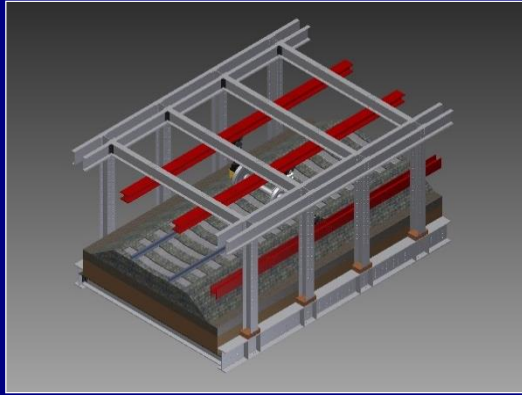


# UIUC Full-Scale Laboratory Track Bed



**FRA Tie and Fastener BAA - Industry Partners Meeting**  
**Incline Village, NV**  
**7 October 2013**

Riley Edwards, Marcus Dersch, and Ryan Kernes



U.S. Department of Transportation  
**Federal Railroad Administration**

**RAILTEC**  
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

# Outline

- Current Experiments and Deficiencies
- Mission
- Objectives
- UIUC's Full Scale Track System
  - Specifications
  - Phases
  - Schedule
  - Business Plan
    - Fixed Costs
    - Operating Costs
- Contact Information



## Previous Laboratory Crosstie and Fastener Experimental Systems' Deficiencies

- Unrealistic boundary and support conditions
- Unrealistic longitudinal rail restraint
- Examples of unrealistic loading
  - No or limited ability to vary lateral/vertical (L/V) load ratio
  - No ability to apply representative loading contact
  - No or limited ability to vary contact point
  - No ability to simultaneously apply load to both rail seats
  - No ability to simultaneously apply varying load magnitudes to adjacent rail seats

# RailTEC Setup - Mission and Objectives

- **Mission:**
  - Design and execute a laboratory frame to accommodate representative full-scale track experimentation to improve the understanding of crosstie and fastening system component response and performance
- **Objectives:**
  - Improve upon existing full-scale crosstie and fastening system experimental setup deficiencies
  - Use wheel-rail contact to apply loads to track structure
  - Support track components with ballast, sub-ballast, and subgrade, compacted to achieve representative track stiffness
  - Facilitate multiple test protocols (e.g. static, dynamic) based on divergent experimental objectives
  - Ensure all varieties of track components can be accommodated
  - Facilitate measurement of loads, stresses, displacements, and strains
  - Allow for measurement of component degradation rates

# RailTEC Setup - Technical Capabilities

## Track Loading System

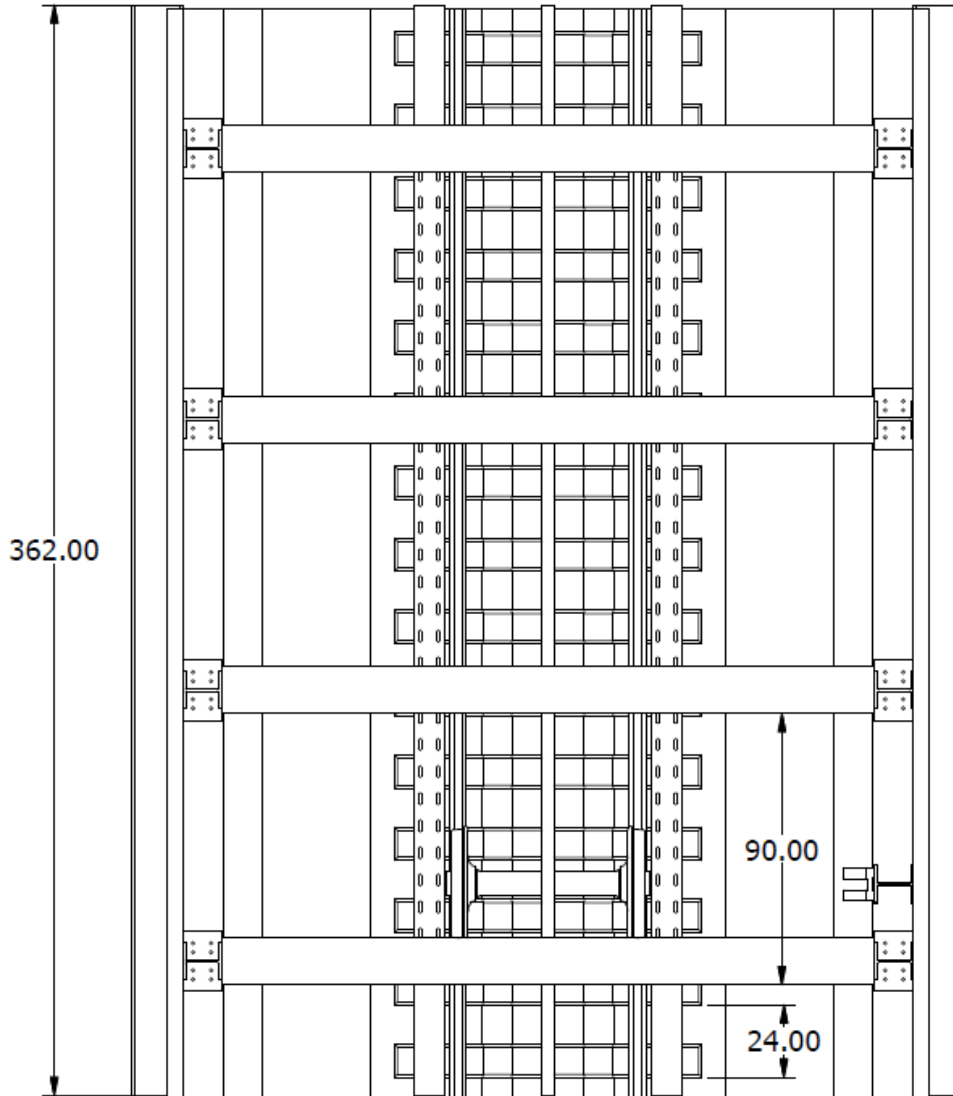
Specification	Purpose	Capability
15' Frame Height	Provide Realistic Support Conditions	Construct varying full-depth track section designs <i>Initial track design: 34" of subgrade, 10" of sub-ballast, and 21.5" of ballast</i>
30' Frame Length	Provide Realistic Boundary Conditions	Construct a multi-crosstie track panel to adequately distribute load and restrain rail in the longitudinal direction Simultaneously study multiple track sections <i>Initial track design: 11 crossties at 24" spacing</i>
18' Frame Width	Provide Realistic Boundary Conditions	Construct a full-width track section without providing unrealistic lateral ballast confinement <i>Initial track design: 10.5' width at top of ballast and 1.75:1 design slope</i>

