Ejection Safety for Advanced Helmet Mounted Displays

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Objective

- Develop helmet technology alternatives to optimize aerodynamic loading on the head and neck during ejection at 600 KEAS while equipped with Helmet Mounted Displays (HMD's)
- Maintain similar functionality and protection of existing aircrew helmet
- Attempt to reduce overall helmet mass to offset the added mass of HMDs

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Approach

- Develop helmet technology concepts
- Evaluate concepts using computational fluid dynamic analysis
- Physical tests of helmet components
- Prototype fabrication
- Finalize and optimize design in full-scale testing

Design and Evaluation Tools

- Conceptual:
  - Pro/Engineer: Computer Aided Design Software
  - PowerFLOW: CFD Analysis, Numerical Simulation
  - MADYMO: Dynamic Inertial Assessment
- Experimental:
  - Helmet Test Apparatus: Biokinetics Test Lab
  - Wind Blast Testing: Biokinetics Air Cannon
  - Wind Tunnel Testing: Low and High Velocity
  - Open Jet Wind Blast

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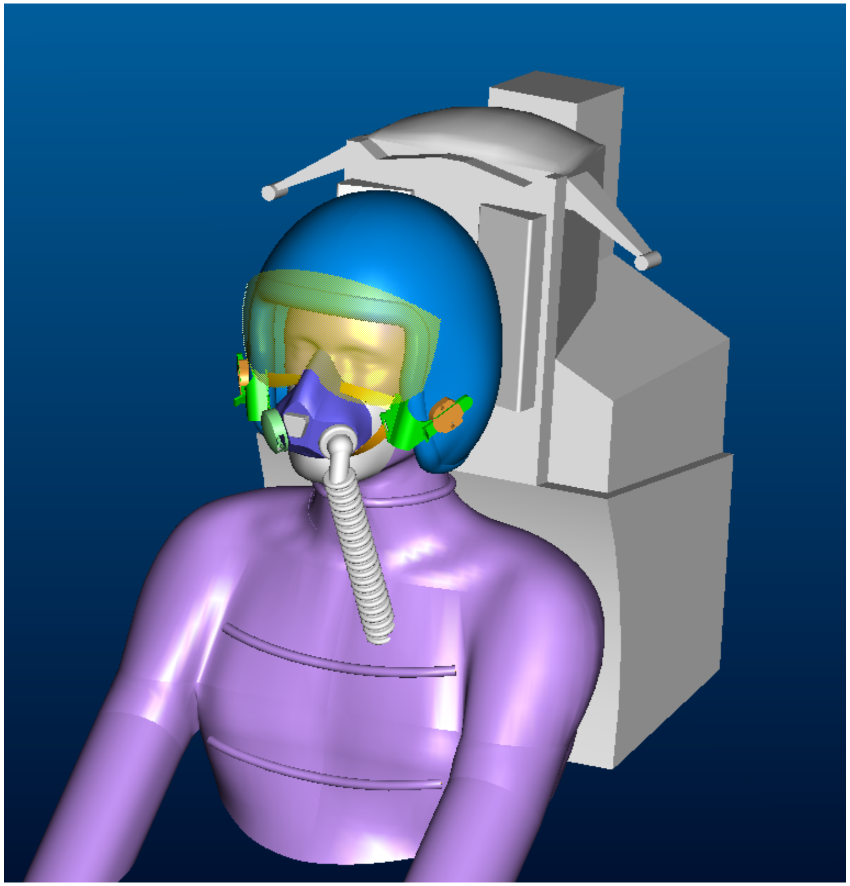
Computational Fluid Dynamic Analysis

CFD Model Set-up

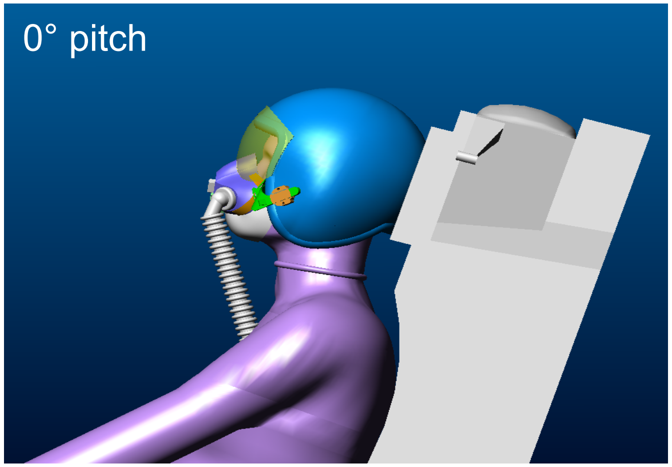
Model components

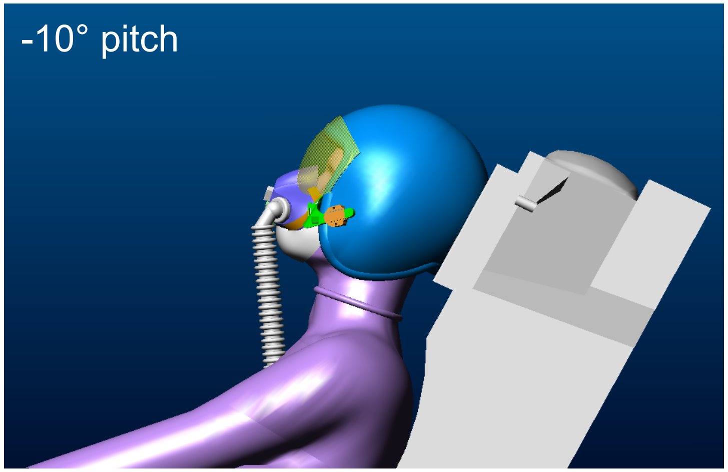
- ACESII seat
- Pilot (50 %'ile male)
- HGU-55/P helmet
- MBU-20/P oxygen mask
- Visor
- Ribs to simulate the turbulence from the flight suit



