



Symposium on Emerging Developments in Multi-Disciplinary Multi-Hazard Engineering

September 18, 2007

Critical Issues in Achieving a Resilient Transportation Infrastructure

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Resilient Infrastructure

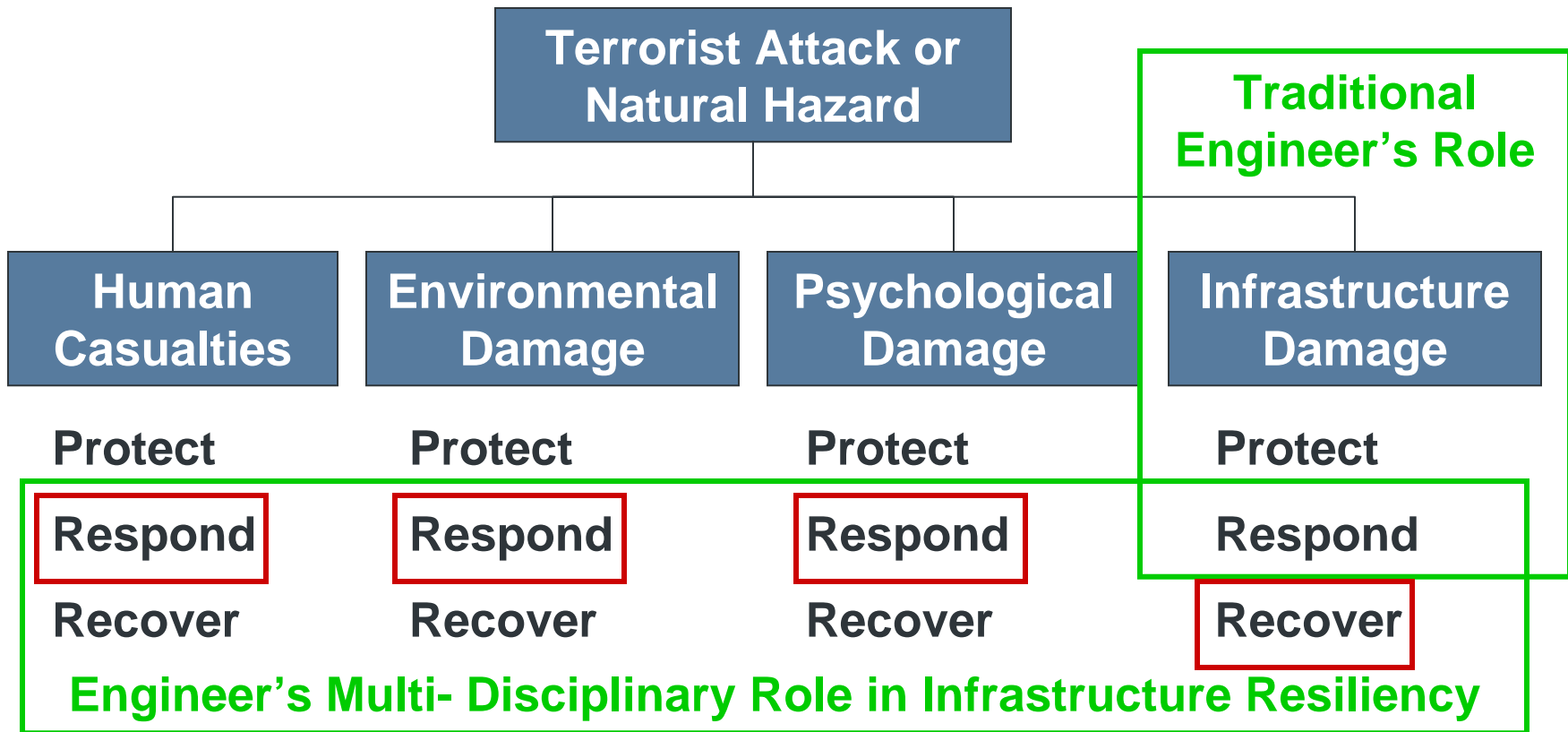
Resilient Infrastructure

- Nature of Terror and Hazard Damage and Focus on Infrastructure Resiliency
- Traditional versus Broader Focus of Engineers
- Extreme Events - Anticipating the Unexpected
- Engineer's Expanded Role
- Multi-Hazard/Multi-Disciplinary Mitigations

