Rail Milling in North America — A First Look

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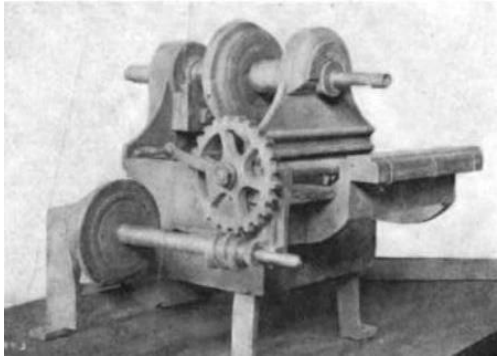
Contributions by Toronto Transit Commission

Content

- Rail milling refresher
- TTC subway requirements
- TTC Milling Program
- Looking back and ahead

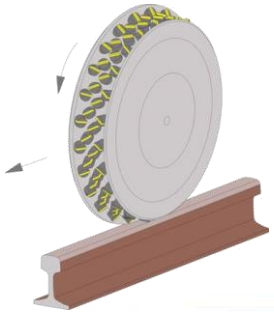
Rail Milling Technology

- Milling of work pieces since 19th century
- Non - abrasive rotary cutting process
  - Chips cut out of surface
  - Heat transfer into chips and tool
- High precision CNC machine upside-down on a locomotive
- Challenge: moving work piece & moving machine



Milling Machine, 1818, wikipedia

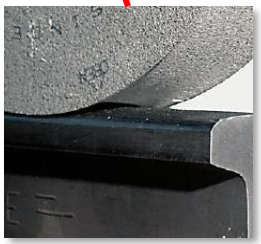
Rail Milling Machine SF02, 2016, LINMAG



Milling Process

Initial rail condition (damaged, worn)

Milling tool



Polishing tool

Metal chips

Quality control

Finished rail condition (quality and precision)

Milling Technology Analysis

Strengths

- Full Profile restoration
- Complete damage removal
- Low / high 1-pass metal removal
- High surface quality
- Spark and dust free process
- Environmental friendly / no waste on track
- No heat input to rail material

Weaknesses / Opportunities

- Profile flexibility – one milling tool for one profile

  BUT

  - **Profile quality and accuracy**

- Milling speed

  BUT

  - **One pass**
  - **High ft/h of finished track**

Toronto Transit Commission

- Operator of bus, subway, streetcar, and paratransit services in Toronto
- Subway: 4 lines with total of 77km / 48mi.
- 75 Stations / 878 cars
- Annual ridership: 416 mio in 2018

TTC: Motivation for Milling

- Assessing Milling Technology for several years
- Areas that have not been ground or could not be corrected by grinding
- Main Problems: corrugation, RCF and profile degradation
- Spark and dust free technology
  - No delays due to potential fires after grinding

Timeline

- First North American Milling Tender published in late 2017
- Award of milling contract to Rhomberg Sersa in mid 2018
- Arrival of milling machine in November 2018
- First milling shift by mid December 2018

Machine selection

- Capacity for extended weekend milling shifts
  - Chip storage, fuel tank and milling spare parts
- SF02T-FS rail bound machine in production
- Leased SF02 Truck from Linsinger

Technical Specification SF02W-FS Truck

- Flexible deployable milling machine for transit and main line application
- Key characteristics
  - 0.1 – 1.0mm (0.004 – 0.04 in) metal removal in one pass
  - Average milling speed: 400-420 m/h (1312 – 1378 ft/h) dependent on track/rail conditions
  - Travel speed up to 45km/h – 29 MPH
  - Can process level crossings and switches

Requirement: Re-Railing

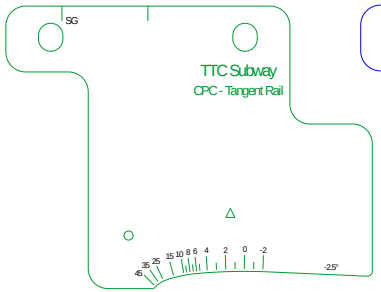
- Re-railing and towing capability required by TTC
- Re-railing: Combination of hydraulic cylinders and sliding plates
- Put a de-railed machine back on rails in a tunnel

