Occupant Protection Project

Validation of THOR Finite Element Model

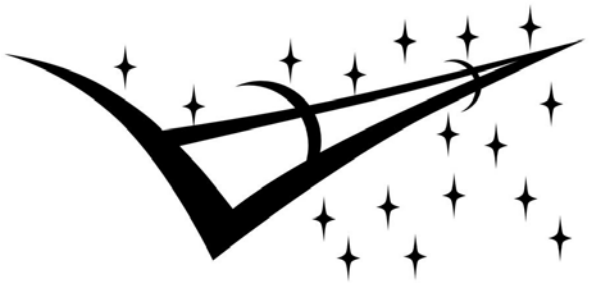
Erik Moore

University of Nebraska – Lincoln

Jeff Somers and Jessica Wells

Occupant Protection

SPACE LIFE SCIENCES
SUMMER INSTITUTE



Introduction

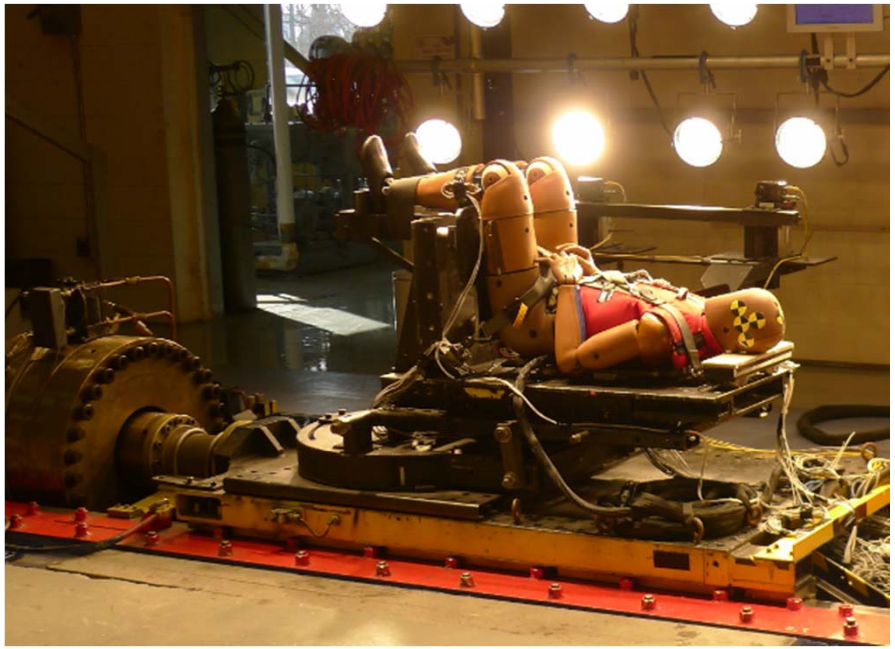
- Hometown: Eagle River, Alaska
- University of Nebraska-Lincoln
  - Biological Systems Engineering
  - Minor - Biomedical Engineering
- Career Interests in Biomechanics and Medicine

