Hybrid Consist & Battery Electric Locomotive

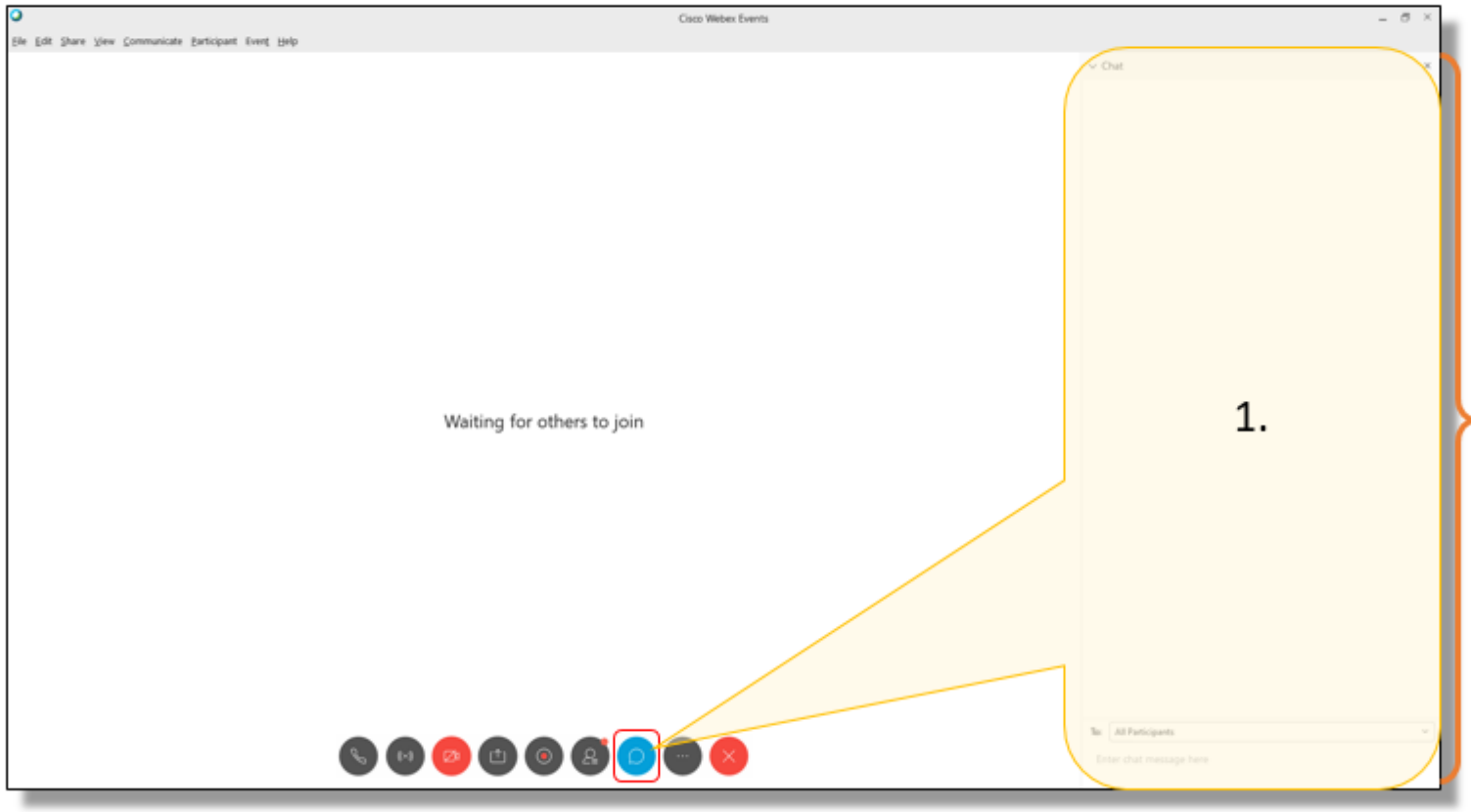
Webinar Question & Answer

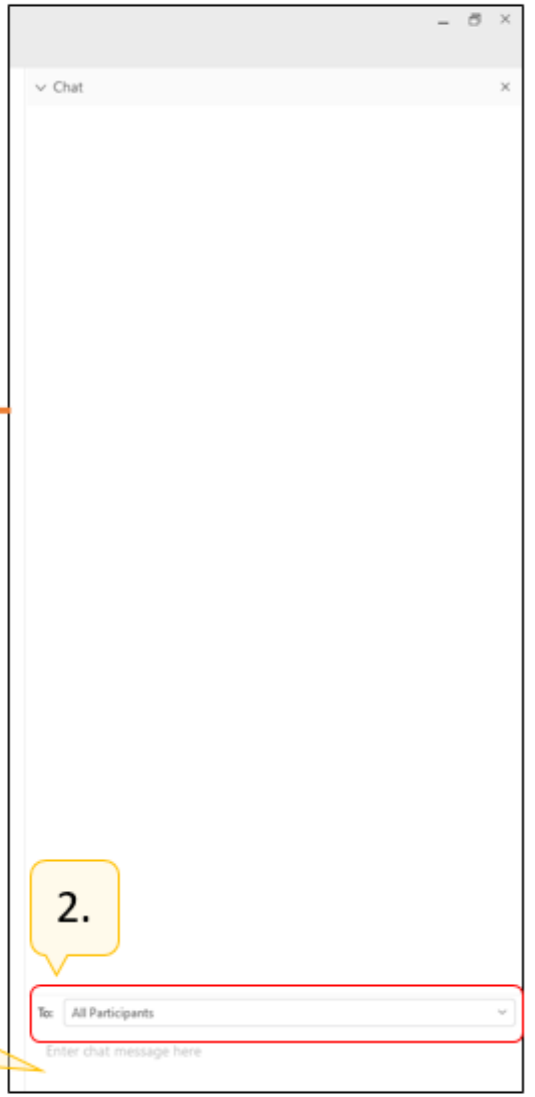
Questions and answers will be presented through “Chat”.