Baseline HGU-55/P with Standard Visor

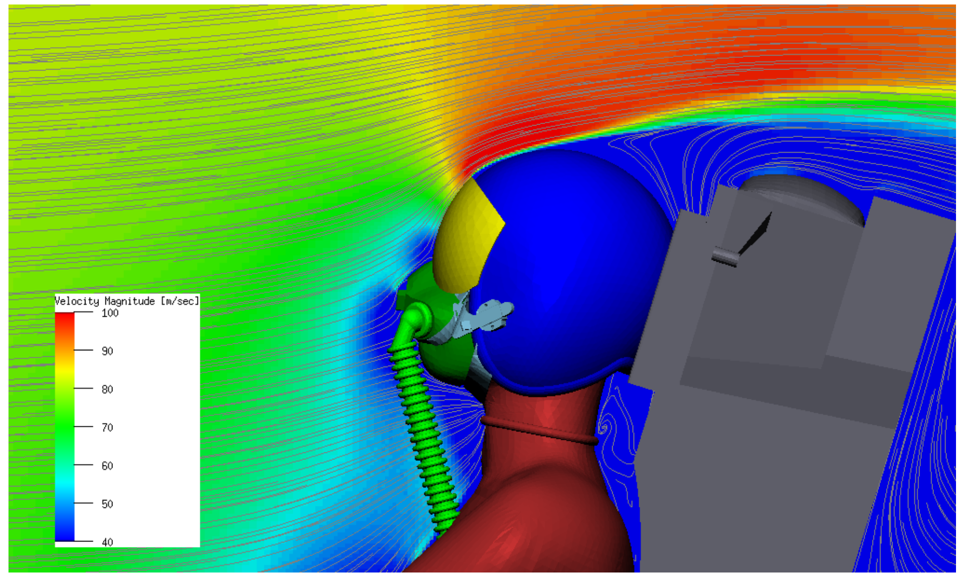
- 0° and 10° pitch
- 0° yaw
- 165 KEAS
- Standard visor and accessories
- To be used for PowerFLOW validation

