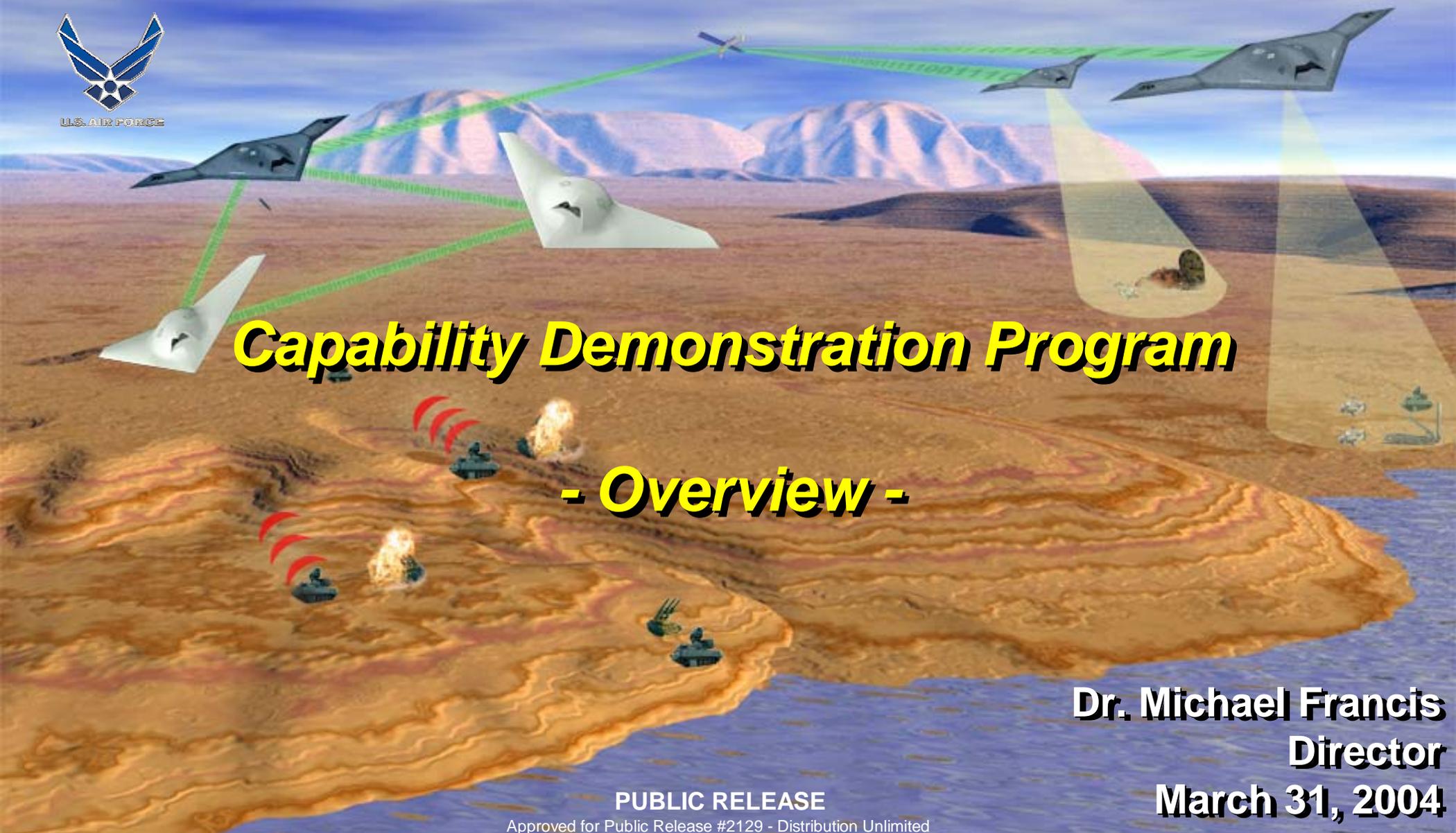




# Joint Unmanned Combat Air Systems



## Capability Demonstration Program

**- Overview -**

**Dr. Michael Francis  
Director  
March 31, 2004**

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# Overview

- **Background/History**
- **Program Direction**
- **Vision/Missions**
- **Common Operating System**
- **J-UCAS Program Elements**
  - Common Systems & Technologies
  - Boeing X-45 Systems
  - Northrop Grumman X-47 Systems
- **Operational Assessment**
- **Conclusion**

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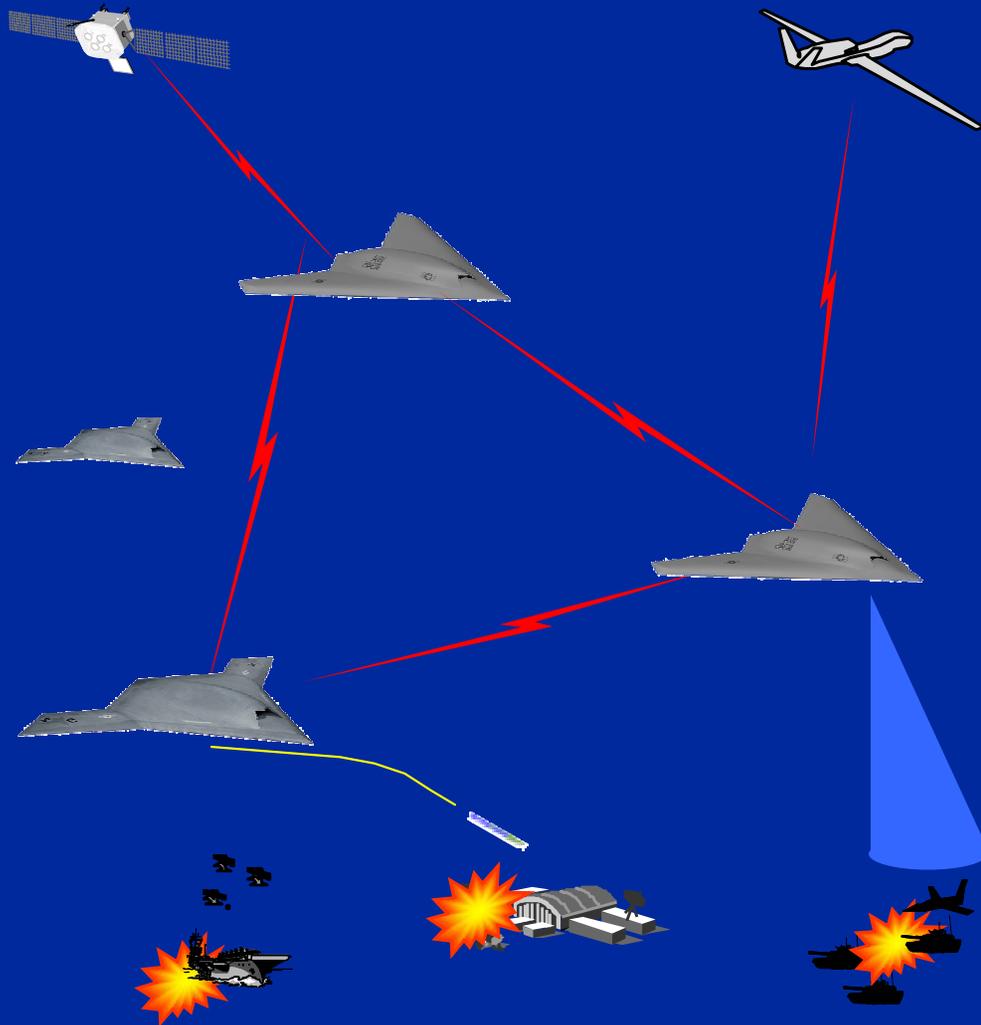
## *Joint Unmanned Combat Air Systems -- Unique Joint Program*