1. To chat, select the “Chat” icon.

2. Please select all participants, so everyone can see your questions.

3. Type your question in the message box and hit enter. A BNSF Hazmat representative will answer your questions.



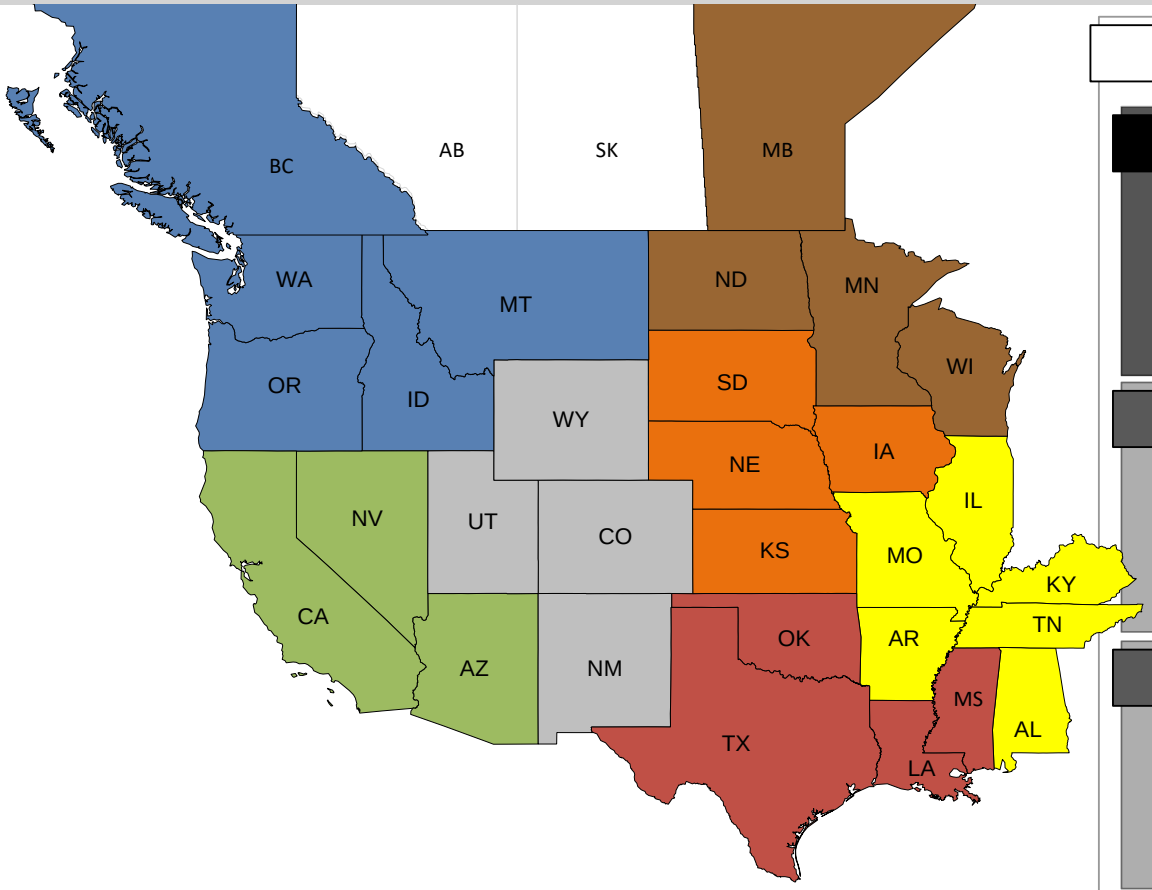


3. Type your question and hit enter.

Who and What We Are…..

- **32,500** Miles of Track, **44,000+** employees
- Operating in **28** States, **3** Canadian Provinces
- Over **8,000** Locomotives
- Operating approximately **1,600** trains per day
- 2019 – **1.6 Million** Hazardous Material Shipments
- 2019 Capital Investment of **$3.57 Billion**

HAZMAT Region Map



BNSF HAZMAT

BNSF HAZMAT REGION MAP

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Agenda

- Diesel Electric Locomotives
  - Awareness - How do they work?
  - Emergency Response
- Battery Electric Locomotives (BEL)
  - Test Plan
  - Awareness - How do they work?
  - Emergency Response

Locomotives – Diesel Electric

- Hybrid Diesel electric powered.
- Locomotives are connected with air and electrically.
- Distributive power rear / middle units operated by remote control.
- 2-Person Crew – Engineer & Conductor.
- Other locomotives may contain personnel (Deadheading).

- 4400 Horsepower 150,000 Pound-feet of torque
- Operating RPM range 200-1050.
- Weight 420,000 lb.
- 5000 kw of electrical power.
- Can move 1 Ton of freight 500 miles on 1 gallon of diesel.

