EGNOS AVIATION SERVICES EVOLUTION –

EASE PROJECT

Anne Cloerec (Egis) | 16th February 2022

Funded by the European Union

EGNOS Aviation Service Evolution (EASE) Project

April 2018
–
June 2019

EUSPA technical supervision on behalf of DG DEFIS

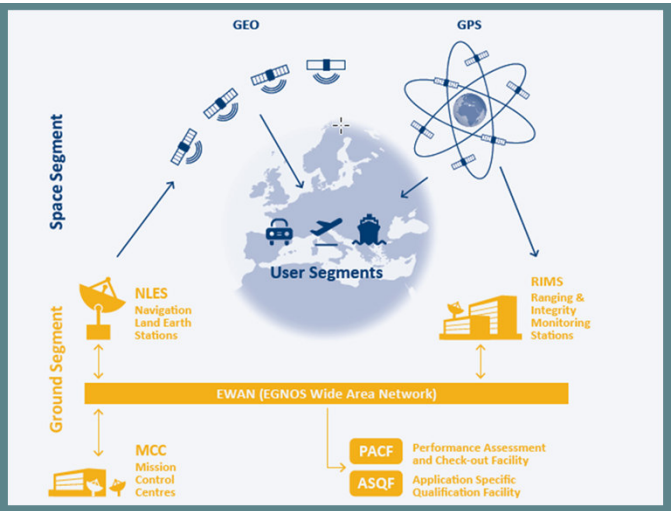
Beyond EGNOS V3, after 2025

Egis Aviation BU

[Egis Avia - France (consortium leader)
+ Helios (UK)]
+
Thales Alenia Space (Subcontractor)

Support of ESSP and DSNA (French ANSP)

EGNOS



OUTLINE

Objectives of the EASE project and areas of investigation

Methodology

Outcomes

- EGNOS Services for CNS/ATM beyond Navigation – ADS-B
- EGNOS Vertical Reference Service
- SBAS authentication requirements and implementation analysis
- EGNOS approach services below CAT I minima

OBJECTIVES OF THE EASE PROJECT

Support the roadmap definition for the long-term evolution of the EGNOS program beyond the EGNOS Service Release of EGNOS V3 by providing answers about technical feasibility, viable business models and implementation timeline for new services.

Key stakes

- Challenging project for the European Commission/EUSPA to support their strategic decision-making process

AREA OF INVESTIGATION

Directions proposed by European Commission for investigating potential evolutions of EGNOS services beyond 2025

- Enlarge the provision of EGNOS services to Communication Navigation Surveillance (CNS) and Air Traffic Management (ATM) beyond navigation, notably to address **surveillance (ADS-B)** and possibly support **timing services for communication systems**; this approach is aligned with the vision of integrated CNS.
- Provide **additional features to increase the robustness against external intentional or unintentional threats/attacks to the EGNOS navigation service**, for instance by adding authentication to GNSS signals or ad hoc features at antenna and receiver level.
- **Enhance the navigation, positioning and/or timing performance** provided at user level, for instance by improving the vertical position accuracy and the time-to-alert to enable supporting approach procedures below CAT I operational minima**.**

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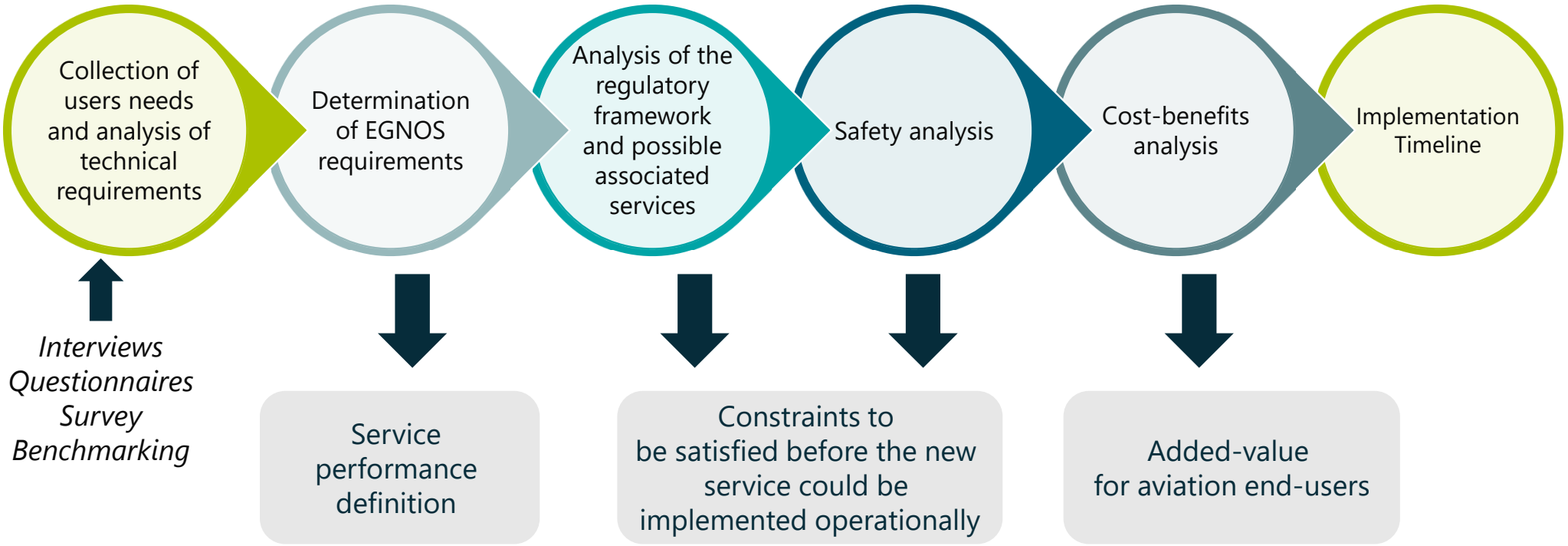
Lead by Egis/Helios
Lead by Thales Alenia Space

