REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
05/19/2020	Conference Briefing	

4. TITLE AND SUBTITLE
Department of Defense Mode S Interrogators

5a. CONTRACT NUMBER
W56KGU-18-D-0004

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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5d. PROJECT NUMBER
0720C60DIF

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
The MITRE Corporation
202 Burlington Road
Bedford, MA 01730

8. PERFORMING ORGANIZATION REPORT NUMBER
PRS-20-1279

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
United States Army (ACC-APG)

10. SPONSOR/MONITOR'S ACRONYM(S)
ACC-APG

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
DISTRIBUTION STATEMENT A. Approved for public release: distribution unlimited.

13. SUPPLEMENTARY NOTES
Preprint submission to DoD AIMS User Working Group

14. ABSTRACT
DoD needs to equip with Mode S interrogators in order to establish a complete air picture. Mode S is different from other civil and military interrogation modes. There are many ongoing efforts working to create a self-sustaining process for DoD Mode S Interrogators to receive spectrum supportability in the US National Airspace System.

15. SUBJECT TERMS
Air Traffic Management; Military Operations (General); Mode S Interrogators; aircraft identification

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE		15	Susan Carpenito
					19b. TELEPHONE NUMBER *(Include area code)* 781-271-7646

Department of Defense Mode S Interrogators

2020 (Virtual) DoD AIMS User Working Group

Amy Baker

May 2020

MITRE | SOLVING PROBLEMS FOR A SAFER WORLD

Outline

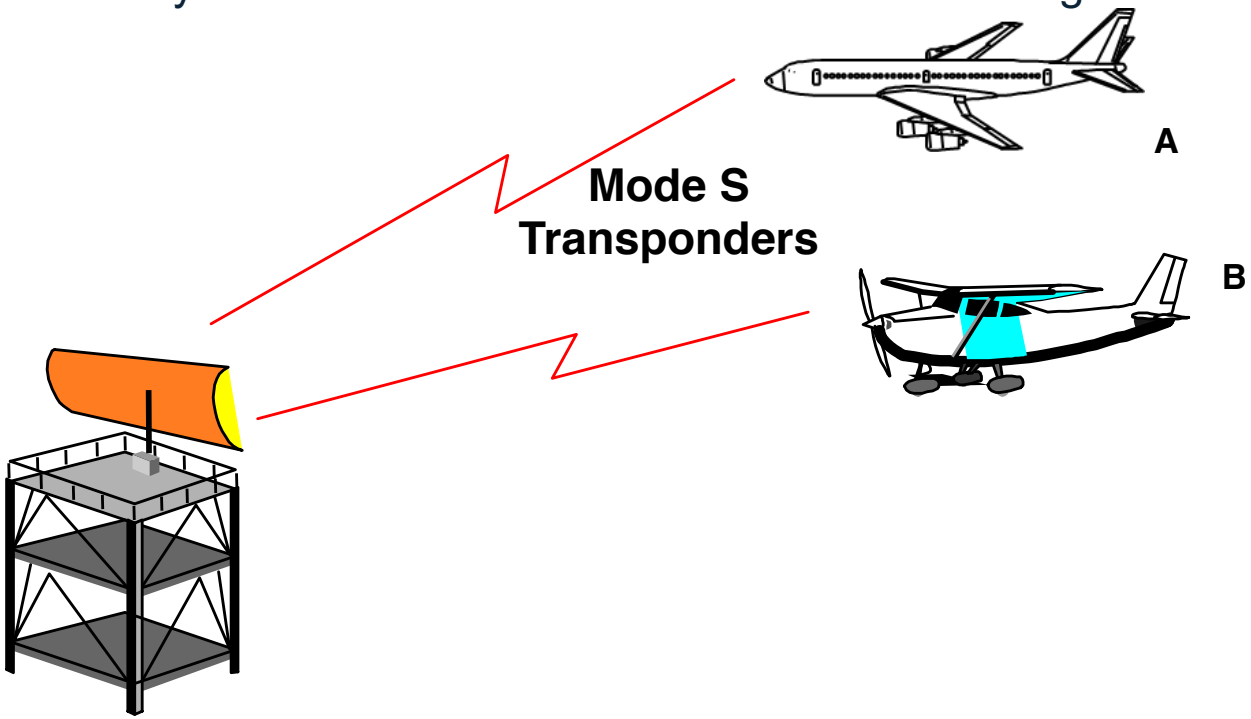
- What is Mode S?
- Why is Mode S needed?
- Why is Mode S different?
- Ongoing Efforts
  - DoD/FAA Mode S Consolidated Working Group (CWG)
  - DoD AIMS Mode S Tiger Team
  - DoD Mode 5/S JCONOPS Development
- Summary