- **DARPA-Air Force-Navy Development – Effective 1 Oct 2003**
  - Program Office in Arlington, VA
- **Outgrowth of Earlier DARPA Programs**
  - Uninhabited Tactical Aircraft (UTA)
  - DARPA-USAF Unmanned Combat Air Vehicle (UCAV)
  - DARPA-Navy Unmanned Combat Air Vehicle (UCAV-N)
  - 2 Prime Contractors -- Boeing (X-45), Northrop Grumman (X-47)
- **Network-based System-of-Systems**
  - Focus on Specific Mission Applications
- **Atypical Program Architecture**
  - Spiral Development ... Cutting Edge Technology ... ATDs
  - Operational Systems Focus ... Operational Assessment
  - Aggressive Timeline
- **Large Program - \$Multi-B over the FYDP**

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# Collaborative Operations



## **Improve System Performance**

- Reduced Target Location Time
- More Assured Target Identification
- Sustain Ground Tracking
- Improve Targeting Precision
- Rapid Battle Damage Assessment

## **Increase System Versatility**

- Multiple Engagement Options
- Deep/Denied Environments
- Diverse Missions

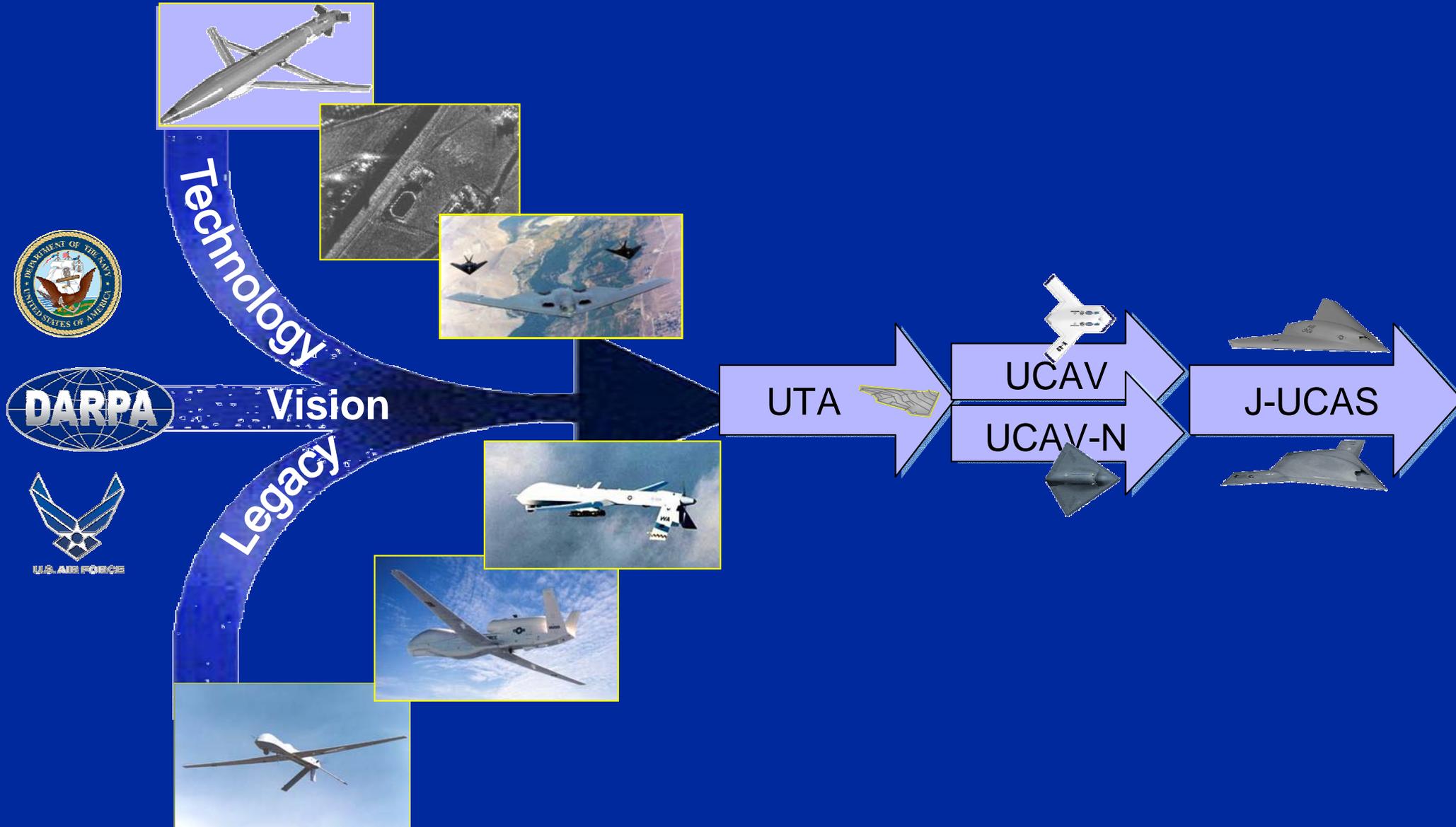
## **Enhance Survivability**

- Group Self Defense Tactics
- Novel CONOPS (e.g. Bi-static Ops)
- Graceful System Degradation

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# J-UCAS Program Origins



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DARPA Perspective --

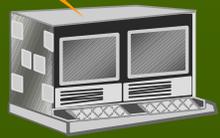
# Uninhabited Tactical Aircraft (UTA) -- 1994-96



Operations Control

### DARPA's Motivation

- Decades of DARPA Information Technology
- High Performance Aircraft Experience
- UAV Program History
- Dept of Defense Warfighting Vision
- Versatile, Affordable Power Projection Potential



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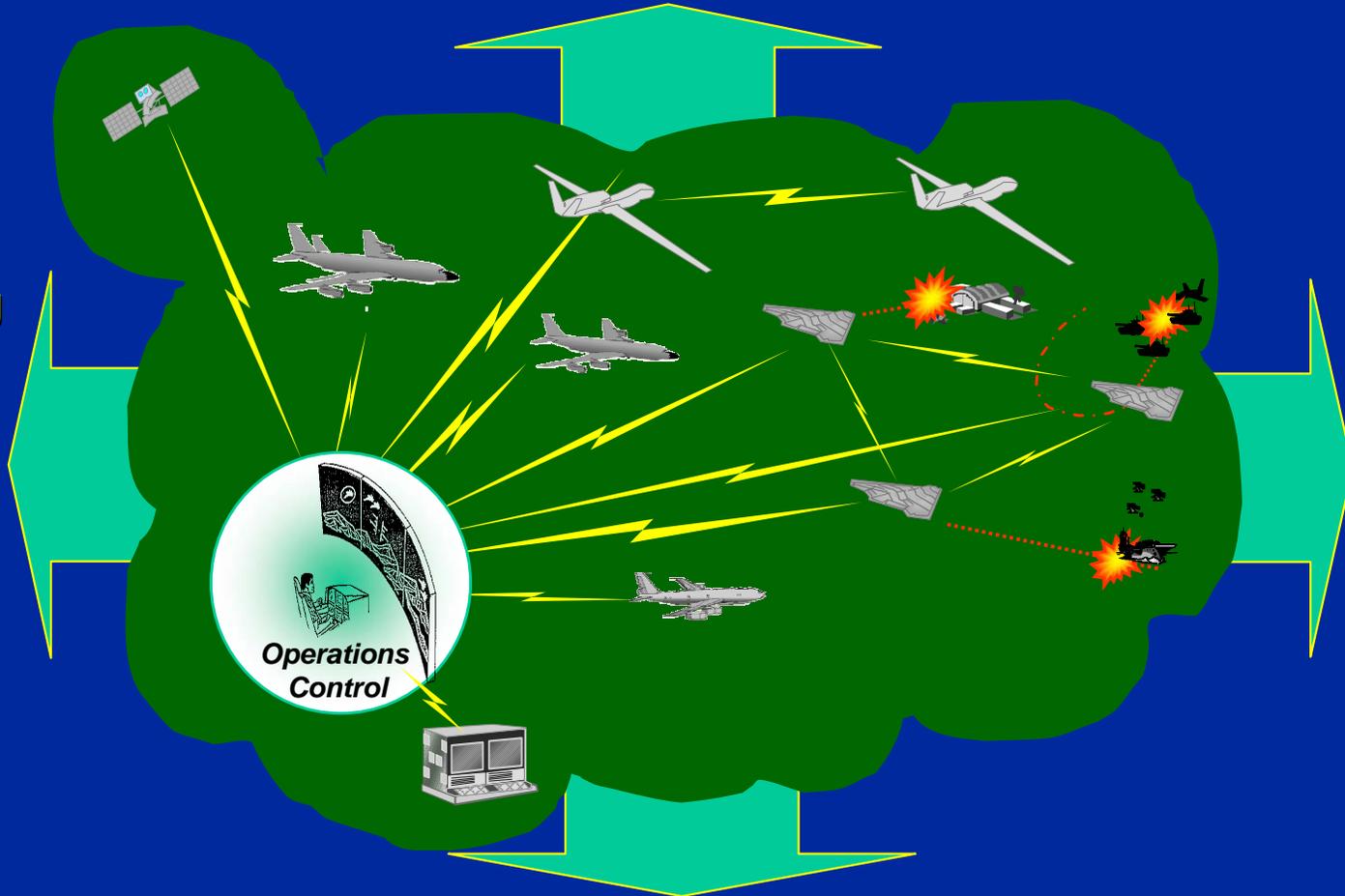
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# Uninhabited Tactical Aircraft -- Program Architecture Implications

