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
  – Measures effect on spine, ribs and internal organs

• **SID** - Side Impact Dummy
  – More sophisticated spine & neck
  – More natural seating position
  – Primarily used to study whiplash

• **BioRID** - Rear Impact Dummy
  – Tests effectiveness of child restraints
  – Studies effect of airbag on a child

• **CRABI** - child dummy (6, 12 & 18 months)
  – More later…

• **THOR** - 50th percentile male
  – Most up-to-date model
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

Rotary

Linear

Angular

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

- 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 gimbaled 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
Femur - Construction

- Needs to represent the 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
"...and here's one I knackered earlier"
Comics

© Original Artist
Reproduction rights obtainable from
www.CartoonStock.com
Comics

THE ROADS ARE TREACHEROUS
SO I'M GOING OUT
References

• http://inventors.about.com/library/inventors/blcrashtestdummies1.htm
• http://inventors.about.com/library/inventors/blcrashtestdummies.htm
• http://en.wikipedia.org/wiki/Crash_test_dummy
• http://www.ftss.com/history.cfm
• http://auto.howstuffworks.com/crash-test1.htm
• http://www.freerepublic.com/focus/f-news/1345871/posts
• http://www.jhu.edu/~gazette/julsep98/jul2098/20dummy.html
• http://www%2Dnrd.nhtsa.dot.gov/departments/nrd%2D51/Biomechanics_Trauma.html
• http://www.cartoonstock.com/directory/c/crash_test_dummy.asp
• http://www.autoliv.com/Appl_ALV/alvweb.nsf/htmlpages/library_dictionary
References