Track Maintenance for High Speed Rail

Railroad Infrastructure Diagnosis and Prognosis

David E. Staplin, PE

University of Nevada Las Vegas, October 17, 2018

RAIL TEAM

HNTB

Track Maintenance for High Speed Rail – Perspective

- Currently, by international standards, there is no HSR in North America
- There is a large body of experience in higher speed rail
  - Amtrak NEC, speeds up to 150 MPH
  - Porter, IN to Detroit, MI, speeds up to 110 MPH
  - Poughkeepsie, NY to Hoffmans, NY, speeds up to 110 MPH
  - Joliet, IL to East St. Louis, IL, speeds up to 110 MPH
- Even though North America is not quite there yet, the lessons from around the world are clear
  - Technology is transferable
  - Will require North American railway engineers to think differently
- Focus here is on true high speed (300 KPH or higher)

What is a Good Approach to High Speed Track Maintenance?

- Starts with good construction standards focused on
  - High quality track structure, **UNIFORMLY** supported
  - Track quality is also married to systems
- Performance based safety and maintenance standards
  - Safety is job one, ride comfort is job two
  - Track and vehicle perform dynamically as a system
- Inspection and maintenance based on data
  - Requires automated inspection backed by data analysis
  - Maintenance plans based on proactive repair
  - Dedicated maintenance windows
- Good work methods

A Look at Performance Based Standards

- What about FRA 213 Subpart G?
  - FRA standards are prescriptive, based on high probability of derailment
  - Can't afford to operate HSR at rejection limits
    - Speed restrictions kill schedules and service reliability
    - Does not give repair crews time to properly plan and execute work
    - Ride quality probably impacted before rejection limits reached
  - Multiple small defects (within limits) can cause problems
    - Combination defects
    - Small defects that lead to harmonic behavior of vehicles, discomfort
- Vehicles may not tolerate some deviations in lower track classes governed by 213 Subparts A thru F

A Look at Performance Based Standards

- Where do we start?
  - With a known vehicle
    - Suspension type, characteristics must be a known, also car body parameters
    - Existing vehicle should have a dynamics “model” already developed
  - If the vehicle is entirely new, a dynamics model must be developed
    - Can estimate parameters initially
    - Must verify with prototype when built and tested
- Once rolling stock models are available, they can be tested
  - On existing track based on data from geometry cars and other sources
  - Deviations can be identified that excite the vehicle
    - FRA has limits on wheel/rail interactive forces (L/V, NAL, etc.)
    - Those passing FRA but violating ride comfort criteria

A Look at Performance Based Standards

- At the end of the day, good riding comfort will be obtained when:
  - Geometry deviations are identified that excite the vehicle
    - Single deviations
    - Multiple deviations of the same type
    - Combination deviations
  - Wheel/Rail interaction is controlled
    - Poor contact geometry can trigger hunting or high interactive forces
    - Efficient conformality between wheel and rail can be:
      - Modeled
      - Tested with prototype
- When the vehicle/track forces are under control, the track maintenance work load will be minimized

A Look at Performance Based Standards

- The standards particular to an HSR system should include limits based on:
  - Action required by regulator (FRA)
  - Action required by internal standards, especially where ride quality is conpromised
  - Getting out and doing planned renewals/repairs economically before the first two bullets kick in

Inspection and Maintenance Based on Data

- Be prepared for big data
  - Multiple inspection systems tied together generate huge amounts of data
  - Trending based on advanced statistical tools requires large amounts….
    - Bayesian methods
    - Neural networks
    - Be able to handle small probability occurrences
- With autonomous sensors, can inspect real time in revenue service
- Inspection trains perform many types of inspection at revenue speed
- Those functions inspecting at speeds slower than revenue must fit into scheduled maintenance windows

Inspection and Maintenance Based on Data

- Inspection frequency should be based on what the data shows:
  - Degradation rates, statistically derived
    - Based on probability envelopes, not simple mean trend lines
    - Typically data exhibits saw-toothed tendencies
  - Minimum intervals that guard against small probability events
- Communications systems go hand in hand with real time inspection
- Inspection can be accomplished by identifying exceptions to normal
  - VTI accelerometer reading that does not match normal results
  - Helps cover unanticipated failure modes

Inspection and Maintenance Based on Data

- Technology supporting inspection is good and will only get better
- Work still needed to make systems cross talk (software protocol)
- Examples:
  - Drones with cameras for external roadbed integrity
  - GPS antennae for location
  - LIDAR for location and shape (i.e. ballast section)
  - GRMS for lateral track strength
  - Line scan cameras for tie and fastener integrity
  - Accelerometers for measuring Vehicle Track Interaction (VTI)
  - GPR for internal roadbed integrity, ballast condition
  - Non-stop testing for internal rail flaws
  - Rail surface analyzers

