NATIONAL ERGONOMICS Conference & ErgoExpo®

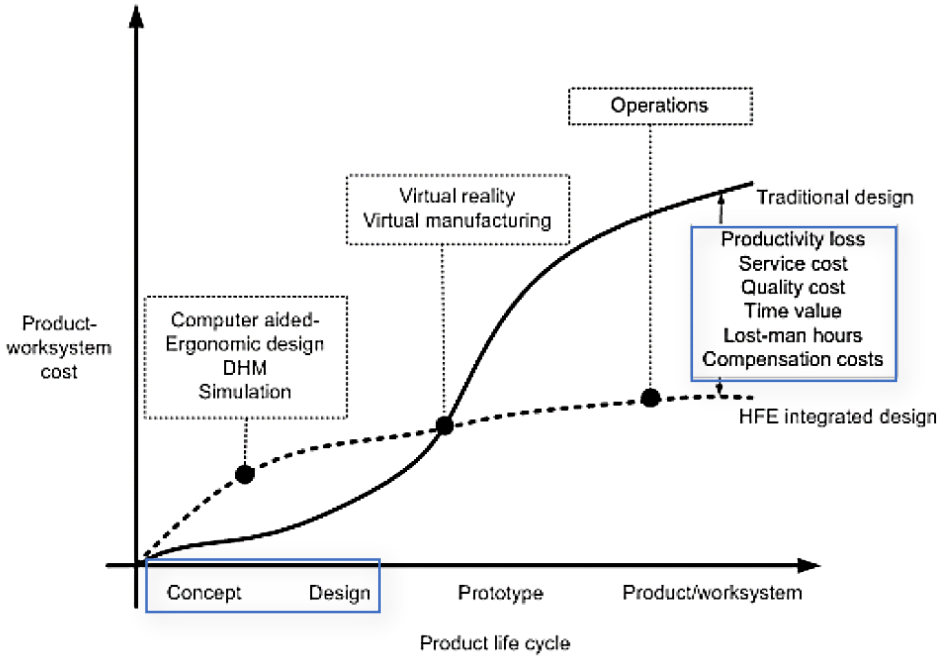
Application of Digital Humans in Workstation Design

Presented b: Gus Arroyo, MS, CPE, ASP

What is Digital Human Modeling (DHM)?

Process of developing digital human models using anthropometric and biomechanical database, for ergonomic evaluation of product, process and workstation in virtual environment

Why Use DHM?



Chaffin, D. B. (2005). Improving digital human modelling for proactive ergonomics in design. *Ergonomics*, 48(5), 478-491.

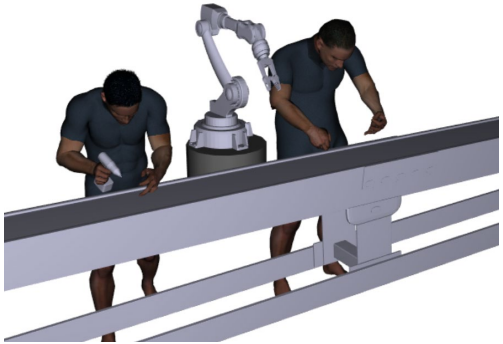
What is Santos?

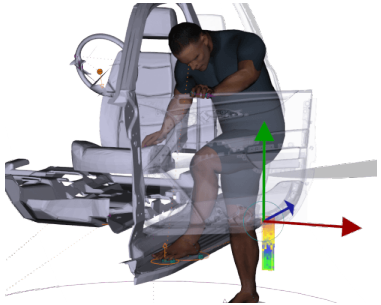
- **An Anatomically Correct Human in a Virtual World**
  - **Create digital human models** with realistic appearance and biomechanical fidelity
  - **Simulate endless series of scenarios** to test human-system interactions
  - Comprehensive toolkit set to **analyze human performance and biomechanical stress**

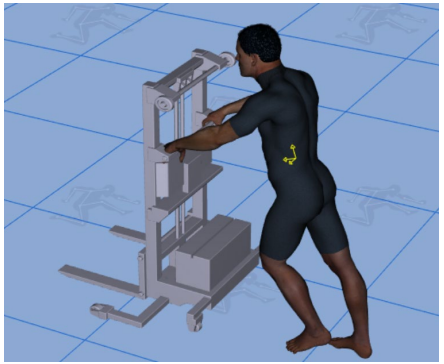
Basic Functions

What Can Santos Do?

