Equipping for ASAS

ASSTAR findings: Aircraft Equipage for Airborne SEParation applications

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on behalf of the ASSTAR consortium

www.asstar.org

Sixth Framework Programme

Presentation Overview

1 : ASAS ASEP principles

2 : The challenge

3 : Findings on equipage for Airborne SEParation

Principal objective of this presentation is to relay and discuss ASSTAR findings on airborne systems requirements

What is ASSTAR

- Advanced Safe Separation Technologies and AlgoRithms
  6th Framework R&D STREP Programme, (Jan 05 – Nov 07), European Commission Directorate General RTD sponsored, led by DSNA with the following partners

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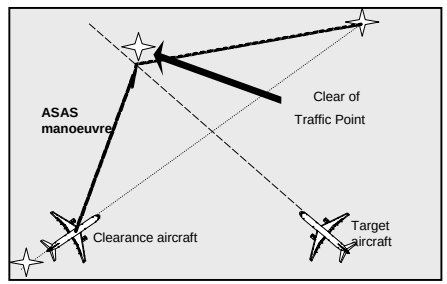
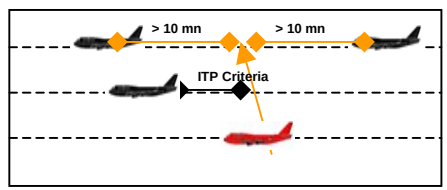
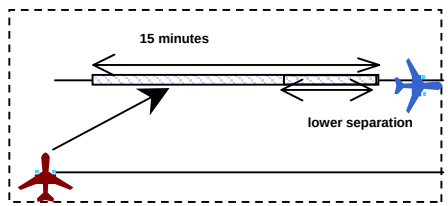
- ASAS Separation Applications focus- Package 2 constituents
  - **Crossing & Passing**
  - **In Trail Procedure**
  - **In Trail Follow**
  - Initial study on novel **In Trail Merge**





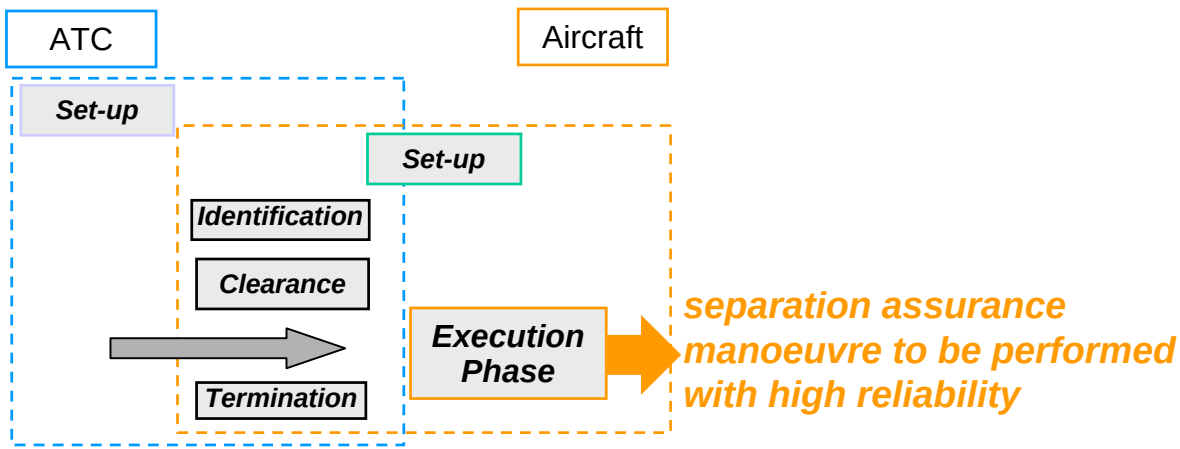


Sixth Framework Programme · ASSTAR

1 - ASAS ASEP principles

ASAS SEParation Operational Principle

Aircraft calculated **optimal, efficient manoeuvre , within separation minima*,** with on-board ASAS means, on the basis of air-air broadcast Navigation Data

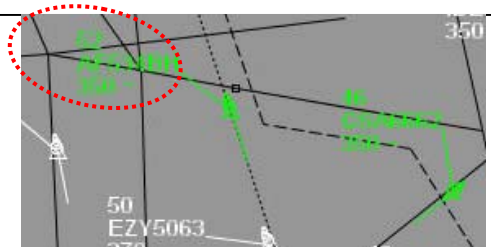


* *More optimal & efficient than the ATCO "rule of thumb" vectoring*

Procedure (e.g. ASEP C&P)

