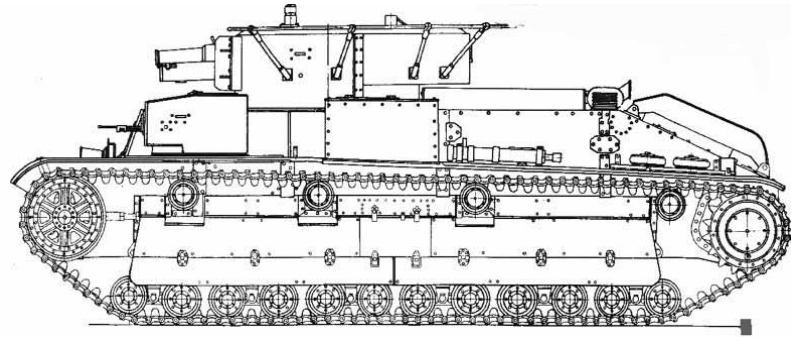


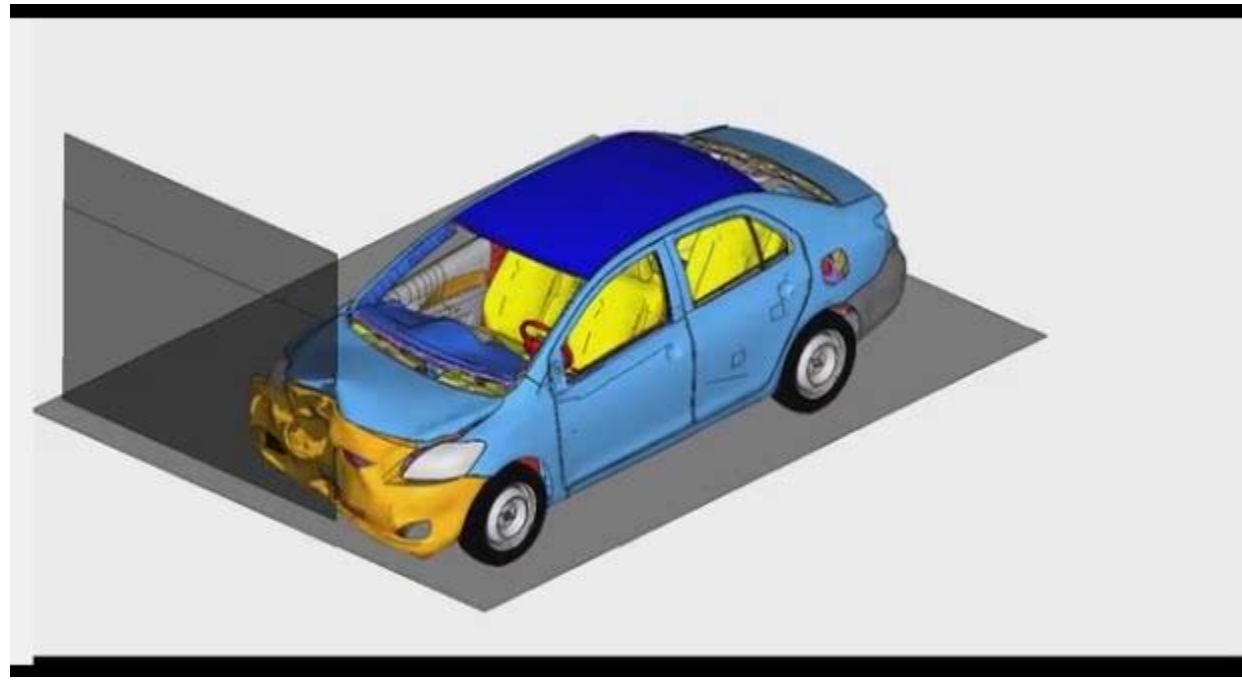
SANTOS®: The Virtual Soldier



Why the Virtual Soldier?



Physical
prototypes



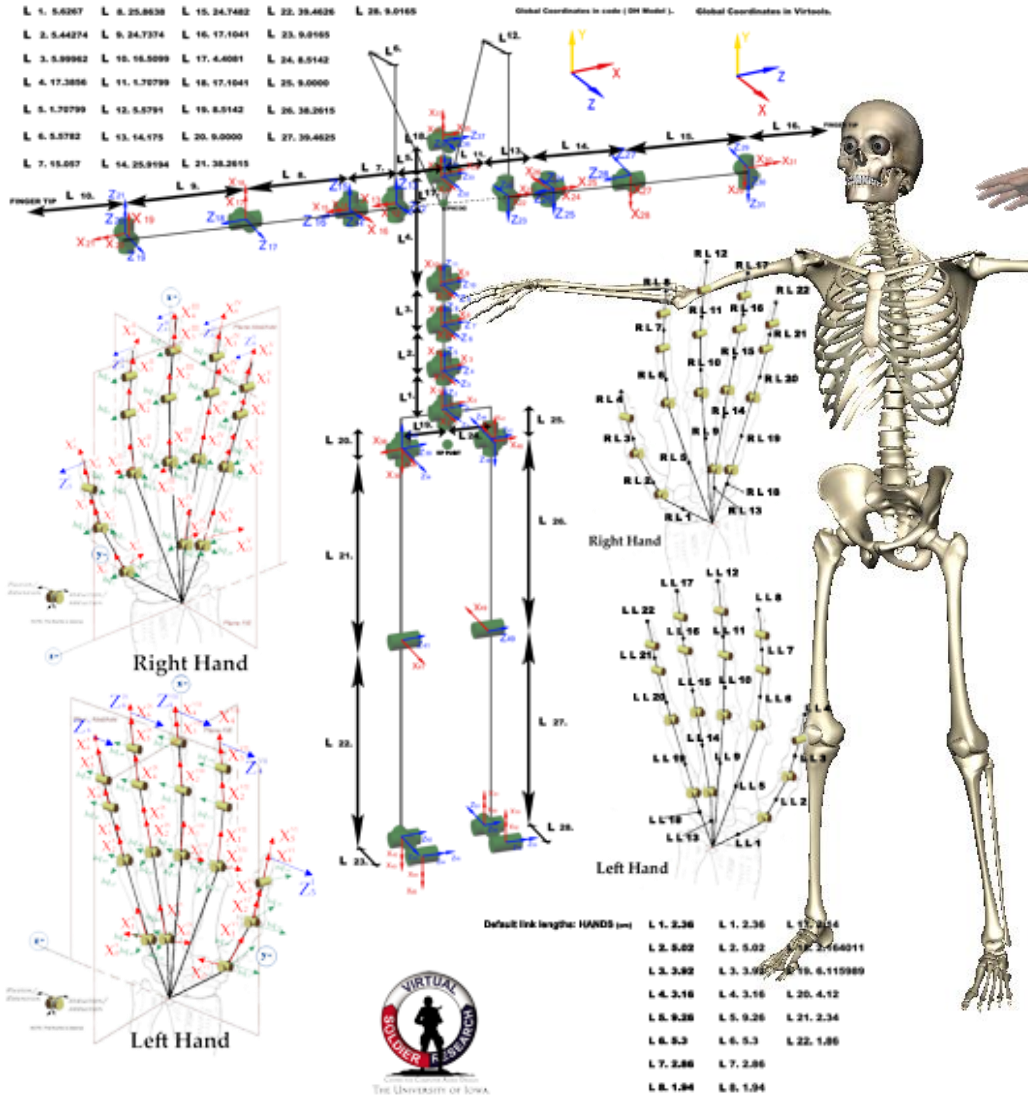


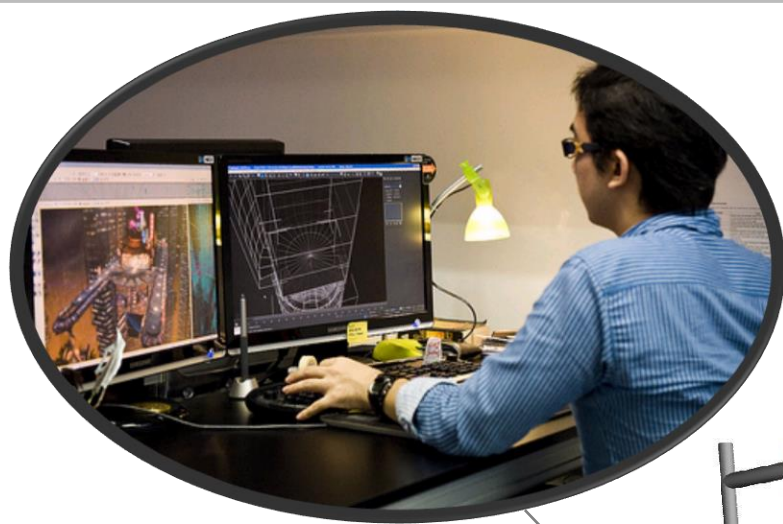
For test only.
Use for publishing prohibited.

In 2005....



