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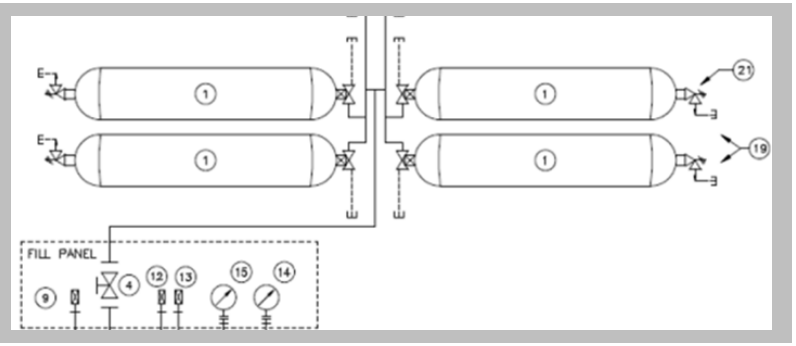

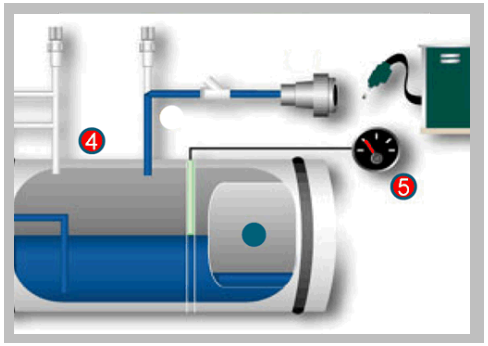

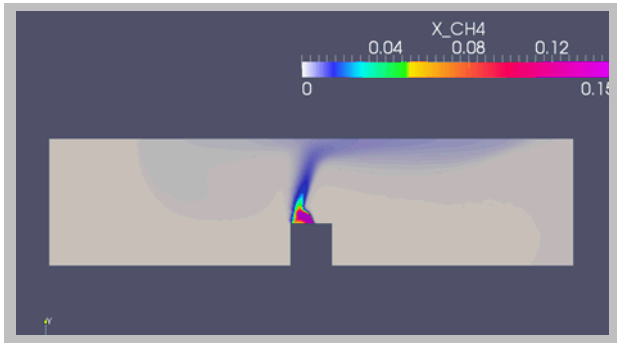

Natural Gas Vehicles Facility Analysis

Project sponsored by DOE Clean Cities:

Technical & Analytical Assistance

Myra Blaylock, PhD

Sandia National Laboratories

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SAND NO SAND2016-10561 PE

SNL Project Motivation

- Improve **codes and standards** for gaseous fuel vehicle **maintenance facility** design and operation to reflect technology advancements