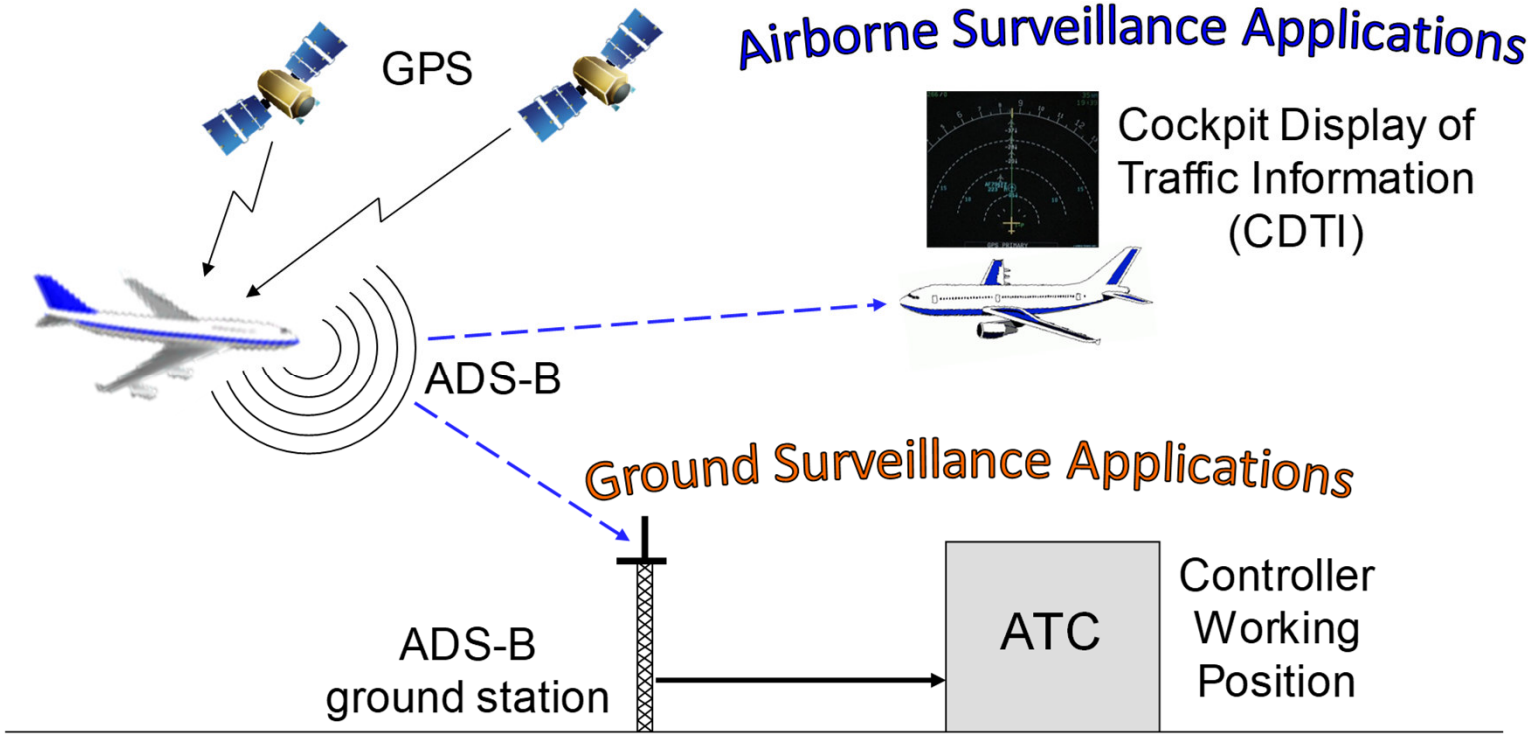
METHODOLOGY



EGNOS SERVICES FOR CNS/ATM BEYOND NAVIGATION – ADS-B

OUTCOMES

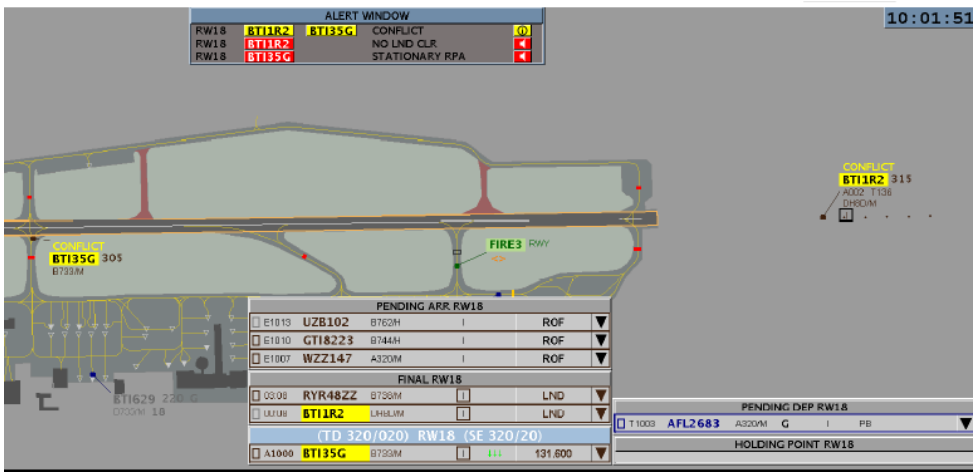
AUTOMATIC DEPENDENT SURVEILLANCE -BROADCAST



EGNOS-ENABLED ADS-B APPLICATIONS

Enhanced A-SMGCS application: Use of ADS-B to enhance the surveillance quality (by providing an additional surveillance means) at airports already equipped with A-SMGCS. This solution allows improving the A-SMGCS surveillance and alerts and routing functions.

Alternative A-SMGCS application: Use of ADS-B as a sole means (cooperative sensor) to provide an alternative surveillance means with the required performances for an "A-SMGCS like". One non-cooperative sensor shall also exist.

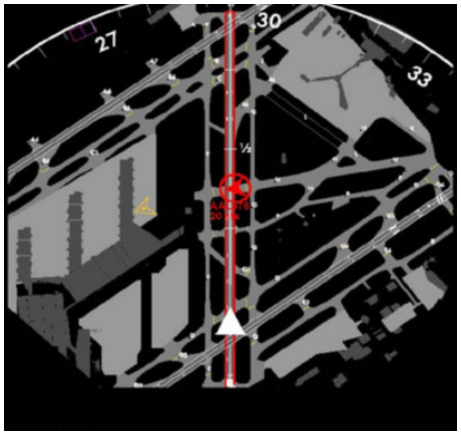


A-SMGCS: Advanced - Surface Movement Guidance and Control System

EGNOS-ENABLED ADS-B APPLICATIONS

SURF-A (Traffic Alert on SURFace) application: Enhanced on-board system providing alerts to the flight crew with respect to surrounding traffic to prevent collisions on the runway.

SURF-IA application: Providing flight crew with visual awareness on the airport moving map display and indications and alerts (aural and on devices) about situations where collision hazard exists or a collision appears imminent. The objective is to help decrease the likelihood and severity of runway incursions and collisions on or near the airport surface.



