Human Robot Interaction

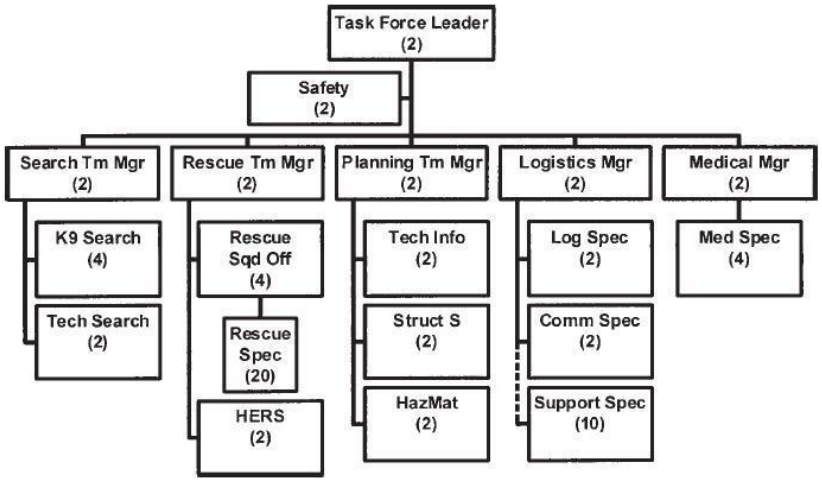
Urban Search and Rescue Robotics

Terminology

- **USAR or US&R**
  - Urban Search and Rescue
- **Emergency First Responder:**
  - Fire, Police, Ambulance, Paramedic
- **TEEX**
  - Texas Engineering Extension Service
    - Texas A&M University
- **NIST**
  - National Institute of Standards and Technology
    - U.S. Department of Commerce
- **DHS**
  - U.S. Department of Homeland Security
- **FEMA**
  - Federal Emergency Management Agency
    - Part of DHS
- **CBRNe/EOD/EDU**
  - Chemical, Biological, Radiological, Nuclear and explosive/Explosive Ordinance Disposal/Explosive Disposal Unit

Urban Search and Rescue and the Task Force System

- A Specialized technical rescue capability for the
  - location,
  - medical stabilization,
  - rescue, and
  - evacuation
- of entrapped people following a structural collapse
- First Responders Organized into Task Forces (TFs)

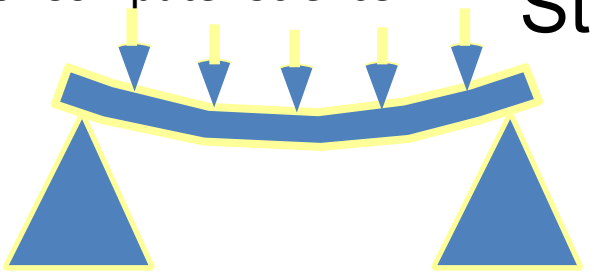


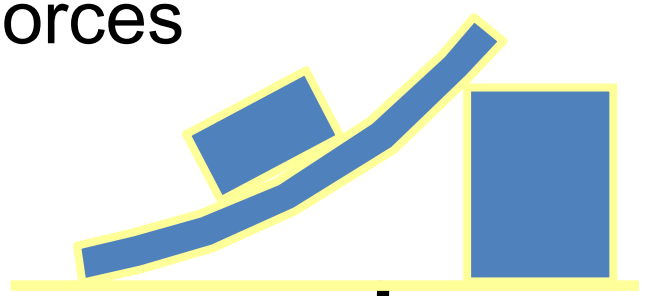
Structural Collapse?