# Technical Capabilities (Cont.)

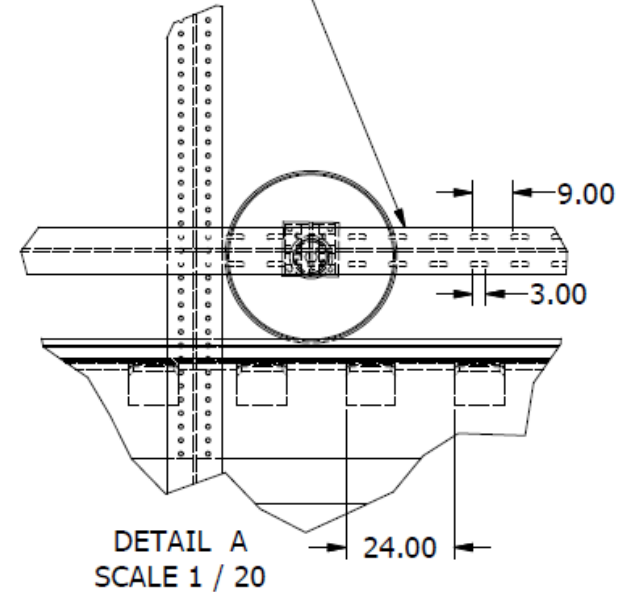
## Track Loading System

Specification	Purpose	Capability
General Dimensions	Future Vision	Perform experiments on super-structure (varying crosstie and fastener design) and sub-structure (track transistions, ballast gradation, etc.)
Instrumented Wheel Set	Provide Realistic Loading Inputs	Ensure the applied load is imparted into the track system with realistic wheel/rail contact mechanics Accurately quantify the load applied to the track structure
2 Actuators and 1 Ram	Provide Realistic Loading Inputs	Easily vary the lateral/vertical load ratio Simultaneously apply various load magnitudes to each rail seat Execute static, short term dynamic, and long term deterioration experiments <i>Initial design: two-55 kip actuators and one-100 kip hydraulic ram</i>

