Technology Maturation for the Automated Aerial Refueling (AAR) Project

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Outline

- Early Systems Engineering (SE) in Acquisition
- Technology Maturation (Tech Mat) in Early SE
- AAR Program Background
- Tech Mat Planning for AAR

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How Do AF and DoD Define Systems Engineering?

"Air Force SE involves comprehensive planning, management, and execution of rigorous technical efforts to develop, field, & sustain robust products and systems…

- *SE collects, coordinates, & ensures traceability of all stakeholder needs into a set of system requirements through a balanced process that takes into account effectiveness, performance, cost, schedule, and risk."*

AFI 63-1201, *Life Cycle Systems Engineering*

- Technical Planning
- Requirements Mgt
- Interface Mgt
- Risk Mgt
- Configuration Mgt
- Technical Data Mgt
- Technical Assessment
- Decision Analysis

Integrated AT&L Life Cycle Mgt System, V.5.3.4, 15 Jun 09

When Does AF Say SE Should First Be Applied?

"Application of SE fundamentals must begin with concept inception, and must cover all efforts across all life cycle phases, to include sustainment & disposal, for all Air Force products & systems.

Early SE provides an audit trail from the users' capability gaps & needs, through concept selection, high-level system requirements refinement, & documentation of development plans."

AFI 63-1201, *Life Cycle Systems Engineering*

AFRL/CC will ensure incorporation of SE methodologies tailored for AFRL technology development done in support of evolutionary acquisition programs.

AFI 63-101: Acquisition & Sustainment Life Cycle Management

Science & Technology (S&T) Role in Early SE

AF Early Systems Engineering Guidebook (v1, Mar 09) states the following:

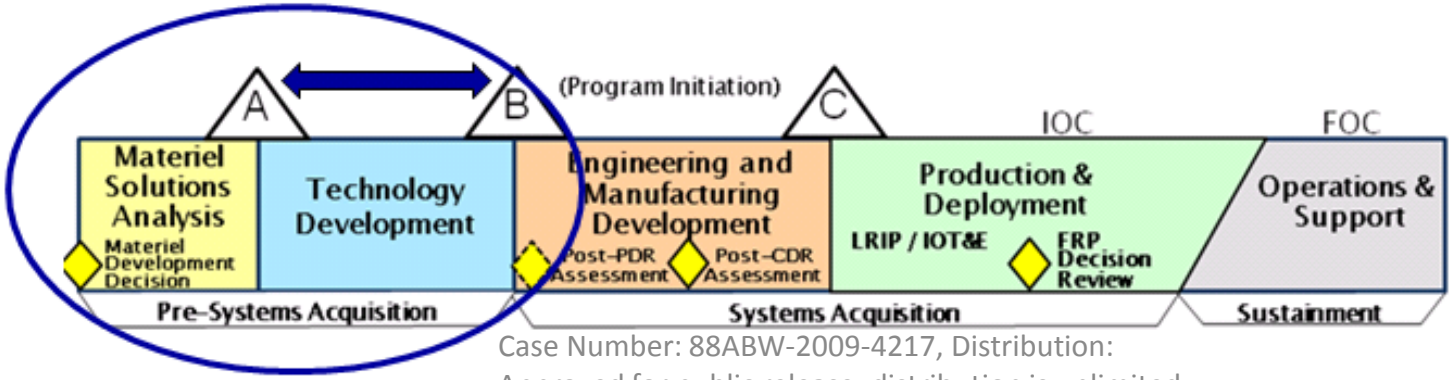
A technology organization, typically AFRL, works with acquisition organizations to ensure:

- Relevant technologies are considered, and that they are compatible with the desired time frame and expressed acceptable risk levels
- New approaches made possible by emerging technologies, as well as technologies that will improve a system's effectiveness and/or reduce its cost, are suggested
- Risks and uncertainties associated with new technologies are estimated, and impacts are assessed
- Insight as to user/operator needs is gained, allowing technologists to better focus their technology roadmaps

Does Early SE Pay Off?