- The catastrophic loss of the load carrying capacity of a structure
- Stability governed by a simple equation

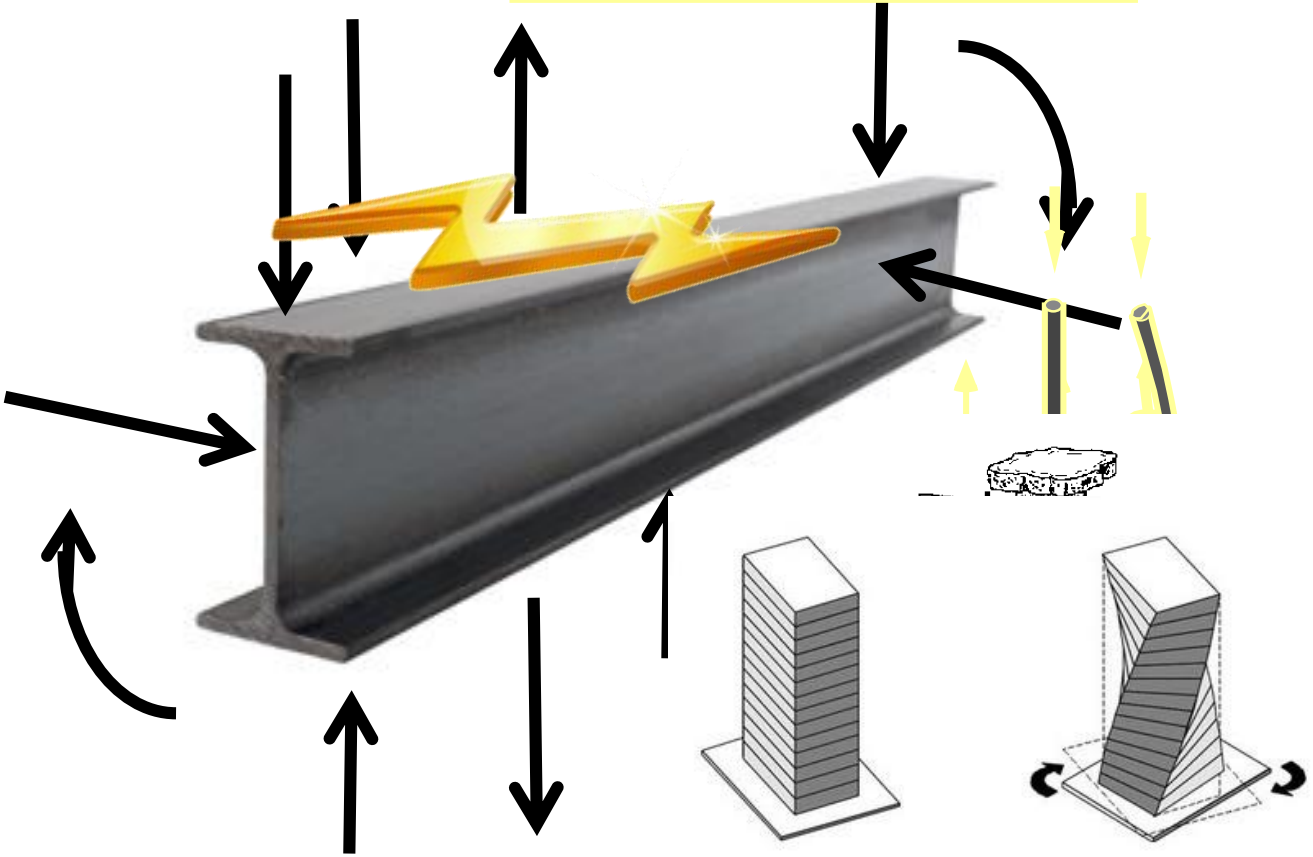
$$L_S + L_D <= T$$

Structural Forces



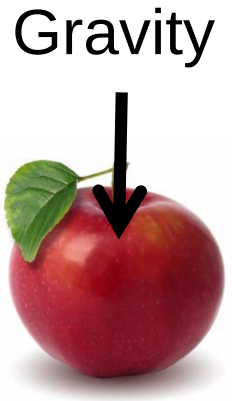


- Compression
- Tension
- Bending
- Shear
- Torsion



Load

- Forces that a structure is designed to withstand within a tolerance
  - Let T represent a “tolerance”
- Static Load (L_S)
  - Combination of constant (~) forces
    - Eg. Gravity
- Dynamic Load (L_D)
  - Combination of changing forces over time
    - Eg. Moving cars, wind, etc.