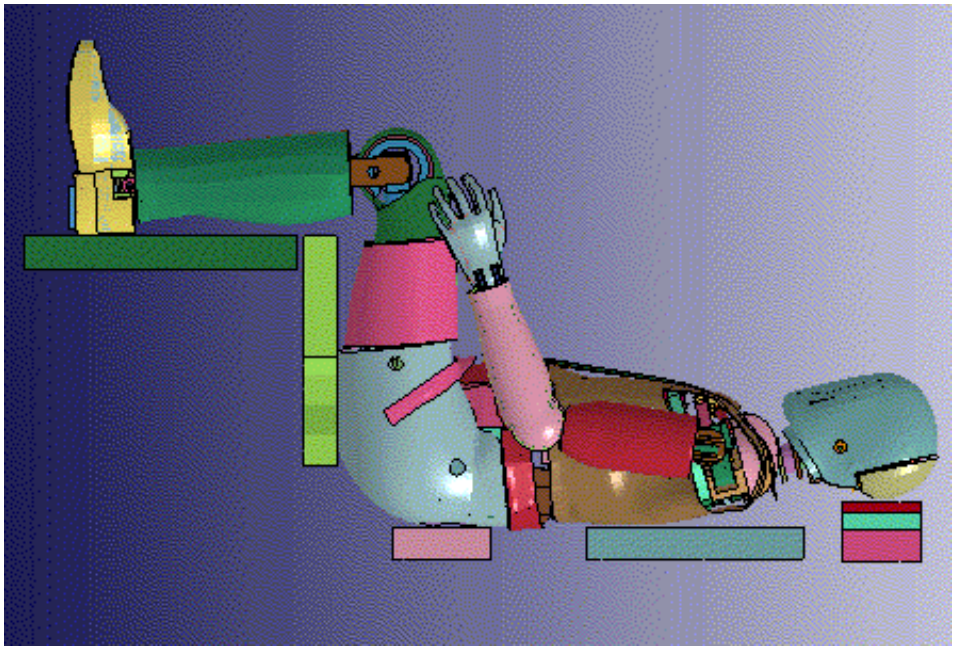
Background

- Occupant Protection Project works to ensure safety of the crew during dynamic phases of spaceflight
  - Deconditioning of the crew
- Sled tests to accelerate humans and crash test dummies
  - NASCAR, IndyCar, Orion tests
- Develop requirements for Orion
- Creating Finite Element Model of the ATD to simulate tests

Objectives of Internship

- Validate Finite Element Crash Test Model
- Compare Physical tests with Computer Simulation
- Correlation Analysis of model accuracy

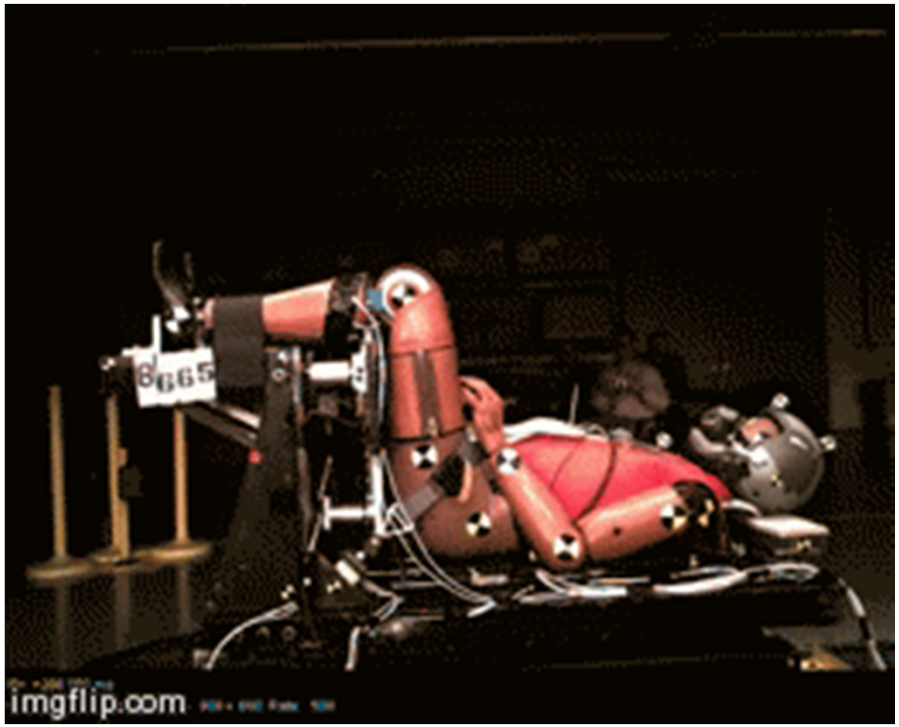




Methods and Procedures

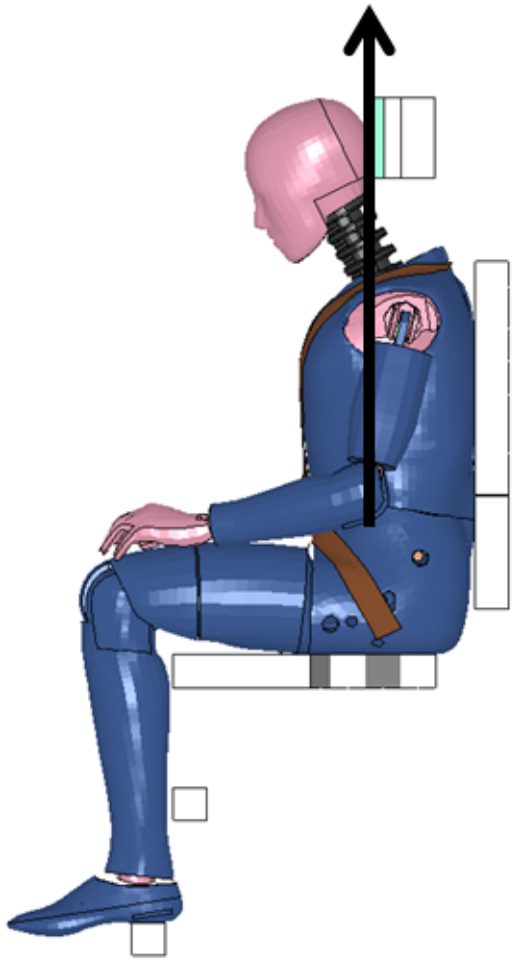
- Process previously completed physical trials and obtain kinetic data
- Run simulations of finite element model using LS-DYNA
  - Process simulations, create graphs and injury risk calculations
- Developed MATLAB,