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Word Bank

Protect – Prevent Harm or Damage

Respond (Physical) – Prevent Collapse or Limit Damage

Respond (Human/Ecological) - Incident Management/Rescue

Recover – Use Redundancy or Restore Operations

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Primary Objectives of Threat and Hazard Mitigation

Resilient Infrastructure

- Focus resources (\$, people, equipment, and time) on mitigating the number of casualties
- Focus resources (\$, people, equipment, and time) on shortening the recovery period (Resiliency)

Focus resources on mitigating the number of casualties

- Limit propagation of collapse beyond point of attack/hazard
- Facilitate Evacuation, Rescue and Incidence Management

Harden egress routes

Provide incident feedback and protocols for first responders

Harden life safety systems (alarms, lighting, communications)

Improve egress way-finding (signage, fluorescent path markings for self evacuation)

Focus resources on shortening the recovery period

- Pre-disaster Implementation

Harden, shield, armor, and/or insulate critical elements to prevent catastrophic failure

Provide redundancy to prevent local failure from progressing

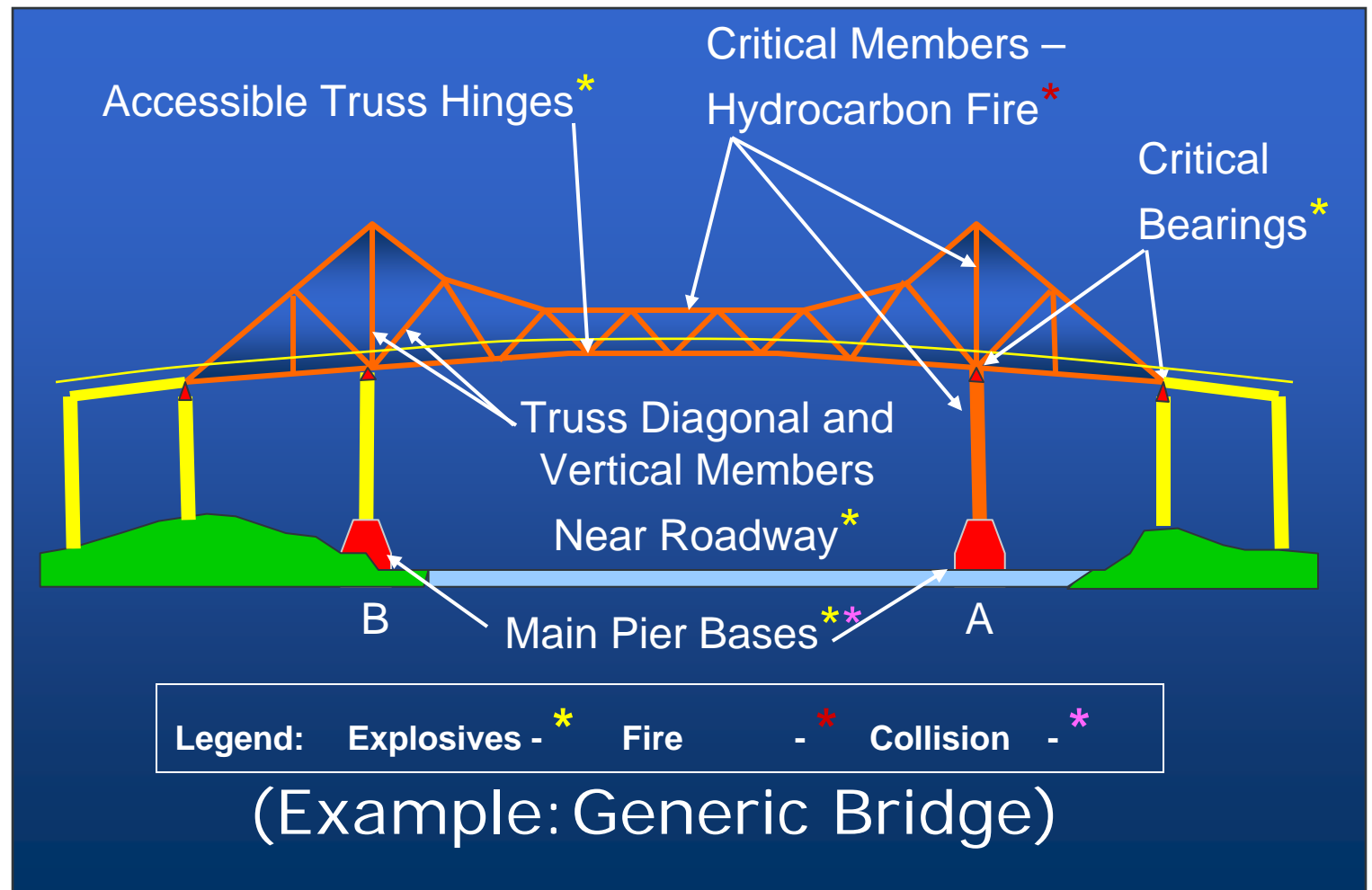
Provide redundancy to maintain function of the system at reduced level

