Mitigating Track Buckling from Heavy Train Braking Using Automated Alerts

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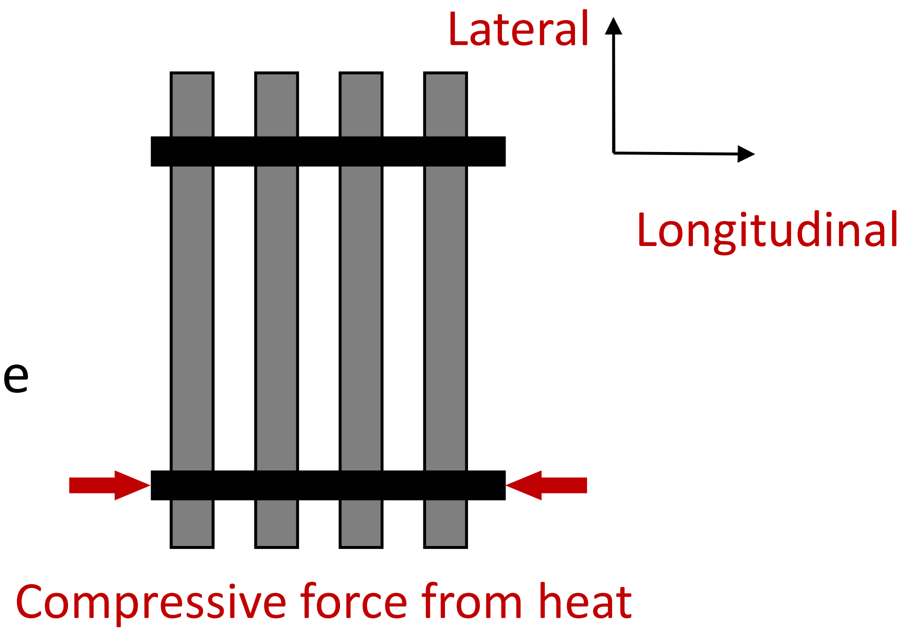
Outline

- Introduction
- Background – Track Buckling
- Heat from Train Braking
  - Data Collection and Analysis
  - Key Takeaways
- Solution Development and Automated Alert Implementation
- Future Considerations

Background – Track Buckling

- Track buckles pose a significant risk to trains derailing in CWR territory
- Factors typically:
  - Longitudinal Forces
    - Compressive force from rail expansion typically caused by heat
  - Lateral Forces
    - Required impetus to trigger the buckle
      - i.e. dynamics from train handling



Background – Track Buckling

- Track components restrain these forces
- When the forces are released, track buckles occur

Photo source: https://www.newcivilengineer.com/latest/roads-melt-and-rail-tracks-buckle-as-uk-heatwave-strikes-27-06-2018/

Background – Heat of Rail from Trains

Heating Source Addressed:

- Trains passing over rail add heat

Previous evidence of rail temperature being raised by trains passing:

- Anecdotal and recorded incidents
- Track buckles/sun kinks reported following multiple heavy trains descending steep grades