The Santos® Model





Gaming



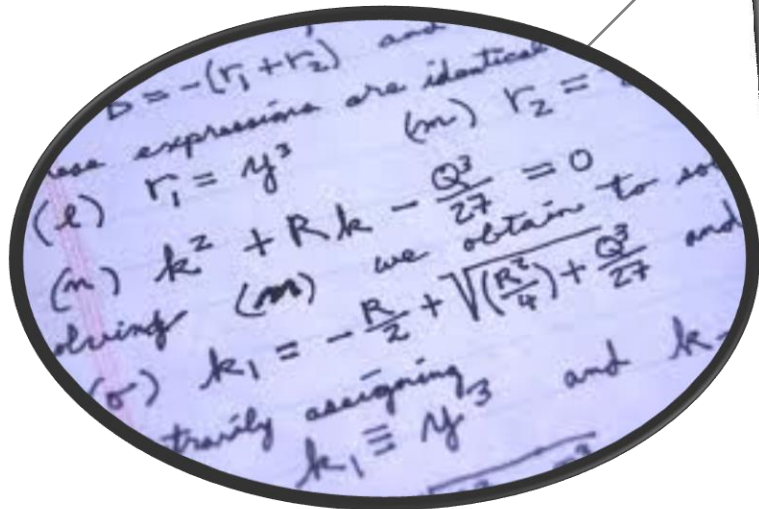
Hollywood

@ Iowa



Engineering

Health/Medicine



Santos and Sophia





Deviation from Neutral

Spine

Right Arm

Left Arm

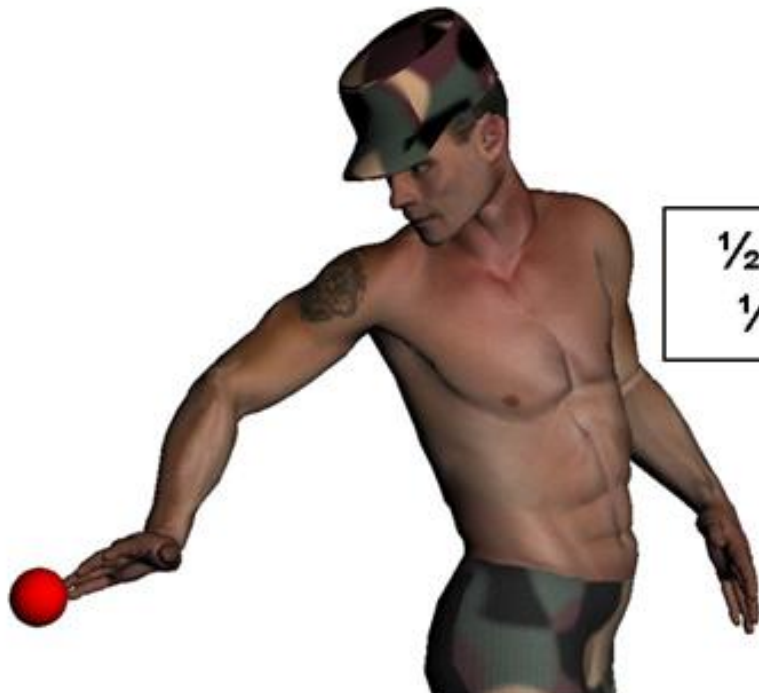
Neck

Right Leg

Left Leg

Developing behavior: AI

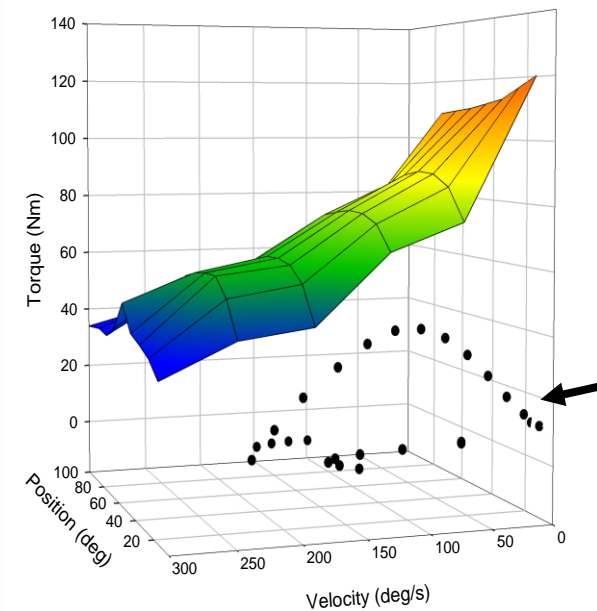
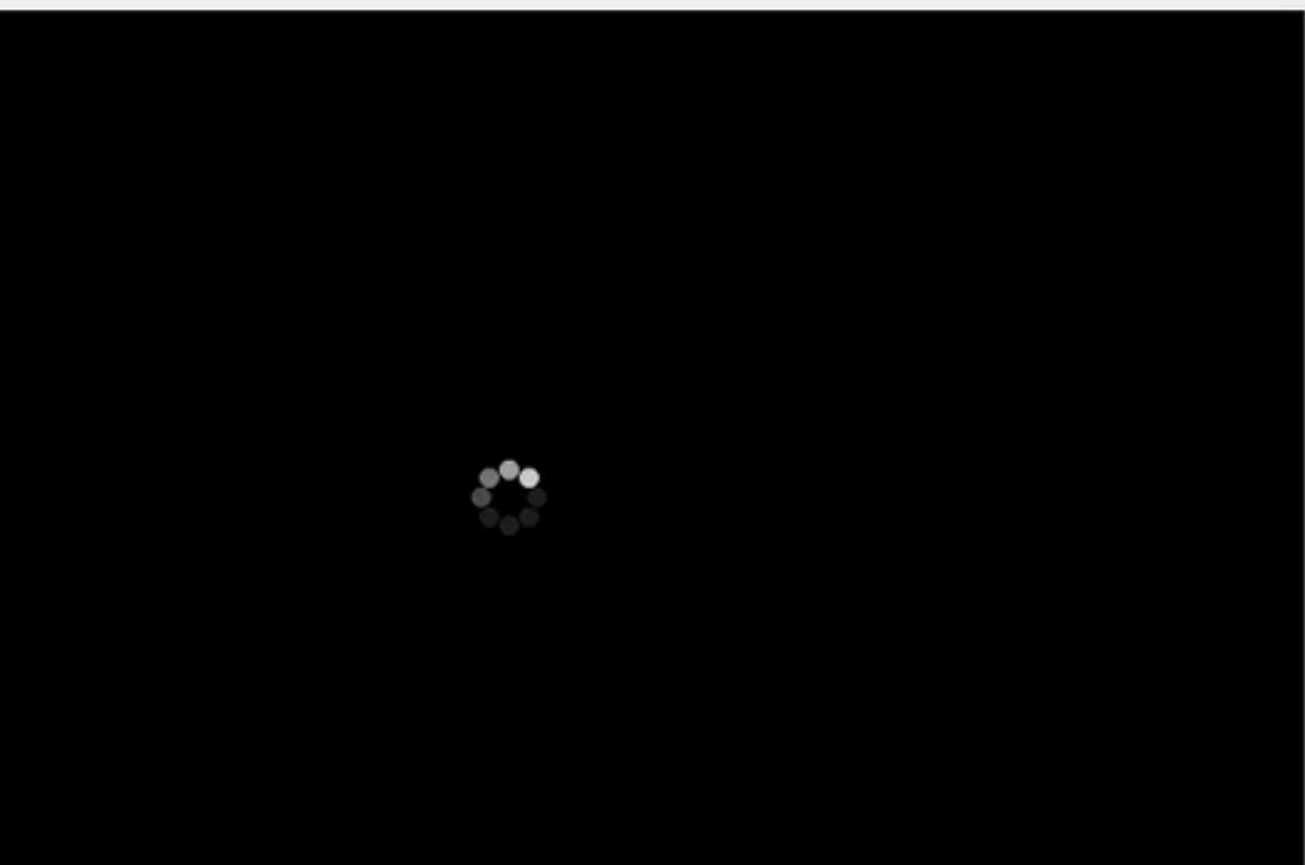
Santos: touch the sphere!



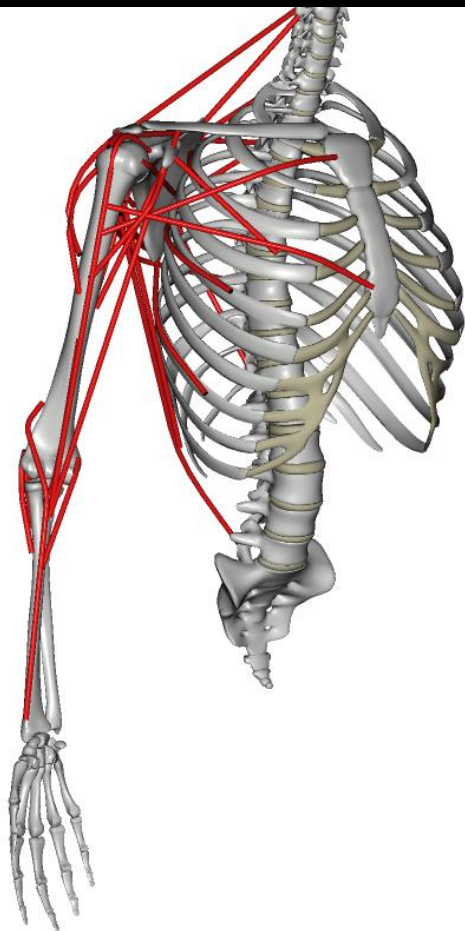
$\frac{1}{2}$ Visual Displacement
 $\frac{1}{2}$ Joint Displacement