Setup phase + Identification

ATC positively assesses an opportunity for an ASAS manoeuvre ; identifies Clearance aircraft and Target,
Transmits ASAS request to aircraft ;
Aircraft reports positive identification



Clearance phase

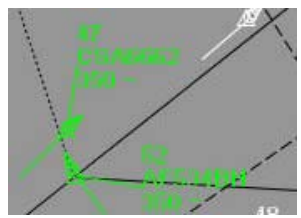
ATC issues the ASAS clearance ; optimally informs target

Execution

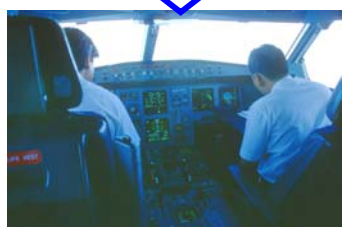
Clearance Aircraft executes ASEP manoeuvre
using on-board ASAS function
No ATC intervention in regular circumstances

Termination phase

Aircraft reports clear of traffic …
ATCO resumes separation task & responsibility,
(assesses that separation at COT is effective and resumes responsibility)



Principle in transferring resources & tasks



- **Operational Principle**
  - To **delegate the separation** manoeuvre** to a given clearance aircraft

Current ATC

Conflict Detection → Instruction → Monitoring → Clear of Traffic → Resume Navigation

Using airborne separation

Conflict Detection → Identification → ASEP Clearance → No ATCO Monitoring → Clear of Traffic → Resume Navigation

Resources are only necessary over a short period of time and in advance

** *Regulatory separation minima maintained (i.e. radar 5Nm, procedural benefiting from much better accuracy allowing near radar separation minima).*

Safety Analysis results

Most dimensioning hazards

Causes :

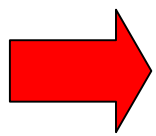
- Loss of ADS-B Out from target aircraft
- Degraded quality / Loss of ADS-B Navigation data from target aircraft
- Degraded quality / Loss of Navigation data on Clearance Aircraft
- Incorrect ADS-B Navigation data from target aircraft
- Crew / System misinterpretation of ASEP manoeuvre

Hazards :

- loss of ASAS guidance information / Erroneous manoeuvre
- Unexpected behaviour of the Target Aircraft
- Incorrect determination of Clear Of Traffic

Effects

- separation minima transgressed
- Guides aircraft outside the manoeuvre boundaries/constraints



RISK :

collision

Key operational findings

The various ASAS SEParation application have

- Common Operational procedures features, inter alia :
  - Identification of the designated aircraft
  - Phraseology,
  - Procedure phases
- Comparable Safety assessments which
  - Highlighted STRINGENT requirement in system performance
  - Determine the performance parameters to meet separation minima
- Besides the main principle of SEPARATION, ASAS application would bring wider benefit through
  - combined deployment ASEP-ITP+ASEP-ITF, ASEP-ITM+ASEP-C&P
  - ASEP applications considering “simple” conflicts involving TWO designated aircraft (one in front + one behind, or one above +one below

2 - The ASAS challenge

The challenge

CURRENT SEPARATION RESOLUTION PROCEDURE (performed by ATC)

- ATC : potential conflict : COMM. (voice) instruction (NAVigation order) … with some margin
- Crew / a/c executes instruction (Navigation – control loop)

Overall system operation consists in a separation instruction, with an INDEPENDENT monitoring loop on execution of this action (surveillance)

- This loop's Independence contributes to higher integrity, by identifying and acting on discrepancies / blunders, failures (e.g. Pilot input error ; Nav error)

ASAS SEPARATION RESOLUTION PROCEDURE

- ASAS function detects target position via broadcast. datalink (COMM) ;
  elaborates optimal conflict resolution manoeuvre, executes manoeuvre which must maintain separation
- the essential difference is **reliance on data, even if monitored, that is not independent** (common failure mode)
  - This concerns both ownship and target position
  - Fast time simulation results show that Navigation errors (either from the ownship or from the target) significantly increased **difficulty in providing ASAS resolutions.**
  - **More important : Safety objectives ; Integrity performance to be attained**

