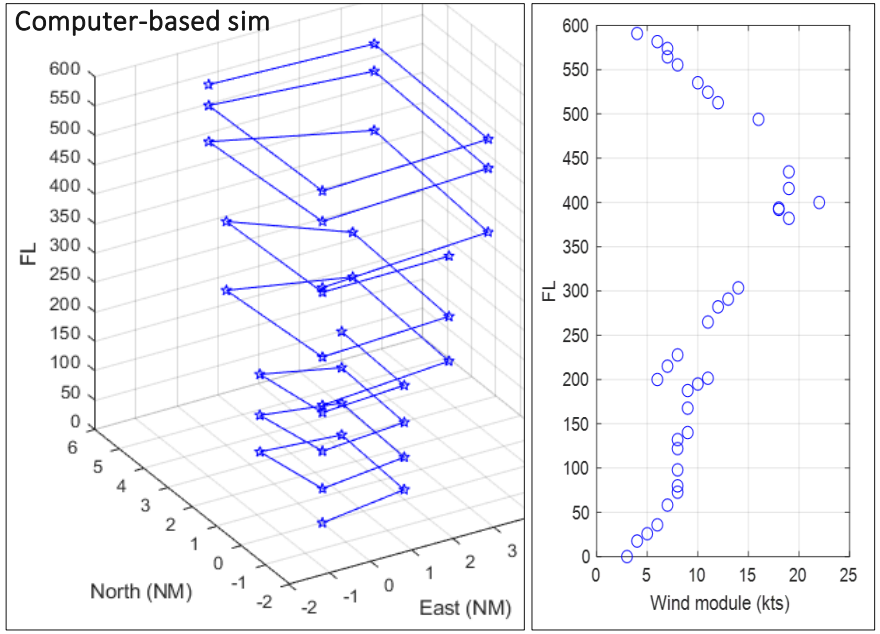
Motorised HTA fixed-wing

Free LTA balloons

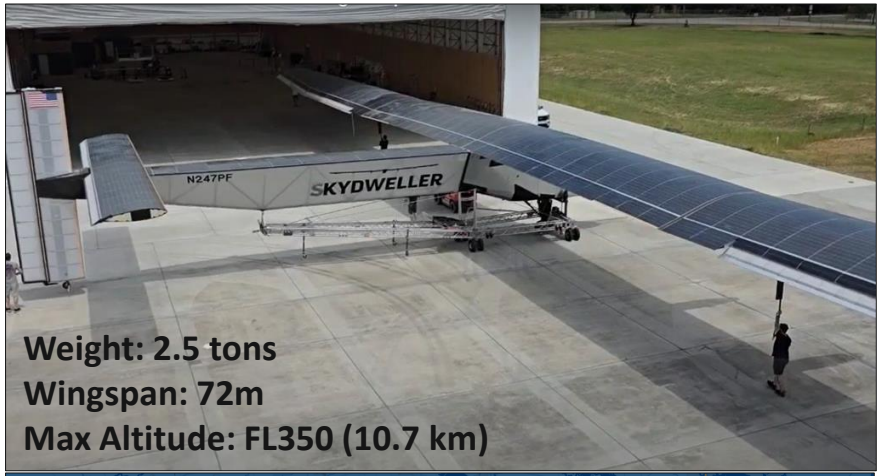
Manoeuvring LTA balloons

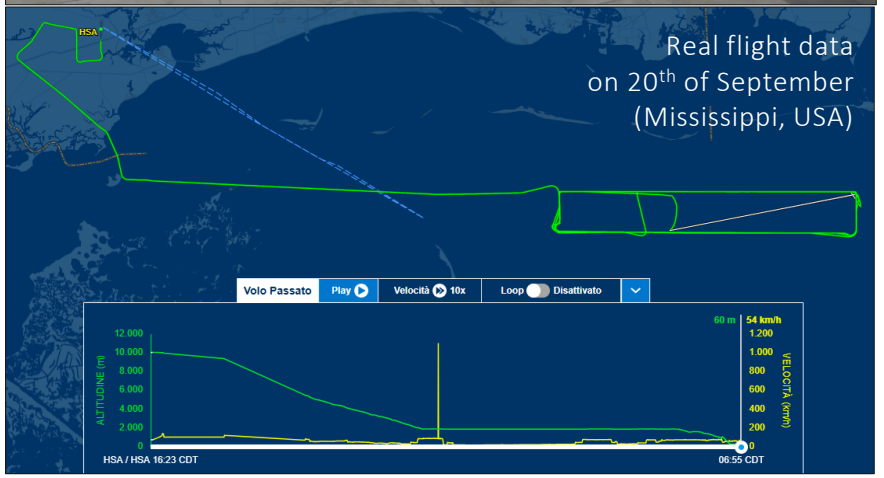
Motorised LTA airships

AALTO



Skydweller





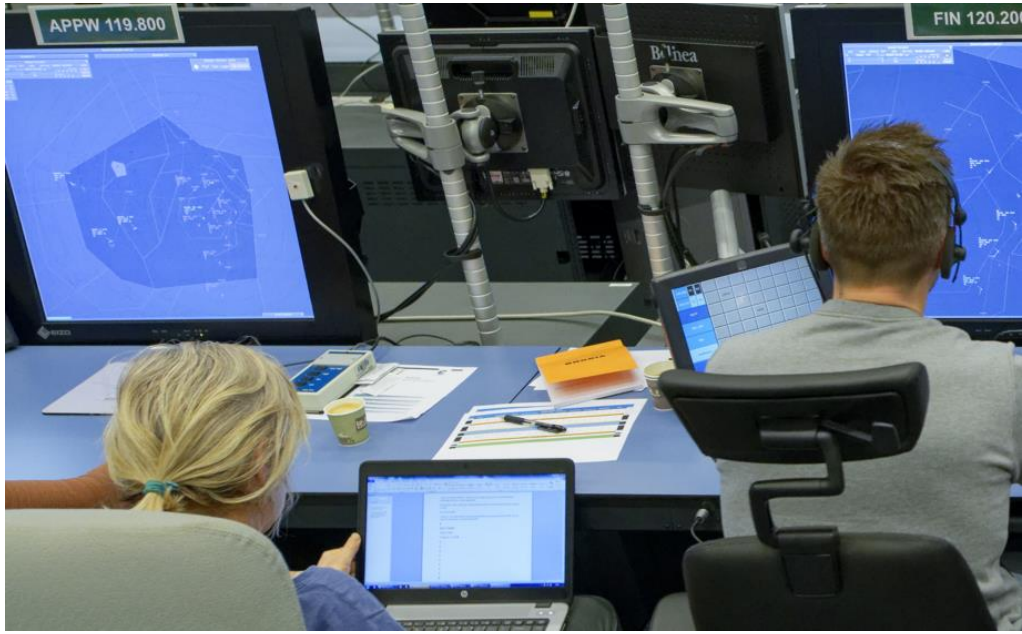
HTA: Heavier Than Air, LTA: Lighter Than Air

Echo 2 – Dissemination WS, WP 2 “HAPS Integration”

WP 2 Validation plan (VALP) – Real-Time Simulation

ECHO2 WP2 Real Time Simulation

- HAPS (MHTA): Transit in controlled airspace
- 4D Operating Zone
- ATC managed and non-managed HAPS