Understanding limits of Human Strengths



Santos has Strength & Fatigue



THE UNIVERSITY OF IOWA



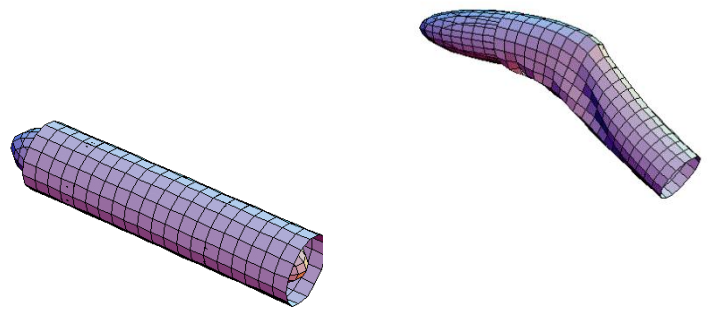
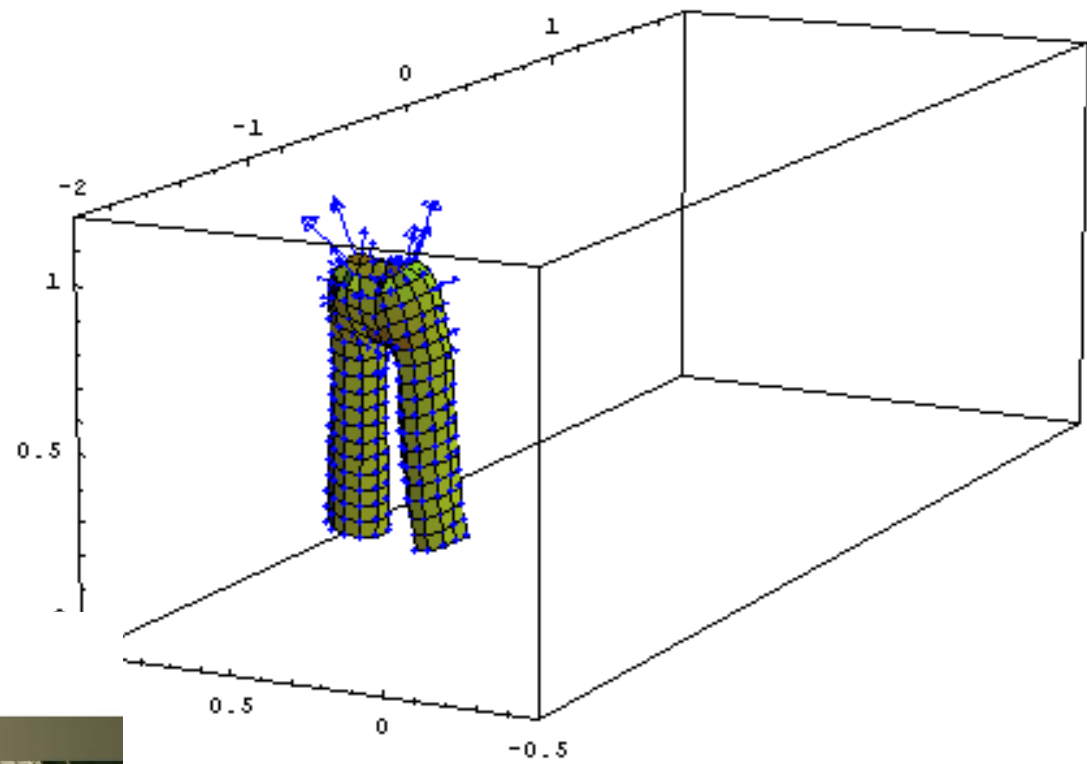
Modeling physiology



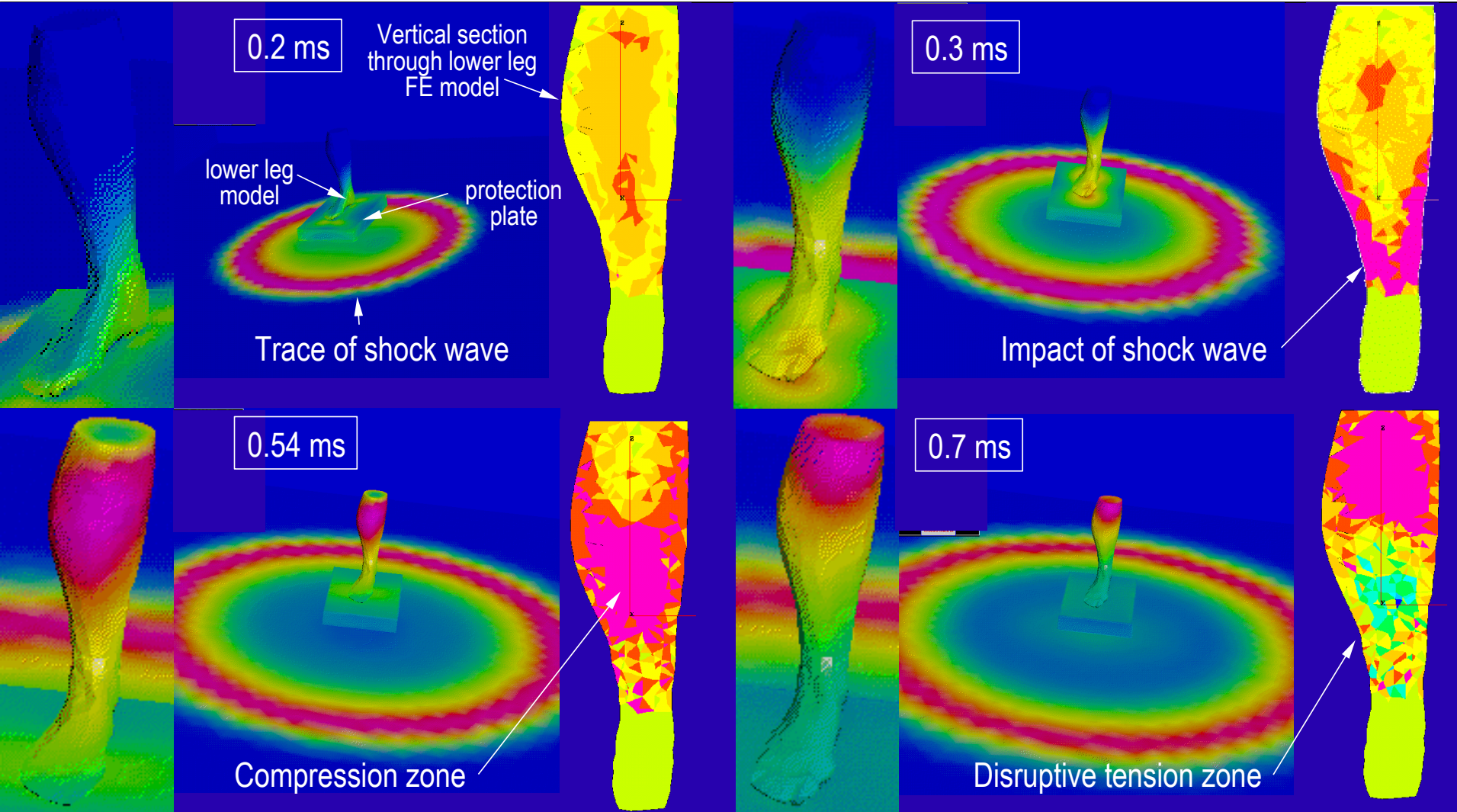
The mathematics of physics



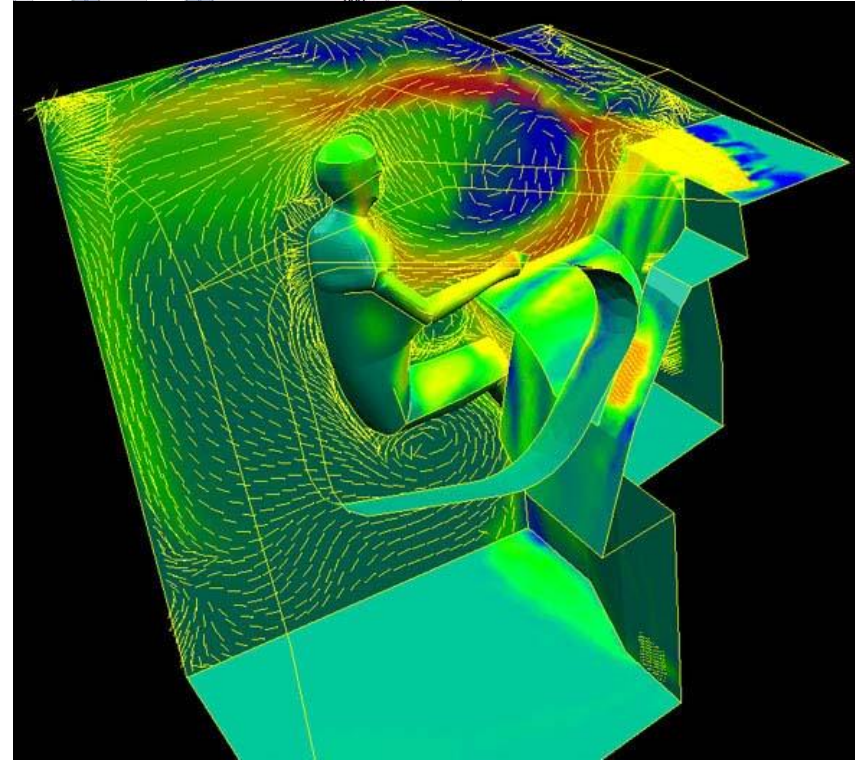
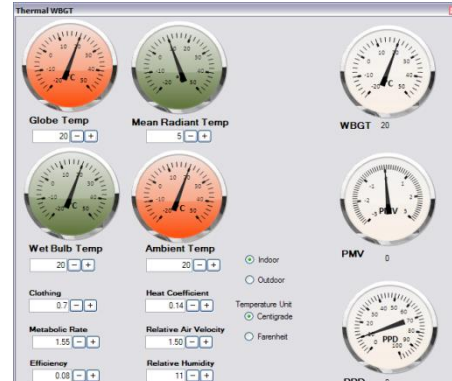
NBC clothing modeling



