

AFRL-VA-WP-TP-2004-314

**AUTOMATED AERIAL REFUEL (AAR)
TECHNOLOGIES AND
CHALLENGES**

Delivery Order 0048

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APRIL 2004

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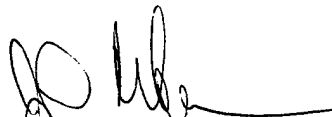
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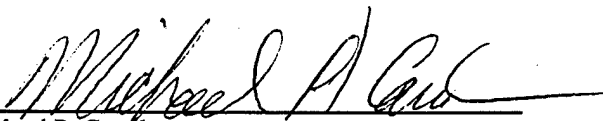
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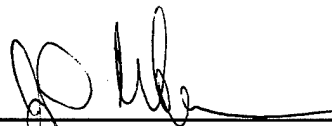
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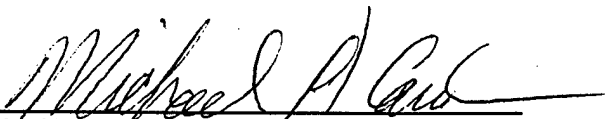
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REPORT DOCUMENTATION PAGE					Form Approved OMB No. 0704-0188				
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1. REPORT DATE (DD-MM-YY) April 2004		2. REPORT TYPE Conference Presentation Slides		3. DATES COVERED (From - To)					
4. TITLE AND SUBTITLE AUTOMATED AERIAL REFUEL (AAR) TECHNOLOGIES AND CHALLENGES Delivery Order 0048				5a. CONTRACT NUMBER F33615-00-D-3052-0048					
				5b. GRANT NUMBER					
				5c. PROGRAM ELEMENT NUMBER 62201F					
6. AUTHOR(S) David R. Riley				5d. PROJECT NUMBER A00T					
				5e. TASK NUMBER					
				5f. WORK UNIT NUMBER 0D					
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) The Boeing Company Phantom Works 775 East Marginal Way P. O. Box 3999 Seattle, WA 98124-2499				8. PERFORMING ORGANIZATION REPORT NUMBER					
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Vehicles Directorate Air Force Research Laboratory Air Force Materiel Command Wright-Patterson Air Force Base, OH 45433-7542				10. SPONSORING/MONITORING AGENCY ACRONYM(S) AFRL/VACC					
				11. SPONSORING/MONITORING AGENCY REPORT NUMBER(S) AFRL-VA-WP-TP-2004-314					
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.									
13. SUPPLEMENTARY NOTES Conference presentation slides presented at the AIAA Section Meeting, St. Louis, MO, 4/13/04.									
14. ABSTRACT This paper talks about the challenges of Aerial Refueling of Unmanned Air Vehicles.									
15. SUBJECT TERMS									
16. SECURITY CLASSIFICATION OF: <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <tr> <td style="padding: 2px;">a. REPORT Unclassified</td> <td style="padding: 2px;">b. ABSTRACT Unclassified</td> <td style="padding: 2px;">c. THIS PAGE Unclassified</td> </tr> </table>			a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified	17. LIMITATION OF ABSTRACT: SAR		18. NUMBER OF PAGES 26	
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified							
19a. NAME OF RESPONSIBLE PERSON (Monitor) Jacob L. Hinchman					19b. TELEPHONE NUMBER (Include Area Code) (937) 255-8427				



Automated Aerial Refuel (AAR) Technologies and Challenges

AIAA Section Meeting

13 Apr 04



Video Courtesy Bihle Applied Research



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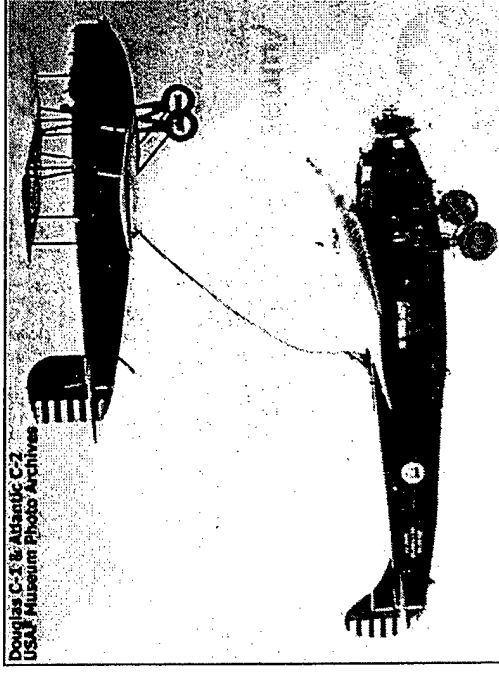
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Presentation Outline



- Background
 - Significance to Air Force
 - AAR Program Key Aspects
 - AAR Project Approach
 - National AAR Team
- Conceptual Design Development Process
 - AAR Process
 - CONOPs and Requirements
- Conceptual Designs
 - Selection Process
 - Conceptual Design Families
- Simulation Development
- AAR's Future





