# Crash Test Dummies

"You have to consider that a test dummy basically motivates all restraint design, whether belts or airbags"

-Rolf Eppinger,

Chief of the National Transportation Biomechanics Research Center

Tanya Starret and Steph Liddle

http://injurycases.net/pi/videos/dummies.wmv

# Goals of test dummies


- Human like
- Determine injuries which will occur
- Consistent
- Resilient

# History - 1930s

- Car crash fatalities are on the rise
- The inside of a car is a very dangerous place
- Automobile makers start to think about safety

  BUT ***NO DATA !!***

# History - Cadaver Testing

- Test to see what the body can withstand
  - i.e. Crushing and tearing forces

- Tests Conducted:
  - steel ball-bearings dropped on skull
  - body thrown down elevator shafts
  - cadavers subjected to crashes and roll overs

# History - Cadaver Testing

Problems:

- Most cadavers from elderly Caucasian males
- Couldn’t use accident victims
- No two cadavers are the same
- Child cadavers hard to obtain

Improvements are made but new data acquired from these tests is scarce…

Researchers look elsewhere…

# History- Animal Testing

- Primarily used pigs
  - Similar internal structure
  - Can be put in a seated position
- Studied impalement by steering column and decapitation
- Information helped redesign the interior of the cabin
  - Dashboard padding - Too hard or too soft?
  - Levers, knobs, buttons - Placement?
  - Rearview mirror - Stiffness?

# History- Animal Testing

Animal testing gathered useful data BUT

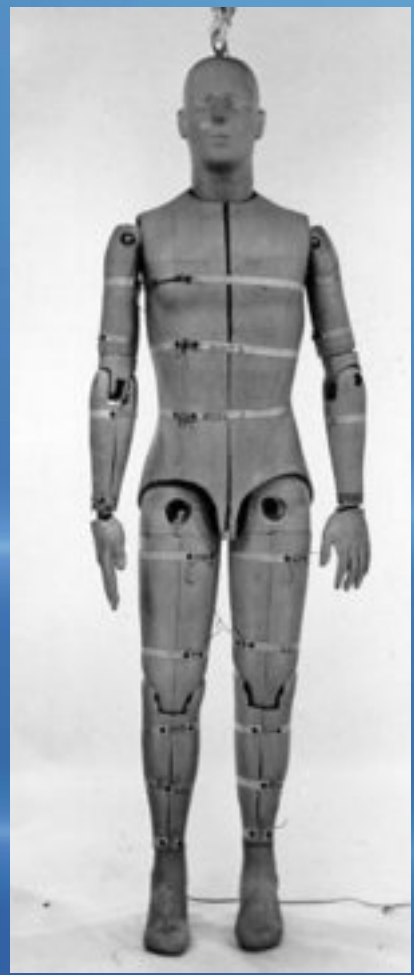
- Opposition from Animal Rights groups
- PIGS ARE NOT HUMANS!!

Again researchers looked to other solutions…

# History - Sierra Sam

- 1949 - Introduce **Sierra Sam,** *the original crash test dummy*
  - Designed from information gathered from cadaver and animal testing
  - Tested aircraft ejection seats
- The creator of Sierra Sam went on to create *Sierra Stan* and the *VIP-50* crash test dummies
  - Inconsistent results
  - Unreliable

GM needs something better…



# History - Hybrid I

- 1971 - GM Introduces **Hybrid I**
  - 50th percentile male dummy
  - Combines best features from VIP-50 and Sierra Stan
  - More durable
  - More consistent results
- Problems:
  - Data acquired doesn't give enough insight into how to reduce injury.
  - Can only test effectiveness of restraint

# History - Hybrid II

- 1972- Hybrid II
  - Improved response in knee, spine and shoulder
  - Better documentation
  - First dummy to meet the requirements of the Federal Motor Vehicle Safety Standard (FMVSS)

Responses still not human enough!!

Hybrid I & II still of limited use…

# History - GM gets serious

- Research sitting position in cars
  - i.e. relationship of posture to eye position
- Test different materials
- Research value of adding internal elements
  - Ex. Rib cage
- Biomechanical data helps determine ideal stiffness of materials
- Better production machinery
  - More accurate, reliable dummies

# History - Hybrid III

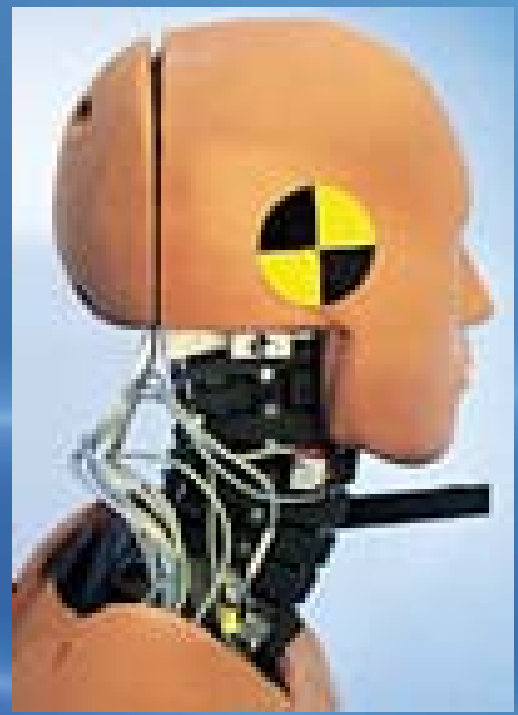
- 1976 - GM introduces Hybrid III, 50th percentile male
  - New neck & thorax
  - More transducers -- better data collection
  - Industry Standard
- Hybrid III becomes a family man
  - Big brother, 95th percentile male
  - 5th percentile female
  - 3 & 6 year old child dummies
  - CRABI - baby dummy

# Present Day - Dummy Varieties

- ***Hybrid III family*** - Frontal impact dummies
- ***SID*** - Side Impact Dummy
  - Measures effect on spine, ribs and internal organs
- ***BioRID*** - Rear Impact Dummy
  - More sophisticated spine & neck
  - More natural seating position
  - Primarily used to study whiplash
- ***CRABI*** - child dummy (6,12& 18 months)
  - Tests effectiveness of child restraints
  - Studies effect of airbag on a child
- ***THOR*** - 50th percentile male
  - Most up-to-date model
  - More later…

# THOR's day at the office

- Pre crash 'tests'
  - Head bouncing test
  - Pendulum swing
  - Chest attack
- Getting dressed
  - Yellow clothes
  - Covered in grease paint
  - Stickers



