Bird Strike Mitigation for Aviation

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Outline

- Background
  - » Bird Strikes in Aviation
  - » Previous FAA efforts
- Ohio University Research Items
  - » Overall Approach
  - » Universal Access Transceiver (UAT)
  - » TIS-B/FIS-B Considerations
    - Focus on TIS-B messages
    - FIS-B messages will be next quarter
  - » TIS-B Target Report Formatting/Distribution
  - » Applicability of Target Report
  - » Plans

Background: Bird Strikes in Aviation

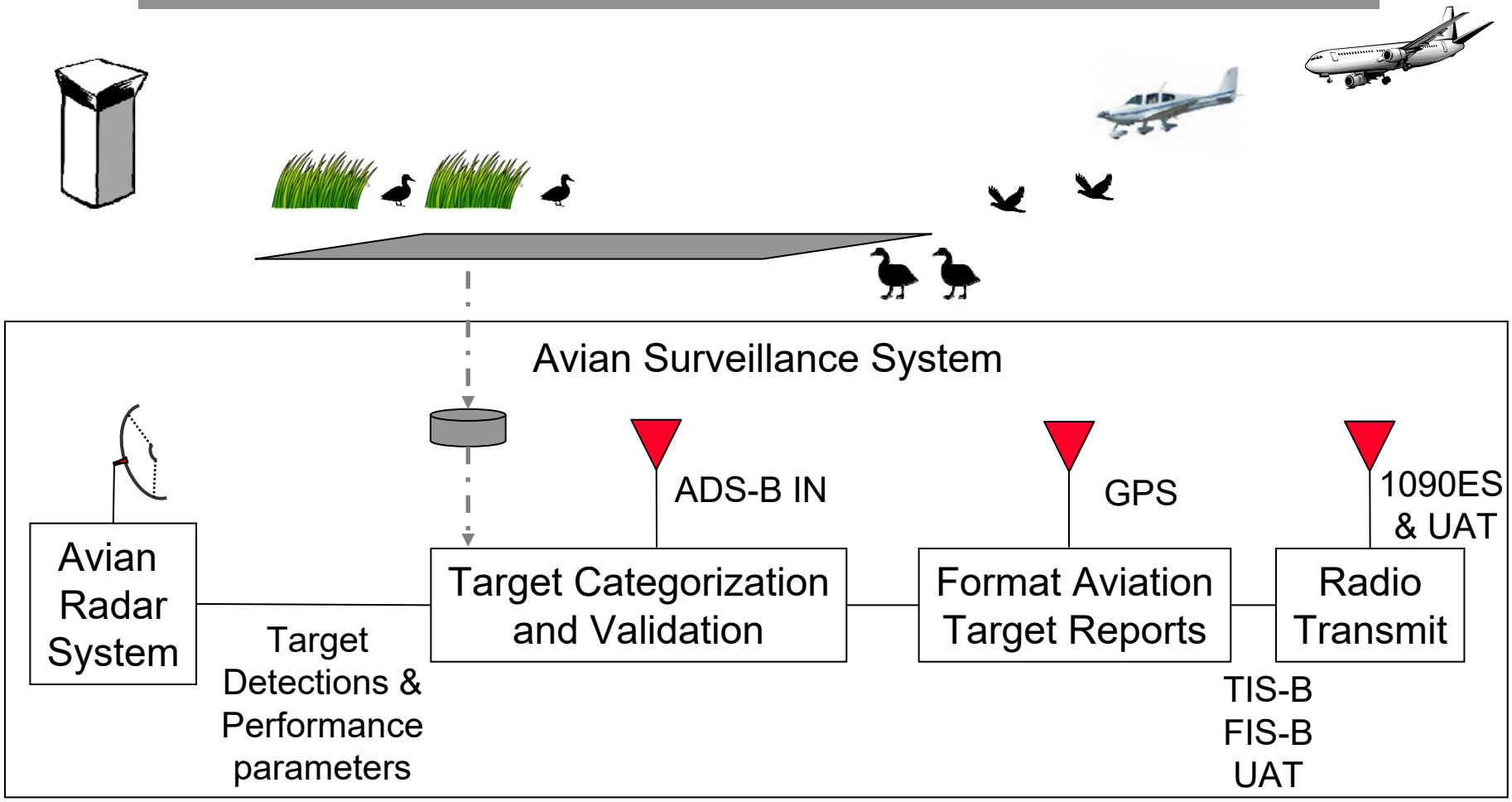
- **Occur when a bird collides with an aircraft; usually cause little damage, but can be devastating (ex. American Airlines Flight 1549 Hudson River incident).**
- **Roughly 10,000 strikes are reported annually; estimates suggest that as few as half of total strikes are reported.**
- **Less than 8% of strikes occur above 3,000 feet and 61% occur at less than 100 feet (according to FAA Wildlife Hazard Management Manual).**
- **FAA estimates $400 million in damages annually are attributed to bird strikes in the United States alone, and over $1.2 billion in damages occur annually worldwide.**