Significance to Air Force

■ Unmanned Aerial Vehicles

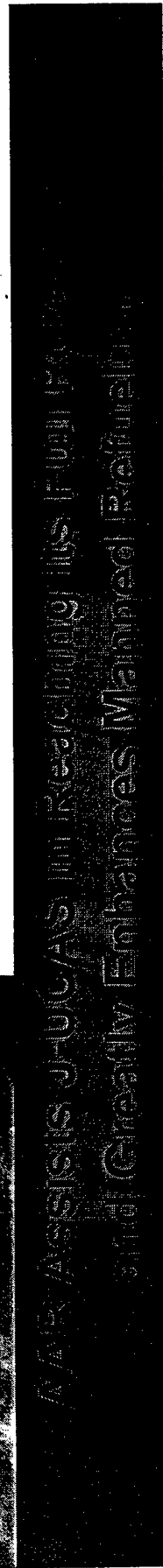
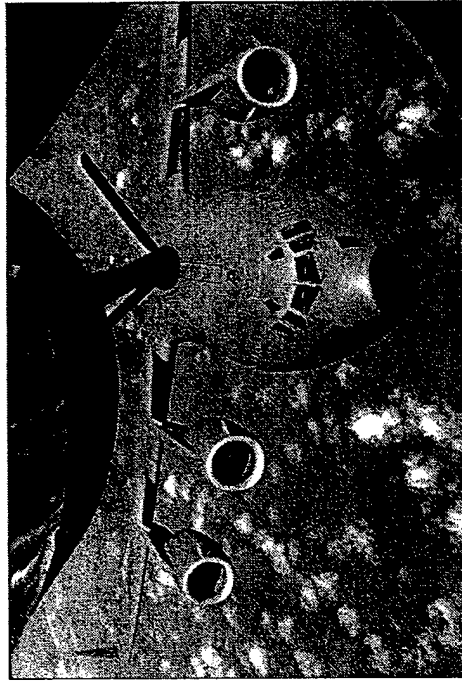
- Extends Range
- Shortens Response for Time-Critical Targets
- Maintains In-Theater Presence Using Fewer Assets
- Deployment with Manned Fighters and Attack Without the Need of Forward Staging Areas



"If we decided to fly them across the ocean, we have to work on things like automatic air refueling" -Gen. John Jumper, USAF, August 2001

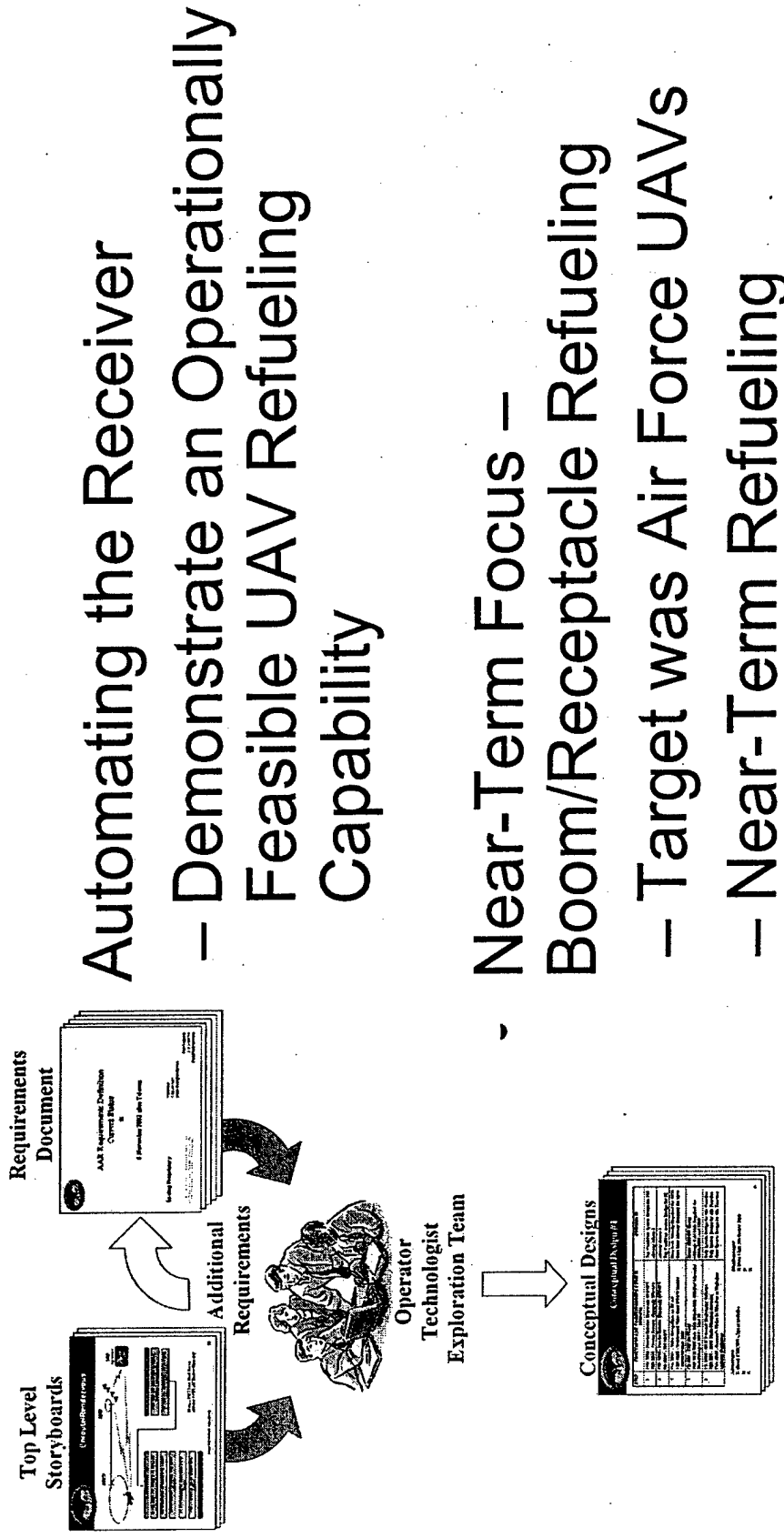
■ Manned Aircraft

- Provides Adverse Weather Operations
- Improves Fueling Efficiency
- Reduces Pilot Workload