2006 Defense Acquisition Performance Assessment (DAPA) Project Report Survey states:

- 96% of respondents cited at least one of the following three areas as critical to maintaining program cost, schedule, and performance (shown in ranked order):
  - **Requirements instability**
  - **Funding instability**
  - **Tech maturity**
- The greatest trade space, and thus the largest risk reduction opportunity, exists between Milestones (MS) A and B



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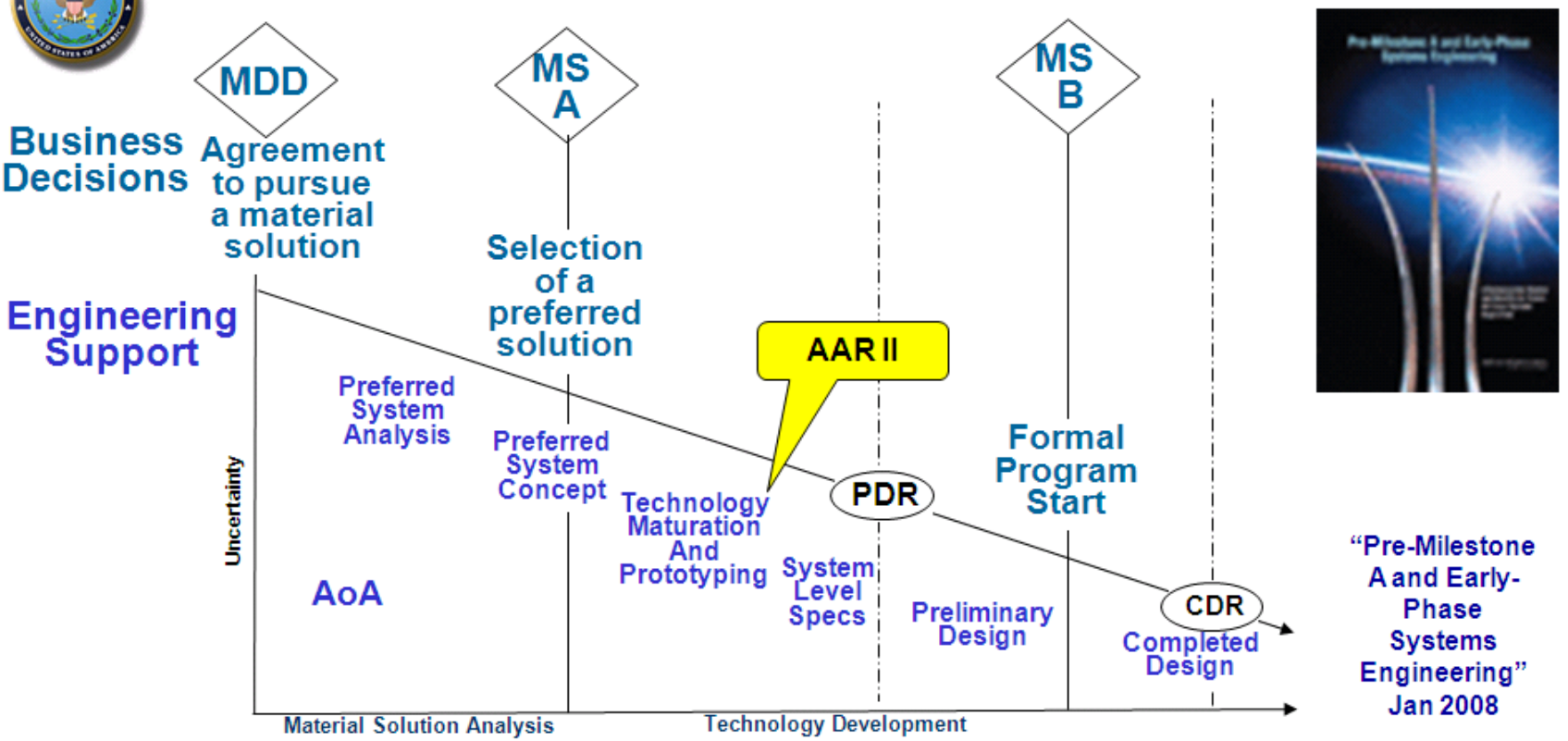
SE Provides a Technical Foundation for Acquisition



"Pre-Milestone A and Early-Phase Systems Engineering" Jan 2008

Systems Engineering is effective when it informs, and is informed by, other Acquisition process owners

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AAR Phase II
National AAR Team