  and various programming skills



Case Description

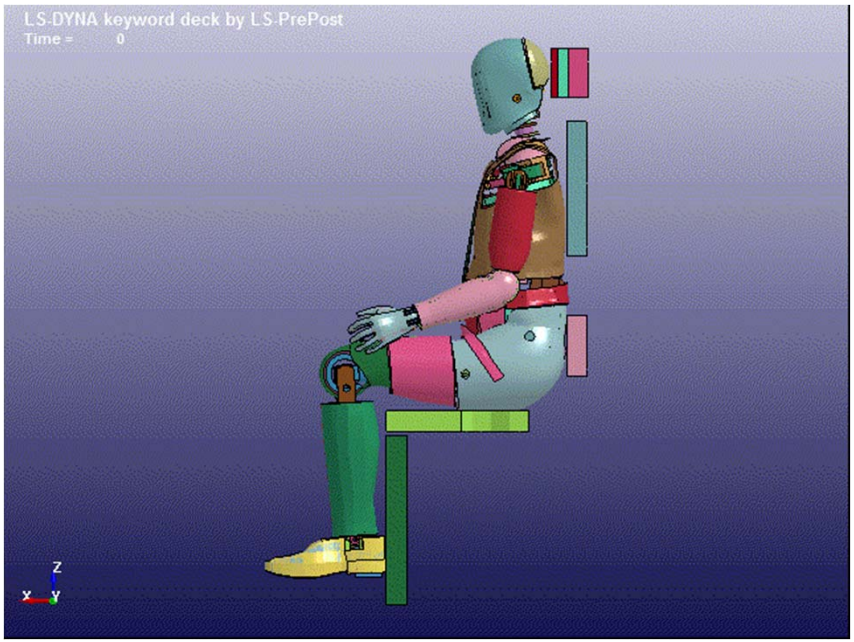
Test Number	8665
Study Number	201302
Impact Direction	Spinal (+Z)
Cell	E2
Impact G Level	10.0
Rise Time [ms]	70.0
Max G Level [G]	9.7
DeltaV [ft/s]	0.9
DR	12.6
Subject Type	MANIKIN-M
Subject ID	THOR-K
Subject Height [in]	67.0
Subject Sitting Height [in]	35.7
Subject Weight [lbm]	164.0
Subject Age	N/A
Seat	Base2
Restraint Configuration	MB-6
Suit Configuration	HGU-55/P Helmet



Summary

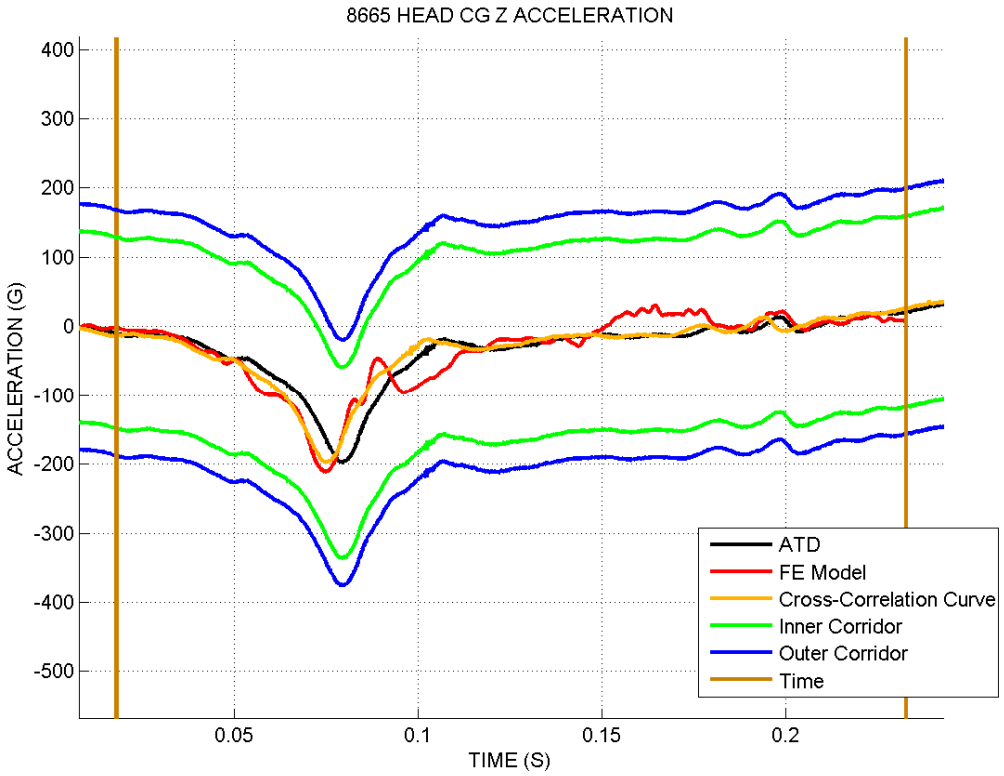
Metric	Unit	Value	Limit
Brinkley β	**N/A**	**0.55 (Low)**	**1.0 (Low)**
$+DR_x$	N/A	0.0	35
$-DR_x$	N/A	0.0	-28
$\pm DR_y$	N/A	0.0	±15
$+DR_z$	N/A	12.6	15.2
$-DR_z$	N/A	-1.6	-13.4
HIC 15	**N/A**	**20.0**	**340**
HIC 36	N/A	23.4	340
BrIC	**N/A**	**0**	**0.04**
N_{ij}	**N/A**	**0.3**	**0.5**
N_{TE}	N/A	0.0	0.5
N_{CE}	N/A	0.2	0.5
N_{TF}	N/A	0.3	0.5
N_{CF}	N/A	0.3	0.5
N_{TL}	N/A	0.0	0.5
N_{CL}	N/A	0.2	0.5
Neck Axial Compression Force Duration	N/A	0.4	1
Peak Neck Axial Compression Force	**lbf**	**-255**	**-130**
Neck Axial Tension Force Duration	N/A	0.0	1
Peak Neck Axial Tension Force	**lbf**	**0**	**200**
Maximum Chest Compression	**in**	**0.51**	**0.98**
Peak Lateral Shoulder Contact Force	**lbf**		**607**
Peak Acetabular Lateral Force	**lbf**		**360**