http://auto.howstuffworks.com/crash-test-video.htm

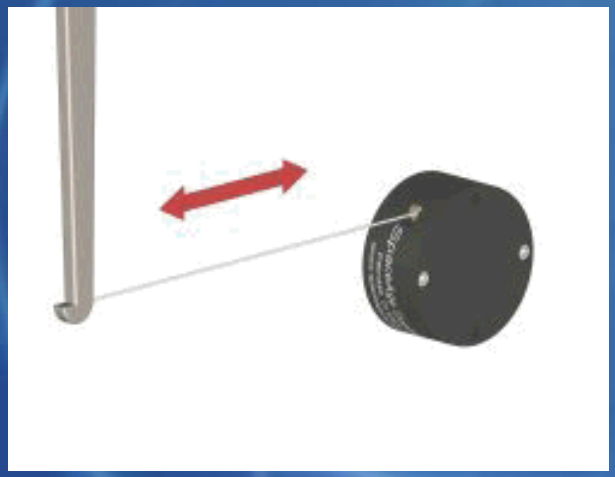
# Instrumentation

1 – accelerometers

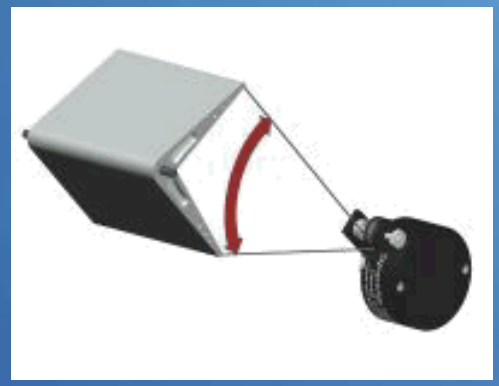
2 – load cells

3 – string potentiometers

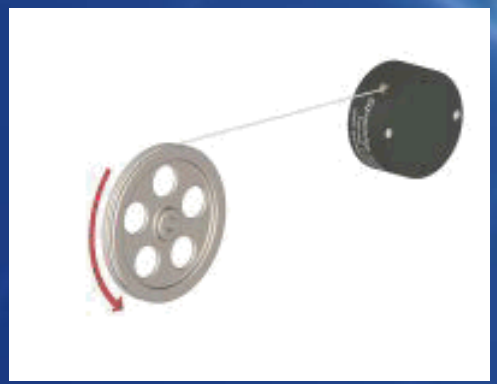
# Potentiometers



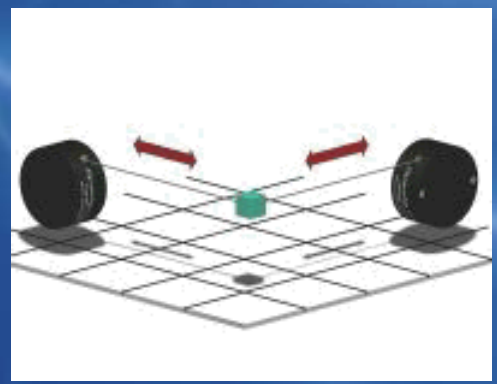
Linear



Angular



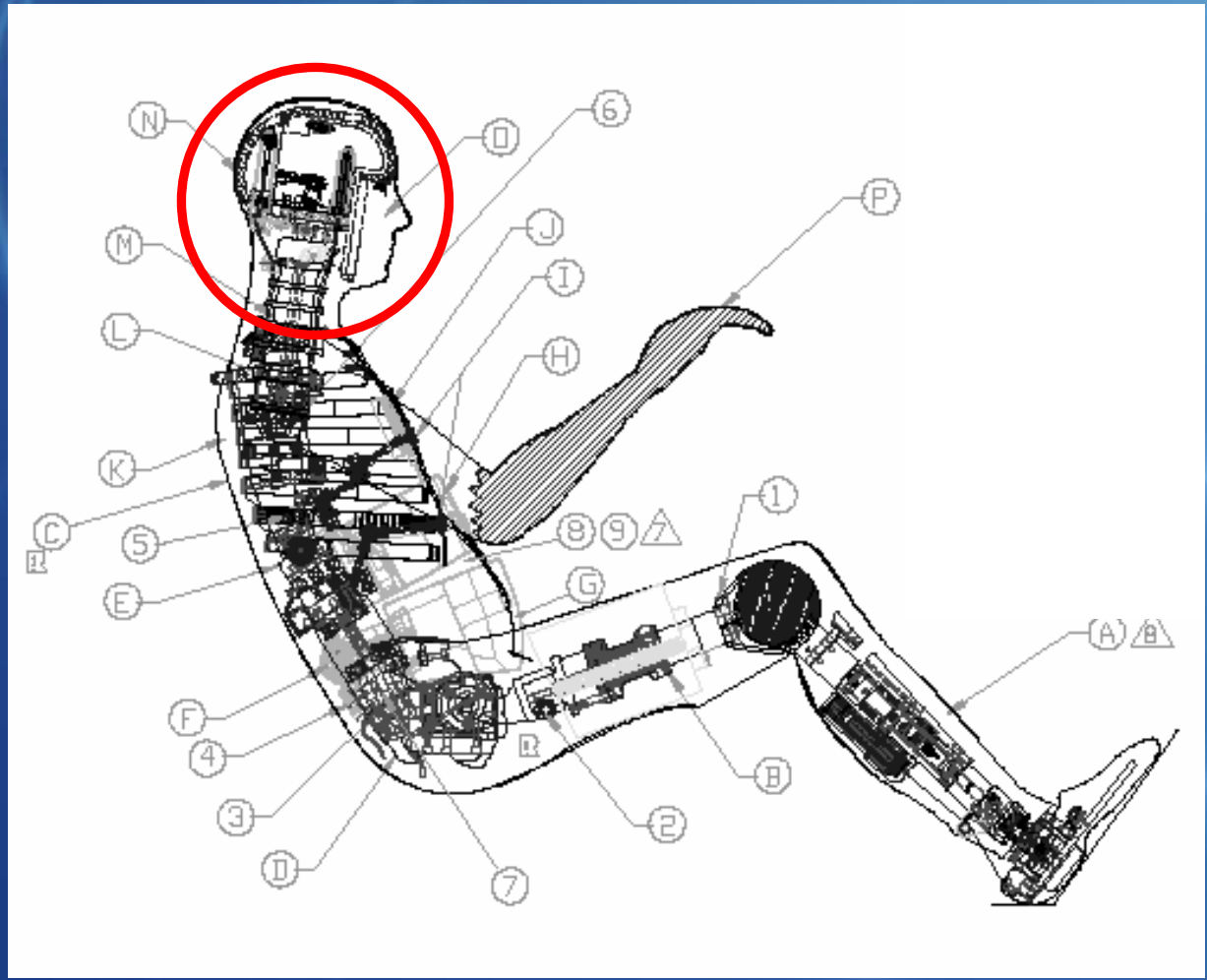
Rotary



2 - D

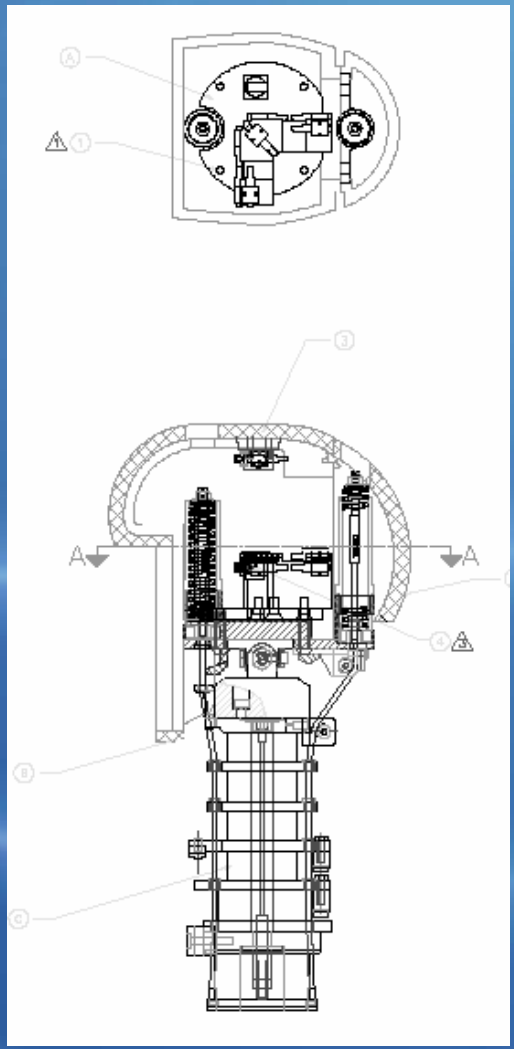
3 - D

# How it all works:
# A detailed look at THOR



# Head Instrumentation

- Weighted head
- Bi-axial tilt sensor
  - Measures the relative angular orientation
- Uni-axial accelerometers
  - Reconstruct head kinematics



