



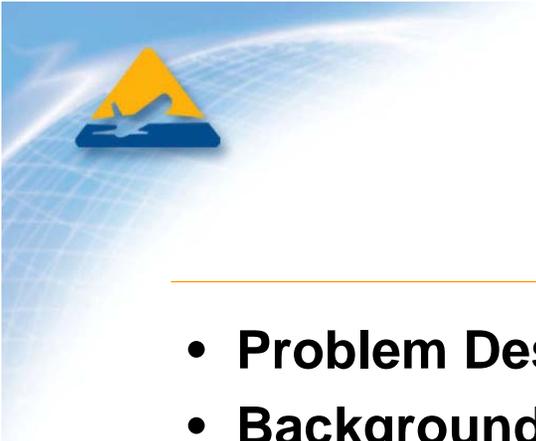
CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)

ASSAP Issue # SP6: Initial Initial Thoughts on Dual Link Reception of ADS-B

MITRE/CAASD

Roxaneh Chamlou

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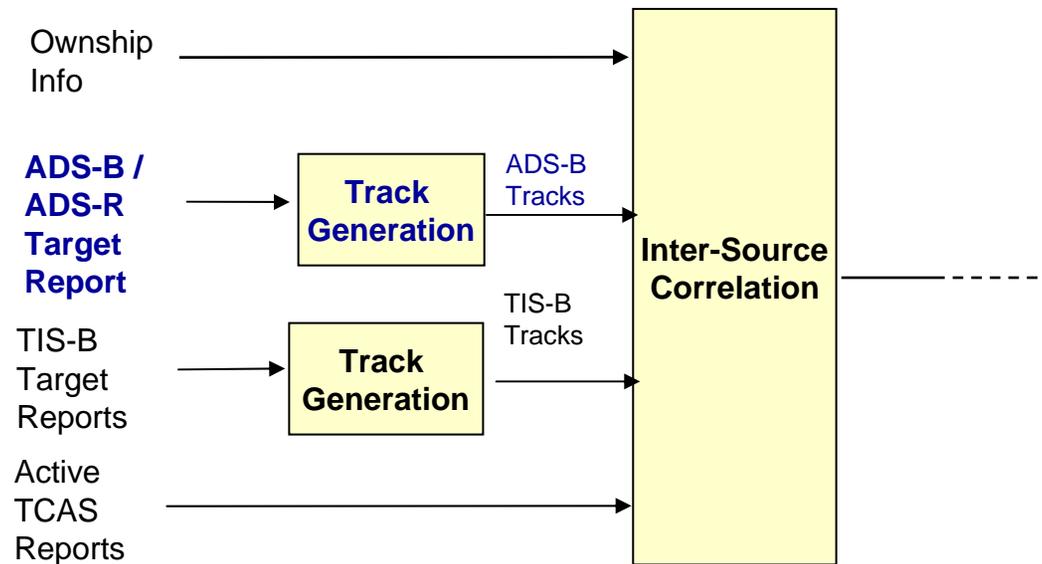
Outline

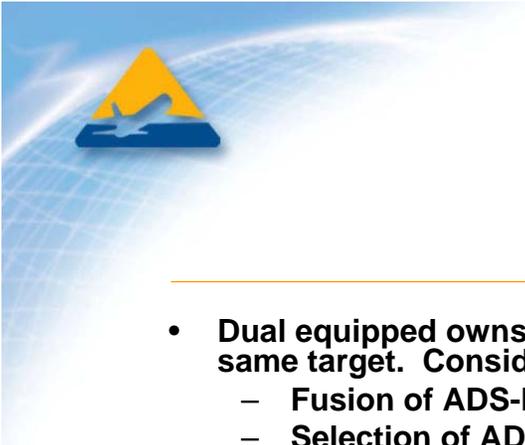
- **Problem Description**
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Problem Description

- One proposed function in the strawman ASSAP functional architecture is **Source-Level Tracking for ADS-B/ADS-R**
 - Establish tracks from ADS-B/ADS-R and TIS-B sources separately (Track Generation).
 - Note: this is an extension of the statement in the ASA MASPS which did not explicitly call out ADS/R
 - Establish tracks from ADS-B and TIS-B traffic reports (Section 2.4.3.4, Page 46).

