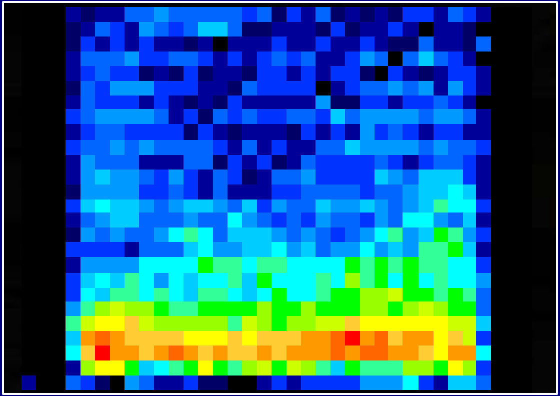
Field Instrumentation of Concrete Crosstie Rail Seats for Investigating Rail Seat Pressure Distribution



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Federal Railroad Administration

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Outline

- Current Objectives of Experimentation
- Testing Background
  - Laboratory Experimentation
- July 2012 Field Instrumentation
  - TLV Experimentation
- Conclusions
- Future Work
  - Field Instrumentation
  - Tool for Pressure Estimation

Current Objectives of Experimentation with Matrix Based Tactile Surface Sensors (MBTSS)

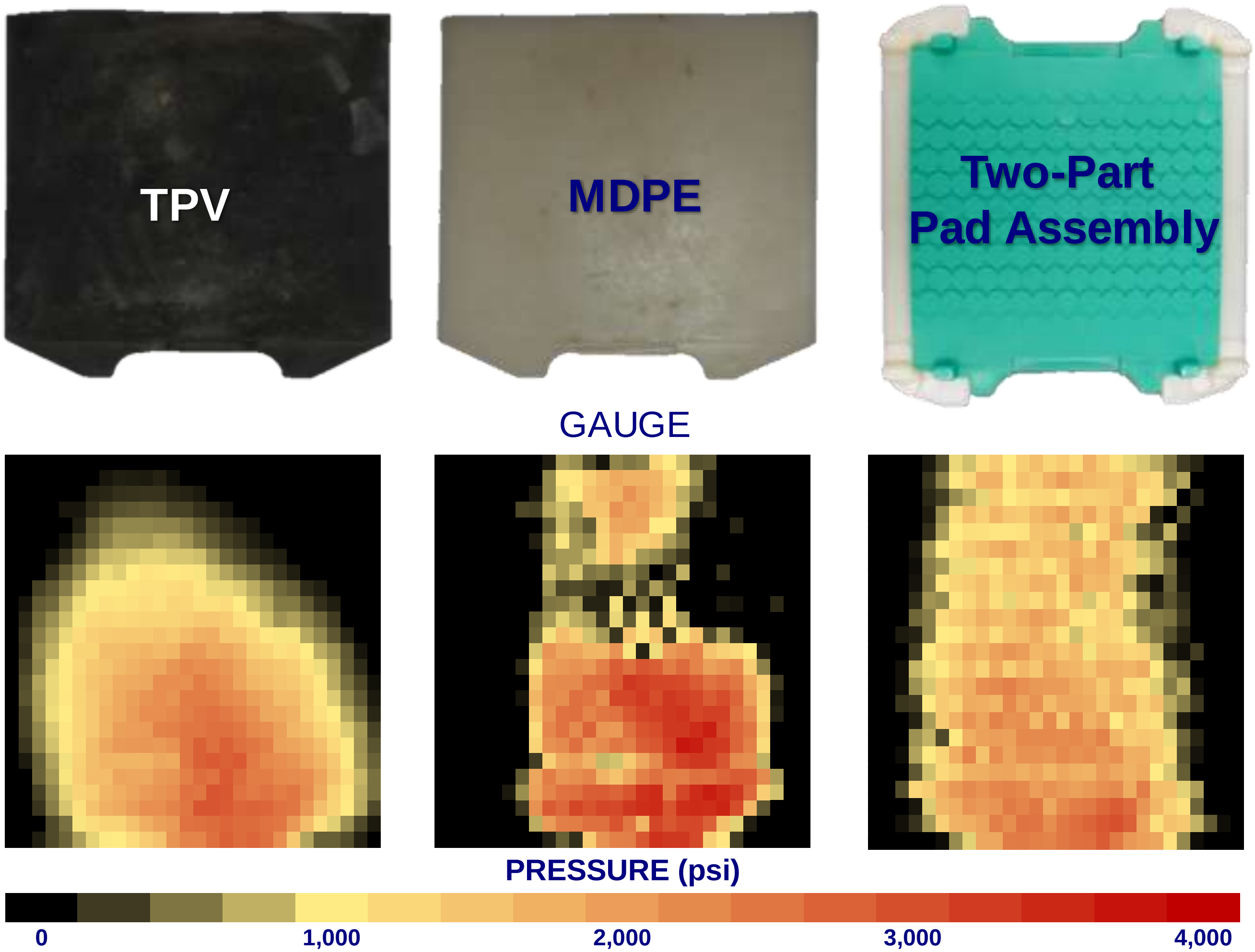
- **Measure magnitude and distribution of pressure at the concrete crosstie rail seat**
- Investigate the feasibility of crushing as a mechanism leading to rail seat deterioration (RSD)
- Gain improved understanding load transfer from wheel/rail interface to the rail seat
- Compare pressure distribution on rail seats:
  - – Under various loading scenarios
  - – Under various fastening systems
- Identify regions of high pressure and quantify peak values

MBTSS Testing Background

- Proven feasibility for use on concrete crosstie rail seats
- Laboratory experimentation performed varied:
  - Rail pad materials, geometry, and type
  - Fastening clip type
- Lessons learned from experimentation at Transportation Technology Center (TTC) in 2011-12
  - Protection and sizing of sensors is critical
  - Need for an input load to correlate to raw sum data
- Data collection speed limitations
  - 100 Hz