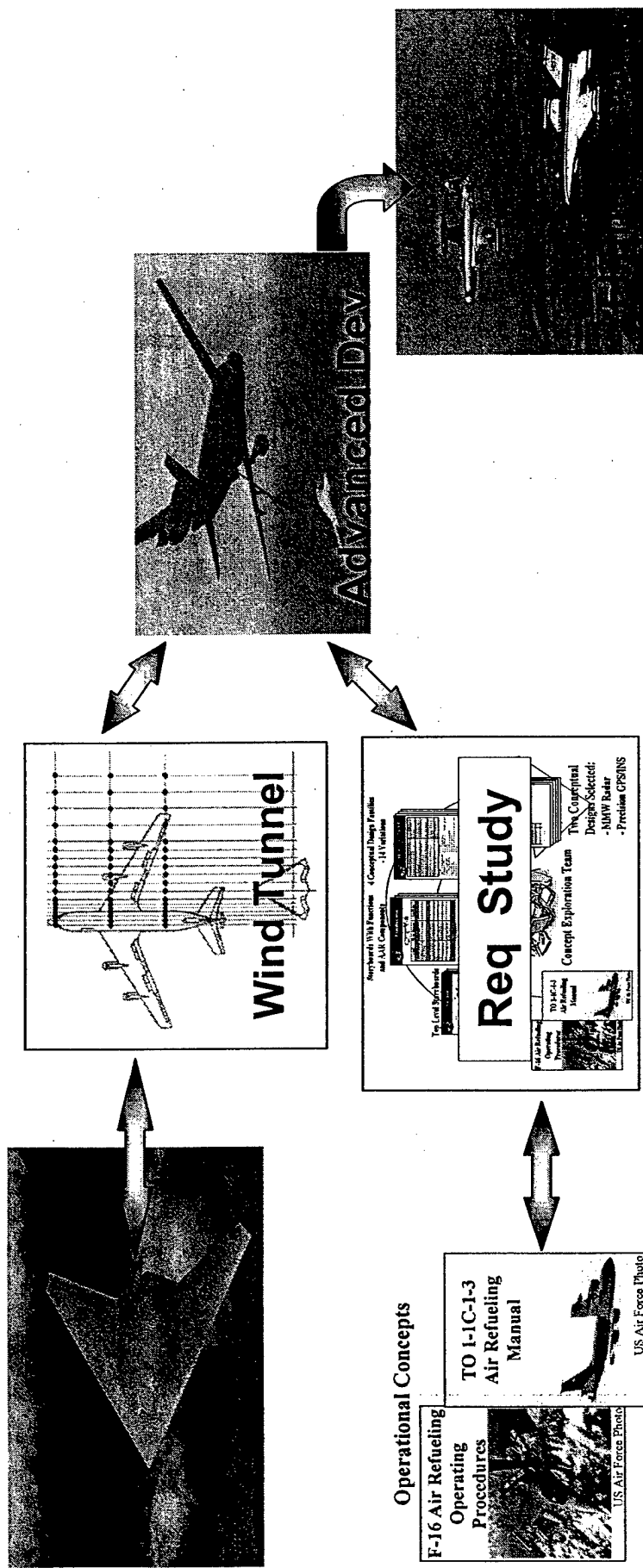
AAR Program Key Aspects



... World ... from ... to ...
... Technology Transition



Heavy User Involvement From AMC/XPR, ACC/DRZ, ASC/FB, And DARPA





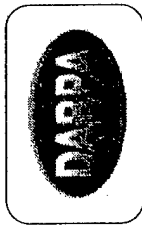
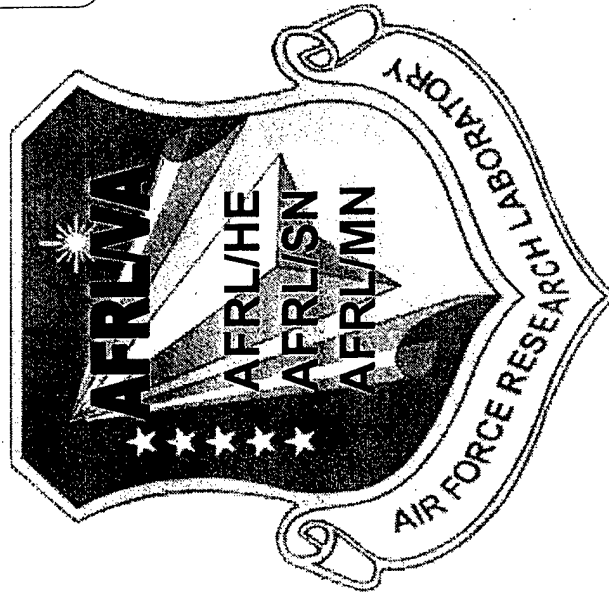
National AAR Team