Armor-IED-ballistics



Thermal Considerations



Example Research Programs



Testing armor



Joint Torques Visualizer

Santos

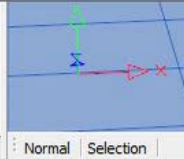
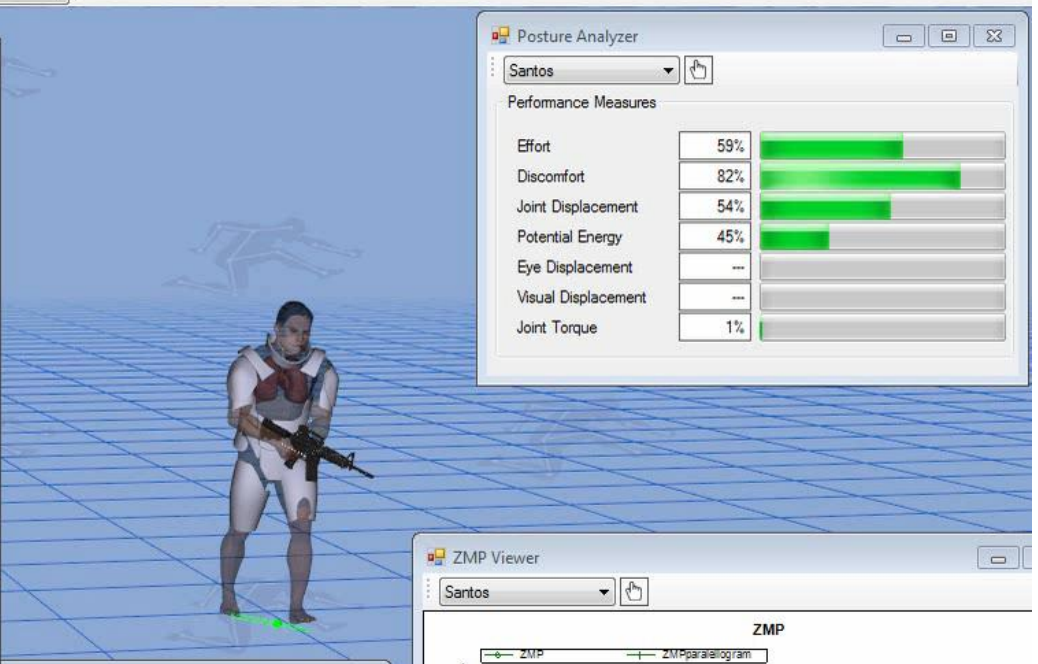
Joint	Value	Percentage
Spine1_1	2.74%	100%
Spine1_2	-19.06%	100%
Spine1_3	-0.92%	100%
Spine4_1	3.06%	100%
Spine4_2	-16.81%	100%
Spine4_3	-1.22%	100%
Spine7_1	3.16%	100%
Spine7_2	-14.69%	100%
Spine7_3	-1.17%	100%
Spine10_1	3.11%	100%
Spine10_2	-12.67%	100%
Spine10_3	-0.71%	100%
Clavicle_Right_1	-9.38%	100%
Clavicle_Right_2	-6.02%	100%
Shoulder_Right_1	5.12%	100%
Shoulder_Right_2	9.18%	100%
Shoulder_Right_3	7.04%	100%
Elbow_Right_1	-10.49%	100%

Posture Analyzer

Santos

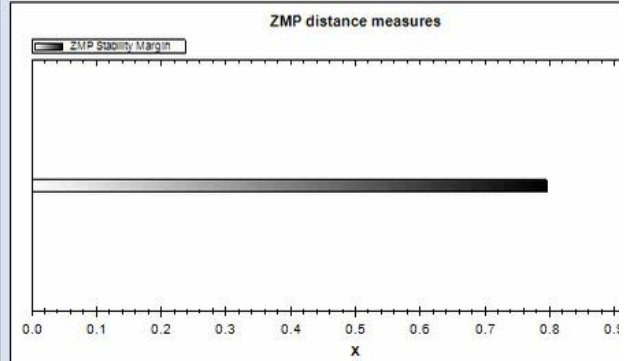
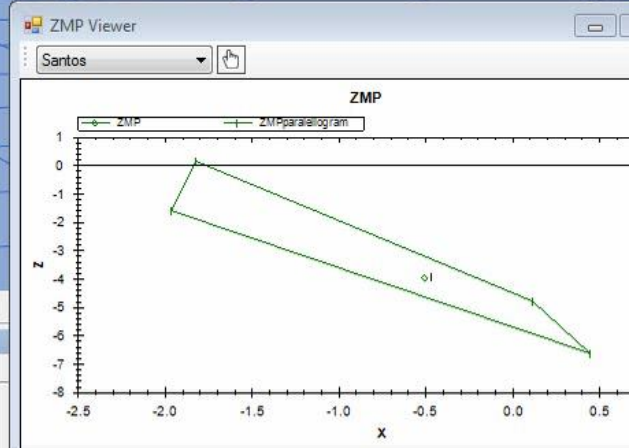
Performance Measures

Effort	59%
Discomfort	82%
Joint Displacement	54%
Potential Energy	45%
Eye Displacement	---
Visual Displacement	---
Joint Torque	1%



Santos

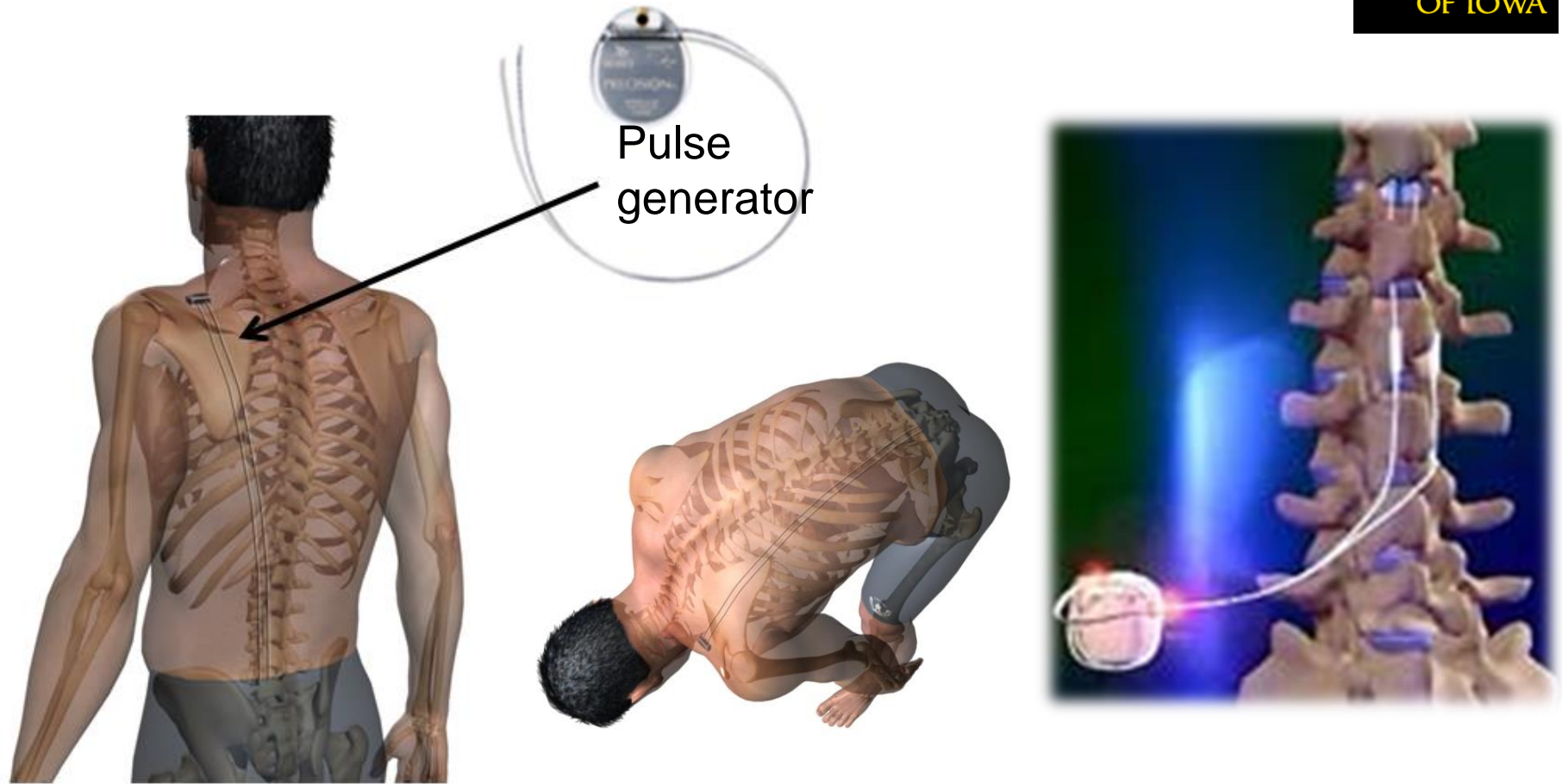
Neck_1	-6.72
Neck_2	2.86
Neck_3	6.47
Head_1	-0.27
Head_2	-26.74
Shoulder	
Clavicle_Right_1	1.49
Clavicle_Right_2	-11.4
Shoulder_Right_1	81.24
Shoulder_Right_2	44.44
Shoulder_Right_3	-149.99
Clavicle_Left_1	-4.68
Clavicle_Left_2	-15.24
Shoulder_Left_1	89.98
Shoulder_Left_2	24.76
Shoulder_Left_3	-119.78
Arm	22.63%



Testing the physics of rides



Testing medical devices



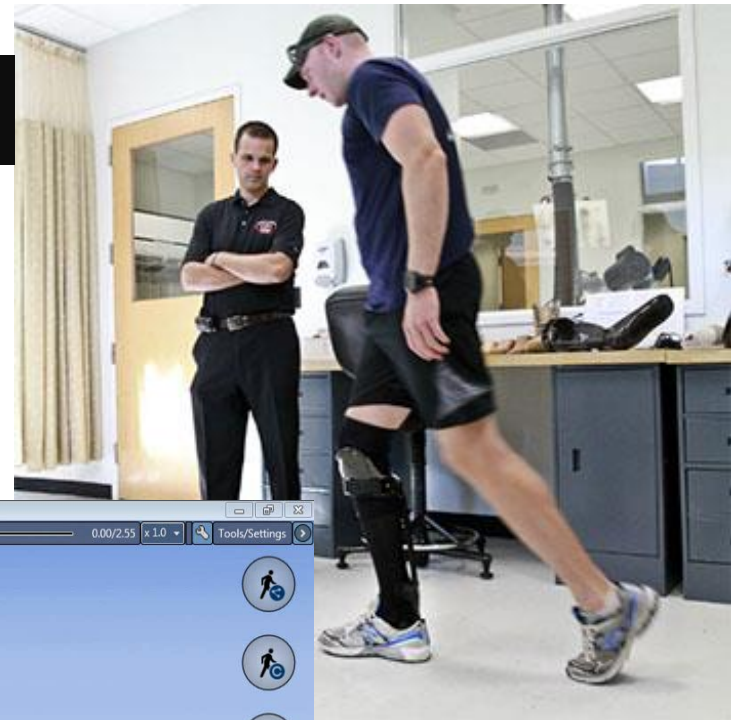
Patients who qualify for neurostimulation therapy report a 50 to 70% reduction in overall pain