Laboratory Experimentation: Rail Pad Assemblies

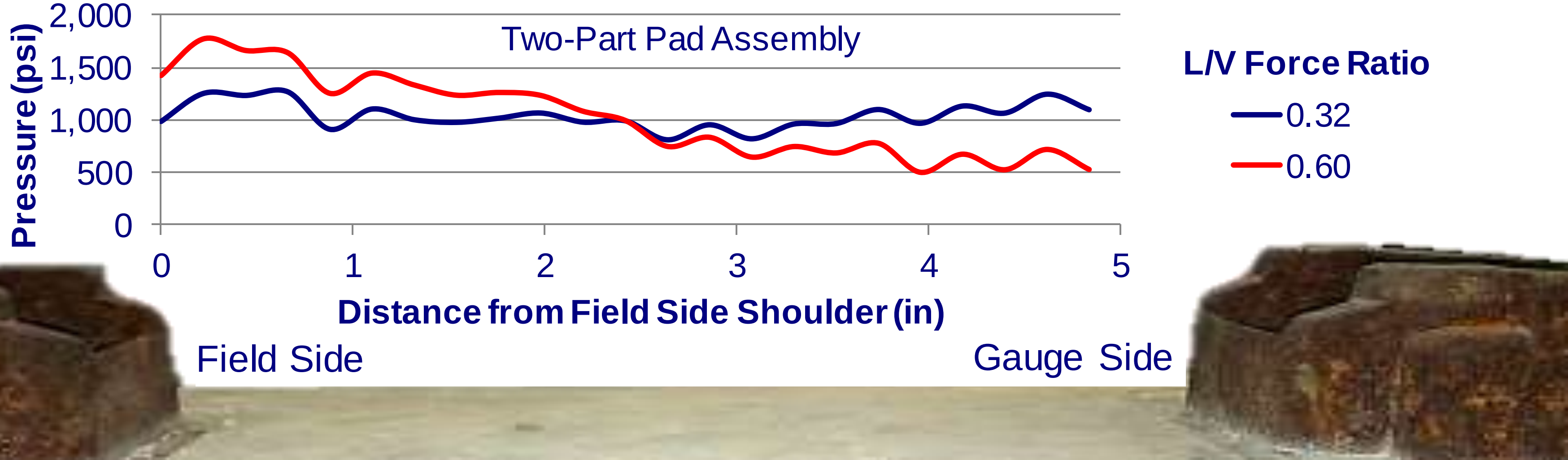
- Load Applied: 32.5 kip vertical, 16.9 kip lateral (0.52 L/V Force Ratio)



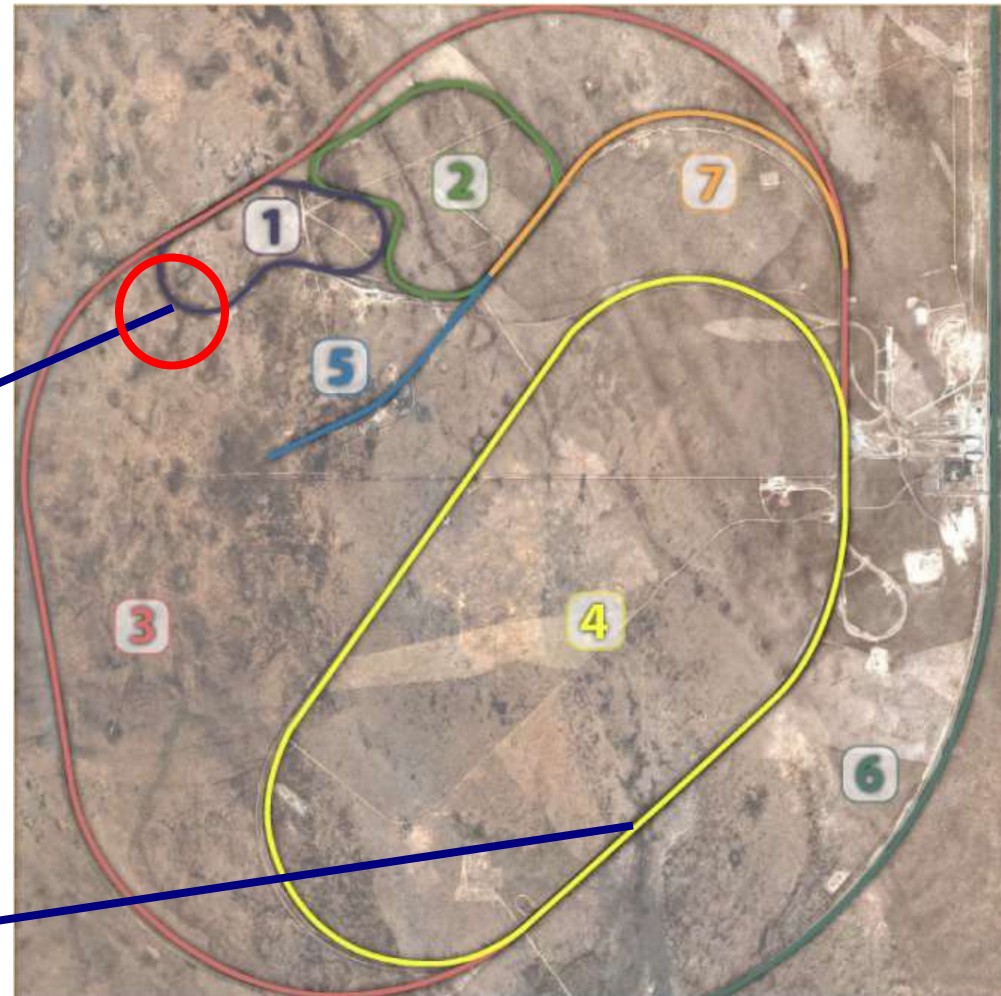
	TPV	MDPE	Two-Part Pad Assembly
Contact Area (in^2)	25.8	19.0	23.9
Max Pressure (psi)	2,925	3,721	2,990

Conclusions from Laboratory Testing

- **Rail Pad Test**
  - Lower modulus rail pads distribute rail seat loads over a larger contact area
    - Mitigates highly concentrated loads at this interface
    - Allows greater rail base rotation
  - Two-Part Pad Assembly
    - Maintains relatively consistent contact area under increasing L/V force ratios
    - Peak pressures similar to the lower modulus TPV pad
- **Effect of Lateral/Vertical (L/V) Force Ratio**
  - Higher L/V force ratios cause a concentration of pressure on the field side of the rail seat, resulting in higher peak pressures

