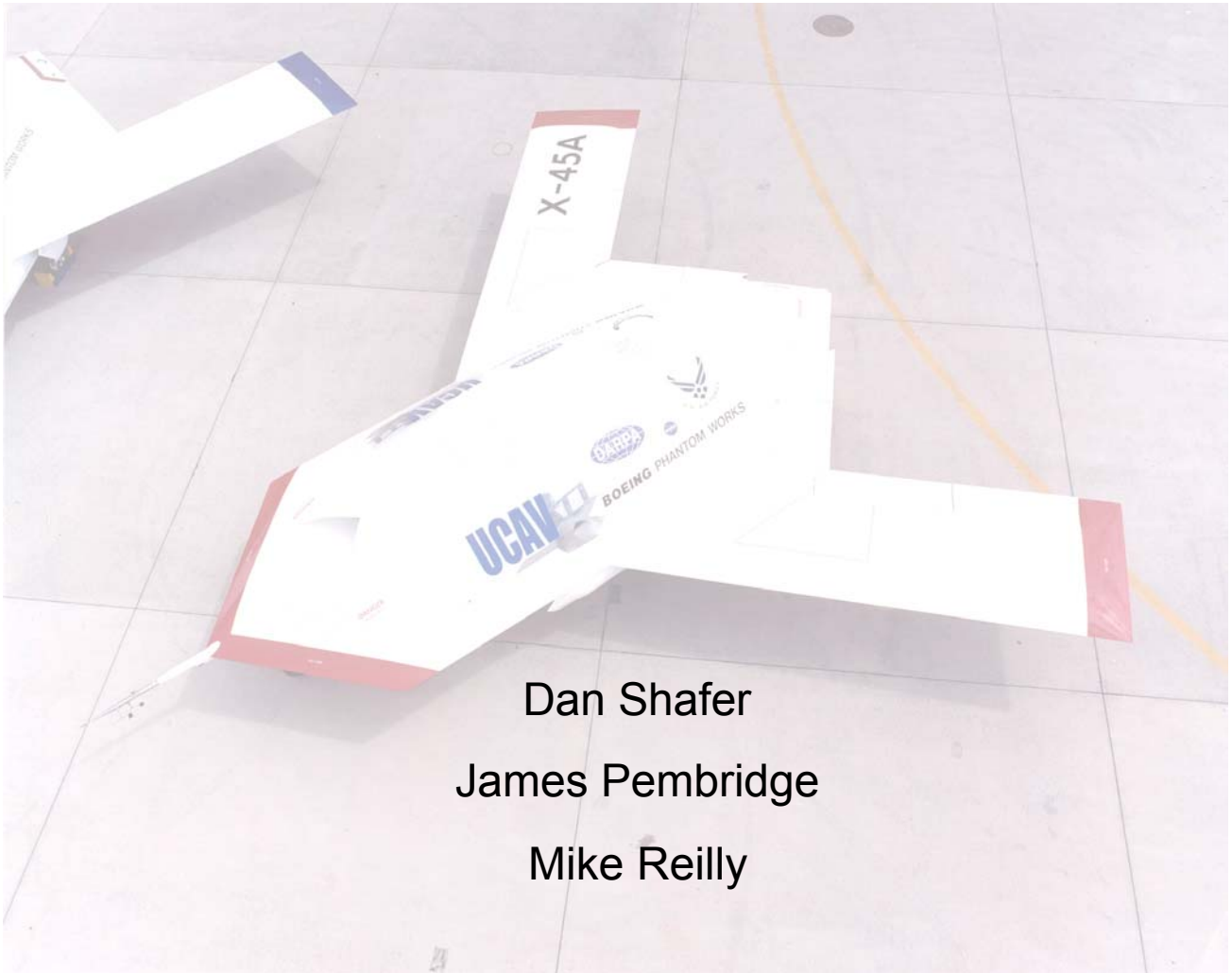
Unmanned Combat Air Vehicles



Dan Shafer

James Pembridge

Mike Reilly

Outline

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

Purpose / Mission

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

http://www.darpa.mil/j-ucas/index.htm