Ref: http://www.faa.gov/airports/airport_safety/wildlife/media/wildlife-strike-report-1990-2013-usda-faa.pdf

Ohio University Research Plans: Overview

- Goal: Reduce bird strikes for aviation
- Investigating a standalone avian target processor
- Utilize ground-based radar detection via avian radar systems and Information/signal transmission to ATC tower and aircrafts in/around airport
  - »Implement specialized avian ground-based radar on the airport property
    - Produce target detections and performance parameters
  - »Target categorize and validation
  - »Create target reports suitable for transmission in NAS
- Transmit Interface to NAS via aviation data links
  - »Aircraft: ADS-B equipped and non-ADS-B equipped via 1090ES and UAT
  - »ATC tower: via ADS-B

Ohio University Research Plans: Overview



Related RTCA Documents for Avian Messages

1. DO-242A Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS-B)
2. DO-338 Minimum Aviation System Performance Standards (MASPS) for ADS-B Traffic Surveillance Systems and Applications (ATSSA)
3. DO-318 Safety, Performance and Interoperability Requirements Document for Enhanced Air Traffic Services in Radar-Controlled Areas Using ADS-B Surveillance (ADS-B-RAD)
4. DO-348 Safety, Performance and Interoperability Requirements Document for Traffic Situation Awareness with Alerts (TSAA)
5. DO-319 Safety, Performance and Interoperability Requirements Document for Enhanced Traffic Situational Awareness During Flight Operations (ATSA-AIRB)
6. DO-286B Minimum Aviation System Performance Standards (MASPS) for Traffic Information Service - Broadcast (TIS-B)
7. DO-260B with Corrigendum 1 - Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance - Broadcast (ADS-B) and Traffic Information Services - Broadcast (TIS-B)
8. DO-282B with Corrigendum 1, Minimum Operational Performance Standards for Universal Access Transceiver (UAT) Automatic Dependent Surveillance – Broadcast

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9. DO-267A Minimum Aviation System Performance Standards (MASPS) for Flight Information System - Broadcast (FIS-B)
10. DO-358 Minimum Operational Performance Standards for Flight Information System – Broadcast (FIS-B) with Universal Access Transceiver (UAT)

Avian Radar Info Received

- **Information on the SRC, BSTAR Avian Surveillance and Warning System, Accipiter Avian Radars, and DeTect, Merlin, Avian Radar Systems:**
  1. **Performance Specifications that, for example, include minimum radar cross section, range, number of targets supported, target update rates, azimuth, and elevation resolutions/performance, range performance, etc.**
  2. **Interface Control Documents (ICDs) that, for example, discuss output target detections/reports on data busses (data format and content, message structures, etc.), bus hardware and software communication protocols, etc.**
  3. **Test reports on any performance and test assessments of the avian radar systems.**
  4. **Any design documents such as Final Design Reviews, delivery documentation, etc for the avian radar systems.**
- **A non-disclosure agreement has been executed between Ohio University and SRC regarding proprietary data.**
- **Received *Interface Control Document (ICD) for the Asterix Interface on the BSTAR* Version 1.14, 10 February, 2016 (Export Controlled Data)**

ASTERIX

All-Purpose **ST**ructured **E**urocontrol Su**R**veillance **I**nformation E**x**change

- EUROCONTROL Standard
- Primarily used by Air Traffic Control (ATC) Centers
- ATM Surveillance Data Binary Messaging format (and ASCII)
- Allows transmission of harmonized information between any surveillance and automation system
- Suitable for real-time implementation
- For specific applications, data items are able to be grouped into 256 separate categories
- Defines structure of data to be exchanged over communication medium
- **Support for Presentation (6) and Application (7) layers as defined by the OSI Model**