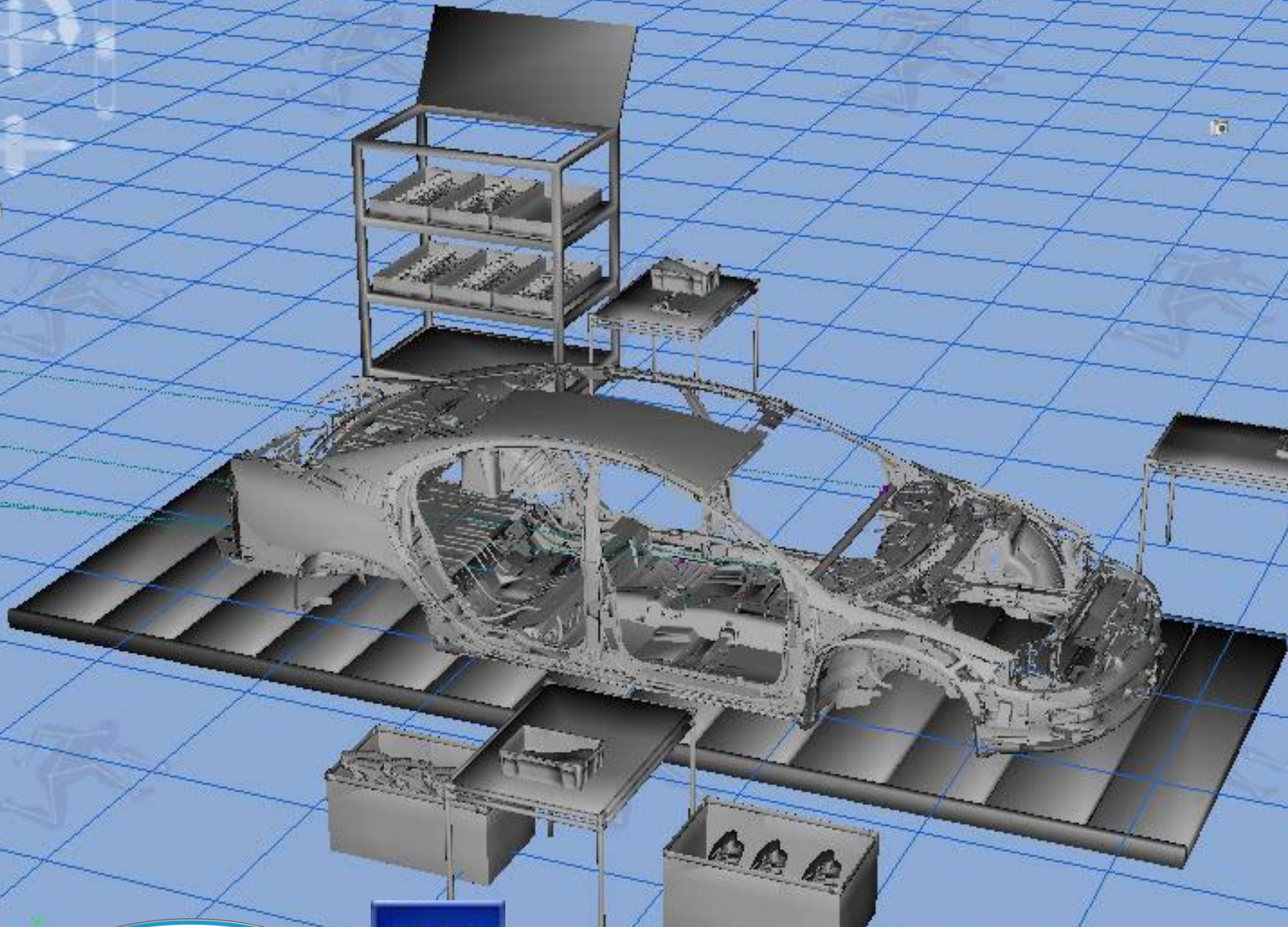
Fitting prosthetic devices



U.S. ARMY MEDICAL DEPARTMENT
BROOKE ARMY MEDICAL CENTER

Center for the Intrepid



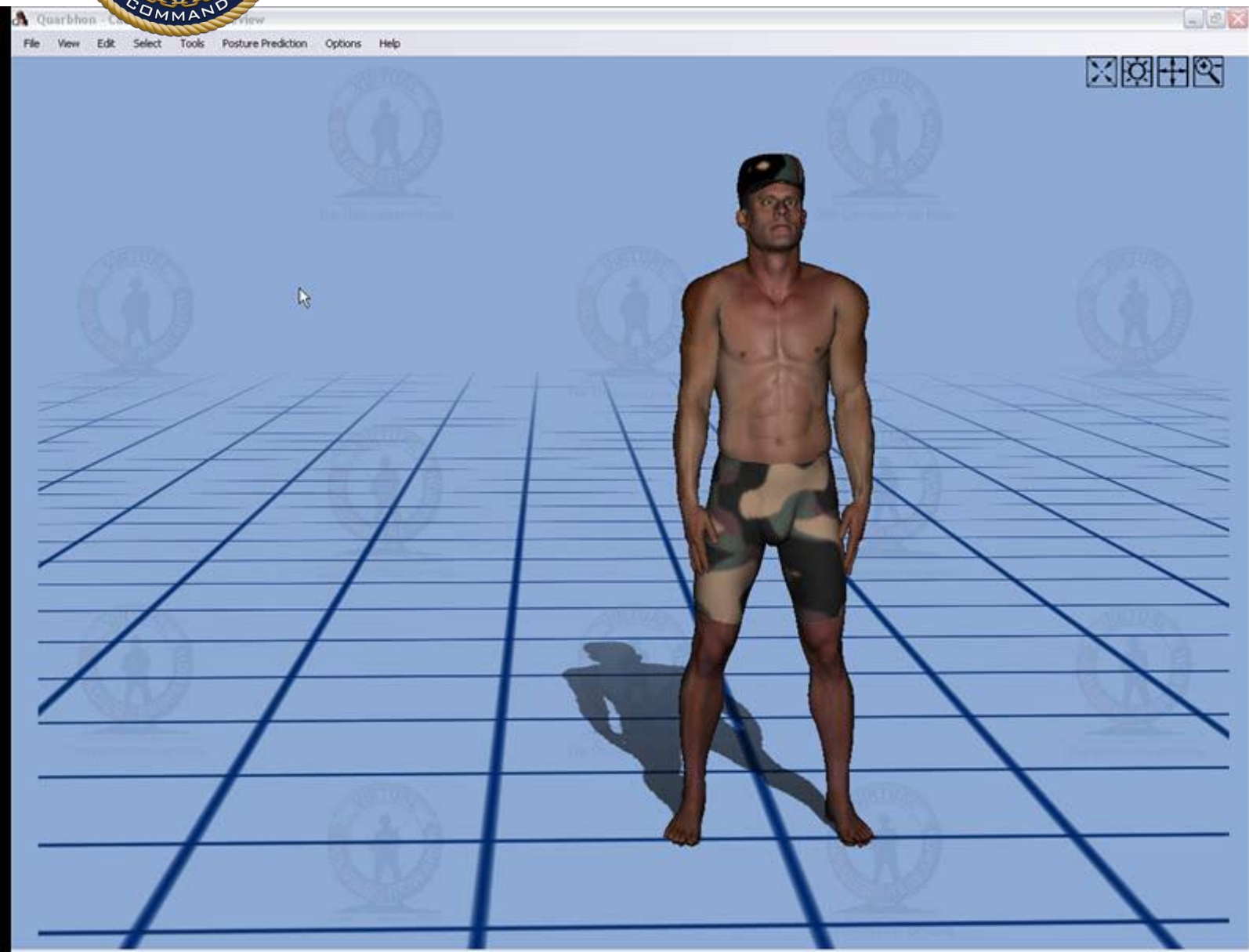


DAIMLERCHRYSLER



NAVAL AIR
SYSTEMS COMMAND

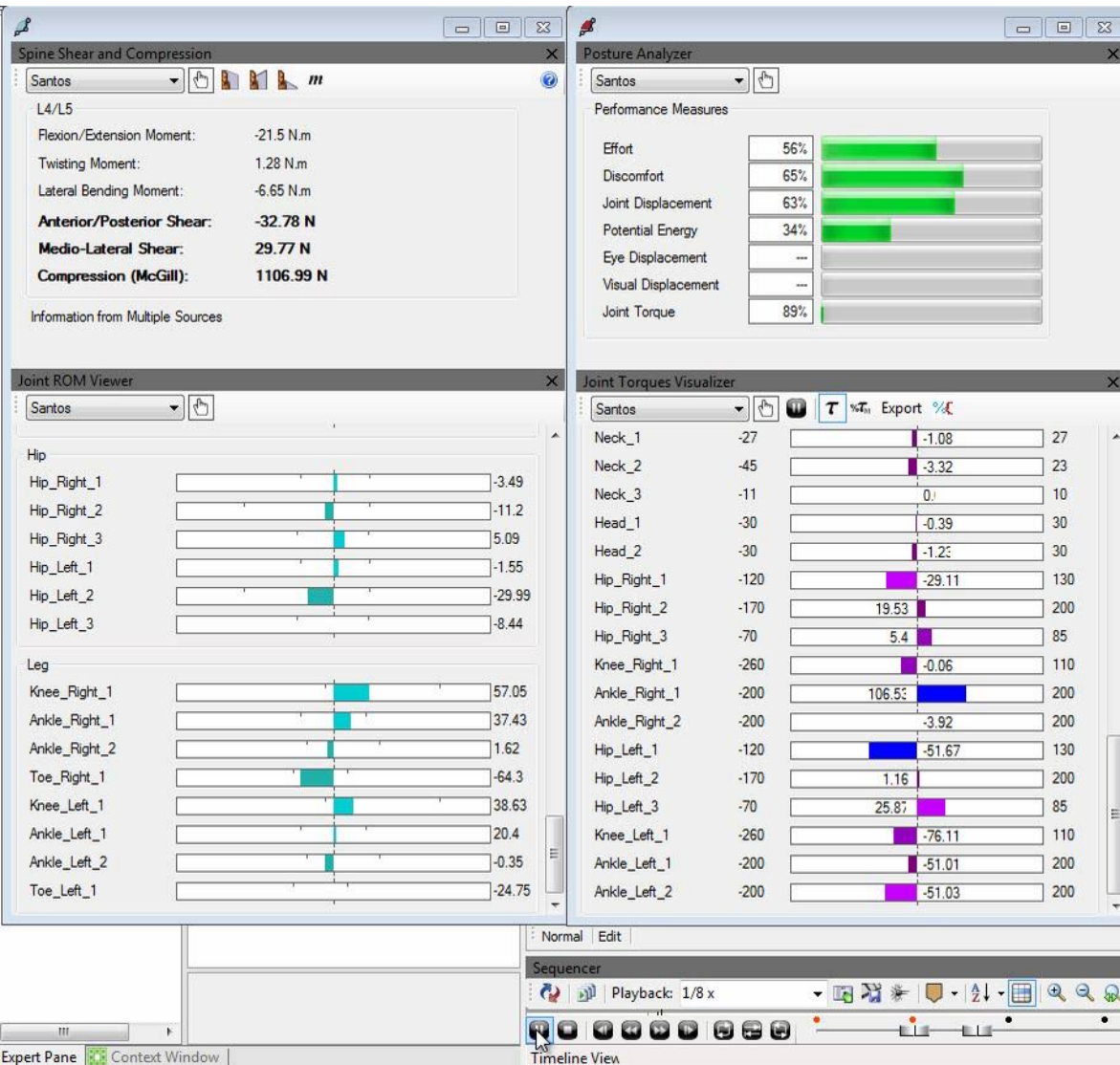
Test warfighting cockpits



TALOS: Tactical Assault Light Operator Suit



Testing exoskeletons



A proud Iowa team



Lightening the load



Lightening the load





Reset Scene



Change Units



Help



View



Avatars



Configuration



Scenarios



Output

Dashboard

Performance

1x speed

