On-Board Performance Monitoring and Alerting Mechanism & Navigation Specifications for UAS Flight Operations

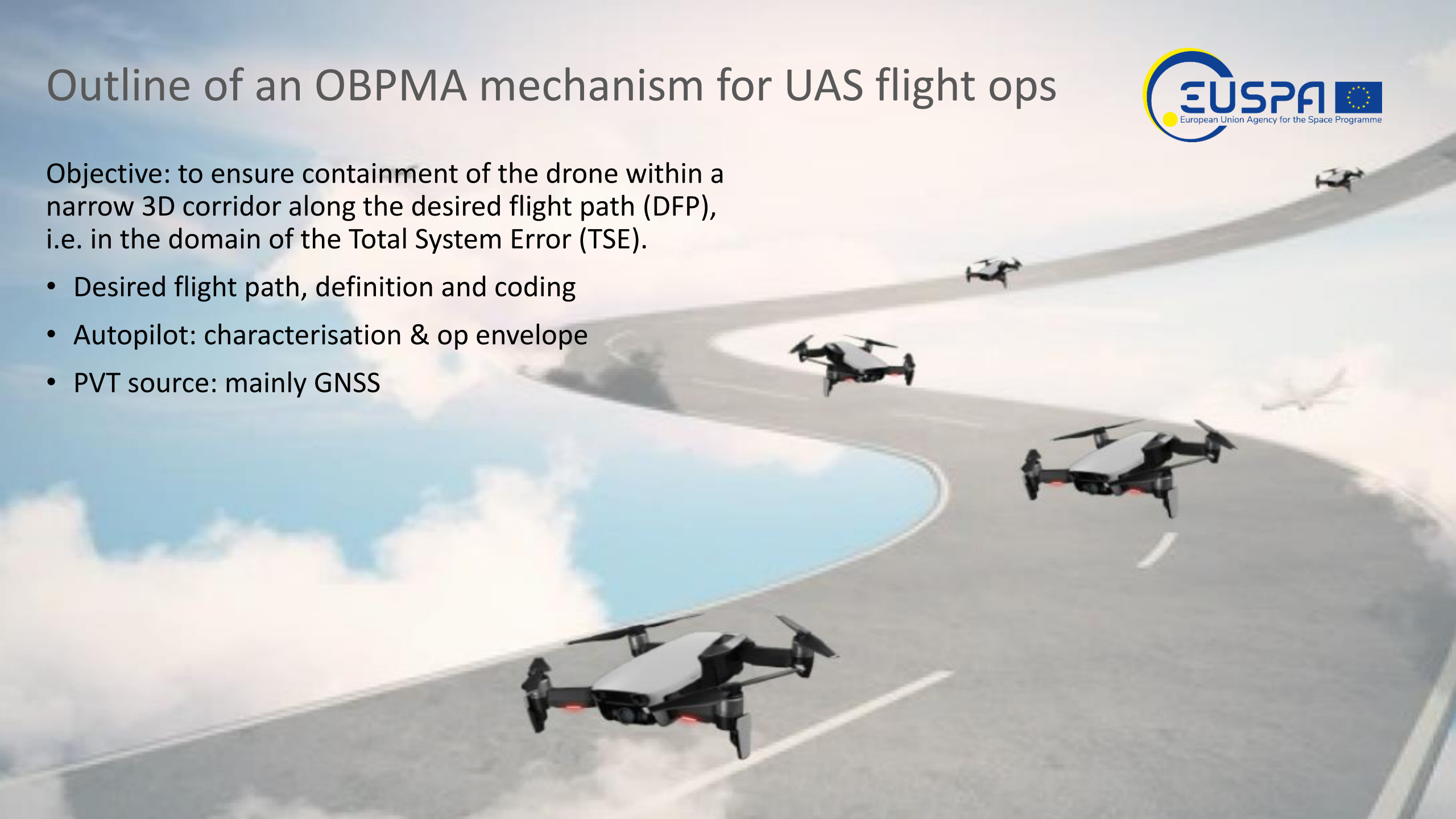
Pablo Haro

“Space and UAS”, World ATM Congress 2022, Madrid, 22 June 2022

Outline of an OBPMA mechanism for UAS flight ops

Objective: to ensure containment of the drone within a narrow 3D corridor along the desired flight path (DFP), i.e. in the domain of the Total System Error (TSE).