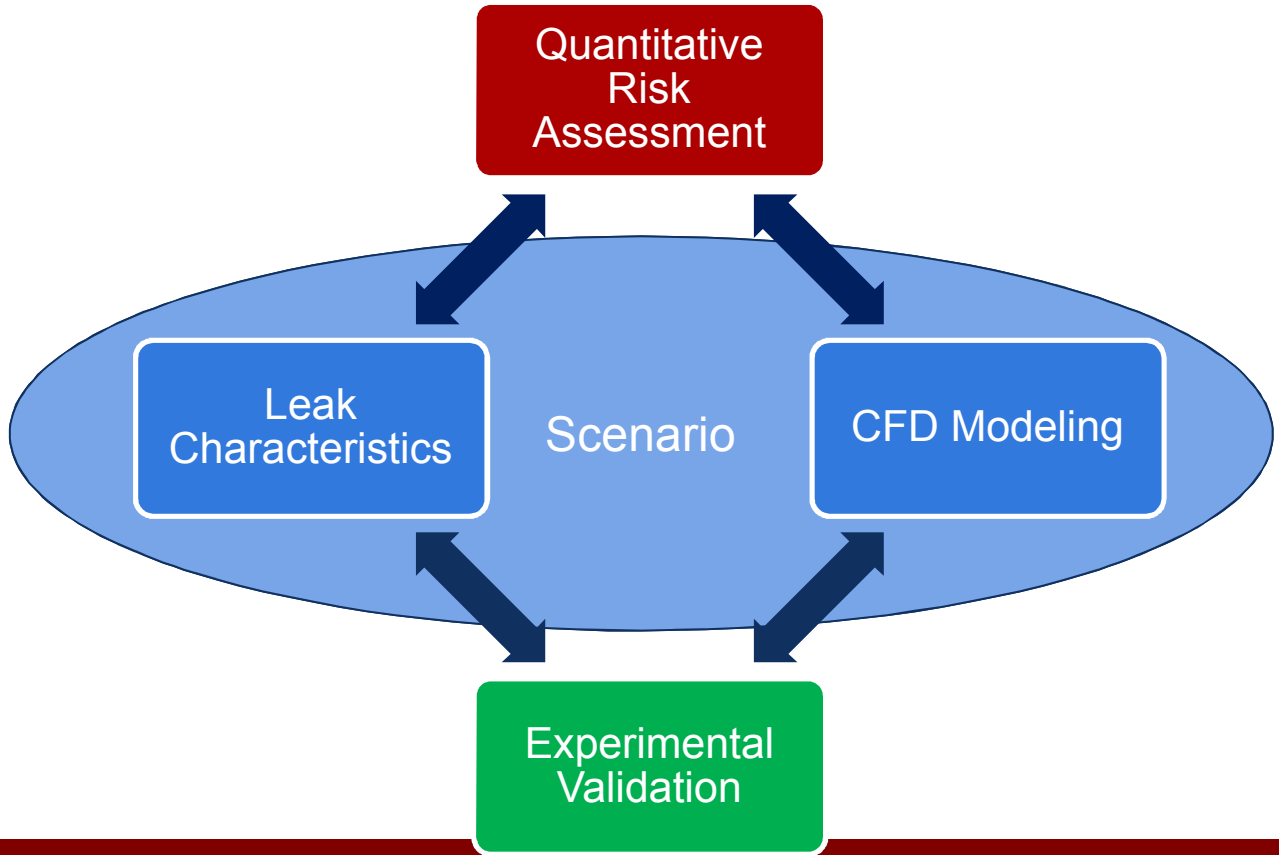


Image: http://www.energyburrito.com/tag/natural-gas-vehicles/

CNG Properties

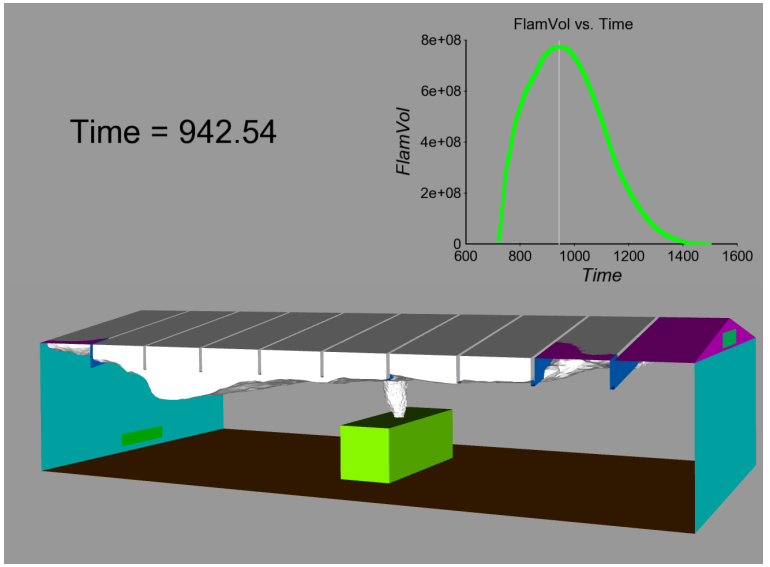
- Density: lighter than air
  - 0.56 kg/m^3 compared to 1.225 kg/m^3
- Flammability Range:
  - 5% to 15% by volume
- Typical Tank Size
  - Light Duty: ~350 L at 250 bar (3600 psi)
  - Heavy Duty: ~700 L at 250 bar (3600 psi)
- Typical leak
  - Most likely is a crack in a pipe or hose: ~3 L of fuel
  - Worst case is failed valve to full tank