Click and hold or right-click for more options

00:00.00



Stair Ascend



Stair Descend



Stair Ascend Steep



Stair Descend Steep



Vertical Jump



Ladder Climb



Reset Scene

Change Units



View



Configuration



Scenarios



Analysis

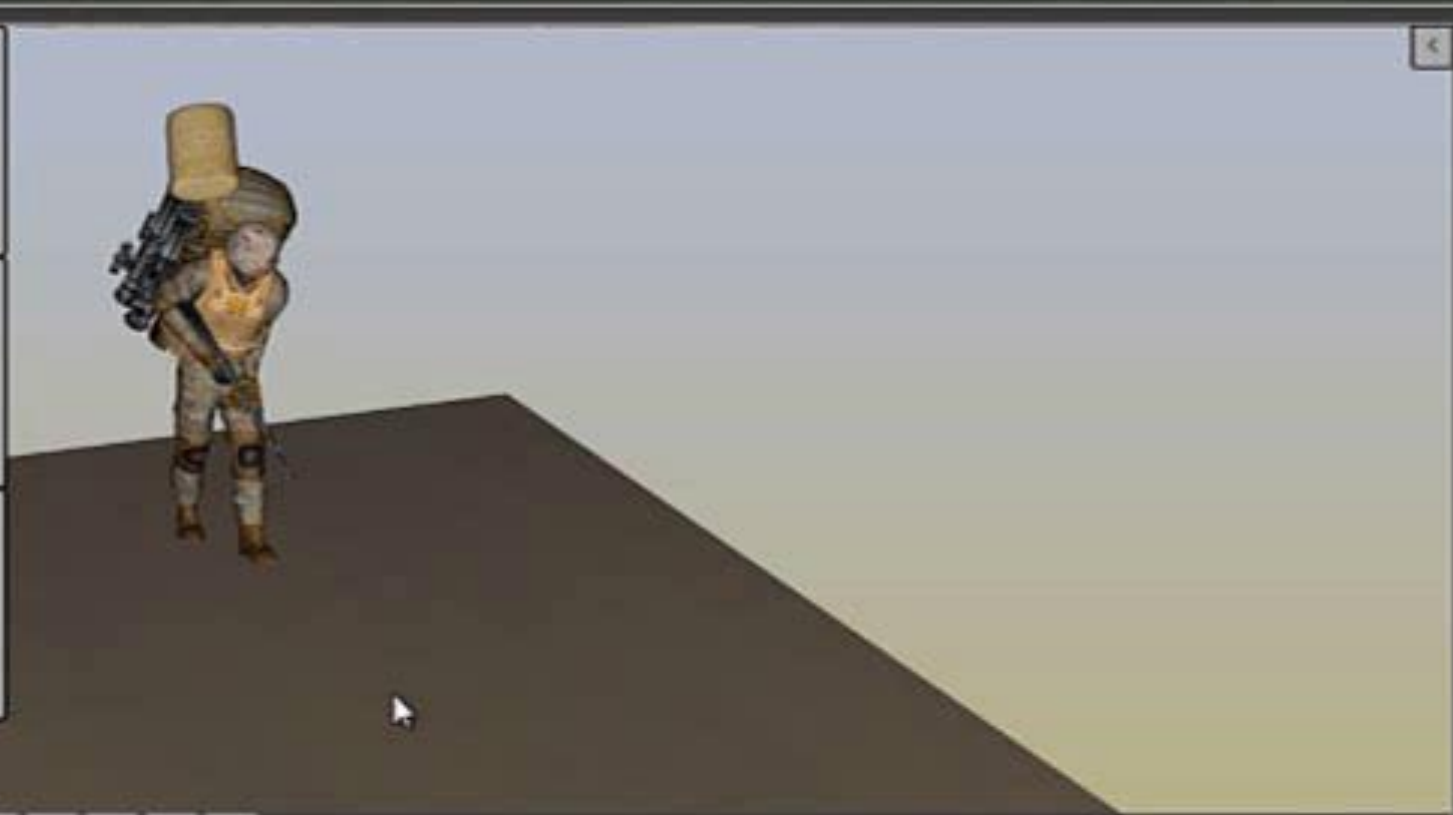


Output

Dashboard

Summary

Analysis



1x

Off



00:00:00



Show Torque Map



Show Spine Display



Show GRF Display



Show CoM Display

Height (m)

2.383437

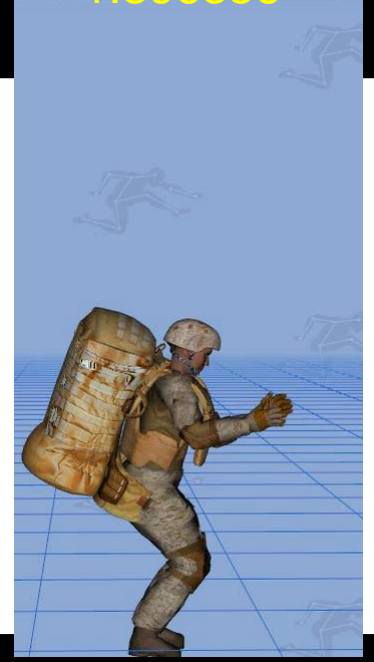
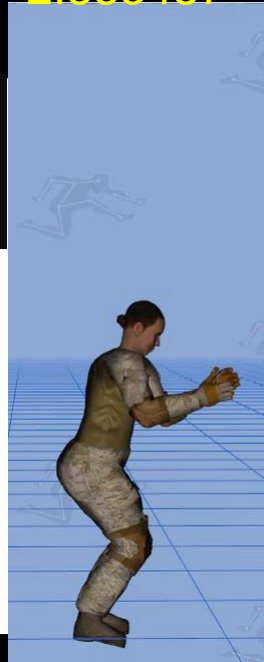
2.283680

2.191515

2.025596

1.896856

Sophia
60 kg



Height (m)