EGNOS REQUIREMENTS AND SERVICE MODEL

- Need to enhance ADS-B performance to satisfy surface operations requirements:
  - SBAS requirements

Operations / Indicators	ADS-B to support enhanced A-SMGCS	ADS-B to support alternative A-SMGCS	SURF-A	SURF-IA
Horizontal accuracy 95%	**HFOM < 10m** (NACp=10) or **HFOM < 3m** (NACp = 11)	**HFOM < 10m** (NACp= 10)	**HFOM < 30m** (NACp = 9) But **HFOM < 10m** recommended (NACp=10)	**HFOM < 3m** (NACp = 11) to **HFOM < 30m** (NACp = 9)
Vertical accuracy 95%	≤45 m	≤45 m	≤45 m	≤45 m
Integrity	≤ 10^{-7} (worst value)	≤ 10^{-7} (worst value)	10^{-5}	10^{-4} for indication and caution and 10^{-5} for warning
Horizontal Velocity Accuracy (NACv)	< 3m/s (NACv = 2)	< 3m/s (NACv = 2)	< 10m/s (NACv=1)	< 10m/s (NACv=1)

- ESP remains Navigation Service provider
  - No major regulatory constraints; safety assessment to be done to support the implementation of EGNOS-enabled ADS-B applications
  - EGNOS V3 architecture sufficient for EGNOS-enabled ADS-B applications
  - Need to further investigate if a specific Service Level is required as part of the SoL service
  - ESP costs associated to support EGNOS-enabled ADS-B applications are only limited to the regulatory upgrading and associated processes.

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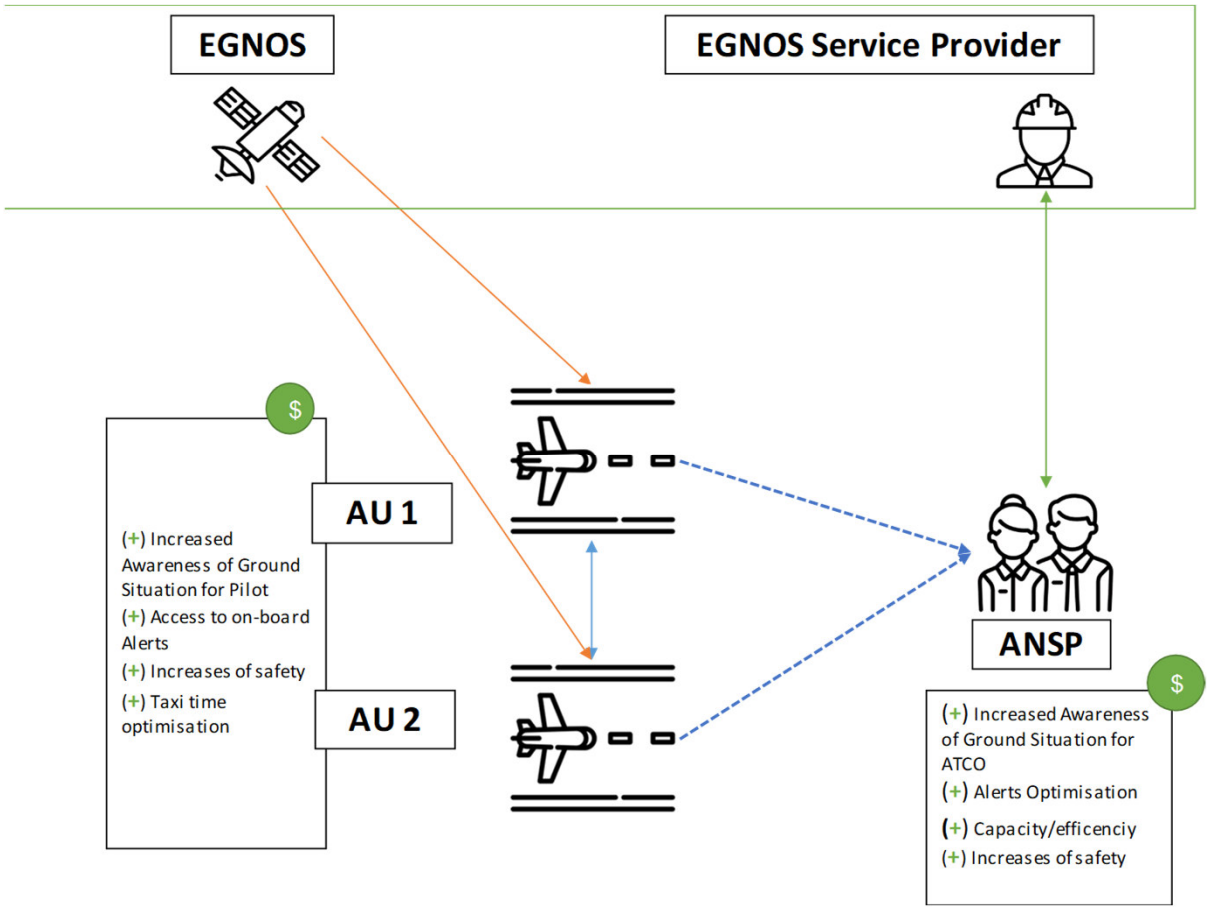
FEASIBILITY AND IMPLEMENTATION TIME

- No impact on EGNOS to be used as the same source for navigation and surveillance in Europe
  - Existing safety barriers would allow to have very low likelihood of major incidents;
  - Quantification of the safety barriers to be further refined;
- Feasibility: EGNOS V2 and target V3 seems sufficient to satisfy ADS-B requirements
  - Need to assess or confirm if EGNOS can provide HFOM < 3m
  - Additional work to verify or adapt ground SBAS receiver to surface operations
  - No velocity requirement captured in EGNOS MRD
- Initial date of operations: 2029, considering all enablers.

COST-BENEFITS ANALYSIS



COST-BENEFITS ANALYSIS

	Costs			Benefits	
Services per segment	**ANSP**	**AU**	**ESP**	**ANSP**	**AU**
Enhanced A-SMGCS at airports already equipped with A-SMGCS	200K€ (update of A-SMGCS fusion process)	100K€ per aircraft (DFMC/SBAS receiver)	Regulatory costs	Not quantified	Taxi time benefits: **70K€ to 2M€** (medium to very large airports)
Alternative A-SMGCS at airports not equipped with A-SMGCS	**2,5M€** (Ground infrastructure, data fusion process, vehicles)	**100K€ per aircraft** (DFMC/SBAS receiver)	Regulatory costs	**Safety benefits: 1K€ to 50K€** (small to medium airports)	**Taxi time benefits**: **14K€ to 250K€** (small to medium airports) **Safety benefits**: **20K€ to 7M€** (small to medium airports)
SURF-A/SURF-IA	NA	**100K€ per aircraft** + ADS-B IN equipment (DFMC/SBAS receiver)	Regulatory costs	Not quantified	Not quantified