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

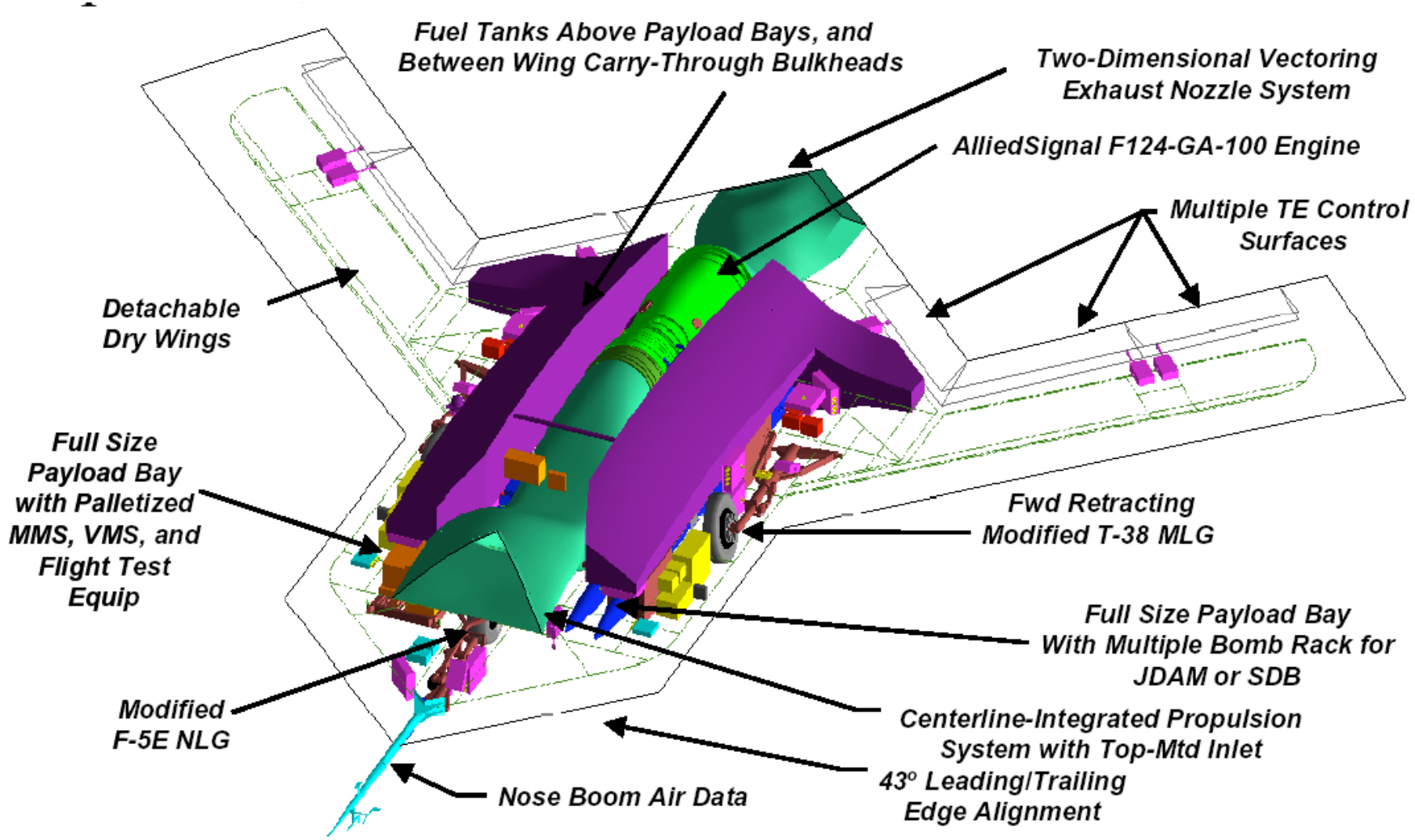
- Stealth and low observability features
- Still Experimental
- Truck Based support Systems
- Highly Automated, One Operator can control up to four Air Vehicles