- Clearance and reachability
- Vision
- Obstacle avoidance
- Egress analysis
- Strength requirements
- Static fatigue
- MSD/injury risk (NIOSH limits)







Shoe Manufacturing

Problem Statement

Press Machine in Shoe Insole Production

- **Client Request**
  - Need quantitative assessment to support buy-in from leadership for redesign
  - Multiple incident reports
  - Need data for current design and proposed design

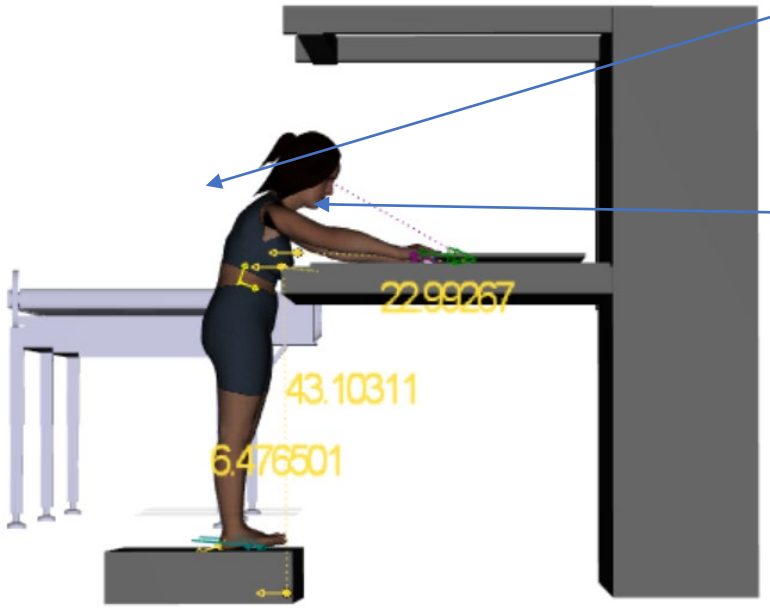
Task Simulation and Analysis

Conditions

Range of anthropometric models

From ground level to 7” platform

Various duty cycles



Metrics

Outcome

- **Equipment and task specific data to drive solutions – no general guidelines**
  - Height and repetition ranges within “safe limits”
  - Optimal height suggestion to minimize spinal loading and arm fatigue
- **No employee needed to recreate task or replicate “worst case” scenarios**
- **Testing redesign variations without expensive prototypes or ongoing consultant support**

Pharmaceutical Industry

Problem Statement

Shipping/Receiving in Pharmaceutical Industry

- **Client Request**
  - Injury reports linked to material handling tasks
  - Need assessment to support purchase of material handling lift tables
  - Evaluate effectiveness of current interventions e.g., biomechanics training

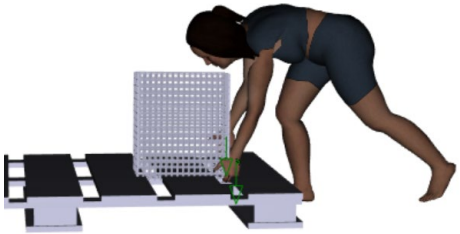
Task Simulation and Analysis

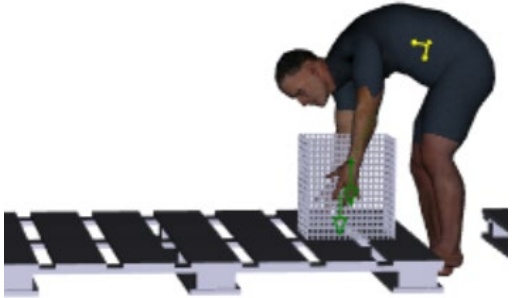
Conditions

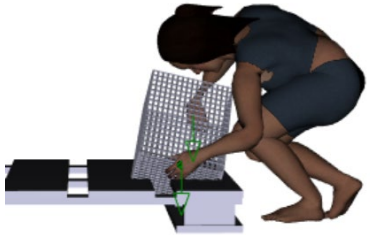
Different anthropometric models

Various common lifting postures

Risk data when introducing interventions







Outcome

- **Client has quantitative data to support purchase of new equipment**
- **Assessment not limited to current workforce or task conditions**
  - Postures that cannot be assessed with traditional ergo tools were evaluated (i.e., golfer's lift)
  - People of different heights were simulated
  - Highlighted loads that exposed employees to highest risk
- **Simulations provide visual aid for training purposes**

Robotics (WIP)

BSI Always Striving for Innovation

Robot-Human Interface

- **BSI is investigating how to better conduct ergonomic analysis of robot-human interfaces:**
  - Can human resist force from a robot?
  - Can human work safely outside robot envelopes?
  - Can human reach critical system controls e.g. EMO?