# Face – the skin

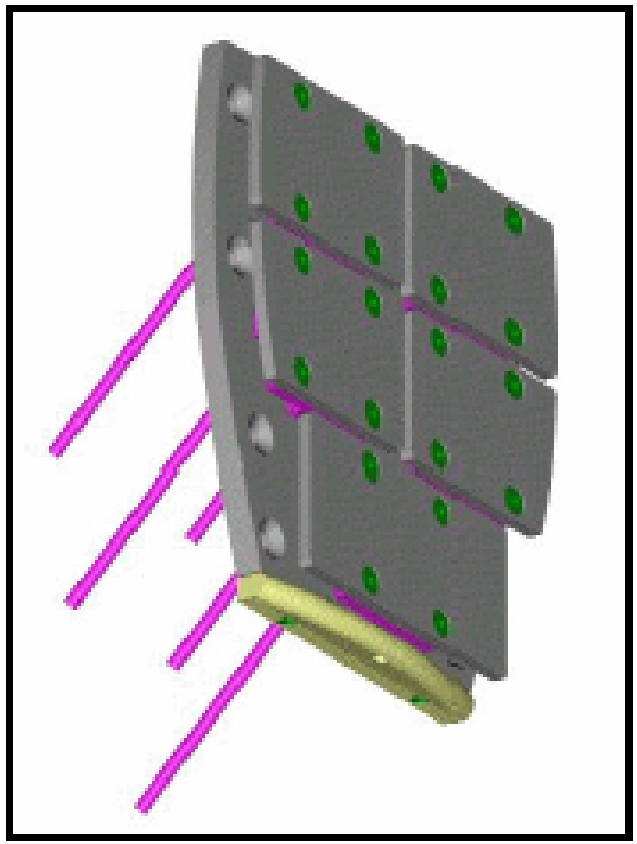
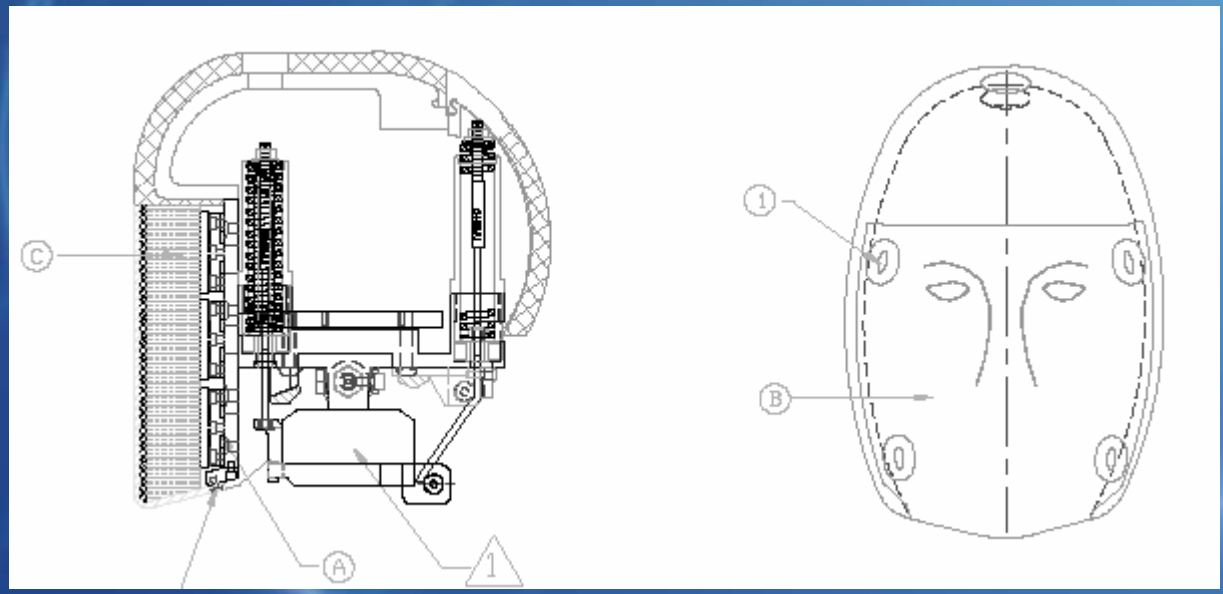


**Figure 3.1**- Face assembly

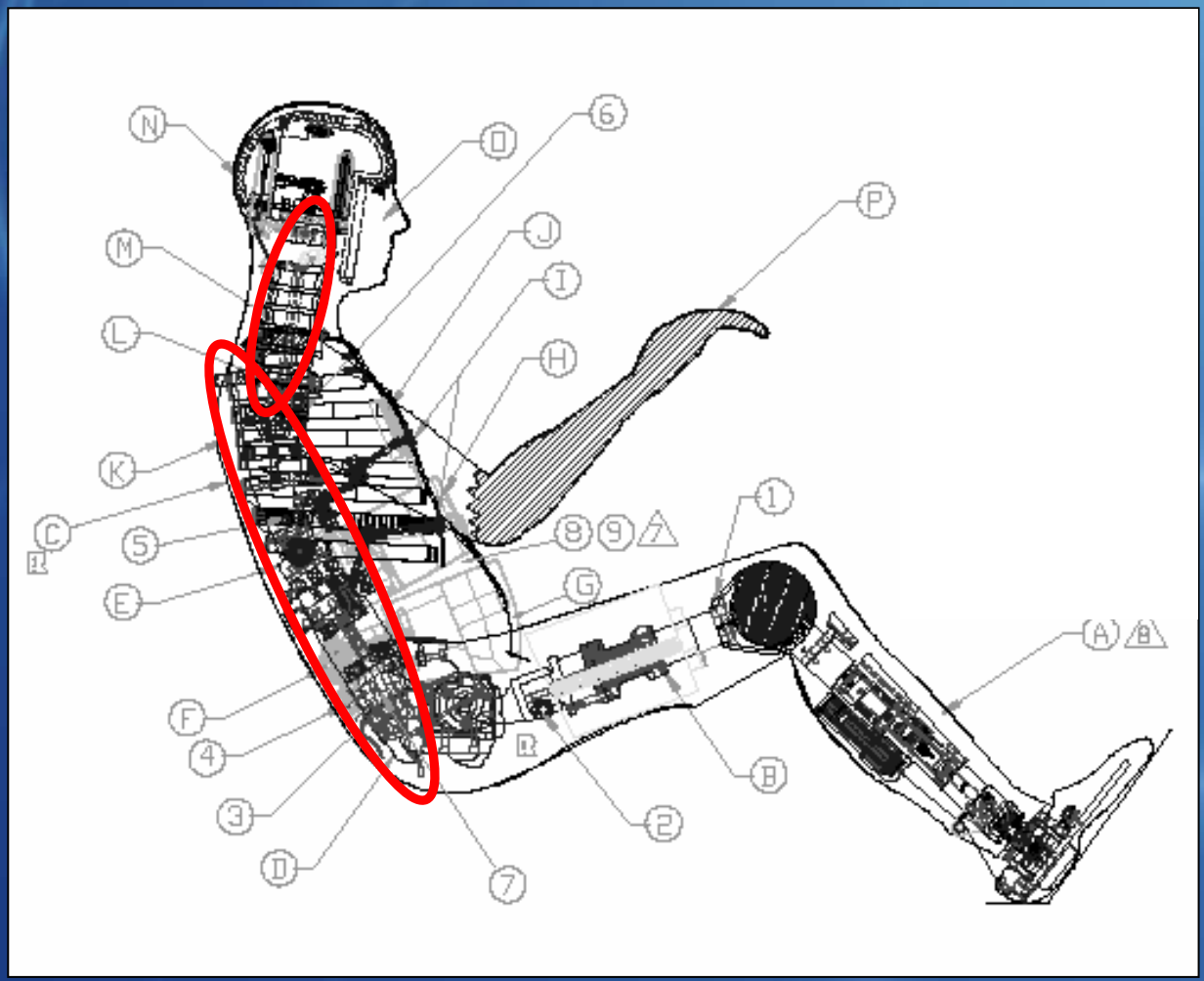
- Human soft tissue
  - Rubber and foam model human skin allowing researchers to determine if human skin would be compressed or torn during a similar experience

# Face Instrumentation



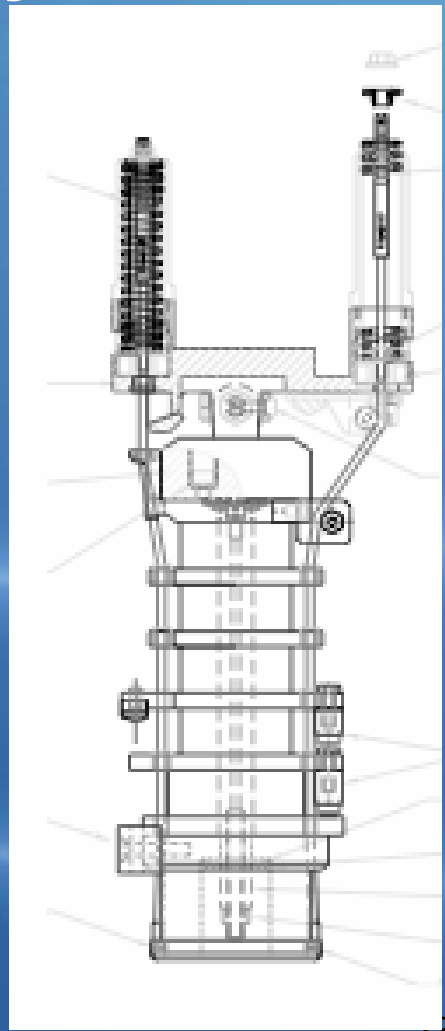

- Improvements
  - Uni-directional load cells
  - Located at each eye, on either cheek and the center of the chin

