

Acoustic Birefringence for measuring Rail Neutral Temperature

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Based on results from:

**Enhanced Acoustic Birefringence Method
for Measuring Longitudinal Rail Stress**

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FRA Project Manager: Robert Wilson, PhD

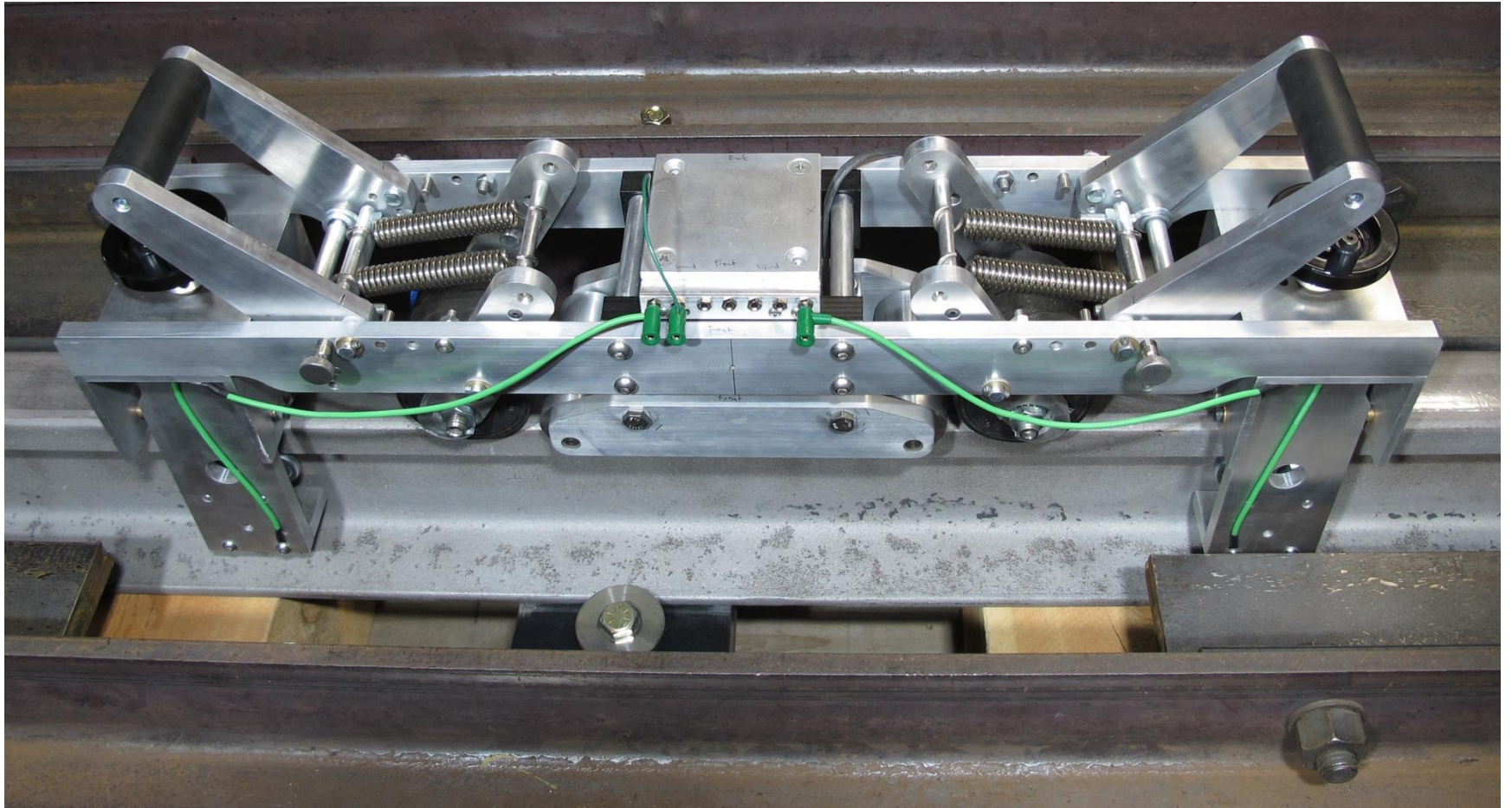


Research Approach