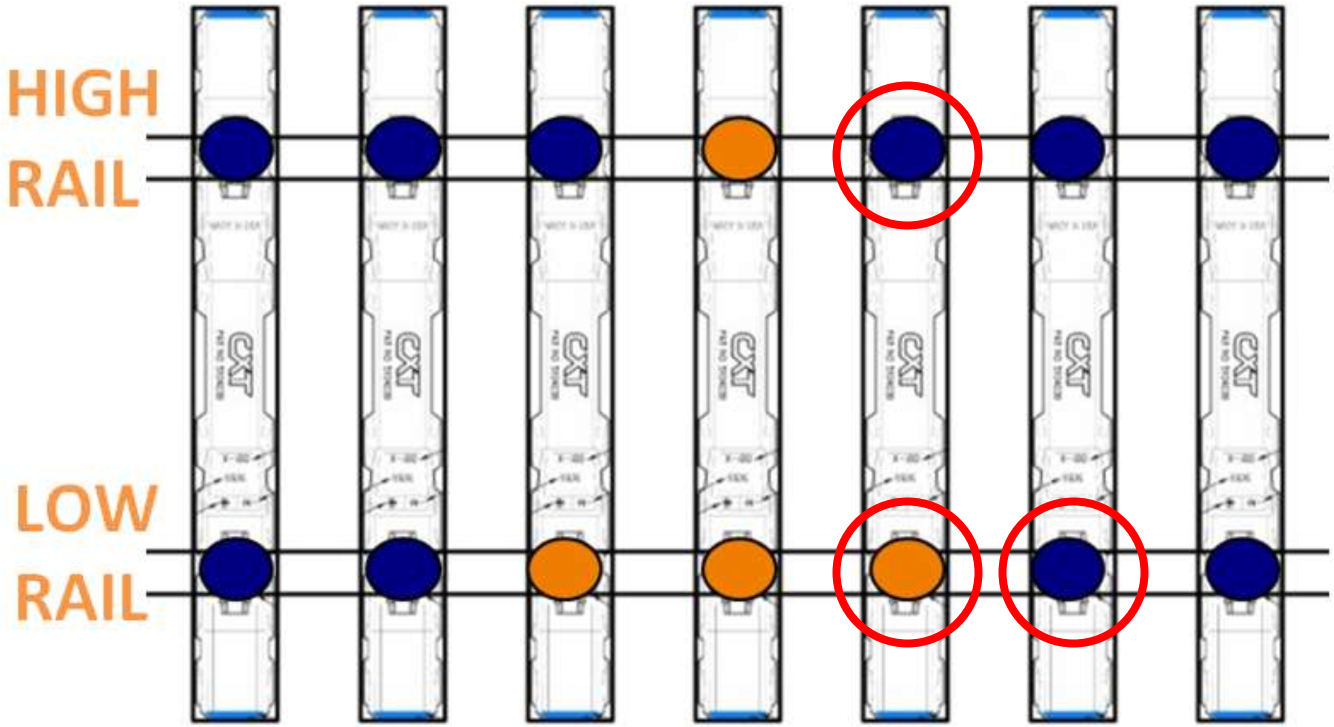


TTC Field Testing Locations



TTC Field Testing Locations

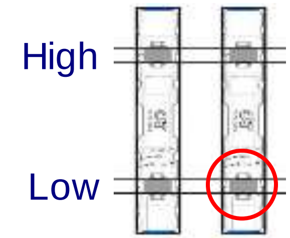
- Instrumented section of track using various instrumentation technologies to capture loads and behavior of various aspects of the concrete crossties and fastening systems

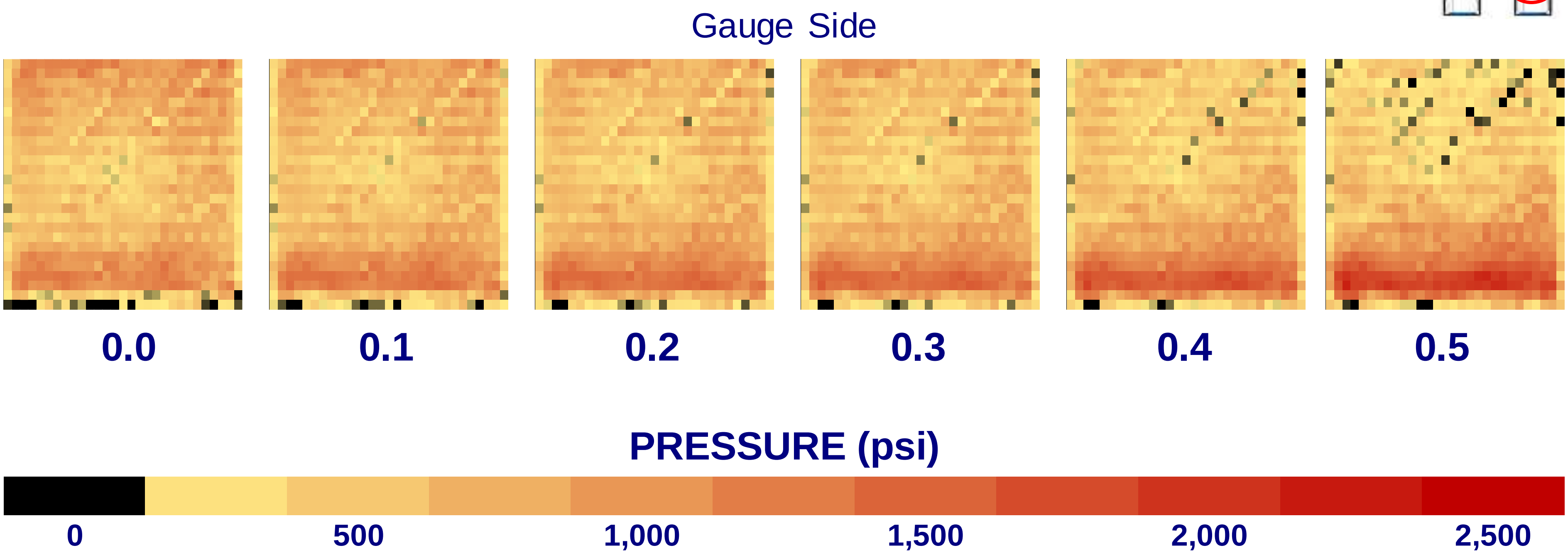


Track Loading Vehicle (TLV) Testing

- L/V force ratio testing: continuous 40 kip vertical load applied
  - Lateral loads ranging from 0 to 20 kips
  - L/V force ratios ranging 0 to 0.5
- Assumption that 50% of load applied to rail is carried by crosstie immediately below loading (literature reviews and strain gauge data)