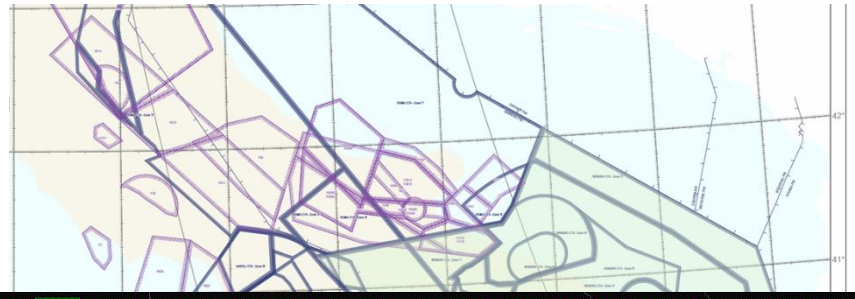


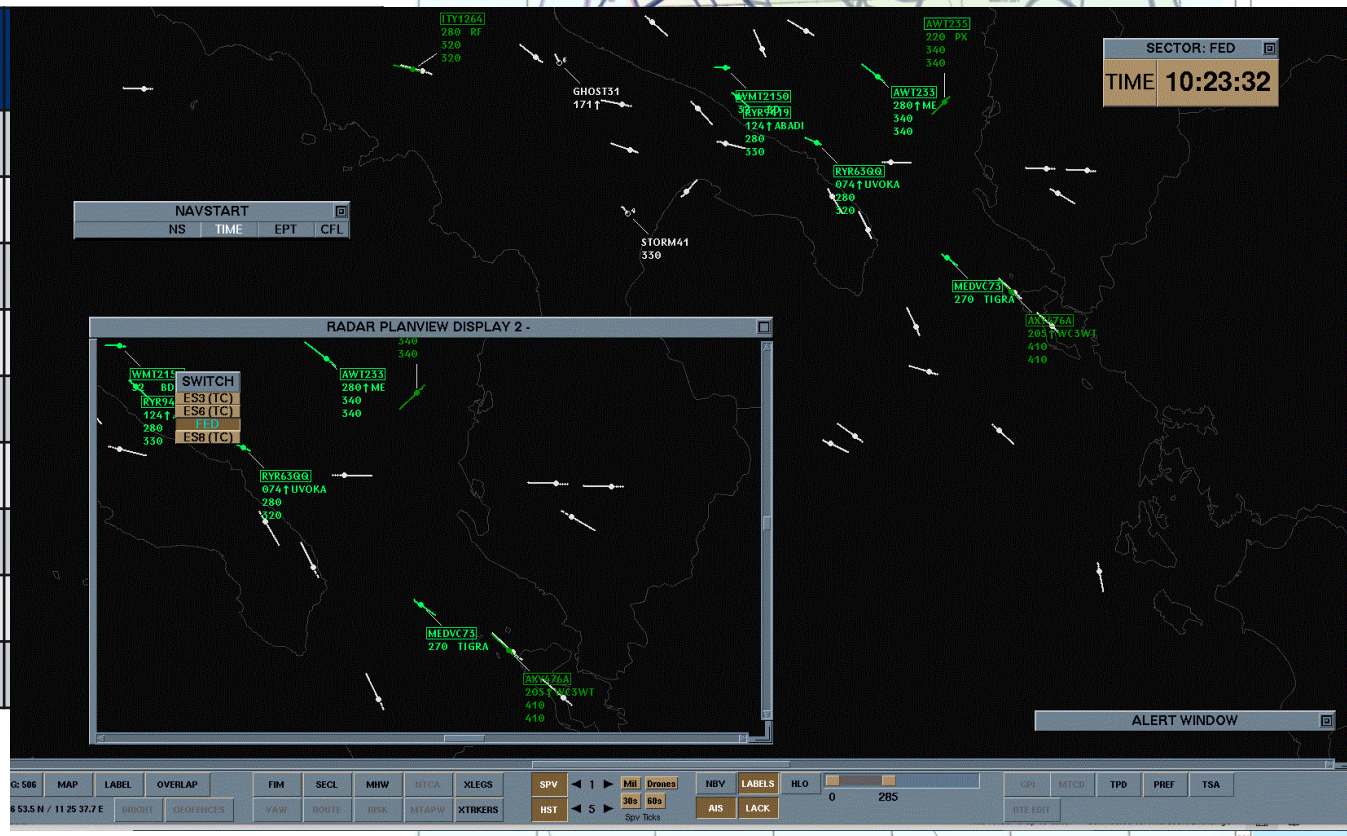
- Timeframe: February-April 2025
- Where: EUROCONTROL Innovation Hub, Brétigny
- Simulator: ESCAPE (TMA & en-route)

RTS Operational Environment

- Four Measured Sectors (EC + PC)
- Mission Control Centre (approx.)

Sectors	Sector name	FLs	CWP	PWP
Brindisi LOWER	**ES3**	GND-FL285	2	2
Brindisi MIDDLE	**ES4**	FL285-FL345	2	2
Brindisi UPPER	**ES6**	FL345-FL375	2	2
Brindisi TOP UPPER	**ES8**	FL375-FL660	2	2
HAPS Mission Control	HMC	MSL-FL999	1	1
HAPS FEED	FHAPS	FL660-FL999	1	0
EAST FEED	FE	GND-FL660	1	0
WEST FEED	FW	GND-FL660	1	0
Total			12	9