Safety impact

The ARCHITECTURAL CHALLENGE

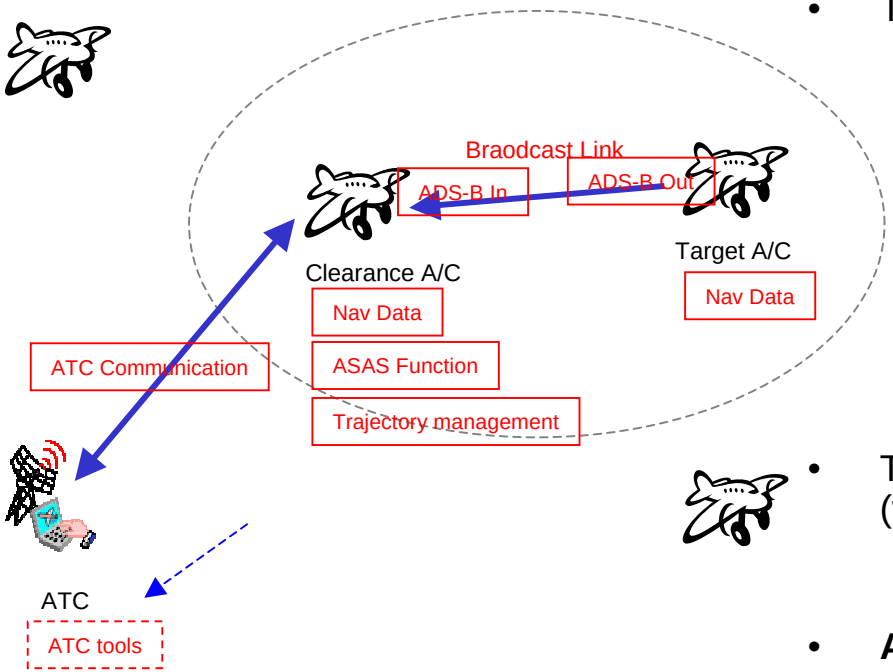
- To Guarantee Separation – a level of Safety must be attained
  - collective contribution C-N-S components to the system performance

- Safety is **either entirely dependent on the on-board ASEP** implementation which :
  - Obtains & calculates target separation
  - Calculates the separation manoeuvre
  - Guides aircraft along that manoeuvre within an expected procedural envelope.
  - And within separation minima with the target
- The on-board ASAS implementation will therefore need to meet the performance required to attain the extremely high required level of safety

- **OR could be spread** across on-board ASEP implementation and an independent ground monitoring/alerting loop

3 - Findings on equipage for Airborne SEParation applications

Equipage



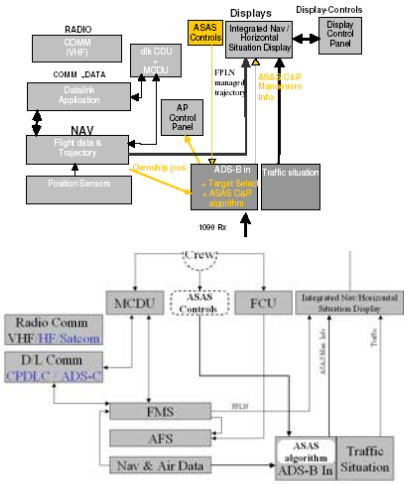
- To execute ASAS (**CLEARANCE A/C**)
  - ADS-B* IN (reception of surrounding ADS-B out squitters)
  - Ownship Navigation position & trajectory function ; Performance function (e.g. climb)
  - ASAS, incl. HMI, separation monitoring / alerting
  - Interfaces (CDTI, Nav, …)
  - ATC – aircraft comm. (datalink desirable, although can be designed for voice)
- To participate in an ASAS manoeuvre (**target**)
  - Navigation position & ADS-B* OUT
- **ATC**
  - ATC control system
  - Communication to /from a/c
  - Possibly monitoring (e.g. positioning discrepancy)

* ADS-B* IN (which is broadcast communication link conveying aircraft derived navigation data)

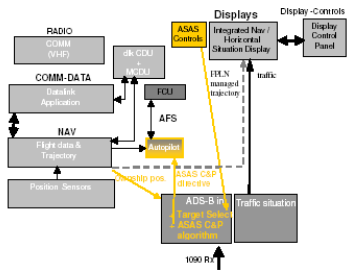
Airborne implementation

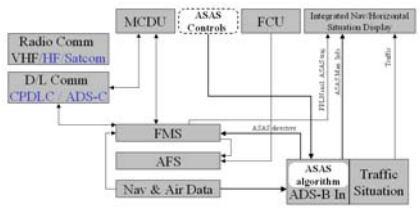
ASSTAR documented and discussed various alternatives' Advantages and Drawbacks