ACC/DR



ASC/FB
ASC/GR



AMC/XP

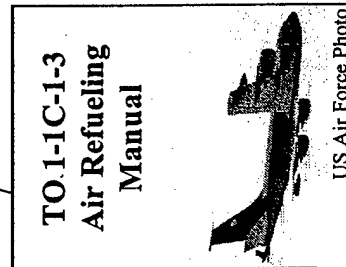
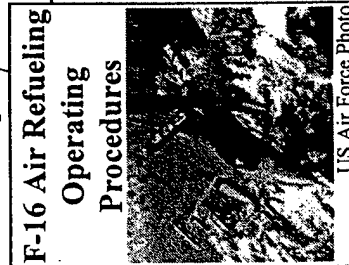
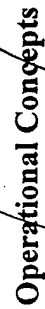
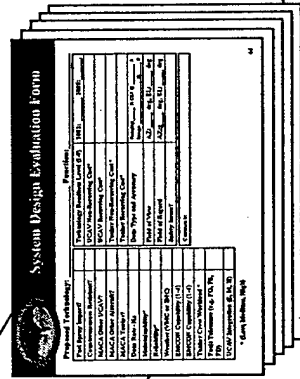
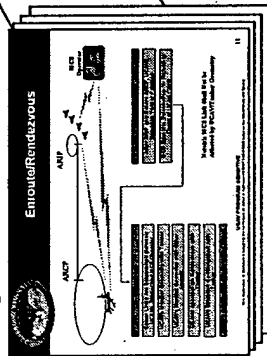
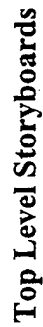
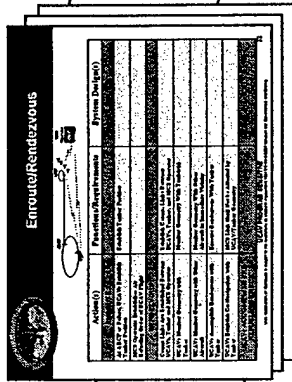
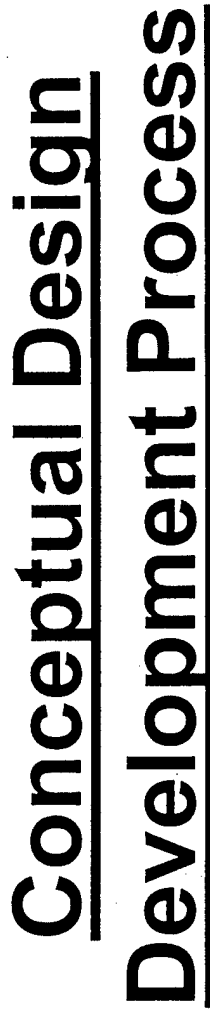