Photo source: https://jesstopper.wordpress.com/2012/04/21/s-is-for-sun-kink/

Data Collection – Summer 2021

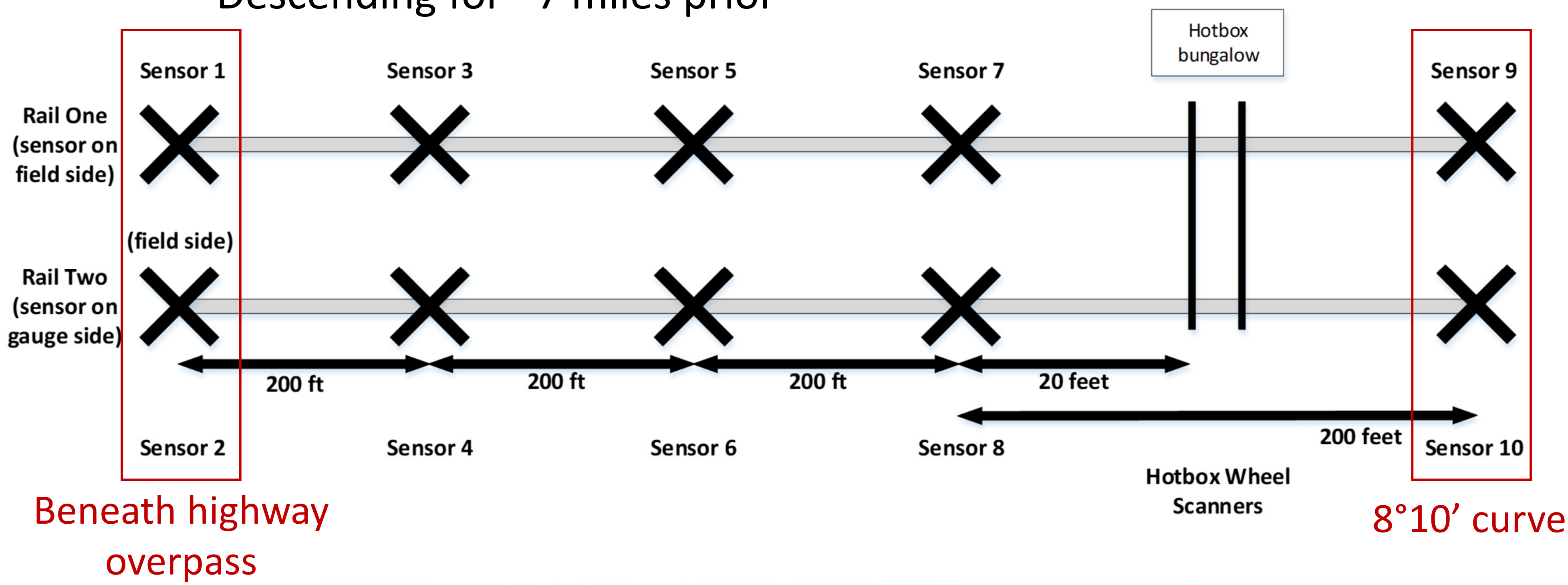
- Sensor setup:
  - 10 magnetic rail temperature sensors
  - Placed in the web of the rail