- Post-disaster Implementation

Make provisions to isolate or limit damage in the response mode

Prepare disaster recovery plans and procedures and arrange for resources to carry them out in an emergency recovery mode

Example of Extreme Event: Fire on a Bridge

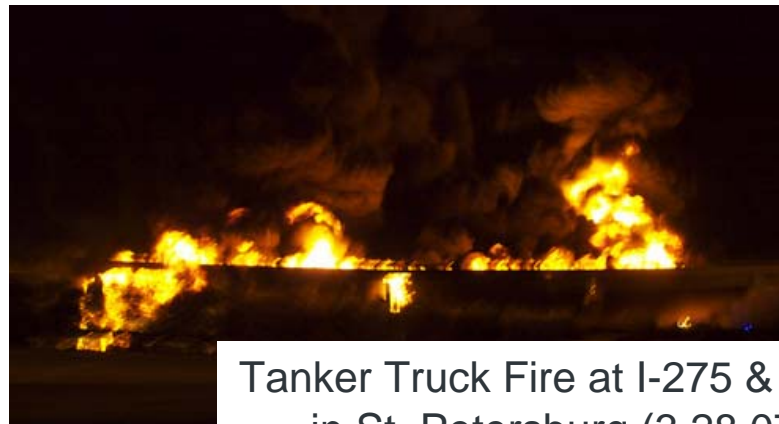


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Incendiary Threats



Tanker Truck Fire at I-80
in Wisconsin (3.28.07)



Tanker Truck Fire at I-275 & I-375
in St. Petersburg (3.28.07)



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Oakland Tanker Fire

- Overturned tanker truck
 - April 29, 2007
 - 8,600 gallons of gasoline
 - Temperatures > 2,500 °F (1,371 °C)
 - 2 hours for firefighters to get fire under control (using water)



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Oakland Tanker Fire

- Timeline
 - 3:41am – tanker overturns
 - 3:55am – Oakland FD arrives at scene
 - 14 minutes
 - 4:02am – I-580 overpass collapses
 - 21 minutes
 - Approx. 5:30am – fire under control



Special to the Chronicle / Philip Liborio-Gangi



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[Collapse Video \(ABC\)](#)