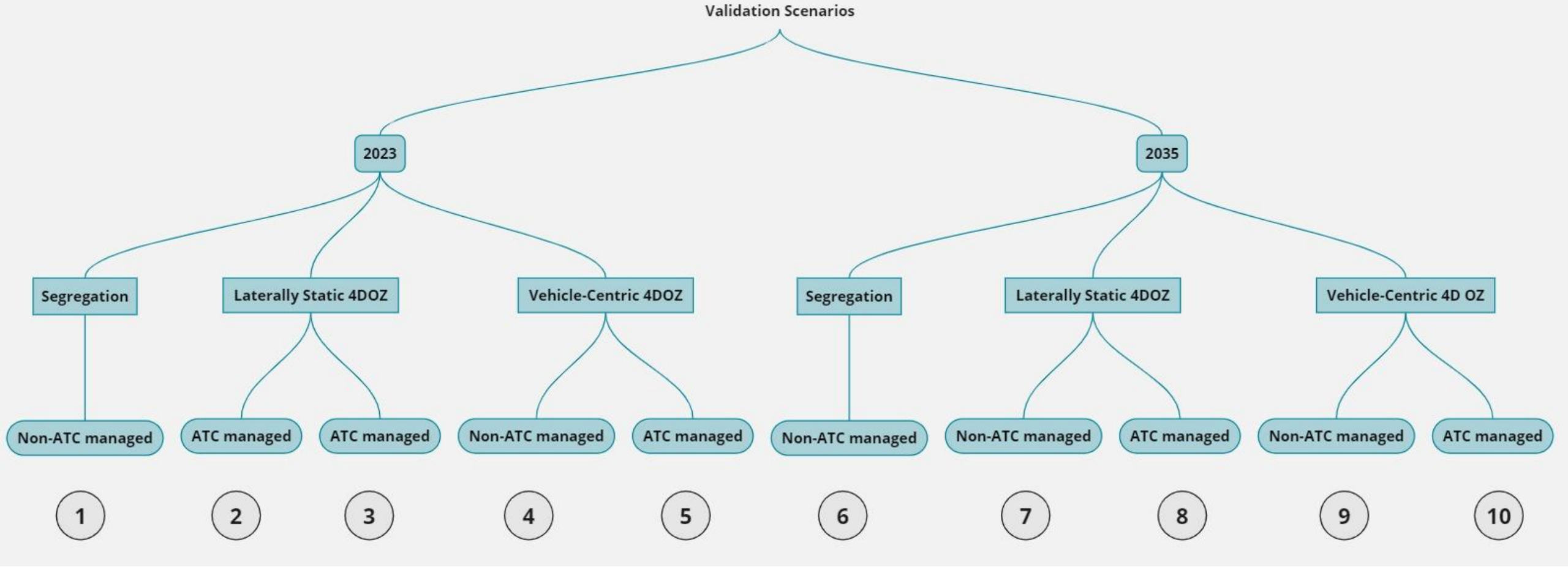
RTS Schedule & Participants

	Dates	ENAV	ENAIRE	NAV Portugal	LFV	NATS	Total
Acceptance Test #1	February 17-20, 2025	**4**	**0**	**0**	**0**	**0**	**4**
Acceptance Test #2 and Training	March 10-14, 2025	**4**	**1**	**1**	**1** (+1?)	**1**	**8**
RTS	April 7-11, 2025	**4**	**1**	**1**	**1** (+1?)	**1**	**8**

RTS Validation Scenarios 1/3

- Timeframe
  - 2023 (Traffic sample 03/09/2023 - 3-hour time window from 9:30 to 12:30 PM)
  - 2035 (+34.4% - annual growth rate of 2.5%)
- Operating method
  - TRA (Temporary Reserved Area)
  - Laterally Static 4D OZ
  - Vehicle-Centric 4D OZ
- HAPS collaboration level:
  - Non-ATC managed HAPS
  - ATC managed HAPS (within the vehicle's operational limits)

RTS Validation Scenarios 2/3



RTS Validation Scenarios 3/3

- Repetition of the most relevant scenarios with different HAPS mixes:
  - Take-off (Grottaglie Spaceport)
  - Climbing through controlled airspace (en-route)
  - Transition to uncontrolled airspace
  - Planned re-entry into controlled airspace for recharging
  - Planned re-entry into controlled airspace for descent
  - Landing (Grottaglie Spaceport)
- Varying 4DOZ sizing (and radar separation minima)
- Non-nominal situations:
  - Higher drift, emergencies or lost c2 link, …