- Two months of data: August and September

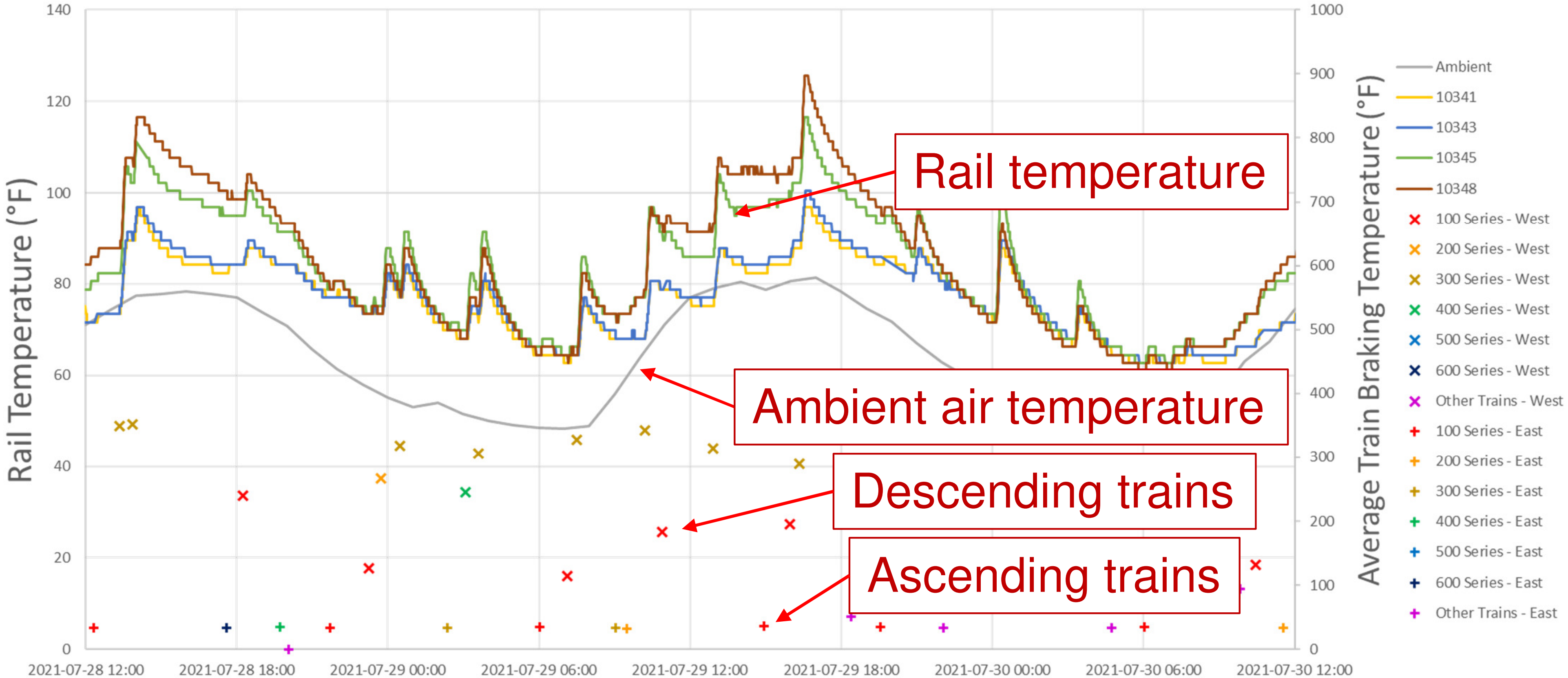
Wireless Temperature Sensor

Data Collection – Summer 2021

- Test Location Adjacent to Hot Box Detector (HBD): Grade: 2%
  - Descending for ~7 miles prior