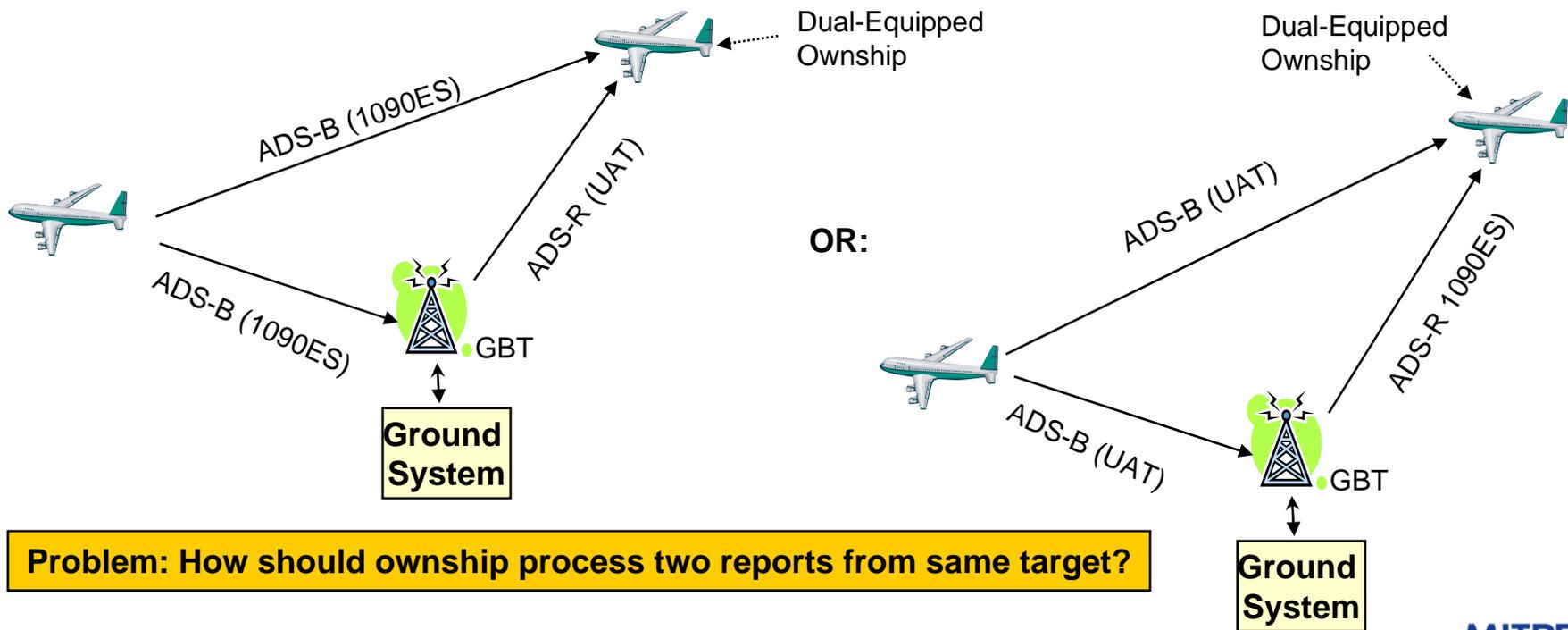




Problem Description (cont'd)

- Dual equipped ownership can receive both ADS-B (direct) and ADS-R (rebroadcast) reports on the same target. Consider two alternatives:
 - Fusion of ADS-B and ADS-R reports.
 - Selection of ADS-B as the primary source and acceptance of ADS-R for track update only when ADS-B reception has ceased for x seconds.