High End, Survivable Platforms  
Increase Mission Versatility

Demanding  
Timelines  
Favor High  
Levels of  
System &  
Platform  
Autonomy



Lethal  
Capabilities  
Demand  
Human  
Decisions/  
Involvement

Attritable Platforms Offer Low  
Acquisition and O&M Costs

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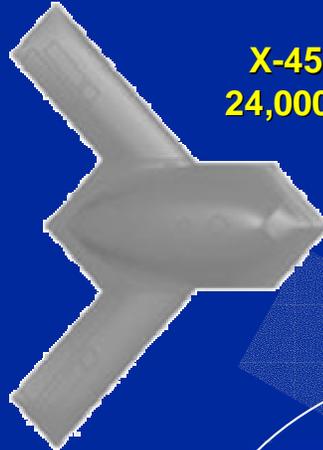


# Program Evolution



**X-45A**  
12,000 lb

**DARPA-USAF UCAV ATD**



**X-45B**  
24,000 lb



**X-45C**  
36,000 lb



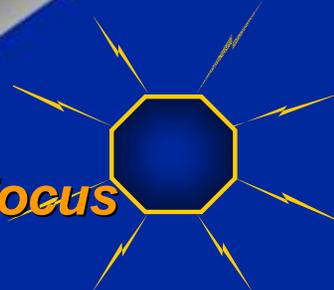
**X-47A**  
5,000 lb

**DARPA-Navy UCAV-N**



**Common Sensors  
& Weapons**

**Joint Focus**



**Common  
Operating  
System**



**X-47B**  
42,000 lb

FY99

FY00

FY01

FY02

FY03

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# ***Program Direction & Expectations***

- ***OSD Objectives (23 Jun 03 USD/AT&L Memorandum)***
  - Demonstrate feasibility & flexibility of the J-UCAS concept
  - Conduct Joint Operational Assessment of J-UCAS capabilities
    - ***OA in FY07-09 timeframe ... facilitate early service decision***
  - Maintain competitive environment throughout the program
- ***Service OA Expectations (OA Capability Statements)***
  - Diverse mission priorities
    - ***USAF – SEAD / Electronic Attack***
    - ***Navy – Persistent Surveillance / Reconnaissance***
  - Demanding air vehicle characteristics
    - ***Range / radius / endurance***
    - ***Payload options – type / weight / volume***
    - ***Signature – Affordable LO to the next level***
    - ***Carrier suitability (Navy)***
    - ***Air refueling***

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# ***Program Planning Considerations --***

## ***Assumptions, Constraints, Other Factors ...***

- **Aggressive Timeline**
  - FY07 OA start date
- **Competition Mandated**
- **Focus on “Shadows On Ramp”**
- **Services Driven Missions & Vehicle Requirements**
- **OA Capabilities Statements**
- **Sensor/Payload Developments Staggered**
  - Balance Service Needs And Technology Maturity
  - Driven By Available Funding
  - Common Elements, Where Possible (Cost Savings)
- **Common Operating System Assumed**
  - Development Initiated In FY04
- **Current Air Vehicle Designs Have Matured**
  - Key To Meeting Timeline
  - X-45C Passed Mid-term Design Review
  - X-47B Passed Systems Requirements Review

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# Joint Unmanned Combat Air System -- The Vision

- **Versatile Combat Capability**
  - Global Operations
  - Suppression of Enemy Air Defenses (SEAD)
  - Electronic Attack
  - Persistent Surveillance
  - Deep Strike
- **Manned Force Augmenter**
  - Unique, Difficult Missions
  - Operational Synergy
  - Force Amplification
- **Network-Centric Operations**
  - Network-based Architecture
  - Multi-Vehicle Collaboration
  - High Levels of Autonomy
  - Flexible Human Intervention
  - Enhanced Situation Awareness
  - Dynamically Adaptive System
  - Predictable Battlefield Effects
  - ... Unpredictable Tactics
- **Affordable System-of-Systems**
  - Common Operating System
  - Air Vehicle Compatibility
  - Reduced Support Costs

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# J-UCAS Program (Fall 2003)



Technology  
Vision  
UAV Legacy

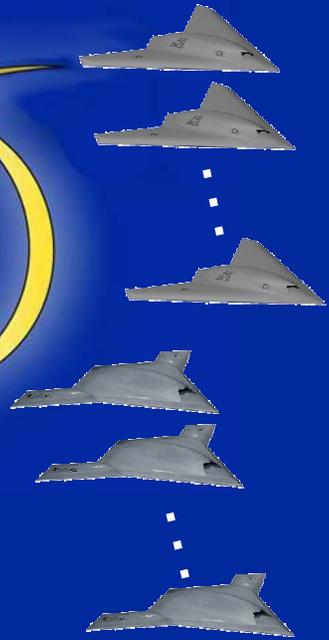
System Demonstration Program:  
*Demonstrate J-UCAS technical feasibility, military utility and operational value*

Operational Assessment and Effects Based Development  
*Provide the Services with program options*

Demo  
Autonomous Ops  
Multi-vehicle Ops  
Dynamic Tasking

Demo  
Survivability  
Supportability  
Carrier Suit

Op Ass't  
SEAD  
Surveillance  
EA  
Strike



Then

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# J-UCAS Program (Spring 2004)



Technology  
Vision  
UAV Legacy



System Demonstration Program:  
*Demonstrate J-UCAS technical feasibility, military utility and operational value*

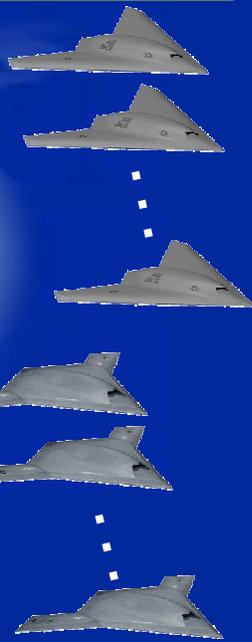
Operational Assessment and Effects Based Development  
*Provide the Services with program options*