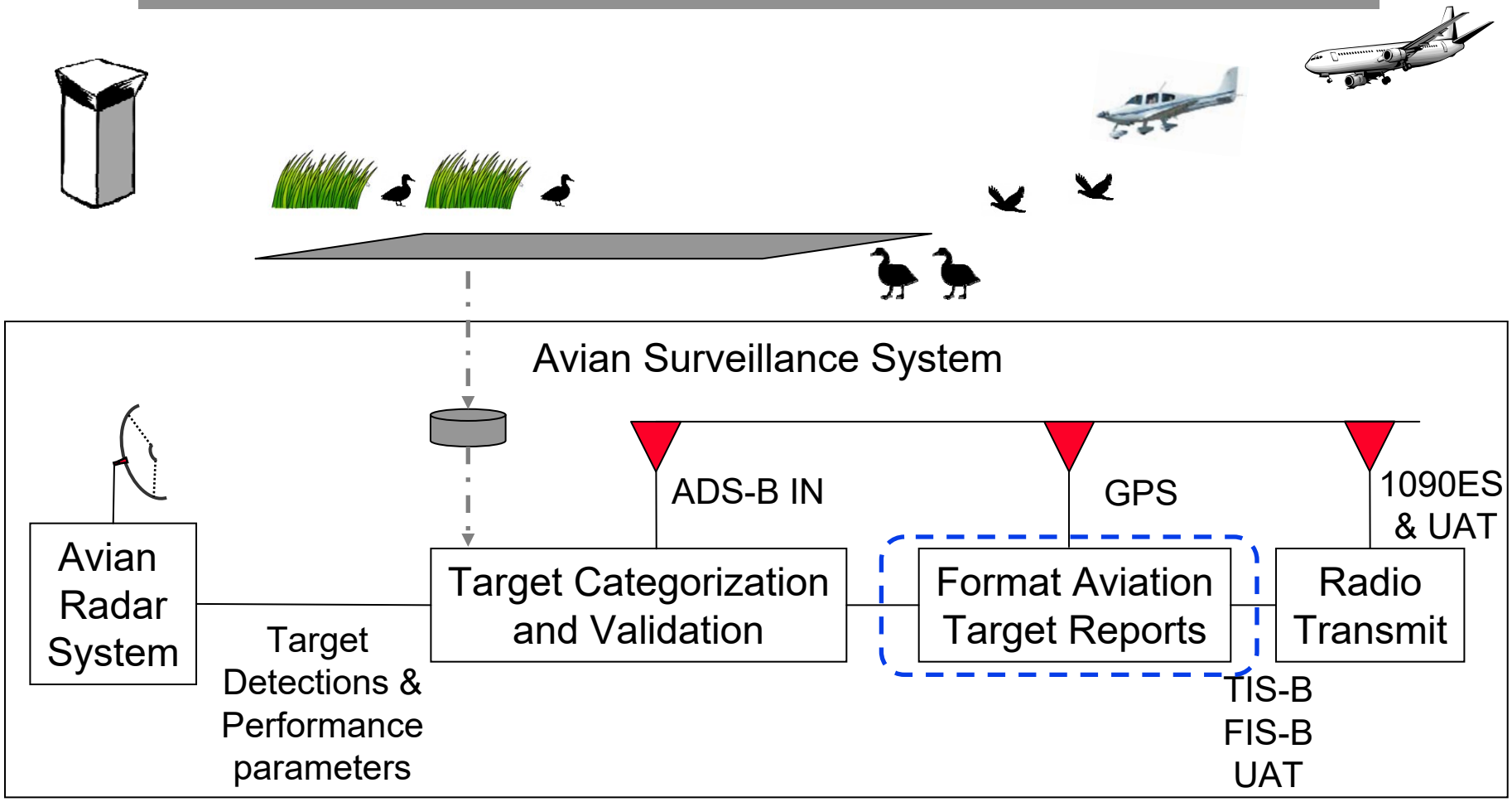
Ref: ASTERIX Overview http://www.eurocontrol.int/asterix

To TIS-B or FIS-B Avian Targets?

- **Typical TIS-B:**
  - » **Broadcast data collected from ground-based radar**
  - » **Broadcast to participating users for cockpit display of traffic information**
  - » **Messages can be sent via 1090ES or UAT**
- **Typical FIS-B:**
  - » **Broadcast data collected from external sensors**
  - » **Weather text, weather graphics,**
  - » **NOTAMS (notice to airmen)**
  - » **ATIS (Automatic Terminal Information Service)**
  - » **Periodic broadcast requirements**
  - » **Transmitted on UAT only**
- **Plan to explore both, but for now, we will focus on the TIS-B structure and will explore FIS-B over the next quarter**

Ref: DO-242A Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS-B), pg 124/475.