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

Source: http://www.darpa.mil/j-ucas/index.htm

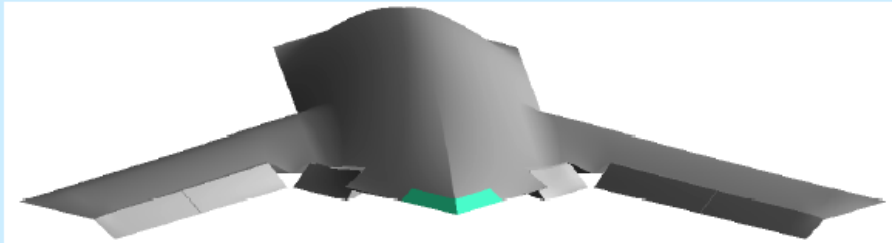
Component Integration



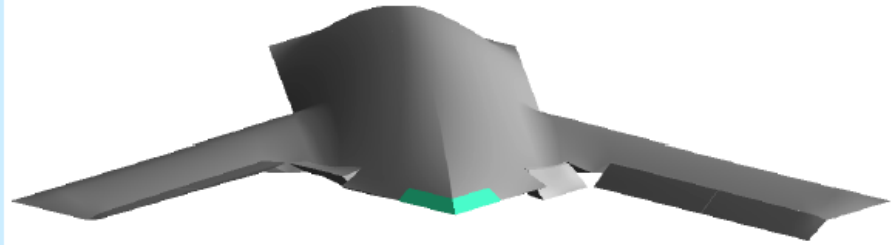
Source: Wise, Kevin, "First Flight of the X-45A Unmanned Combat Air Vehicle (UCAV)", AIAA 2003-5320

Controls

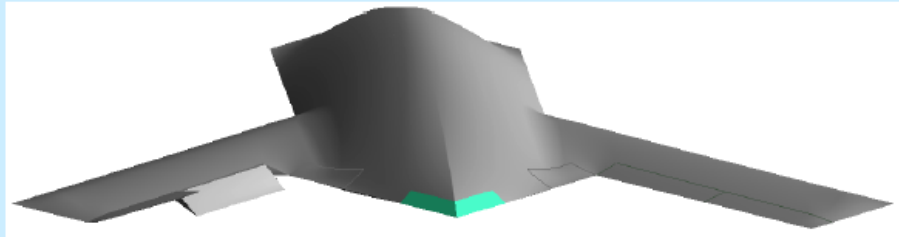
***Pitch Control*: Symmetric Deflection of Elevons**



***Roll Control*: Differential Deflection of Elevons**



Yaw Control: Nozzle Vectoring + 'Crow-Mixing' of Outbd/Mid Elevons



Source: Wise, Kevin, "First Flight of the X-45A Unmanned Combat Air Vehicle (UCAV)", AIAA 2003-5320

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

Source: Garner, M., "HSI Issues from a USAF Pilot/Combat UAV Test Operator Perspective", AIAA 2002-3434