Maintenance Plans Based on Proactive Repairs

- Fix it before it breaks
  - Less disruption, less service impact
  - Less costly to do planned repairs then running around fixing broken things
  - Trend degradation from big data streams, combine with probability models
- When something does fail in-service, chase the root cause to ground
  - Check against degradation trend models
    - Outlier?
    - Model need updating?
  - Was there a clue of impending failure from a secondary inspection source?
- Requires analyses of many possible failure modes

Maintenance Plans Based on Proactive Repairs

- Renewal versus repair
  - In a complex asset (i.e. turnout) consider workload likely in the future and how many outages/mobilizations would be required to repair components one at a time rather than replace the whole turnout
    - Outages may impact customers
    - Mobilizations impact labor costs
  - Renewals are preferred when repairs might jeopardize ride quality
    - Sometimes repair quality in the field is difficult to obtain
    - If possible, repair materials should be specifically designed to fit in a worn situation

Maintenance Plans Based on Proactive Repairs

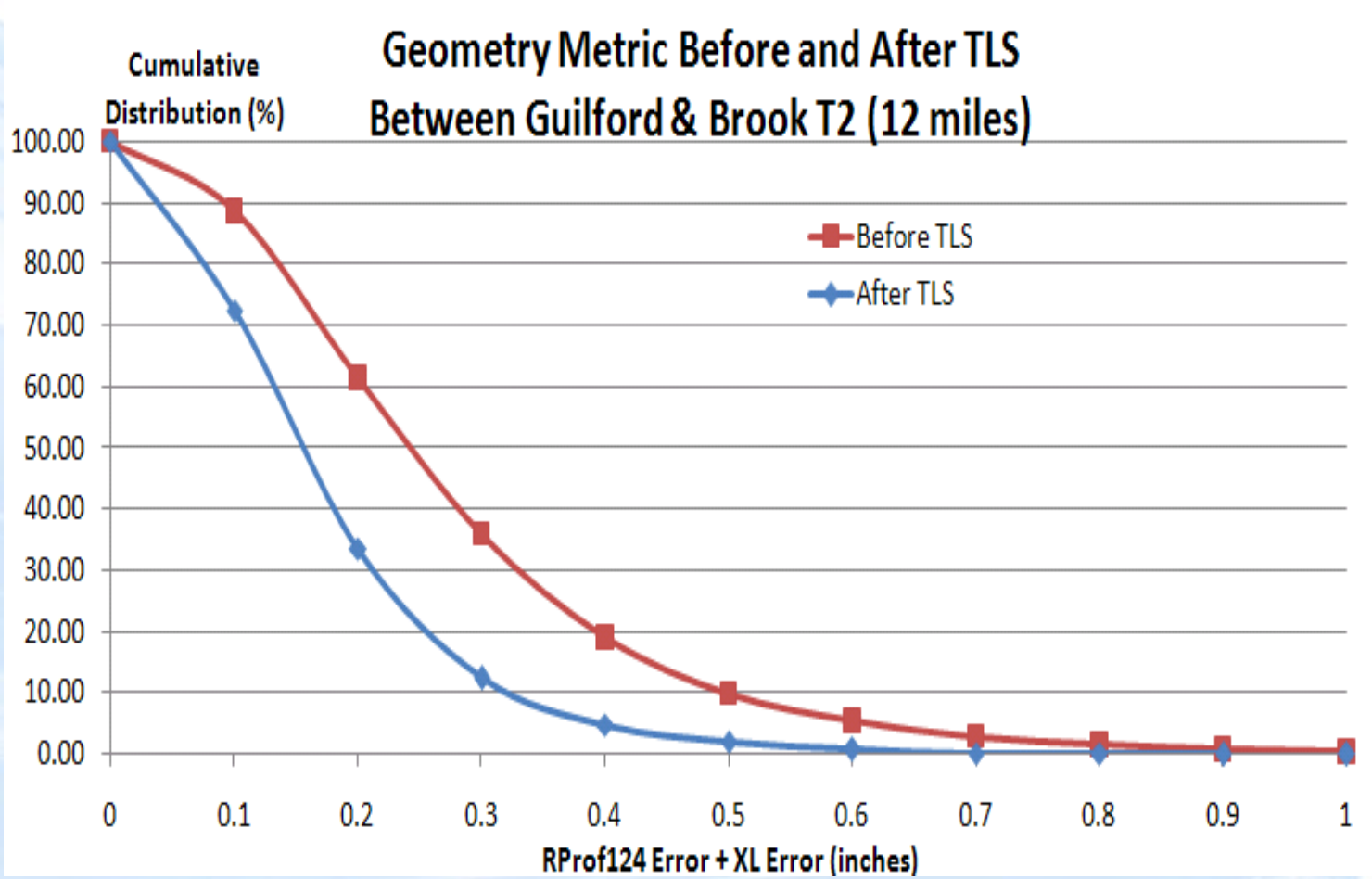
- Focus Areas
  - Safety/Reliability
  - Ride Comfort
  - Forecasting asset replacement
- Examples
  - Integrity of track structure
  - Geometry
  - Rail surface and profile
  - Track support
    - Subgrade
    - Ballast condition