Image: http://www.energyburrito.com/tag/natural-gas-vehicles/

Addressing Code Issues with Risk Assessment and Modeling

- HAZOP study identified which scenarios are most critical to alleviate and understand better through simulations

- NFPA 30A restricts sources of ignition from areas within 18” of ceiling
  - Based on legacy releases of gasoline

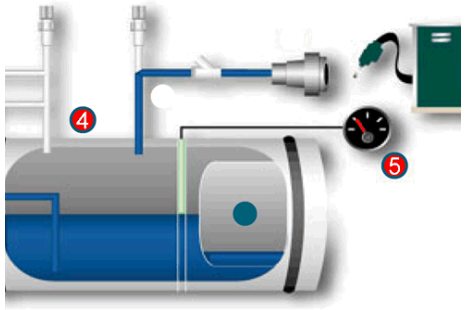


Modeling demonstrates that simple ceiling stand-off distance does not capture hazardous areas

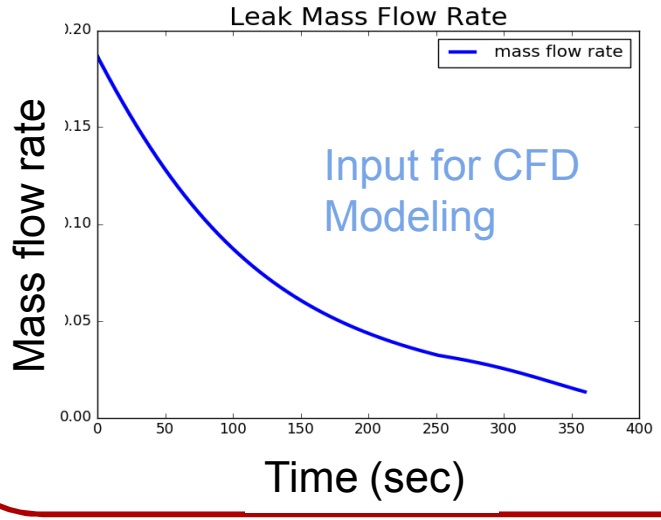
Network Flow Modeling: Upstream of Leak

Fast transient system analysis

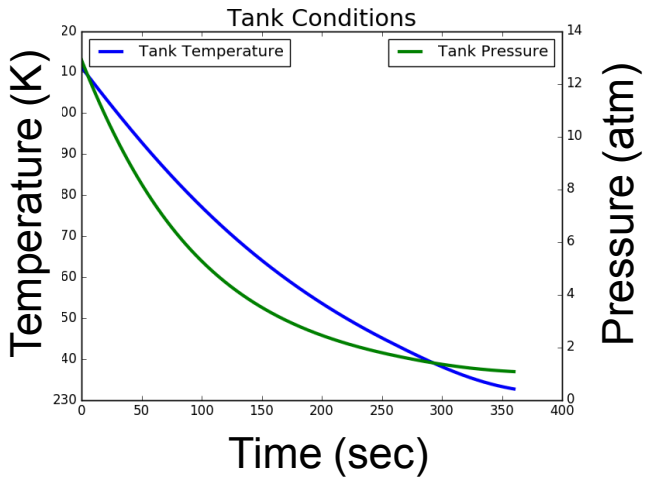
- Models venting/leaks of complex CNG/LNG tank and tubing systems