COST-BENEFITS ANALYSIS CONCLUSIONS

- EGNOS-enabled ADS-B applications have the primary objective to enhance safety, which makes difficult the benefit monetisation
  - Safety benefits monetised based on operational consequence of incidents
- Alternative A-SMGCS:
  - Return on Investment possible if A-SMGCS allows to prevent at least one incident;
  - Monetisation of reduction of delays for airspace users during low visibility to be done to provide additional quantified benefits
  - Conservative assumption on the number of concerned airports which may be higher
- Enhanced A-SMGCS:
  - Possible benefits related with optimisation of the taxi-time
  - Highly beneficial to very large and large airports and less significant for medium airports
- SURF-A and SURF-IA:
  - No quantification possible
  - Real benefits on airports without A-SMGCS
  - Opportunity for SBAS to be further consolidated considering other applications

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RECOMMENDATIONS

- Consolidate SBAS requirements based on the final A-SMGCS surveillance requirements
- Confirm that EGNOS can provide HFOM < 3m and can commit for surface operations
- Confirm quantification of the safety barriers and the impact on the likelihood of hazards
- Confirm the need for a dedicated service level in the SDD for the provision of EGNOS-enabled ADS-B based services
- Cost benefits analysis to be further progress based on a refinement of the quantification of the benefits

EGNOS SERVICES FOR CNS/ATM BEYOND NAVIGATION – TIMINGS OR OTHER SERVICES

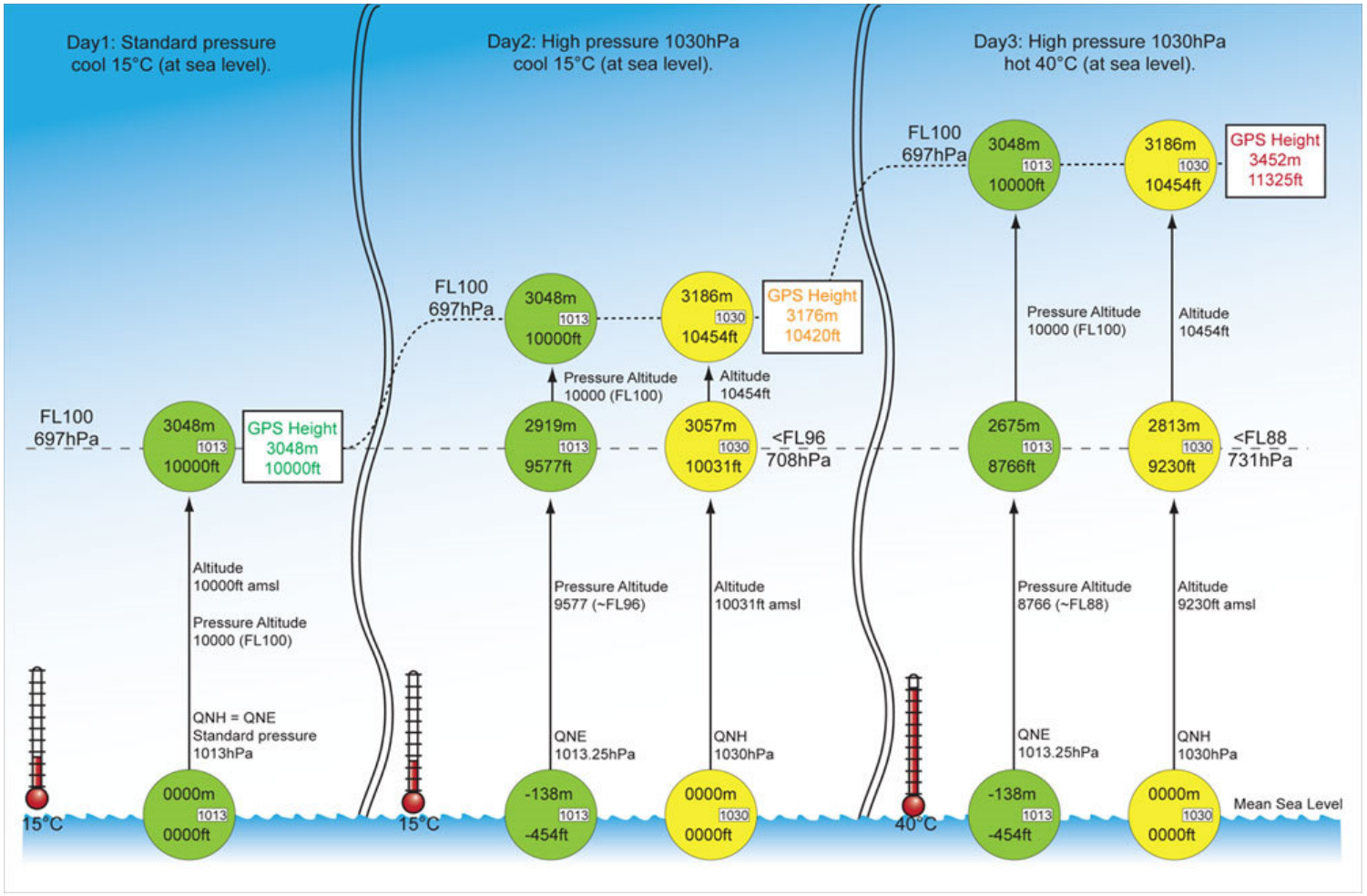
OUTCOMES

FUTURE SERVICE SELECTION

"**Use of EGNOS as a new altitude reference system**" named as "**Vertical Reference Service**"

- Global harmonisation of the reference system for altitude based on GNSS therefore removing the limitations (reduced performance due to atmospheric conditions) and the error margin of the current barometric system.
- All Airspace Users, providing a common denominator for both manned and unmanned aviation.

BAROMETRIC HEIGHT COMPARED TO GPS CALCULATED HEIGHT



CONCEPT AND SBAS REQUIREMENTS

- Use of SBAS as a single global reference system for altitude.
- Proposed incremental approach:
  - Implementation of the service in the TMA only at the beginning targeting those current operations already benefiting from geodetic altitudes – e.g. LPV approaches –
  - Extending later to cover all operations
- Key issue to ensure the feasibility of the service: Development of a clear way forward for the conversion between barometric and geodetic altitude needs to be defined and built into the vertical reference service CONOPS.