- Desired flight path, definition and coding
- Autopilot: characterisation & op envelope
- PVT source: mainly GNSS



Assessment of PBN Nav Specs for UAS

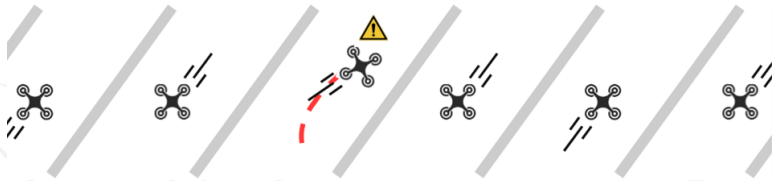
- RNP Lateral / Vertical

Drone	Sensor	$\sigma_{HNSE\ Lat}$ [m]	$\sigma_{Lat\ FTE}$ [m]	RNP Lateral [m]	σ_{VNSE} [m]	σ_{VFTE} [m]	RNP Vertical [m]
Fixed wing	GPS-EGNOS	1.23	12.76	25.13 ~ 25	2.04	5.10	10.77 ~ 11
	GPS-Galileo	1.70		25.23 ~ 25	3.18		11.78 ~ 12
	GPS	3.27		25.82 ~ 26	6.63		16.39 ~ 16
Rotary wing	GPS-EGNOS	1.23	5.10	10.28 ~ 10	2.04	2.55	6.40 ~ 6
	GPS-Galileo	1.70		10.54 ~ 11	3.18		7.99 ~ 8
	GPS	3.27		11.87 ~ 12	6.63		13.92 ~ 14

[Values to be validated]

- EUSPA projects assessing and validating RNP-like concepts for UAS ops: REAL, DELOREAN, REALITY, …

REALITY



DELOREAN

Real

- Feedback on the OBPMA mechanism and PBN nav specs from UAS operators and manufacturers, USSP, etc., will also be gathered at the ***User Consultation Platform (UCP) 2022***, 3rd October in Prague.

Linking space to user needs

Get in touch with us

www.euspa.europa.eu

EU4Space | EUSPA | @EU4Space | @space4eu | EUSPA

The European Union Agency for the Space Programme is hiring!

Apply today and help shape the future of **#EUSpace!**

Rationale (1/2)

- A concept for an OBPMA mechanism and nav specs tailored to drone flight ops are proposed.

- In response to requirements stated in the ‘EASA SC Light UAS - Medium Risk’, applicable to SAIL III & IV of the specific category.

    - *“Suitable means of compliance (MOC) with this SC will be key to ensure proportionality and to ensure that the same certification basis is suitable for a very wide range of designs including a range of MTOM. No MOCs are presented so far, as they will be developed in a second stage …”*

- Three airworthiness specifications have been identified in the ‘SC Light UAS – Medium Risk, Subpart F – Systems and Equipment’, where the proposed OBPMA mechanism would play a role and could be considered as a possible MOC.

Rationale (2/2) – airworthiness specifications in SC Light UAS – Medium Risk, Subpart F – Systems and Equipment

- **Light-UAS.2510 Equipment, Systems and Installation**

  …

  (3) if the SAIL is IV, a means for detection, alerting and management of any failure or combination thereof, which would lead to a hazard, is available.

  …

  4. MOC for Light-UAS.2510 (medium risk) will be defined by EASA at a later stage.

- **Light-UAS.2511 Containment**

  "a) No probable failure of the UAS or of any external system supporting the operation must lead to operation outside the operational volume.