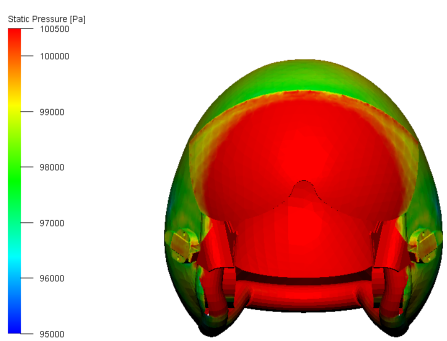


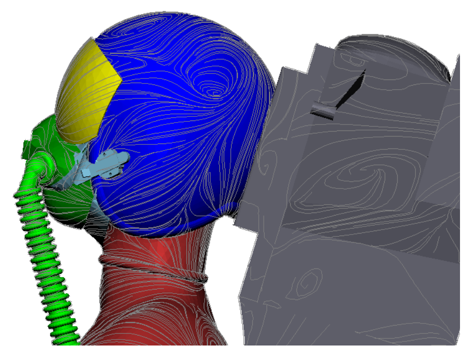


Baseline Result 0°

- Clift=0.514
- Cdrag=0.639
- Cpitchmoment=1.136

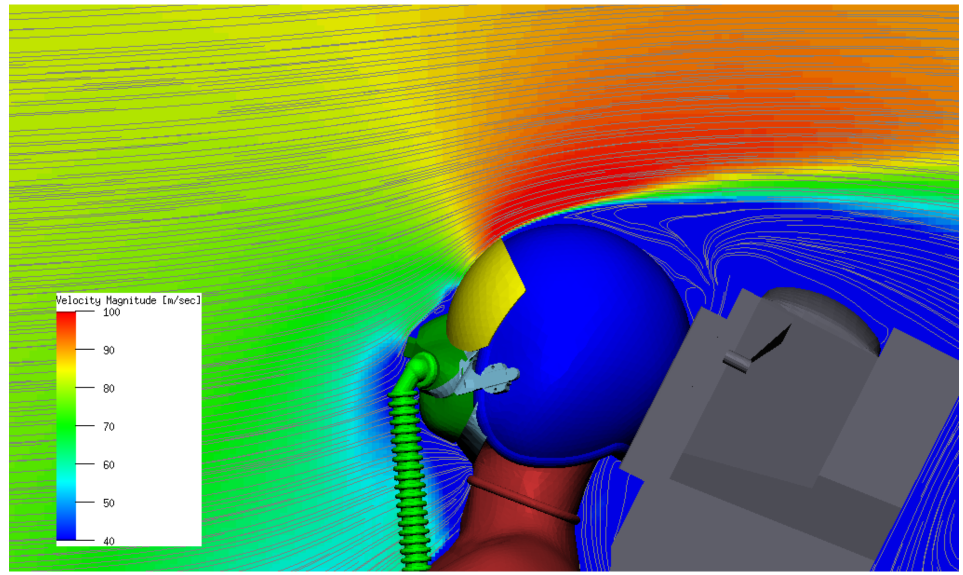


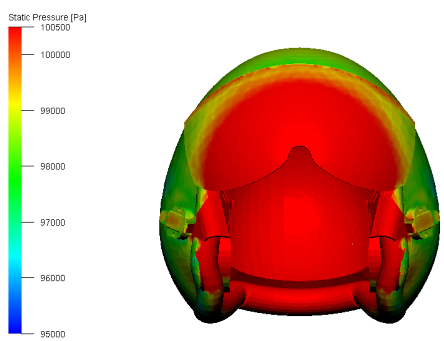


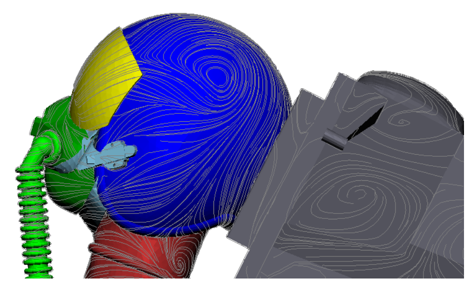


Baseline Result 10°

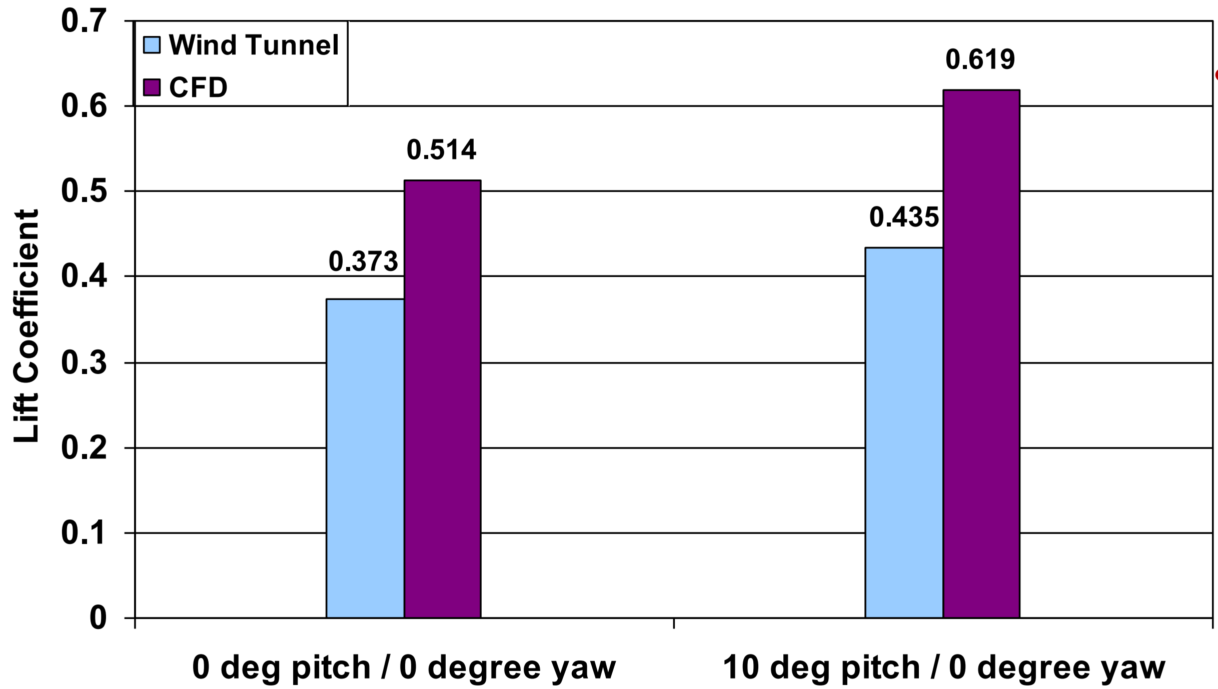
- C_{lift}=0.619
- C_{drag}=0.646
- $C_{pitchmoment}$=1.076