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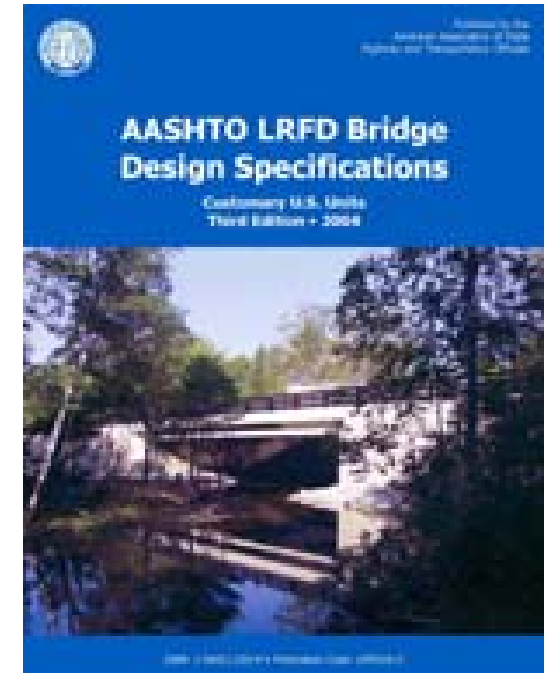
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Infrastructure Resiliency Designing For Extreme Events

**Designing
for
Extreme
Events**

- Design Standards
 - Extreme Events
 - Seismic, Vessel Collision
 - Wind (Long Span Bridges Only)
 - **Hydrocarbon Fire?**
 - **Terrorist Attack (Man-Made)?**
 - **Vehicular Impact?**
 - **Flooding?**
 - **Progressive Collapse**
 - **Life Safety**
 - **Rapid Recovery**



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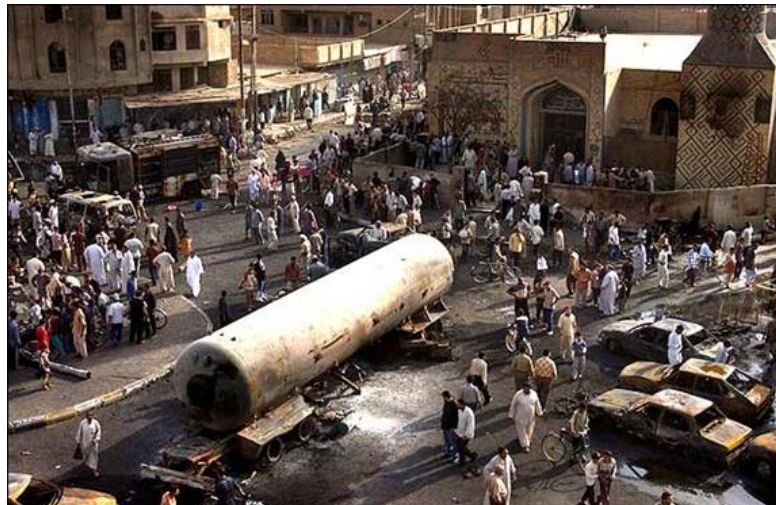
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Malfunction Junction, AL

**Hydrocarbon
Vehicle Fire**



**Weaponization of
Hazmat Transport**

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**Terrorism
Man-Made
Hazards**

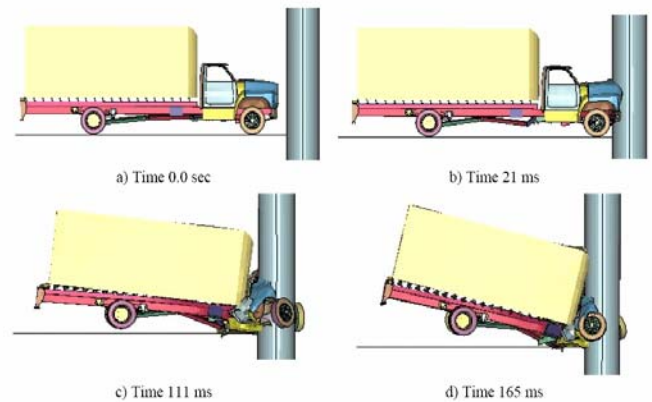
- Targeted Infrastructure
 - Single Point Vulnerability
 - Multiple Soft Targets
 - Open Access
- Conventional Explosives
- Precision Demolition
 - Emerging Threats