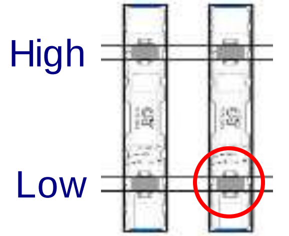
TLV Varying L/V Force Ratios at HTL

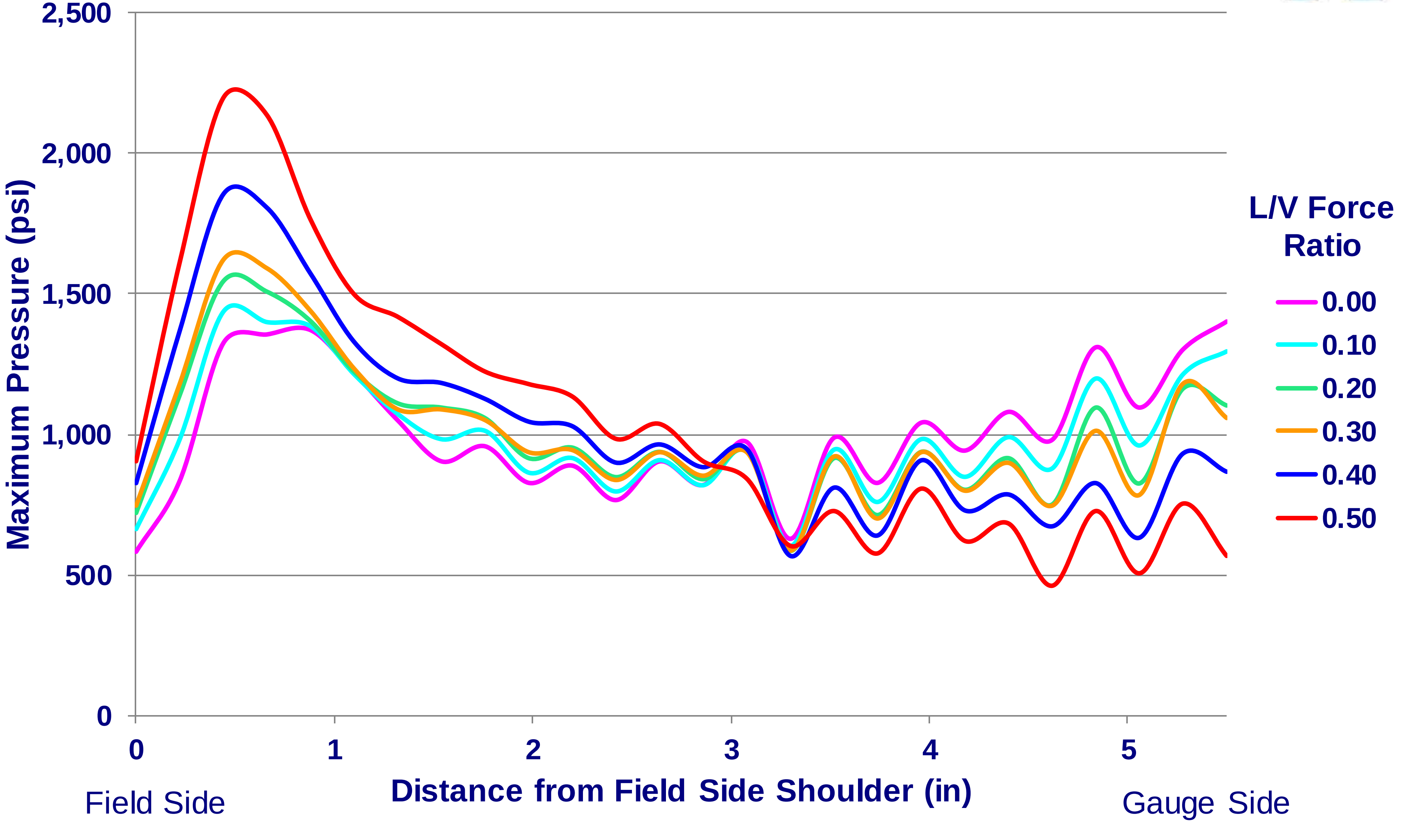




- 40 kip vertical load applied to rail, lateral load varying based on respective L/V ratio
- Maximum pressure at **0.0** L/V force ratio = **1,400 psi**
- Maximum pressure at **0.5** L/V force ratio = **2,200 psi**