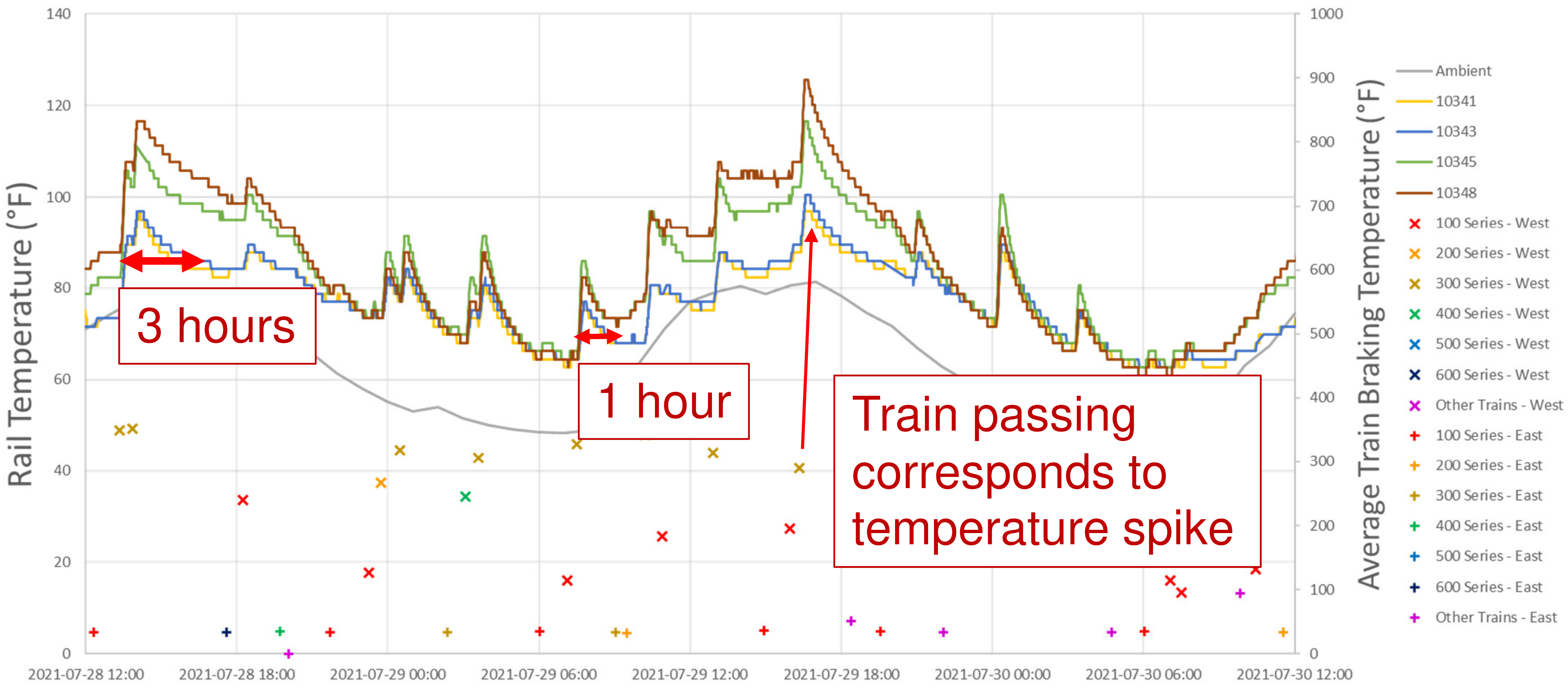


Study Results



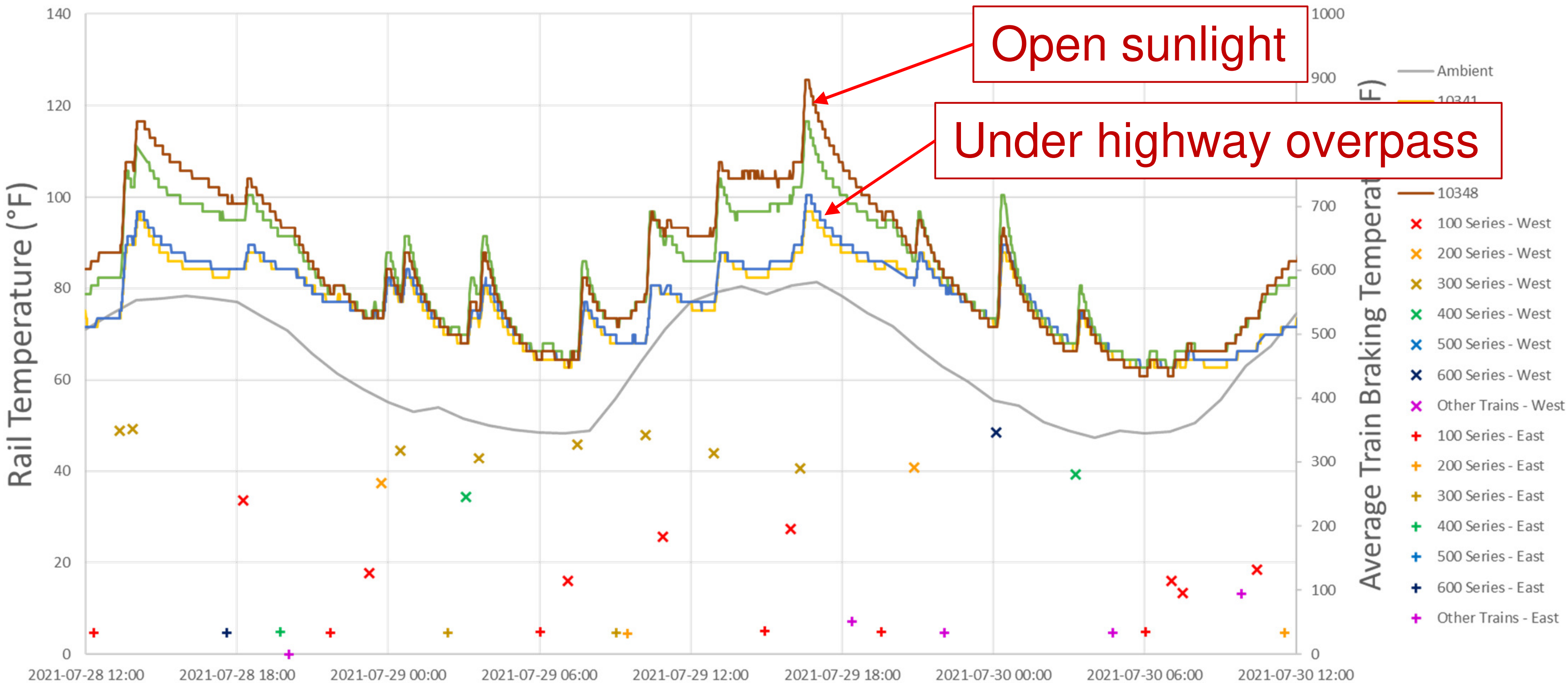
Study Results

- Increases in rail temperature directly correlate with temperature of the train brakes