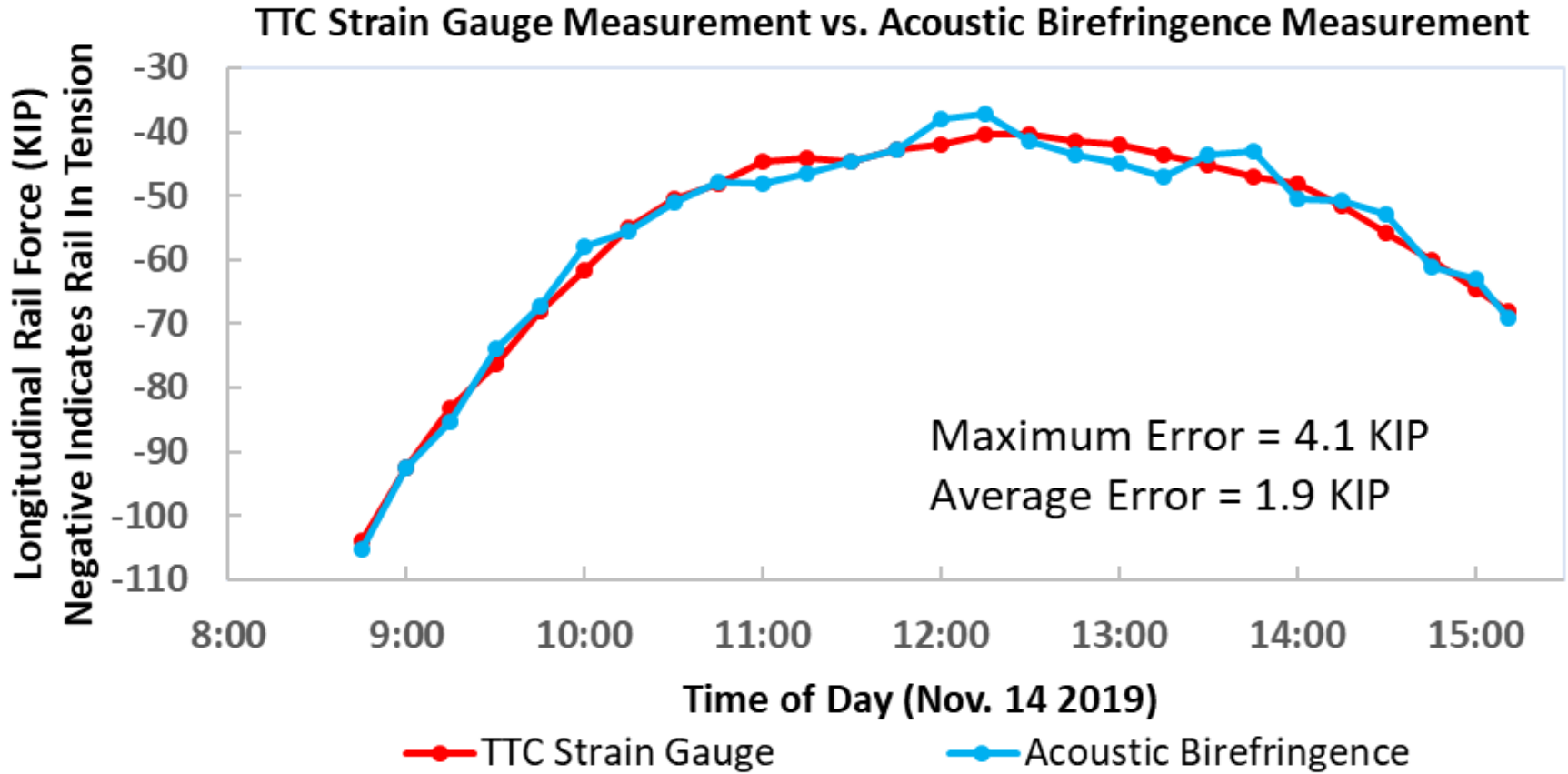
- Started with existing AB instrumentation developed through NSF SBIR
- Developed Rail Stress Test Fixture
- Simulates thermally-induced stress up to 165 kip in both tension and compression
- NIST-traceable load cells as force reference
- Nine sample rails tested
- Linear AB-stress relationship ($R^2 = 99.9\%$)
- Upgrades to Rail Alignment Guide