Illustration of Problem:





Background Information

- First, we have to establish that ADS-B, TIS-B, ADS-R `services can be distinguished by the receiver subsystem. The following table suggest what information could be used for this distinction. (Verification on the next slide.)

Link Type Service Type	UAT		1090ES	
	Address Qualifier	SIL	DF Type	
TIS-B	2 (ICAO ID)	0	DF18, CF2, IMF0 (fine, ICAO)	
	3 (Tracker ID)	0	DF18, CF5, IMF0 (fine, Track ID)	
ADS-R	2 (ICAO ID) 1 (self-assigned temporary)	> 0	DF18, CF6, IMF0 (ICAO) DF18, CF6, IMF1 (anonymous)	
ADS-B	0 (ICAO ID)	> 0	DF17	
	1 (Temporary ID)	> 0	DF17	
	4 (Surface)	> 0	DF17	
	5 (Fixed)	> 0	DF17	



Background Information (cont'd) - Verification of Capability to Distinguish between ADS-B, ADS-R and TIS-B Services

- **1090ES Link**
 - *Distinguishable by DF and CF types*
- **UAT**
 - *The Address Qualifier for the does not distinguish between ADS-R and TIS-B when the address is based on ICAO address (i.e., AQ = 2). Under Segment 1, the value of SIL can be used to distinguish the services under this condition:*
 - *ADS-R will have a non-zero SIL according to footnote from ASA MASPS Vol 1, DO-289, Table 3-8, SIL Encoding:*

It is assumed that SIL for a specific position sensor is static. Thus, for example, if an ADS-B participant reports a NIC code of 0 because four or fewer satellites are available for a GPS fix, there would be no need to change the SIL code until a different navigation source were selected for the positions being reported in the SV report.
 - *TIS-B will have SIL set to zero according to the draft Essential Spec.*



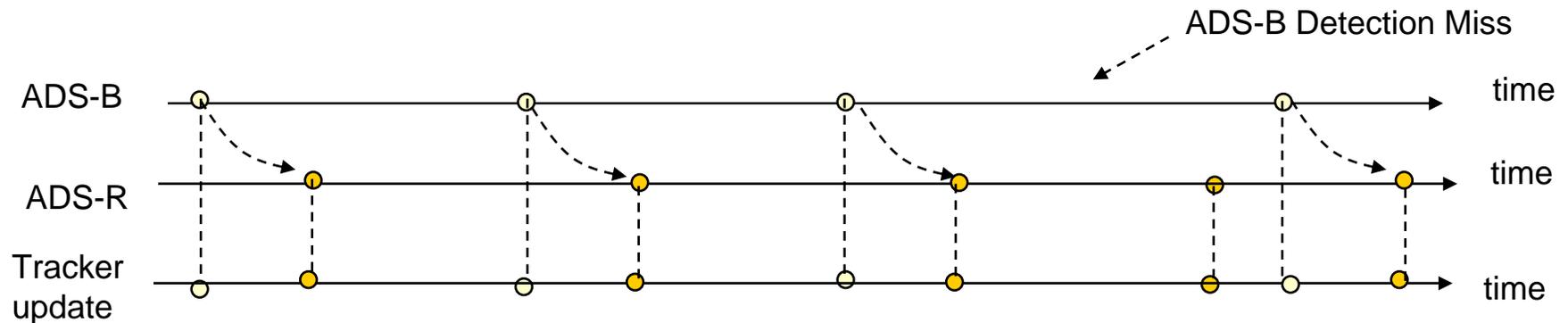
Background Information (cont'd)

- **The SBS ADS-B/ADS-R Critical Services Spec will most likely have ADS-R requirement on:**
 - **Latency**
 - **Compensation for latency in the ADS-R state vector**
 - **For the 1090ES: 1090ES Messages broadcast up to aircraft (from a UAT Message reception on the ground) will extrapolate to the Time of Transmission.**
 - **For UAT link: UAT Messages broadcast up to aircraft (from a 1090ES Message reception on the ground) will be extrapolated to the beginning of the UTC second in which the broadcast occurs (as in the Non-Precision UTC coupled mode).**
- => ADS-R reports are providing extrapolated position information at the rebroadcast time.**