2.511551

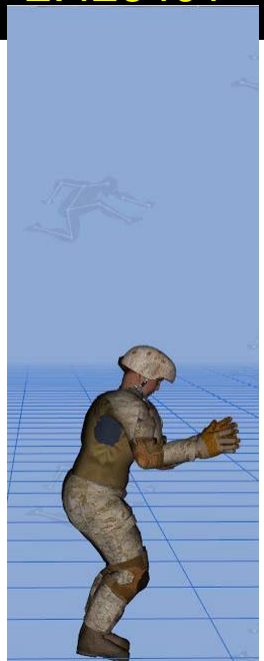
2.426401

2.298920

2.089685

1.932893

Sophia
51 kg



Lightening the load

No Backpack



90 Kg (198 lb) Backpack

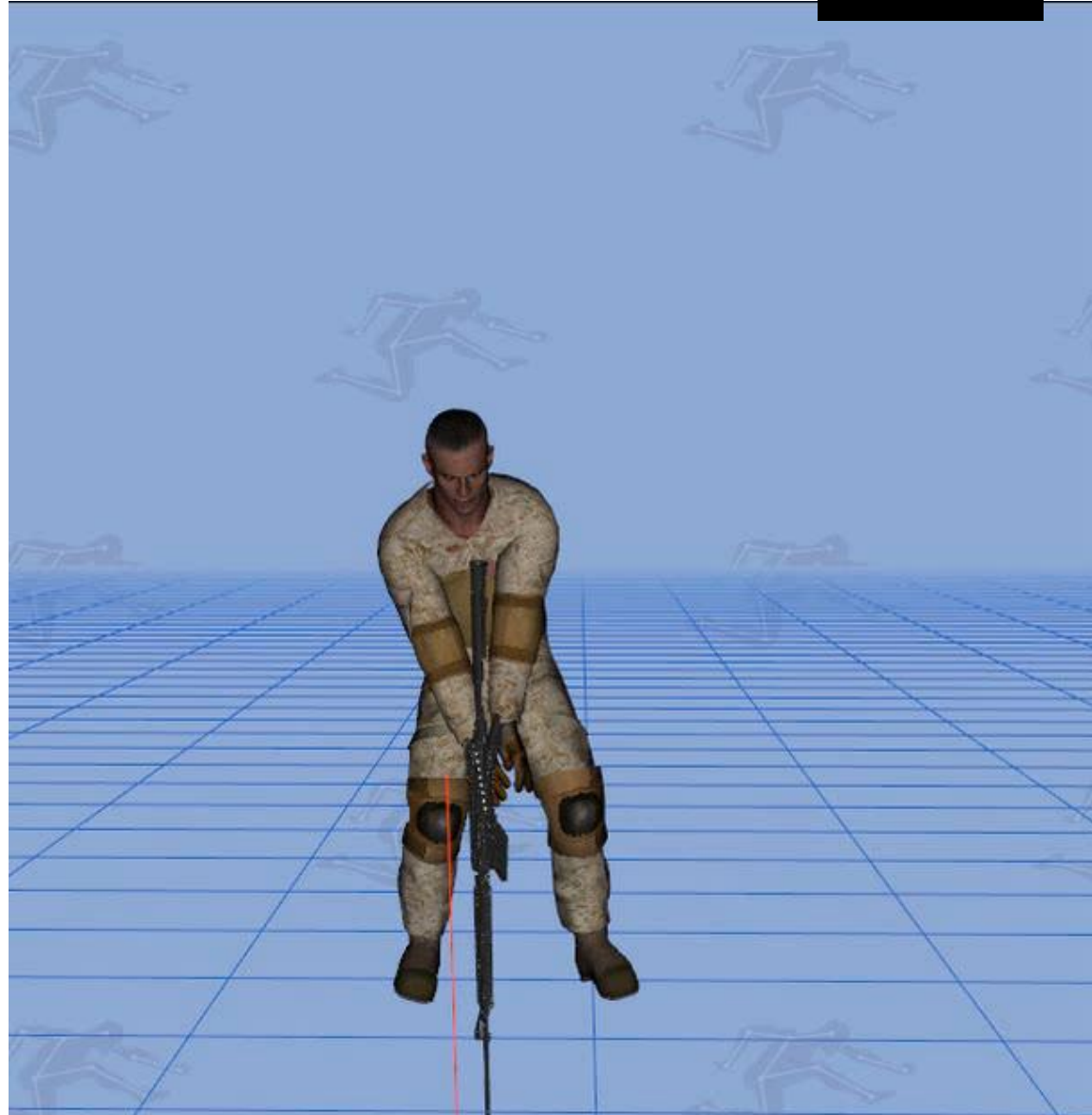


100 Kg (220 lb) Backpack



The Future

- Sports
- Injury prediction
- Intelligence
- Aging Santos
- Child Santos

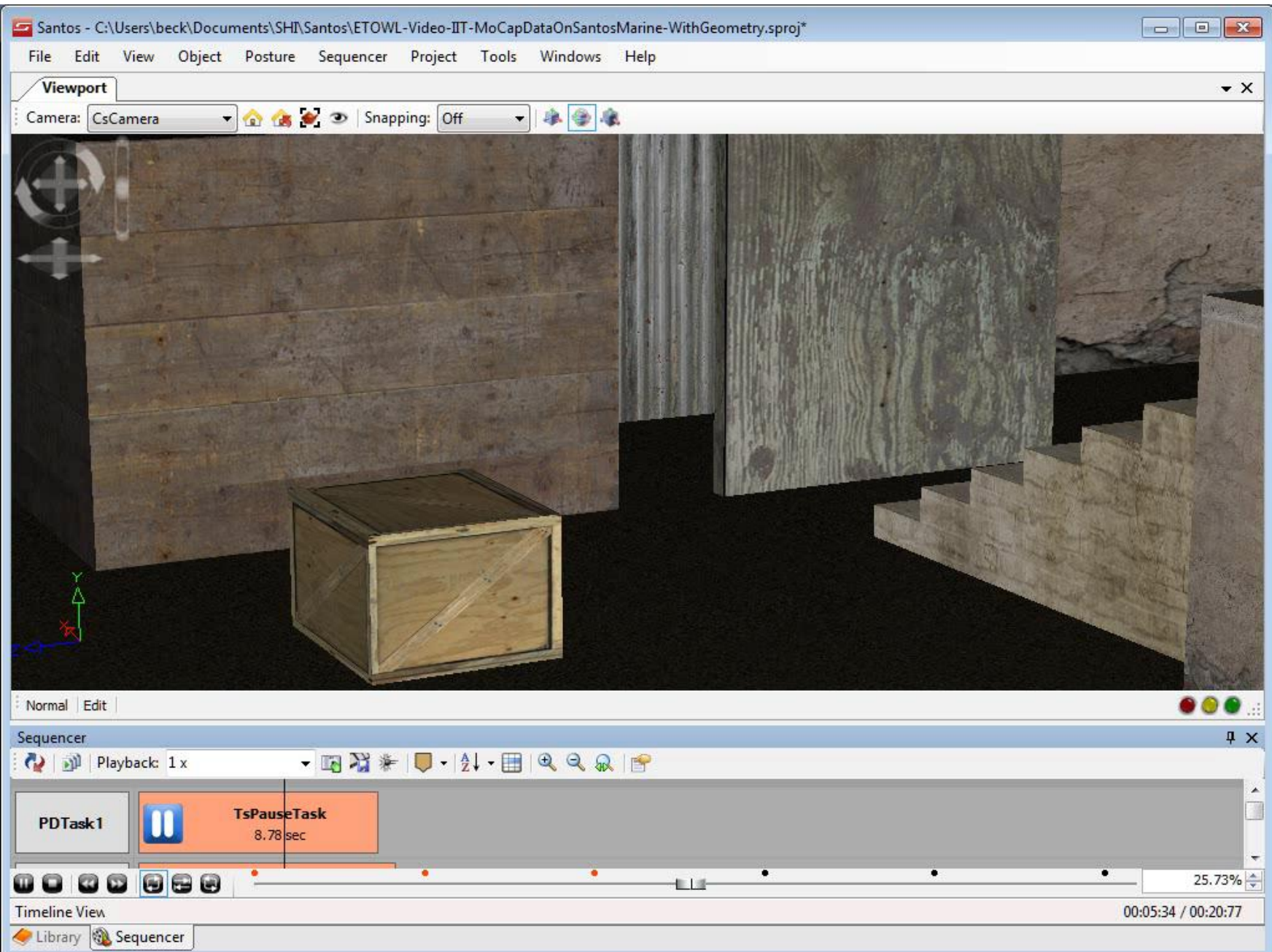


Thank you!





The Task Sequencer



Height (m)

2.498672

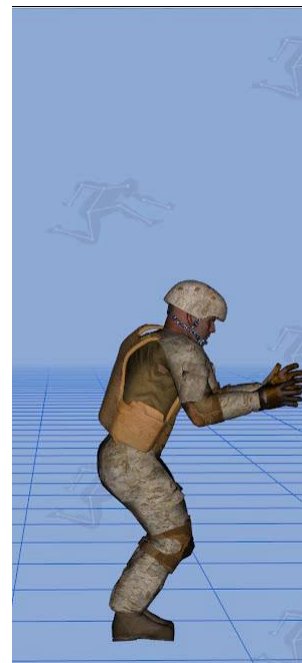
2.401209

2.310071

2.131725

1.990143

Santos
79 kg



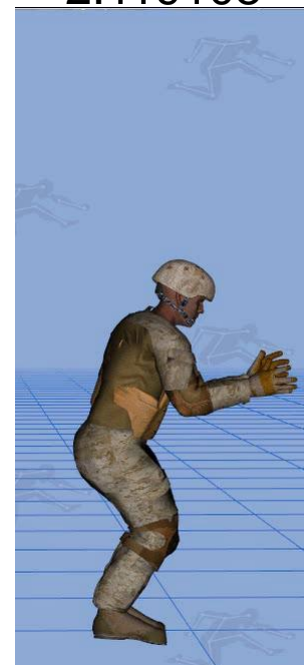
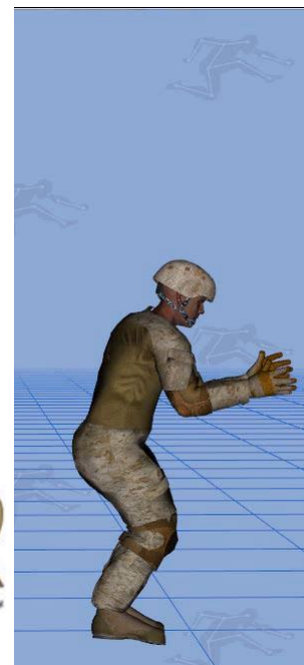
2.180130