- The requirements identified by the industry experts are very generic and are meant to cover the most stringent operations of all airspace users – RPAS

Indicators	Vertical reference service
Horizontal accuracy 95%	<1m
Vertical accuracy 95%	<5m

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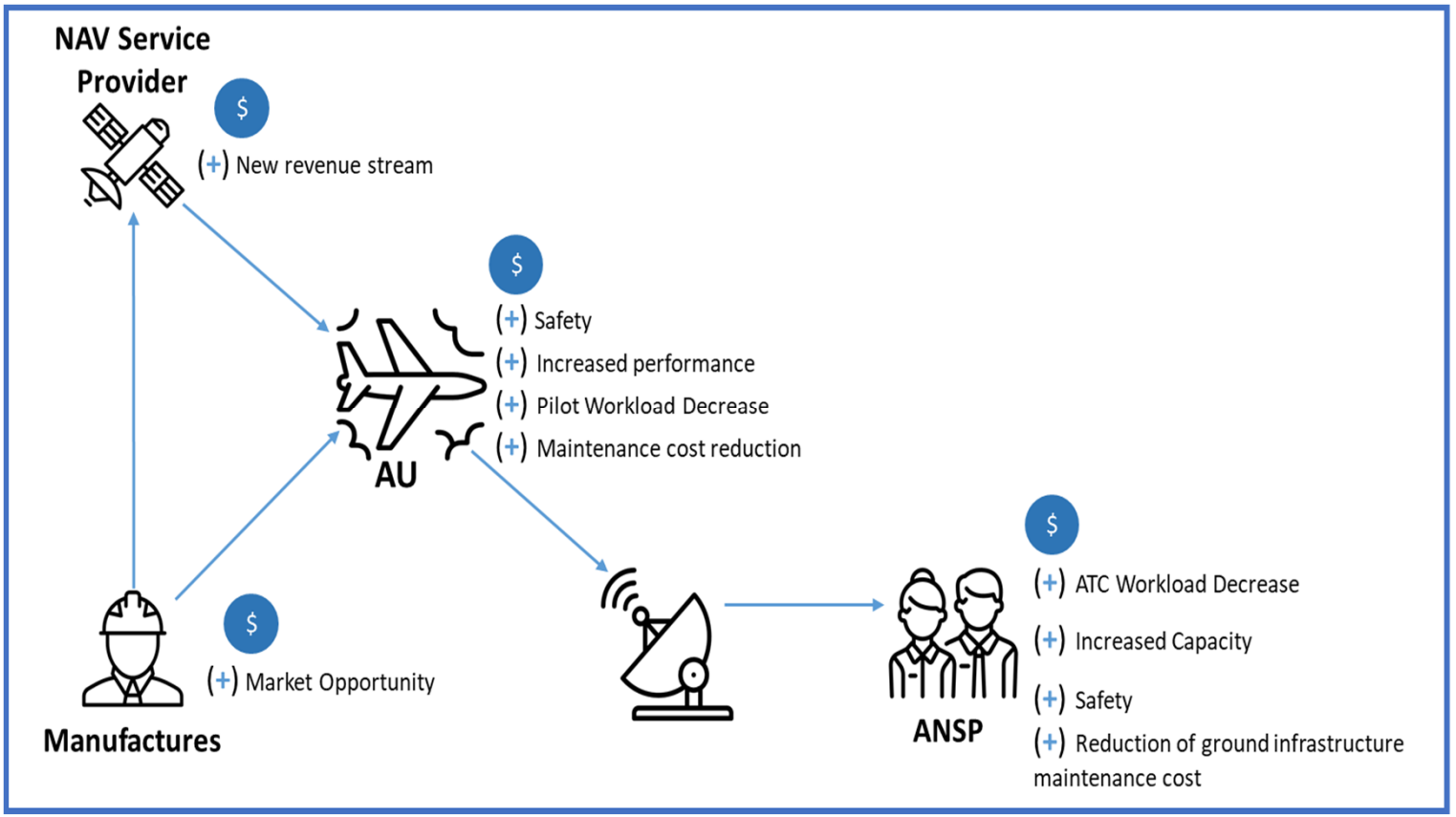
FEASIBILITY AND IMPLEMENTATION TIME

- The standardization phase will have to deliver the required avionics and standards for altitude conversion and sharing of data between all stakeholders.
- Regulatory environment
  - The new vertical reference service fits in well within the regulatory environment and processes required for a new pan-European service to be brought into the market.
  - Due to its global nature, the implementation of the service would require changes to be done at ICAO level to allow the calculation of altitude related date to be done using the geodetic methodology.
- It is feasible to bring the new vertical reference service into the market within the timeframe identified by the study (2037-2057).
- The forward fit approach for CA and the long-term plan put in place for the equipage of the GA fleet would provide a solid ground for ensuring the Airspace Users buy-in. Due to so the slow roll-out of the service, the disruptions would be minimal and the upgrades could be completed in time.

COST-BENEFITS ANALYSIS



COST-BENEFITS ANALYSIS

<table>
<tr><th colspan="2"></th><th colspan="3">Costs</th><th colspan="2">Benefits</th></tr>
<tr><th colspan="2">Services per segment</th><th>ANSP</th><th>AU</th><th>ESP</th><th colspan="2">ANSP</th><th>AU</th></tr>
<tr><td rowspan="2">Vertical Reference Service in Oceanic area</td><td>2037</td><td rowspan="4">500K€ per ANSP (ATM system upgrade for new data feed)</td><td rowspan="3">GA: 1,5K€ per aircraft (for retrofit)

No additional costs for forward fit for either of the AUs</td><td>NA</td><td colspan="2">5,9M€</td><td>680K€</td></tr>
<tr><td>2057</td><td>NA</td><td colspan="2">3,8M€</td><td>23,3M€</td></tr>
<tr><td rowspan="2">Vertical Reference Service in continental area</td><td>2037</td><td>NA</td><td>8M€</td><td rowspan="2">Maintenance benefits :
900K€ (small airports)
190K€ (medium airports)
190K€ (large airports)</td><td>790K€</td></tr>
<tr><td>2057</td><td>NA</td><td>5M€</td><td>157M€</td></tr>
</table>

RECOMMENDATIONS

- Develop and put forward a proposal to a wider number of stakeholders to gage their interest.
- Start discussions with European and international organisations to understand the feasibility of such a change at both European and global level.
- Develop a demo mission including a mock-up service and the development of an actual vertical reference box as planned.
- Develop a more mature CONOPS as part of the mock-up service
- Run fast time simulations to the demo mission simulating the 700ft vertical separation minima and therefore providing an initial view on the concept of operations.
- Engage a more detailed study to understand the various requirements that are needed to support all phases of flights in all airspace types