Navy



NORTHROP GRUMMAN

Electronic Systems



Conceptual Designs

- Navigation Based
- Sensor Based



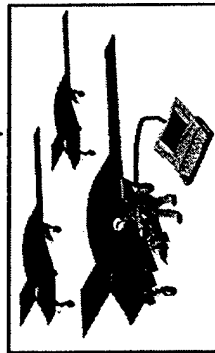
J-UCAS Mission/AAR

Overview



Generic Communication for Storyboard Charts

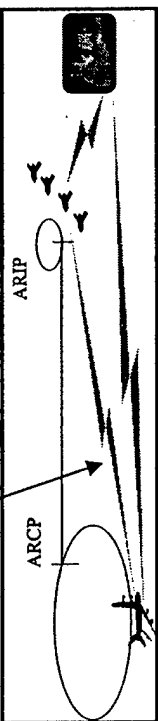
Ground Ops



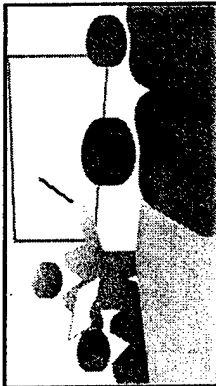
En Route



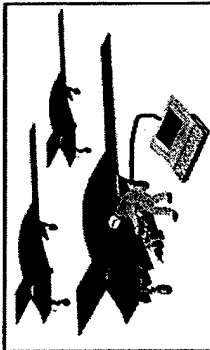
Rendezvous



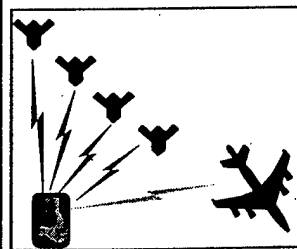
Mission Preparation



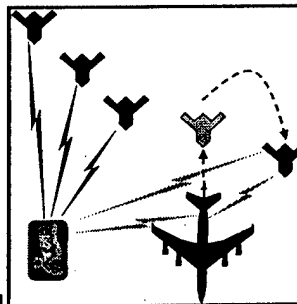
Post-Flight



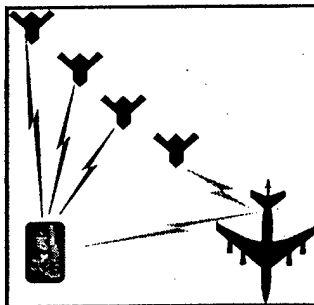
Post-AR Procedures



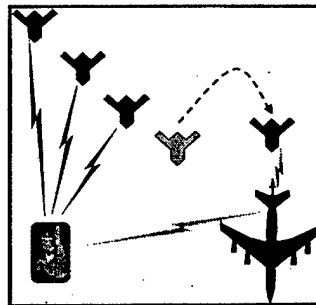
Disconnect



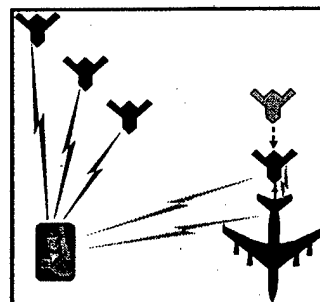
Observation Position



Pre-Contact Position

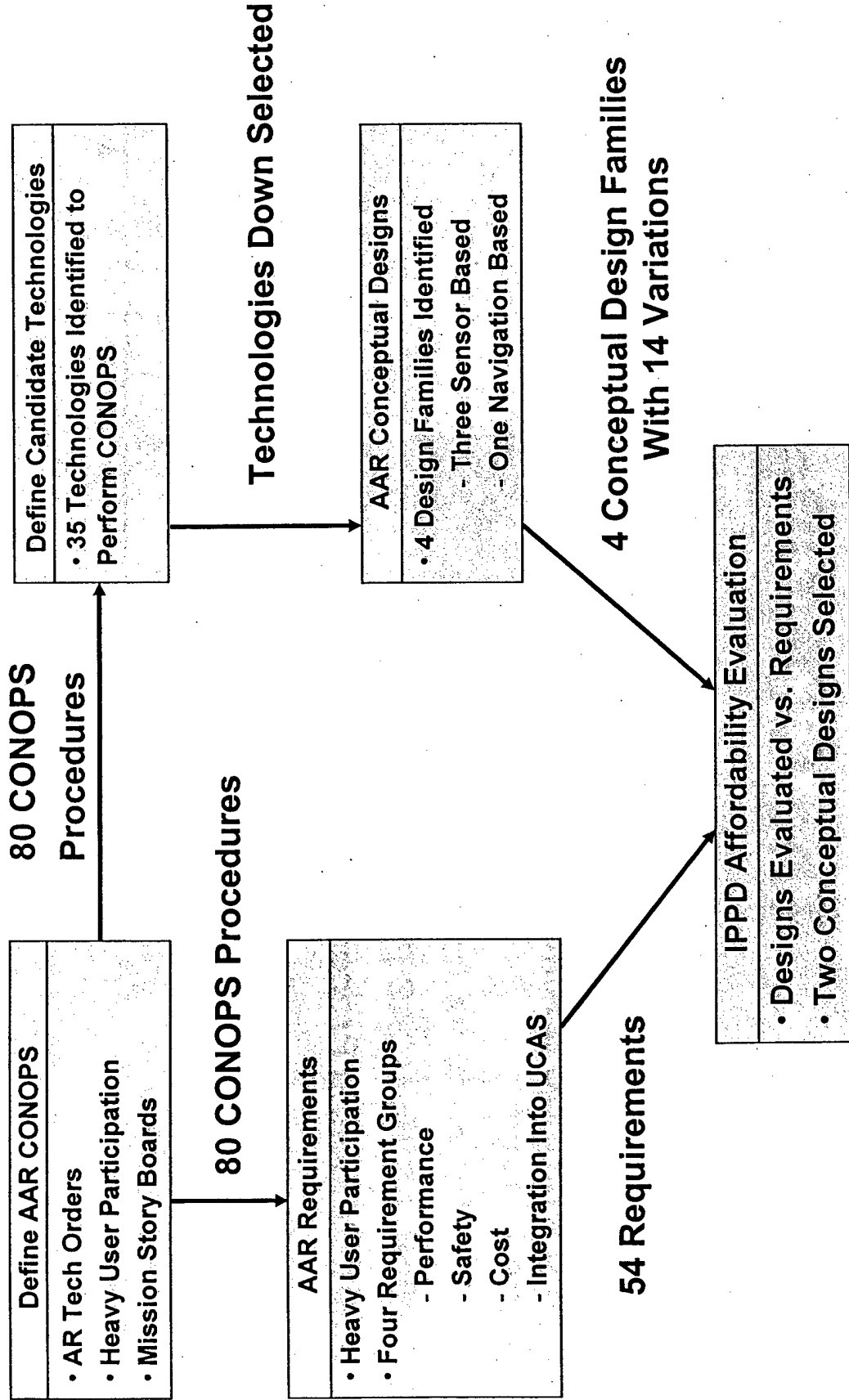


Contact Position





The AAR Process

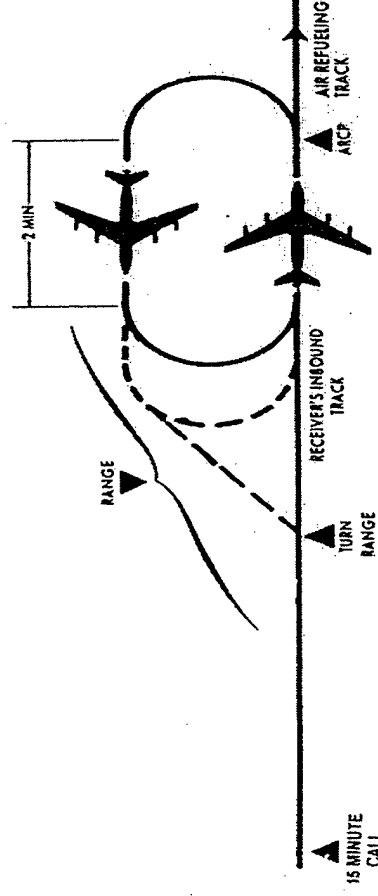




The CONOPS



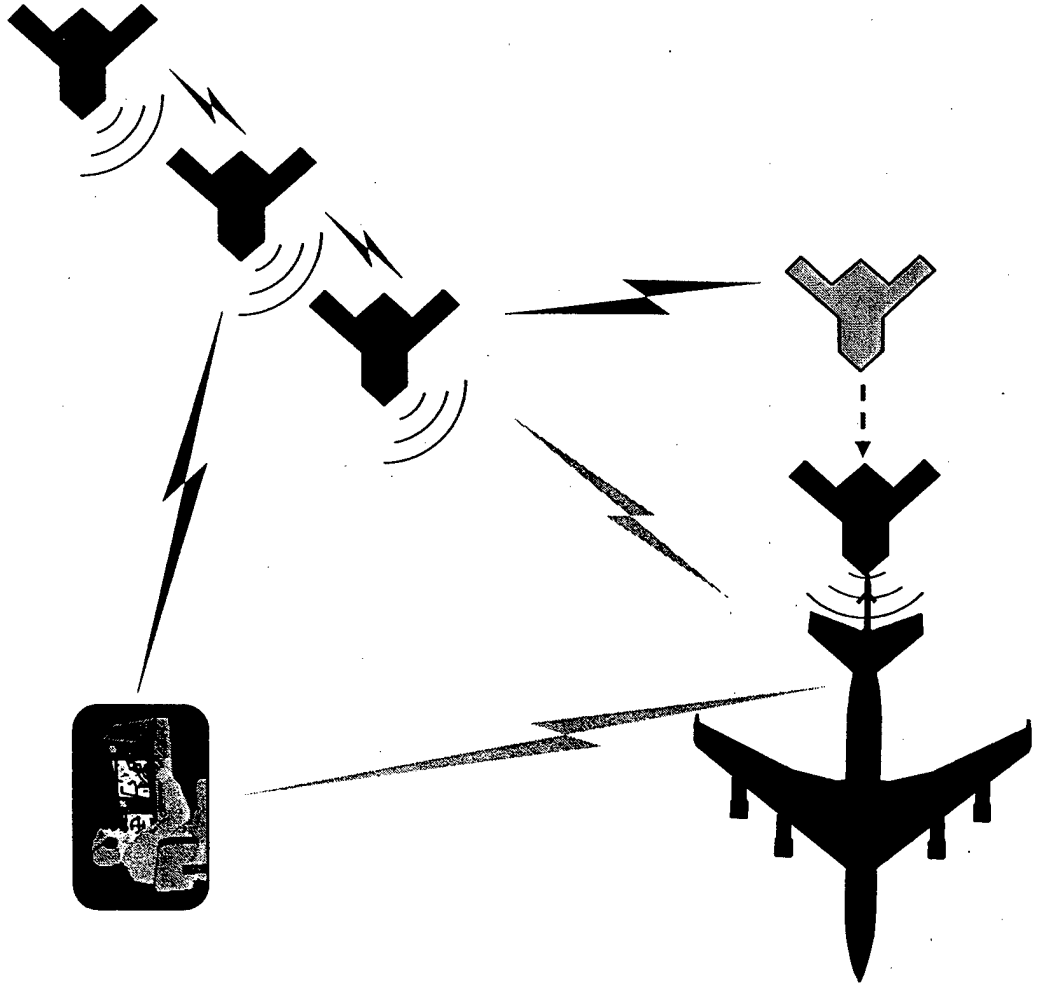
- Working with ACC & AMC to Develop Conops
- Used F-16 Procedures As Baseline
- Refueling 4-Ship UCAS Packages
- Manned Refueling Procedures



Based AAR Procedures On Current Manned Aircraft Procedure
Ensuring Seamless Integration, Ease Transition