Demo  
Autonomous Ops  
Multi-vehicle Ops  
Dynamic Tasking

Demo  
Survivability  
Supportability  
Capability

**Replanned Program**

Op Ass't  
SEAD  
Surveillance  
EA  
Strike



- Common Operating System
- Common Elements
  - Sensors
  - Weapons
  - Communications



Now

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# Way Ahead

- **Redefine Program Effort**
  - Reflect Prioritized Objectives
  - Capture New Program Emphasis & Balance ... Common Lexicon
  - Time-Phased Development ... Synchronize Events & Milestones
  - Integrate Risk Mitigation Approach
- **Initiate Common Systems Developments**
  - Common Operating System (Technical & Business Plans)
  - Other Common Elements (Sensors, Comms, ...)
- **Redistribute Resources**
  - Modify Existing Contracts to Reflect Redefinition, as Needed
- **Integrate Government Support Team**
  - DARPA-USAF-Navy-SETA Team
  - Reduce Redundancy ... Increase Collaboration
  - Allocate Tasks – JPO, Service Elements, Integrated Teams

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# J-UCAS System Elements



## Operational Infrastructure

- Communications Relay
- Navigation
- Sustainment
- Transport



## Communications

- Secure Links/Network
- LOS or BLOS Ops



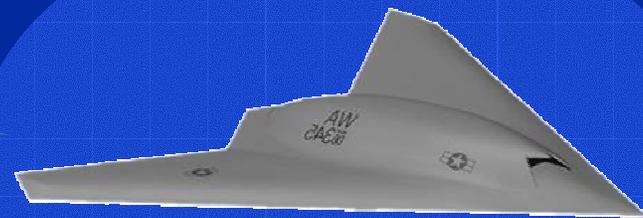
## Control Station(s)

- Physical HSI (Displays, I/O, ...)
- Launch/Recovery Control
- Vehicle-Payload Operations
- Human Crew



## Direct Support

- Maintenance
- Logistics
- Launch/Recovery Infrastructure



## Platform/Vehicle(s)

- Mission-Tailored Design
- Vehicle Management
- Vehicle Autonomous Functions

## Operating System

- System C2 & Interfaces
- Comms Management
- Mission Planning
- Autonomous Functions
- Health/Status
- Logical HSI ...

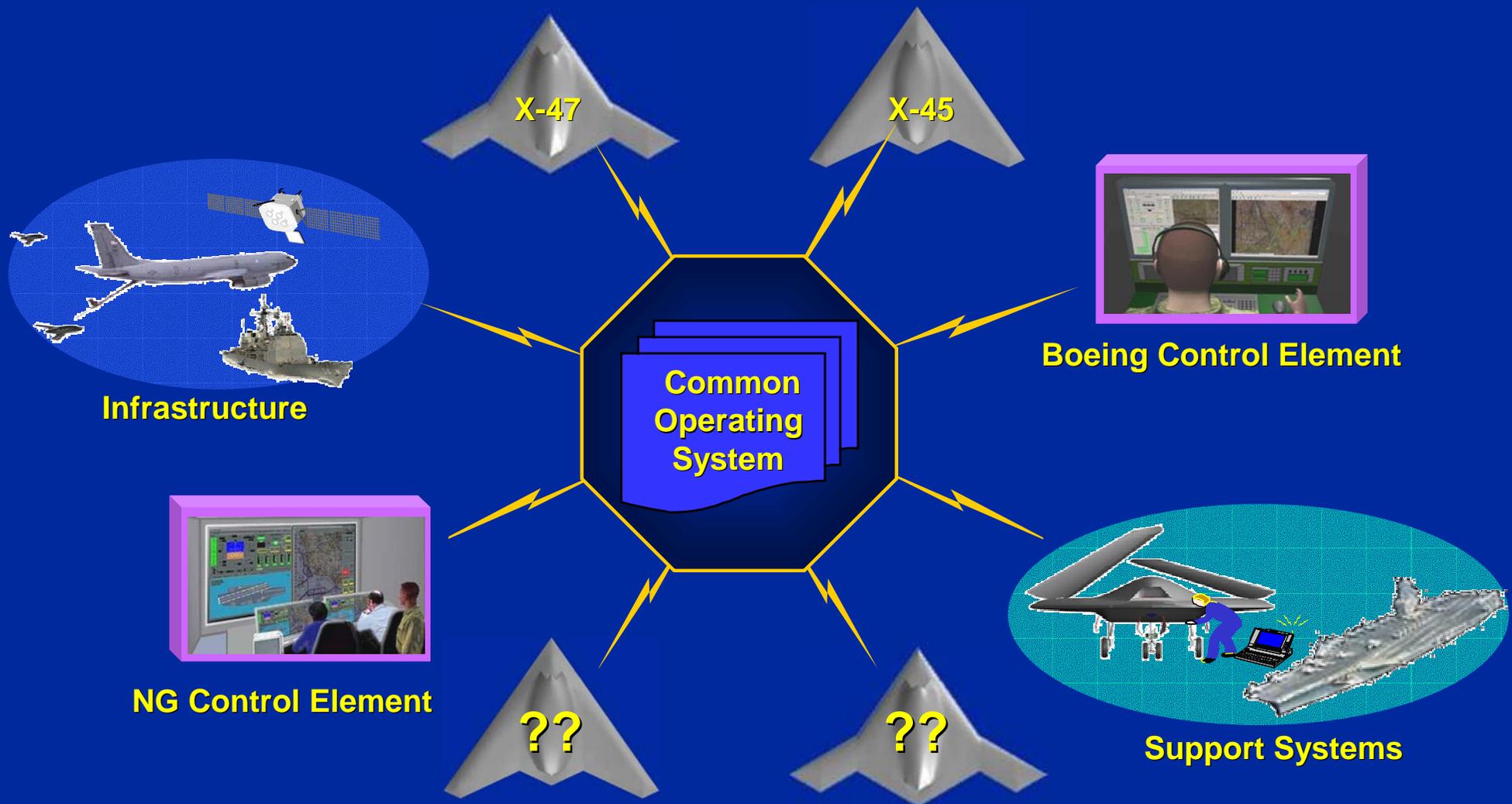
## Payload Systems

- Sensor(s)
- On-Board Processing
- Data Relay
- Weapons



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# The Integrated System



- *Intra- and inter-operable elements ... GIG-compliant network*
- *Flexible autonomy and H-I-L operations ... Dictated by mission*
- *Range-payload performance dictated by platform selection*

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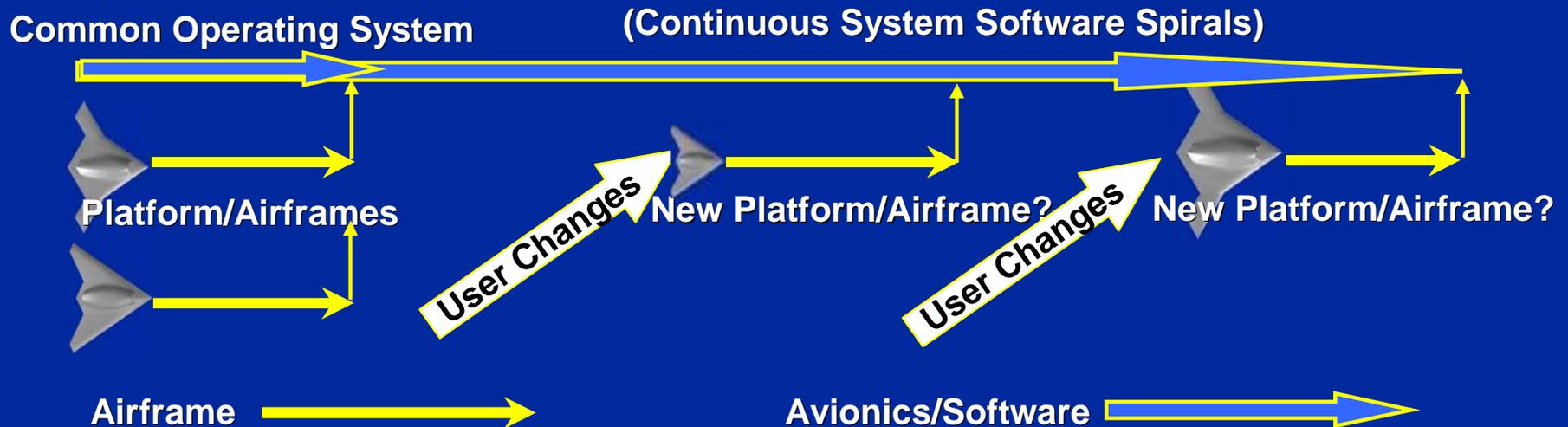
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# Decoupling the Operating System