TLV Varying L/V Force Ratios at HTL





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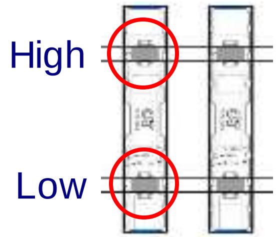
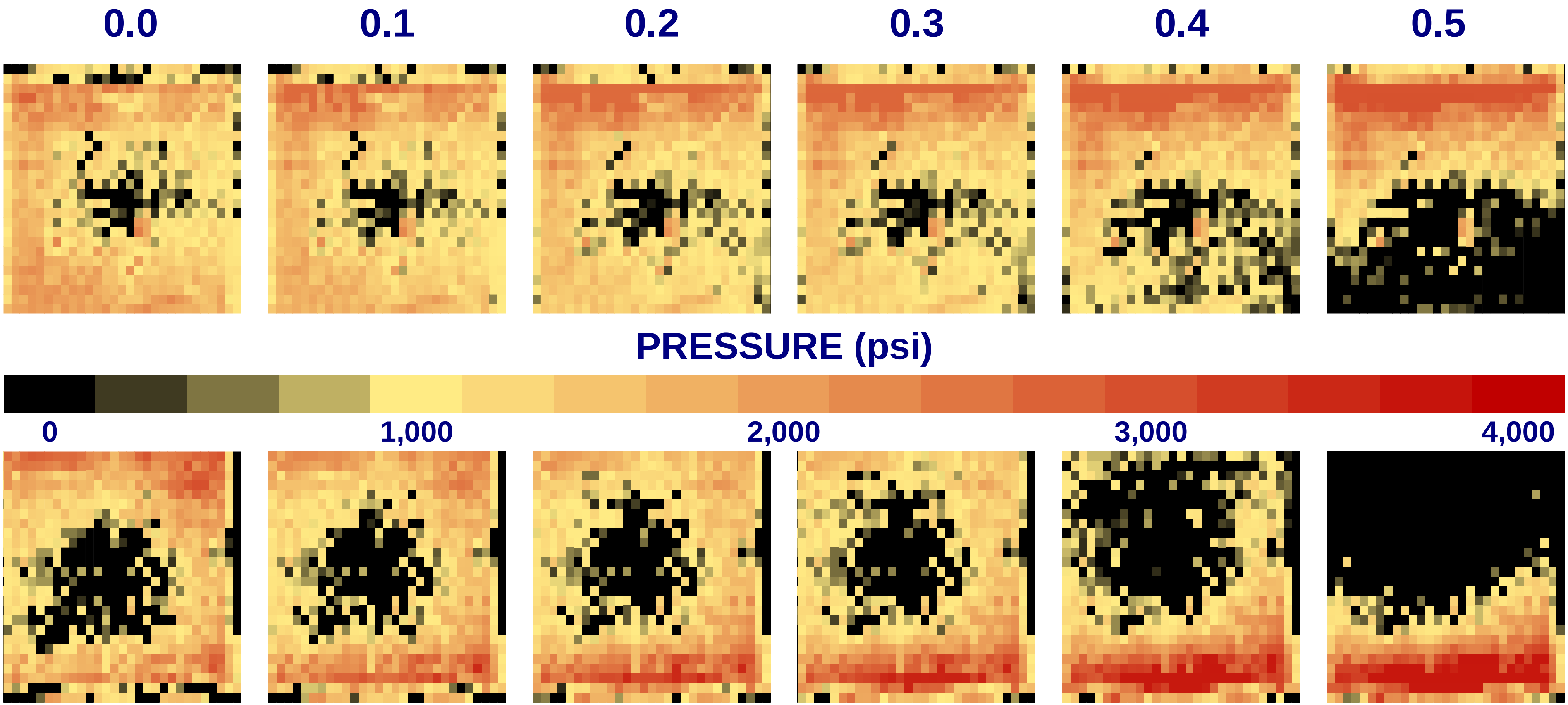
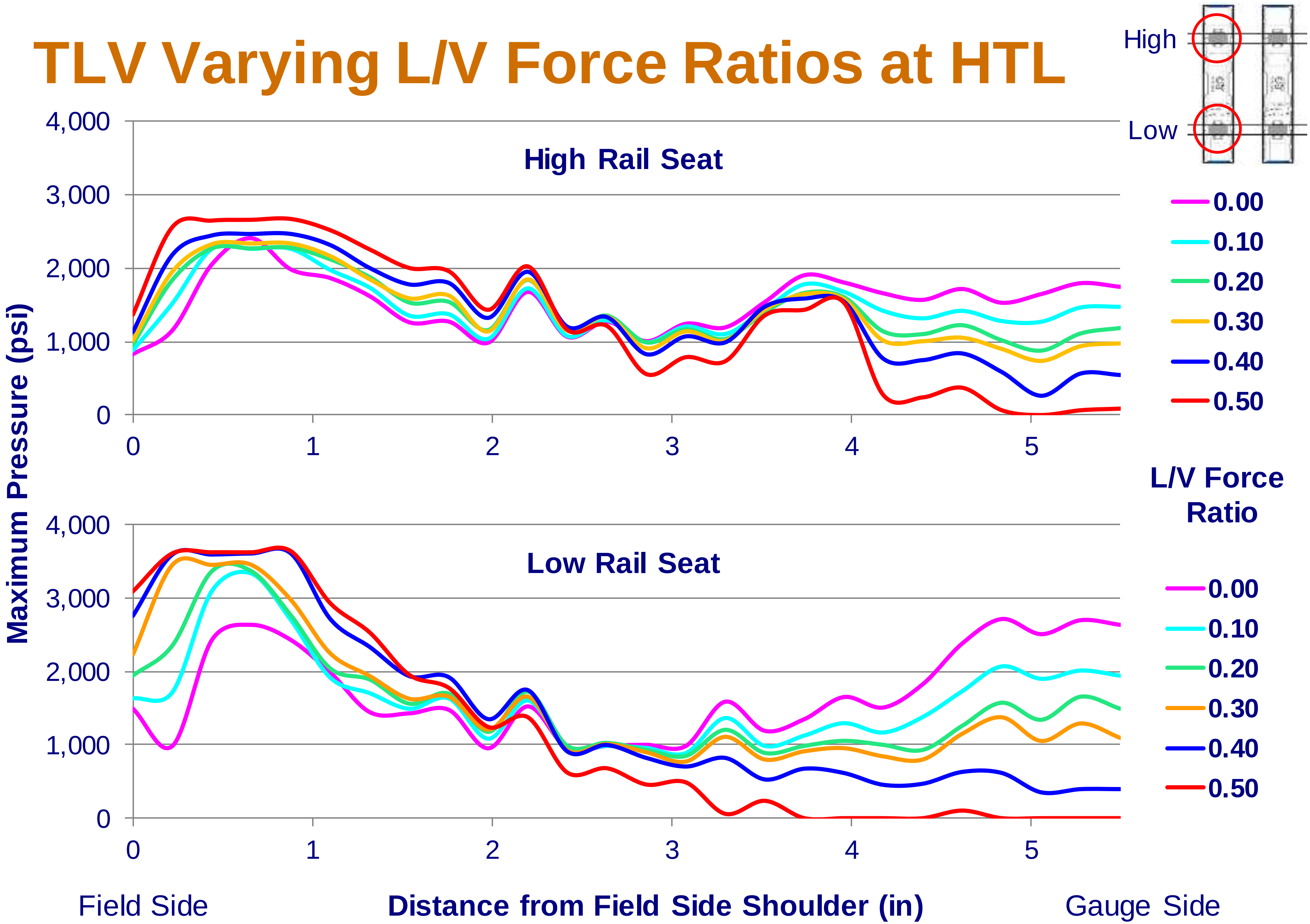