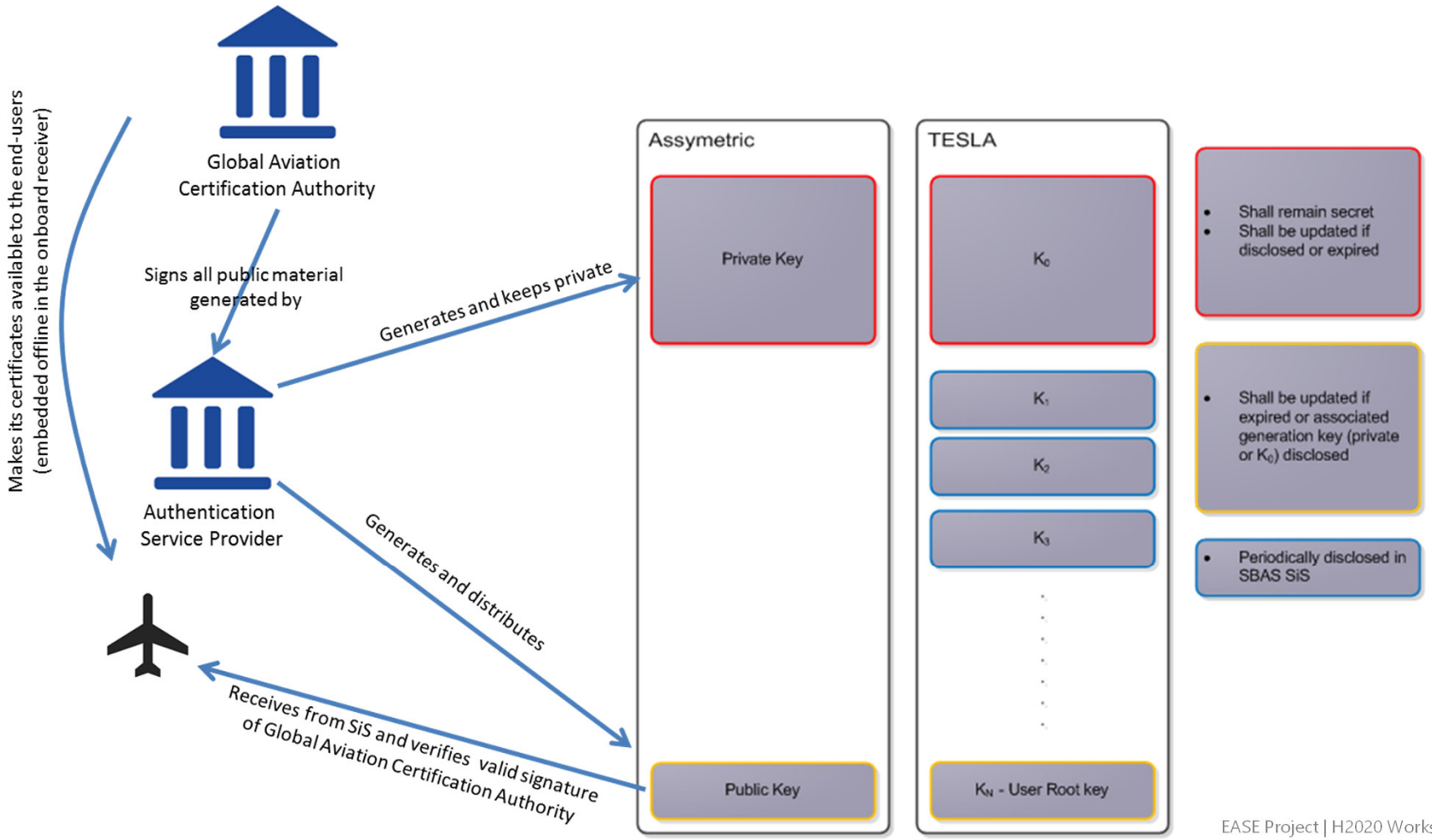
ROBUST SBAS SERVICES REQUIREMENTS AND IMPLEMENTATION ANALYSIS

OUTCOMES

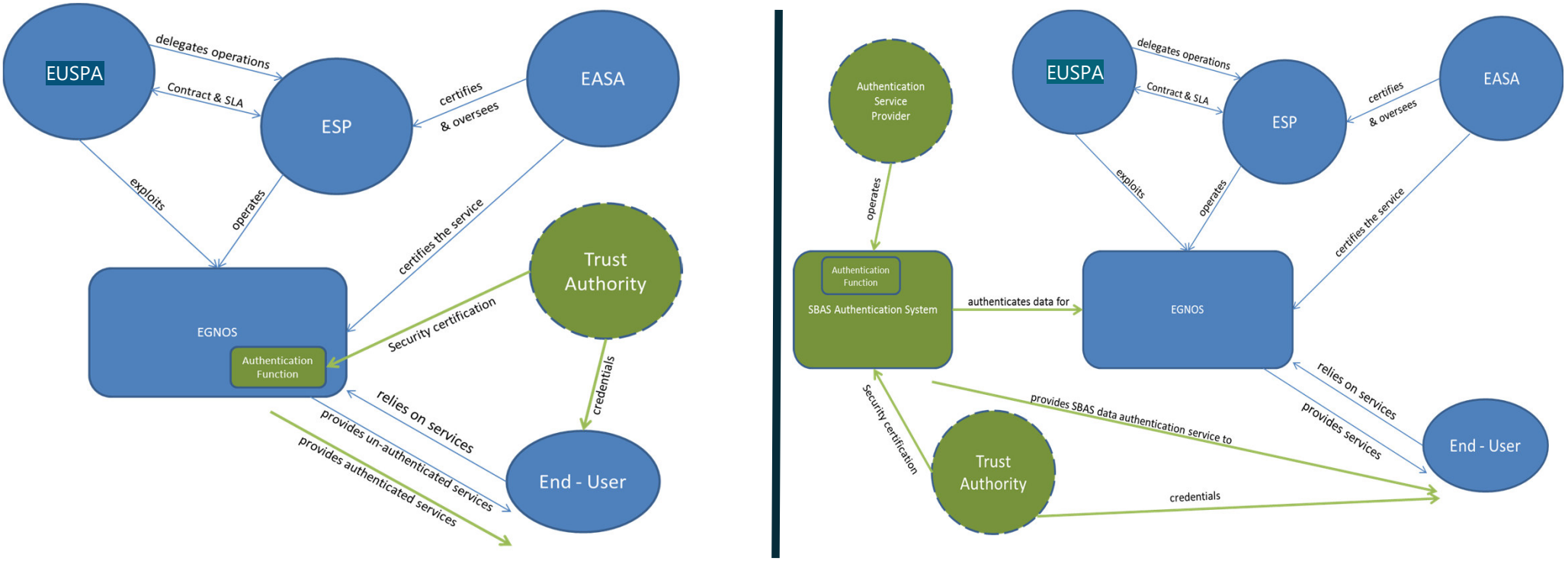
AUTHENTICATION SOLUTION

- Authenticating SBAS messages is a solution against spoofing as a minimum function to be developed
- **Asymmetric or TESLA based solutions** are recommended considering SBAS use in the civil aviation community
- Implementation:
  - Authentication data should be transmitted in the SiS potentially through a dedicated channel (i.e. SBAS L5Q)