# Neck and Spine



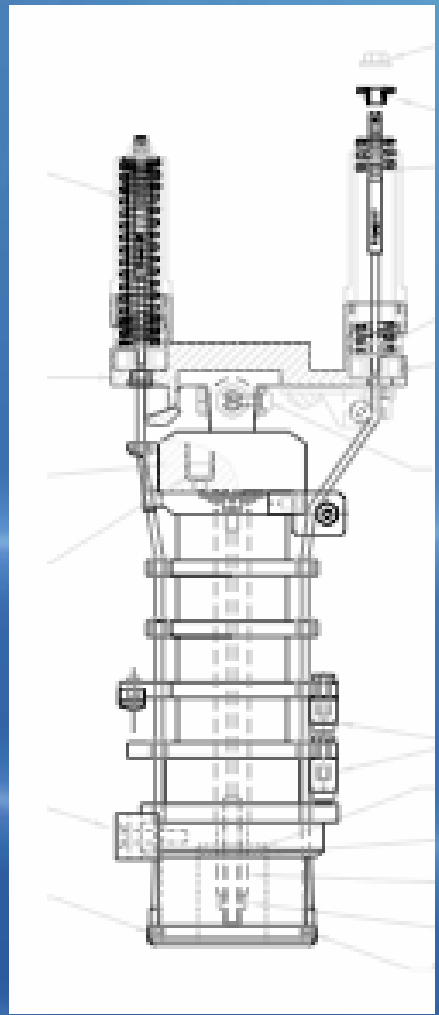
# Neck Assembly

- Multi-directional response
  - Compression springs in front and back to simulate muscle reaction
  - Soft rubber stoppers to restrict motion in forward, backward and sideways directions
  - Alternating aluminum disks and rubber pucks simulate vertebra



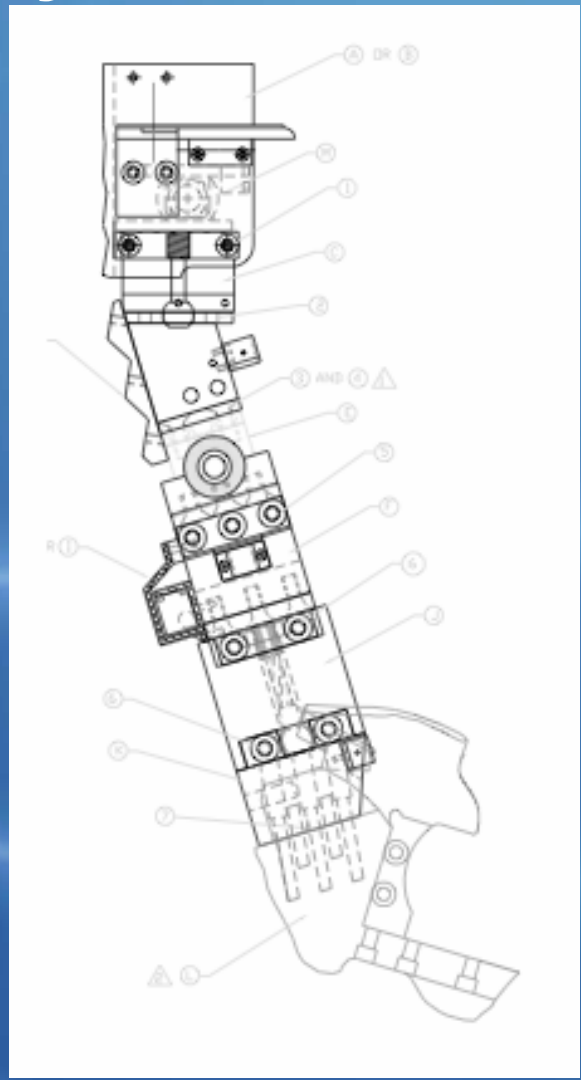
# Neck Assembly

- Sensors
  - *Miniature load cells*: compression of springs
  - *Six component load cell*: force and moment and top and base
  - *Rotary potentiometer*: relative rotation between head and neck



# Spine Assembly

- Posture & Bending
  - Neck and lower thoracic pitch change mechanism
    - Anthropomorphic locations
  - Two flex joints
  - Allow THOR to assume different postures
- Sensors
  - Tri-axial accelerometer
  - Thoracic load cell