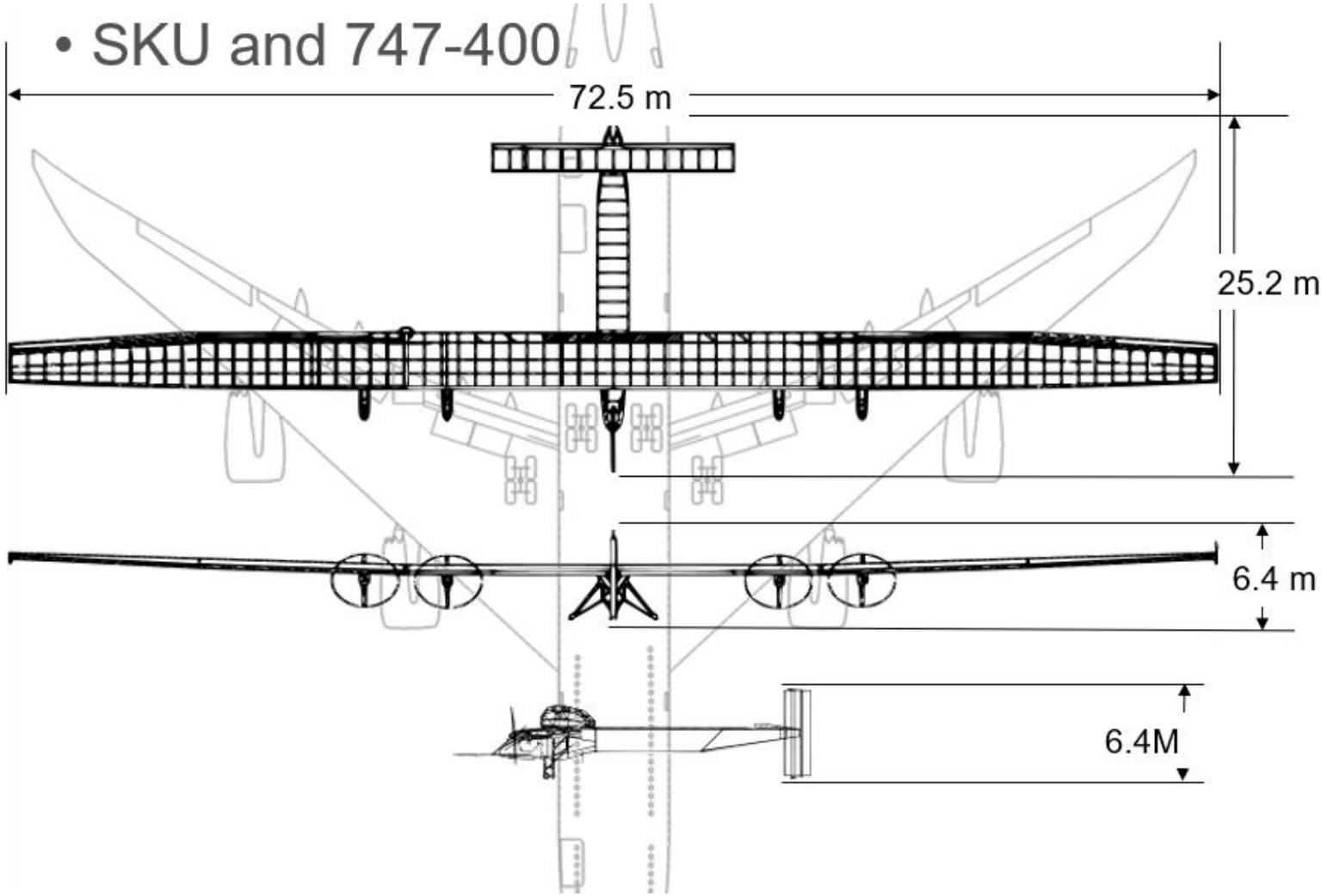
Echo 2 – Dissemination WS, WP 2 “HAPS Integration”

WP 2 Validation plan (VALP) – Flight Trials AALTO

Echo 2 – Dissemination WS, WP 2 “HAPS Integration”

WP 2 Validation plan (VALP) – Flight Trials Skydweller

The Skydweller Platform



Statistics

- Maximum Altitude: >35,000 feet
- Airspeed: Cruise 25 KEAS
- Propulsion: 4 x 14 KW electric motors
- Energy: 4 x 220-304 V High Voltage Batteries
- Power Generation: 65KW Solar Array
- Max Takeoff Gross Weight: 2550Kg

Demonstrated History / Development:

- Robust aircraft: >750 flight hrs + around the world flight
- Redundant human-rated fly-by-wire
- Rigorous development of software/hardware (CS-23, CS-25, DO-178, DO-160, etc.)
- Demonstrated 22.5h flight uncrewed mode in relevant weather.
- Low turnaround time between operations
- Flown and coordinated flights in non-segregated airspace in the US.