KEY MANAGEMENT

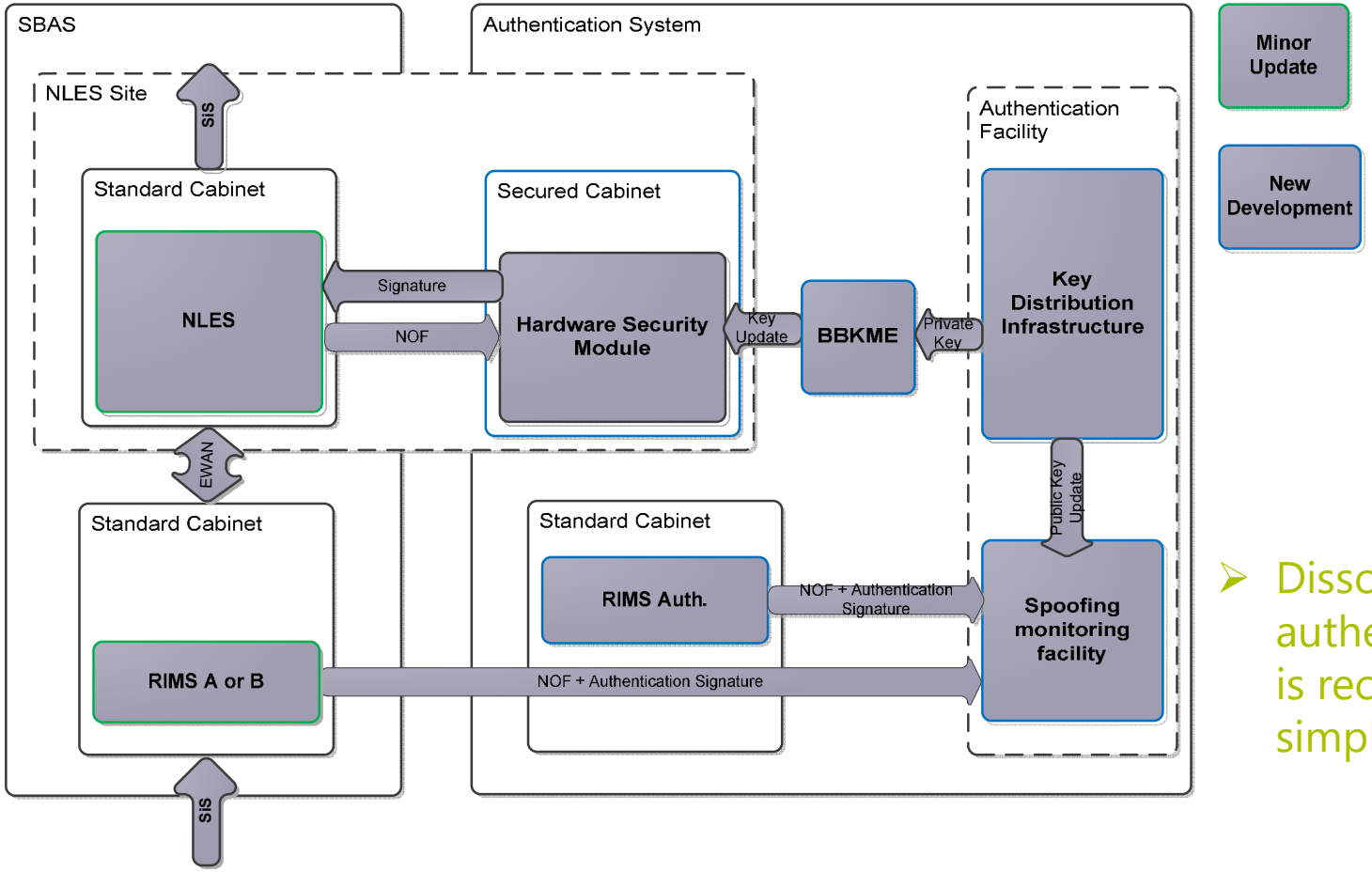


BUSINESS MODEL FOR SERVICE PROVISION



- It is recommended to have the Authentication Service Provider be the SBAS service provider

SYSTEM IMPACT USED AS BASIS FOR TENTATIVE ROADMAP



- Dissociating SBAS and authentication ground segments is recommended for simplification matters

TIMELINE AND ASSOCIATED COSTS

- Implementation timeline
  - Updating the ground segment would take less than 3 years, ignoring standard and receiver development constraints

- The costs for the deployment of an SBAS authentication service include:
  - System related costs
    - Not exhaustive list of sub-system impacted: CPF, NLES and RIMS;
    - Optionally, a new RIMS dedicated to authentication signatures verification can be developed and deployed in addition of existing RIMS
  - User receiver costs

EGNOS APPROACH SERVICES BELOW CAT I MINIMA

OUTCOMES

IDENTIFICATION OF POTENTIAL NEW EGNOS APPROACH SERVICES BEYOND CAT I

Two services (currently defined for ILS or equivalent) analysed:

- **SA CAT I (Special Authorisation CAT I)**
  - Already used in other regions of the world like USA and Australia (for ILS or equivalent) and defined in EASA NPA AWO (2018)
  - Operational credit to extend instrument segment of CAT I approach down to DH 150 ft
  - Approval from the competent authority and specific SA CAT I certification required in Europe
  - CAT I runways with specific requirements (ex.: in case of irregular terrain, verification of aircraft type/runway combination in operations in CAT I or better conditions)
  - Specific on-board requirements (ex. autoland or HUD, …)
- **CAT II**
  - Equivalent to existing CAT II