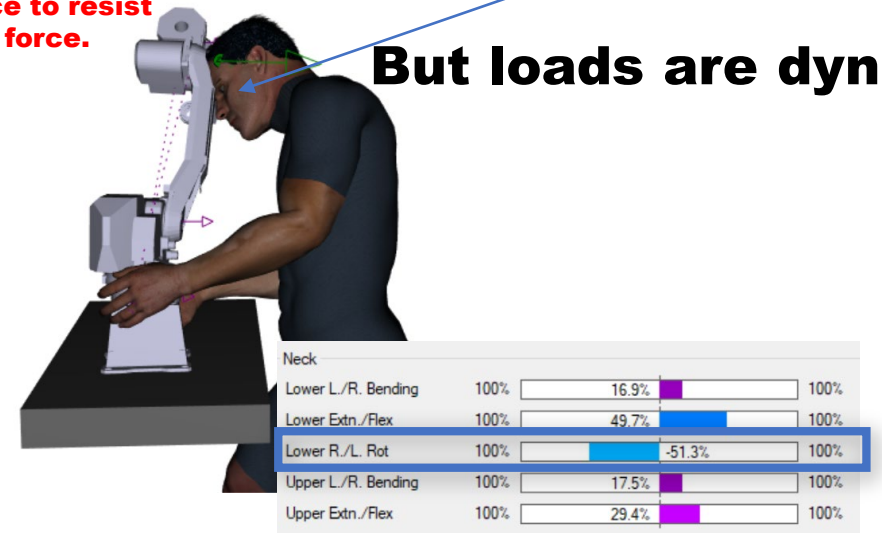
External Loading Effects on Joint Strength

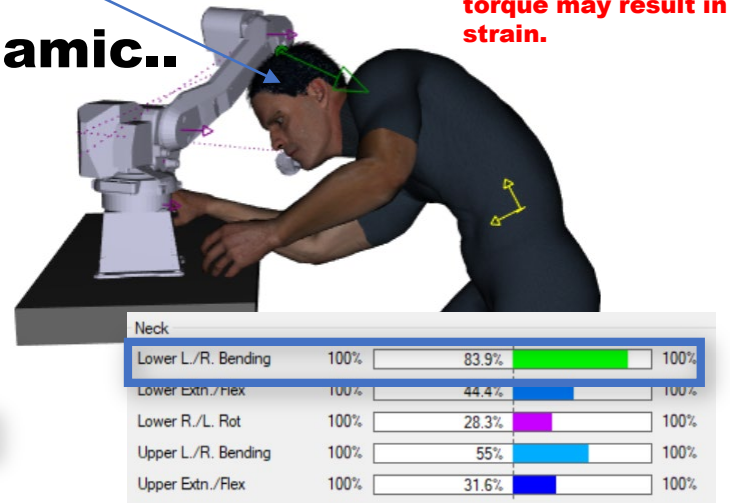
Force from Robotic Arm= 130 N (ISO/TS 15066 MPF for head)

Lower neck joint for rotation most affected. They require 51.3% of max force to resist external force.

But loads are dynamic..

Lower neck joint for extension most affected. They require 83.9% of max force to resist external force. Working near/at/above maximum joint torque may result in muscular strain.



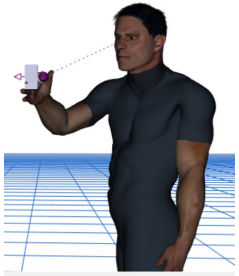


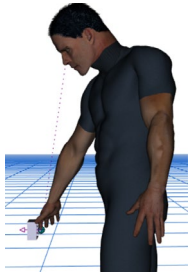
% Neck Strength (% of task strength/ maximum strength)