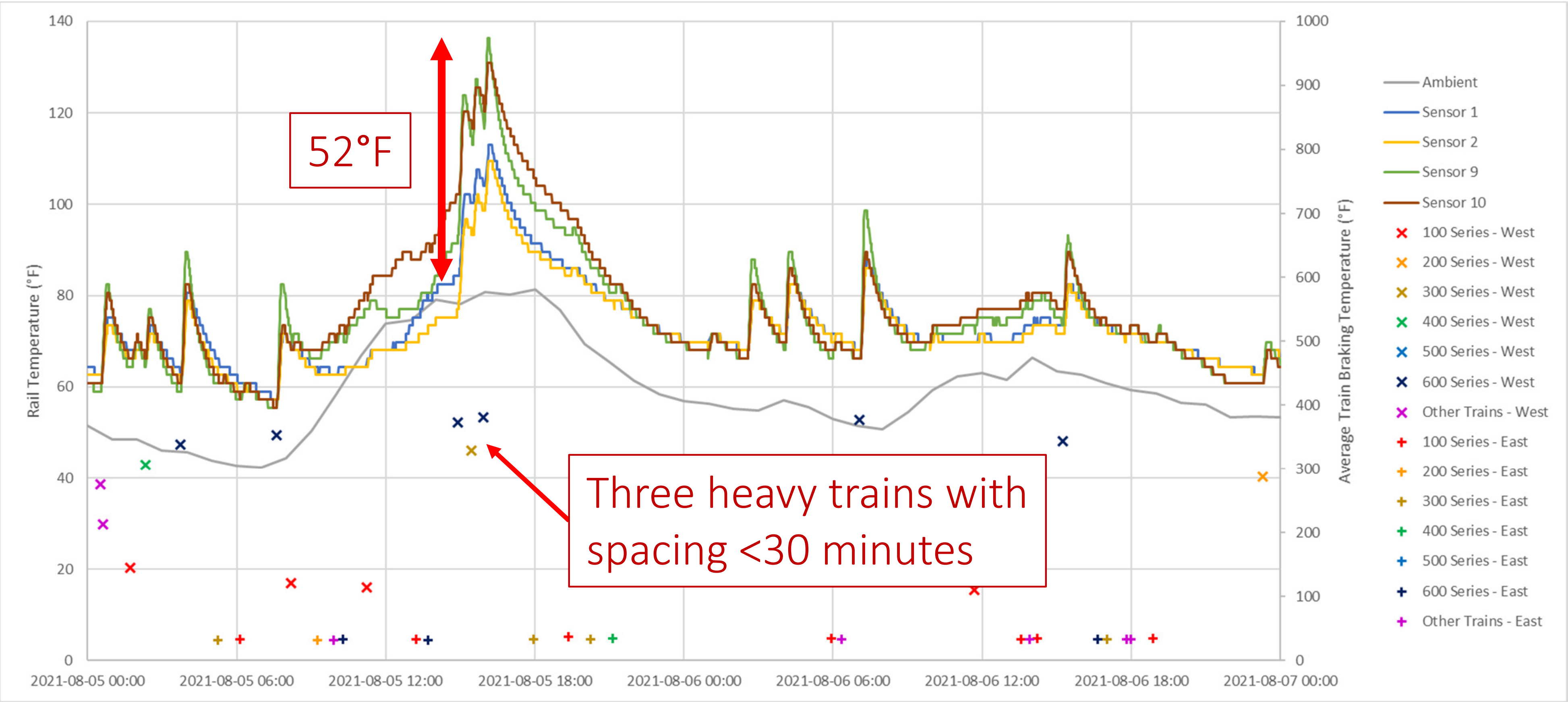


Study Results