Air Vehicles
Human Effectiveness
Sensors
Information

BOEING

LOCKHEED MARTIN

NORTHROP GRUMMAN

Calspan

Rockwell Collins

CTSi

Aurora FLIGHT SCIENCES

GENERAL DYNAMICS
Advanced Information Systems

Booz | Allen | Hamilton

SIERRA NEVADA CORPORATION
ELECTRONIC SYSTEMS AND INTEGRATION
INNOVATIVE & AGILE TECHNOLOGY SOLUTIONS

AARII Team Combines War fighters with Nationally Recognized Technologists

Significance to Air Force

- **Unmanned Aerial Vehicles**
  - **Extends Range**
  - **Shortens Response for Time-Critical Targets**
  - **Maintains In-Theater Presence Using Fewer Assets**
  - **Allows Deployment with Manned Fighters and Attack Without the Need of Forward Staging Areas**

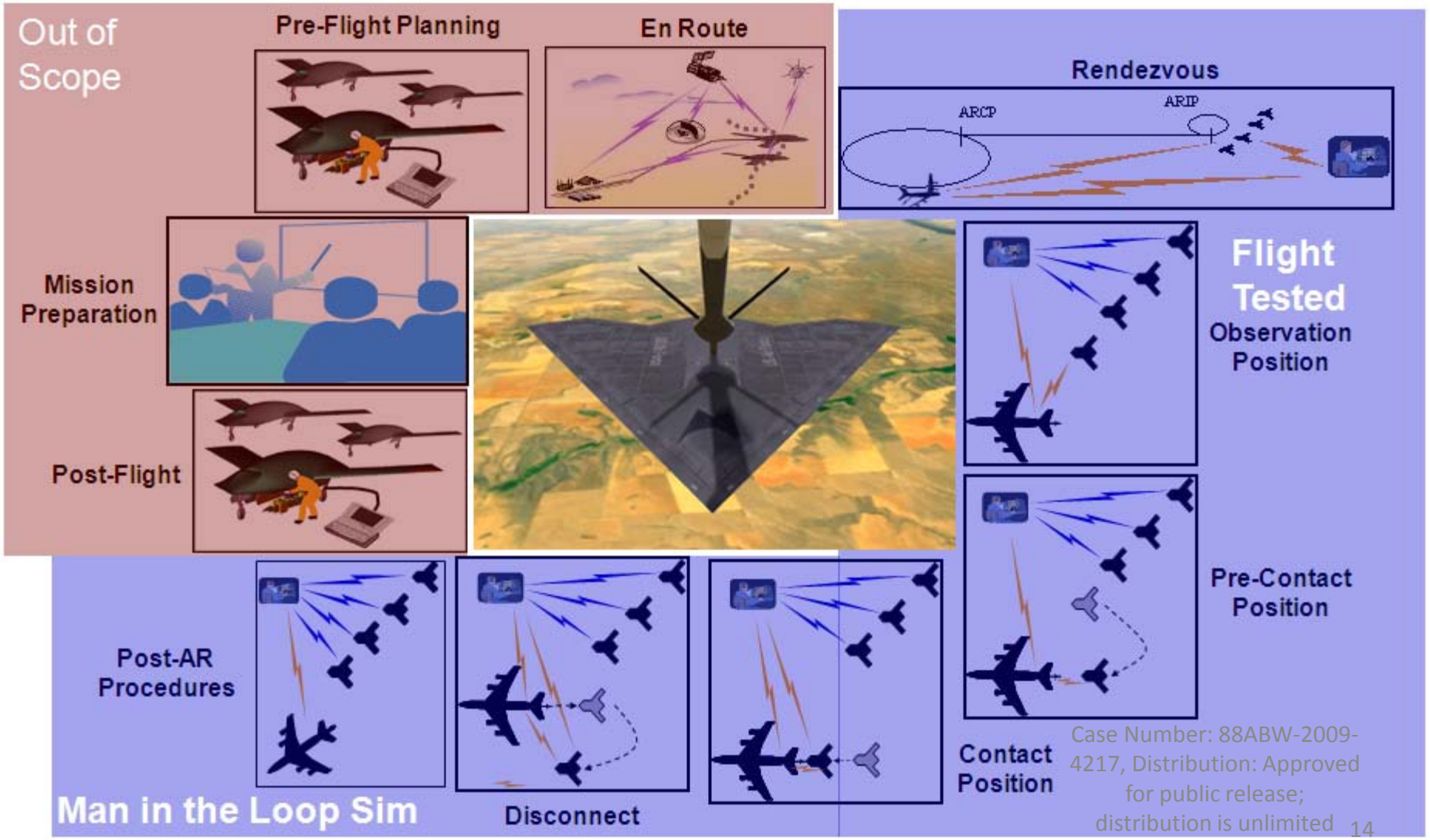
- **Manned Aircraft**
  - **Provides Adverse Weather Operations**
  - **Improves Fueling Efficiency**
  - **Improves Pilot Workload**

