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Analysis of Electromagnetic Fields in Urban Environments

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Electromagnetic fields in urban environment

- Electric transmission lines
- Electrical substations
- Rail/Metro systems
- Commuter buses
- Cell towers

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Construction industry electrocution

- Leading cause of death (CCRT) – 40 / year
- Average of 411 workers electrocuted each year
- Highest frequency of occurrence among major industry sectors

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Construction industry

- Fatal electrocution
  - Body part of electrical circuit
  - Overstimulate nervous system
  - Damage internal organs
- Indirect
  - Burns
  - Falls

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Chicago Skyway Bridge

- Workers experienced electrical shock while repairing bridge span

Historic Examples of Worker Shock from Induced Currents

- 1990 Maersk Constellation, Hawaii
  - Workers shocked on cranes and cables
  - Source : AM radio station
- 2001 Kosciuszko Bridge, NYC
  - Workers shocked on man lift
  - Source : AM radio station
  - Demolition of “protective shield” of gas tanks

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Chicago Skyway Bridge

- No direct high energy electrical power connection
- No local AM radio stations
- High power electrical transmission lines close to bridge

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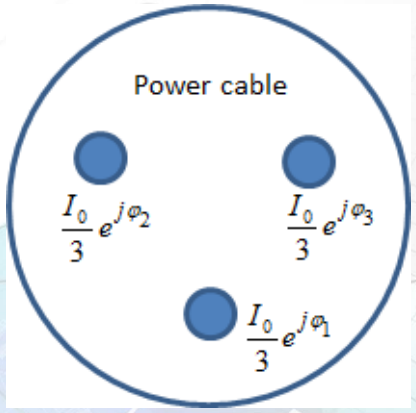
COMSOL model

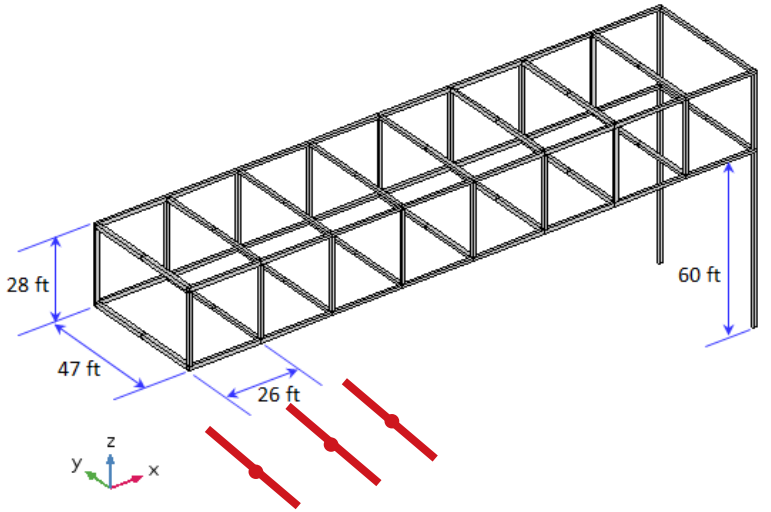
- *Magnetic Fields* (mf) physics interface to solve Maxwell's 2nd equation:

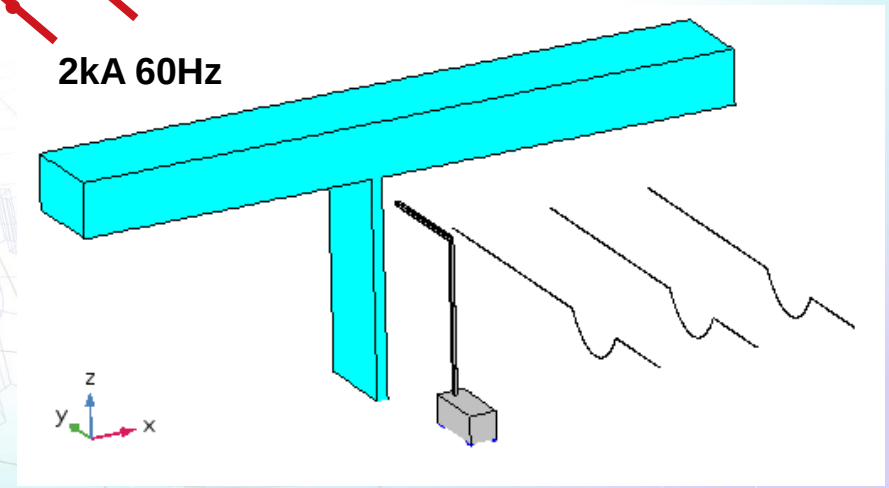
$$\nabla \times \boldsymbol{H} = \boldsymbol{J} + \frac{\partial \boldsymbol{D}}{\partial t}$$