Good Work Methods - Examples

- All track, particularly when ballasted, must be referenced
  - Referenced means a system that enables staff to know where each foot (meter) is in space (x,y,z) with a high level of accuracy
    - For design
    - Where it is currently
  - Tampers capable of working with references can put track back on design
  - With only internal chords as reference, the tamper will only be able to smooth with the following long-term impacts:
    - Curves points will drift, possibly with mismatched superelevation
    - Curves will drift from uniform to variable radii
    - Tangents will develop multiple bearings
- Referencing track is becoming less expensive as technology improves

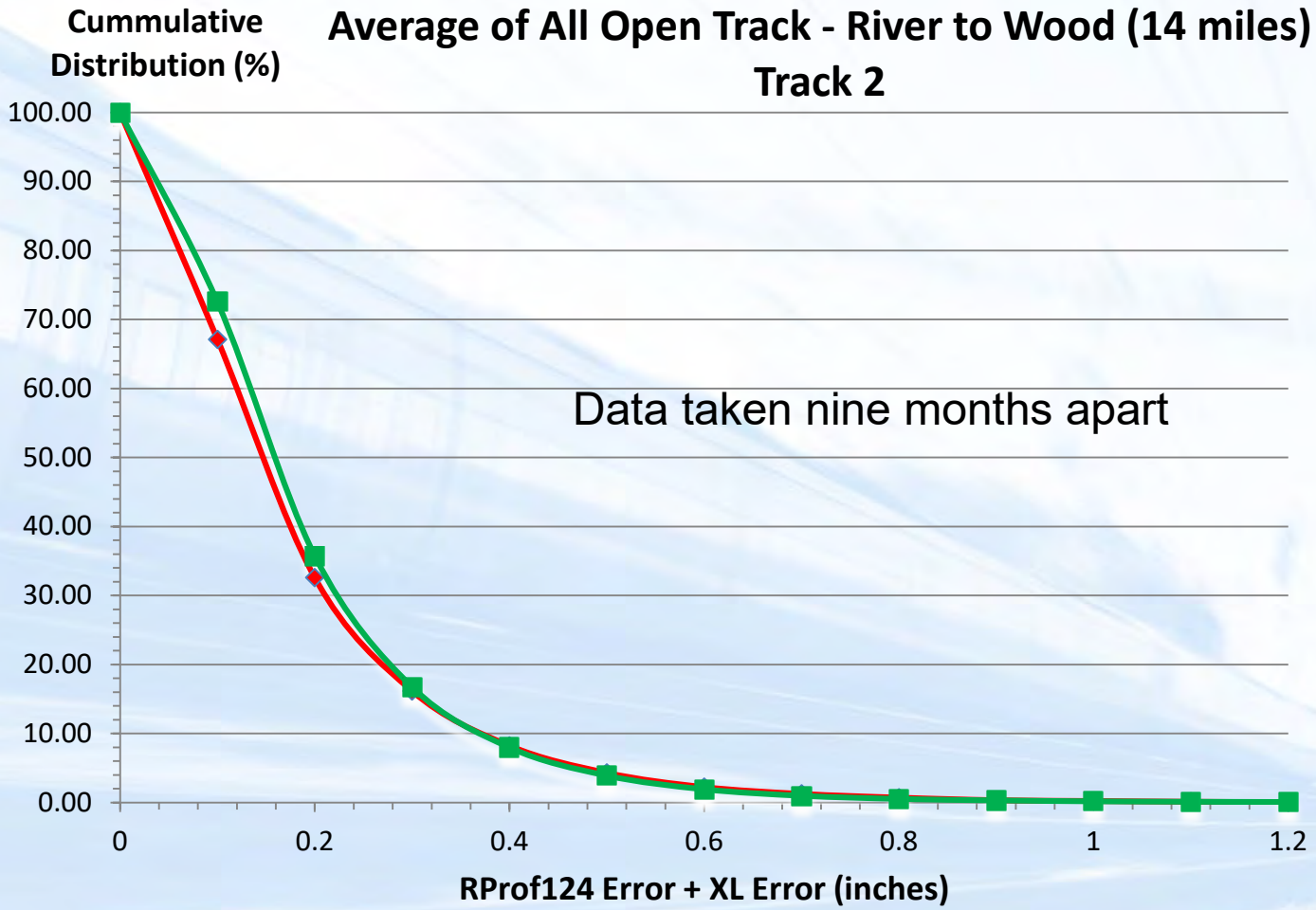
Good Work Methods - Examples

- Measure track quality before work
- Measure track quality after work as well
- Notice in the example that there are still significant errors at the 10nth percentile level after work
- Why?
- Study and fix process!



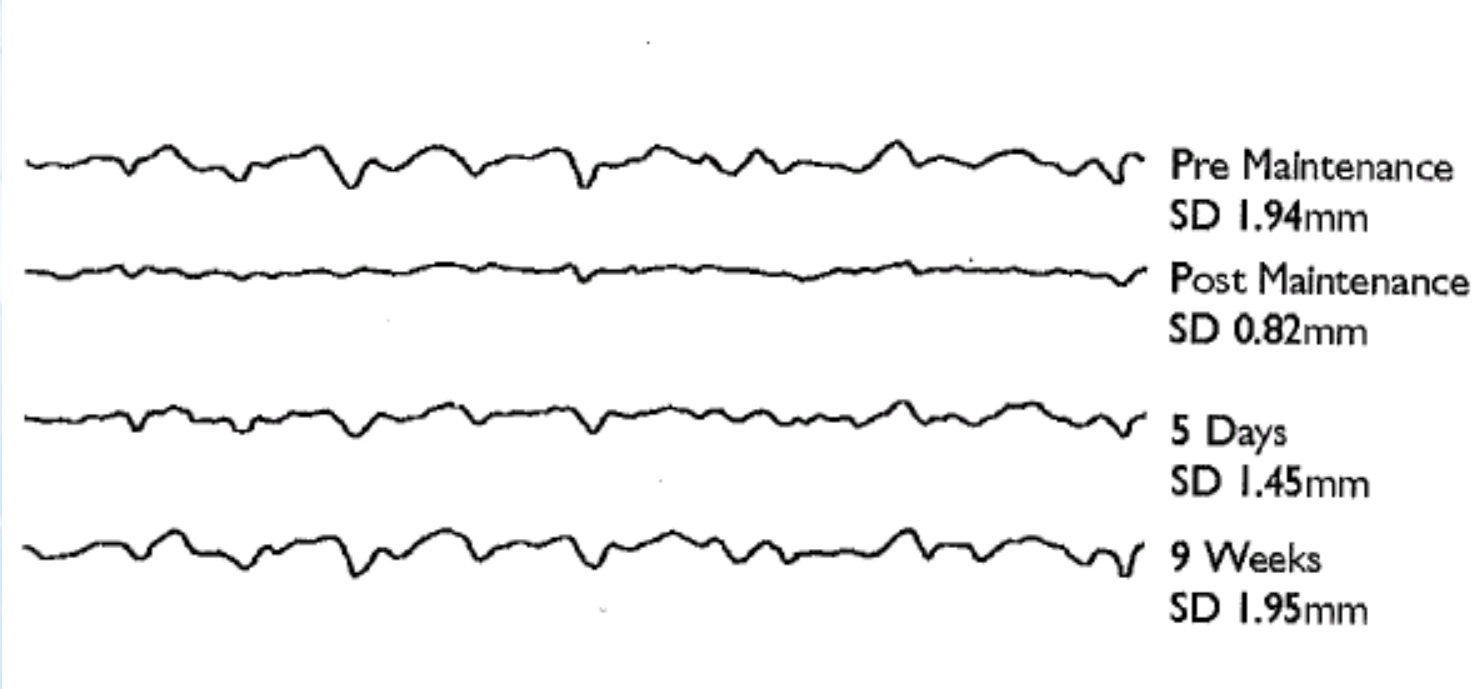
Good Work Methods - Examples

- "After" measurement for surfacing shows almost no improvement
- How can that be?
- Problems with US equipment, methods?