Spills / Leaks

Green	Cooling Water
Red	Diesel Fuel
Black	Lube Oil
Clear	Battery Acid
Blue	Toilet Tank Fluid
Yellow Tint	Compressor/Gear Oil

Locomotive Compartments

Engine

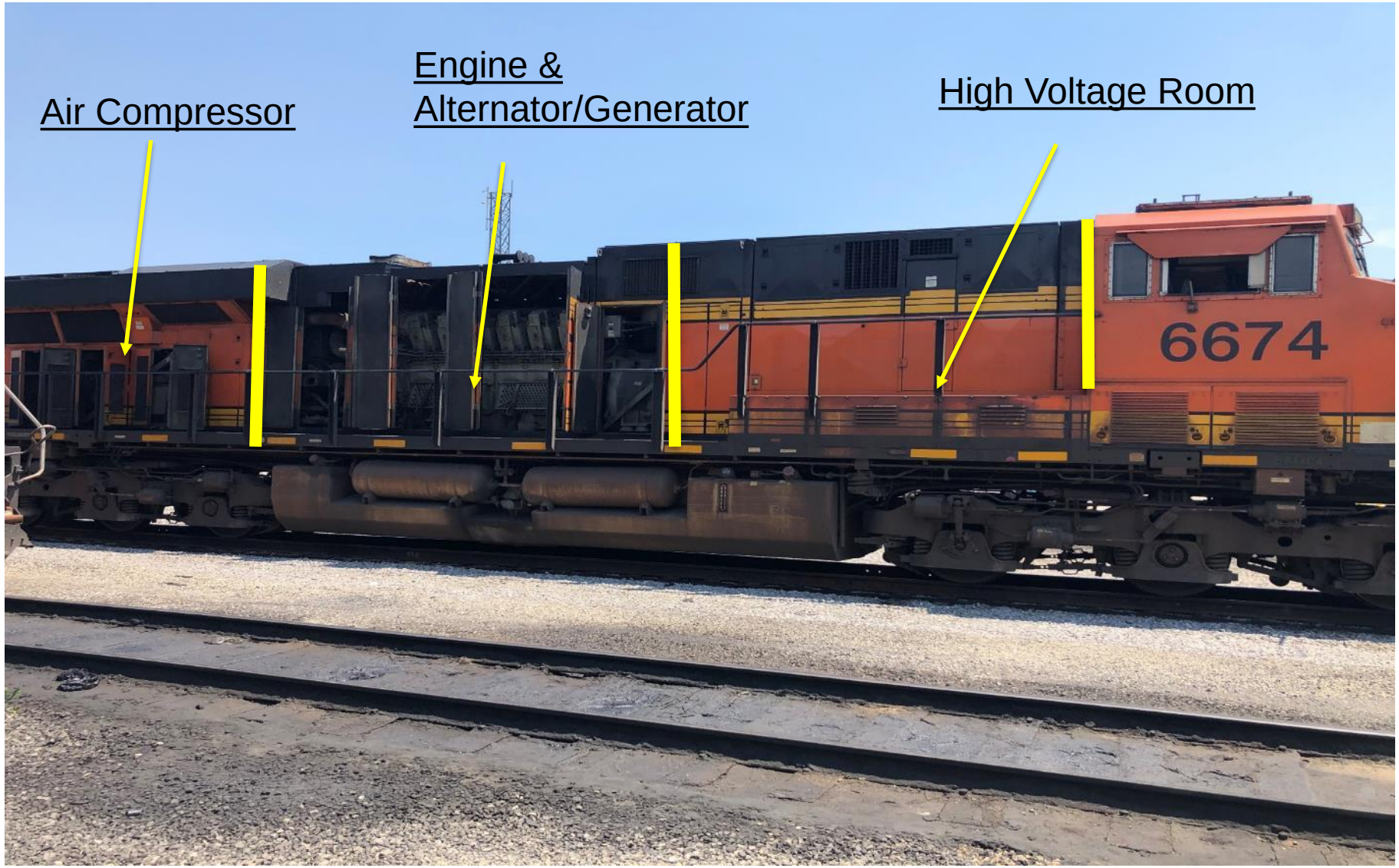
Cab

Traction Motors &
Fuel Tank

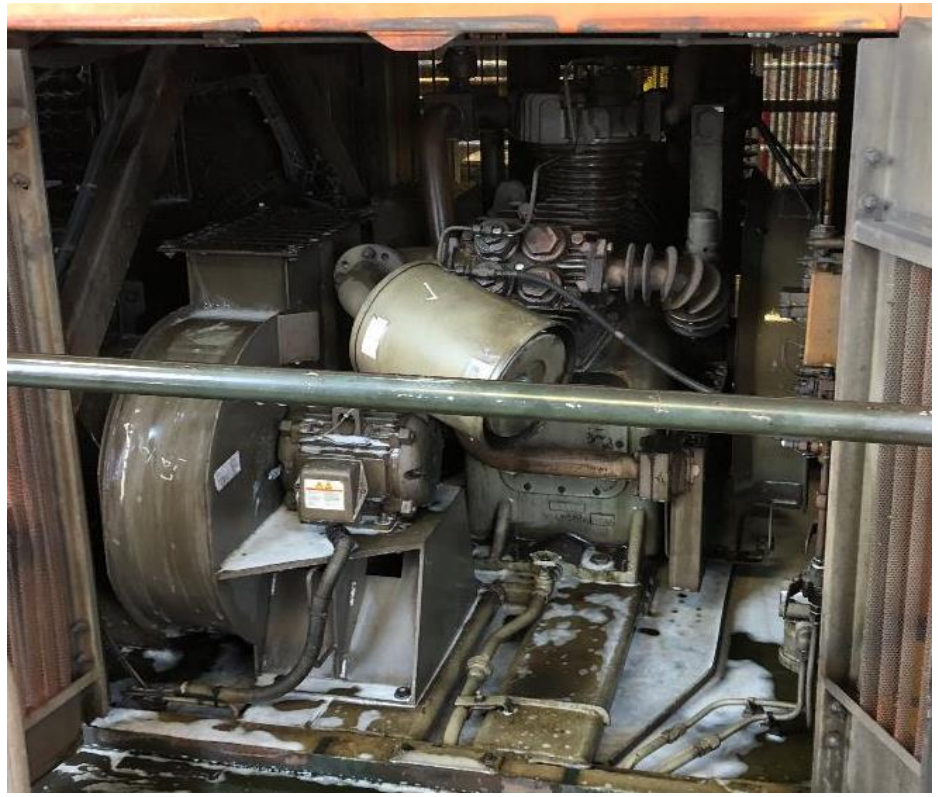
Batteries

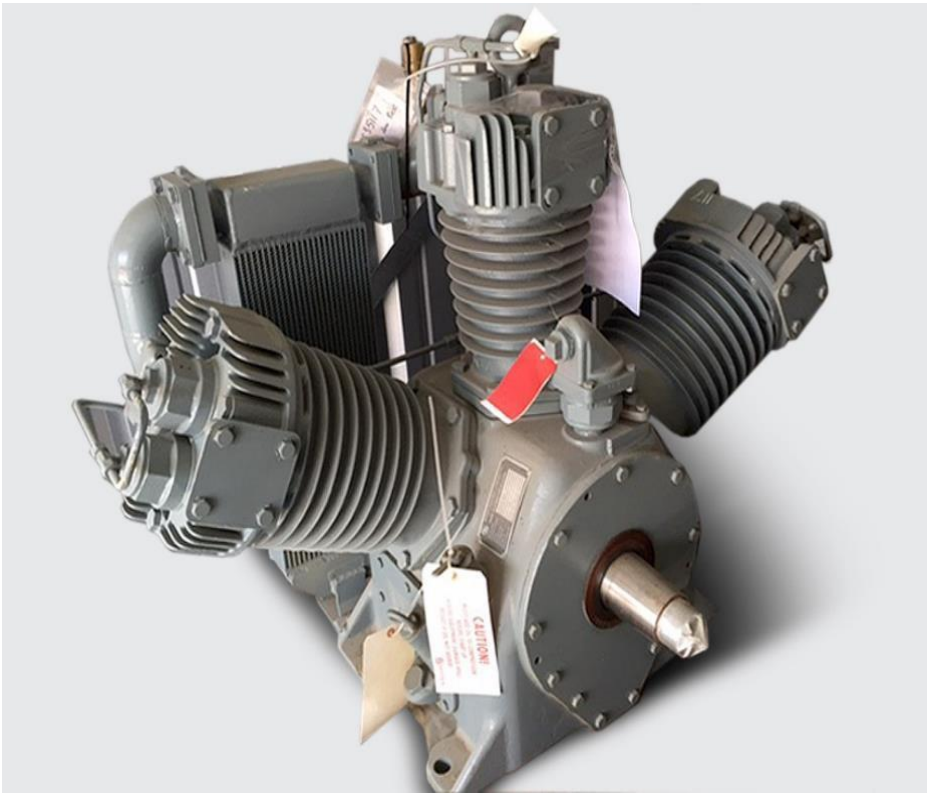
Two 32 volt (64 total) 3200 amp lead acid batteries
Contains 30 gallons of Sulfuric Acid
Over-charged lead acid battery can produce hydrogen sulfide

Locomotive Engine Compartment



Air Compressor





High Volume High pressure 2 stage Compressor
Electrically driven or direct shaft driven
Up to 160 PSI
10 Gallons for oil

Radiators

Radiators are located in the roof above the compressor
Contains up to 400 Gallons of green died H2O not antifreeze

Engine Room

Engine

Alternator/Generator

Retention tank / Belly Pan
holds 400 gallons

Engine & Alternator/Generator

High Presser fuel lines
20,000 PSI

Low Presser fuel pump
14 GPM

Power Assembly
Contains Piston,
injector, and all valves.

Turbocharger

Exhaust

600-3000 Volts
Up to 1500 Amps
Power output can power a neighborhood of 1000 houses