Generates leak input boundary conditions for CFD modeling



Calculates time required for tank to empty

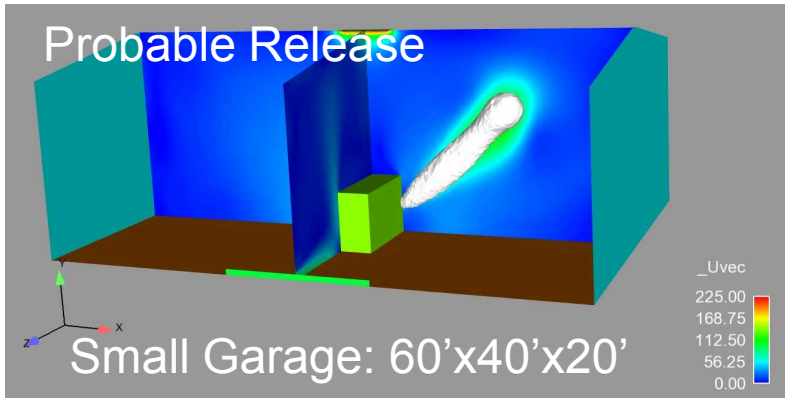


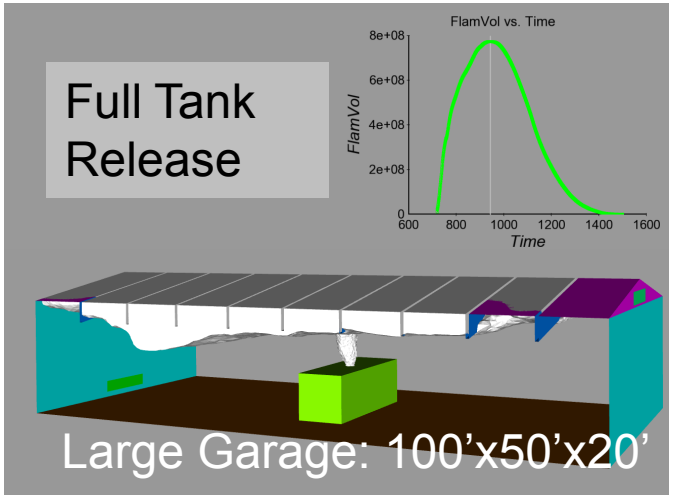
Fast and accurate modeling of leaking tanks and piping provides high quality CFD boundary conditions

3D Computational Fluid Dynamics Modeling

Risk Assessment identified several scenarios to model:

- Two sizes of garages
- Leak location and amount