Ohio University Research Plans: Overview



UAT Avian Message Development

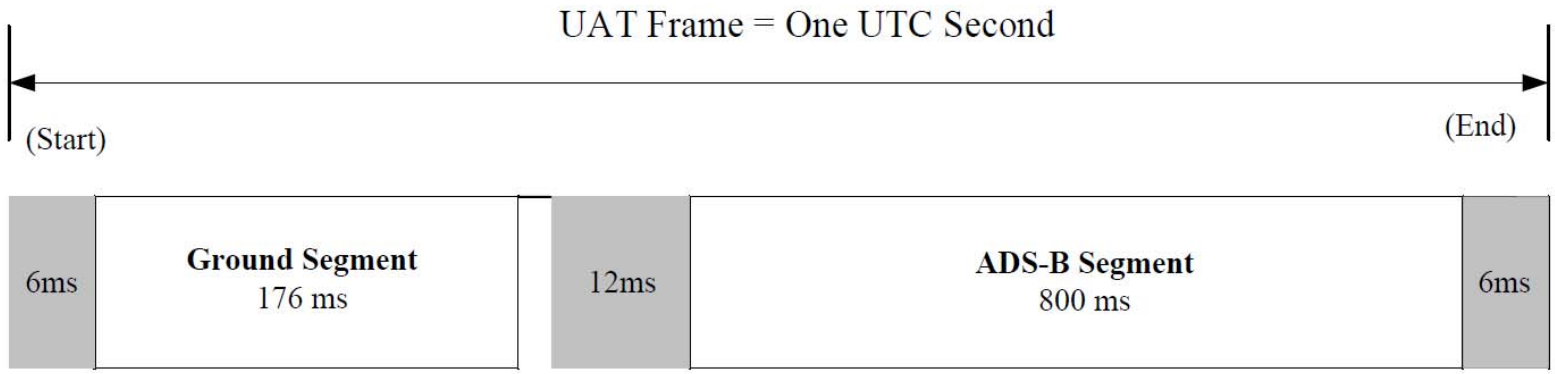
- Plan to give priority to UAT Avian message development (before 1090ES TIS-B)
- Allow for development of both FIS-B and TIS-B messages at the same time, supported by one data link
- Both of these TIS-B and FIS-B messages are planned to be transmitted by the stand-alone Avian Radar System (as a ground based surveillance subsystem)

Universal Access Transceiver (UAT)

- **Frequency: 978 MHz**
- **Vertical Polarization**
- **Designed to be a multi-purpose data link for surveillance related applications**
  - » **Nominal channeling signal rate: ~1Mbps**
- **Can support:**
  - » **Automatic Dependence Surveillance-Broadcast (ADS-B),**
  - » **Flight Information Service-Broadcast (FIS-B),**
  - » **Traffic Information Service-Broadcast (TIS-B),**
  - » **Potentially other applications**
- **"Uplink" from ground contains:**
  - » **176ms of 1000 ms UAT Frame=1 UTC second**
  - » **Weather, flight information , advisories, etc.**
- **"Downlink" from Aircraft:**
  - » **800ms of 1000 ms UAT Frame=1 UTC second**
  - » **ADS-B information**
  - » **"TIS-B information is preferably transmitted by the ground-based broadcast facility in the ADS-B Segment of the UAT frame"; Ref: RTCA MOPS, UAT DO-282B, pp. 38/704.**

Ref: RTCA, MOPS for UAT ADS-B, DO-282B, SC-186, Dec. 13, 2011

UAT Transmission Frame (per second)