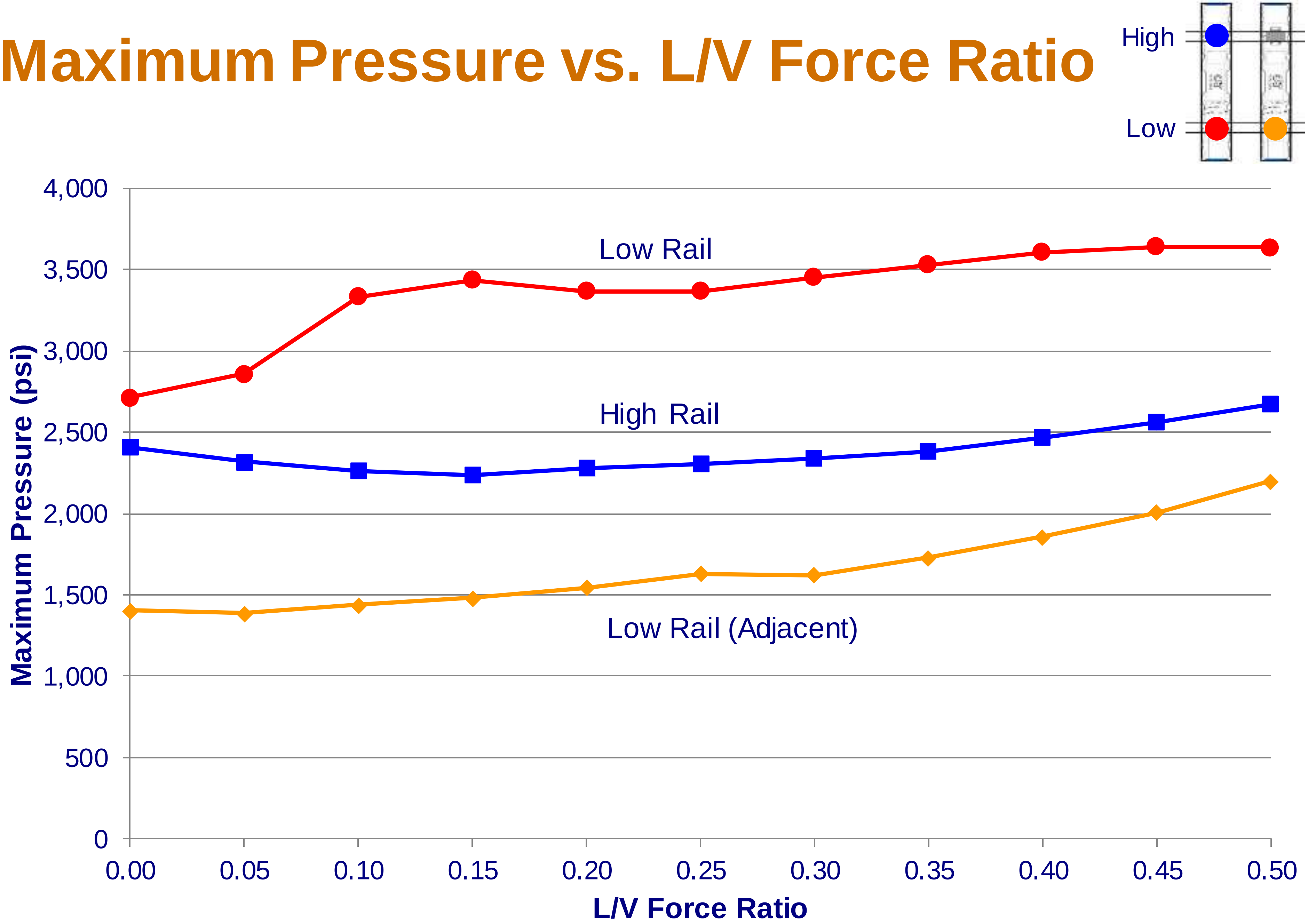


- High Rail Seat:
  - Max. pressure at **0.0** L/V = **2,400 psi**
  - Max. pressure at **0.5** L/V = **2,700 psi**
- Low Rail Seat:
  - Max. pressure at **0.0** L/V = **2,700 psi**
  - Max. pressure at **0.5** L/V = **3,640 psi**