Results indicate that flammable concentrations can occur in regions not protected by NFPA 30A (lower than 18" from the ceiling).
Results can be used to assess sensor placement.

Where is the flammable gas in a likely scenario?

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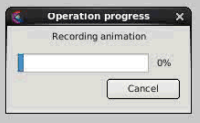
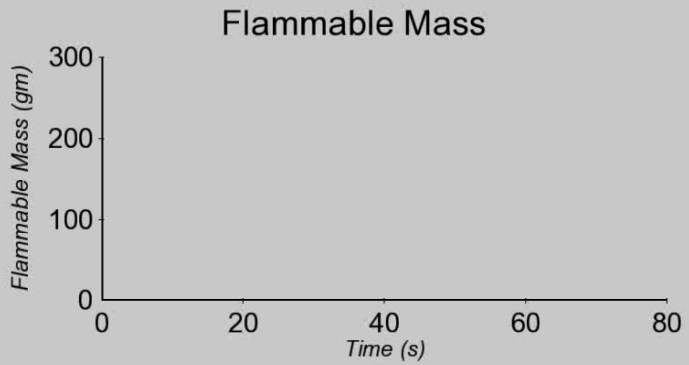
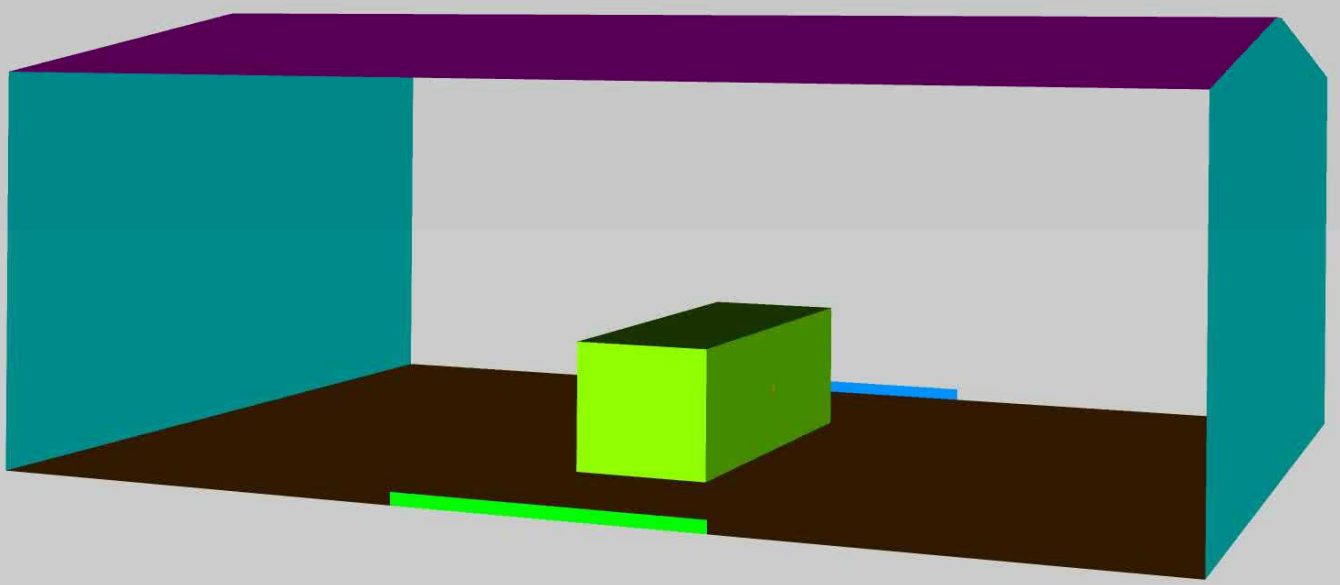
CNG Fuel System Line Cracking