Example CONOPS: Contact Position



Authorized UCAS Stabilizes in Pre-Contact Position
Boomer Authorizes UCAS to Contact Position
Authorized UCAS Stabilizes in Contact Position
Boomer Plugs UCAS
UCAS Acknowledges Contact to MCS Operator
Confirmation of Contact Is Provided to Tanker
UCAS Maintains Contact Position
UCAS Takes Fuel



Overarching User Requirements



- User Relevance Requires:
 - Protect Tanker From Collision With UCASs
 - Identify and Design Most Affordable Solution
 - Consider Impact to Rest of UCAS System of Systems (SoS) Impact
 - Minimal Impact to LO Design
 - Minimize (or Eliminate) Tanker Modifications
 - Minimize Impact to Refueling Mixed Fleet Operation

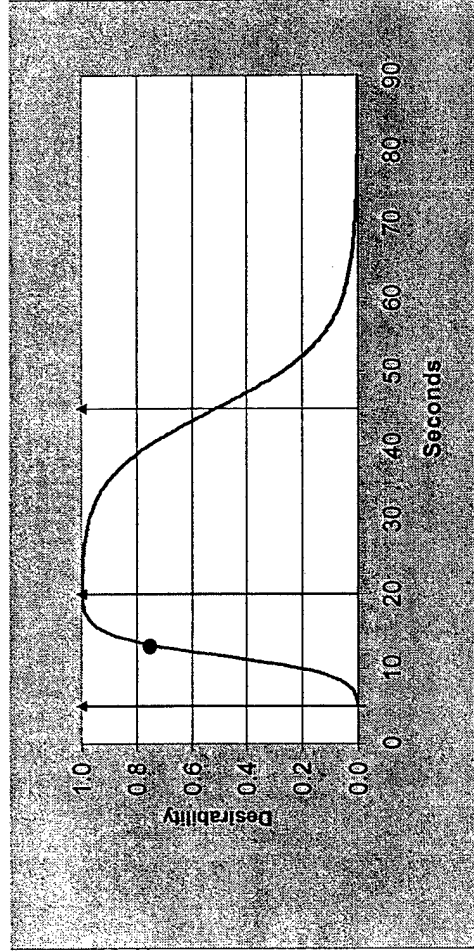


AAR Requirements:

Performance Example

P001B: Refueling Efficiency: Closure to Contact

- UCNAV will move smoothly and efficiently from the Precontact Position to the Contact Position upon Boomer authorization.



Time (seconds) from Boomer authorization (to close to contact) until receiver stabilizes in Contact Position. Threshold is the typical time for piloted aircraft.