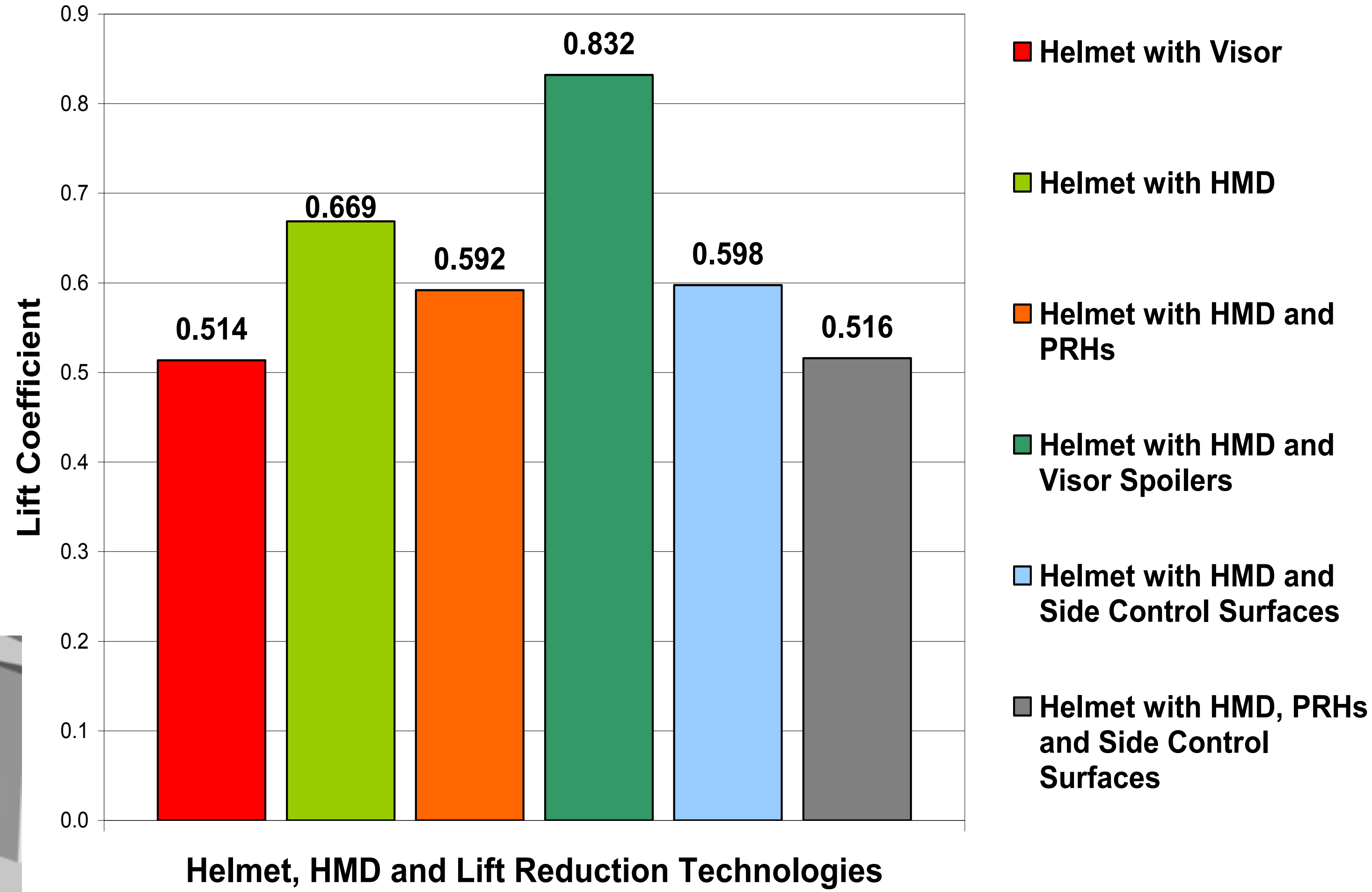
CFD Comparison to Tunnel Results



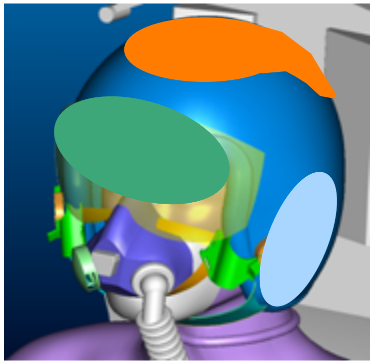
- Powerflow results are nominally 40% higher than available tunnel data because of inability to model the force interaction between helmet and seat.

- Looking at relative trends the design approach assumes that a for a given reduction in PowerFlow a similar reduction in tunnel lift would be expected.