- Three phase power cable represented by *Edge Current* boundary condition



- Simplified geometry of bridge and surrounding structures





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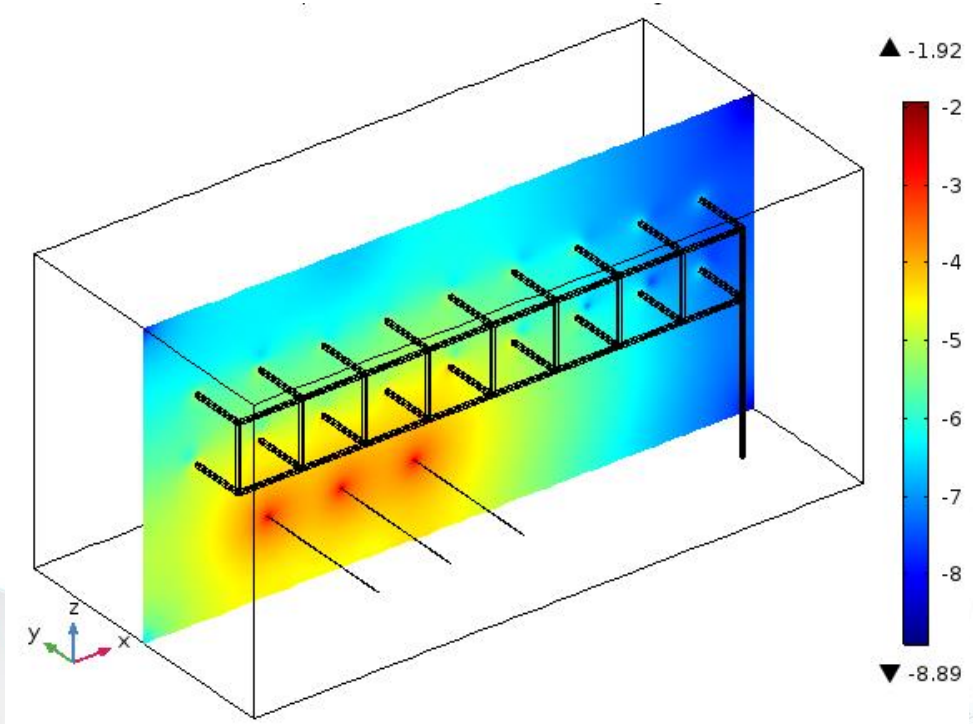
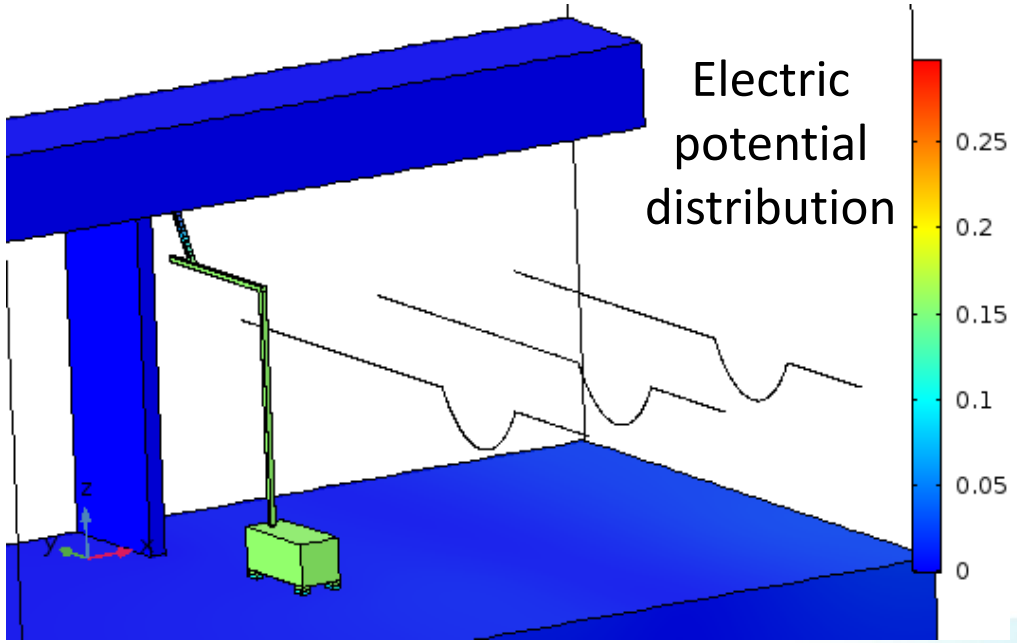
COMSOL model: Results