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

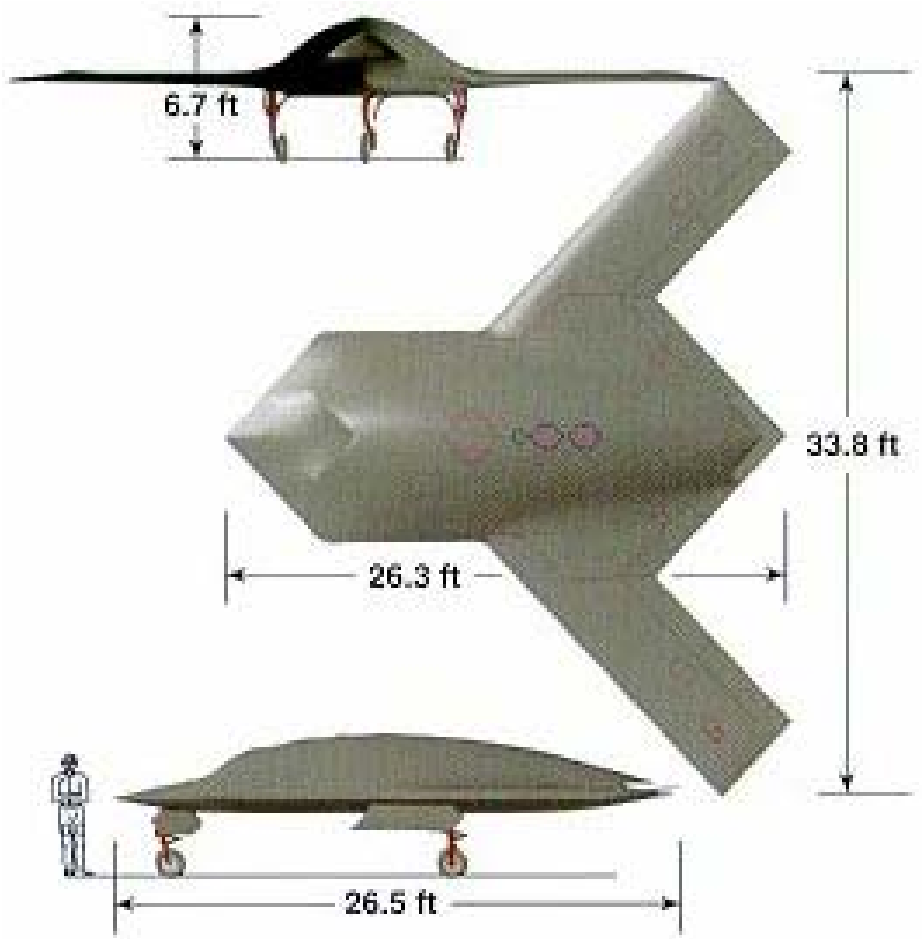
AIAA paper 98-1032

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

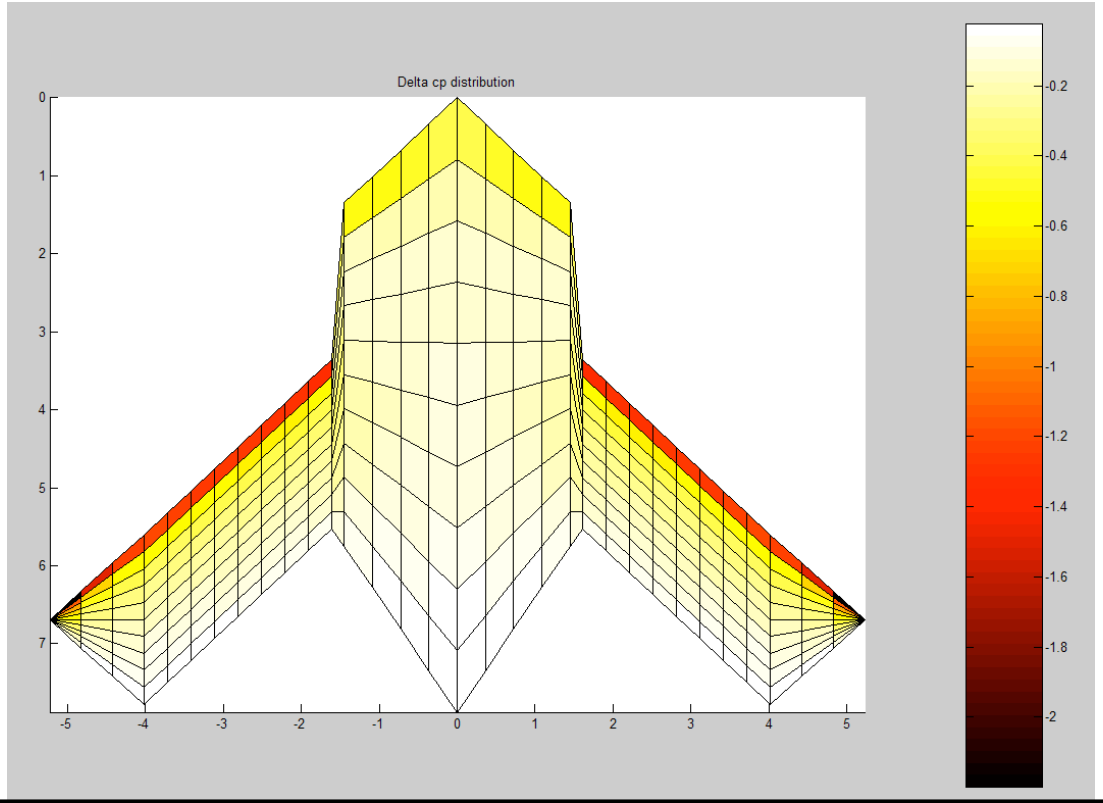


http://www.invisible-defenders.org/programs/uavs/x-45-design-man.htm

Empty Weight	8,000 lbs
Fuel Weight	2,690 lbs
Payload	1,500 lbs
Operating Altitude	35,000 ft
Cruise Mach No.	0.80

Source: Wise, Kevin, "First Flight of the X-45A Unmanned Combat Air Vehicle (UCAV)", AIAA 2003-5320