Helmet Configurations Tested



Application areas of anti-lift features



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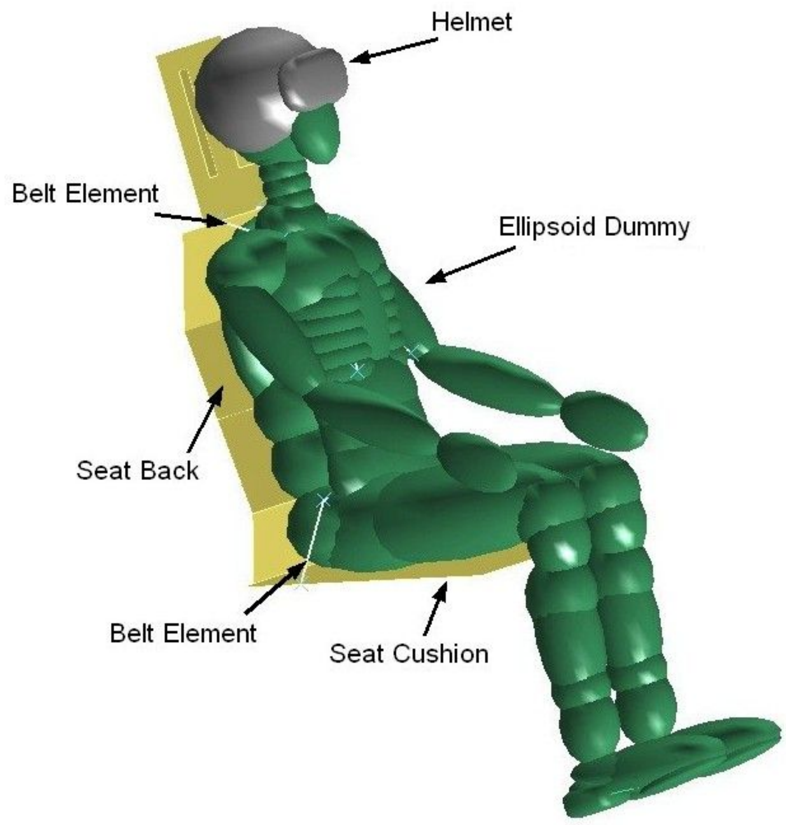
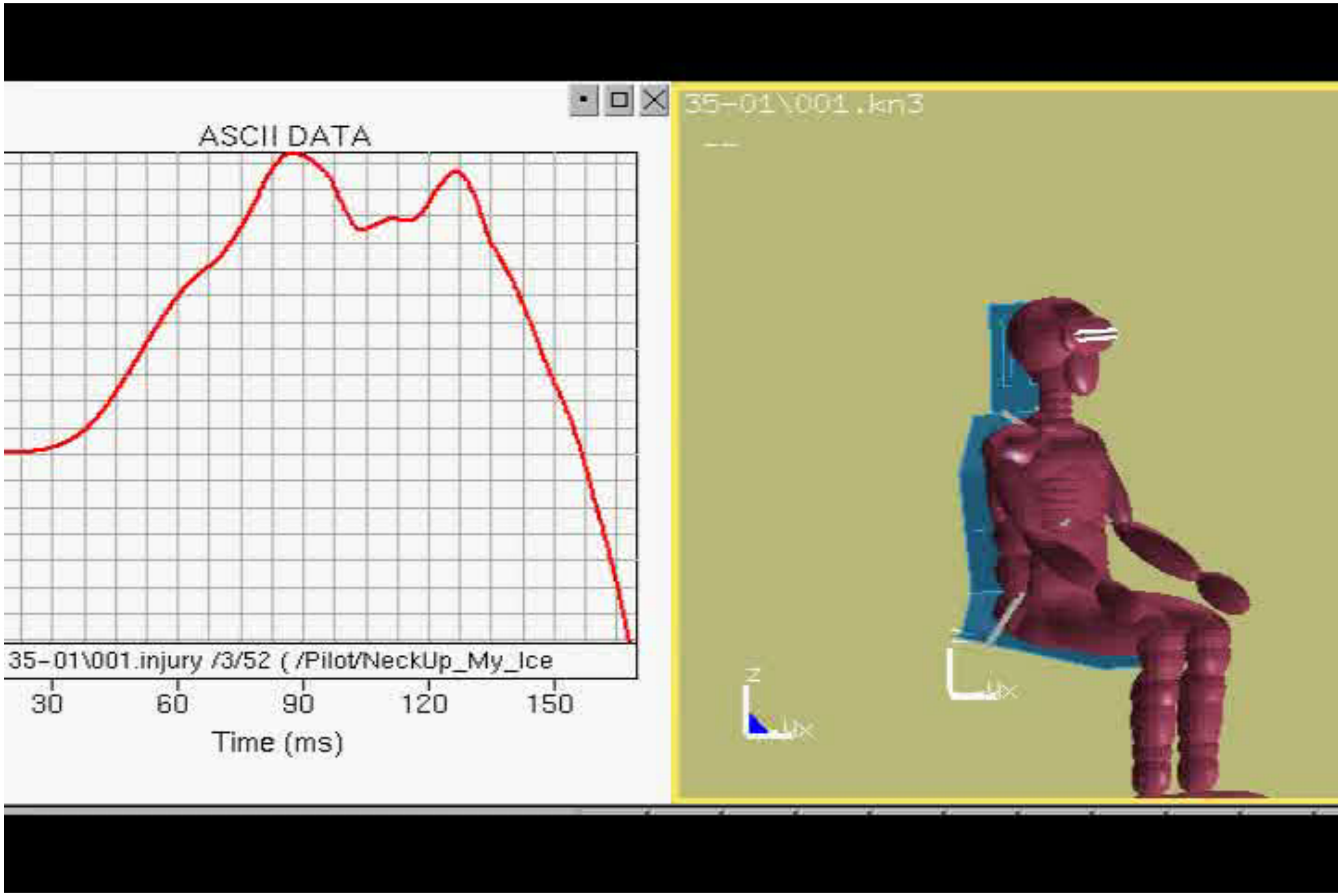
Dynamic Inertial Assessment

Lumped Mass Ejection Model

- Inertial load from a helmet during ejection would act to reduce the aerodynamic lift
- MADYMO model (Hybrid III) used to evaluate the effects of inertial loading on the head and neck as a result of ejection
- A typical acceleration pulse of an ACES II seat was used as input to the MADYMO model
- Varying masses, simulating HMD's were added to evaluate the effects