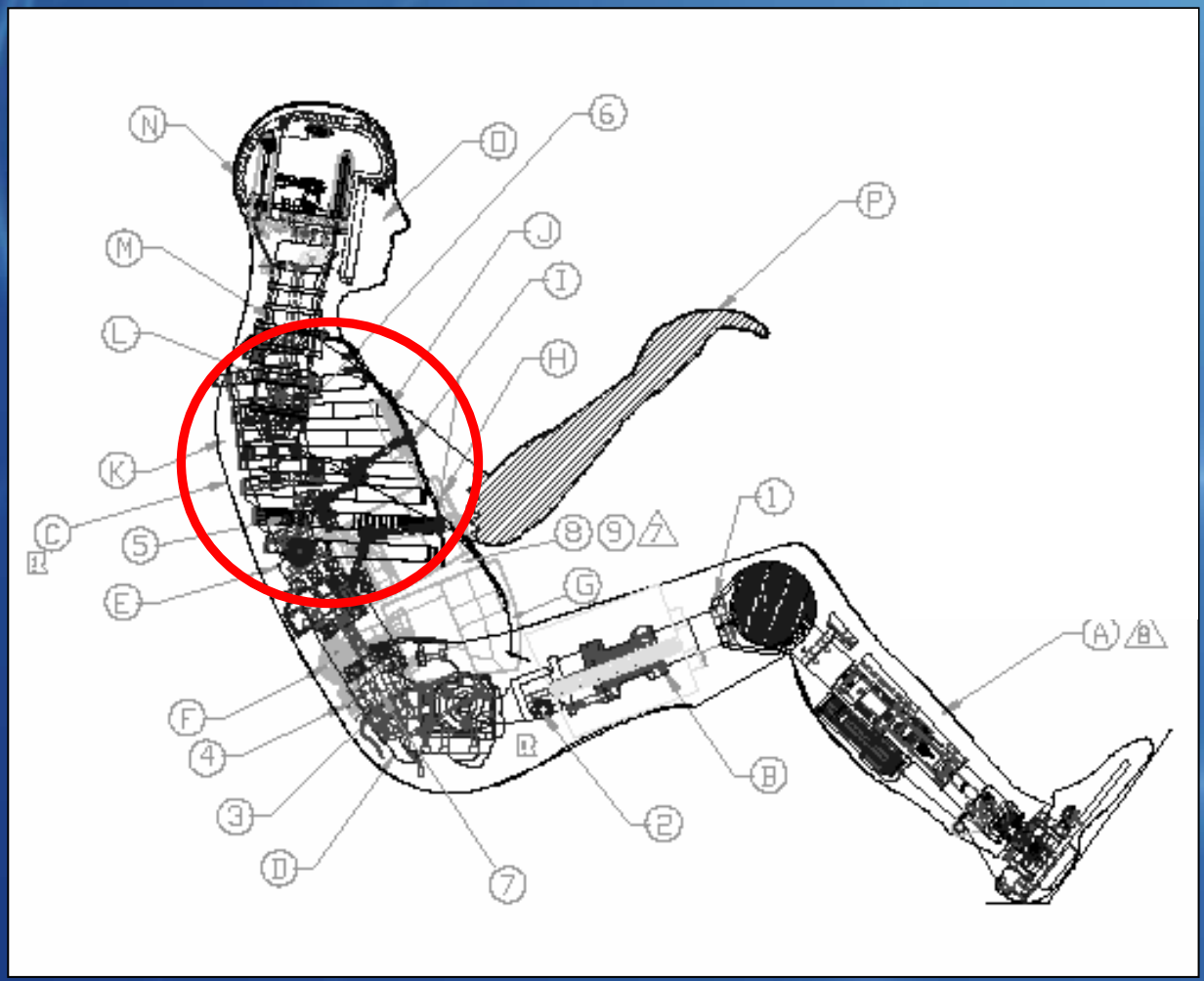


# Posture comparison

- Neck position

- Posture

# Thorax and Mid Sternum



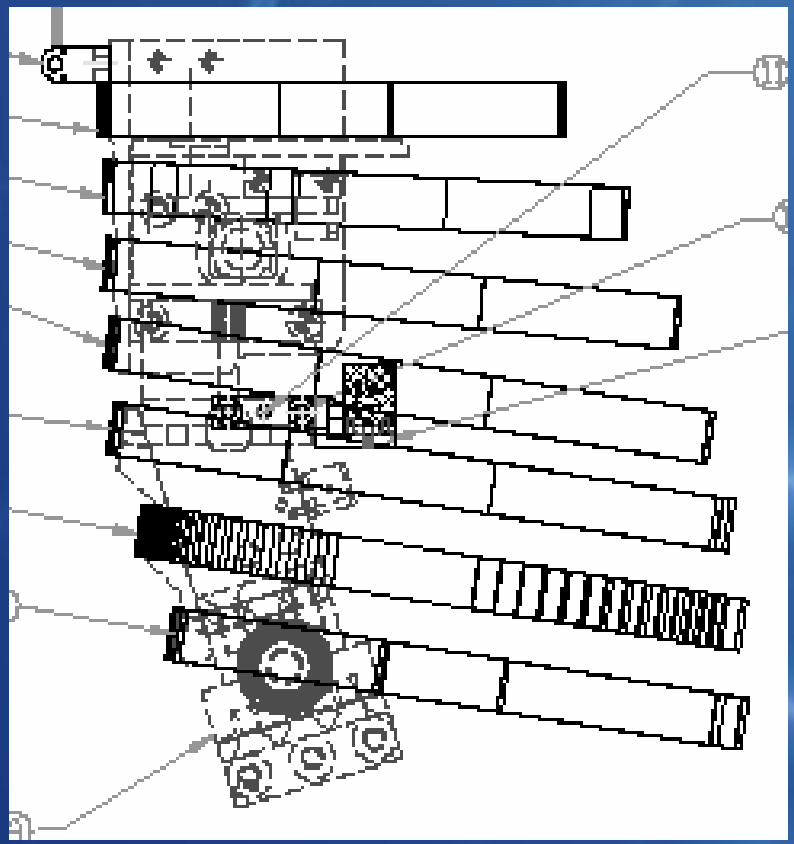
# Thorax - CRUX

CRUX – compact rotary unit

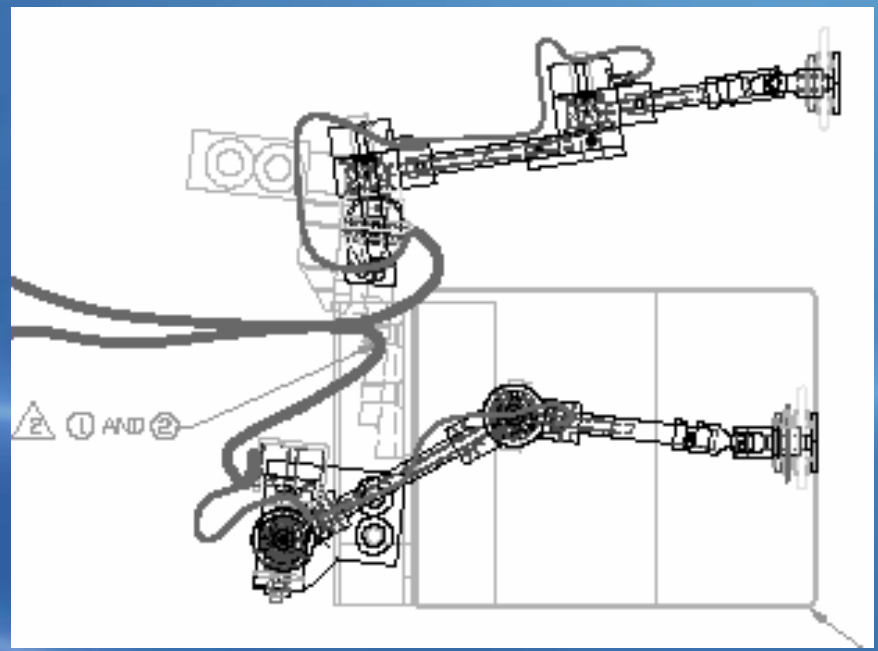
- Made from 3 rotary potentiometers
- Universal joint attaches one end to rib cage
- Other end attached to spine
- Initial, dynamic and final positions of unit can be determined