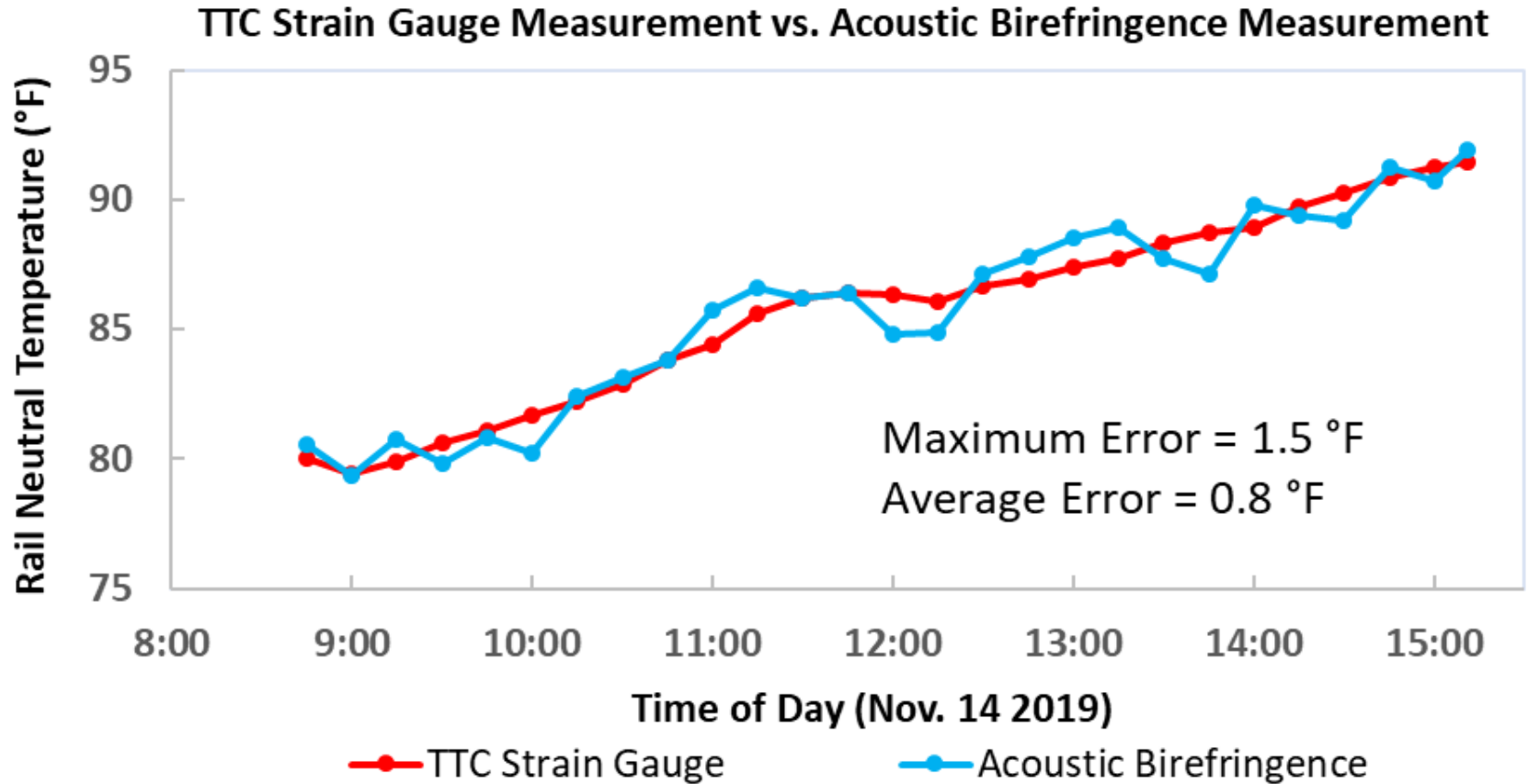
Rail Alignment Guide



Field Test Results (on HTL at TTC)



Field Test Results (on HTL at TTC)



Q1 - Technology Type?

Acoustic Birefringence (AB)

Rail-specific EMAT-based ultrasonic transducer

- Phased array for determining fast/slow polarization angles
- Optimized aperture and beam shape for top of rail
- Options for web or under rail foot for fixed applications

Custom Instrumentation and Signal Processing

- Time-of-Flight to billionths of a second

Rail Alignment Guide

- Ensures accurate and repeatable lateral alignment



Q2 - Reference-Free?

At Present - No

- Initial calibration to a known longitudinal stress is required

As Future Goal - Plausible

- We propose additional research to survey loose rail strings and analyze residual stress patterns

Engineer's Motto - "You can't fix what you haven't measured"



Q3 - Spot Measurement or Moving Platform?

Spot Measurement

- Potential products include fixed-location devices and portable devices for spot measurements
- Rail repair and RNT adjustments

Moving Platform

- A moving platform (Hi-Rail, etc.) is probably not feasible due to the required measurement precision



Q4 - Risks to Commercialization?

Technical, implementation, and validation

- Minimal risk for relative stress measurement
- Research phase complete for relative stress measurements
- Lab and field results show $< 5^{\circ}\text{F}$ RNT error contribution
- Ready to develop and commercialize fixed and/or portable RNT devices

Regulatory and operational challenges

- Acoustic Birefringence is non-hazardous and non-destructive
- No significant rail or test site preparation is required
- Measurement time estimated at 10 to 20 minutes per rail



Q5 - ROM Cost Prototype/Validate in 9 months?

Relative Stress Measurement Applications

- No additional research or validation required
- ROM estimate of \$0K

Absolute Stress Measurement Applications

- Develop automated tool for mapping residual stress in loose rail
- Gather and analyze comprehensive database of residual stress patterns for all CWR rail weights, manufacturers, etc.
- ROM estimate of \$250K



Q6 – ROM Cost Commercialize in 2 Years?

Relative Stress Measurement Applications

- Technology is validated and ready to proceed to product and application development
- Proposal to FRA includes prototype development of fixed-location device
- Seeking industry discussions on other potential applications and application priorities
- ROM estimate of \$450K for commercial prototype of fixed-location device

Absolute Stress Measurement Applications

- Difficult to estimate without analysis of residual stress behavior across all CWR rail types
- Best-case ROM estimate of \$750K



Q7 – Track Configurations and Conditions?

No significant impact anticipated

- Ultrasonic waves used for Acoustic Birefringence are fully-contained within the rail volume
- No external influences are expected
- In field testing to date, no unexpected influences observed
- No issues transferring from lab to field environment

Minor Considerations

- The rail alignment guide requires access to upper web
- Excess surface contamination



Q8 – Field Testing to Date

In-Situ Rail Test at TTC

- Comparison to HTL section instrumented with strain gauges

Residual Stress Survey at TTC

- Residual stress survey along selected sections of three 80 ft. loose rail strings