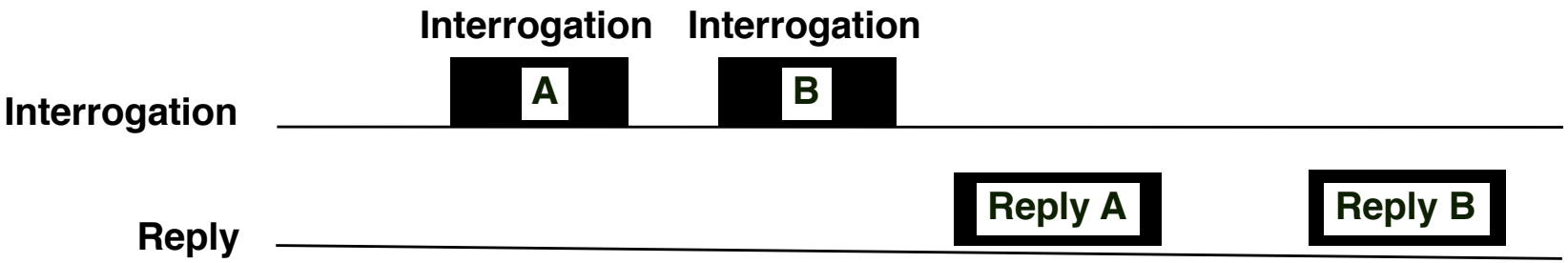
What is Mode S?

- Secondary Surveillance Radar (SSR) technology
  - Improved version of Air Traffic Control Radar Beacon System (ATCRBS) Mode 3/A and Mode C
- Developed in the 1970's but brought to the forefront in the 1990's with the "Airport and Airway Safety and Capacity Expansion Act" requiring aircraft to have Traffic Collison Avoidance System (TCAS)
  - TCAS uses Mode S technology
  - Allows pilot to see relative position and velocity of surrounding air traffic
  - TCAS II issues evasive maneuvers

Why is Mode S Needed?

Elimination of Synchronous Garble with Selective Addressing





Improvement over ATCRBS - Mode S Interrogations A & B are scheduled such that Replies A & B do not garble

Content derived from: MIT Lincoln Laboratory 'The Story of Mode S.pptx' Fall 2000

Why is Mode S Needed?

Necessary To Ensure Identification of Civil Aircraft

- **Mode S required on aircraft transponders in European airspace since 2009**
  - Mode A is limited to 4096 unique identifiers
- **European Air Navigation Service Providers are assigning the same Mode A Code (1000) to all aircraft on certain air traffic routes**
  - Unable to differentiate aircraft by Mode A code, must use Mode S Flight ID
- **Continued increase in prevalence of Mode A Code 1000 throughout Europe**
  - Example: United Kingdom “no longer issue[s] approvals for ground based (including maritime) or airborne IFF/SSR Mode A/C interrogators.[1]”
- **DoD reported instances of multiple civil aircraft simultaneous over Mediterranean Sea with Mode A = 1000**