## Traditional System Development



## J-UCAS System Development Concept





# Common Operating System

## Rationale

- **Ensures Common Architecture, Protocols, and Interfaces**
- **Decreases Complexity Of System-of-Systems Integration**
- **Assures Intra- and Inter-operability of J-UCAS Elements**
- **Enables Autonomous Collaborative Operations**
- **Decouples Air Vehicle & Other Hardware From System's Information Technology Component**

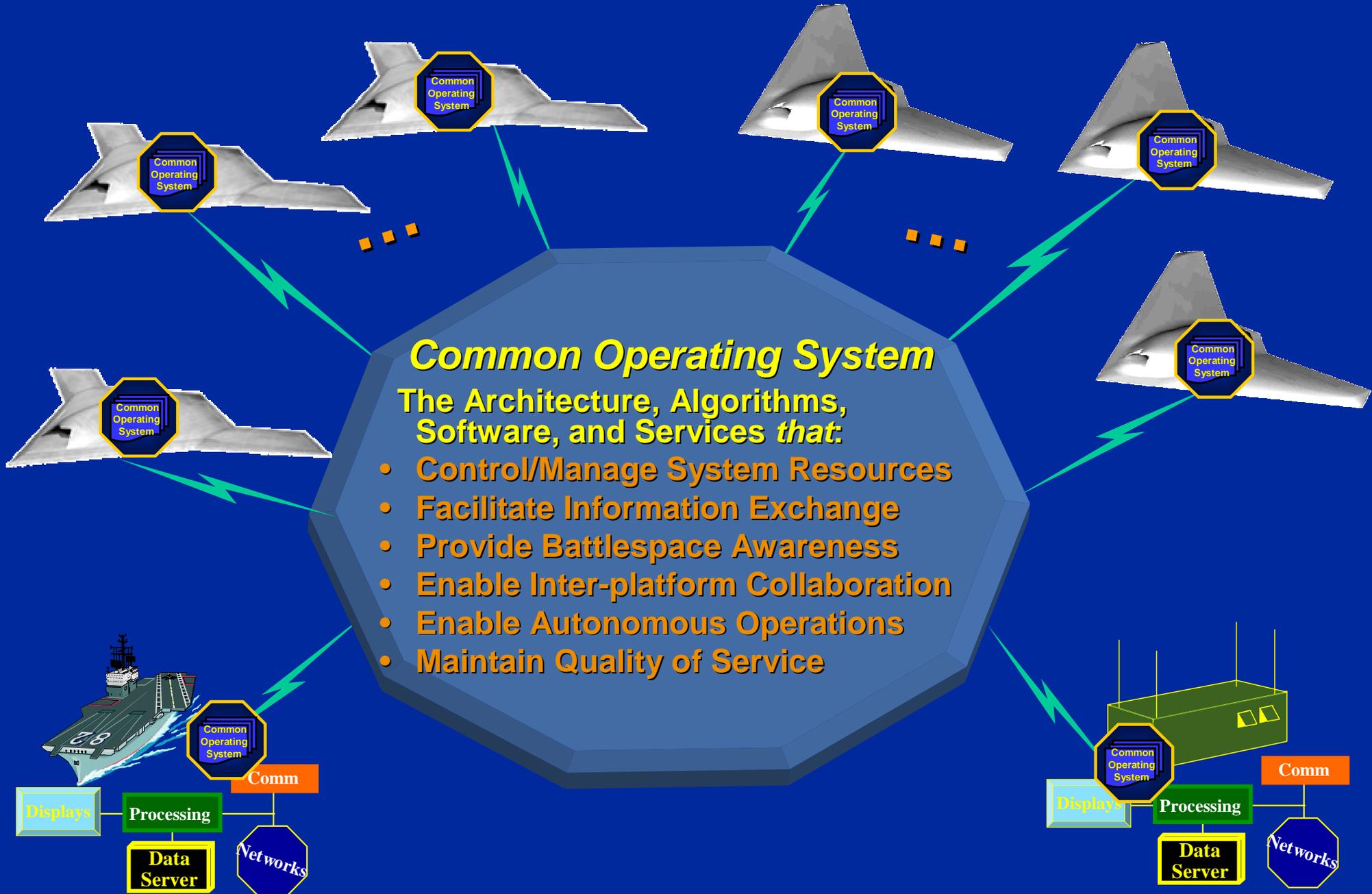
## Impact

- Not dependent on single contractor
- Reduces cost of entry for new technologies
- More rapid fielding of capabilities
- Improves ability to upgrade/modify
- Enables inter-vehicle collaboration
- Enables information exchange with external entities (e.g. platforms, C2)
- Increases op tempo & network centric warfare capabilities
- Improves battle-space awareness
- Minimizes impact of platform changes on system development
- Provides mechanism for evolutionary system improvements

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# Common Operating System



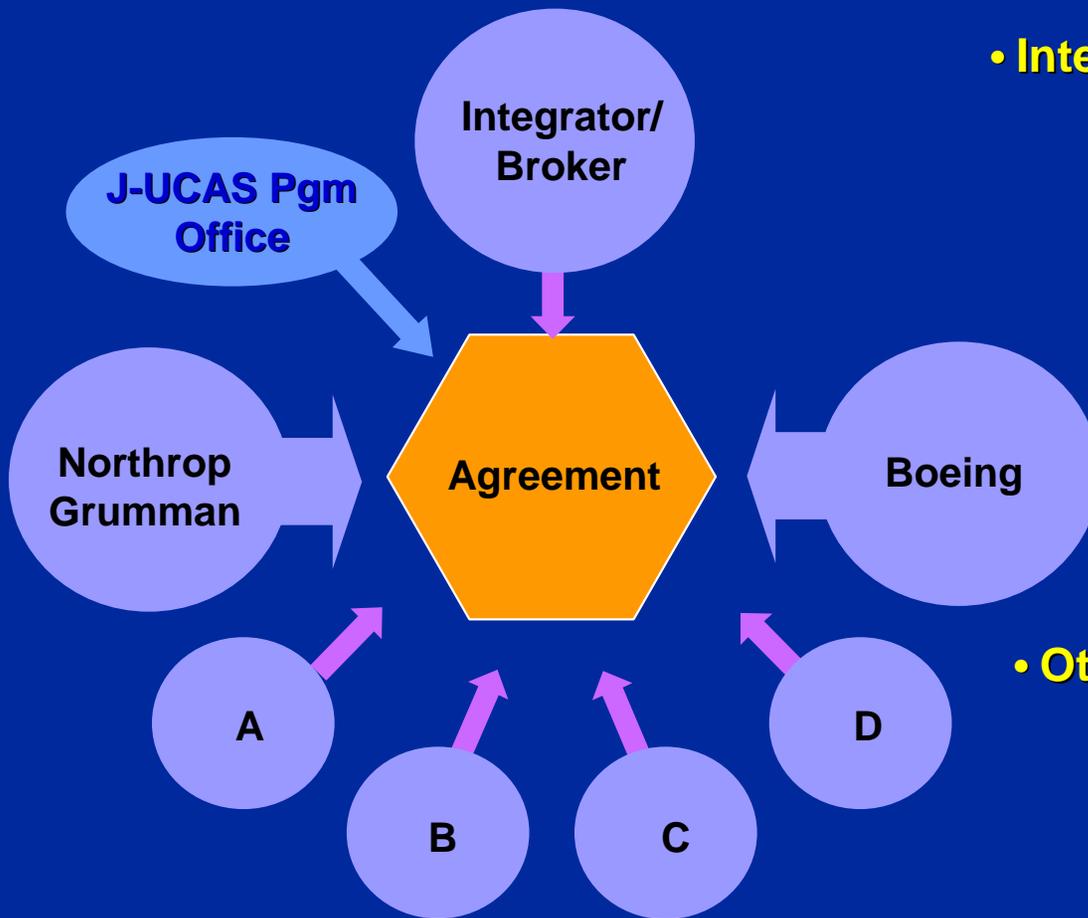
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# Common Operating System