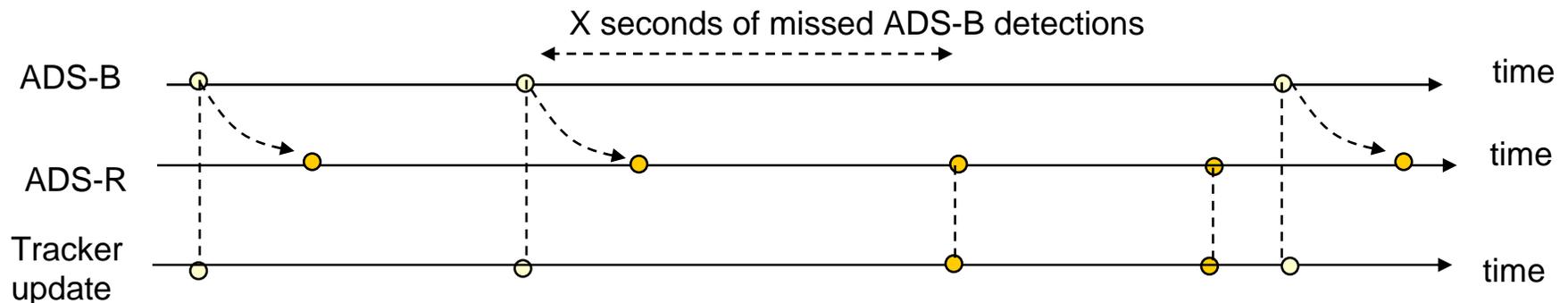


Discussion of Alternatives

- **Fusion Alternative:** Update the ADS-B source level tracker with either ADS-B or ADS-R (that arrives later and is compensated for the latency).



- **Source Selection Alternative:** Do not update with ADS-R unless ADS-B has not been received for x seconds.





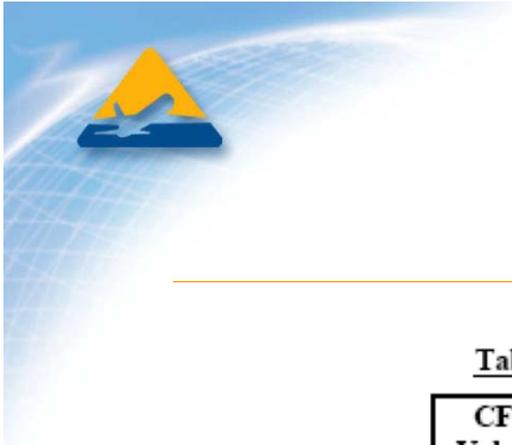
Assumptions and Conclusions

- **Assumption**

- Both alternatives assume the address in the ADS-R message is not altered from the original ADS-B message (i.e., ADS-B and ADS-R are correlated by their address).
 - Investigate validity of assumption. For example, what happens when the ADS-B address is anonymous in 1090ES and is rebroadcast over UAT
 - **If rebroadcast can alter the address, a spatial correlation between ADS-B and ADS-R may be required rather than a simple address matching scheme.**

- **Conclusion**

- Tentatively: dual equipped A/V can operate conflict free. Two alternatives seems viable:
 - Fusion of ADS-B and ADS-R.
 - Selection of ADS-B as the primary source and acceptance of ADS-R for track update only when ADS-B reception has ceased for x seconds.
- The tradeoff is between processing load and algorithm complexity.