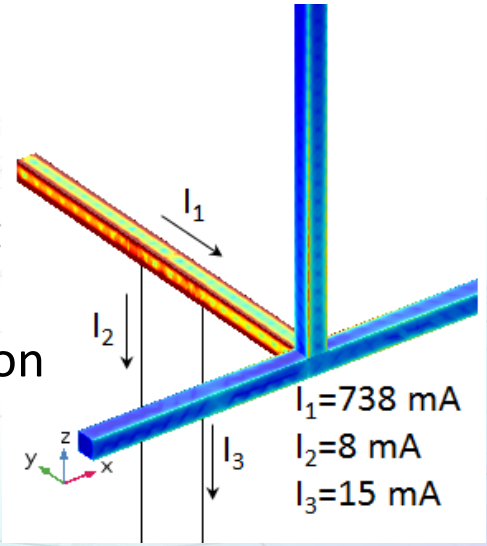
Magnetic field distribution



Electric potential distribution

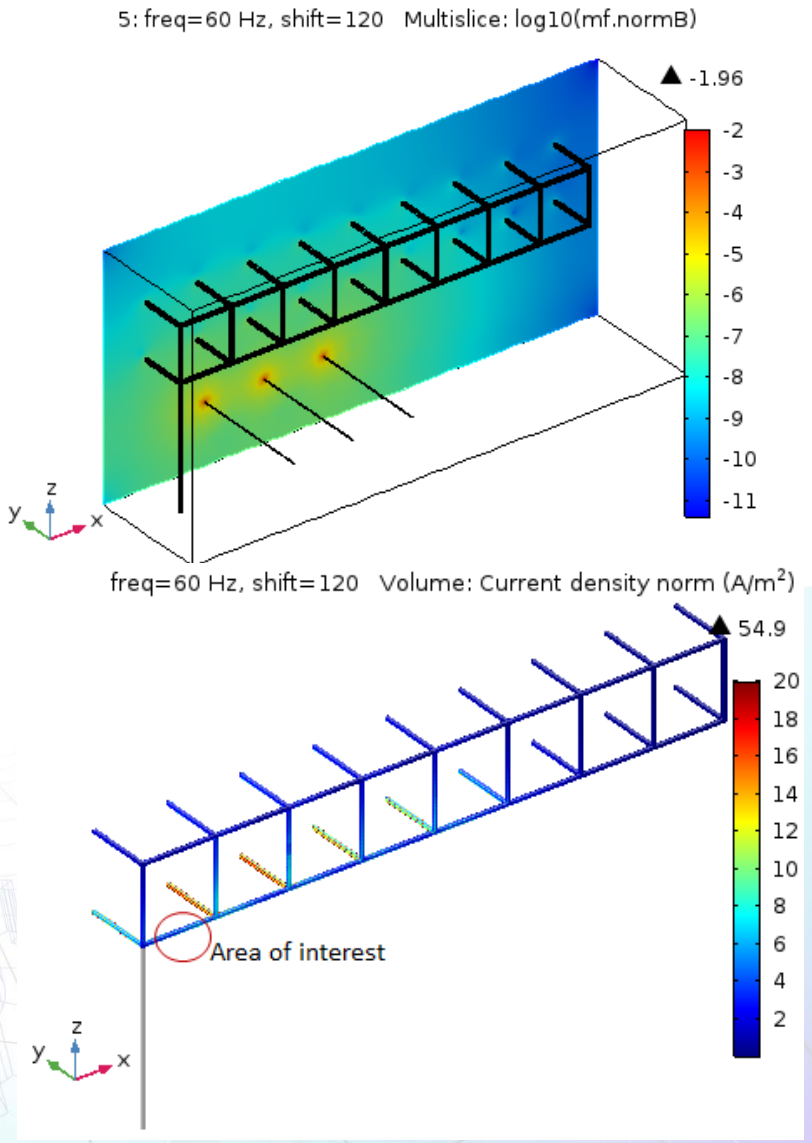


Current density distribution



Induced Current: Bridge structure

- Time varying magnetic field of power line induces currents in bridge
- Induced currents ~100mA
- Bridge structure represents a ground connection
- Bridge structure unlikely to be source of electrical shock