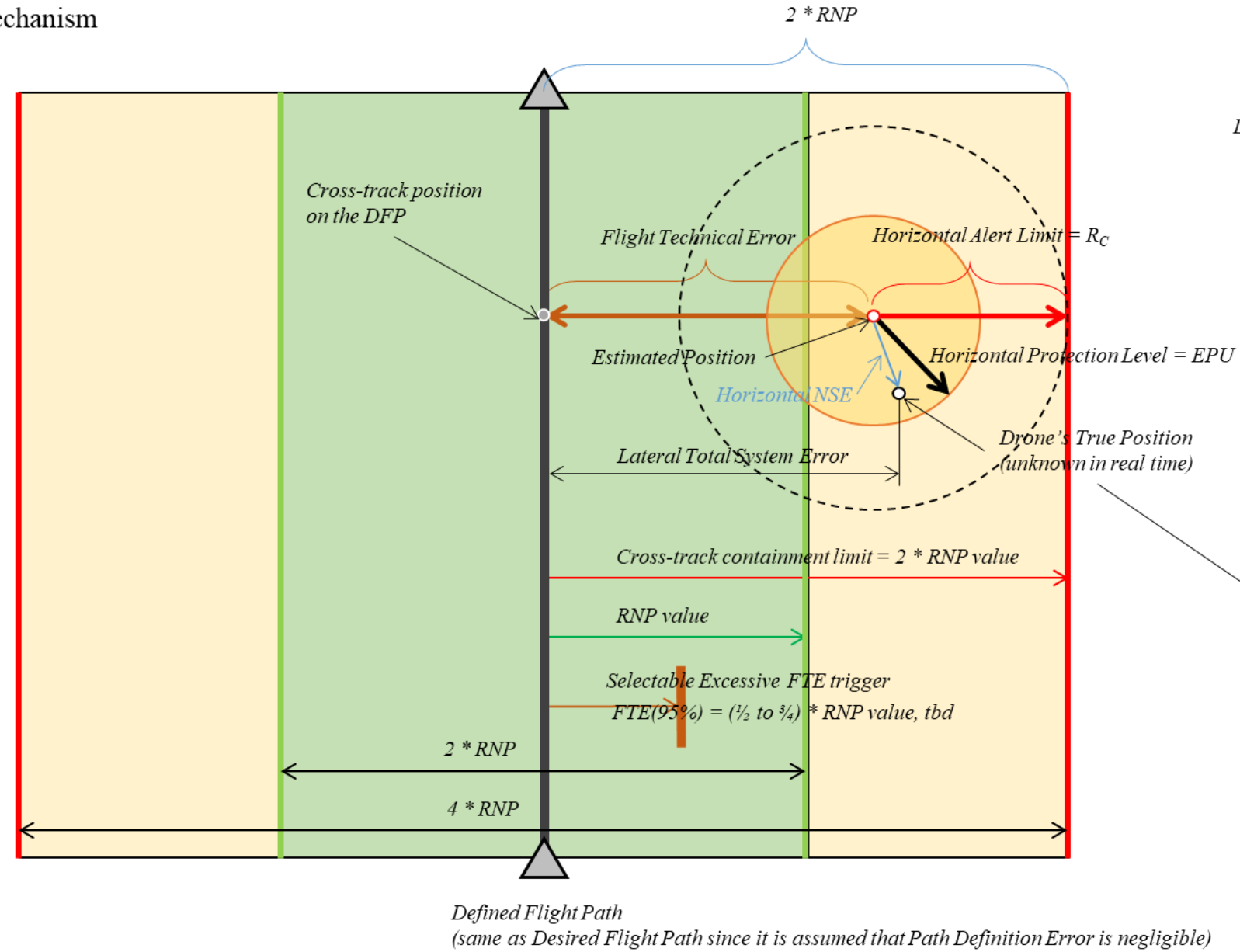
  …

- **Light-UAS.2529 UAS Navigation Function**

  "The UAS must ensure that the UA remains within the applicable spatial limitations or if applicable the intended flight path in all flight phases."

  …

Integrity mechanism



Defined Flight Path
(same as Desired Flight Path since it is assumed that Path Definition Error is negligible)

HAL(t) = 2 * RNP – FTE(t)

Dynamic alert limit

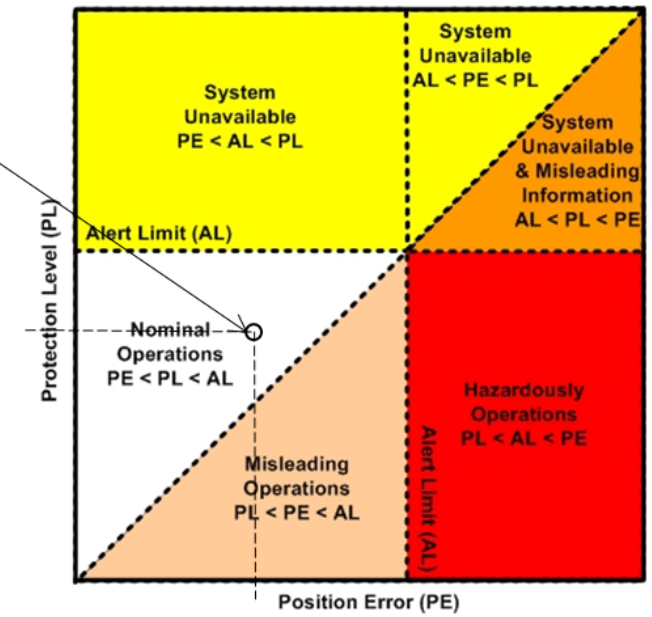
½ width of containment region

Known in real time by the autopilot

If HPL > HAL, alert triggers
If HPL ≤ HAL, no alert

Nominal operations:
HNSE<HPL<HAL

Other cases, as illustrated in the Stanford diagram



Source: ESA navipedia; Note: PE = HNSE

RNP x = Lateral TSE(95%) = ± x m corridor for the RNP value or 'accuracy limit'
*P(TSE > 2 * RNP, without alert) = P(HNSE > HAL = 2 * RNP – FTE, without alert) < 1E-α (Integrity Risk per flight hour)*

HMI, 'red zone' in the Stanford diagram