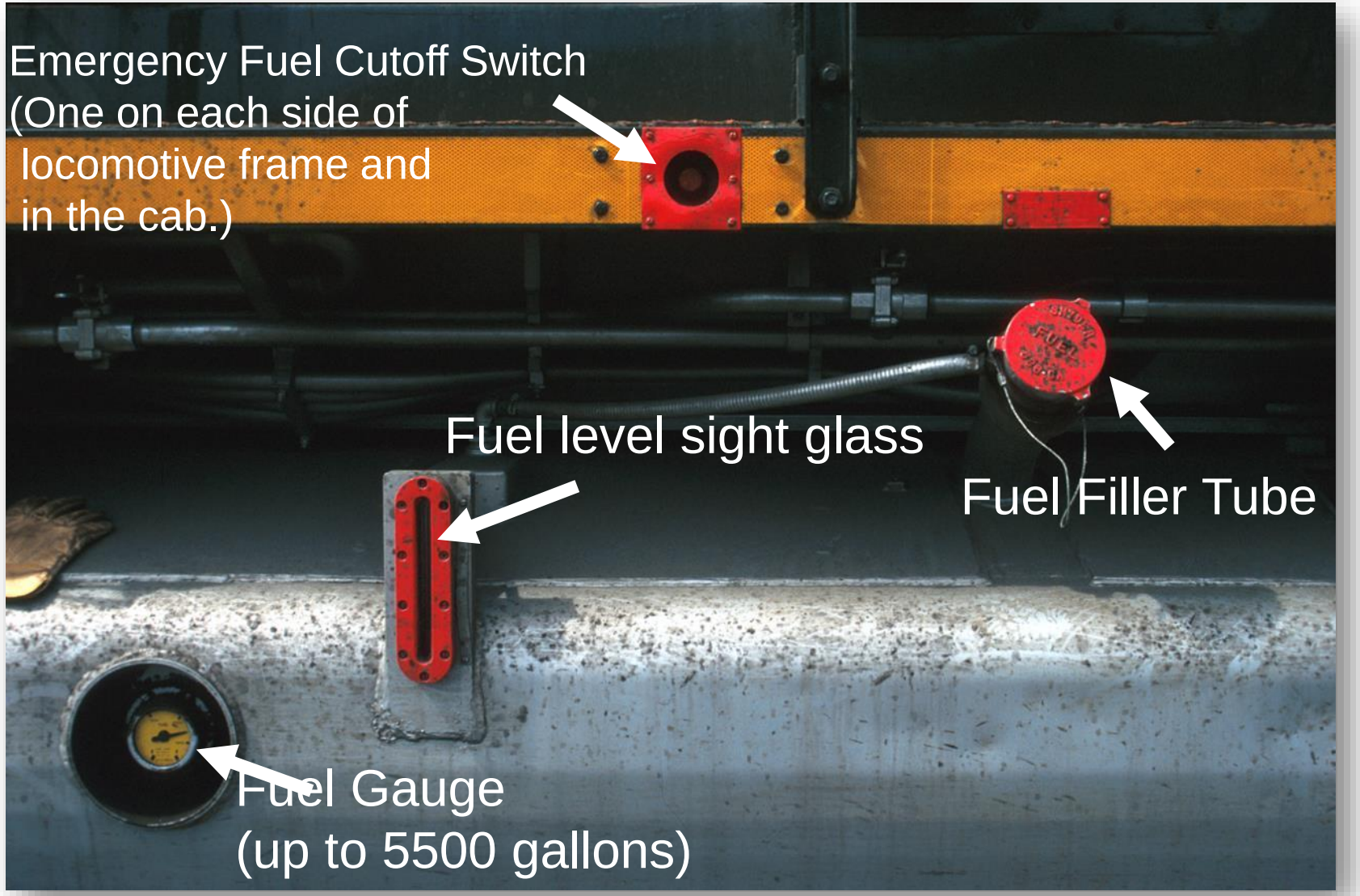
High Voltage Room

Door located behind cab rear door

Some will have a barrier across

Invertor stacks store a HUGE amount of stored electricity

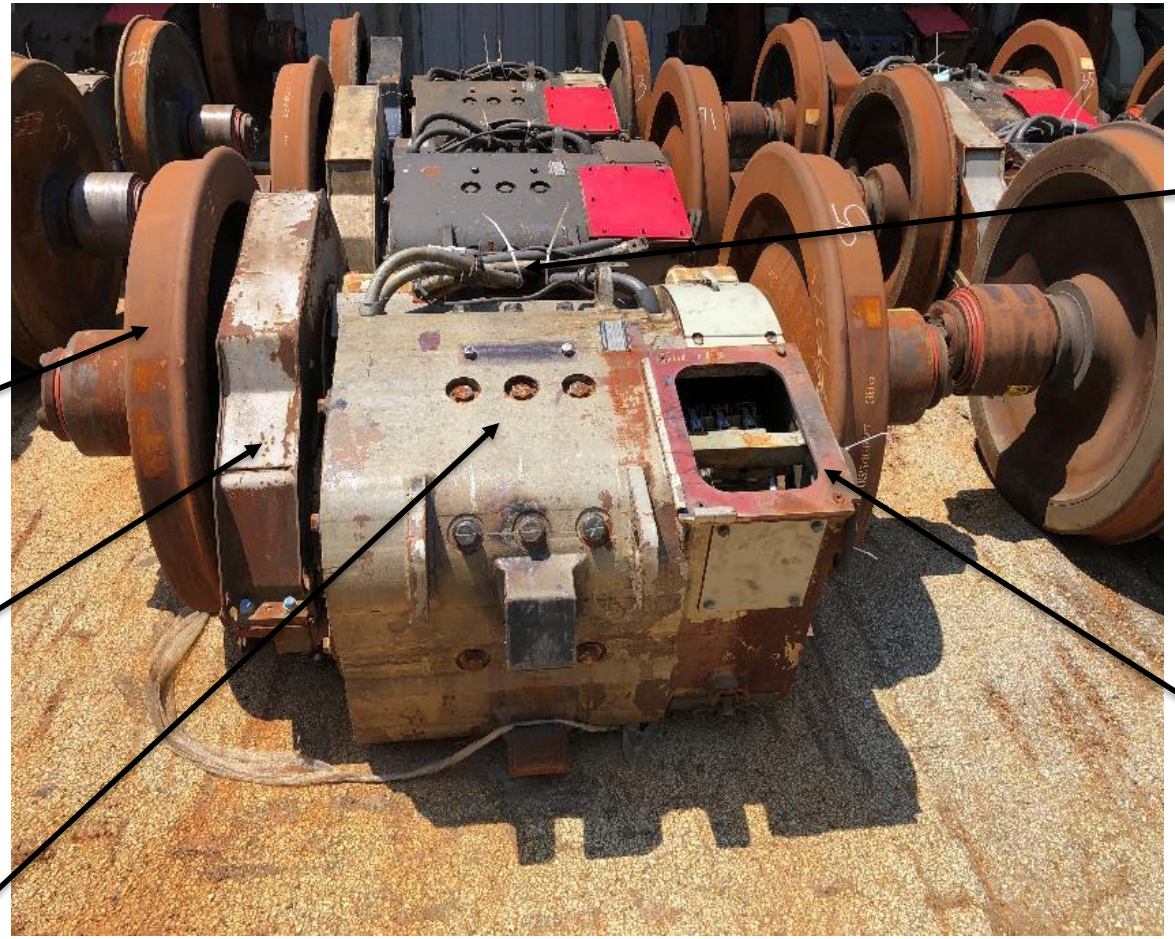
Locomotive Fuel Tank



Locomotive Traction Motors and Fuel/Air tanks

Tank runs under the locomotive
Fuel tank has baffles but is open it does not have compartments
Fuel tank is made out of ½ to 1 inch steel
Fuel lines run up to the Engine Room

Locomotive Traction Motor



High Voltage Wiring

Wheel Set

Gear Box
8 Gallons of gear oil

Air Cooling Vent

Electric Motor

Locomotive Traction Motor

Motor

Wheel set

Locomotive fire response

Recommended Practices for Responding to and Fighting Locomotive Fires:

- Be aware that locomotives have limited space in the cab, on the walkways, and to inside access panels.
- Responders wearing PPE, SCBA, or bunker gear can have difficulty gaining access to many areas.
- NEVER climb on the roof of a locomotive.
- Take response actions from the ground or walkway.
- Use dry chemical or CO_2 fire extinguisher.
- AFFF foam applications for ground fires or pooled fuel fires surrounding locomotives ONLY.
- Protect immediate exposures near the locomotive, i.e. dried grass, bridges, structures, etc.