Lumped Mass Ejection Model



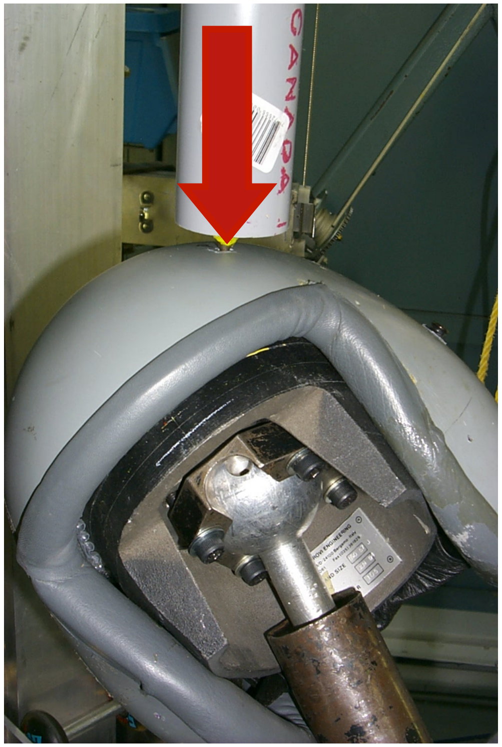
Summary of MADYMO Results

Measured Neck Loads	Forces		Moments
	Fore-aft (N)	Vertical Compression (N)	Flexion (Nm)
Maximum	90.6	584.8	12.6
Minimum	78.1	644.1	8.4
Average	83.6	613.8	10.9

Laboratory Testing

Impact and Penetration Evaluation

- Modified HGU/55-P helmet subjected to impact and penetration testing



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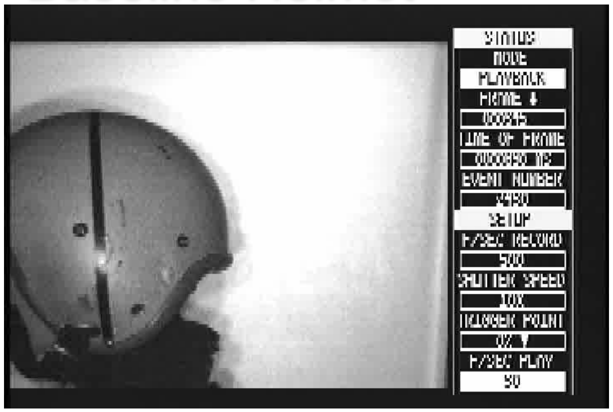
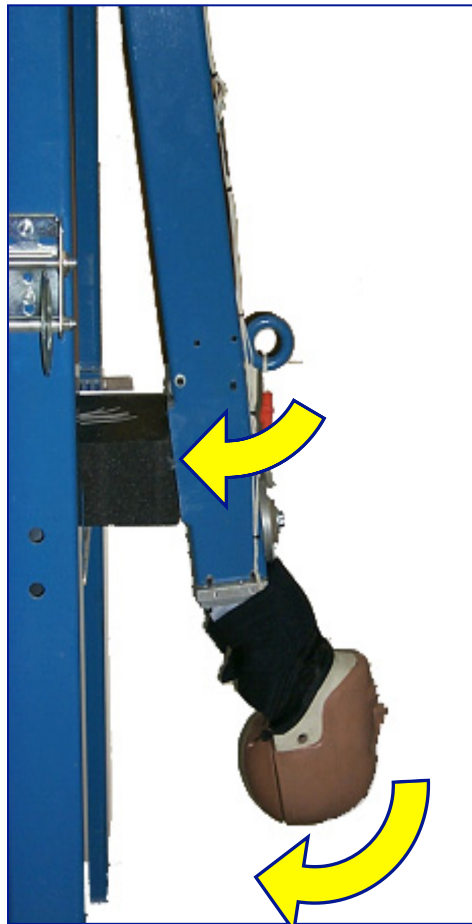
Helmet Stability: Using A Neck Pendulum