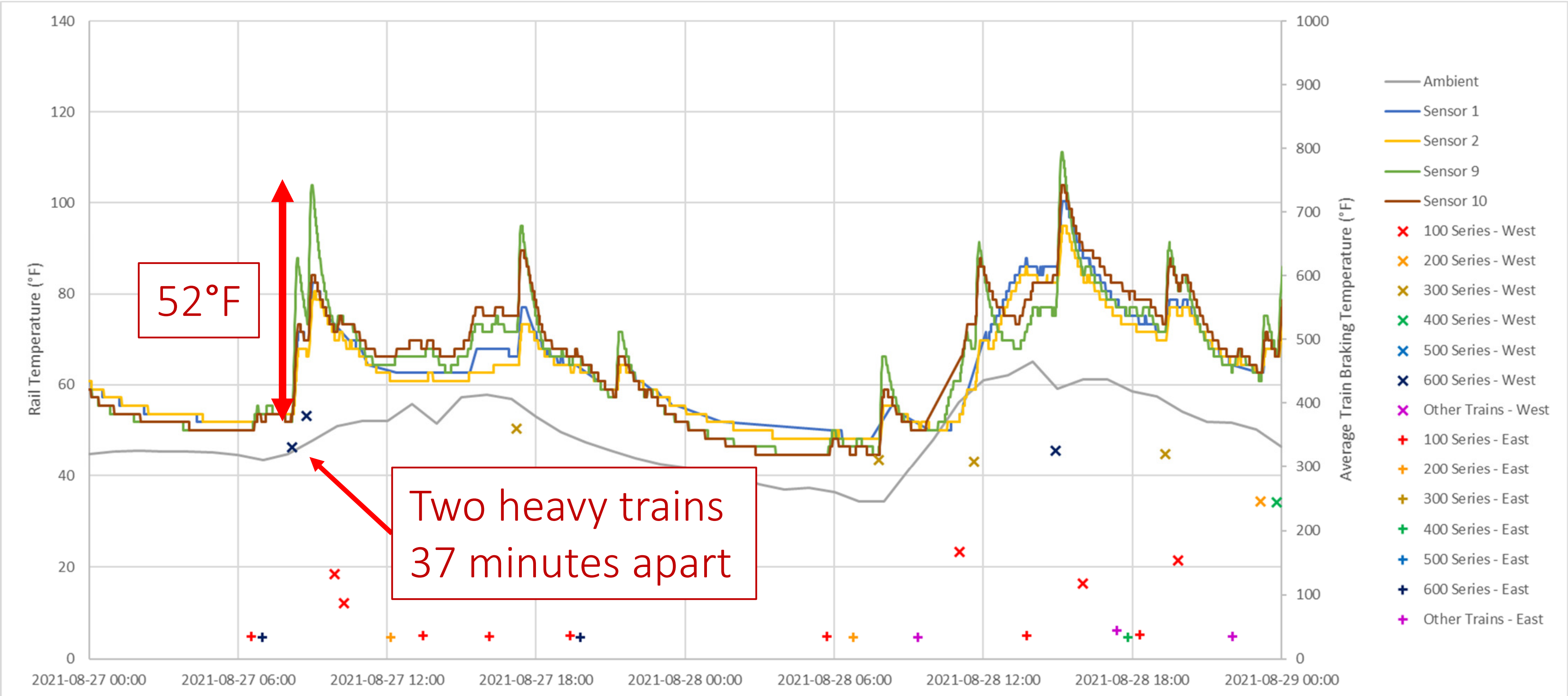
- Sunlight amplifies the effects of ambient heat