Reference Material - Do-260A MOPS volume 1

Table 2-106: “CF” Field Code Definitions in DF=18 ADS-B and TIS-B Messages

CF Value	ICAO/Mode A Flag (IMF)	Meaning
0	N/A	ADS-B Message from a non-transponder device, AA field holds 24-bit ICAO aircraft address
1	N/A	Reserved for ADS-B Message in which the AA field holds anonymous address or ground vehicle address or fixed obstruction address
2	0	Fine TIS-B Message, AA field contains the 24-bit ICAO aircraft address
	1	Fine TIS-B Message, AA field contains the 12-bit Mode A code followed by a 12-bit track file number
3	0	Coarse TIS-B Airborne Position and Velocity Message, AA field contains the 24-bit ICAO aircraft address
	1	Coarse TIS-B Airborne Position and Velocity Message, AA field contains the 12-bit Mode A code followed by a 12-bit track file number.
4	N/A	Reserved for TIS-B Management Message AA field holds TIS-B Service Volume ID + other information (e.g., MSB of reference position for the service volume)
5	0	Fine TIS-B Message AA field contains a non-ICAO 24-bit address
	1	Reserved
6-7	N/A	Reserved



Reference Material - Proposed Change to Annex 10, Vol. IV for TIS-B Management Messages

Proposed changes and Additions to Doc 9871

1. Change to Appendix 2, Section 3.3

3.3 CONTROL FIELD ALLOCATION

The content of the DF=18 transmission shall be defined by the value of the control field, as specified in the following table.

CF Field Code Definitions in DF=18 ADS-B and TIS-B Messages		
CF Value	ICAO/Mode A Flag (IMF)	Meaning
2	0	Fine TIS-B message, AA field contains the 24-bit ICAO aircraft address
	1	Fine TIS-B message, AA field contains the 12-bit Mode A code followed by a 12-bit track file number
3	0	Coarse TIS-B airborne position and velocity message, AA field contains the 24-bit ICAO aircraft address
	1	Coarse TIS-B airborne position and velocity message, AA field contains the 12-bit Mode A code followed by a 12-bit track file number.
4	N/A	Reserved for TIS-B/ADS-R management messages AA field holds TIS-B the service ID <u>in the form of the encoded latitude and longitude (12-bit CPR encoding of each) of the center of the TIS-B or ADS-R service volume (i.e., nominally the ground station location – see note), + other information (e.g., MSB of reference position for the service)</u>
5	0	TIS-B messages that relay ADS-B Messages using anonymous 24-bit addresses
	1	Reserved
6	0	ADS-B rebroadcast. (ADS-R) using the same type codes and message formats as defined for DF=17 ADS-B messages AA field contains the 24-bit ICAO aircraft address
	1	ADS-B rebroadcast. using the same type codes and message formats as defined for DF=17 ADS-B messages AA field contains a 24-bit anonymous aircraft address

Note. Typically the TIS-B and ADS-R service volumes will be centered around the location of the ground station location generating the broadcast. However, it is possible for the announced center of the service volume to be offset from the actual ground station if doing so provides for a better representation of the actual service volume. See 3.4.6.4 for more information.



Reference Material - UAT DO-282AVol 1 MOPS Table 2-12 “Address Qualifier Encoding”

ADDRESS QUALIFIER.

<i>Address Qualifier (binary)</i>			<i>Address Type</i>
<i>Bit 27</i>	<i>Bit 26</i>	<i>Bit 25</i>	
<i>0</i>	<i>0</i>	<i>0</i>	<i>ADS-B target with ICAO 24-bit address</i>
<i>0</i>	<i>0</i>	<i>1</i>	<i>ADS-B target with self-assigned temporary address</i>
<i>0</i>	<i>1</i>	<i>0</i>	<i>TIS-B target with ICAO 24-bit address</i>
<i>0</i>	<i>1</i>	<i>1</i>	<i>TIS-B target with track file identifier</i>
<i>1</i>	<i>0</i>	<i>0</i>	<i>Surface Vehicle</i>
<i>1</i>	<i>0</i>	<i>1</i>	<i>Fixed Beacon</i>
<i>1</i>	<i>1</i>	<i>0</i>	<i>(Reserved)</i>
<i>1</i>	<i>1</i>	<i>1</i>	<i>(Reserved)</i>