Locomotive Fires

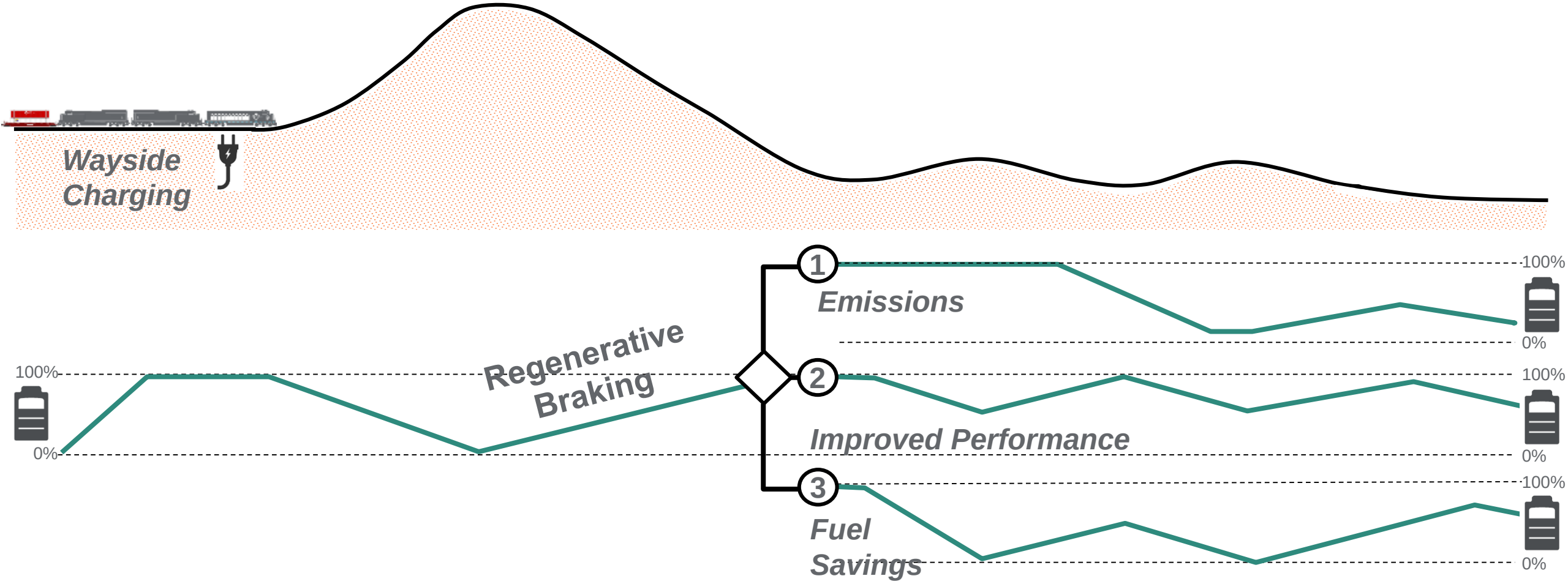
Engine/Exhaust/Turbo
Dynamic Break Grids

Cab
Traction Motor

Locomotive on Fire

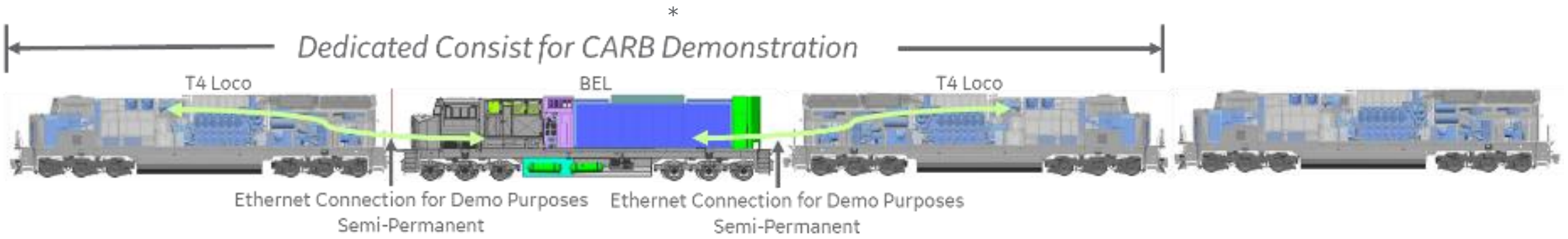
Locomotives –Battery Electric

What is the goal?



Battery storage technology allows for new locomotive opportunities.