**Figure 16.7**- Lower Right CRUX installed

# Thorax – CRUX with Ribs

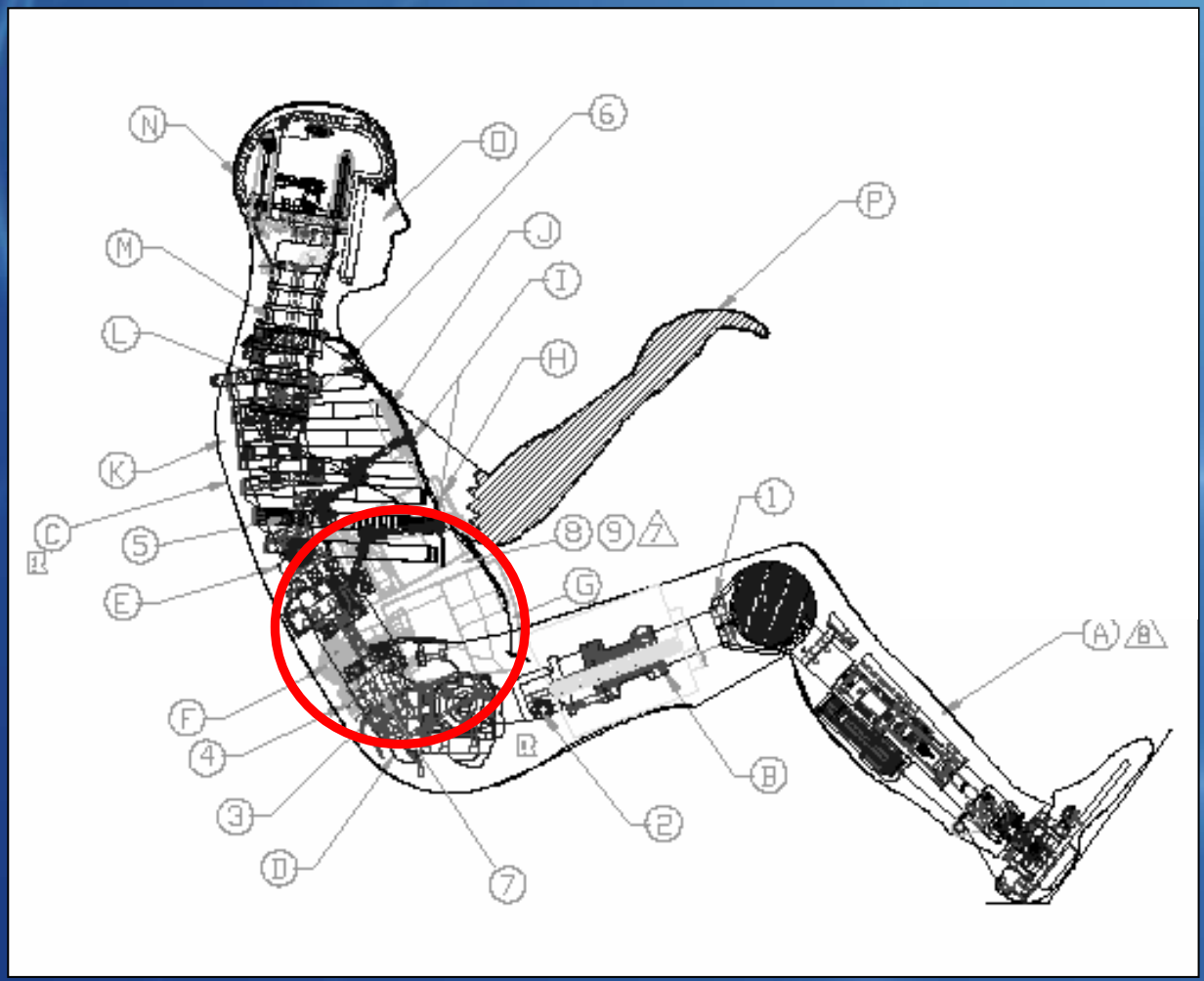


Elliptical ribs

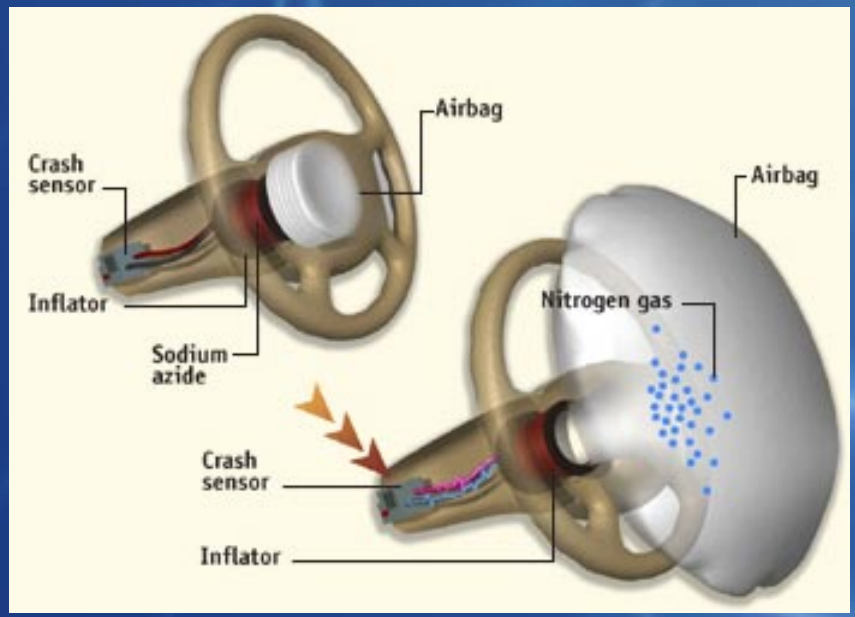



Upper and Lower Right CRUX

# Abdomen



# Upper Abdomen

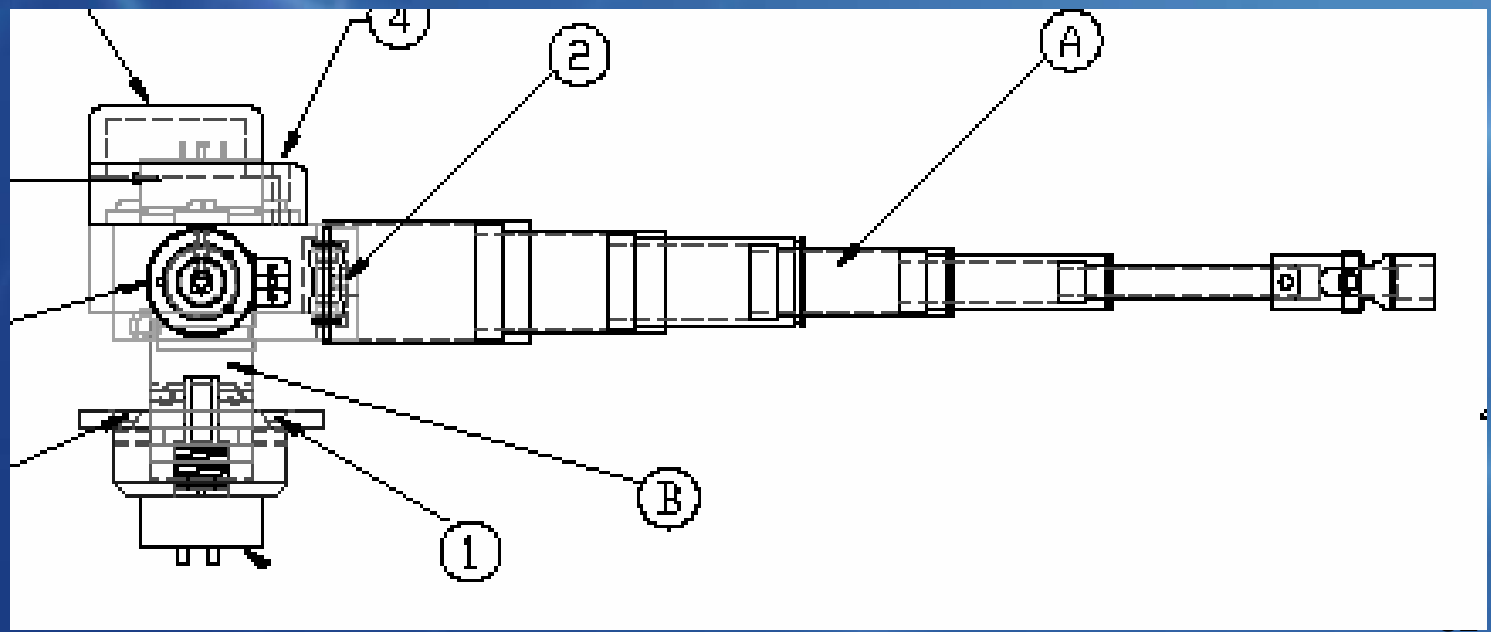



- Major damage caused by steering wheel and airbag
- Uniaxial accelerometer
- Uniaxial potentiometer