Manual Controls

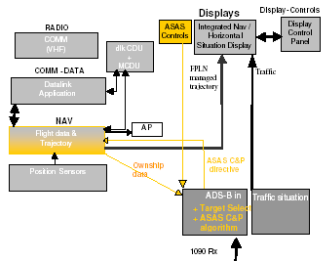


FMS control with external ASAS

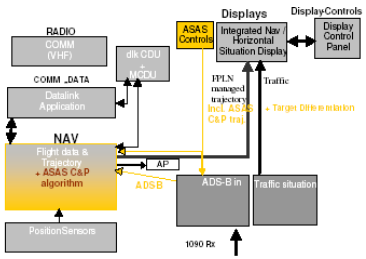


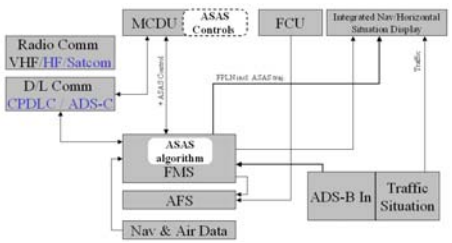


Autopilot Controls

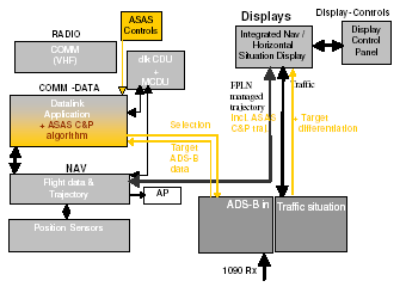


FMS / ASAS integrated controls



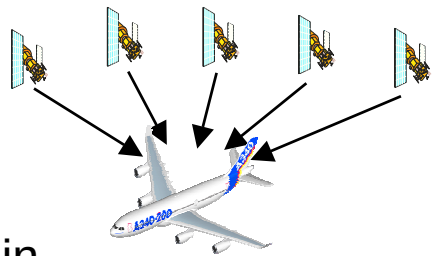


ASAS embedded with Data link - FMS interfaced



Navigation Data and broadcast datalink

Navigation



- Manoeuvre definition and execution **rely** strongly on **clearance** aircraft and **target** aircraft **position integrity and continuity**
- The expected Safety level will rely on one of two variants in system design :
  - either **extremely high confidence in positioning systems (both clearance aircraft and target aircraft**), in the case of ASAS reliance entirely on aircraft navigation data
  - **or ground monitoring/alerting control loop with independent position data**

Broadcast datalink

- **Data Integrity** : however this is easily ensured through protocol and software (e.g. CRC)
- **But more importantly : robust ADS-B datalink** to ensure **continuity** of broadcast transmission

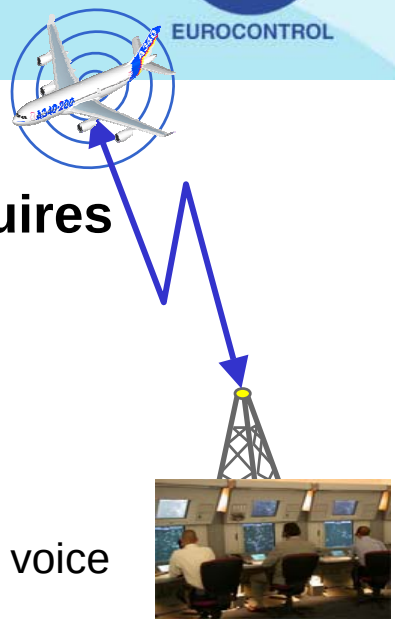
ASAS, Trajectory Function

- **ASAS function**
  - manoeuvre **guarantees adequate separation*** with target aircraft **during the entire ASAS execution period** ; it is updated continuously taking into account current conditions
- **Trajectory management / Execution of manoeuvre**
  - **predictable** (standardisation to be developed, for a common representation amongst all parties)
  - Elaborates **reliable manoeuvres** OR interfacing to means while satisfying safety requirement
  - within a **defined ASAS procedure volume**
- **Crew interface**
  - **traffic situation** display with capability to **designate** a target
  - **capability to manage the manoeuvre**

- Such features contribute to safety of the manoeuvre, and shall be **integrated into cockpit and avionics design philosophy with compatible features** and also **commensurate with safety criticality**
- **Simple, probably automated** (crew activation, monitoring)

*that should not transgress a minimum value with a given probability

Communication



ATC dialog during ASAS manoeuvre initiation phase requires

- several information elements to be exchanged
- integrity of communicated data ensured

- CPDLC datalink preferred against voice
  - implementation of new ASAS messages requiring new standards (id voice phraseology)
- communication availability at termination is also important