Locomotive Operation



Mainline Mode: Service Operation

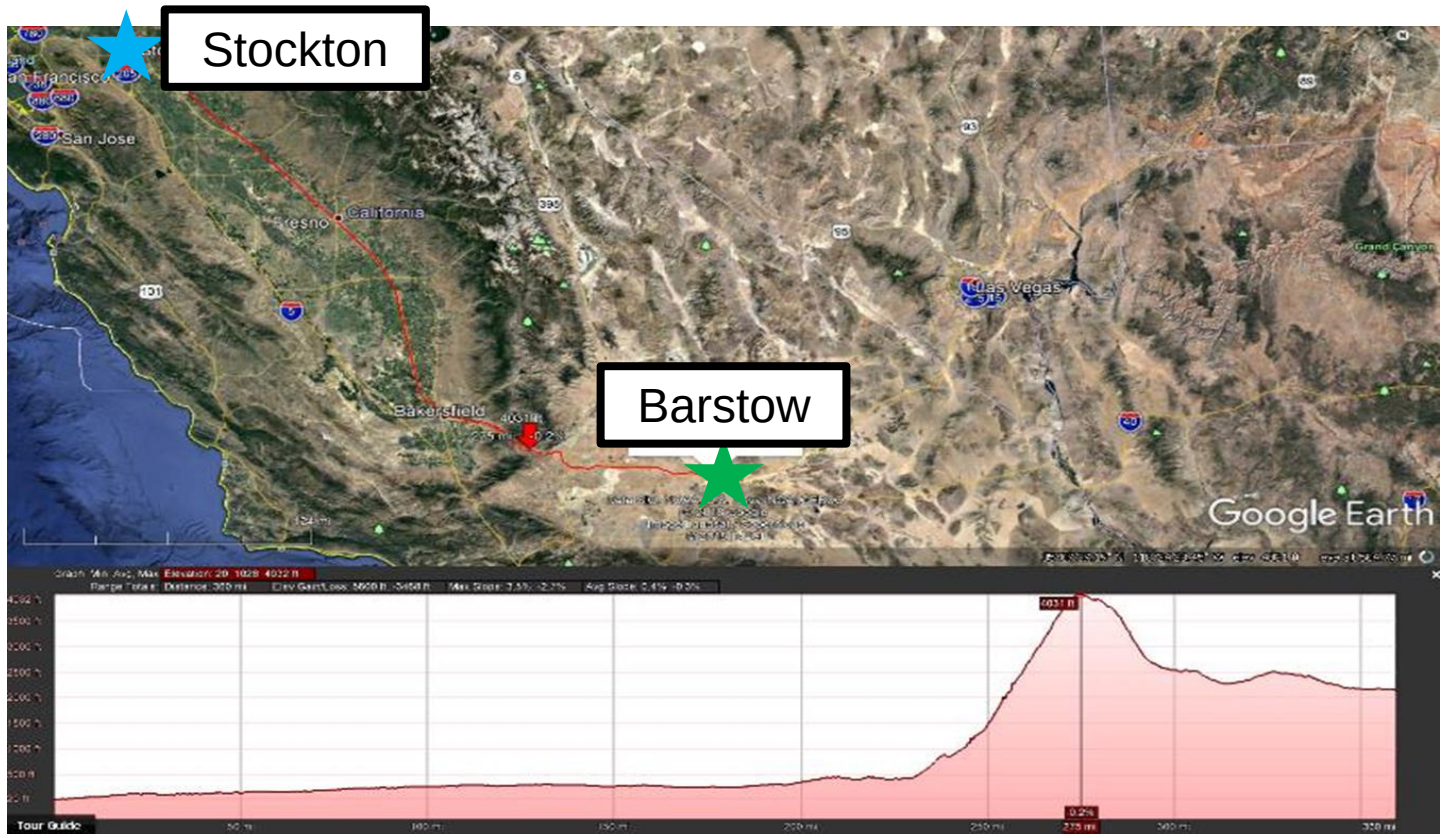
- Between Stockton & Barstow
- Revenue service operation
- Total fuel/emissions reduction

- Combination with "mate" locomotives allows for hybrid operation
  - Demonstration operation from mate units with BEL TO version

Yard Mode: Consist & Train

- Stockton yard
- Yard train movement
- Near-zero emissions operation; diesel units idle
- Treats as one "green zone"

Test Plan



Testing Plan - Barstow Depart				
Mon			Barstow Depart	1800
Tues	Stockton Arrive	1225		
Wed	Stockton Depart	740		
Thurs	Barstow Arrive	130	Barstow Depart	1800
Fri	Stockton Arrive	1225		
Sat	Stockton Depart	740		
Sun	Barstow Arrive	130	Barstow Depart	1800
Mon	Stockton Arrive	1225		
Tues	Stockton Depart	740		
Wed	Barstow Arrive	130	Barstow Depart	1800
Thurs	Stockton Arrive	1225		
Fri	Stockton Depart	740		
Sat	Barstow Arrive	130		
Sun				

- Stockton, CA to Barstow, CA (High dynamic brake use)
- Wayside charging in Stockton
- Additional testing to follow successful initial testing

BEL Overview

Op Cab
- No Change

Aux Cab
- New Arrangement
- 480VAC Bus
- High Voltage Area

Blower Cab
- Traction Blower
- Aux Blower
- HV/LV cabinets
- Batt Cab Door
- High Voltage Area

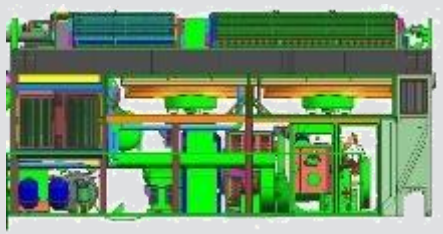
Battery Cab
- Climate controlled
- 20 Racks
- 500 50V NMC Modules