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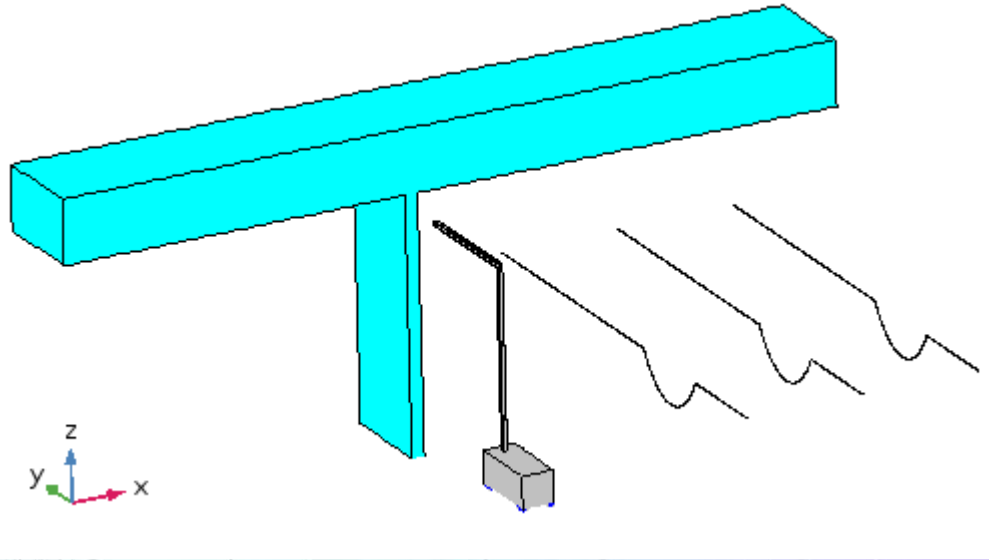
Induced Potential: Surrounding structures

- Floating potential in Manlift ~600V
- Manlift structure electrically isolated by rubber tires
- Measured potentials validate model predictions



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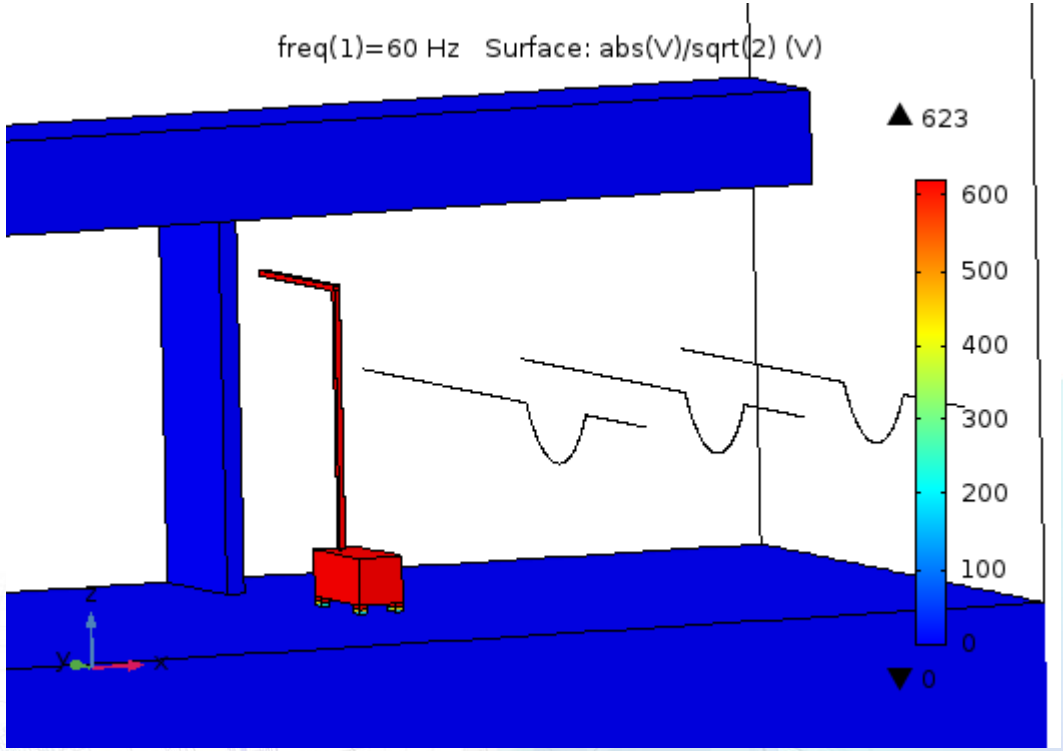
Electrical Shock due to Manlift