4 - Summary & Conclusions

Key airborne implementation findings

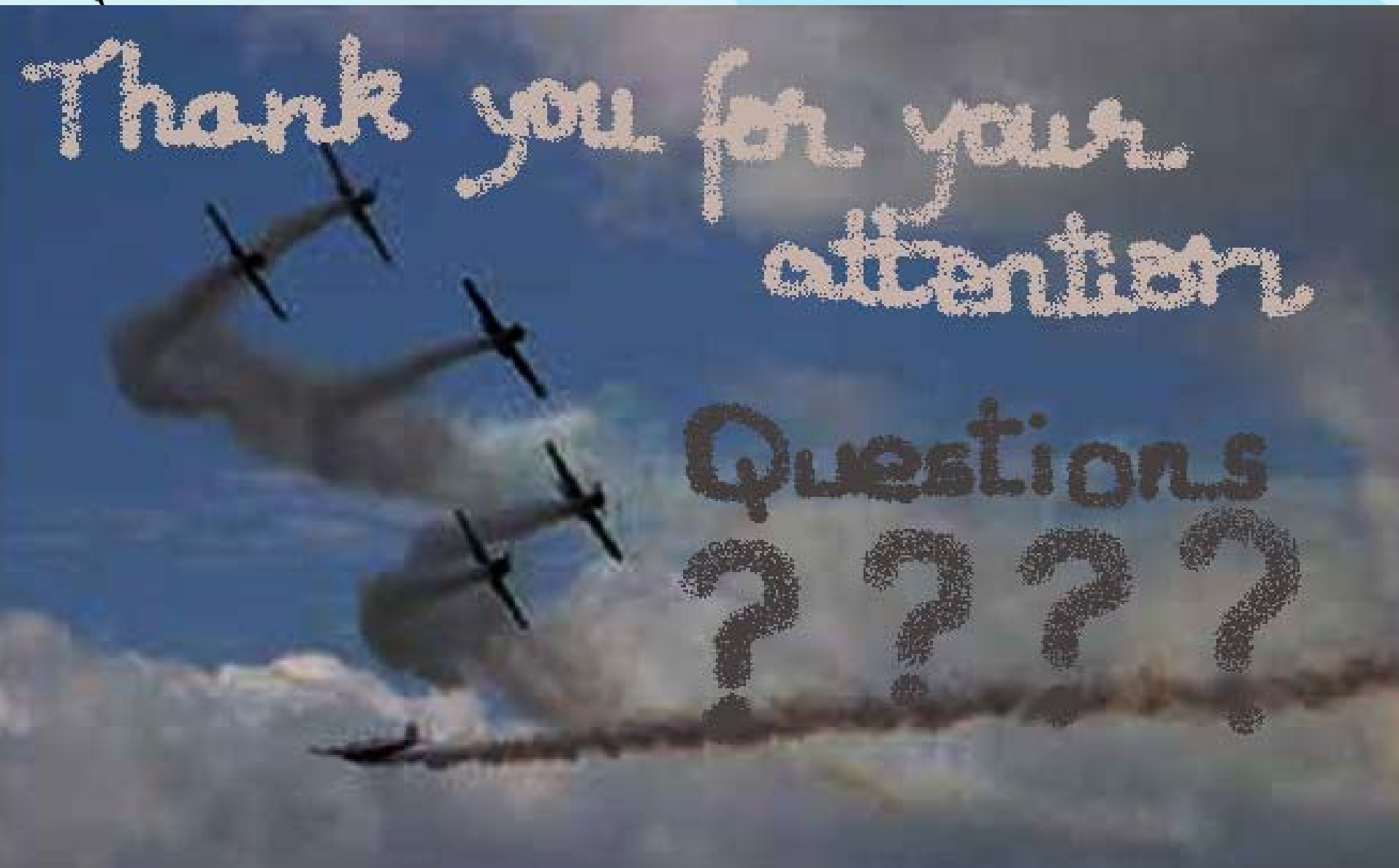
- **Future standardisation will be the driver of ASAS-SEP procedures, operations, some technical areas – safety analysis and resulting allocations will of paramount importance in system design options**

In the case where the safety level relies entirely on aircraft

- **Integrity / Continuity of Nav. position** at both target aircraft and clearance aircraft level ()
  - To pursue this finding activities need to be launched
  - Close links expected between future airborne separation standards and navigation performance
- **High continuity broadcast datalink**

- **ASSTAR recommends the Use of Datalink** (e.g. CPDLC) **for ASEP applications:**
  - single transaction / simple setup and capability to combine multiple sets of information in clearance
  - Datalink integrity capability suppresses requirement for additional mitigations – e.g. readback.
  - Datalink is a Basic common factor for all future concepts

- **TCAS remains** an **independent safety net** function ; **Traffic display** should however be **consolidated** for operational reasons, and according to cockpit philosphy.


Thank you for your attention
Questions
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