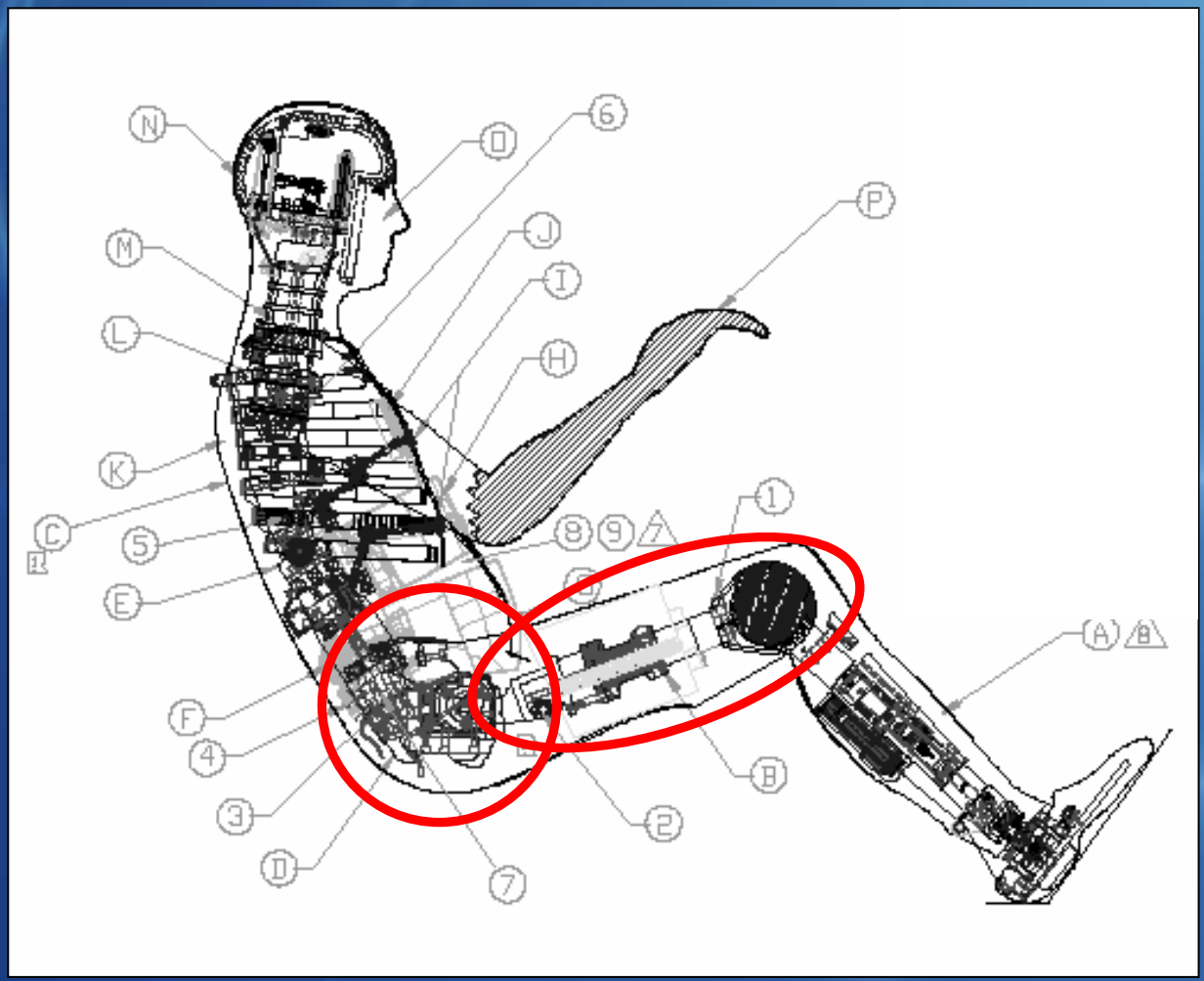
# Lower Abdomen - DGSP

DGSP – double gimballed string potentiometer

- Improved measurement of seat belt intrusion



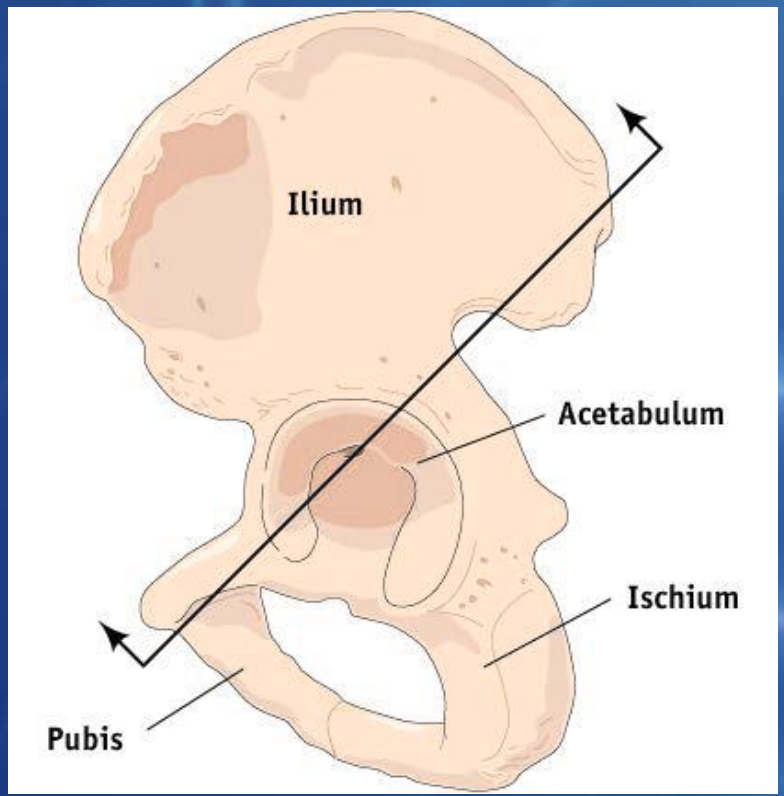
# Pelvis and Femur



# Previous Tests

- Lower body injuries are HUGE!!
- Previous tests showed femur was weaker than hip
  - Dummies femur wasn't conducting force toward pelvis

# Improvements




Pelvis

- 3 – axis acetabular load cell at hip joint
- Belt load sensors on iliac notch

Femur

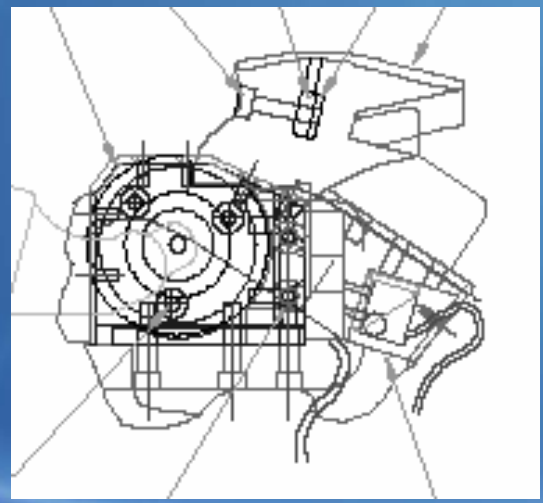
- Correct force transmission through femur into pelvic



http://guide.stanford.edu/Publications/43-1.jpg

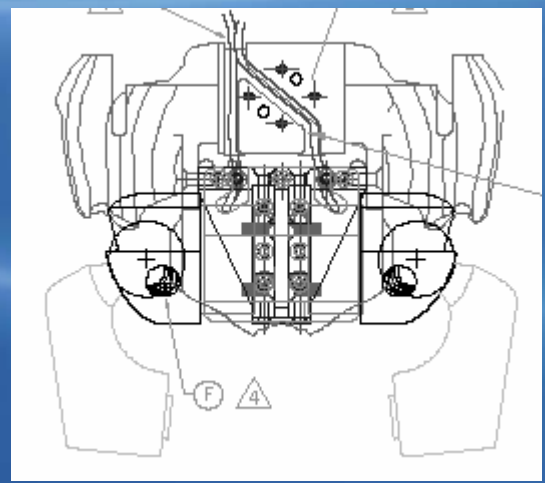
# Pelvis – Construction

- Cast aluminum structure
- Tri-axial accelerometer in rear cavity
- Improved sensors