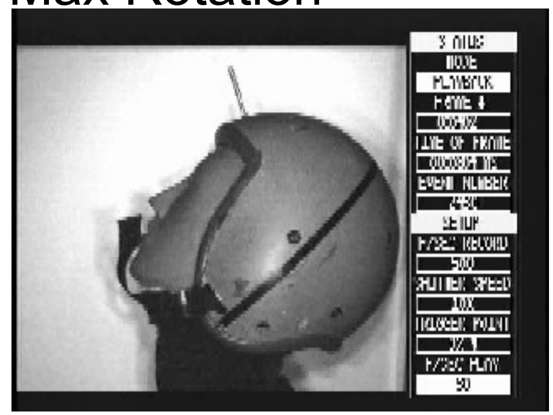
Baseline Helmet



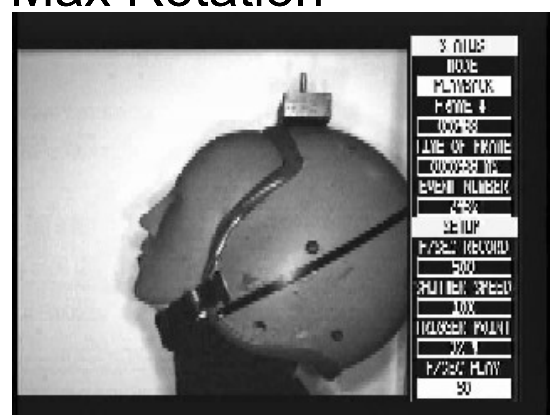
With HMD Mass



Max Rotation



Max Rotation



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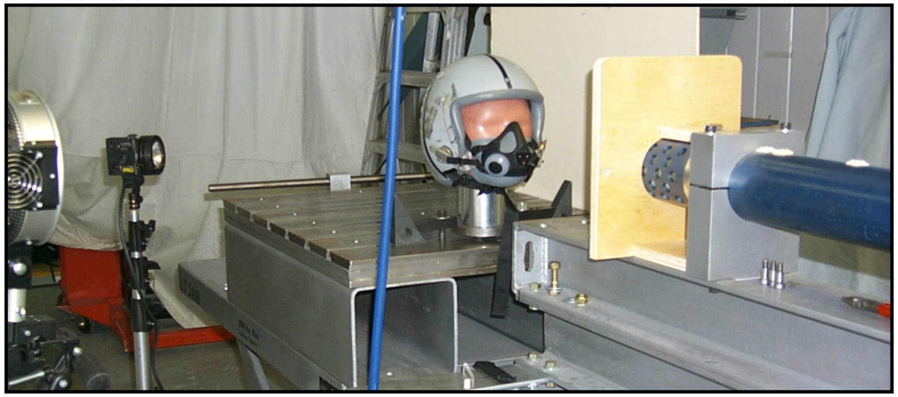
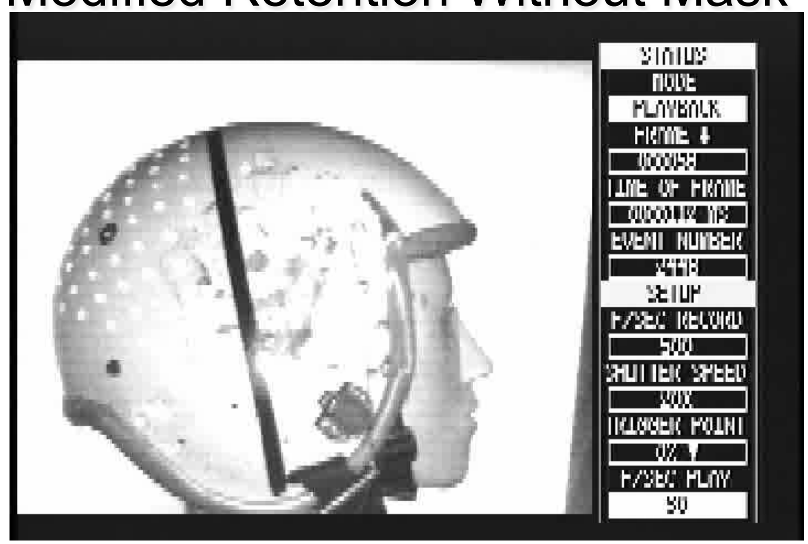
Helmet Stability: Wind Blast