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Vehicle Impact



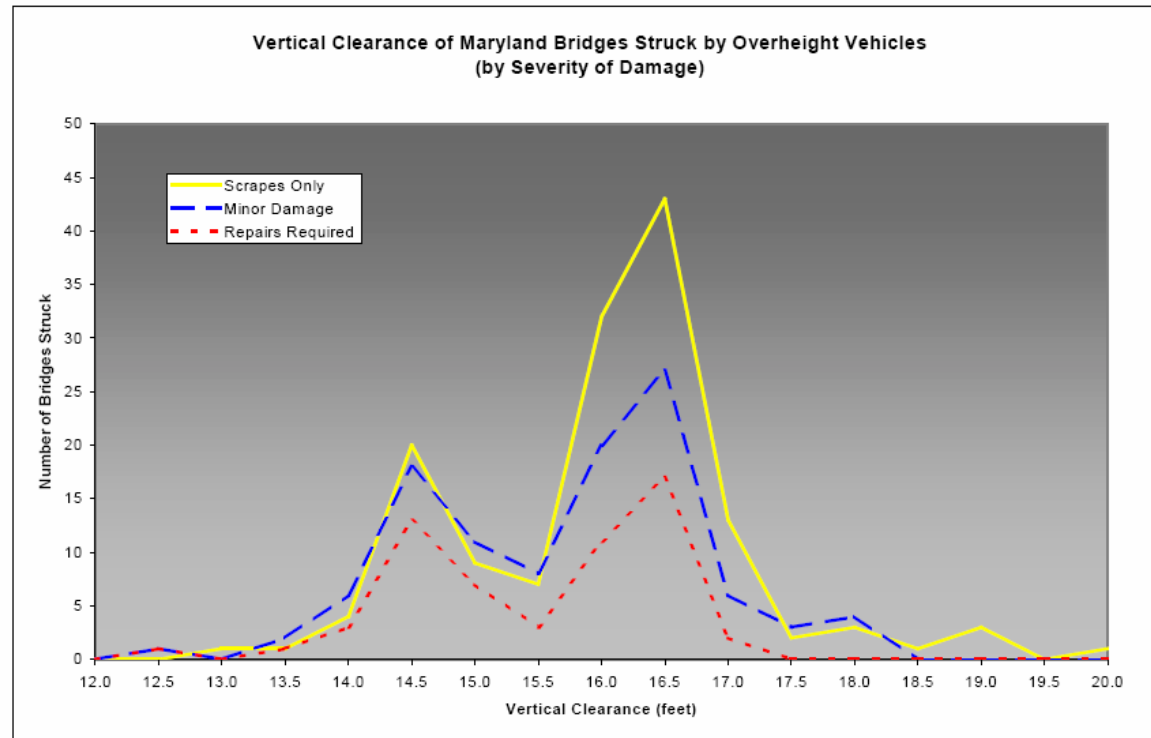
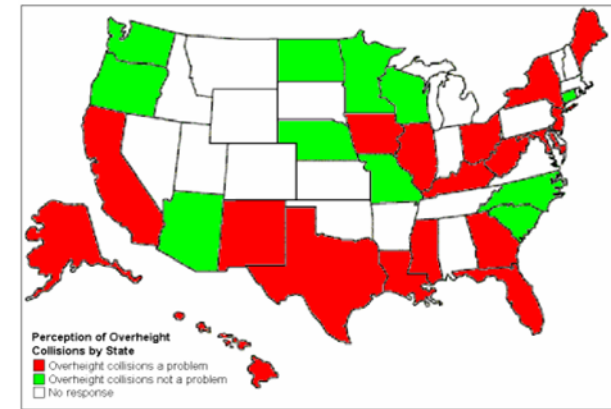
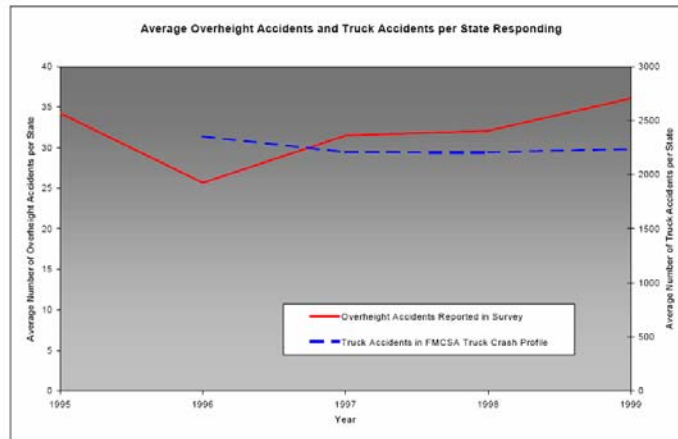
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**Vehicle
Impact**