The Aircraft is LARGE!

Systems On-board to Support Operations

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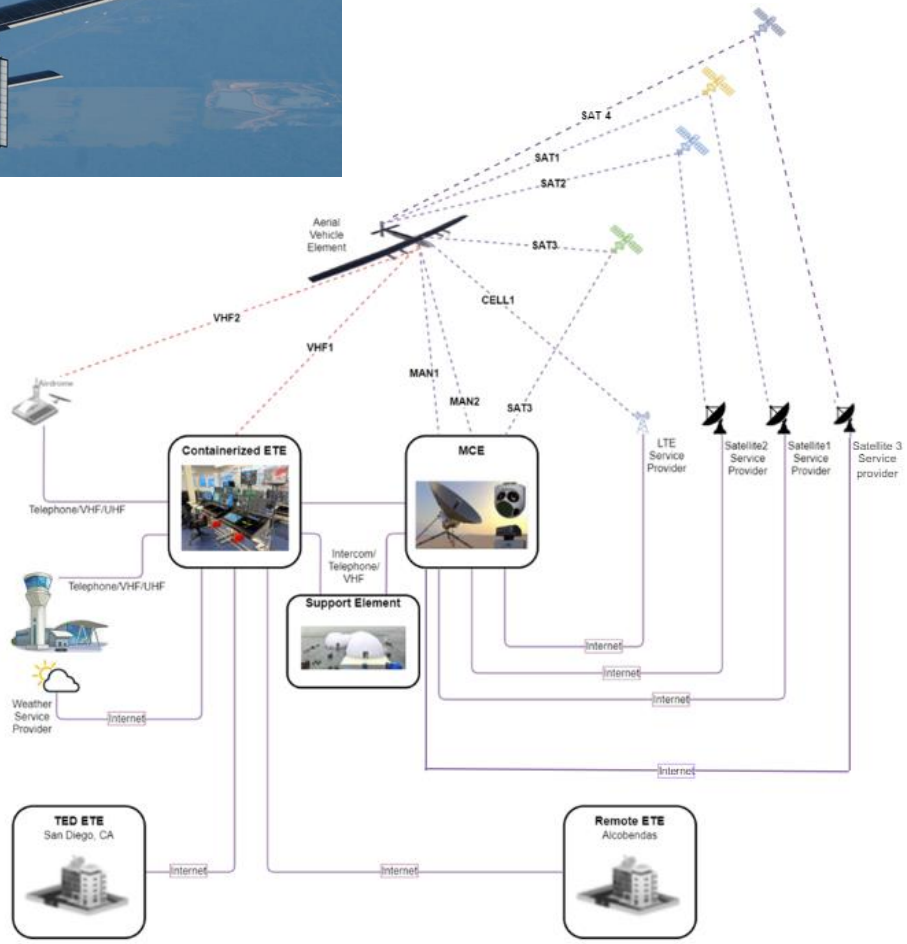
Relevant Platform Features