No ventilation
Flammable Mass region shown in white

Time = 0.00 sec

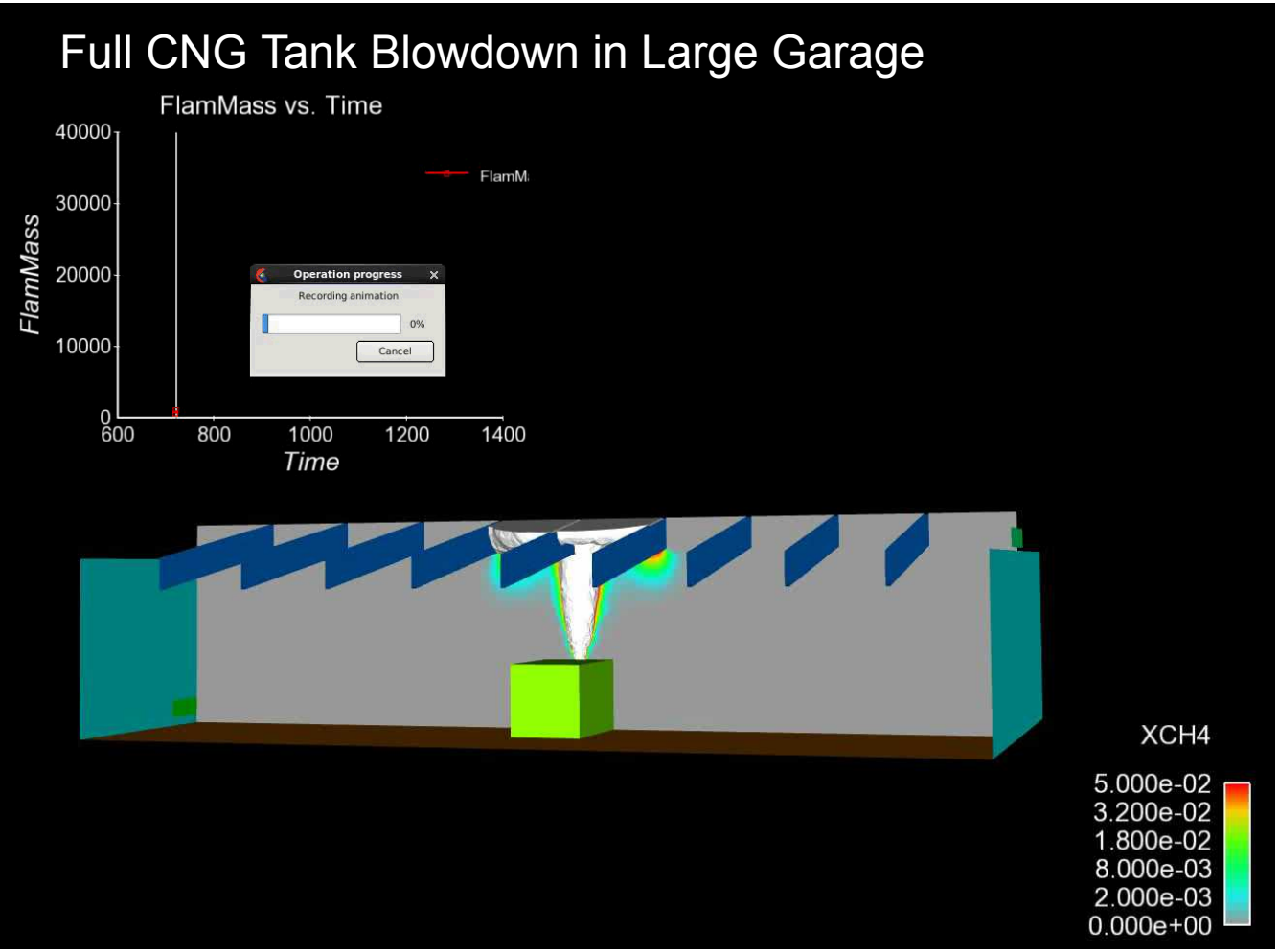






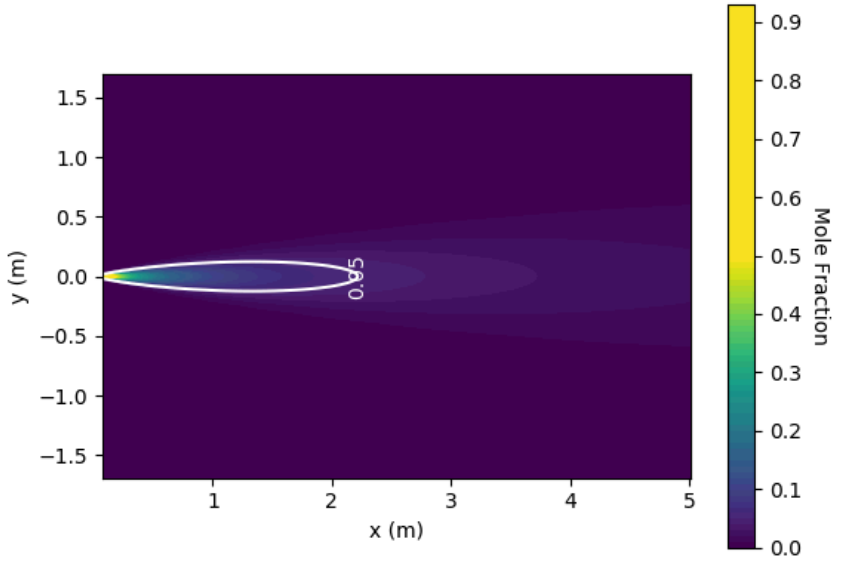
Can we have beams?
What does ventilation do?

Answers: Yes. Helps, to an extent



Plume Modeling

- Analytical solution to get size of plume
- IFC: Depressurize tanks to 250 psi before entering garage



Thank you!

Questions?

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Extra Slides

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Natural Gas Vehicle Maintenance Garage