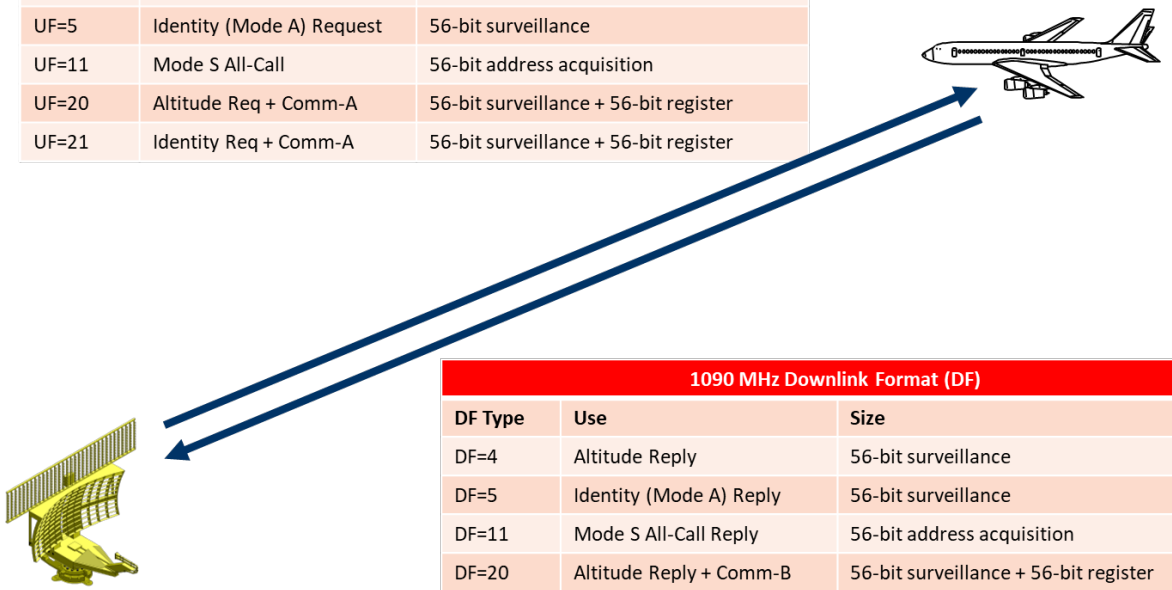
[1] Operation of IFF/SSR interrogators in the UK: Planning principles and procedures, January 2019

Why is Mode S Needed?

Additional Aircraft Data

- **In addition to aircraft identification information, Mode S equipped aircraft can provide (list not all encompassing):**
  - Aircraft selected altitude
  - Aircraft barometric pressure setting
  - Roll angle
  - True track angle
  - Speed/Velocity
  - Inertial vertical velocity