## 3 Levels

## Consortium-like Business Arrangement



- **Integrator/Broker/Observer**

Unique Role ... Not an LSI ... No Other Integrator ... Facilitator ... Referee  
No Intellectual Property

- **Program Primes – Key Stakeholders**

Fractional Ownership  
Platform Integrators – Physical, Functional  
S/W Developers  
COS Collaborators

- **Other Contributors**

... Based on Potential Contribution(s)  
Small Houses  
Other Primes  
Traditional Subs  
Commercial Providers

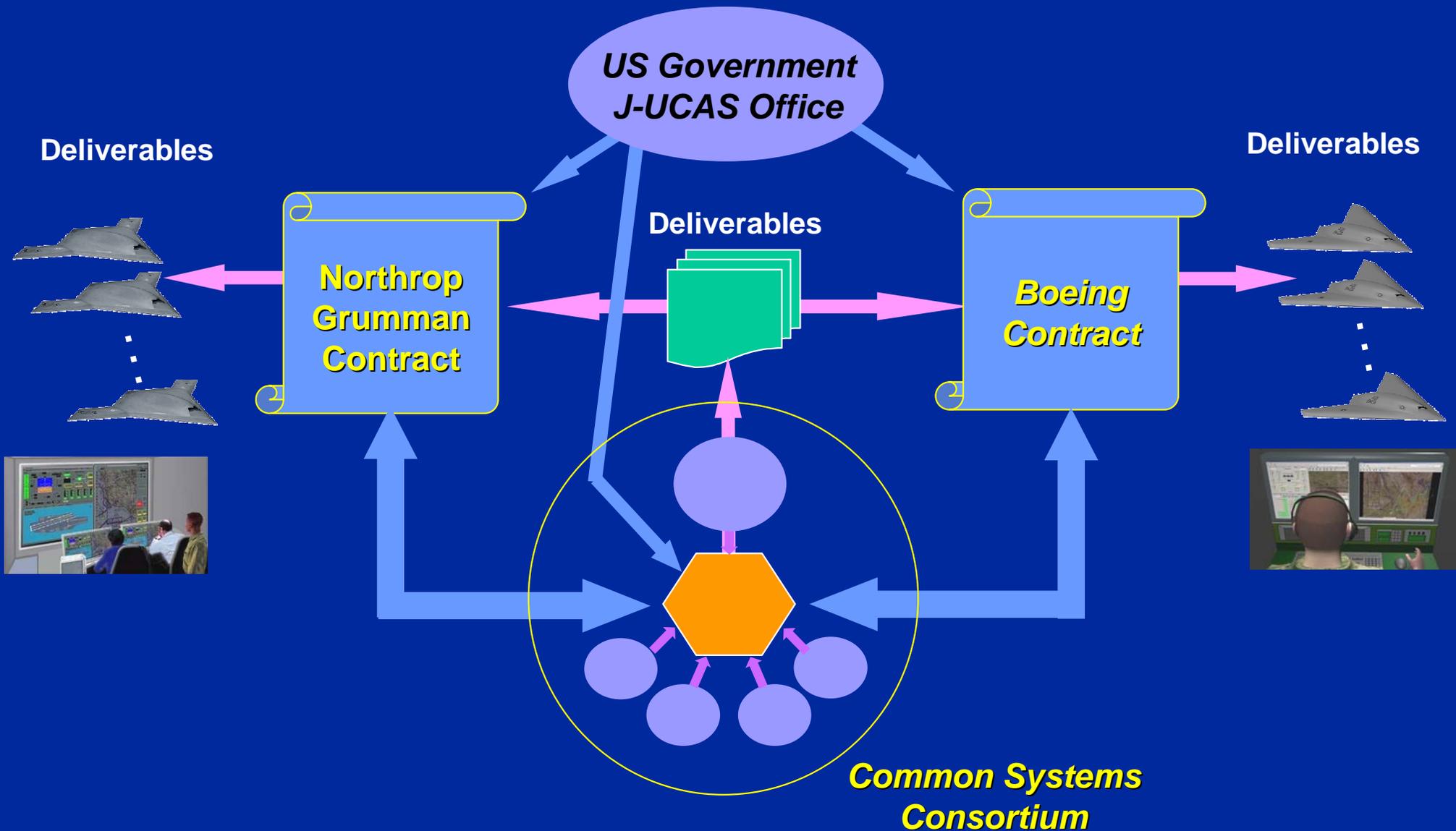
**Business dynamics promote competition & ownership ...  
Increased idea pool decreases technology risk**

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# Program Relationships



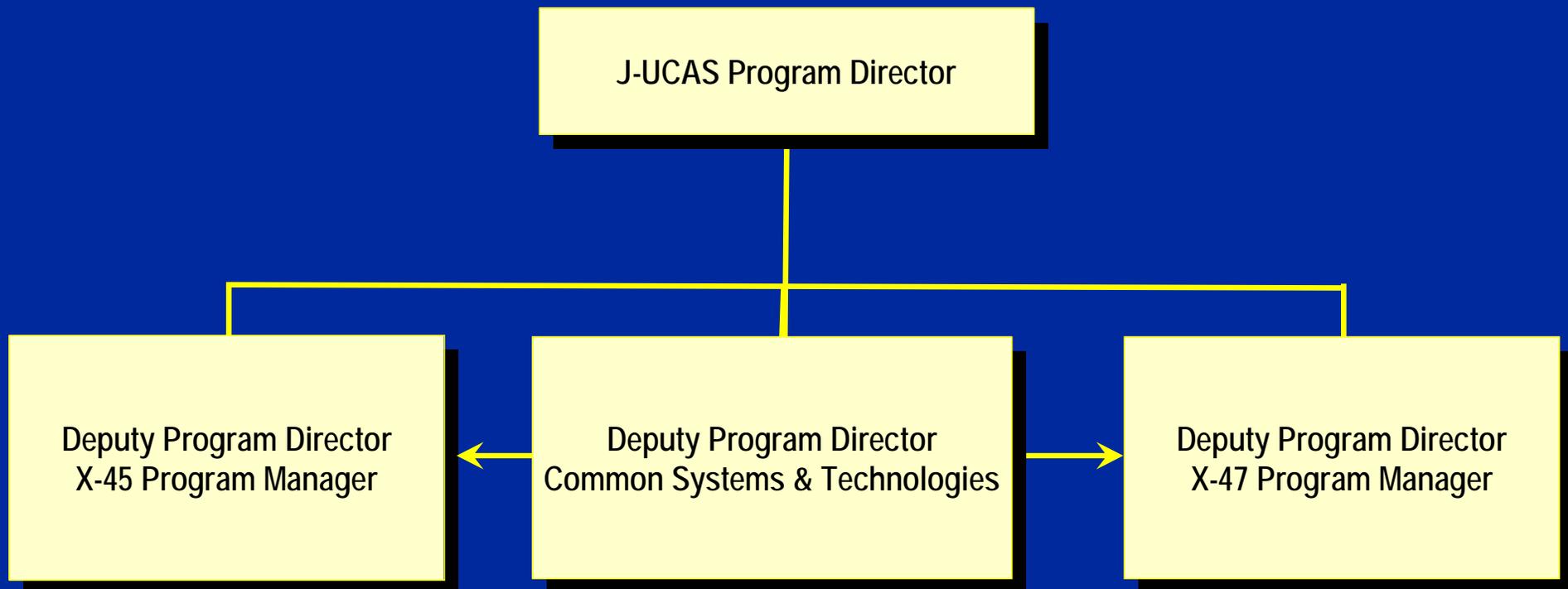
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# J-UCAS Office Structure