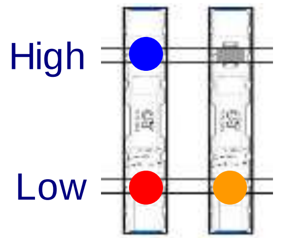
TLV Varying L/V Force Ratios at HTL

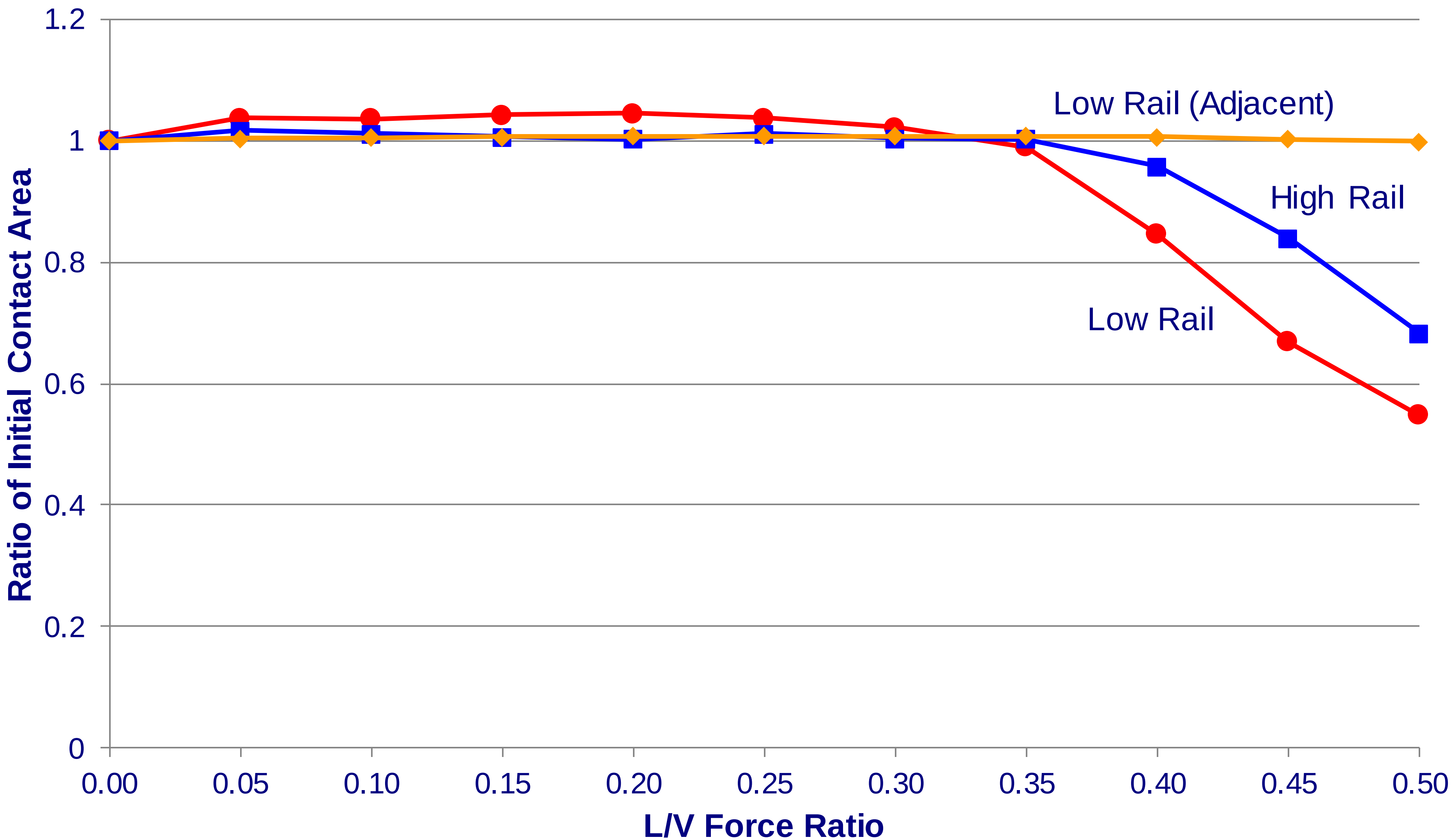


Maximum Pressure vs. L/V Force Ratio



Contact Area vs. L/V Force Ratio



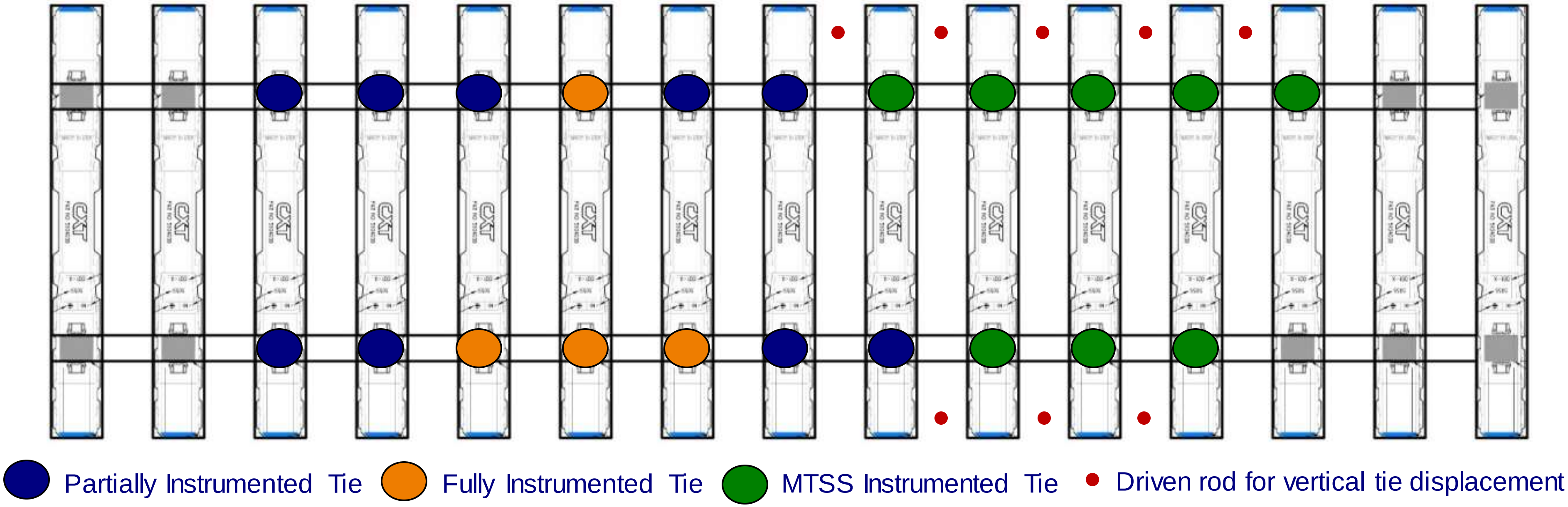


Conclusions

- Laboratory and field data both show same increase of load on field side under increasing L/V force ratios
- Maximum pressures did not exceed 3,640 psi, but more extreme conditions could cause higher values
  - Crushing as a mechanism of RSD does not appear feasible under these load magnitudes and L/V force ratios
  - Other factors like motion, moisture must also be considered
- Variability in rail seat support conditions can occur from tie to tie
- Allowable movement of the rail base can affect the distribution of pressure at the rail seat
  - Greater rotation decreased contact area and increased maximum pressures

Future Work: Field Instrumentation

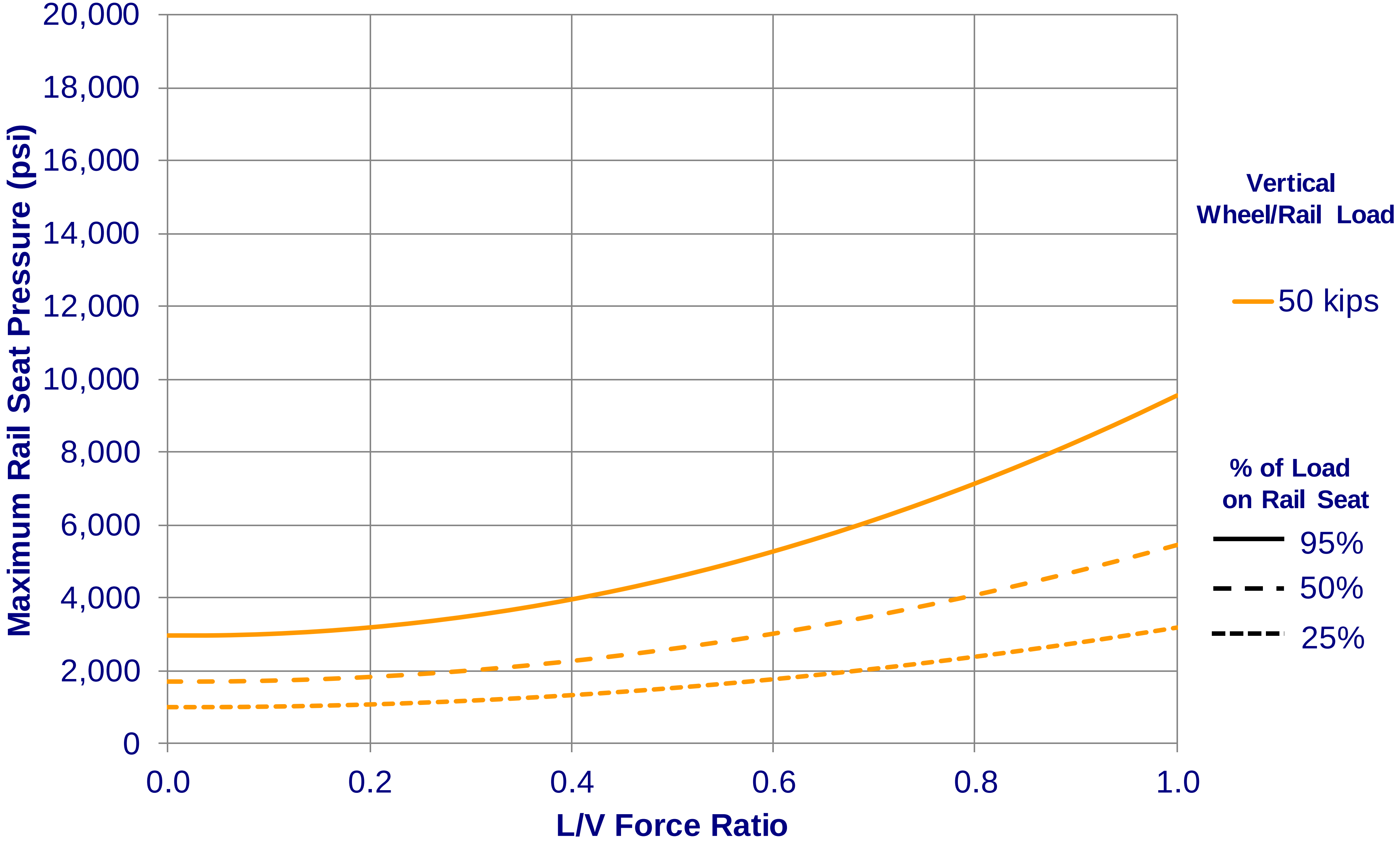
- Collect data from 8 sensors simultaneously
- View distribution of a single load over multiple crossties
- Collect greater quantity of high vs. low rail seat data points
  - Determine linearity or non-linearity of transfer of load from low to high rail seats under increasing train operating speeds
- Investigate effect of crosstie support conditions on load distribution by correlating MBTSS data with crosstie deflections