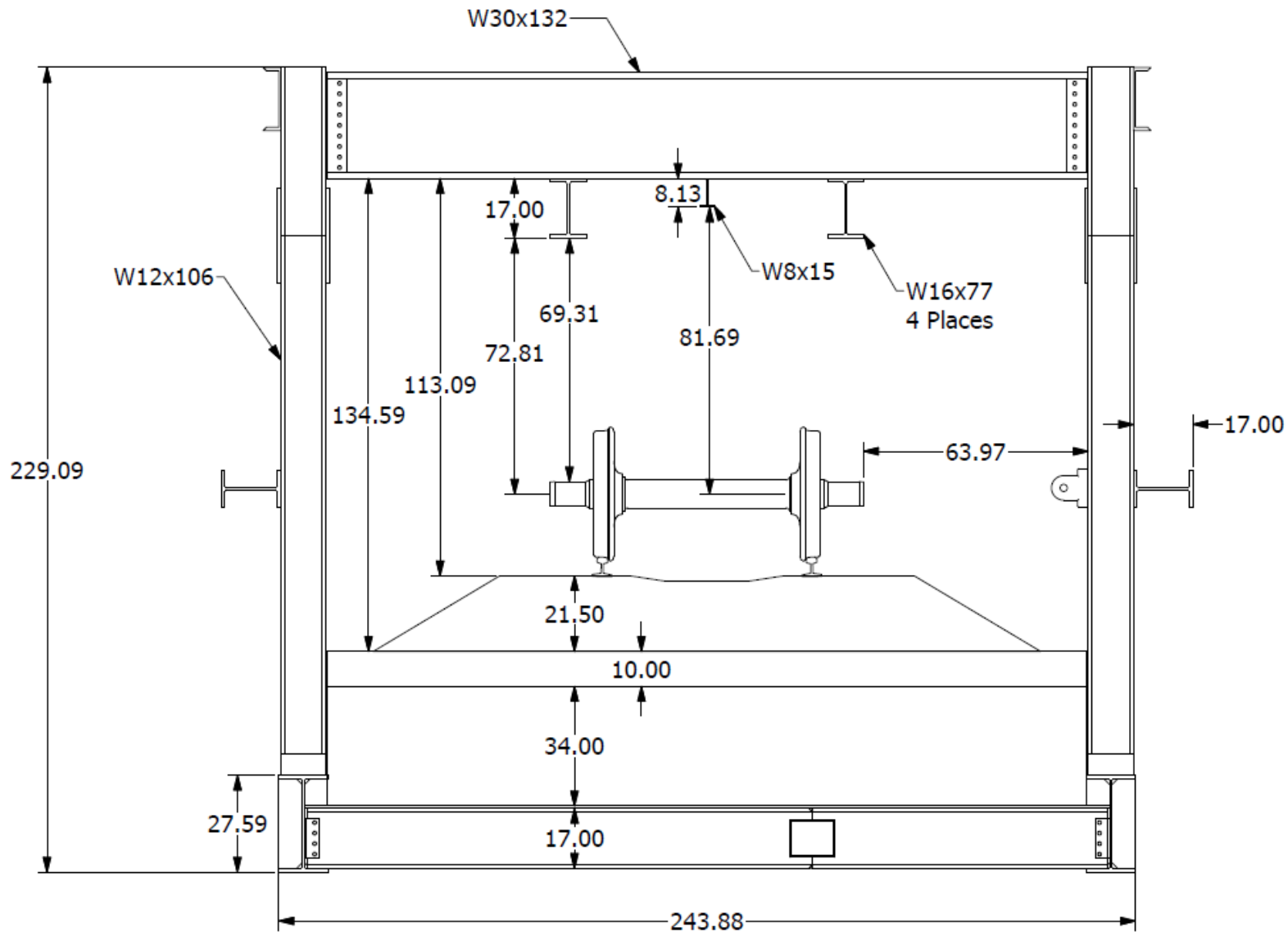
# Full Scale Laboratory Track Bed: Design Plan and Wheel-Set Profile View



3" slots at  $\text{Ø}1\frac{1}{16}$ "  
 Slots are 9" apart and run between upright columns.