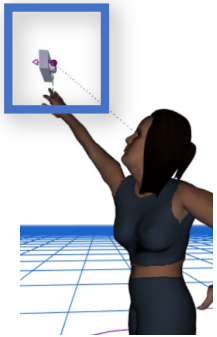
Emergency Components

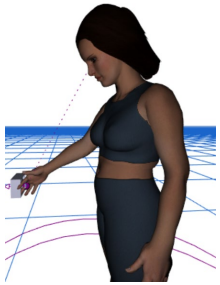
E-Stop and Light Tower

Reaching Capabilities

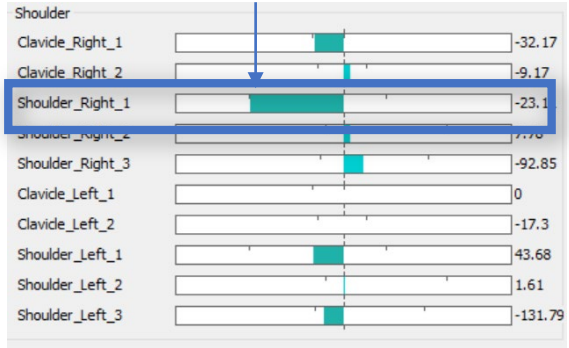




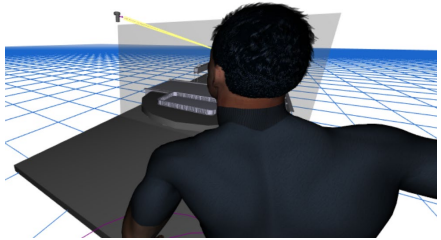


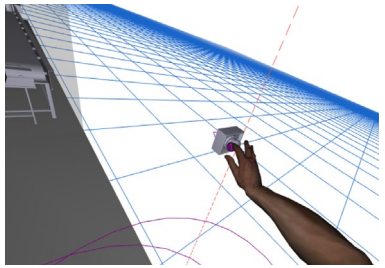


Right Shoulder Max Reached

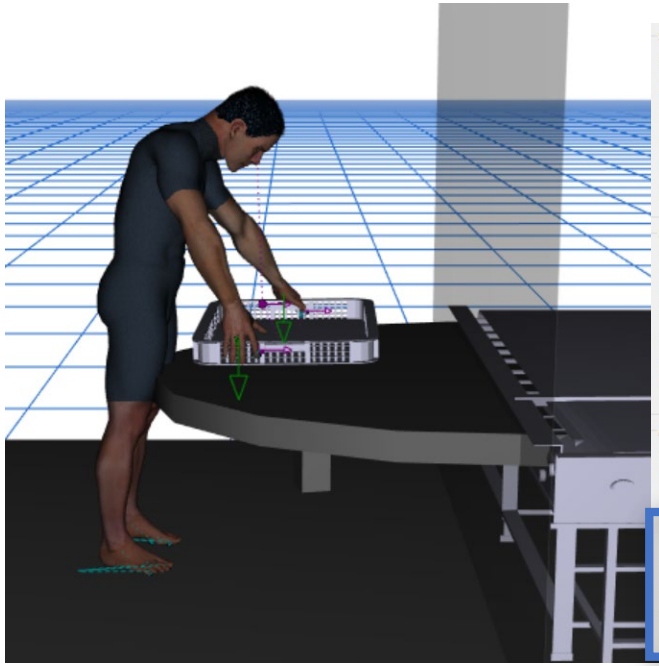


Visual Acuity



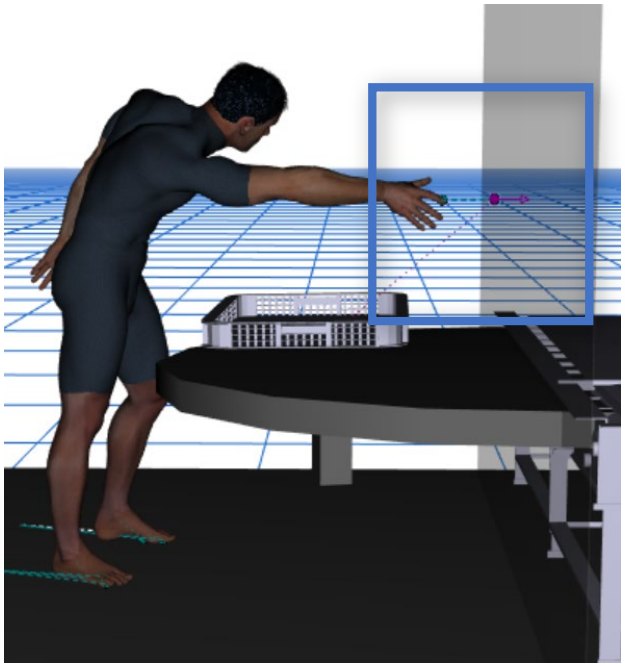


Loading/Unloading



Joint Strength (%of task/max)

Spine				
Low L./R. Bend	-130.2	42.3		110.4
Low Extn./Flex	-303.5	-145.4		163.7
Low R./L. Rot	-66.9	-2.7		66.7
High L./R. Bend	-146	33.9		93.9
High Extn./Flex	-292.9	-111		248.5
High R./L. Rot	-66.8	-7.1		69
Shoulders				
R. Abd./Add.	-57.6	-7.7		60.4
R. Extn./Forward Flex	-80	36.9		72.1
R. Int/Rot/External Rot	-17	4.3		35.7
L. Abd./Add.	-45	-18.2		54.9
L. Extn./Forward Flex	-83	26.6		71.1
L. Int/Rot/External Rot	-18	1.8		35.3
Arms				
R.Elbow Flex/Extn.	-55.9	-12.5		38
R.Wrist Pro./Supination	-6	-2.2		8.1
R.Wrist Extn./Flex	-7.7	-6.1		13.7
L.Elbow Flex/Extn.	-54.5	2.2		35.3
L.Wrist Pro./Supination	-6	-4		8.1
L.Wrist Radial/Ulnar Dev.	-13.3	4.6		11.7
L.Wrist Extn./Flex	-7.4	-6.5		13.8