Back-to-back Trains: Example #1

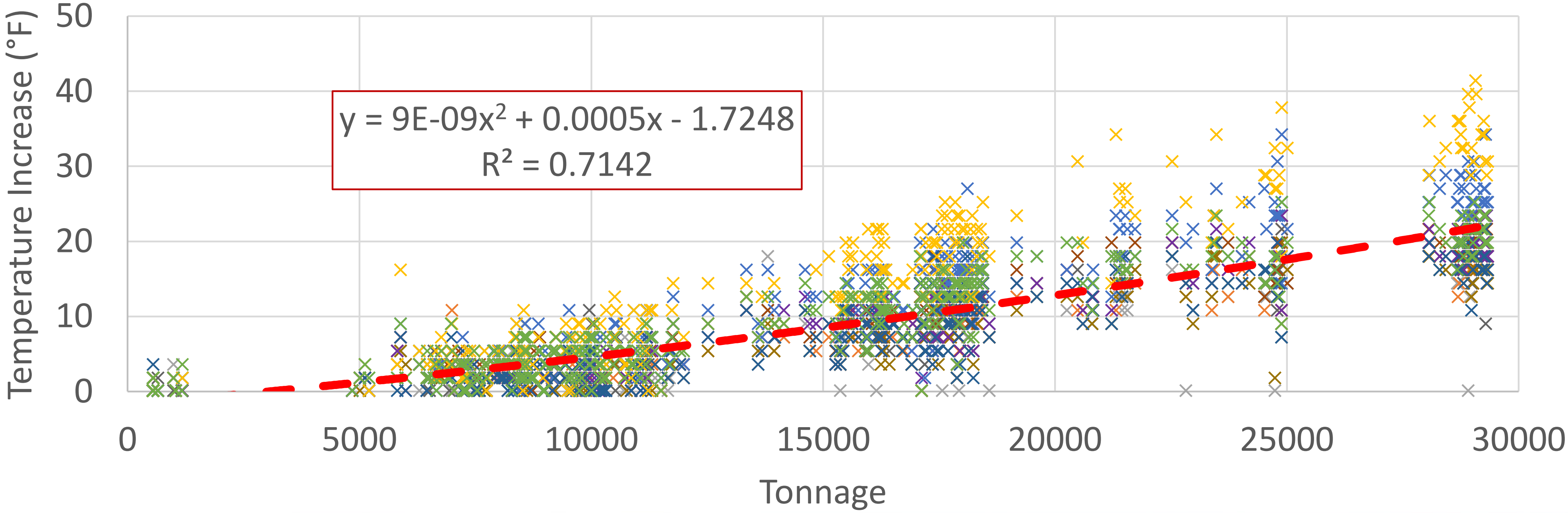


Back-to-back Trains: Example #2



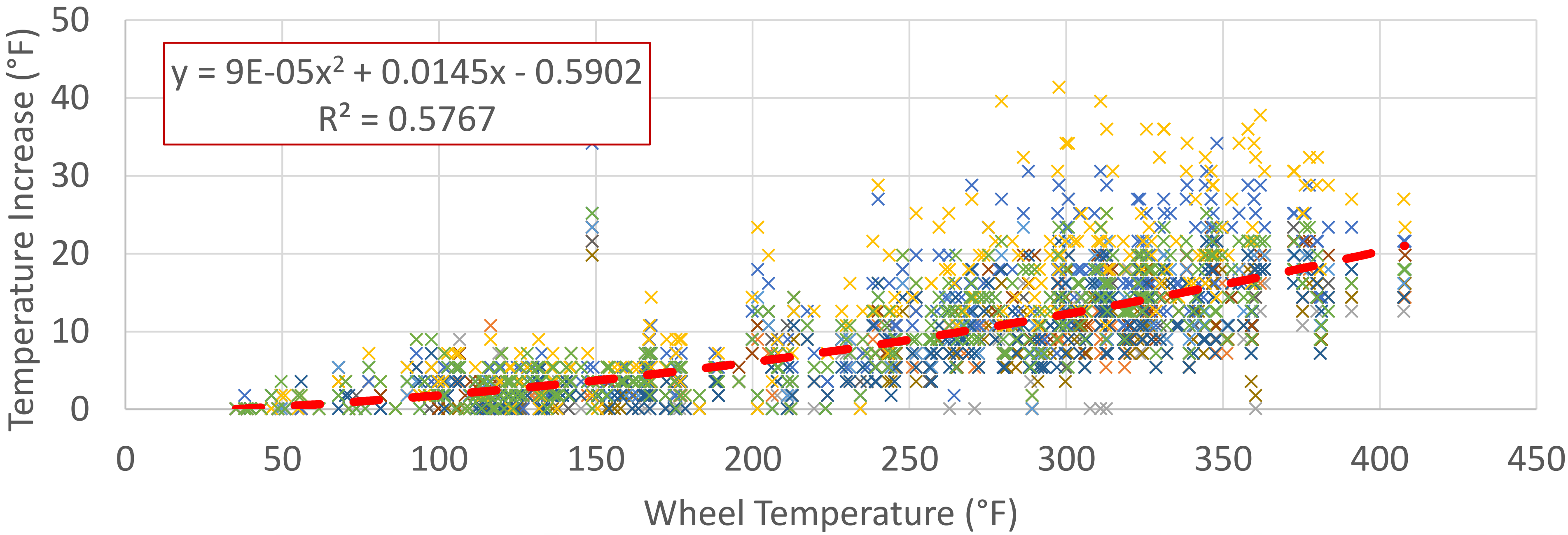
Trends: Train Temperature vs Tonnage

- Heat transfer to the rail increases with tonnage
- Stronger correlation than wheel temperature



Trends: Wheel Temperature vs Tonnage

- Heat transfer to the rail increases with wheel temperature
- Weaker correlation than against tonnage



Measured Temperature Increases

- Highest recorded rail temperature: **136.4°F**
  - Ambient Temperature: **81°F**
- Trains above 16500 tons add **10°F** to **20°F**
  - Amplifies in sunlight, up to **30°F**
    - Worst case: **41°F**

Higher magnitudes than expected

Thermal Expansion

- Calculating thermal expansion in unrestrained rail:

$$\Delta L = L\ (inches) \times \Delta T \times e$$

Where ΔL = rail expansion or contraction in inches
L = rail length in inches
ΔT = temperature differential in °F
and e = coefficient of rail thermal expansion

Heat Added from Braking		Rail Expansion Inches per Mile
5.55°C	10°F	4.1
11.11°C	20°F	8.2
16.67°C	30°F	12.3
22.22°C	40°F	16.3

- Need to restrain up to 16 inches of expansion in a mile from train heat alone

More Key Results

- Back-to-back heavy trains (within 30 minutes) added typically **40°F**
  - Worst cumulative increase was **52°F**

- Majority of the transient heat is dissipated within 1 to 3 hours

- No significant heating effects from:
  - Ascending trains
  - Lower tonnage trains

Heavier, descending trains brake more and add more heat.