Good Work Methods - Examples

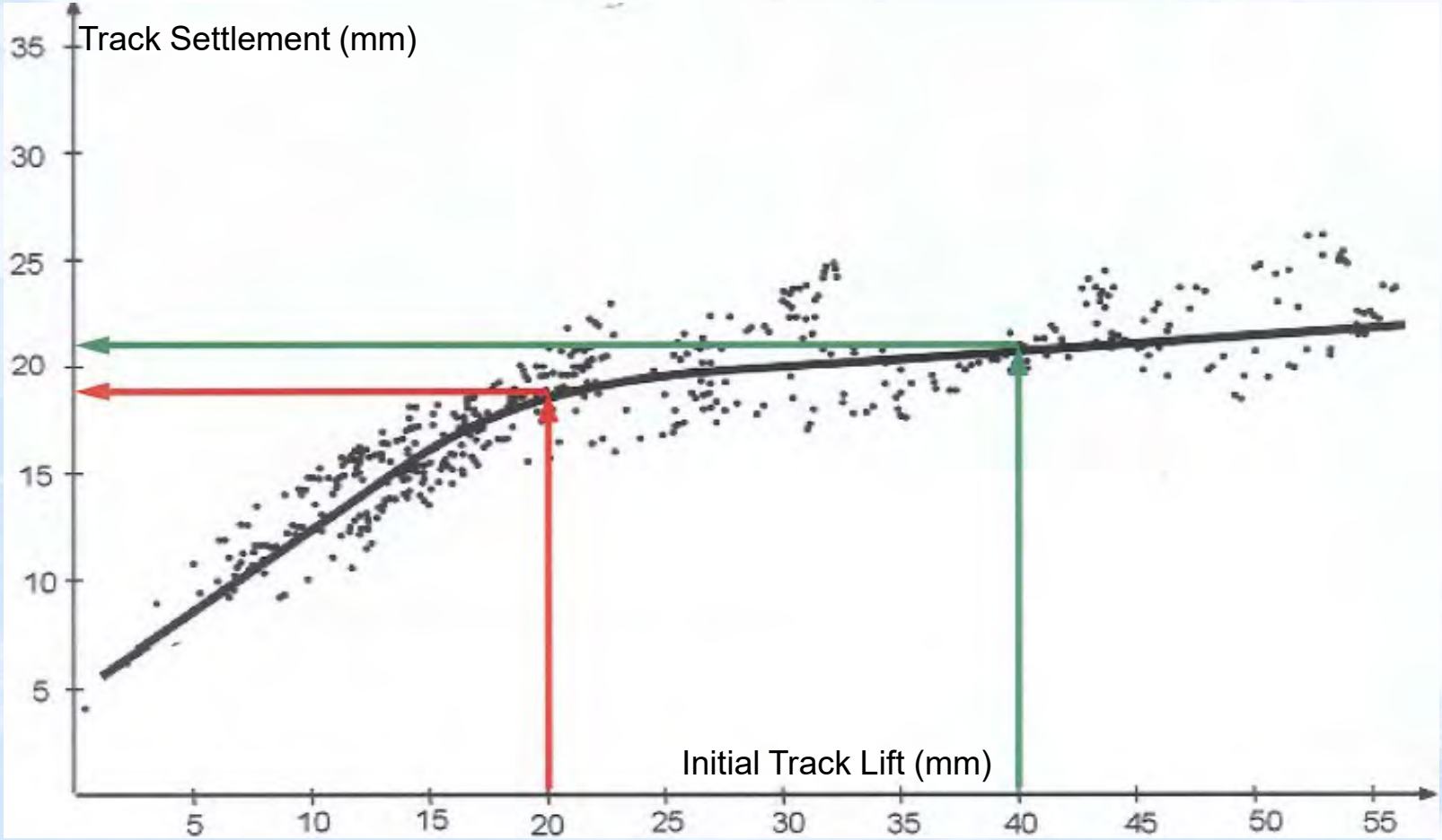
- Turns out to be a problem worldwide as this data from Europe shows
- Track returns to its former shape quickly after surfacing
- Why?



Courtesy Steven Chrismer, PhD

Good Work Methods - Examples

- Track raises less than 20mm are not durable
- Track has to be “over lifted” to achieve desired results
- Making surface corrections without over lifting results in short return tamping cycles
- Short tamping cycles destroys ballast…
- Ballast renewal is dis-ruptive and expensive



Courtesy Steven Chrismer, PhD

Summary – Keys to Good High Speed Track

- Good construction standards
- Performance based safety and maintenance standards
- Data driven inspection and maintenance
- Good work methods

THANKS FOR YOUR ATTENTION!