Unmanned Combat Air Vehicles

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Outline

• Mission
• Current UCAVs
• Component / Configuration
• Human Systems Integration
• X-45A Analysis
• Overall Assessment
Purpose / Mission

• UCAV – Unmanned Combat Air Vehicle
• Military purposes
  • Suppression of Enemy Air Defense (SEAD)
  • Bombing runs
  • Surveillance
• Mission
  – Range = 1000 nm w/ 2 hrs loiter
  – Average payload = 4500 lb

Current UAV / UCAV's

“Take the Pilot Out Of Harms Way”
Navy / Marines Pioneer

- Flew over 300 Missions over Persian Gulf
- Used for Surveillance and Bombing Missions
- The single most valuable intelligence collector *
- STOL Aircraft

* LtGen Boomer, USMC
Air Force Predator

- Long Endurance
- Medium Altitude
- Surveillance and Reconnaissance Missions
- Operational In Bosnia Since 1995
- Also been used to drop Missiles
- 450 lb Payload Capacity
Boeing X-45

- Stealth and low observability features
- Still Experimental
- Truck Based support Systems
- Highly Automated, One Operator can control up to four Air Vehicles
UCAV Milestones

• X-45A
  – First Flight, May 22, 2002
  – Release of unguided bomb, March 20, 2004
  – Precision-guided release, expected soon

• X-47A Pegasus
  – First Flight, February 23, 2003

Component Integration

Fuel Tanks Above Payload Bays, and Between Wing Carry-Through Bulkheads

Two-Dimensional Vectoring Exhaust Nozzle System

AlliedSignal F124-GA-100 Engine

Multiple TE Control Surfaces

Fwd Retracting Modified T-38 MLG

Full Size Payload Bay With Multiple Bomb Rack for JDAM or SDB

Centerline-Integrated Propulsion System with Top-Mtd Inlet

43° Leading/Trailing Edge Alignment

Detachable Dry Wings

Full Size Payload Bay with Palletized MMS, VMS, and Flight Test Equip

Modified F-5E NLG

Nose Boom Air Data

**Controls**

*Pitch Control: Symmetric Deflection of Elevons*

*Roll Control: Differential Deflection of Elevons*

*Yaw Control: Nozzle Vectoring + ‘Crow-Mixing’ of Outbd/Mid Elevons*

Aerodynamic Configuration Drivers

• Removal of human factor constraints
• Cost effective
• Multi-disciplinary, multi-mission design challenges
• High maneuverability and agility
  – 2 design features
    1) Fuselage placement
    2) Planform
Human Factors

- What information does the operator need during flight?
- What is the best way to display this info?
- Are communication links fast enough?
- What controls should the operator have and what should be done autonomously?
- What feedback is necessary from the aircraft?

Operators must be included in the design process

Human Systems Integration Strengths

- Take the Pilot out of Harms Way
- Highly Automated
- Built to allow aircraft system and components to be interchangeable and easily replaced
- Designed for easy Maintenance

AIAA paper 98-1032
Human System Integration Shortfalls

- Displays are non-conventional
- Limited Field of View
- Potentially Ambiguous Information
- Relatively High Operational Costs
- Requires High Levels of Operator Skills

AIAA paper 98-1032
## Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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<tbody>
<tr>
<td>Empty Weight</td>
<td>8,000 lbs</td>
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<tr>
<td>Fuel Weight</td>
<td>2,690 lbs</td>
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<tr>
<td>Payload</td>
<td>1,500 lbs</td>
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<tr>
<td>Operating Altitude</td>
<td>35,000 ft</td>
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<td>Cruise Mach No.</td>
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Vortex Lattice Methods

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<tr>
<th></th>
<th>VLMpc</th>
<th>Tornado©</th>
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</thead>
<tbody>
<tr>
<td>$C_{L\alpha}$</td>
<td>0.053 /deg</td>
<td>0.048 /deg</td>
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<tr>
<td>$C_{m\alpha}$</td>
<td>0.00408 /deg</td>
<td>0.00252 /deg</td>
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</table>
Force Measurements

- 1:46.2 scale
- Boeing 1301 UCAV config
- $C_{L\alpha} = 0.049 /\text{deg}$
- $Re = 142,000$
  (full scale => $Re \approx 30$ million)

# Takeoff / Landing Performance

## First Flight, X-45A

<table>
<thead>
<tr>
<th><strong>Takeoff Performance</strong></th>
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<tbody>
<tr>
<td><strong>T/O Speed</strong></td>
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<tr>
<td><strong>T/O Distance</strong></td>
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<tr>
<td><strong>Climb Rate</strong></td>
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<tr>
<th><strong>Landing Performance</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Approach Speed</strong></td>
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<tr>
<td><strong>T/D Sink Rate</strong></td>
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<tr>
<td><strong>Landing Distance</strong></td>
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</tbody>
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Overall Assessment

• Pros
  – Eliminate pilot casualties
  – More maneuverable
  – Reduce pilot fatigue
  – Flexibility
  – Possibility for future cost reduction

• Cons
  – Limited control abilities
  – Limited pilot reasoning
  – Delayed response time
  – Adaptability to mission modification
Questions?