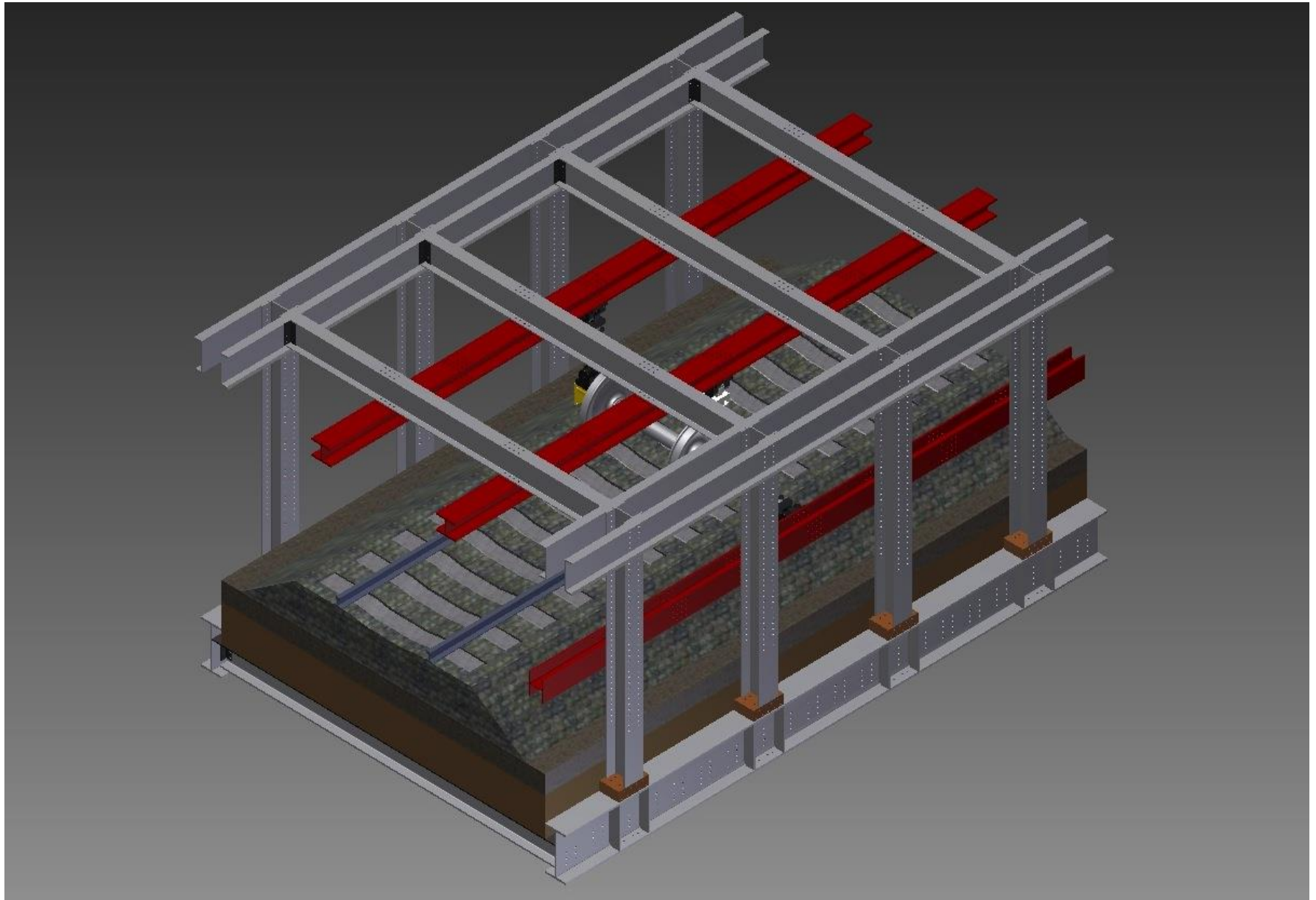


# Full Scale Laboratory Track Bed: Design Elevation View

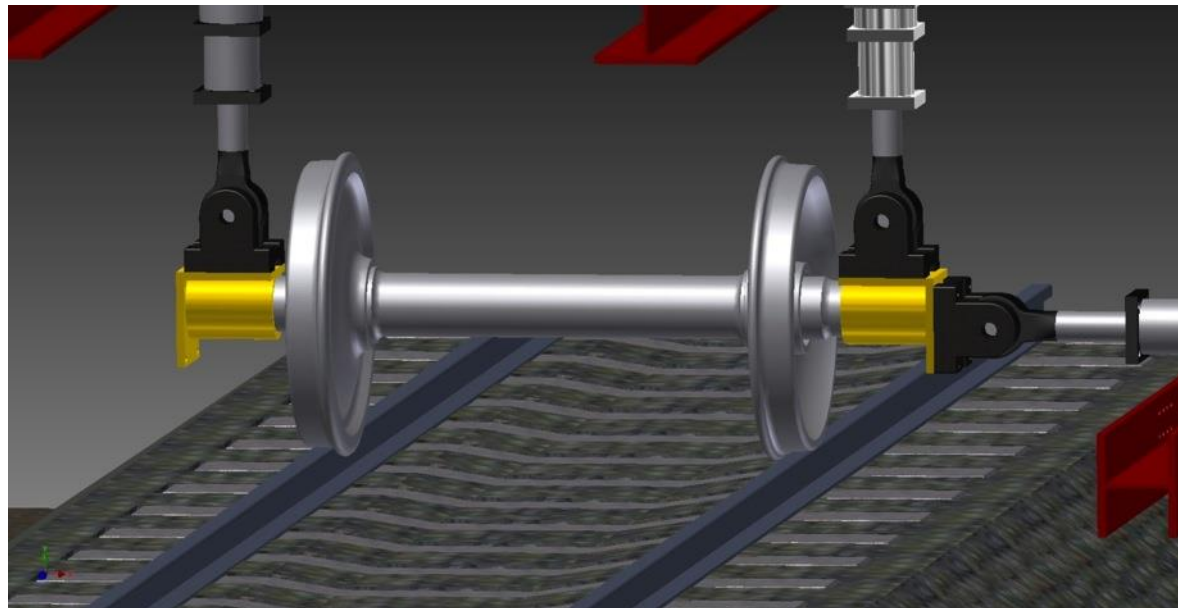
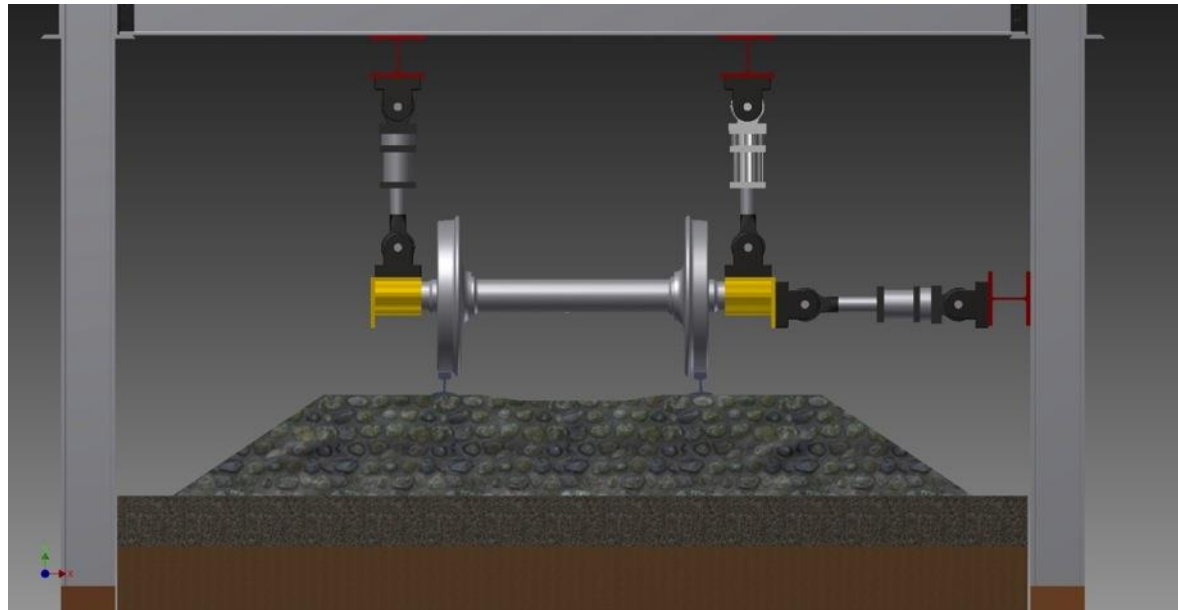