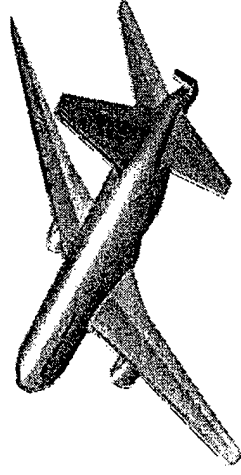
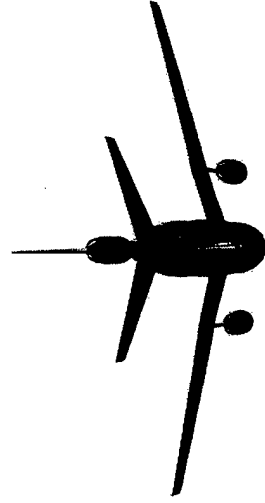
- 4 Areas
 - Performance
 - Safety
 - Cost
 - Integration
- 54 Requirements
- Developed With Direct Warfighter Involvement
- Derived from Battlefield Requirements and CONOPS



Critical Functions Drive AAR

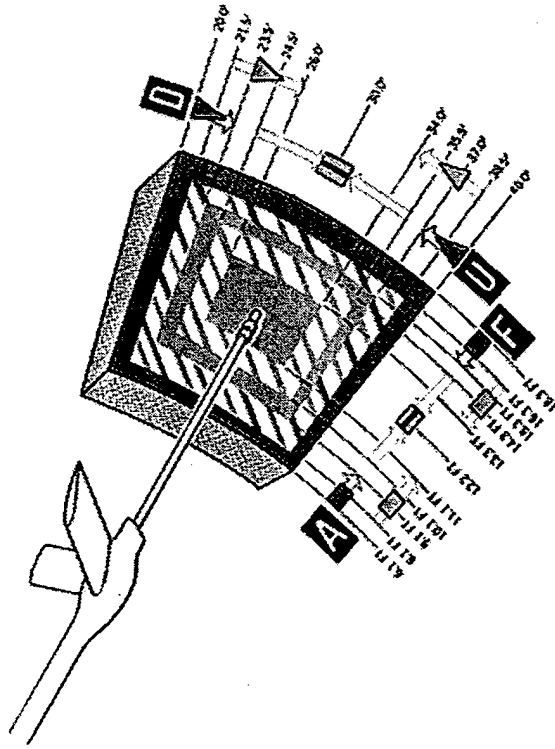
Conceptual Design Selection

- Strongest Design Drivers Functions (In Order of Priority):
 - UCAS Ability to Precisely Maneuver Around Tanker
 - UCAS Ability to Perform Rendezvous with Tanker
- Other Important Functions
 - Bomber Ability to Immediately Command Break-Away
 - Tanker's Ability to Determine Range to UCAS in Real Time (Point Parallel Rendezvous)
 - Tanker's Ability to Communicate with MCS Operator

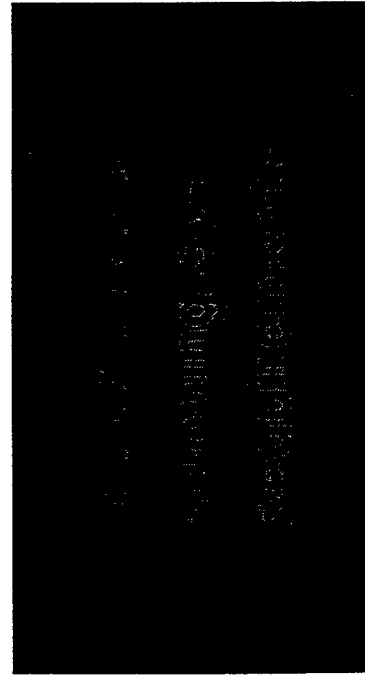
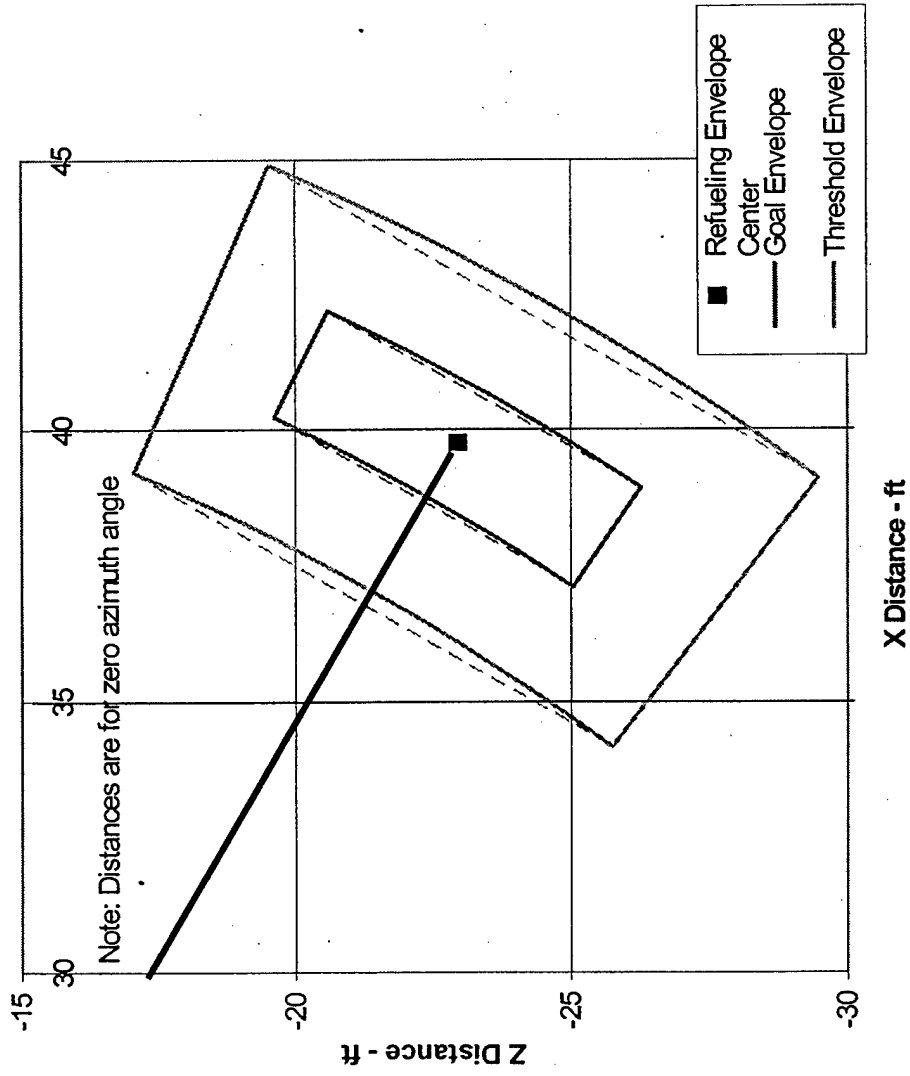