Future Work: Tool for Pressure Estimation

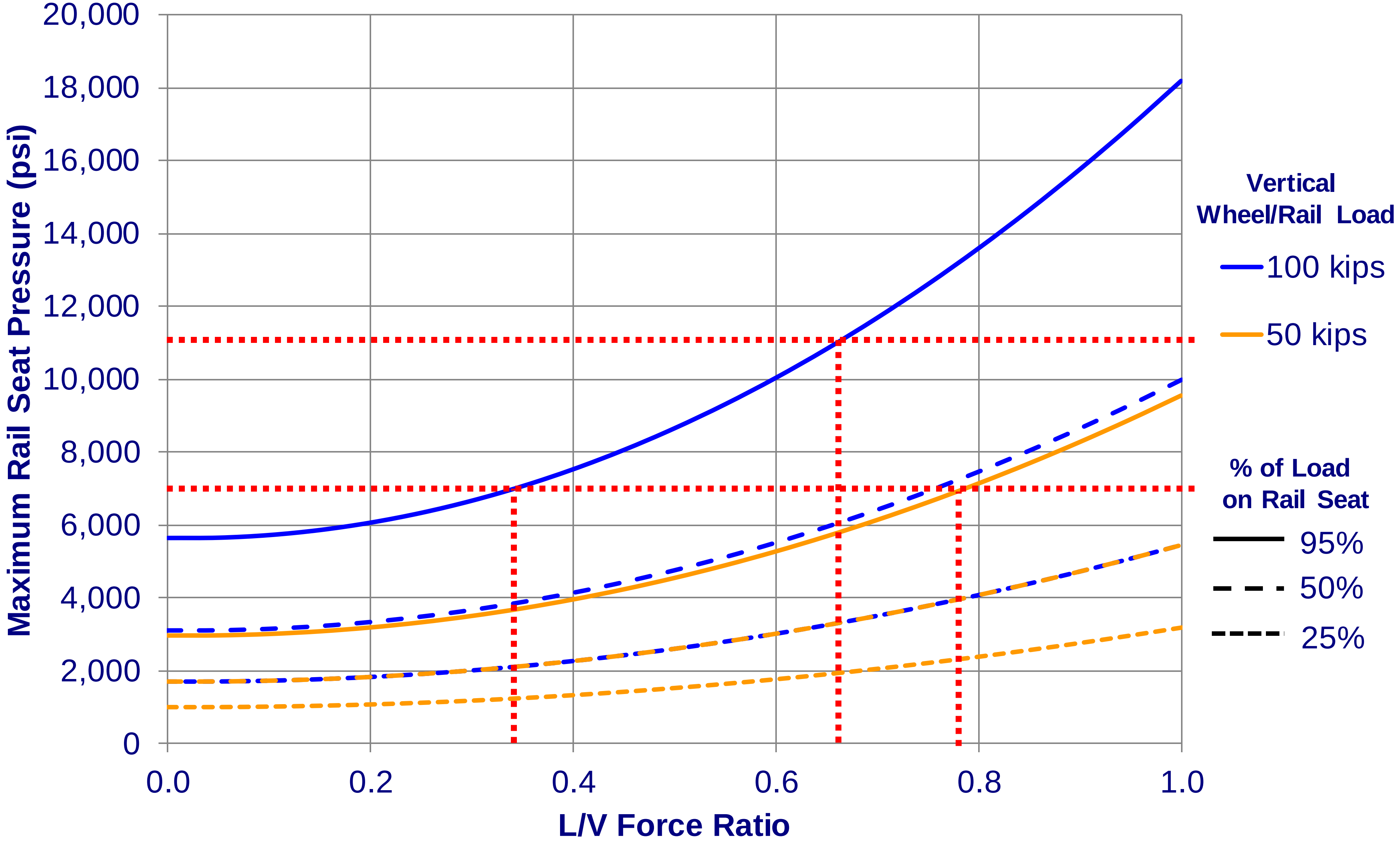
- Analytical tool for calculating maximum rail seat pressure values at various L/V force ratios under different loads
  - In early stages of development, currently theoretical graphs based on available field experimentation data
  - Future field instrumentation plan focusing on collecting data needed to advance and refine this tool
- Benefits to Industry
  - Incorporate proven industry technologies (WILD, IWS, TPD)
  - Estimate pressure distribution
  - Estimate pressure magnitude at rail seat
- Effects design of crossties due to change in bending moment

Future Work: Tool for Pressure Estimation



*Theoretical graph based on available field experimentation data

Future Work: Tool for Pressure Estimation



*Theoretical graph based on available field experimentation data

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Questions & Comments

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