# Full Scale Laboratory Track Bed:



# Full Scale Laboratory Track Bed:



# Laboratory Track Bed Construction: July 18 – Floor Beam Extension and Concrete Pad Complete



# Laboratory Track Bed Construction: July 23 – Floor Constructed



# Laboratory Track Bed Construction: August 15 – Columns Erect and Walls and Floor Constructed



# Laboratory Track Bed Construction: September 17– Lateral Structural Beams Installed



# Laboratory Track Bed Construction: September 23 – Subgrade Construction ~50% Complete



# Laboratory Track Bed Construction: October 4 – Subgrade Construction Complete





# Construction Timeline and Path Forward

- **Construction**

- Frame modification and connections → April-July 2013
- Frame assembly → July-October 2013
- Track construction → September-October 2013
  - Rail, ballast, subballast, and subgrade supplied by CN
  - Crossties supplied by LBFoster CXT Concrete Ties
  - Fastening systems supplied by Amsted RPS
  - IWS calibrated and provided by TTX

- **Hydarulic Systems Installation**

- Hydraulic system and actuators purchased from MTS
- Hydraulic cooling system purchased from BAC

- **Path Forward**

- Development of experimental matrix and instrumentation plan → September-November
- Shakedown → November-December 2013
- Execution of experimental matrix → December 2013-April 2014

# Experimental Matrix Objectives

- Compare to field and laboratory experimentation
  - TLV
  - Train passes
  - PLTM
- Expand upon current field and laboratory experimentation capabilities
- Fill voids in field and laboratory experimentation
- More accurately validate the UIUC 3D FE Model
- Analyze innovative crosstie and fastening system designs

# Experimental Matrix Variables

- **Load Location**
  - Crib center, tie center, tie edge, skewed load (e.g. rail 1 = tie center while rail 2 = offset from tie center)
- **Load Magnitude**
  - Balanced, unbalanced (e.g. rail 1 = 50 kips while rail 2 = 30 kips)
- **Fastening System Clips**
  - 100% installed, 1 rail seat removed, multiple rail seats removed, vary type, vary clamping force (full, reduced, none)
- **Rail Pad and insulator materials**
  - Typical, stiff, flexible
- **Friction**
  - Dry, wet, various friction modifiers
- **Other**
  - Gaps at fastening system interfaces, ballast support condition, deterioration tests

# Future Phases

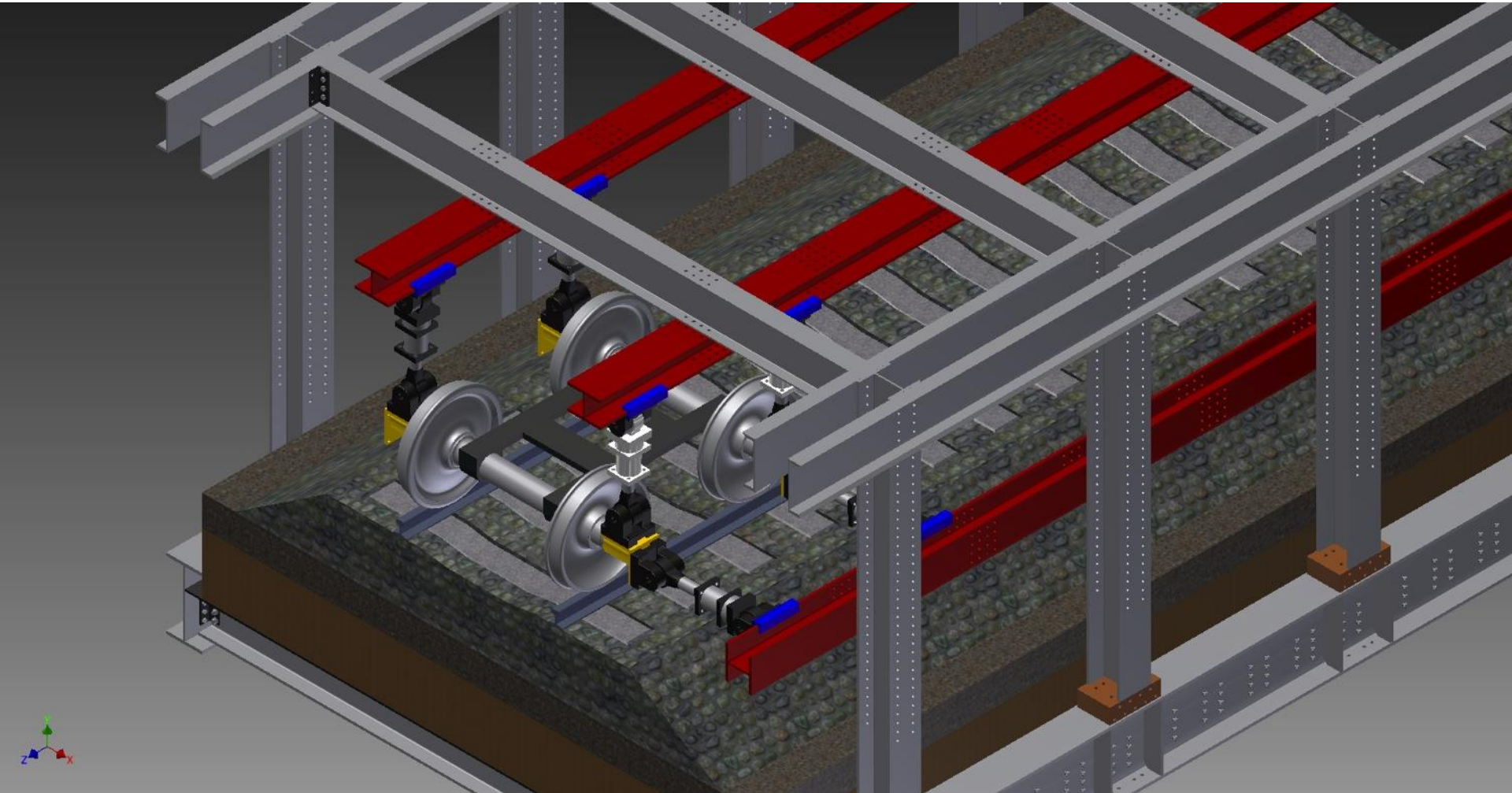
- To be developed when future projects deem necessary and under separate funding
- Load application:
  - Two instrumented wheel sets
  - 6 hydraulic actuators
  - Rolling load