"How does it (J-UCAS) air refuel? … which is persistence and endurance, things men can't do in airplanes"

-Gen. John Jumper, USAF, February 2005

AAR Assists UCAVs in Reaching Its Full Potential, and Greatly Enhances Manned Refueling

UCAS Mission/AR Overview

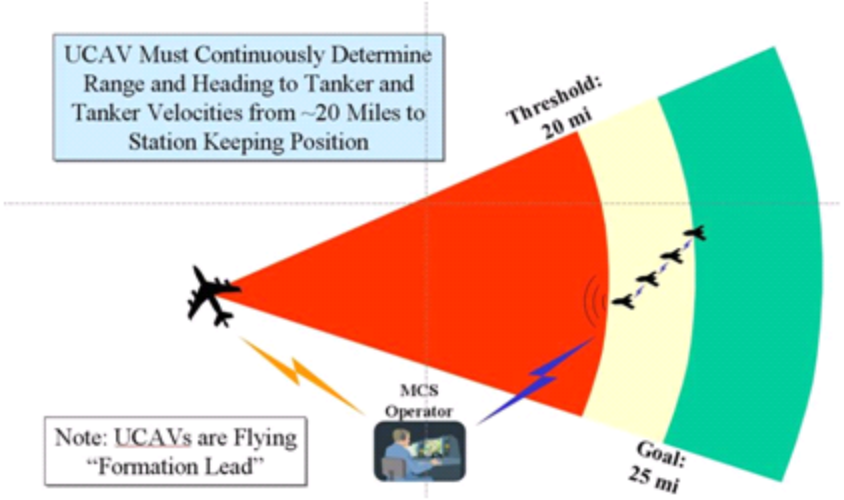


Key Technology Challenges

See Near
- Determine Relative Position with Tankers
  - Using Position/Velocities to Close Control Loop
  - High Confidence in Position Accuracy
  - Avoid Aircraft in AAR Area

Collision Avoidance
- AAR Brings Many Aircraft into Same Airspace

Command and Control
- Assure UCAS Accurately Responds Boomer Break-Away Commands



Aircraft Integration
- Minimize impacts to tanker fleet
- Fit within constrained volume of UCAS
- Precision control of UCAS
- Flight critical integration

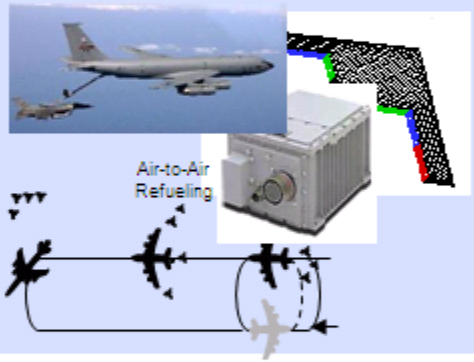
Real World Considerations
- Encryption, latency, drop-outs

AAR Spiral Approach to Technology Development

Spiral 0 – FY08

TRL 5

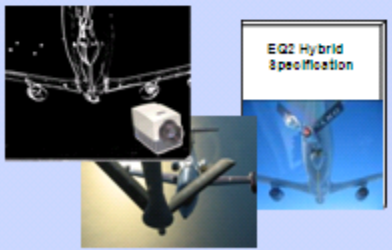
- **Technology Base Development**
  - Initial Specifications
  - ICDs and Architecture
  - Research PGPS Prototype
  - Fighter CONOPs
  - Sensor Augmented System Design/Requirements



Spiral 1 – FY10

PGPS TRL 7

- **PGPS Adv Prototype Development**
  - PGPS Specifications
  - PGPS Prototype System
  - Bomber CONOPs



Spiral 2 – FY12

Hybrid TRL 5

- **Sensor Augmented System Tech Maturation**
  - AAR System Requirement
  - AAR Research Prototype
  - AAR Architecture/ICDs

Precision GPS Closed-Loop Station Keeping Flt Test Aug 06

- **Objectives:**
  - Evaluate updated Precision GPS (PGPS) performance
  - Test automated formation flight in contact position
  - Evaluate EO/IR camera as AAR sensor