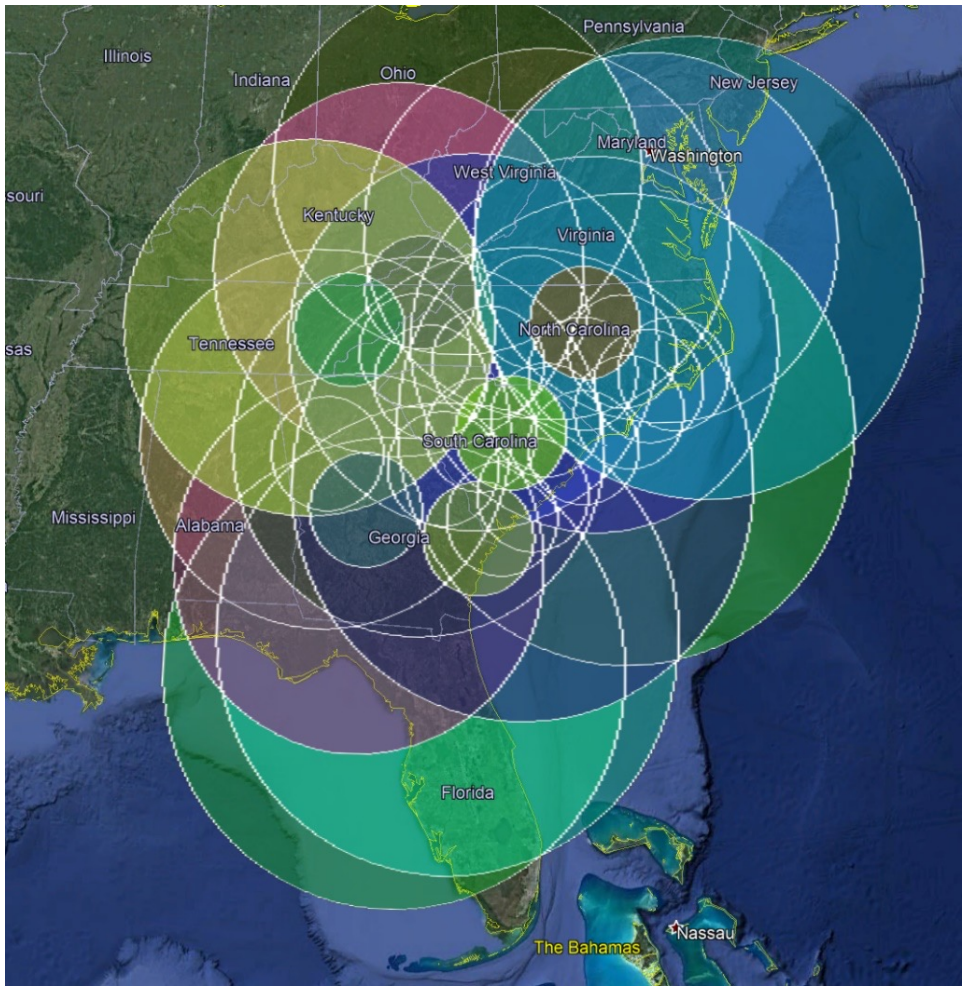
1030 MHz Uplink Format (UF)		
UF Type	**Use**	**Contents**
UF=4	Altitude Request	56-bit surveillance
UF=5	Identity (Mode A) Request	56-bit surveillance
UF=11	Mode S All-Call	56-bit address acquisition
UF=20	Altitude Req + Comm-A	56-bit surveillance + 56-bit register
UF=21	Identity Req + Comm-A	56-bit surveillance + 56-bit register



1090 MHz Downlink Format (DF)		
DF Type	**Use**	**Size**
DF=4	Altitude Reply	56-bit surveillance
DF=5	Identity (Mode A) Reply	56-bit surveillance
DF=11	Mode S All-Call Reply	56-bit address acquisition
DF=20	Altitude Reply + Comm-B	56-bit surveillance + 56-bit register
DF=21	Identity Reply + Comm-B	56-bit surveillance + 56-bit register

Why is Mode S Different?

Because its behavior is dependent on the surrounding environment



- **Individual Interrogator**
  - No interference from other interrogators
  - Should not ‘overload’ the transponder
- **Overlapped Interrogators**
  - Interference to each other which can cause an increase in additional interrogations, which can cause more interference (spiral)
  - Can ‘lock out’ transponders to other interrogators

Why is Mode S Different?

Lock Out vs Non Lock Out

- Two different types of Mode S interrogations
  - All Call – to all aircraft within interrogator range
  - Roll Call – to specific aircraft already acquired by interrogator

- All Calls and Roll Calls include the interrogator's Interrogator Code (IC)

With Lock Out	Non Lock Out
• Once acquired, aircraft is 'locked out' to All Call interrogations from that IC for 18 seconds, on every consecutive addressed interrogation • Aircraft will remain 'locked out' as the aircraft travels through the coverage area of the interrogator • Can only be used when each interrogator in a geographical area is assigned its own IC • Allows for quicker identification of aircraft and better RF spectrum utilization	• Does not 'lock out' aircraft to All Call interrogations • Since all acquired aircraft will continue to reply to All Call interrogations, strict limits on the number of interrogations allowed. Potential for longer time to identify aircraft • Used when interrogators in a geographical area cannot be assigned their own IC • Requires use of lockout override, which will override an aircraft's lock out status if it is 'locked out' to the IC by another interrogator