<b>Part</b>	<b>Capability</b>	<b>Phase</b>
2nd Instrumented Wheel Set	Ability to investigate wheel spacing and affect of adjacent loading as well as simulate steering of trucks	Future
6 Actuators	Ability to provide additional control and variability of loading to the track structure	Future
Drive system	Ability to apply dynamic rolling load	Future
Extension of Frame	Ability to achieve higher speeds, study additional sections simultaneously, and study track transitions	Future

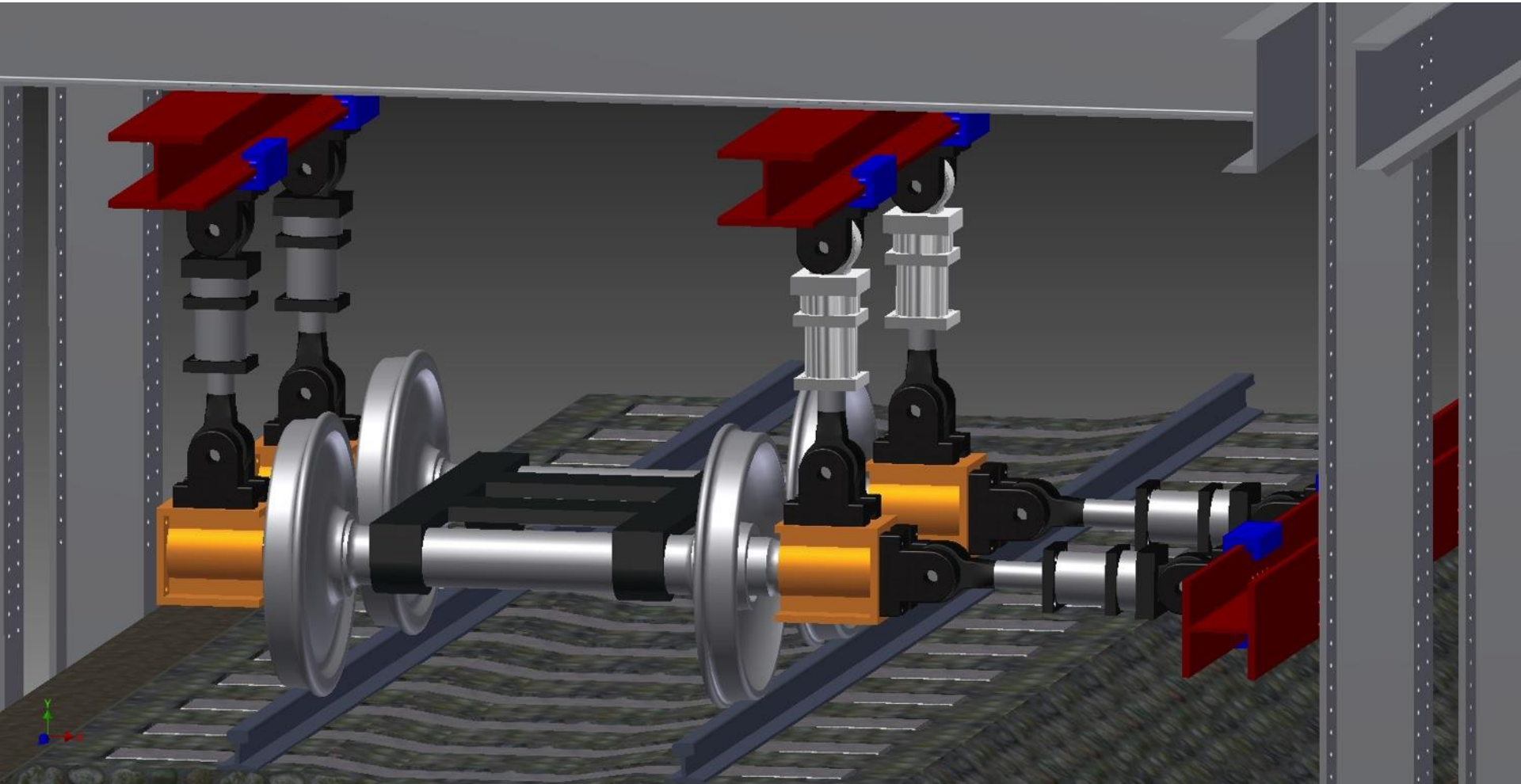
# Future Phase – Full Truck Loading

- Additional wheel set (full truck)
- Independent control of both wheel sets
  - Simulate steering of trucks
- One lateral and one vertical actuator per wheel set
- One hydraulic ram on opposite end of axle on each wheel set
- Addition of second vertical actuator on each wheel set to provide additional control and variability of loading on second side of axle