- **Accomplishments:**
  - Simplex PGPS relnav and automated flight controls held Learjet in contact position for 23 continuous minutes
  - Over 4 hrs of "hands-off" formation flight
  - Over 85 minutes of "hands-off" contact position flight
  - Found sensor suitable for AAR

"The System Held Contact Position Better than I Could", Calspan Test Pilot

AAR UAS Surrogate

- VISTA Manned Surrogate
  - Autonomous Capability with Safety Pilot Override
  - Variable Stability Flight Controls

- Learjet Manned Surrogate
  - Autonomous Capability with Safety Pilot Override
  - Variable Stability Flight Controls

AAR Station-Keeping Flight Test
Example Contact Position Performance

Phase II AAR Test Plan

- **FY10 Precision RELNAV Open-loop Flight Test (PROFT) (Learjet)**
  - Simultaneously collect GPS data from multiple LN-251s for maturing GPS
  - Demonstrate the TTNT Redundancy Features on tanker
- **FY10 RELNAV Open-Loop Flight Test (Learjet)**
  - Verify fixes from PROFT
  - Evaluate EO/IR camera as AAR sensor
- **VISTA Inner-Loop Flight Test**
  - Characterize RELNAV Redundancy Architecture
  - Validate A/C model in VISTA
- **VISTA Station Keeping Flight Test (SKFT)**
  - Evaluate Precision GPS (PGPS) performance
  - Evaluate formation flight control System
  - Evaluate EO/IR camera as AAR sensor
- **VISTA Positions and Pathways Flight Test (PPFT)**
  - Demonstrate end-to-end AAR CONOPS mission including wet hookup and contingency
- **Full CONOPS Simulation**
  - Demonstrate full CONOPS with multiple tankers and receivers
  - Demonstrate mission control capability from AVO to receivers

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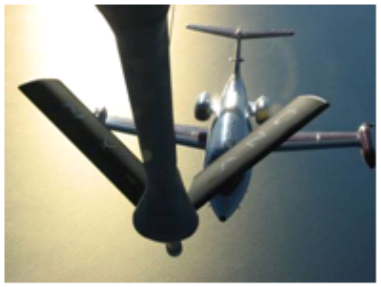
Key Technical Objectives for AAR Phase II

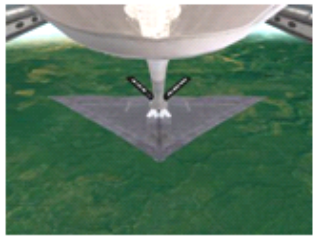
- **Reduce key risks to transition**
  - **Technical maturity, documentation, and impressions**
- **Mature AAR technology into a robust design, with supporting analysis and specifications**
  - **Safety, LO-compatibility, system health monitoring, FMECA, specifications**
- **Develop prototype system based on design demonstrating feasibility of design**
  - **Robust testing of prototype to determine adequacy of design and failure modes**

Automated Aerial Refueling (AAR) Phase II Way Forward

- Demonstrate AAR in a relevant environment through wet hookup

- Focus areas for further maturation
  - Redundancy/contingency management
  - Multi-ship operations
  - Sensor augmented (GPS+EO/IR Sensor) positioning system
  - Robust AAR System/CONOPS Simulation
  - Full AR CONOPS flight test with hookup





Critical Elements of AAR II Technology Maturation Planning

- Technology Participants
- Technology Demonstration Plan
  - Requirements Documentation
  - Program Objective
  - Approach
  - Technology Development Required
  - Applicable Systems
  - Product/Payoff/Exit Criteria
  - Programs/Activities Related to AAR Success
  - Programs/Missions Supported by AAR
  - Technology Milestones List
  - Technology Deliverables
  - Risk Analysis
  - Technology Protection Plan

Critical Elements of AAR II Technology Maturation Planning

- **Acquisition Strategy**
  - Target Acquisition Programs
  - Stakeholders
  - Capability Document
  - Availability Dates for Technologies
  - Functional Strategies
    - Flight Qualification
    - Airworthiness Certification
    - Environmental Qualification
    - Logistics Support
- **Technology/Acquisition Bridge**

Elements of Management Plan to Mature Requirements for AAR

- Process Flow
- Change Requests
- Requirements Change Control Board
- Tools
- Products
  - Baseline
  - Traceability
  - Verification Methods