2.174497

2.119108

2.015748

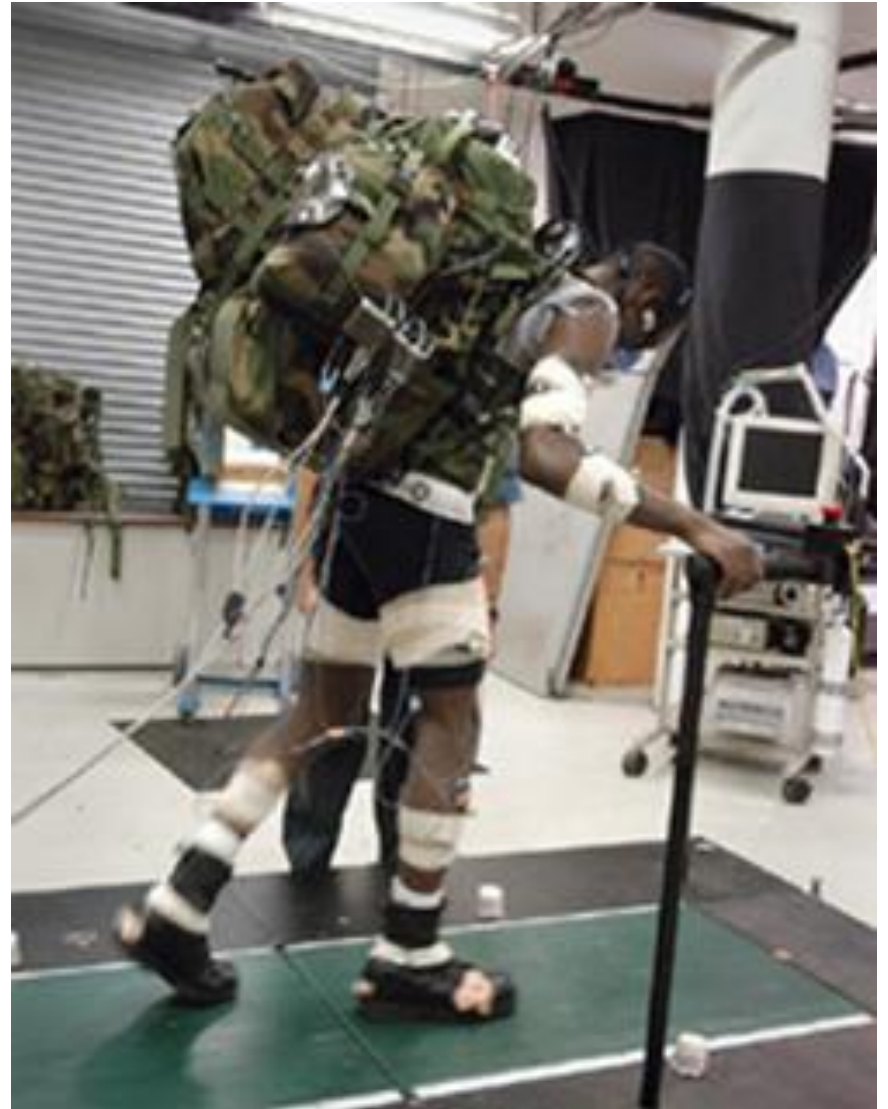
1.946092



Man3
111 kg

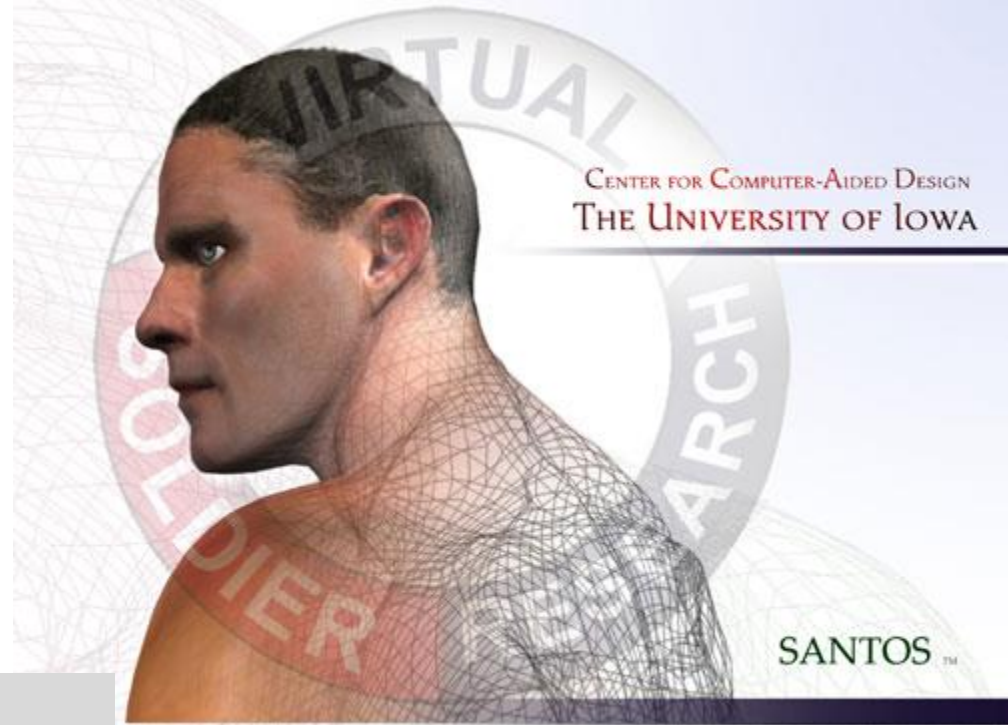
Physics/Dynamics
Intelligence
Strength and Fatigue
Human motion
Balance and stability
Clothing
Physiology
Injury

Santos™



Women in combat





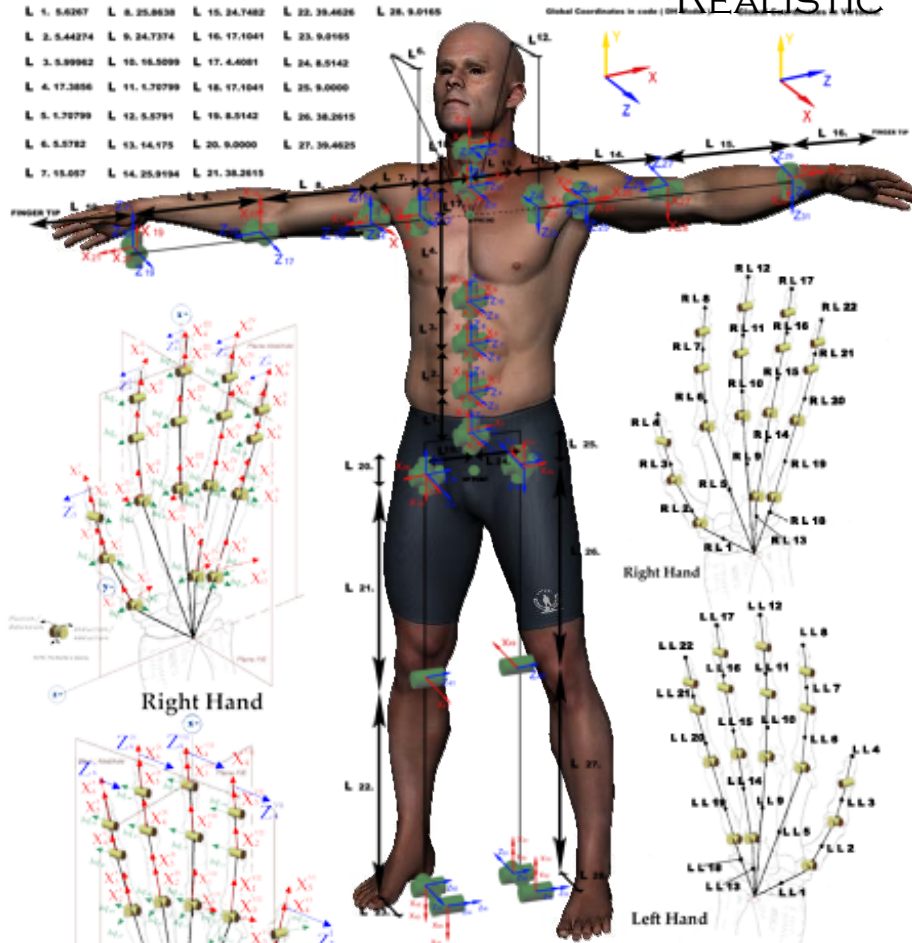
- ✓ A Virtual Human
- ✓ Predicts Behavior
- ✓ Physics-Based





ARTIFICIAL INTELLIGENCE

REALISTIC



L 1, 5.6267	L 6, 25.8638	L 15, 24.7482	L 22, 39.4626	L 26, 9.0165
L 2, 5.44274	L 9, 24.7374	L 16, 17.1041	L 23, 9.0165	
L 3, 5.99982	L 10, 18.5099	L 17, 4.4081	L 24, 8.5142	
L 4, 17.2856	L 11, 1.70799	L 18, 17.1041	L 25, 9.0000	
L 5, 1.70799	L 12, 5.5791	L 19, 8.5142	L 26, 38.2015	
L 6, 5.5782	L 13, 14.175	L 20, 9.0000	L 27, 39.4625	
L 7, 15.057	L 14, 25.9194	L 21, 38.2815		

Default link lengths: HANDS (mm)

L 1, 2.36	L 1, 2.36	L 17, 2.14
L 2, 9.02	L 2, 5.02	L 18, 2.164011
L 3, 3.92	L 3, 3.92	L 19, 6.115989
L 4, 3.16	L 4, 3.16	L 20, 4.12
L 5, 9.26	L 5, 9.26	L 21, 2.34
L 6, 5.3	L 6, 5.3	L 22, 1.86
L 7, 2.86	L 7, 2.86	
L 8, 1.84	L 8, 1.84	





Reset Scene

Select Units



- View
- Avatars
- Equipment
- Postures
- Output



Inventory Manager

- Armor
- Armor Attachments
- Backpacks
- Backpack Attachments
- Helmets
- Helmet Attachments
- More