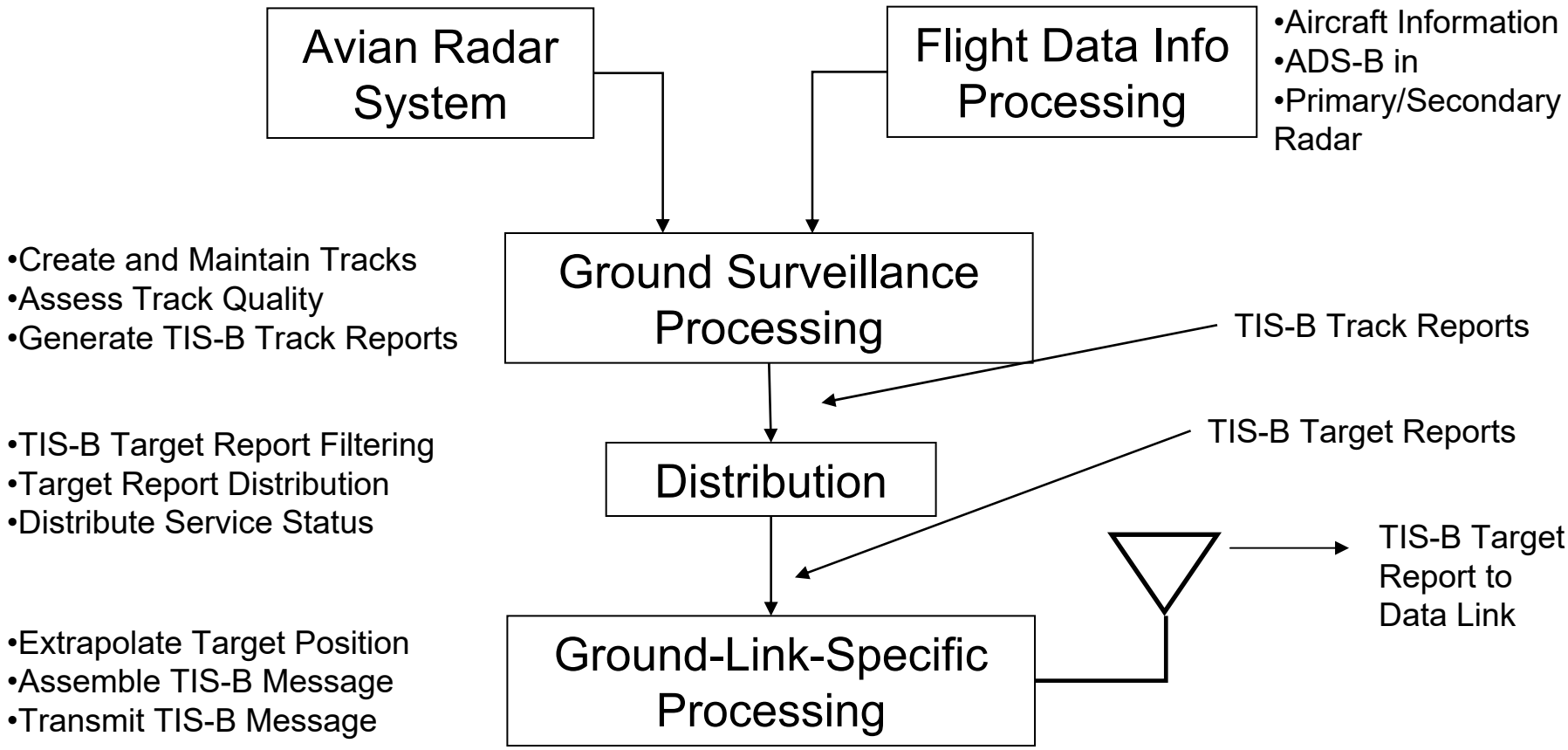
- Ground segment transmission consists of 32 ground broadcast slots @ 5.5 ms in length, each containing 432 bytes of data
  - Avian Radar message would occupy one of these broadcast slots each for TIS-B and FIS-B message support
  - FIS-B data transmitted in this Ground Segment (in dedicated time slot)
- ADS-B Segment 145 messages @ 5.5 ms in length (e.g., xtm by aircraft)
  - TIS-B data transmitted in this ADS-B Segment (Random Access)
- Avian radar systems must be able to track 1000 targets and update no less than every 5 seconds
  - Message capacity vs target reports rates under further assessment.

TIS-B Service

- **Provides ADS-B active users with:**
  - » **Low-latency stream of position reports of non-ADS-B users.**
- **Available to support Service Volumes:**
  - » **Non-ADS-B ground sensors**
  - » **FAA Surveillance and Broadcast Services (SBS) System Ground System radio stations**
- **TIS-B Client: receive avian report (i.e., aircraft or ATC tower)**
- **TIS-B Target: avian target**
- **TIS-B messages can contain higher-priority (i.e., time-sensitive/real-time, etc) traffic information (more so than FIS-B service)**

Ref: DO-338 Minimum Aviation System Performance Standards (MASPS) for ADS-B Traffic Surveillance Systems and Applications (ATSSA), pdf, pg 80/294.

TIS-B Avian Functional Block Diagram



Ref: RTCA, DO286B Minimum Aviation System Performance Standards (MASPS) for TIS-B, Table 3.3, pg. 5

ADS-B Message Reports

- Surveillance State Vector Report (SV)
- Mode Status Report (MS)
- On-Condition Reports
  - » Air-Referenced Velocity Report (ARV)
  - » Target State Report (TS)
  - » Trajectory Change Report (TC)
- Investigate Radar System + Processor as proxy for non-ADS-B-participatory birds via 1090ES or UAT
  - » Capable of transmitting minimum data for SV and MS (DO-242A Section 3.3.2 and Table 3-3a)
  - » Capable of receiving ADSB-IN when forming report

Ref: DO-242A Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS-B), pg 124/475.

Surveillance State Vector Definition

Table 3-6: State Vector Report Definition.

	SV Elem. #	Contents	Required from surface participants	Required from airborne participants	Reference Section	Notes
ID	1	Participant Address [24 bits]	•	•	2.1.2.2.2.1	
	2	Address Qualifier [1 bit]	•	•	2.1.2.2.2.2	1
TOA	3	Time Of Applicability [0.2 s]	•	•	3.4.3.3	
Geometric Position	4a	Latitude (WGS-84)	•	•	3.4.3.4	2, 3
	4b	Longitude (WGS-84)	•	•		
	4c	Horizontal Position Valid [1 bit]	•	•	3.4.3.5	
	5a	Geometric Altitude	•		3.4.3.6	3, 4
	5b	Geometric Altitude Valid [1 bit]	•		3.4.3.7	
Horizontal Velocity	6a	North Velocity while airborne	•		3.4.3.8	3
	6b	East Velocity while airborne	•			3
	6c	Airborne Horizontal Velocity Valid [1 bit]	•		3.4.3.9	
	7a	Ground Speed while on the surface [1 knot]		•	3.4.3.10	
	7b	Surface Ground Speed Valid [1 bit]		•	3.4.3.11	
Heading	8a	Heading while on the Surface [6° or better (6 bits)]		•	3.4.3.12	
	8b	Heading Valid [1 bit]		•	3.4.3.13	
Baro Altitude	9a	Pressure Altitude	•		3.4.3.14	3, 4
	9b	Pressure Altitude Valid [1 bit]	•		3.4.3.15	
Vertical Rate	10a	Vertical Rate (Baro/Geo)	•		3.4.3.16	3
	10b	Vertical Rate Valid [1 bit]	•		3.4.3.17	
NIC	11	Navigation Integrity Category [4 bits]	•	•	3.4.3.18	
Report Mode	12	SV Report Mode [2 bits]			3.4.3.19	