Benefits of DHM

This is not the future, this is now

- **Protect Workers:** The ability to use digital humans instead of humans in current or potential high-risk environments
- **Save Time:** Reduce the amount of time from redesign efforts and evaluations
- **Save Cost:** By decreasing the amount of physical prototypes needed, onsite evaluation time, and likelihood of expensive work injuries
- **Improved Human-Machine-Interaction:** By bringing the human into the loop during the design or design phases

Contact

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Stuck in the Box: Challenges in Glovebox Ergonomics

Presented by: Martha Chan

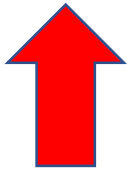
Ergonomist at Los Alamos National Laboratory

Overview

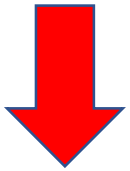
- Specialty ergo
- What is a glovebox?
- How did we get started?
- How are we keeping this going?
- What is on the horizon…

Ergonomics

Fitting a job to a person!

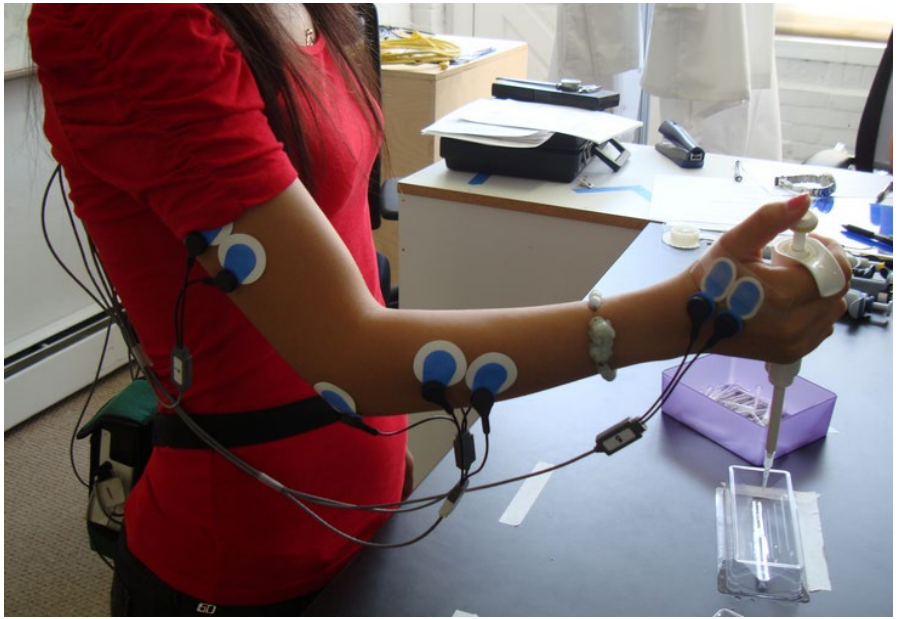


Productivity and comfort



MSD injury and human error risk

Specialty Ergonomics



What is a glovebox (GB)?

- **Containment units used to protect workers from material or material from worker**
- **Atmosphere inside**
  - Positive or negative pressured
  - Filled with different gases
- **Can be single units or multiple units linked**
- **Houses various equipment, chemicals, and materials**

Glovebox

Ideal Glovebox Worker

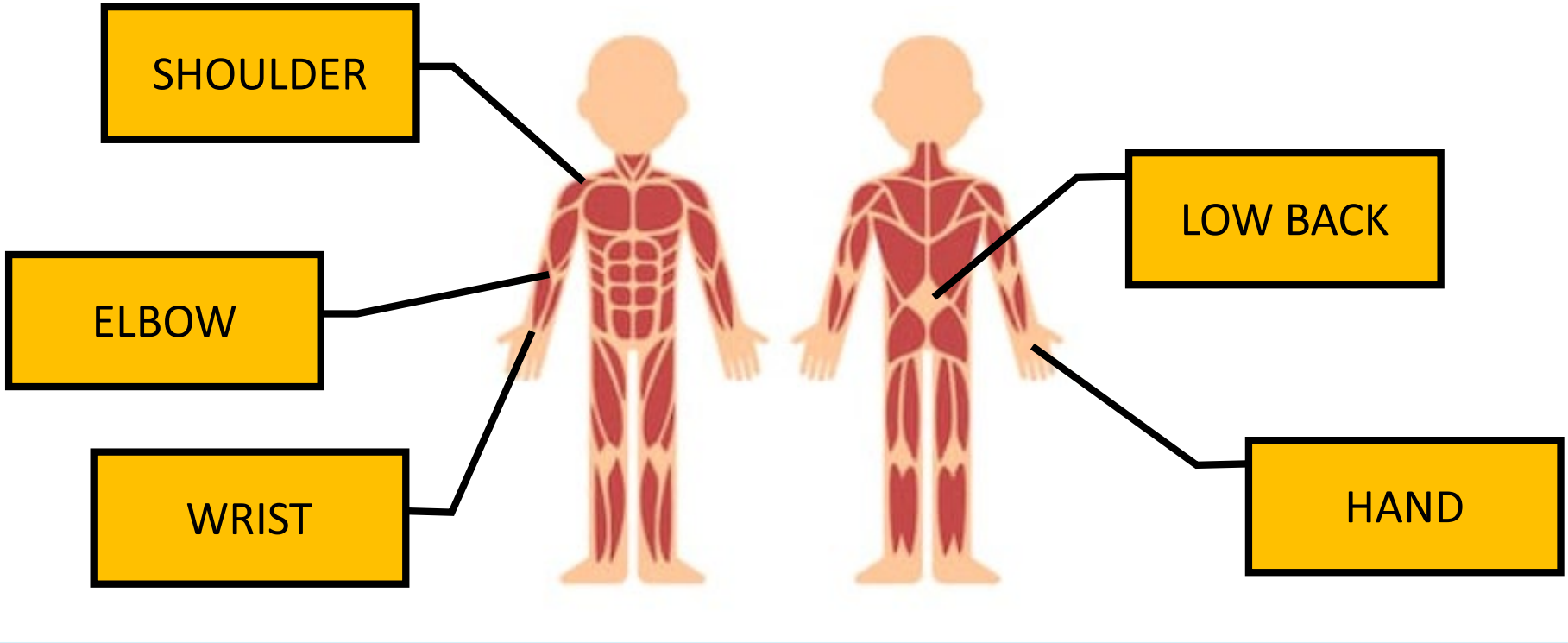
- Overall Height: 5’10”(178cm) **(Female 95th / Male 60th)**
- Arm Length: 28” **(Female 95th / Male 65th)**
- Shoulder Width: 18” **(Female 99th / Male 85th)**