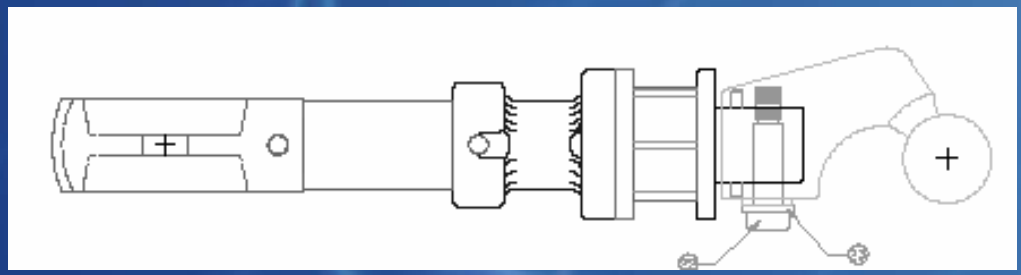


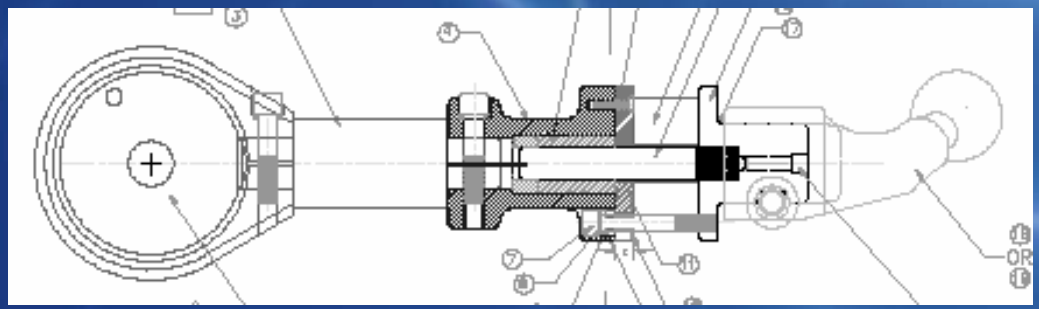
Side view

Top view



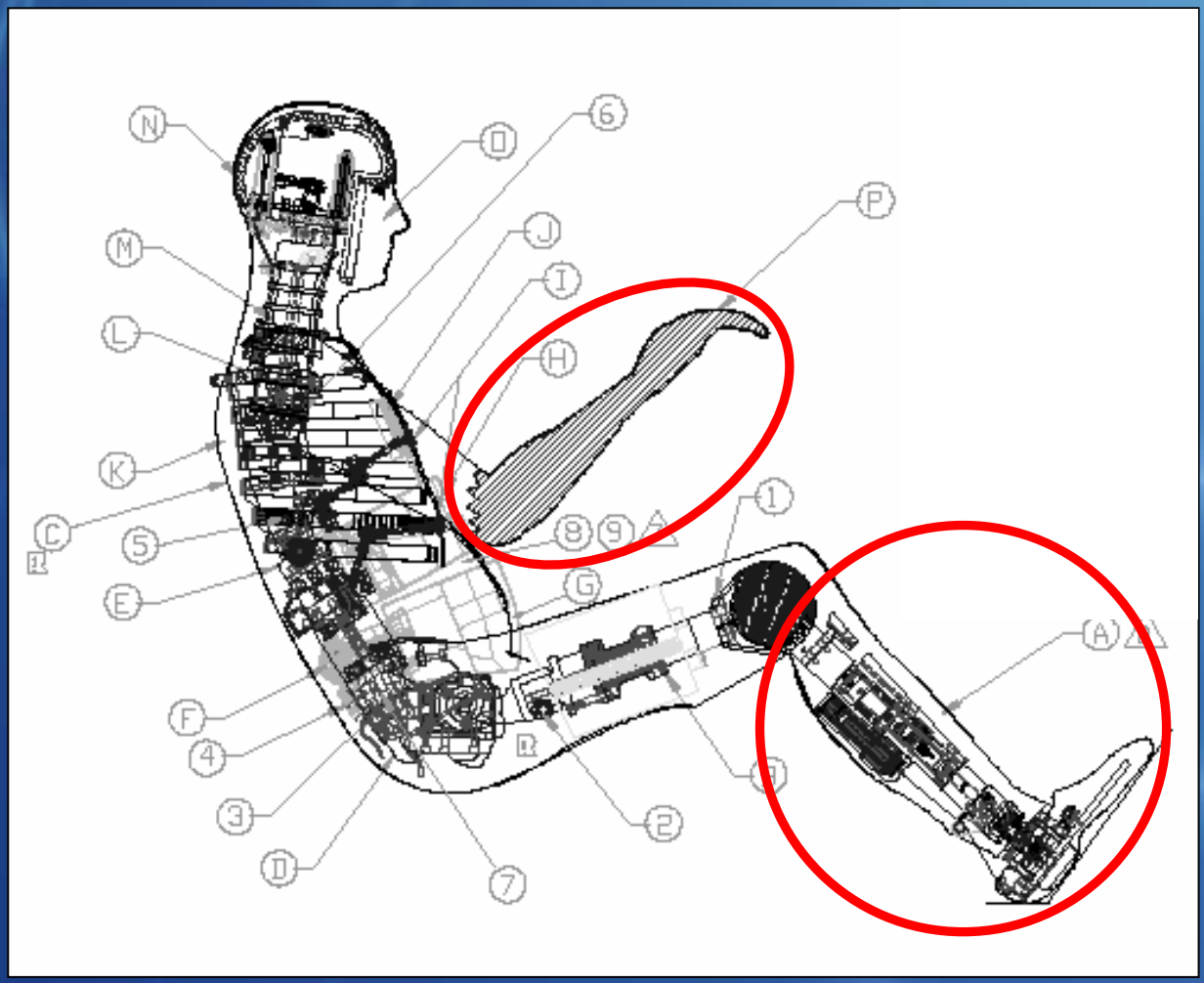
# Femur - Construction



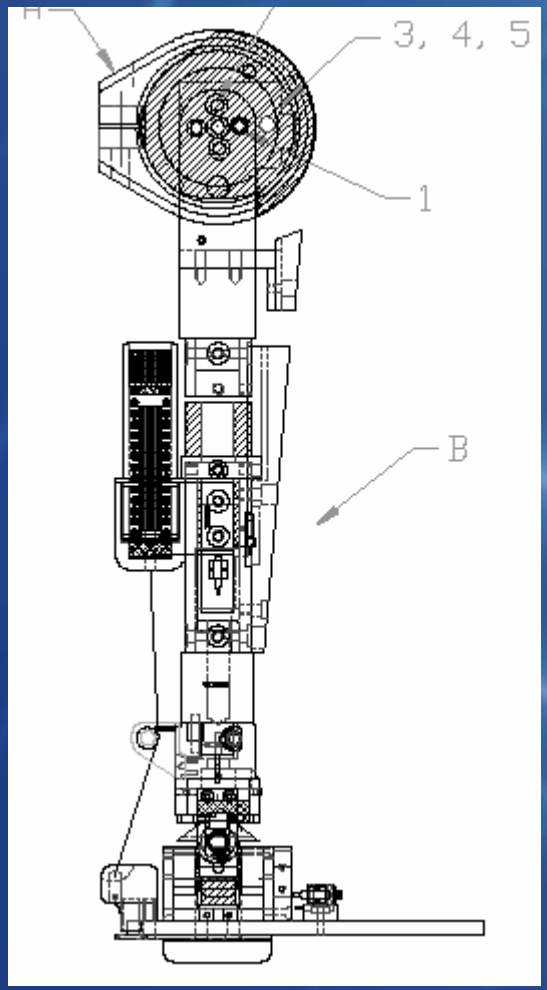


- Needs to represent largest bone in the body
- 6-axis load cell
- Axial compliant bushing creates a biofidelic deflection

# Lower and Upper Extremities



# Lower Extremities




- Lower extremity injuries are most frequent
- Numerous load cells providing data for x,y and z directions
- Achilles cable tension
- Ankle rotation

# Future of Crash Testing

1. New optical and magnetic sensor
   - 3D Imaging capabilities
   - Faster and more precise
     - Better able to measure exact amount of chest compression and head injury
     - Can tell if organ bruised or otherwise damaged
   - Works by triangulation of magnetic fields
   - Measure shearing deformation of the brain
     - Silicon gel will simulate brain tissue
   - Major Problem: interference from metal parts

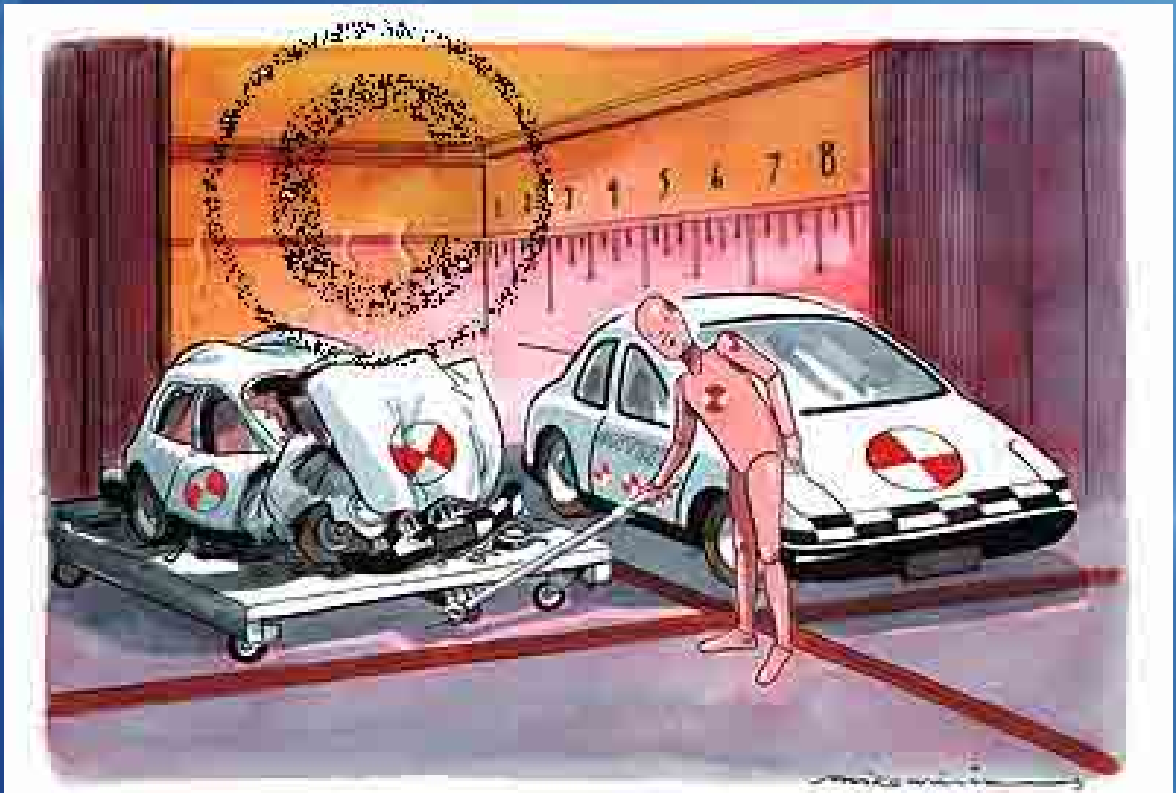
# Future of Crash Testing

2. Computer simulations
   - Goal: to have virtual humans with all internal organs
     - i.e. mathematical models of human systems
   - Programmers not yet able to do full body simulations
   - Success with individual body systems
   - Extremely repeatable tests

# Future of Crash Testing

3. Electronic Airbag sensors
   - Records events of the crash
   - Real world data
   - Every crash provides data to keep others safe
   - Helps improve dummies, simulations and other tests
   - Eventually, sensors all around the car

# Comics



# Comics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# Comics

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