Ongoing Efforts

Goal: Creation of a *self-sustaining* process for DoD Mode S Interrogators to receive spectrum supportability in the US National Airspace System

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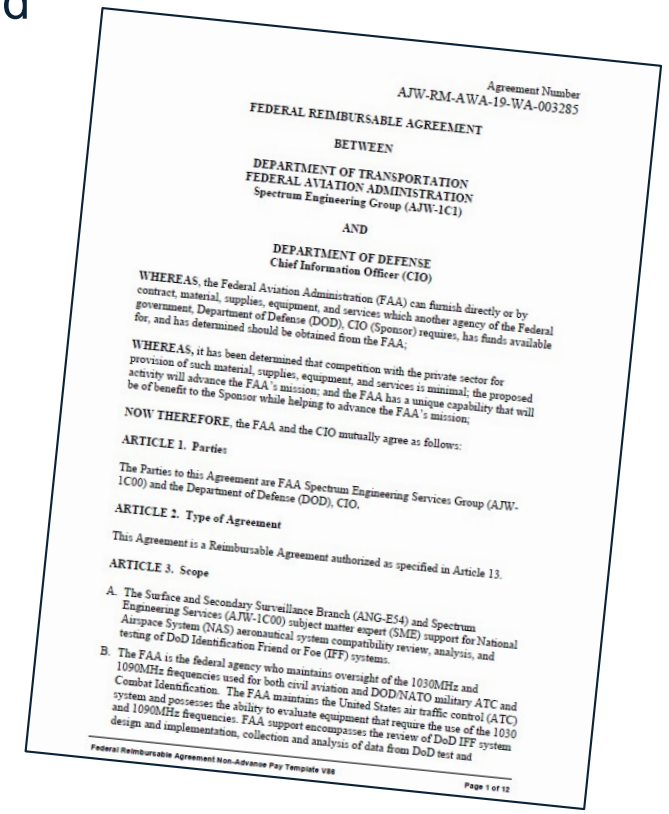
Ongoing Efforts

DoD/FAA Mode S Consolidated Working Group (CWG)

- In 2019, DoD CIO, on behalf of the Services, entered into a 5-year Reimbursable Agreement with the FAA to complete a comprehensive effort to resolve long standing DoD Mode S interrogator operational constraints
  - Service specific Reimbursable Agreements ended in support of DoD centrally executing funding on their behalf
- Work Effort 1: Mode S
  - Individual Mode S IFF System Analysis
  - Multiple System Analysis
  - System and Modeling
  - Revisions to US and International Standards
  - Ongoing Analyses of Mode S IFF Systems
- Work Effort 2: Reverse Mode 5 Analysis and Implementation
- Work Effort 3: IFF Technical Working Group (TWG) Modeling



Agreement Number
AJW-RM-AWA-19-WA-003285

FEDERAL REIMBURSABLE AGREEMENT

BETWEEN

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Spectrum Engineering Group (AJW-1C1)

AND

DEPARTMENT OF DEFENSE
Chief Information Officer (CIO)

WHEREAS, the Federal Aviation Administration (FAA) can furnish directly or by contract, material, supplies, equipment, and services which another agency of the Federal government, Department of Defense (DOD), CIO (Sponsor) requires, has funds available for, and has determined should be obtained from the FAA;

WHEREAS, it has been determined that competition with the private sector for provision of such material, supplies, equipment, and services is minimal; the proposed activity will advance the FAA's mission; and the FAA has a unique capability that will be of benefit to the Sponsor while helping to advance the FAA's mission;

NOW THEREFORE, the FAA and the CIO mutually agree as follows:

ARTICLE 1. Parties

The Parties to this Agreement are FAA Spectrum Engineering Services Group (AJW-1C00) and the Department of Defense (DOD), CIO.