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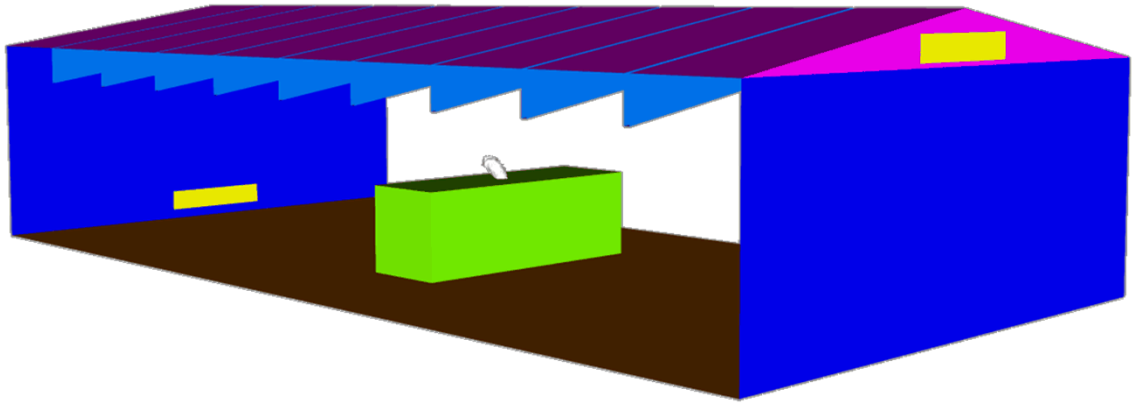
- Dimensions: 100’ x 50’ m x 20’ ; 1:6 roof pitch (60 x 40 x 20)
- Layouts w/ and w/o horizontal support beams investigated:
  - 9 beams (6” x 42”) spaced 10’ & parallel to the roof pitch
- Two vents were used for air circulation
  - Inlet near the floor — outlet along roof of opposite side-wall
  - Vent area for both vents was 2’ x 10’
  - Ventilation rate set to 5 air changes/hour (~2 m/s w/ current vent sizing)
  - Simulations were run with and without ventilation
- NGV modeled as a cuboid
  (8’ x 8’ x 24’)



SNL Project Approach:

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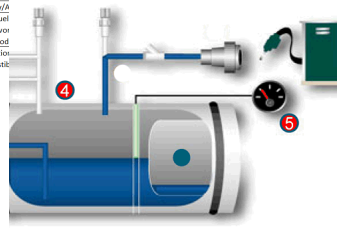
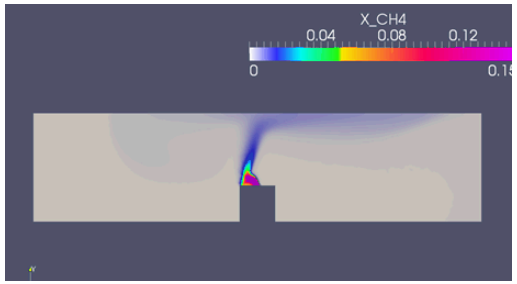
Facility Prevention, Detection & Mitigation Measures							
Prevention of Ignition Features				Detection Method	Mitigation of Ignition Features		
Design		Administrative			Design	Administrative	
1	Electrical classification areas	1	Operating procedures	1	Gas detection (LEL sensor)	1	Automatic emergency shutoff valve	1	Operating procedures
2	Grounding and bonding	2	Housekeeping (combustible material limitations)	2	Fire alarm detection	2	Manual emergency shutoff valve	2	Portable fire extinguisher
3	Non-combustible construction	3	Prohibit smoking	3	Person smelling smoke	3	Automatic fire suppression		
4	Constant ventilation	4	Clean parts with nonflammable solvent	4	Visual Flame	4	Fire barriers		
5	Interlock driven ventilation	5	Floors kept clean of oil and grease			5	Separation distance to exposures		
6	Flexible vent hose attachment to atmosphere	6	Combustible trash placed in covered, metal receptacles						
		7	Limit heat-producing appliances						
		8	Security/A						
		9	Purge fuel repair wor heat-prod						
		10	Separatio combusti						



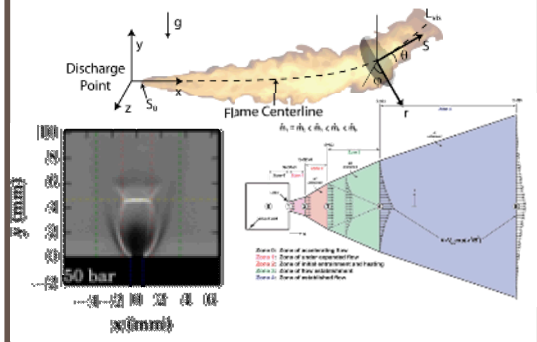
Develop risk analysis

for determining key, high-risk scenarios to further analyze



Apply risk analysis & behavior models to high risk scenarios

in alternative fuel infrastructure



Develop and validate scientific models

to accurately predict hazards and harm from liquid releases, flames, etc.

Enabling methods, data, tools for LNG/CNG safety

Scientific, Risk-Informed Process for Improving Codes & Standards for Maintenance Facilities