How did we get started?

- **A physical therapist who is very tenacious and practical**
  - Many shoulder and elbow injuries in the same area of work – what is happening?

- **Started with partial funding for one ergonomist**

High risk for GB ergo injuries (Top 5)



Shoulder and Elbow: $$$

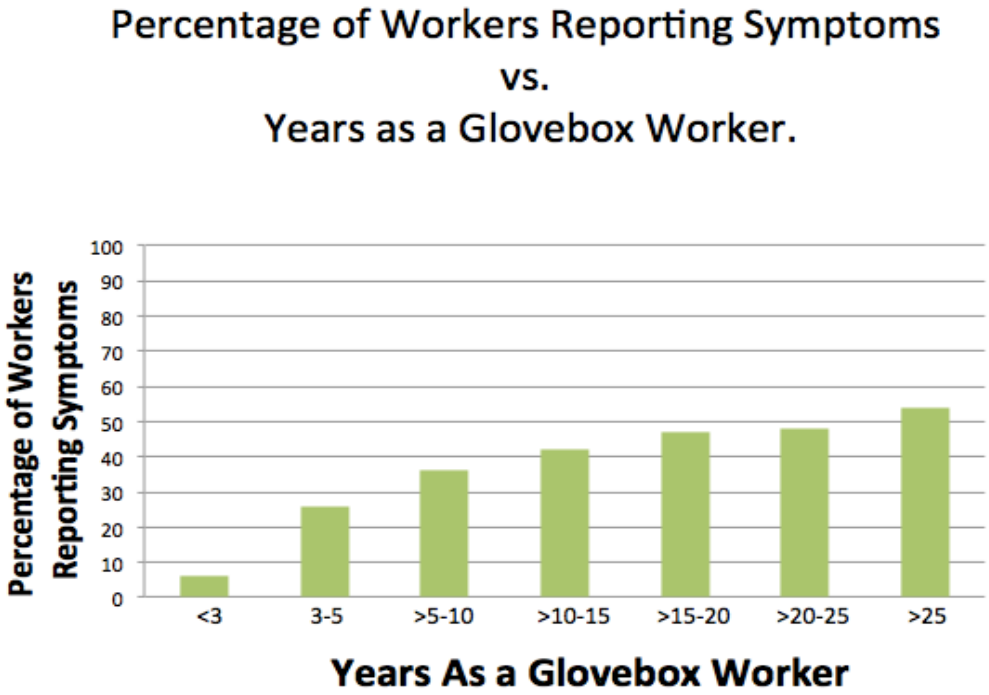
- **Highest severity: surgery and career ending**
- **Highest frequency: 2012-2020 - 14 shoulders & 18 elbows**

  Down from 2004-2012 - 24 shoulders & 37 elbows
- **Most costly:**

  Shoulder surgery direct and indirect cost ~ $120,000 to $200,000 (LANL 2014)

  Elbow surgery direct/indirect cost ~ $100,000 (LANL 2014)