Precision Positioning SystemAccuracy Requirements at Contact

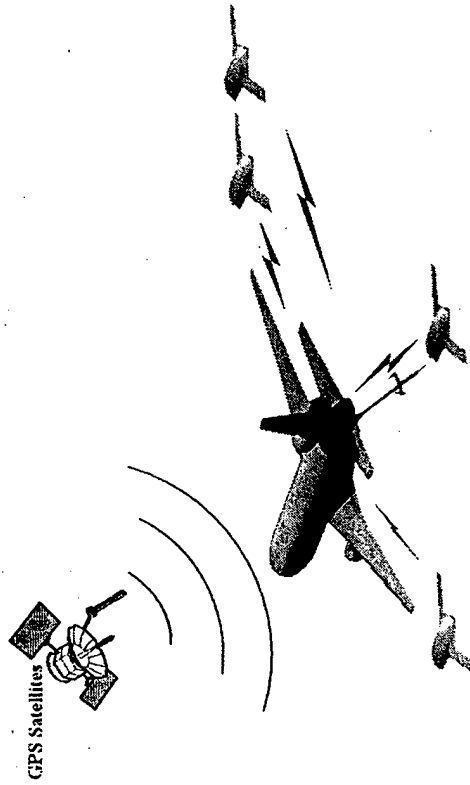


Boom Air-to-Air Refueling Envelope





AAR Conceptual Design Families



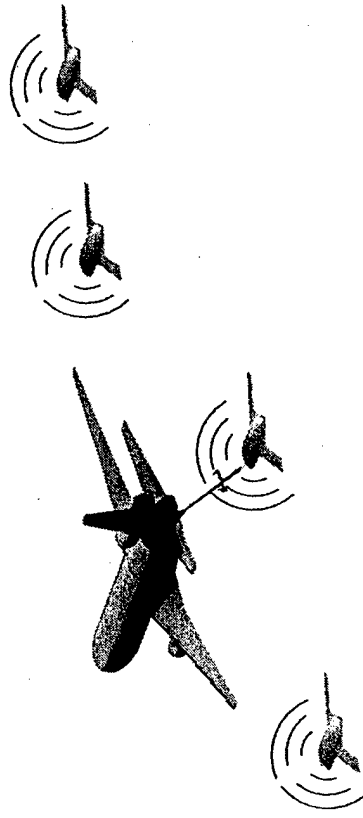
Navigation-Based

Advantages:

- Lowest Technical Risk For Initial Capability
- All Weather Capability
- Compatible With Navy Ops
- Simple Vehicle Integration

Disadvantages:

- Requires Tanker Modifications



Sensor Based

Advantages:

- Most Affordable Conceptual Design
- Sensor May Enable Additional UCAS Capabilities

Disadvantages:

- UCAS Vehicle Integration
- Sensor Development Risk



Simulation Development

- Integrated Aerial Refueling R&D Simulation Being Developed
 - Boomer Station
 - UCAS Operator Station
 - Tanker Pilot Cube
 - Other Receiver Stations
- Provides Test Bed for AAR System Development
 - Allows Rapid Prototyping and Early Operator Interactions
 - Helps Develop and Visualize Correct Story Boards

PC Based Simulation



Infinity Cube Simulation



Early Operator Interaction with the AAR System



Summary

- Automated Refueling Is a Key Capability for UCAS
- Automation Can Provide Significant Improvements in Refueling Capability and Efficiency
- Technology Application to Manned Aircraft
 - Automatic Adverse Weather Rendezvous
 - Situational Awareness and Collision Avoidance for Simultaneous Multiple Receivers
- AFRL, ASC, AMC, ACC, and DARPA have Teamed With Industry
- Concepts Developed in Desktop Simulation Environment can be Quickly Moved to a Man-In-The-Loop Simulation Environment for Boomer, Tanker Pilot, and UAV Controller Evaluations





AAR's Future



- **Continue Requirements Development**
 - Analysis
 - Simulation
 - Off-Line Simulations
 - Real Time “Boomer in the Loop”
- **AAR Technology Maturation**
 - Flight Test
 - Gather Sensor Data
 - Demonstrate Station Keeping Capability
 - Demonstrate Dry/Wet Hookups
 - Boom and Receptacle
 - Probe and Drogue