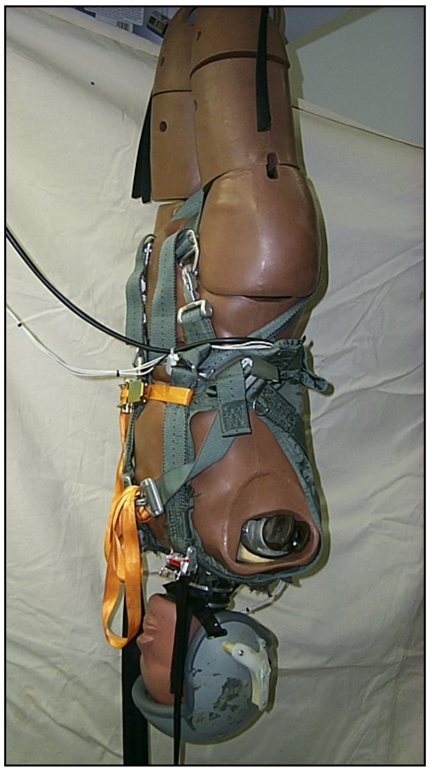
Standard Retention with Mask

Modified Retention Without Mask



Parachute Riser Interference Evaluations

Test Setup



Control Surface Only

Control Surface with Deflector V1

Control Surface with Deflector V2

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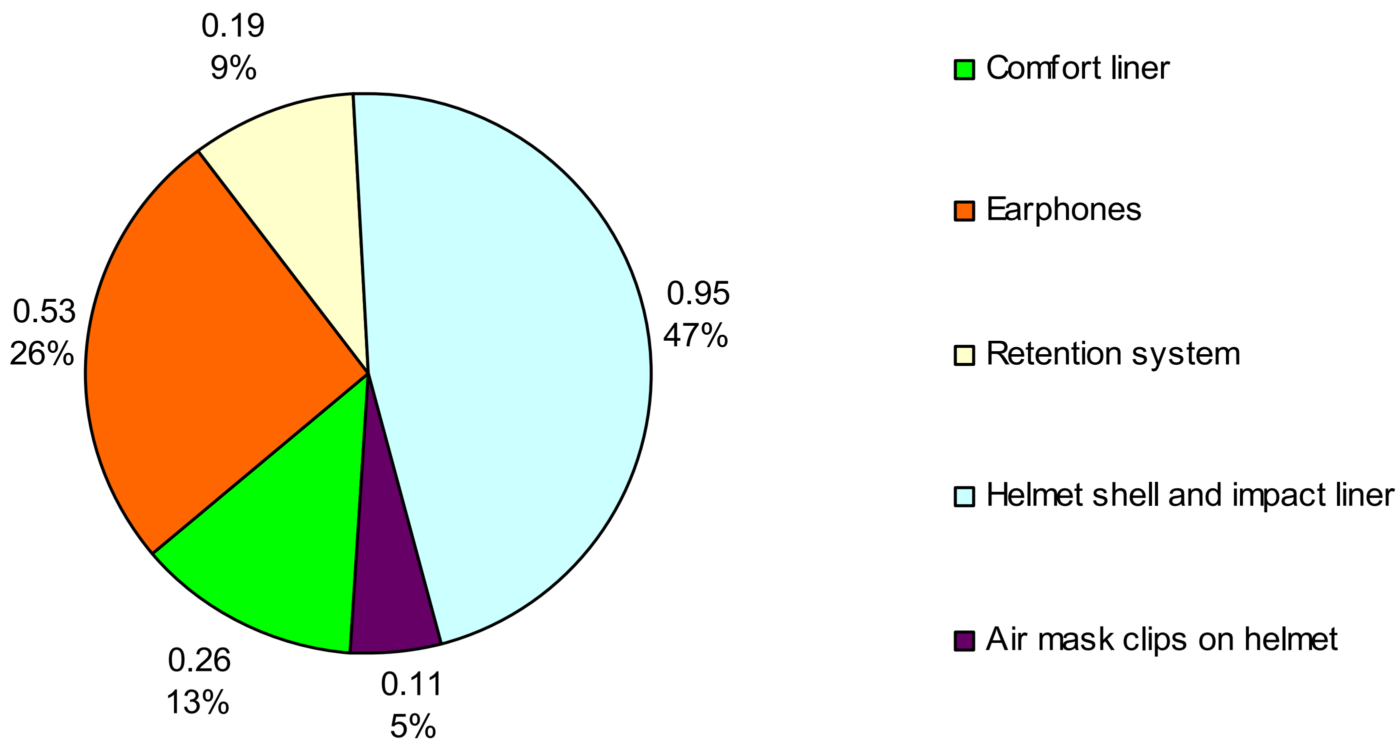
Helmet Mass Reduction of Headwear System

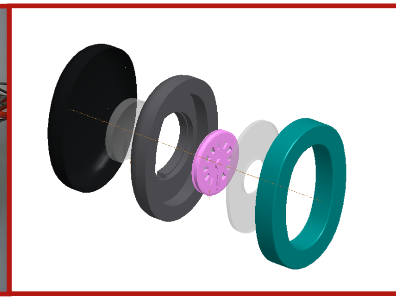
Mass of HGU-55/P Components



Mass of Helmet 2.04 lbm

All Masses are in Pounds

Earphone Mass Reduction

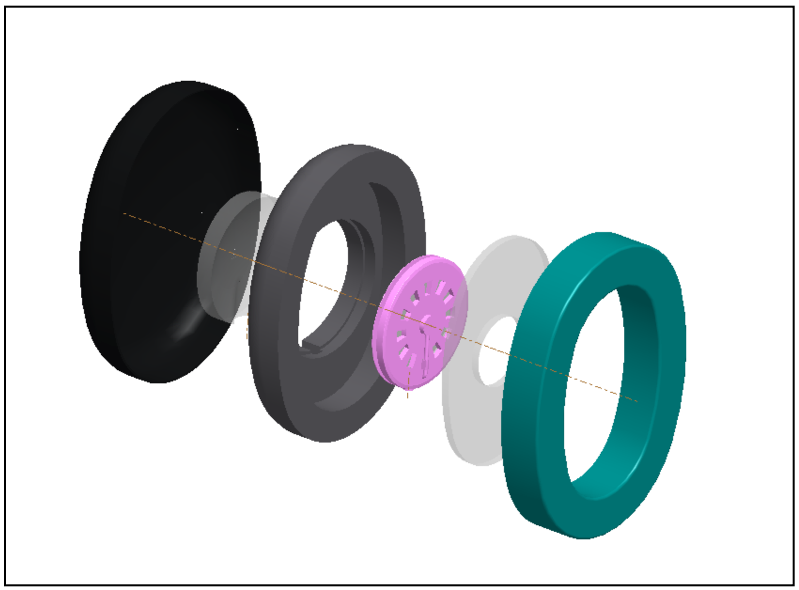


Features	H-154A/AIC (single earphone)	Biokinetics Prototype (single earphone)
Mass	0.249 lb_m	0.158 lb_m
Overall Height	1.85 inch	1.65 inch
Sound Pressure Level	80.8	78.3
Peak G (2 ft drop)	75	~60

- New earphone assembly reduced the overall helmet mass by 9%

Earphone Assembly Concept

- Earphone prototype submitted for acoustical evaluation: performed equally to H-154A/AIC
- Earphone has a crushable element which provides additional impact protection on the side of the helmet



Summary

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Concept Development Status

- Anti-lift technologies verified in CFD*
- Ear-cup design completed and verified*
- Retention system design completed*
- Shell design completed*

* Patent Pending

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Helmet Shell Concept and Prototype