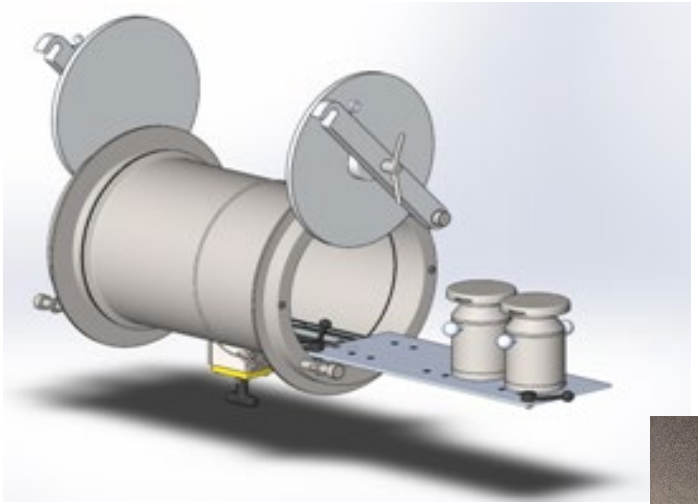
GB Worker Survey



How are we keeping it going?

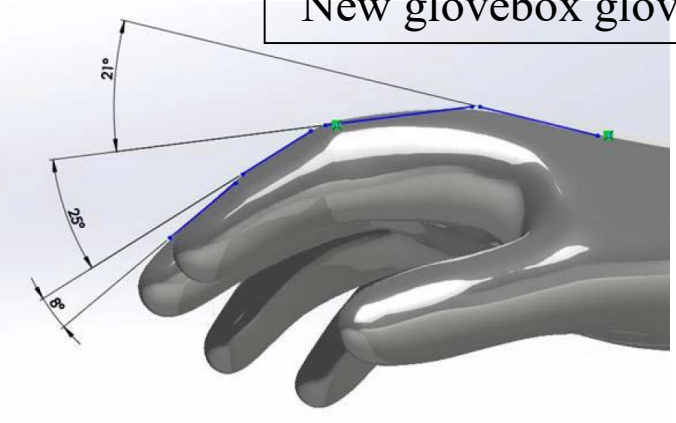
- **Developing custom solutions**
  - Lots of worker engagement
- **Involvement in safety programs**
- **Ergo demonstration room near workers**
- **Provide data-driven GB ergo guidance**
- **Integration into new or retrofit GB planning**
- **Glovebox worker ergonomics training**
- **Sharing ideas with other Department of Energy sites and glovebox users via American Glovebox Society**

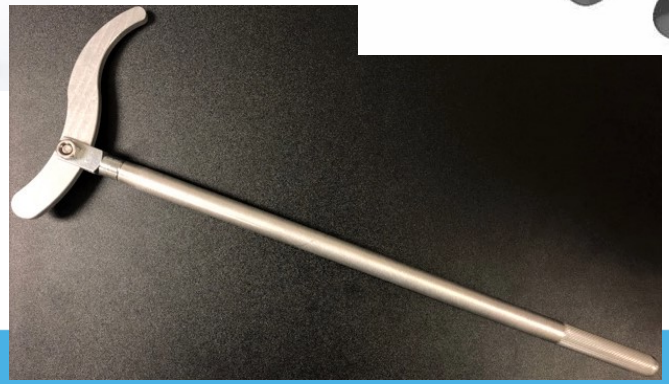
Engineering Solutions



Retractable shelf for airlock

New glovebox glove mold

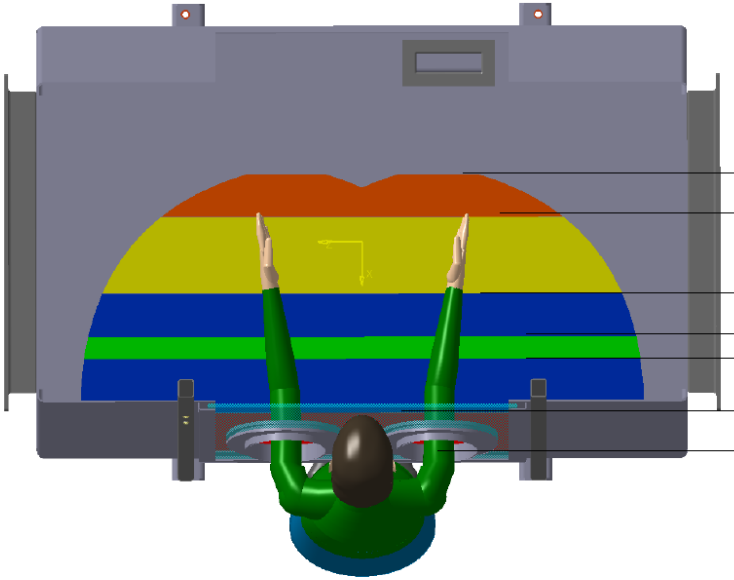




Push/Pull Reach Tool

Functional Work Space

Horizontal Reach Zones: distance from the gloveport ring toward the back of the glovebox