Why Structures Fail

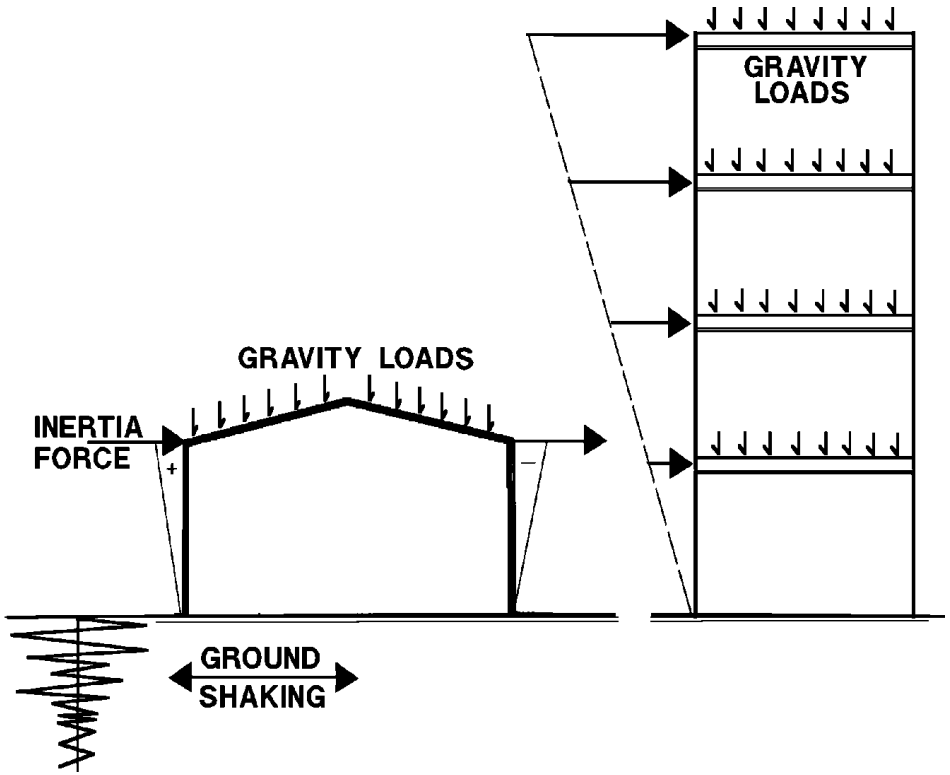
- What happens if $L_S + L_D > T$?

Progressive Collapse

Excess Load: Earthquakes

- Accelerations cause indirect forces

-Magnitude
-Aftershocks (size and number),
-Type of shaking



Video Courtesy NY-TF1

USAR Characteristics

- Dangerous
  - Mexico City Earthquake (1985): 135 rescuers died, 65 in confined spaces
- Responder Intensive
  - 1 survivor, entombed: 4 hours of effort: 10 rescuers
  - 1 survivor, crushed/trapped: 10 hours of effort: 10 rescuers
- Need for Multidisciplinary Management
  - Fire, Police, EMS, Management, Military, dog teams
- Need for speed
  - Victim found within 1 day: 81% survival rate
  - Victim found after 2 days: 36%