Participant Address and Address Qualifier

Table 2-12: "ADDRESS QUALIFIER" Encoding

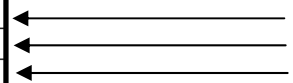
Address Qualifier (binary) Bit 6	Bit 7	Bit 8	Address Qualifier (decimal)	Address Type	Reference subparagraph
0	0	0	0	ADS-B target with ICAO 24-bit address	§2.2.4.5.1.3.1
0	0	1	1	ADS-B target with self-assigned temporary address	§2.2.4.5.1.3.2
0	1	0	2	TIS-B or ADS-R target with ICAO 24-bit address	§2.2.4.5.1.3.3
0	1	1	3	TIS-B target with track file identifier	§2.2.4.5.1.3.4
1	0	0	4	Surface Vehicle	§2.2.4.5.1.3.5
1	0	1	5	Fixed ADS-B Beacon	§2.2.4.5.1.3.6
1	1	0	6	ADS-R target with non-ICAO address	§2.2.4.5.1.3.7
1	1	1	7	(Reserved)	

- **The Participant Address (24 bits) is a unique identifier for all ADS-B participants.**
- **Address Qualifier "3" (encoding shown above) specifies that as the TIS-B data source, the stand-alone system is enabled to assign an address to any and all targets it detects. Ref: RTCA DO-282B § 2.2.4.5.1.3.4**
- **Thus, Avian radar can assign domain specific 24 bit address with appropriate Address Qualifier of "3".**

Ref: RTCA, DO282B Minimum Aviation System Performance Standards (MASPS) for TIS-B p. 64 Table 2-12

Mode Status (MS) Report Definition

	MS Elem. #	Contents [Resolution or # of bits]	Elements That Require Rapid Update	Reference Section	Notes
ID	1	Participant Address [24 bits]		2.1.2.2.2.1	
	2	Address Qualifier [1 bit]		2.1.2.2.2.2	1
TOA	3	Time of Applicability [1 s resolution]		3.4.4.2	
Version	4	ADS-B Version Number [3 bits]		3.4.4.3	
ID, Continued	5a	Call sign [up to 8 alpha-numeric characters]		3.4.4.4	
	5b	Emitter Category [5 bits]		3.4.4.5	
	5c	A/V Length and Width Codes [4 bits]		3.4.4.6	2
Status	6a	Mode-Status Data Available [1 bit]		3.4.4.7	
	6b	Emergency/Priority Status [3 bits]		3.4.4.8	3
CC, Capability Codes	7	Capability Class Codes [16 bits]		3.4.4.9	
		7a: TCAS/ACAS installed and operational [1 bit]	•	3.4.4.9.1	4
		7b: CDTI display capability [1 bit]		3.4.4.9.2	
		7c: (Reserved for Service Level) [4 bits]		3.4.4.9.3	
		7d: ARV report Capability Flag [1 bit]		3.4.4.9.4	
		7e: TS report Capability Flag [1 bit]		3.4.4.9.5	
		7f: TC report Capability Level [2 bits]		3.4.4.9.6	
		7g: Reporting ADS-B Reference Position [1 bit]		3.4.4.9.7	
		(CC Codes reserved for future growth) [6 bits]		3.4.4.9.8	
OM, Operational Mode	8	Operational Mode Parameters [16 bits]		3.4.4.10	
		8a: TCAS/ACAS resolution advisory active [1 bit]	•	3.4.4.10.1	4
		8b: IDENT Switch Active [1 bit]		3.4.4.10.2	3
		8c: Receiving ATC services [1 bit]		3.4.4.10.3	
		(Reserved for future growth) [13 bits]		3.4.4.10.4	
SV Quality	9a	Nav. Acc. Category for Position (NAC_P) [4 bits]	•	3.4.4.11	4
	9b	Nav Acc. Category for Velocity (NAC_V) [3 bits]	•	3.4.4.12	4
	9c	Surveillance Integrity Level (SIL) [2 bits]	•	3.4.4.13	4
	9d	(Res. For BAQ, Barometric Altitude Quality) [2 bits]		3.4.4.14	
	9e	NIC_{baro} - Altitude Cross Checking Flag [1 bit]		3.4.4.15	
Data Reference	10a	True/Magnetic Heading [1 bit]		3.4.4.16	
	10b	Vertical Rate Type (Baro./Geo.) [1 bit]		3.4.4.17	
Other	11	Reserved for Flight Mode Specific Data [3 bits]		3.4.4.18	



Ref: RTCA, DO-242A Minimum Aviation System Performance Standards (MASPS) for ADS-B, Table 3-8, pg. 119, 135/475, June 25, 2002.