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**Flooding
Katrina
Infrastructure
Damage**



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**Progressive
Collapse
Bridges**

Bridges – Progressive / Disproportionate Collapse History

Silver Bridge (1967)



Mianus River (1983)



SFOBB –East Bay Spans (1989)



Queen Isabella Causeway (2001)



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Bridge Demolition

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- Baghdad, Iraq
 - April 12, 2007
 - Al-Sarafiyah Bridge over Tigris River
 - Six wheel truck packed with explosives



Iraq Bridge



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Iraq Bridge



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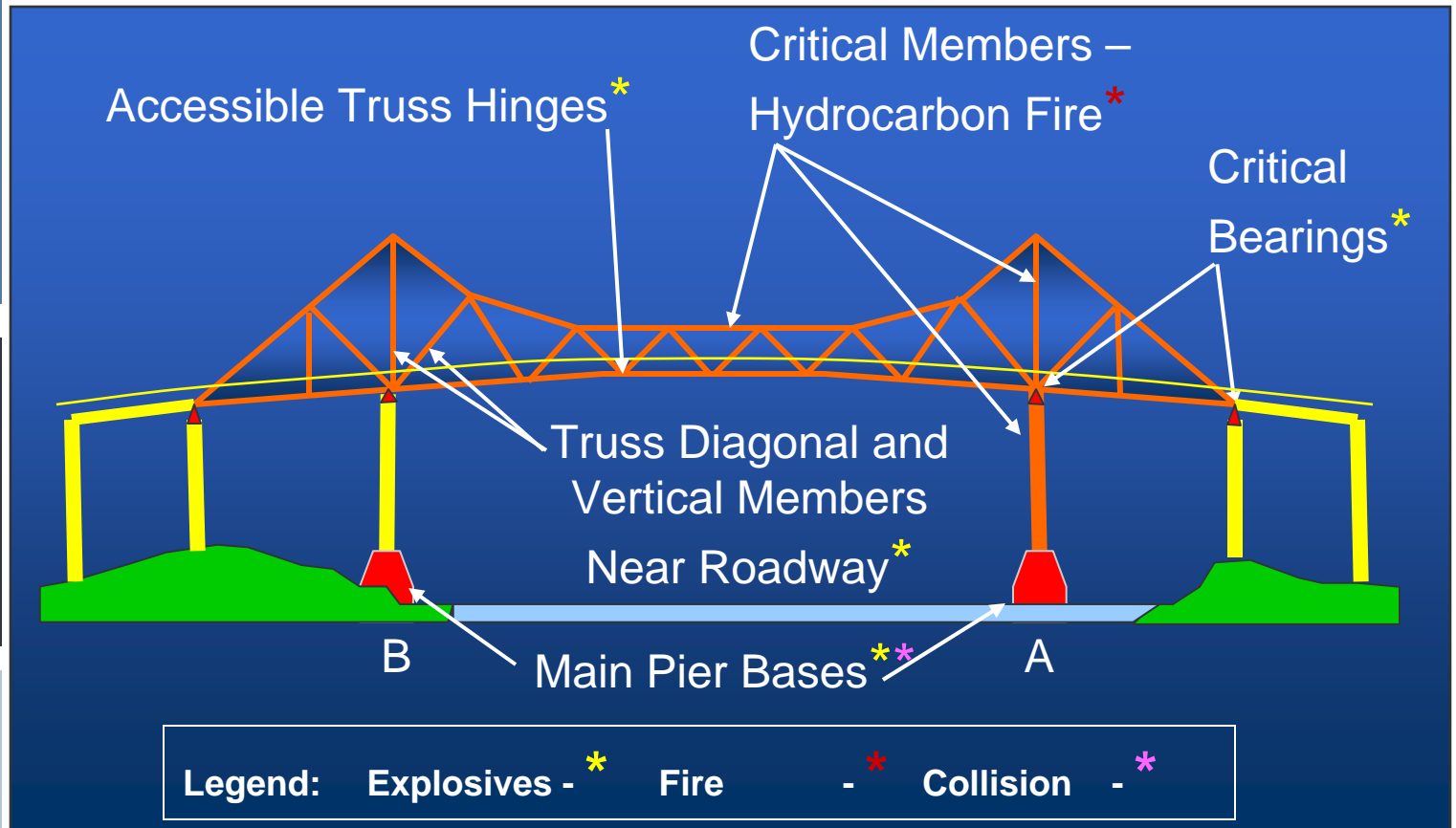
Expanded Engineer's Role