Structural Collapses

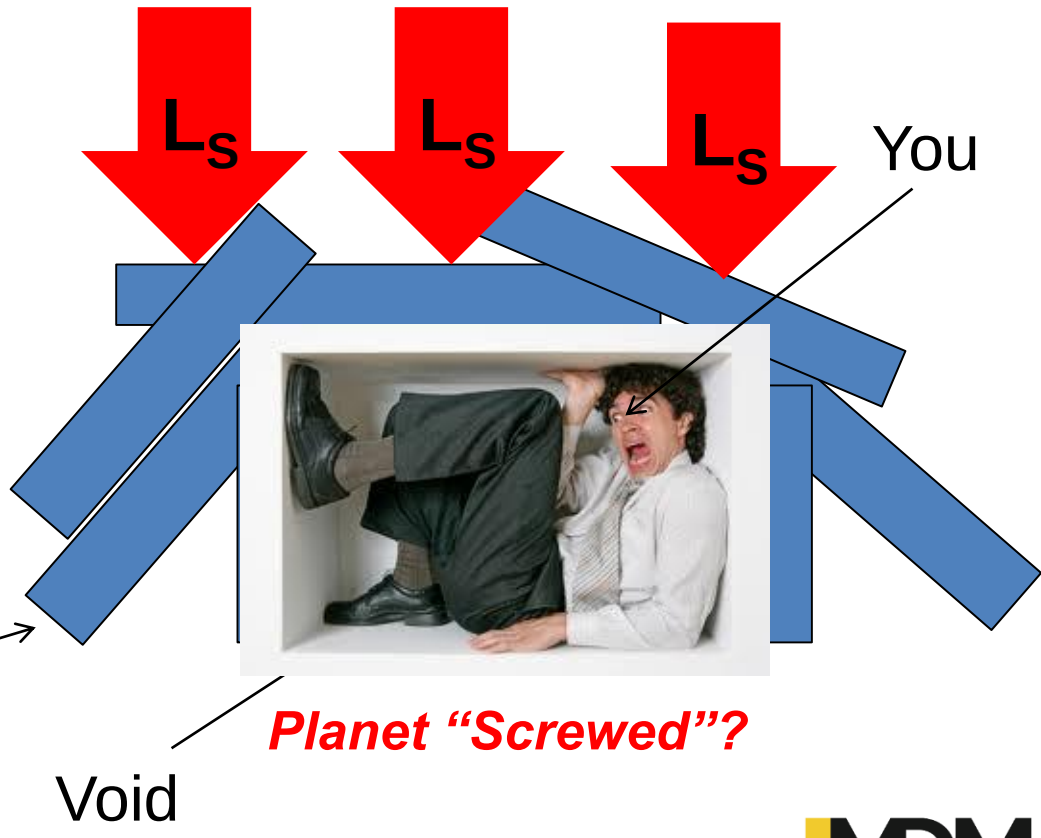
- San Francisco Earthquake (89)
- Taiwan Earthquake (10)
- Haiti Earthquake (10)
- Japan Earthquake and Tsunami (11)

- Oklahoma City Domestic Terrorist Bombing (95)
- Turkey Earthquake (11)
- India Earthquake (11)
- World Trade Center International Ter (01)
- **Elliot Lake (12)**

Elliot Lake, Ontario, Canada

Void

- Materials break, deform and recombine to form new structures of rubble
- New Structures support new loads
  - Cavities form within
  - Potential temporary haven for survivors
- Let`s make this personal
  - How do we find you in…



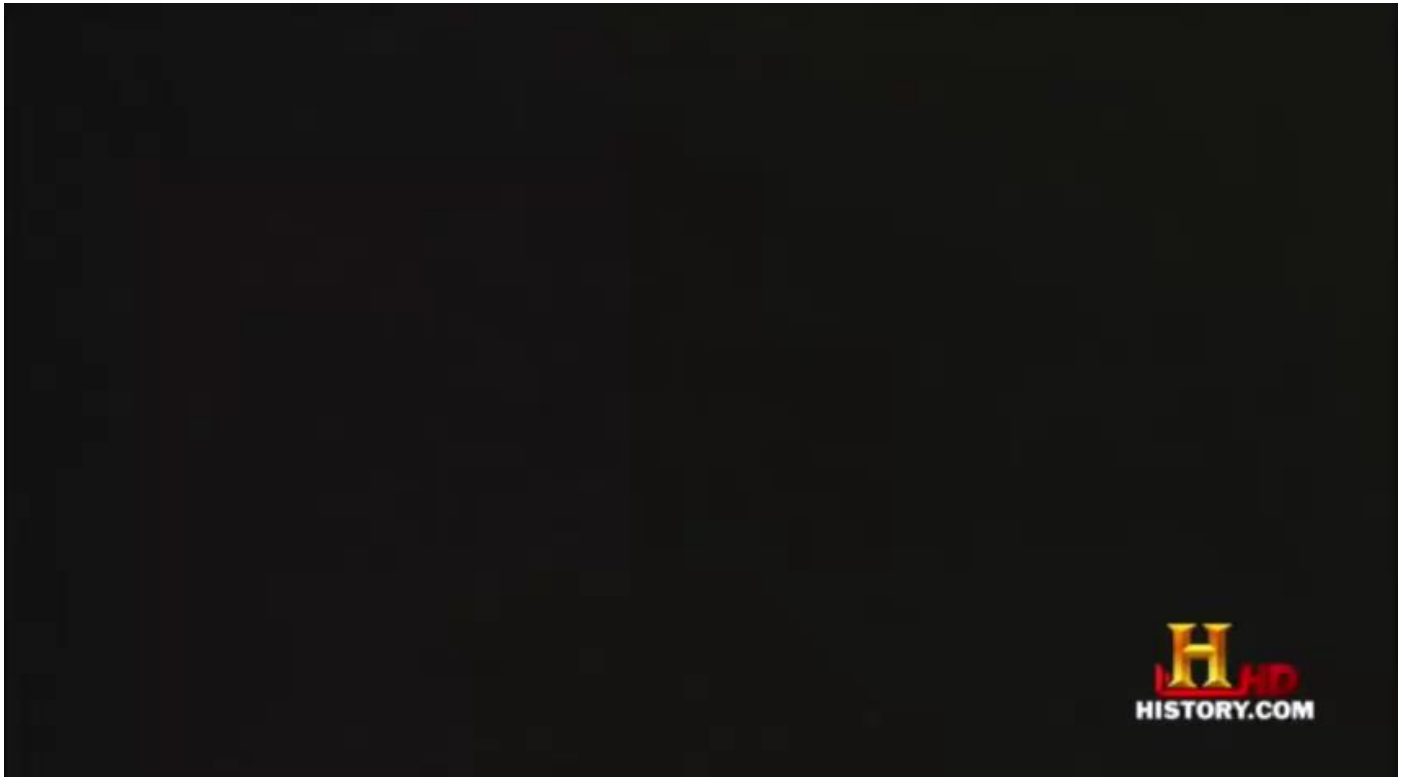
Why use robots for US&R?