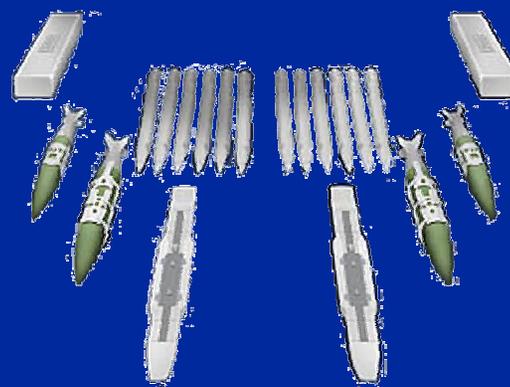
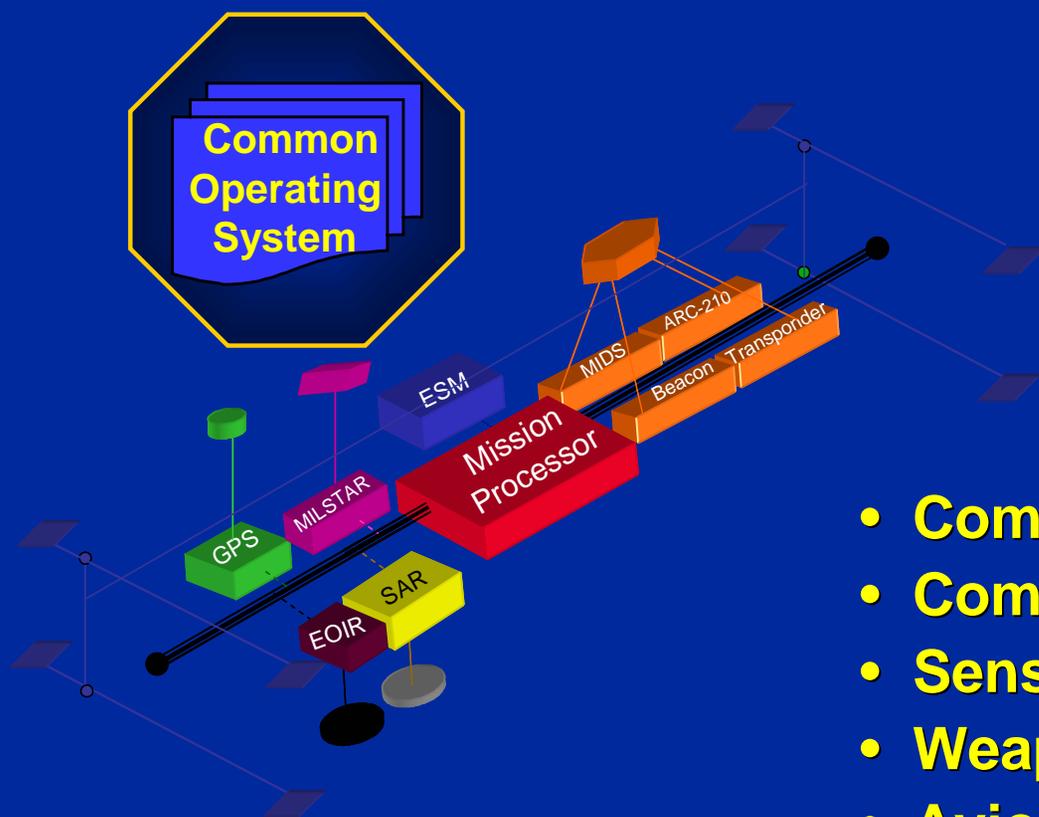
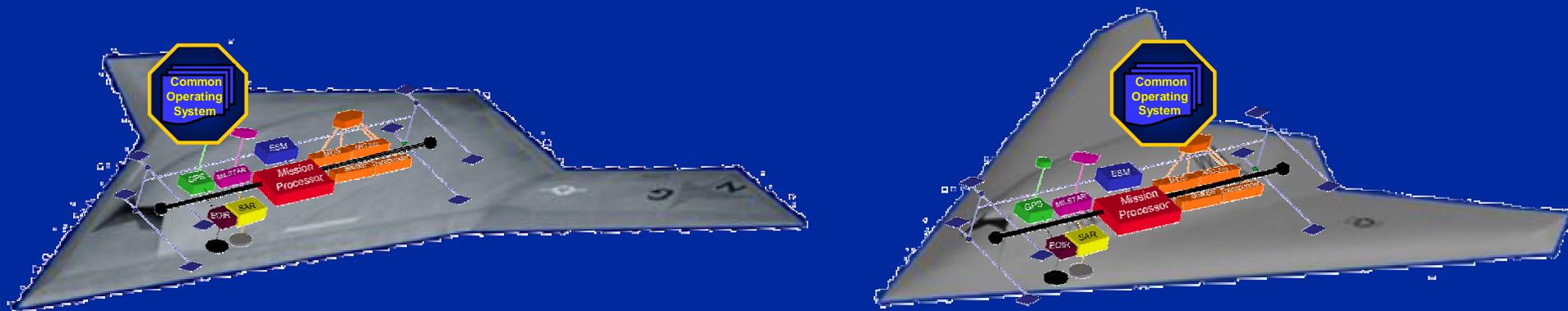
## 3 Major Elements



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# Common Systems & Technologies



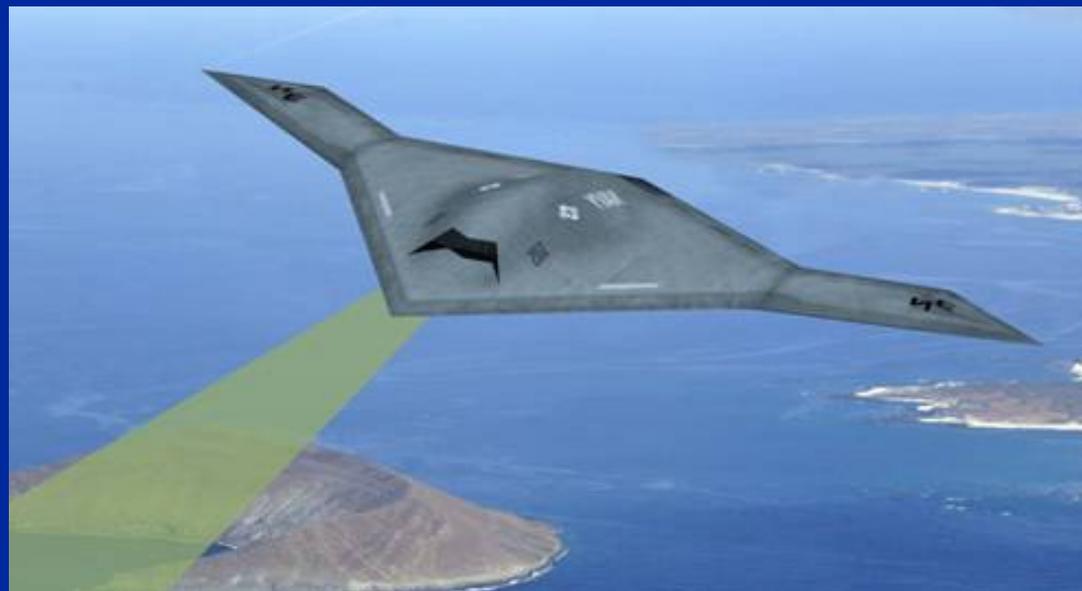
- Common Operating System
- Communications Capability
- Sensors
- Weapons
- Avionics Hardware (e.g. Processors)