ARTICLE 2. Type of Agreement

This Agreement is a Reimbursable Agreement authorized as specified in Article 13.

ARTICLE 3. Scope

A. The Surface and Secondary Surveillance Branch (ANG-E54) and Spectrum Engineering Services (AJW-1C00) subject matter expert (SME) support for National Airspace System (NAS) aeronautical system compatibility review, analysis, and testing of DoD Identification Friend or Foe (IFF) systems.

B. The FAA is the federal agency who maintains oversight of the 1030MHz and 1090MHz frequencies used for both civil aviation and DOD/NATO military ATC and Combat Identification. The FAA maintains the United States air traffic control (ATC) system and possesses the ability to evaluate equipment that require the use of the 1030 and 1090MHz frequencies. FAA support encompasses the review of DoD IFF system design and implementation, collection and analysis of data from DoD test and

Federal Reimbursable Agreement Non-Advance Pay Template V88 Page 1 of 12

Ongoing Efforts

DoD/FAA Mode S Consolidated Working Group (CWG)

- Mode S Interrogator Platform Status
  - Army ATNAVICS AN/TPX-59 - Stage 3 Certification and Frequency Assignment; completed
  - Air Force D-RAPCON AN/UPX-44A - Stage 3 Certification and Frequency Assignment; completed
  - Navy E-2D AN/APX-122A - Stage 3 Certification awaiting signature; expected to be completed under current funding
  - Air Force E-3 AWACS Block 40/45 - Stage 3 Certification and Frequency Assignment being drafted/coordinated; expected to be completed under current funding
  - Navy Shipboard AN/UPX-45(C) - Stage 3 Certification being drafted/coordinated; expected to be completed under current funding
  - Army Sentinel AN/TPX-61 – CWG aware of platform but no active CWG efforts

If you know of a DoD Mode S interrogator platform in development, or thinking about development, please let us know so we can account for it in future workplans

Ongoing Efforts

DoD Mode 5/S Joint CONOPS Development

- JS/J6 and DoD CIO updating “Mark XIIA/B Mode 5 and Mode Select (Mode S) Joint Concept of Operations”
- Addresses DoD unique aspects of Mode S
  - Why Military Command and Control Platforms Need Mode S
  - Cooperative Target Identification Shortcomings
  - Coordination of Interrogator Codes
  - Use of Interrogator Identifier (II) = 0 and II = 15
  - Non – Lockout Interrogation Techniques
  - Tactical Data Link Sharing of Mode S Information
  - Limited Reception of Squitters with Rotating IFF antennas
  - Mode S Interrogator Platforms Use of ADS-B Data
- Available for review/comment upon request
- Expected publication FY20

Ongoing Efforts

DoD AIMS Mode S Interrogator Tiger Team

- DoD AIMS chairs Mode S Interrogator Tiger Team which is creating additional Mode S interrogator requirements and associated testing procedures
  - Members from across the Services, FAA, industry
  - Tiger Team proposals must be accepted by AIMS Configuration Control Board (CCB) before inclusion into any future standard (i.e. follows established process)
- Focus on unique aspects of DoD Mode S interrogations not covered under civilian Mode S interrogator requirements (i.e. ICAO SARPS)
  - Performance Tests
    - Target loading, directed all call performance, maximum range, handling of duplicate Mode S addresses, etc.
  - Spectrum Compatibility Tests
    - Various testing scenarios (parallel flights, multiple interesting paths, zenith cone, etc.) to stress surveillance tracker
    - Goal: Eliminate need for additional testing for spectrum supportability in the US National Airspace System

Summary

- DoD needs to equip with Mode S interrogators in order to establish a complete air picture
- Mode S is different from other civil and military interrogation modes
- There are many ongoing efforts working to create a self-sustaining process for DoD Mode S Interrogators to receive spectrum supportability in the US National Airspace System

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