MS Call Sign Field

- **ADS-B participants call sign:**
- **Up to 8 alphanumeric characters, capital letters A-Z and digits 0-9, and "-"**
- **Considerations for avian targets**
  - » **BIRD**
  - » **BIRD-SML, BIRD-MED, BIRD-BIG**
  - » **FLOCK**
  - » **DUCK**

Ref: RTCA, DO-242A Minimum Aviation System Performance Standards (MASPS) for ADS-B, Table 3-8, pg. 118, 136/475, June 25, 2002.

Emitter Category

Table 2-42: "EMITTER CATEGORY" Encoding

Base-40 Digit (decimal)	Meaning	Base-40 Digit (decimal)	Meaning
0	No aircraft type information	20	Cluster Obstacle
1	Light (ICAO) < 15500 lbs	21	Line Obstacle
2	Small - 15500 to 75000 lbs	22	(reserved)
3	Large - 75000 to 300000 lbs	23	(reserved)
4	High Vortex Large (e.g., aircraft such as B757)	24	(reserved)
5	Heavy (ICAO) - > 300000 lbs	25	(reserved)
6	Highly Maneuverable > 5G acceleration and high speed	26	(reserved)
7	Rotorcraft	27	(reserved)
8	(Unassigned)	28	(reserved)
9	Glider/sailplane	29	(reserved)
10	Lighter than air	30	(reserved)
11	Parachutist/sky diver	31	(reserved)
12	Ultra light/hang glider/paraglider	32	(reserved)
13	(Unassigned)	33	(reserved)
14	Unmanned aerial vehicle	34	(reserved)
15	Space/transatmospheric vehicle	35	(reserved)
16	(Unassigned)	36	(reserved)
17	Surface vehicle — emergency vehicle	37	(reserved)
18	Surface vehicle — service vehicle	38	(reserved)
19	Point Obstacle (includes tethered balloons)	39	(reserved)

- **The MS Emitter Category (Section 3.4.4.5 referenced to Section 2.1.2.2.3) determines the type of target being reported.**
- **Use cluster/point targets depending on what is detected**
- **Also possibility that one of the unassigned values can be assigned as a bird category**

Ref: RTCA, DO286B Minimum Operational Performance Standards (MOPS) for ADS-B, Page 90 Table 2-42.

MS A/V Length and Width Codes

Table 3-10: Aircraft Size (Length and Width) Codes

A/V - L/W Code (decimal)	Length Code			Width Code	Length Category (meters)	Width Category (meters)
	Bit 2	Bit 3	Bit 4	Bit 5		
0	0	0	0	0	0 < L < 15	0 < W < 11.5
1				1		11.5 ≤ W < 23
2	0	0	1	0	15 ≤ L < 25	23 ≤ W < 28.5
3				1		28.5 ≤ W < 34
4	0	1	0	0	25 ≤ L < 35	28 ≤ W < 33
5				1		33 ≤ W < 38
6	0	1	1	0	35 ≤ L < 45	34 ≤ W < 39.5
7				1		39.5 ≤ W < 45
8	1	0	0	0	45 ≤ L < 55	38 ≤ W < 45
9				1		45 ≤ W < 52
10	1	0	1	0	55 ≤ L < 65	52 ≤ W < 59.5
11				1		59.5 ≤ W < 67
12	1	1	0	0	65 ≤ L < 75	65 ≤ W < 72.5
13				1		72.5 ≤ W < 80
14	1	1	1	0	L ≥ 75	W < 80
15				1		W ≥ 80

The width and length of aircraft are encoded by these four bits. The appropriate bit sequence for a cluster target (ie flock of birds) will be assigned by this (Section 3.4.4.6 table 3-10)

Ref: RTCA, DO242A Minimum Aviation System Performance Standards (MASPS) for ADS-B, p. 138

Air-Referenced Velocity Definition

Table 3-15: Air Referenced Velocity (ARV) Report Definition.