22”-26” TERTIARY ZONE

15”-22” SECONDARY ZONE

9”-11” IDEAL ZONE

4”-15” PRIMARY ZONE

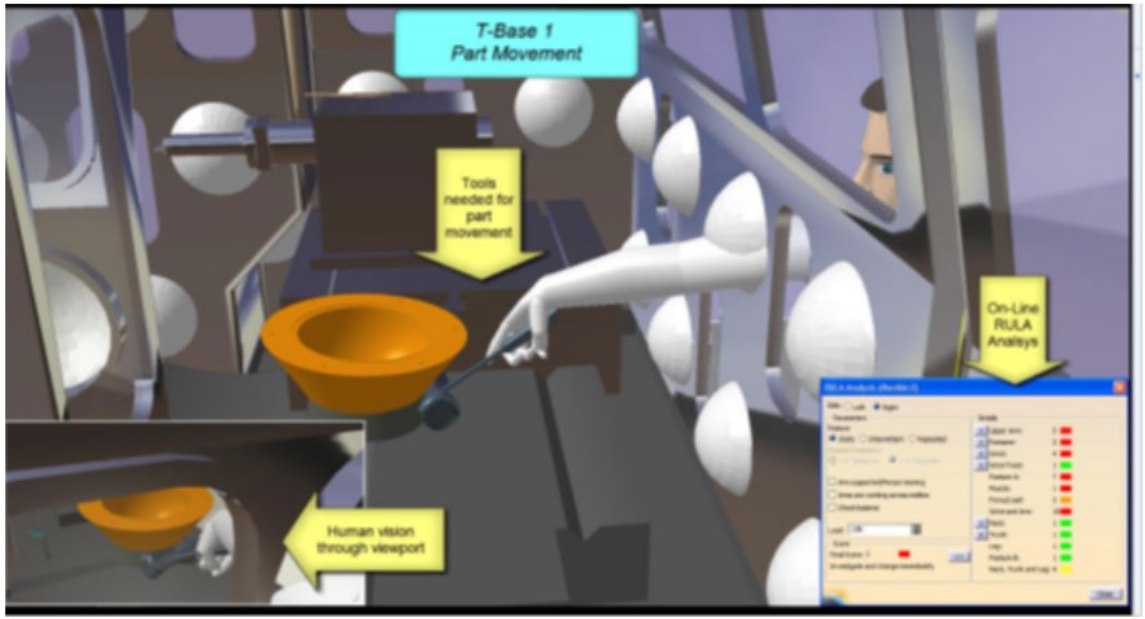
0”-4” AVOID

Y-12 NATIONAL SECURITY COMPLEX

Y-12 National Security Complex • Uranium Processing Facility • UPF SAFE SECURE AGILE MODERN CAPABLE

NNSA

Computer simulation



Identifies clearly the viewing by the operator

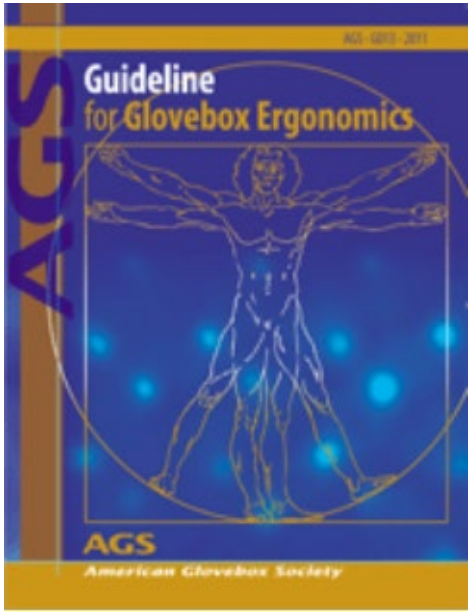
Ergonomics Design Toolbox

- **Anthropometry**
- **Ergonomic Guidelines**
  - ACGIH
  - RULA
  - Many more
- **Computer Simulation**
- **INVOLVE THE OPERATORS!**

Ergonomic Work Habits Toolbox

- Avoid Awkward Postures
- Proper Ergonomic Movements/Positions
- Mini-Breaks
- Gentle Stretches

Resources for GB ergo



SHOULDER BEST PRACTICES

Removing arms from glovebox gloves

- Pull fingers free
- Extract with elbow angled down -improves muscle imbalances

Lots of outreach in the GB world

What is on the horizon…

- **Symptoms survey #2**
- **Increase use of modern computer technology for evaluations: simulation, virtual, and augmented reality**

- **Expanding connections!**
  - With other specialty ergo program to share ideas
  - With other companies that have glovebox work
  - With other glovebox workers

Happy Glovebox Workers

Contact

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