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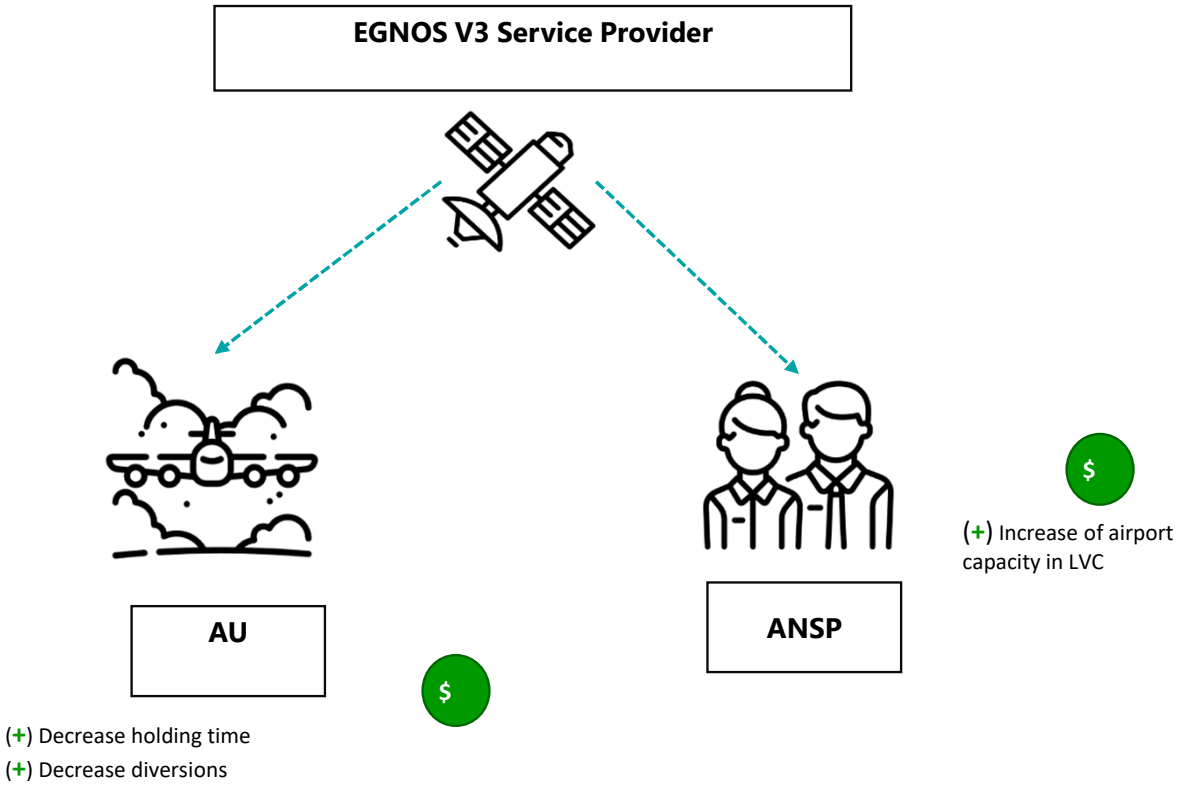
FEASIBILITY AND SBAS REQUIREMENTS

- Interest in having SBAS approaches with minima below CAT I, specially in airports not equipped with approaches below CAT I
  - **Special interest in using existing CAT I infrastructure**
- **SBAS SA CAT I** likely to be supported with EGNOS V3 system and receiver performance specifications (to be validated with real signals)
- **SBAS CAT II** requirements to be developed considering the characteristics of the SBAS system and its integration in the aircraft with other on-board equipment

Operations / Indicators	EGNOS V3 CAT I performance specifications	SA CAT I	CAT II
Horizontal accuracy 95%	16 m (current commitment is 3 m)	15.4 m (Note 2)	6.9 m (Note 4)
Vertical accuracy 95%	4 m	3.8 m (Note 2)	2 m (Note 4)
Integrity risk	2x10-7 / 150s	2x10-7 in any one landing	10e-9 in any one landing
Time to alert (TTA)	6 s	6 s	2 s (recommended 1 s)
Horizontal Alert Level (HAL)	40 m	38.5 m	21 m
Vertical Alert Level (VAL)	10 m	9.5 m	6.1 m
Continuity risk	8 × 10–6 /15 s 10^{-5} ((up to NPA)	8 × 10–6 in any period of 15 s	4x10e-6 per 15 s
Availability	99%	99% to 99.999%	99% to 99.999%
Horizontal Velocity Accuracy (NACv)	NA	NA	NA

COST-BENEFITS ANALYSIS



COST-BENEFITS ANALYSIS

	Costs			Benefits	
Services per segment	**ANSP**	**AU**	**ESP**	**ANSP**	**AU**
SABS SA CAT I at CAT I airport	**260 K€** (IAP and LVP procedure development)	**100 K€** per aircraft (DFMC/SBAS receiver)	NA	3,75h / years 2 K€ – 69 K€ (small to large airports) 42,5h / year 25 K€ – 780 K€	3,75h / years 19 K€ – 2 M€ (small to large airports) 42,5h / years : 225K€ – 23M€ (small to large airports)
SBAS CAT II at CAT I airports	**1,96 M€** (runway infrastructure and IAP and LVP procedure development)	**100 K€** per aircraft (DFMC/SBAS receiver)	NA	7,5h / years 4 K€ – 138 K€ (small to large airports) 85h / year 43 K€ – 1,5 M€I	7,5h / years 19K€ – 2M€ (small to large airports) 85h / years: 450K€ – 47M€ (small to large airports)
SA CAT I or SBAS CAT II at CATII/III airports	**80 K€** per IAP procedure development	**100 K€** per aircraft (DFMC/SBAS receiver)	NA	18 K€/hour of ILS unavailability	560 K€/hour of ILS unavailability

COST-BENEFITS ANALYSIS CONCLUSIONS

- At airports currently equipped down to CAT I operations
  - Interest for the development of SBAS SA CAT I operations.
  - Contribute to improve the access to the airport in low visibility conditions without a significant investment (mainly dedicated Low Visibility Procedures (LVP) and training).
  - No real interest for SBAS CAT II operations if it requires upgrading a CAT I runway into a CAT II runway, which is costly.
- At airports currently equipped with CAT II/III operations:
  - Interest for the development of SBAS SA CAT I or SBAS CAT II operations as complimentary procedures of existing CAT II/III procedures (backup or for serving mixed traffic)
  - The implementation cost of these operations is low because the airports are already equipped with the required infrastructure and have already Low Visibility Procedures (LVP).

COST-BENEFITS ANALYSIS CONCLUSIONS

- For airspace users
  - These potential new SBAS operations require equipping the aircraft with EGNOS V3 receivers as well as training staff. On the other hand, these operations can contribute to reduce the number of flights diverted because of low visibility conditions.

RECOMMENDATIONS

- Consolidate SBAS performance requirements to support SA CAT I
- Validate the assumptions used for the safety analysis based on the use of SBAS CAT I fault-tree
- Derive/consolidate SBAS CAT II requirements and fault tree
- Implement the corresponding enablers (ex.: develop procedure design criteria, update the corresponding standards, etc.)
- Refine generic costs and benefits

COMMUNICATION OF THE RESULTS

- At the **User Consultation Platform** during the European Space week (03/12/2018)

- At **ICAO Navigation System Panel** to present **Authentication findings**

- To **European civil aviation stakeholders** during AEOLUS meeting 3 (June 2018) and meeting 5 (March 2019).

EASE final report available here:

https://ec.europa.eu/defence-industry-space/eu-space-policy/space-research-and-innovation/horizon-2020-0_en

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Support of ESSP and DSNA (French ANSP)

EGNOS