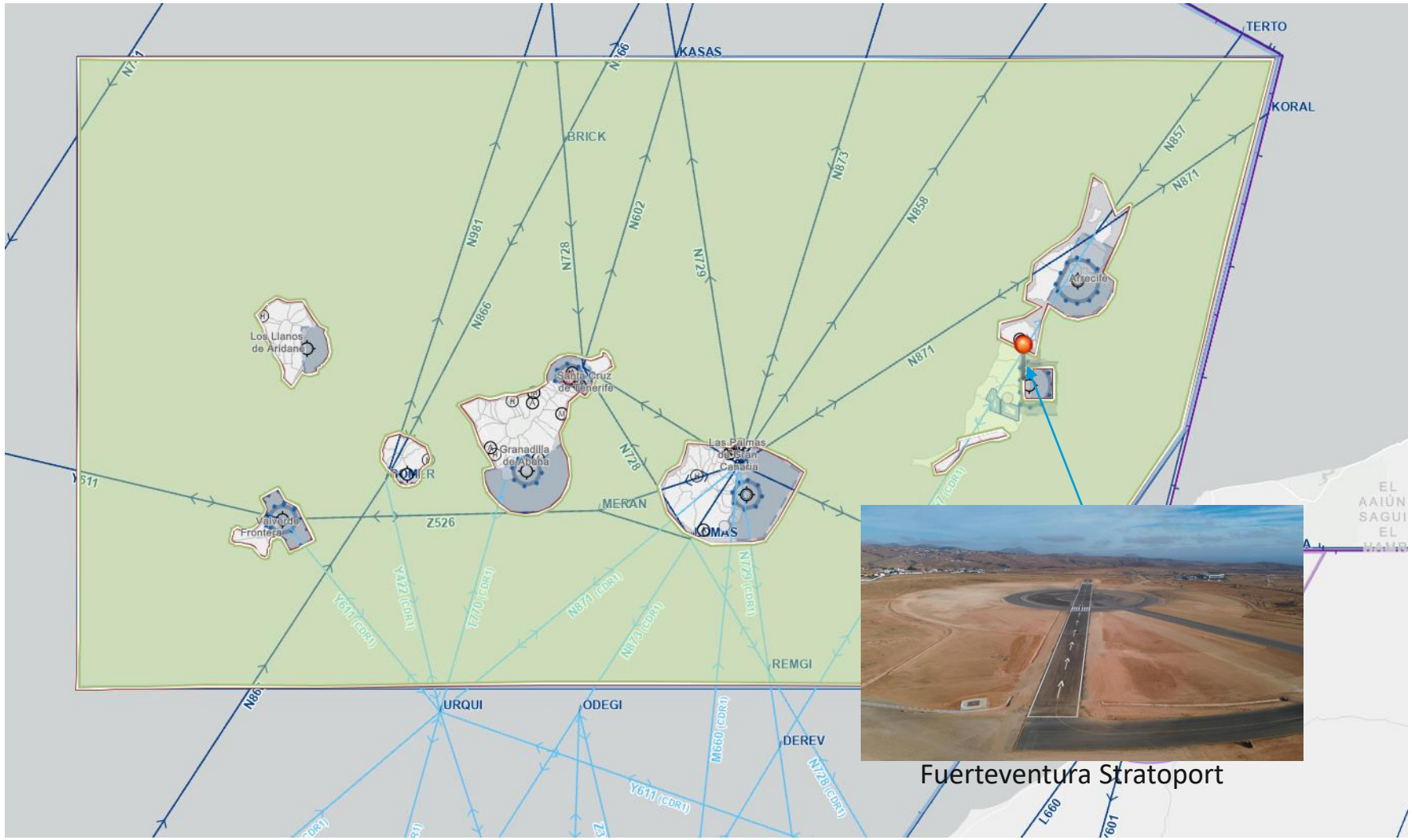
- Human Rated Fly-By-Wire System
- Multi-link Design with 4 SATCOM and 2 LOS datalinks
- Redundant Autoflight System and flight control chain
- Advance Navigation Capabilities down to RNP(0.1)
- TSO'd ADS-B IN and OUT
- VHF Voice Relay
- Certified Light system
- Detect and Avoid Systems
- Deterministic Mission Plan Execution
- Mission Planning and AI pathfinding Optimization tool (Luminar)
- Advance Meteo Capabilities
- Safety Objectives derived from AC 23.1309 for Class I Aircrafts.



The aircraft systems and reliability in equivalent levels to CS-23 aircraft for multiday flights

Flight Operations From Fuerteventura

- Deployment in the Canary Islands Planned May ’25. Operations planned Summer 25
- Targetting SAIL III operation within the green area
- ATS coordination with Canary Islands TMA and Fuerteventura TWR/CTR
- The Area of Operation supports all nominal and non-nominal scenarios
- Deployment base ready in the Fuerteventura Stratoport
- Advanced Meteo System to be deployed in support of ECHO2 and Stratoport Operations



Fuerteventura Stratoport

Aiworthiness being handled with AESA/ENAIRE.

Echo 2 – Dissemination WS, WP 2 “HAPS Integration”

WP 2 Regulation and Standardization – Experience AALTO

ECHO 2

Thank you!

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Co-funded by the European Union