Vortex Lattice Methods

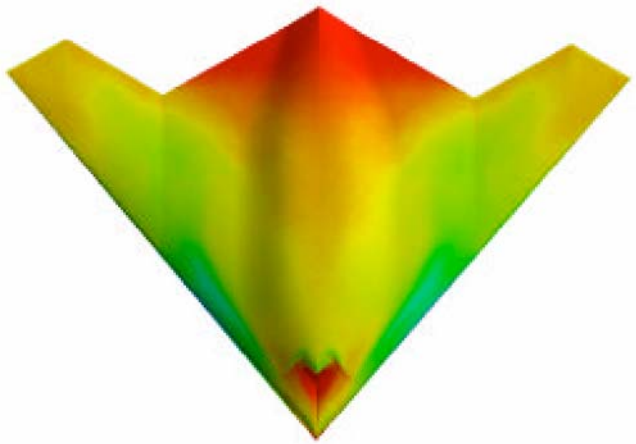


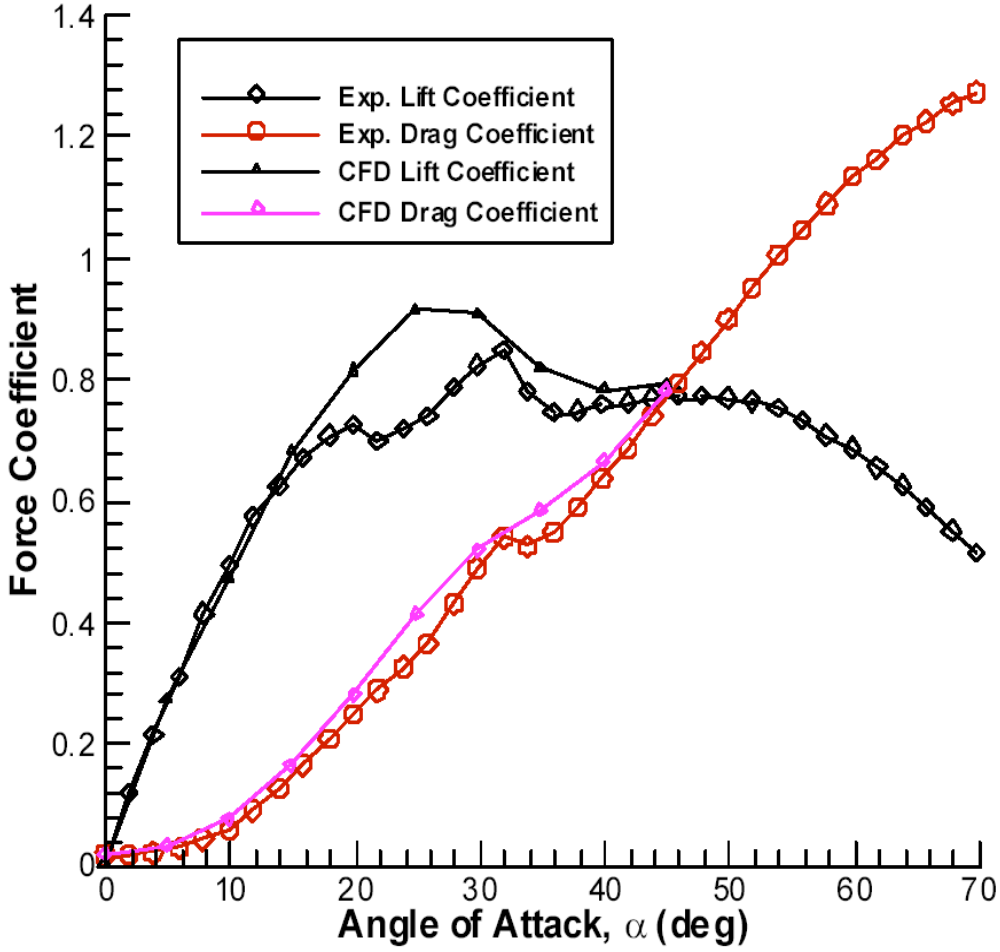
	VLMpc	Tornado©
$C_{L\alpha}$	0.053 /deg	0.048 /deg
$C_{m\alpha}$	0.00408 /deg	0.00252 /deg

Force Measurements

- 1:46.2 scale
- Boeing 1301 UCAV config
- $C_{L\alpha}$ = 0.049 /deg

- Re = 142,000
  (full scale => Re~30 million)





Source: Cummings, R., et al, "Numerical Prediction and Wind Tunnel Experiment for a Pitching UCAV", AIAA 2003-0417

Takeoff / Landing Performance

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: EC02-0106-07 Date: May 22, 2002 Photo by: Carla Thomas
X-45A Unmanned Combat Air Vehicle, or UCAV, technology demonstration aircraft taking off during its first flight at Edwards Air Force Base, California.