	ARV Elem. #	Contents [Resolution or # of bits]	Reference Section	Notes
ID	1	Participant Address [24 bits]	2.1.2.2.2.1	
	2	Address Qualifier [1 bit]	2.1.2.2.2.2	1
TOA	3	Time of Applicability [1 s resolution]	3.4.6.3	
Airspeed	4a	Airspeed [1 knot or 4 knots]	3.4.6.4	
	4b	Airspeed Type and Validity [2 bits]	3.4.6.5	
Heading	5a	Heading while airborne [1 degree]	3.4.6.6	2
	5b	Heading Valid [1 bit]	3.4.6.7	

Optional message transmission, not required at all times. Can be useful to ATC and pilots regarding moving targets when this information is known and able to be transmitted.

Ref: RTCA, DO242A Minimum Aviation System Performance Standards (MASPS) for ADS-B, p. 144

Target State Definition

Table 3-17: Target State (TS) Report Definition.

	TS Report Elem. #	Contents	[Resolution or # of bits]	Reference Section
ID	1	Participant Address	[24 bits]	2.1.2.2.2.1
	2	Address Qualifier	[1 bit]	2.1.2.2.2.2
TOA	3	Time of Applicability	[1 s resolution]	3.4.7.3
Horizontal Short Term Intent	4a	Horizontal Data Available and Horizontal Target Source Indicator	[2 bits]	3.4.7.4
	4b	Target Heading or Track Angle	[1 degree]	3.4.7.5
	4c	Target Heading/Track Indicator	[1 bit]	3.4.7.6
	4d	(Reserved for Heading/Track Capability)	[1 bit]	3.4.7.7
	4e	Horizontal Mode Indicator	[2 bits]	3.4.7.8
	4f	(Reserved for Horizontal Conformance)	[1 bit]	3.4.7.9
Vertical Short Term Intent	5a	Vertical Data Available and Vertical Target Source Indicator	[2 bits]	3.4.7.10
	5b	Target Altitude	[100 ft]	3.4.7.11
	5c	Target Altitude Type	[1 bit]	3.4.7.12
	5d	Target Altitude Capability	[2 bits]	3.4.7.13
	5e	Vertical Mode Indicator	[2 bits]	3.4.7.14
	5f	(Reserved for Vertical Conformance)	[1 bit]	3.4.7.15
Reserved		(Reserved for future growth)	[4 bits]	

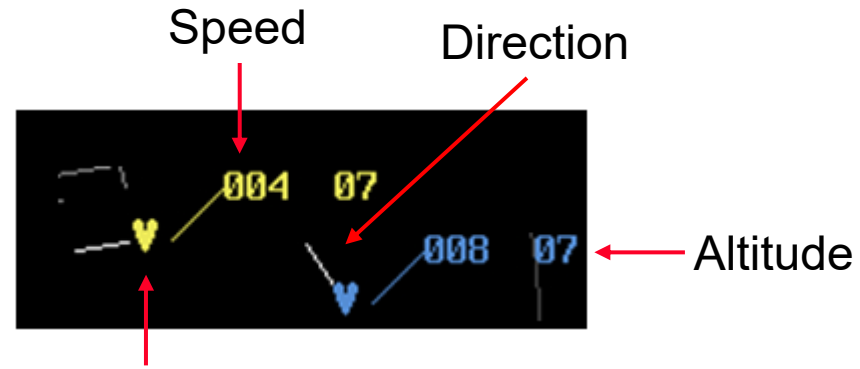
Ref: RTCA, DO242A Minimum Aviation System Performance Standards (MASPS) for ADS-B, p. 146

FIS-B Avian Information

- **Avian activities could be collected and formatted on a FIS-B for advisory purposes:**
  - » **More specific/detailed avian advisory than is currently broadcast on ADAS (Automated Weather Observing System (AWOS) Data Acquisition System (ADAS)).**
  - » **Could be used to collect historical data on avian activity at a particular airport (some of which is done manually today).**
  - » **FIS-B data could be used to illustrate avian regions of activity (i.e., similar to broadcast weather text and graphics information).**

Possible Avian Display Symbology

- **FAA investigated three different potential display formats for avian reports:**
  1. **Text**
  2. **Target, for display on the Standard Terminal Automation Replacement System (STARS)**
  3. **Supervisor.**



- Yellow: Medium priority (i.e., advisory)
- Blue: Low priority

Ref: Anton Koros, ANG-C43, Wildlife Surveillance Concept (WiSC), Socialization Briefing,ANG-C5 Brief, June 25, 2015

Ohio University Research Plans: Conclusion/Report to FAA

- **Plan to provide Quarterly Updates to the FAA via the JUP, over the next quarter, with plans to concentrate on:**
  - » **Continuing to evaluate overall approach**
  - » **Avian Radar output requirements and capabilities**
  - » **TIS-B data link formats**
  - » **FIS-B data link formats**

Bird Strike Mitigation for Aviation

Comments/Questions/Suggestions???

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