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# Sensors

## Potential Surveillance Sensors

- SAR/GMTI
- ESM
- EO/IR



## Key Issues:

- Distributed Control Of Onboard Sensors
- Bandwidth Requirements & Agility
- Integration Of Apertures W/ Platform
- Sensor-to-shooter Issues
- Autonomy In Mission Planning & Execution

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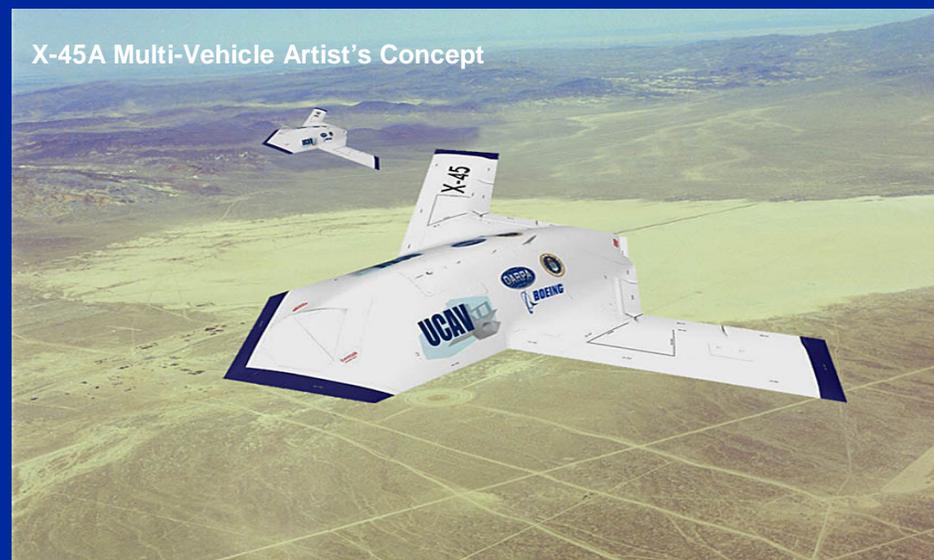


# Boeing X-45A Progress & Plans

- **System Demo Program**
  - Two X-45A air vehicles
    - **Software development assets**
  - T-33 Surrogate test bed
- **Demonstration Plans**
  - Block 2 flights include critical J-UCAS functionality
    - **Inert weapons drop**
    - **SATCOM control/hand-offs**
    - **Multi-vehicle operations**
  - Block 3 integrates intelligent system infrastructure on the air vehicle
  - Block 4 adds intelligence and on-board dynamic mission planning / autorouting



**First inert weapon drops conducted in March 04**



**Multi-vehicle flights expected to be completed in Spring 04**

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# Boeing X-45C Design Progress

- **Demo Program**

- Two air vehicles
- Provisions for sensors, etc
- Survivability, carrier suitability, & weapons release part of demo plan

- **Program Participants**

- General Electric supplying F404 engines & integration
- Leveraging X-45A software development and lessons learned

- **X-45C Carrier Suitable Derivative Design Studies Continue**

- **Other Program Participants**

- General Electric Supplying F404 Engines & Integration



- **X-45C System Milestones**

- Design start date – Jan 03
- MCS shelter delivered – Dec 03
- Mid-Term Design Rvw – Dec 03

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# Northrop X-47A System Development

- **X-47A Pegasus demonstrator leverages Global Hawk and Fire Scout Experience**
- **X-47A Accomplishments**
  - Flight Demo – May 03
  - Simulated a tailhook arrestment point on a carrier flight deck by landing near a predesignated touchdown point
  - Utilized shipboard-relative global positioning satellite (SRGPS) system as the primary navigation source for increased landing precision



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# Northrop X-47B Design Progress

- **Demo Program**
  - Two air vehicles
  - Provisions for sensors, survivability, etc
  - Carrier suitability based demo plan
- **Program Participants**
  - Lockheed-Martin providing expertise
  - Pratt & Whitney supplying F100 engines & integration
  - Leveraging Global Hawk and Fire Scout experience



- **X-47B System Milestones**
  - Design Start Date – Apr 03
  - System Req't Rvw – Dec 03
  - JPALS Demo on USS Truman w/ F-18 surrogate



# ***Operational Assessment (OA) Capability Statements***

- **Tasked by OSD(AT&L) Memo of 23 Jun – Due Dec 03**
  - Prioritized capabilities & measures of effectiveness
- **AF Prioritized Missions (Lethal Strike Inherent In All)**
  - Info Ops
    - **Focus on EW (Electronic Attack, Electronic Warfare Support)**
    - **Augment reconnaissance capabilities**
  - Air and Space Superiority - Offensive counterair (SEAD)
  - Aggressive LO levels stipulated to facilitate all missions
  - Signed by requirements organization vice CSAF
- **Navy Prioritized Missions**
  - Persistent, survivable Surveillance / Reconnaissance
  - Lethal and non-lethal SEAD
  - Long range strike in anti-access environment
  - Carrier suitability stipulated to facilitate all missions
  - Signed by requirements organization vice CNO
- **Developing A Formalized Iterative Process For “Requirements” Support During Development And OA**

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# Toward Operational Air Vehicles

X-45C Concept



## Challenging Objectives

- **Long Range – Combat Radius**
  - 1300 nm with 4500 lb Payload
- **Significant Endurance/Persistence**
  - Demo System: 1000 nm / 2 hrs loiter
  - Objective System: 1000 nm / 3.5 hrs loiter
- **Sizable Payload**
  - Size / Volume & Weight (4500 lb - 2 JDAMs)
  - Multiple Weapons / Sensor Pallets
- **High Platform Survivability**
  - Affordable LO to the Next Level
- **Versatile Sensor Suite**
  - ESM Capability
  - Synthetic Aperture Radar
  - EO / IR Sensor
  - EW / Electronic Attack Payload
- **Carrier Suitability**
  - Catapult Launch
  - Arrested, 3<sup>rd</sup> Wire Landing
- **Global Operations**
  - Air Refuelable
  - Civil Airspace Compatible



X-47B Concept

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# *Program Challenges*

- **Maintain a Continuous Level of Accomplishment**
  - Build Program Momentum & Customer Enthusiasm
- **Create a Competitive Environment**
  - ... by the End of the OA
  - ... without Losing Program Momentum
- **Create an Accepted, Viable Common Operating System**
  - Extensible, Flexible, Open Systems Architecture
  - Best-of-Breed (Industry-wide) Algorithms ... Reach the Vision
  - Effectively Integrated System
- **Complete Program within Available Resources**
  - Clever Allocation of Funds ... Mitigate Known Risks
  - Incentivize Innovation & Invention

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# ***Conclusion***

- **J-UCAS Program Objectives**
  - Demonstrate Feasibility & Flexibility Of The J-UCAS Concept
  - Conduct Joint Operational Assessment Of J-UCAS Capabilities
    - **OA In FY07-09 Timeframe ... Facilitate Early Service Decision**
  - Maintain Competitive Environment Throughout The Program
- **Key System Components**
  - Boeing X-45 Air Vehicle Family
  - Northrop Grumman X-47 Air Vehicle Family
  - Common Systems ... *Common Operating System*
- **Planned Demonstrations**
  - Distributed Adaptive Control Technology / Robust Communications
  - Battlespace Interoperability
  - Affordable LO To The Next Level

***A Transformational System For The Warfighter***

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# Questions?



<http://www.darpa.mil/j-ucas>

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