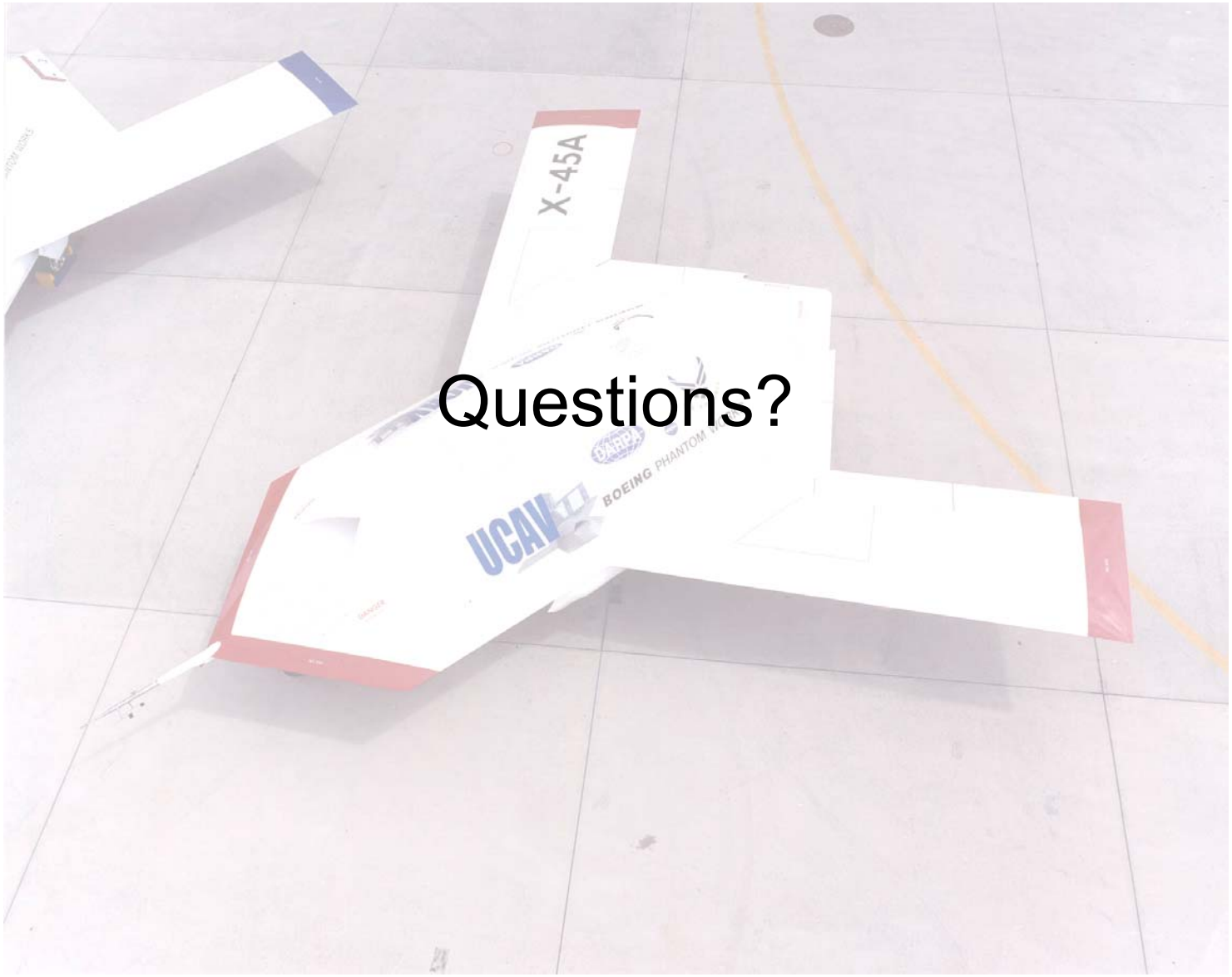
First Flight, X-45A

Takeoff Performance	
T/O Speed	152 KEAS
T/O Distance	4500 ft
Climb Rate	1000 ft/min
Landing Performance	
Approach Speed	175 KEAS
T/D Sink Rate	2.7 ft/s
Landing Distance	3500 ft

Source: Wise, Kevin, "First Flight of the X-45A Unmanned Combat Air Vehicle (UCAV)", AIAA 2003-5320

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?