Pre-event

- Assessment (Pre and Post Disaster)
 - Progressive Collapse
 - Extreme Events
- Design Strategies (New and Retrofit)
 - Protective Measures / Standoff
- Emergency Response
 - Damage Mitigation & Rescue
 - Tabletop Exercises with First Responders

Post-event

- Rapid Recovery
 - Preparedness, Temporary Bridging



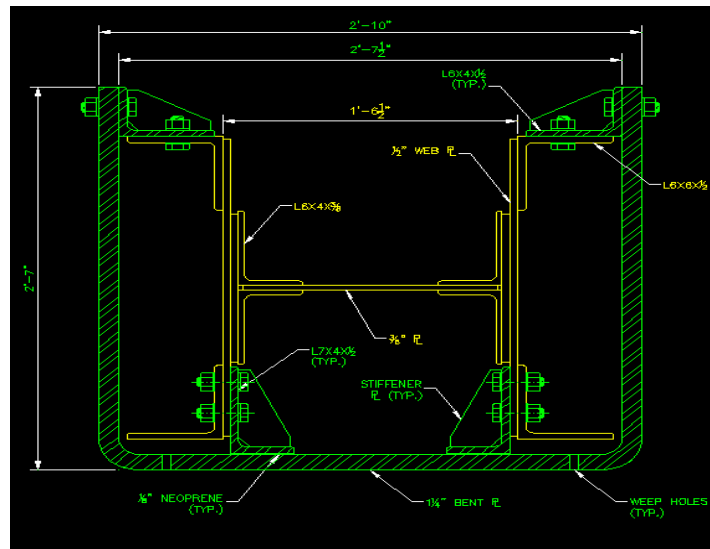
Pre-calculate Scenarios for Incident Management

- Approach path for emergency response vehicles
- Path and elapsed time for evacuation and response
- Standpipe system and AFF equipment and foam storage

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Multi-hazard Mitigations

Multi-Disciplinary/Multi-Hazard Mitigations



Shielding and Plating

- Blast Effects
- Fragmentation
- Standoff for Contact Charges
- Shielding from Hydrocarbon Fire

Potential Countermeasures

Technology to improve situational awareness:



IR Camera: Thermal Sensing of a large field of view

IR Thermometer: Temperature readings at a single point on the structure



Thermocouple: placed in direct contact with structure for a single point temperature reading

Situational Awareness

- CCTV Video Analytics
- Infrared Camera
- Thermocouples
- Strain Gauges

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**Multi-
hazard
Mitigations**

Multi-Disciplinary/Multi-Hazard Mitigations



Rapid Recovery Preparedness

- Independent of Nature of Hazard
- Identify Resources in Advance
- Prepare Reconstruction Plans
- Table Top Exercises with Incident Commander and First Responders
- Crime Scene Investigation