Sand Cab
- Batt Cab Door
- Sand Box's
- Hand Brake

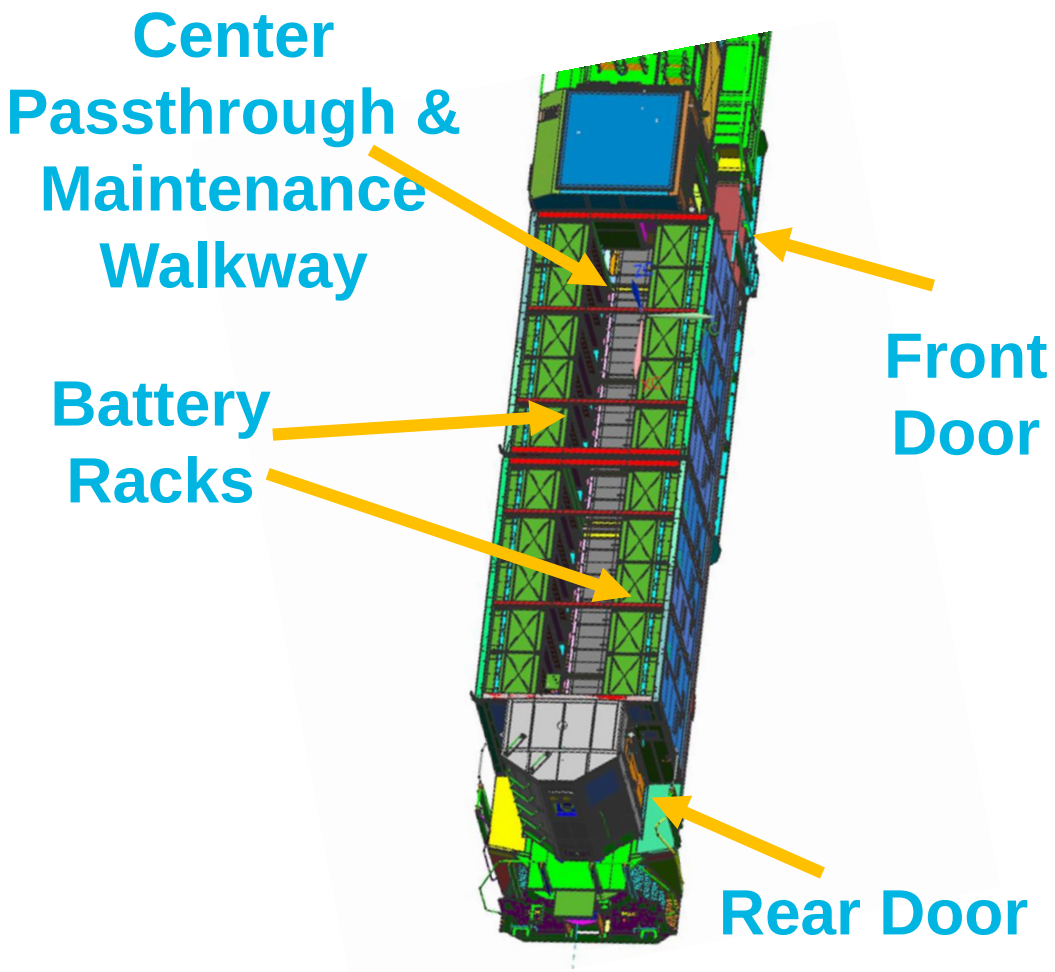
Safety Note:
Cab separation of batteries and high voltage areas
Avoid areas Marked:
"High Voltage"

Repurposed Fuel Tank
- Compressed Air components
- Wayside Charging components (High Voltage)

Eliminated
- Engine
- Alternator
- Cooling System



Locomotive Overview:



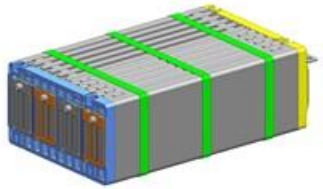
Safety Note:
Enable egress without traversing through battery cab

Front Door Egress (unchanged)

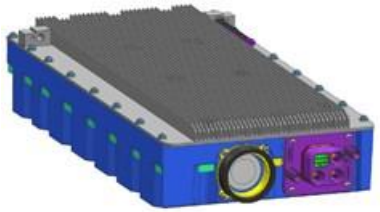
Additional Rear Egress (New ladder)

CARB BEL Demo Battery System Configuration

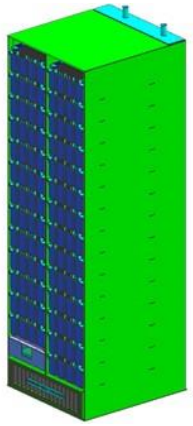
NMC Li-ion Cells



Cell Stacks
(12 Cells)



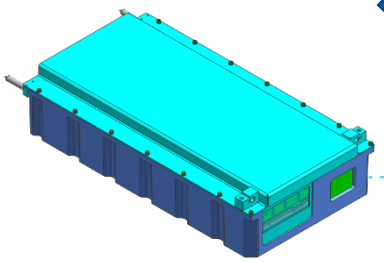
50V Module
Replaceable Unit
(36 Cells, M&B Card)



1250V Rack
(25 Modules, 1 BSC)

BEL Demo
(20 Strings,
5 Strings/Axle)

Monitoring &
Balancing Card



Battery String
Controller

Multi-String
Managers

Control Card, Contactors, Current Sensing, Fuse

- Rack-based system with 50V modules for maximum flexibility and serviceability

Emergency Response

What if there is a fire?

- Press the Emergency Stop and get to a safe distance
- Coordinate between BEL Test Team and Responders

Note:

- Battery system designed to vent gases away from the locomotive.
  - Do not breathe the smoke.
- Designed to prevent uncontrolled battery fire

CARB BEL Demo Venting Locations

Vented gases

- Vented gases may be released from the locomotive at the highlighted positions.

Gas Constituents

- Carbon dioxide
- Carbon monoxide
- Nitrogen
- Hydrogen
- Oxygen
- Several hydrocarbons

Fire Fighting/Cooling

- Tactics similar to other battery electric vehicles
- Water and/or foam can be used for fire fighting and cooling.

Safety Note:
In the rare event a battery vents gases may be seen from the outside of the locomotive. Do not enter or breathe these gases.

Questions & Discussion