- Potential difference of ~600V between manlift and bridge
- Bridge connected to ground
- Worker provides conductive pathway between manlift and bridge



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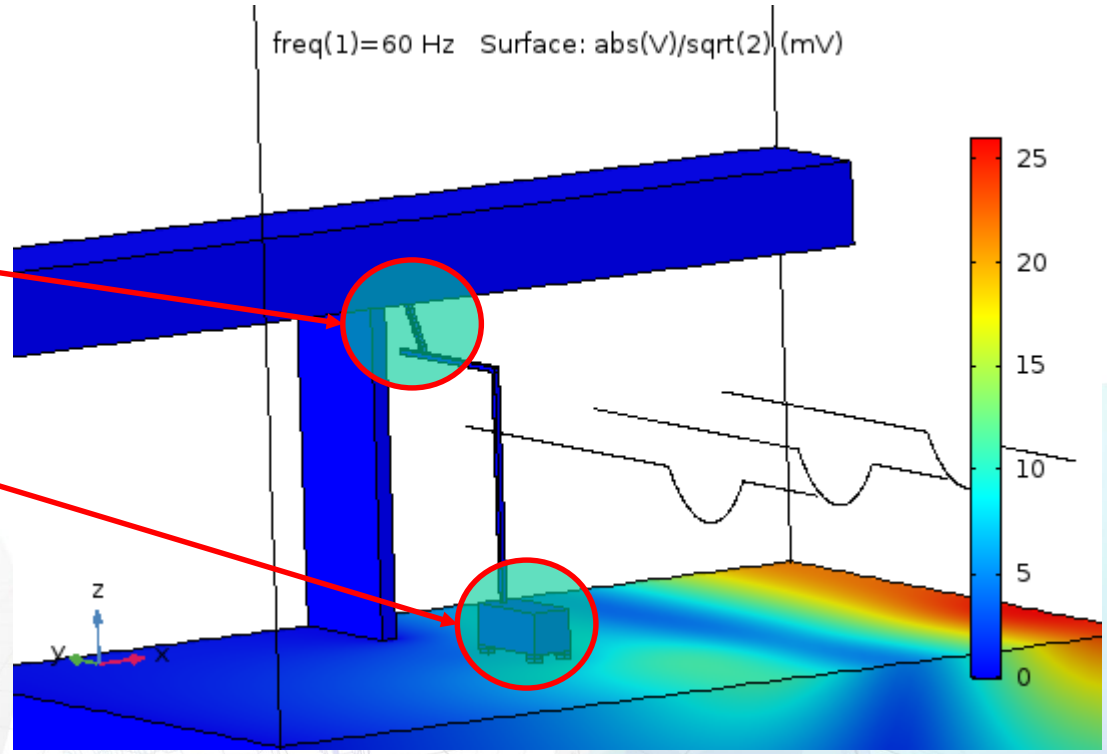
Electrical Shock Mitigation

- Reduce/eliminate potential difference between manlift and bridge
  1. Ground manlift basket to bridge
  2. Ground manlift at the lift base
- Connect conductive jumper cable between bridge structure and manlift basket



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