- Go where humans can't go
- Go where humans shouldn't go
- "Void" search
- Aerial search
- Why not,
  - "We'd use a refrigerator if we thought it would help"
    - Toronto Fire Services, Fire Captain, Heavy Urban Search And Rescue (HUSAR)

US&R Research Pioneer

- Prof. Robin Murphy
  - Formerly: University of South Florida
  - Lately: Texas A&M University
    - College Station, TX
- CRASAR--the place for Robotic USAR Research
- Had good robotics credentials in a field of people with good credentials
- …and then something happened

World Trade Center Terrorist Attack



Fatalities

2,192 civilians;

343 members of the New York City Fire Department (FDNY);

71 law enforcement officers

Robots Officially and Unofficially Used

- Officially
  - Inuktun micro-VGTV (with micro-tracs)
  - Foster-Miller Solem and Talon
- Unofficially
  - iRobot-Packbot
  - SPAWAR-Urbot

TALON™ - HAZMAT
Robot and Operator Control Unit

Problems

- No robot self-awareness/sensing
- Transmission dropout
- Human factor problems
  - Poor interface, difficult to learn and use
- Operator Fatigue
  - Repetitive tasks but highly critical
- Fragile Robots

Disaster City

- Texas A&M University, College Station, Texas, USA
- Controlled Disaster

Response Robot Evaluation Exercises

- Measuring performance on a scale
  - Codifying practice
- Test standards held by American Association for Testing and Materials (ASTM) International
  - Consensus-based
- NCART has contributed to these test methods since 2006

Typical Robot Task: Endurance

- Simple tasks are extremely difficult to accomplish
  - working conditions are so bad.
- Q: What do you get when you challenge 2 old fire fighters to complete a simple robot test?
- A: Free drinks!

Lots of interesting outliers
Can't pass a test at all

State of the art at RREX 2006

- Disaster City, Texas A&M University
- iRobot
- “PACBOT”

School of Computer Science

23 Teams

DARPA ROBOTICS CHALLENGE

$3.5M in prizes

- GOAL: Accelerate progress in robotics and hasten the day when robots have sufficient dexterity and robustness to enter areas too dangerous for humans and mitigate the impacts of natural or man-made disasters.

USAR?

- Dr. Gill Pratt, Program Manager DARPA Robotics Challenge

State of the art 2013

- Waltham, MA
- Boston Dynamics
- “Atlas”

USAR kicks robot ass

- If you want to know about failed U.S. robots, ask a Russian