# Future Phase – Full Truck Loading



# Future Phase – Full Truck Loading

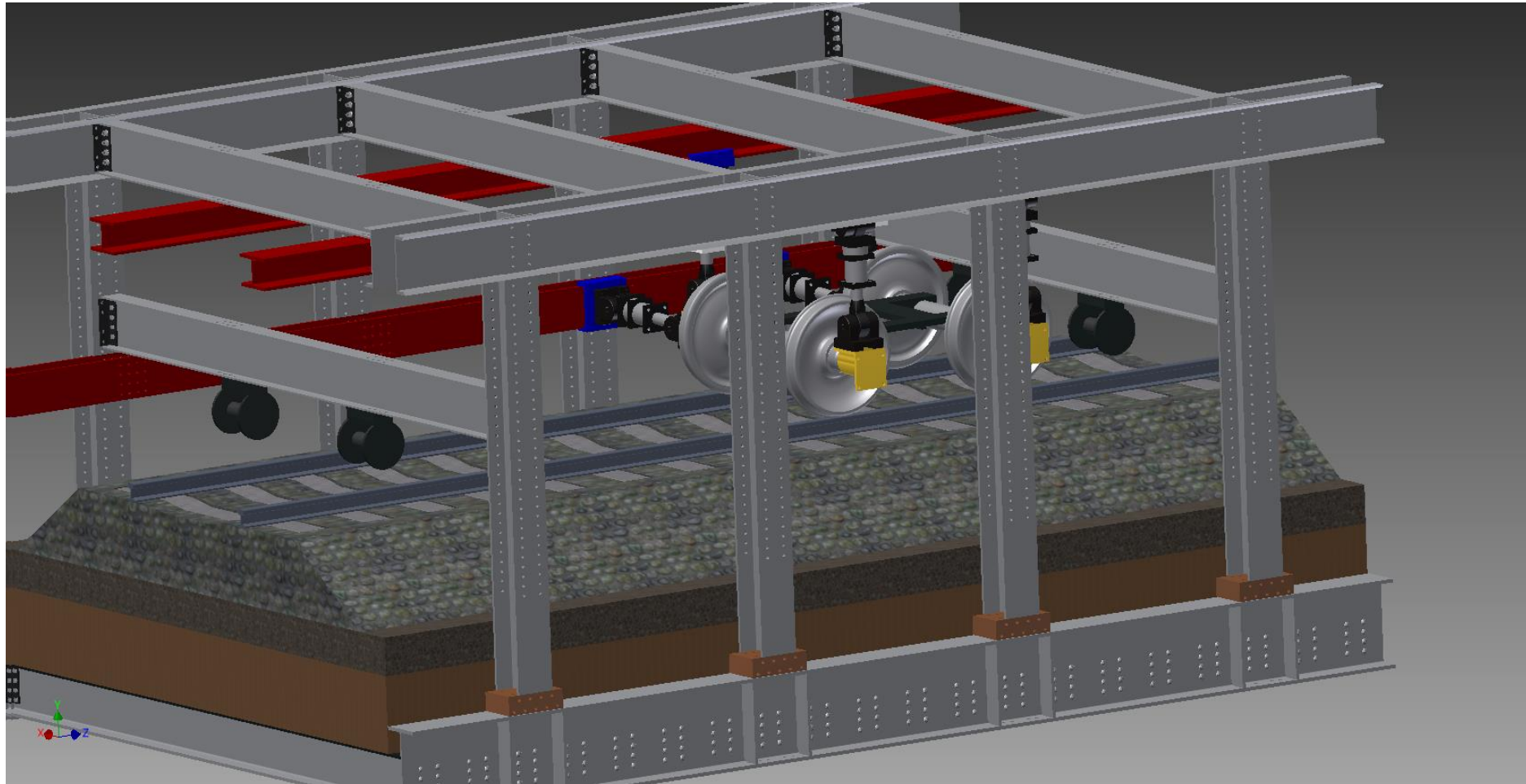


## Future Phase – Moving Truck (Loads)

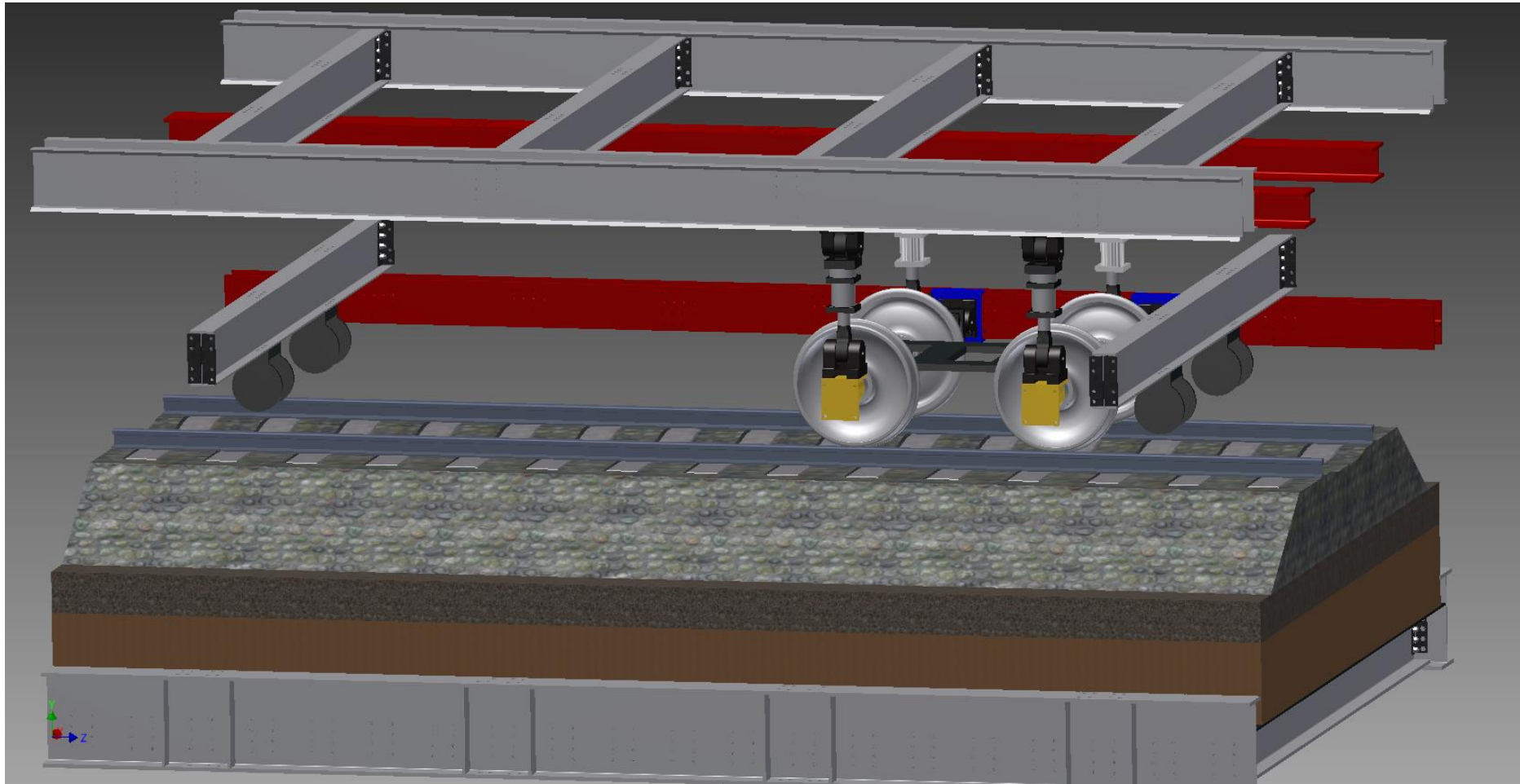
- Addition of drive system to move truck longitudinally
- Apply continuous rolling loading to track
- Extend frame length



# Future Phase – Moving Truck (Loads)



# Future Phase – Moving Truck (Loads)



# Industry Support

- **UIUC, CEE Department, and RailTEC**
  - Provision of Laboratory Facility
  - Cleanup and Retrofit of Laboratory
  - Hydraulic Power Supply and Ancillary Equipment
- **Other Industry Partners**
  - Instrumented Wheel Set (IWS) [TTX]
  - Frame Price Reduction [Amsted Rail]
  - Hydraulic Power Unit Chiller [Amsted Rail]
  - Track Construction Materials [CN Railroad]
  - Track Construction Quality Control [Hanson Professional Services Inc.]
- **Federal Railroad Administration (FRA)**
  - Additional Frame Design, Materials, and Labor
  - Actuators
  - Control System



U.S. Department of Transportation  
Federal Railroad Administration



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U.S. Department of Transportation

## Federal Railroad Administration

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  - Hanson Professional Services, Inc.
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  - TTX Company
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FRA Tie and Fastener BAA  
Industry Partners:



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