Metric	Unit	Value	Limit
Peak Thoracic Axial Compression Force	**lbf**	**1215**	**1300**
Peak Ankle Dorsiflexion Moment	**in-lbf**		**160**
Peak Ankle Inversion/Eversion Moment	**in-lbf**		**150**
Average Distal Forearm Speed	**ft/s**		**27**
Right Arm Flail Force	lbf	11	54
Left Arm Flail Force	lbf	19	54
Right Leg Flail Force	lbf	184	54
Left Leg Flail Force	lbf	145	54



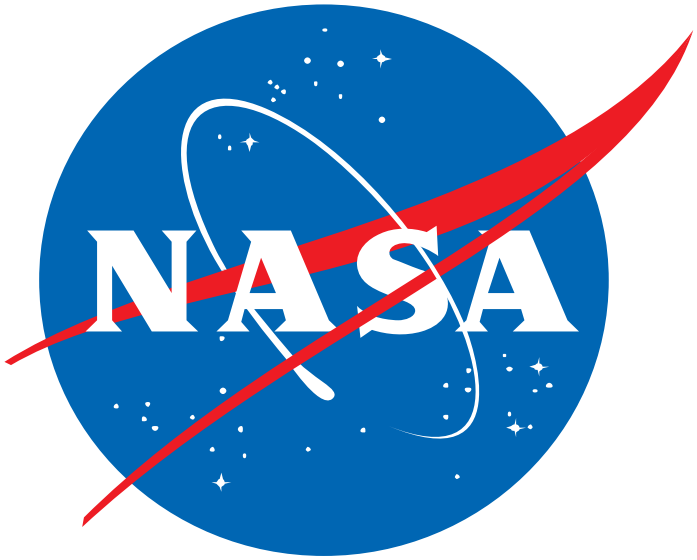
Correlation Analysis and Results

- CORA (Correlation Analysis) used to determine accuracy of model
- Compare all matching measurements
- Use CORA scores to evaluate model
- Most simulations accurate



CORA ANALYSIS	
Corridor Method Score	1.0
Correlation Method Score	0.947
Overall CORA Score	0.979

Discussion

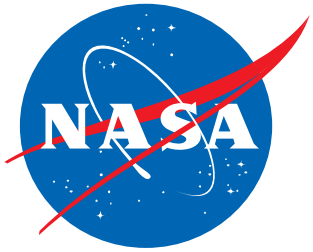


- What I learned during this summer
  - MATLAB
  - Sled testing and the need to protect astronauts
  - All about NASA and their future plans
- What is next for NASA and the Occupant Protection Project
  - Further optimization of the model using CORA scores
  - Compare the Finite Element Model to human tests
  - Create requirements for Orion
- Analysis will help HHP make sure the crew is not exposed to dangerous conditions during flight

Questions?

Thanks

- Jeff Somers and Jessica Wells – Awesome mentors throughout the summer
- Nate Newby
- Lauren Merkle and Judy Hayes
- Missy Mathias and Diego Rodriguez


NASA