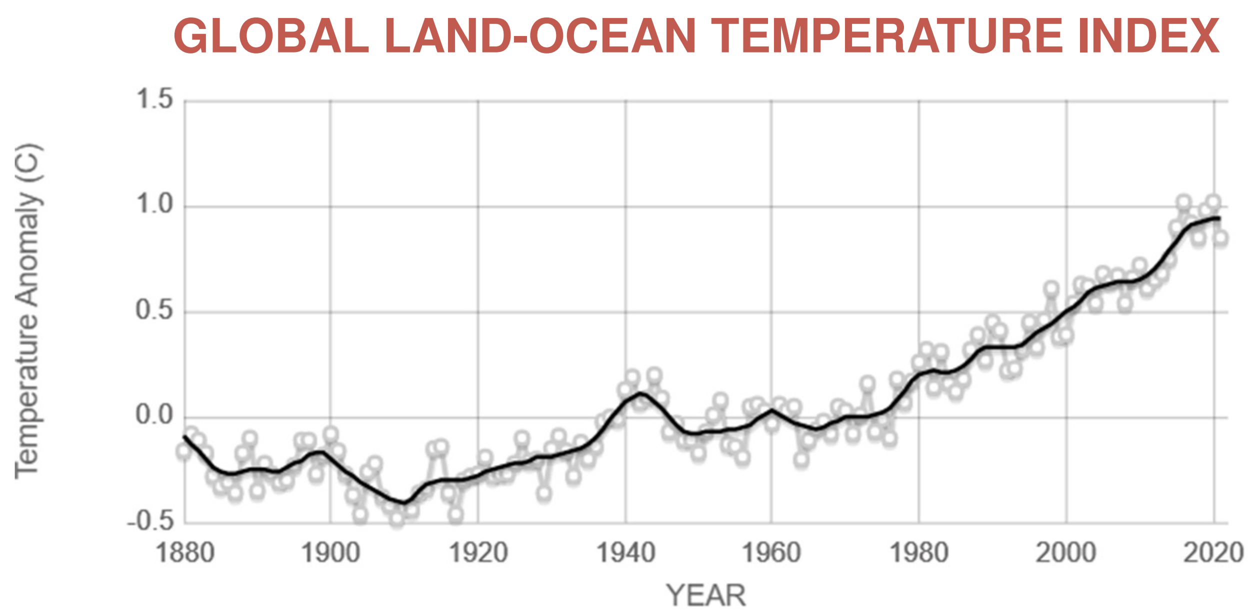
Risk of Cumulative Heat

- Rail Temperature Example:

98°F 36.7°C Ambient Temperature	+	30°F 16.7°C Estimated Sunlight Effects	+	40°F 22.2°C Estimated Back-to-Back Heavy Trains	=	168°F 75.6°C Cumulative Heat Total
Recorded Temperature		Recorded Rail Temperature 127°F				**Increased track buckling risk**

An Ongoing Risk

- Major factors leading to increased rail temperature:
  - Rising global temperatures
  - Increasing train tonnage
  - Heavy grades



Source: climate.nasa.gov

Generating Solutions

- Increase track resistance to track buckling → Improve track infrastructure
- Increase the rail neutral temperature → Lay the rail at higher temperatures

  - Costly and Network-wide Changes
  - Time-consuming

- Need a short-term solution:
  - **How can we mitigate this risk using existing infrastructure?**

Further Solution Development

- Proposed Solution:
  - Utilize existing HBD coverage as a network to monitor ambient temperature and trains

- Target Key Conditions:
  - Heavy grades
  - High ambient temperature
  - Heavy trains back-to-back

Future Considerations

- Optimization of alert algorithms
- Improvements with tracking trains
- Improvements to wayside detectors
- Track improvements to resist forces

End

Questions?