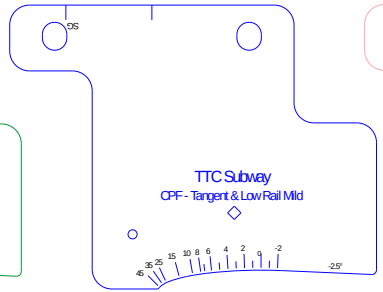
Machine adaptions

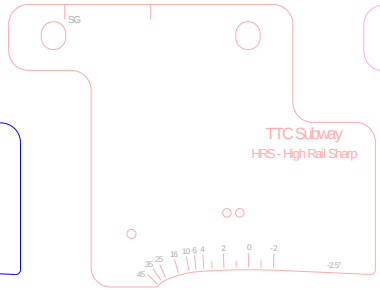
- Truck with street wheels too wide for clearance profile
  - Third rail
- Some side covers had to be removed
- Lighting according to TTC requirements

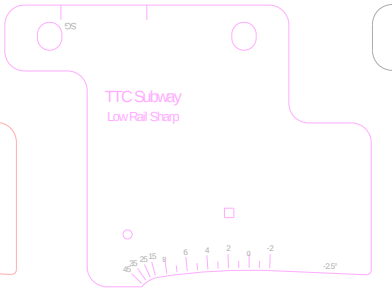
Template Selection

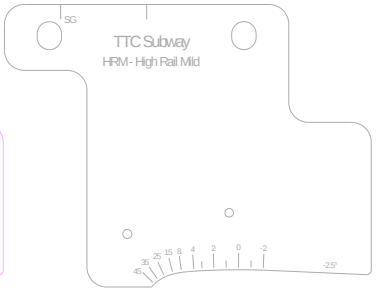
- TTC: 5 different templates
- Reduced to 2 templates by NRC for milling year one: CPC and CPF
  - CPC/CPF: tangent, CPC: hi rail, CPF: low rail
- How many templates can be effectively controlled and maintained in a transit environment?





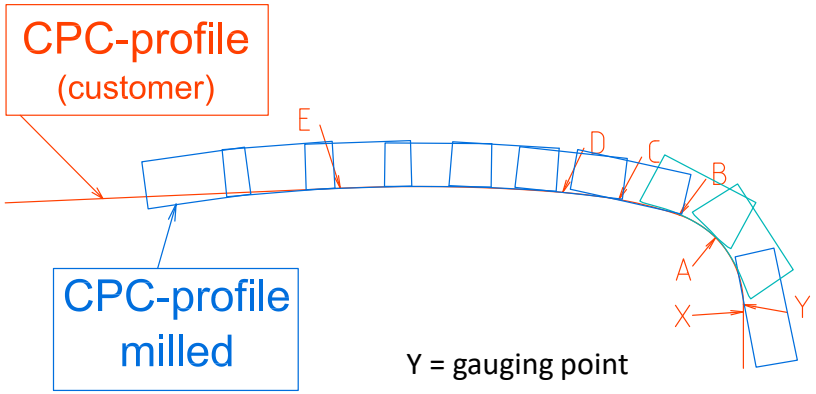


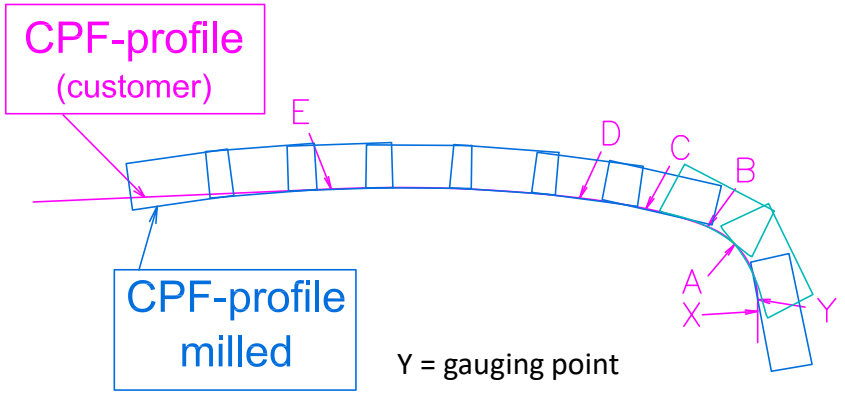




Milling Tool and Template

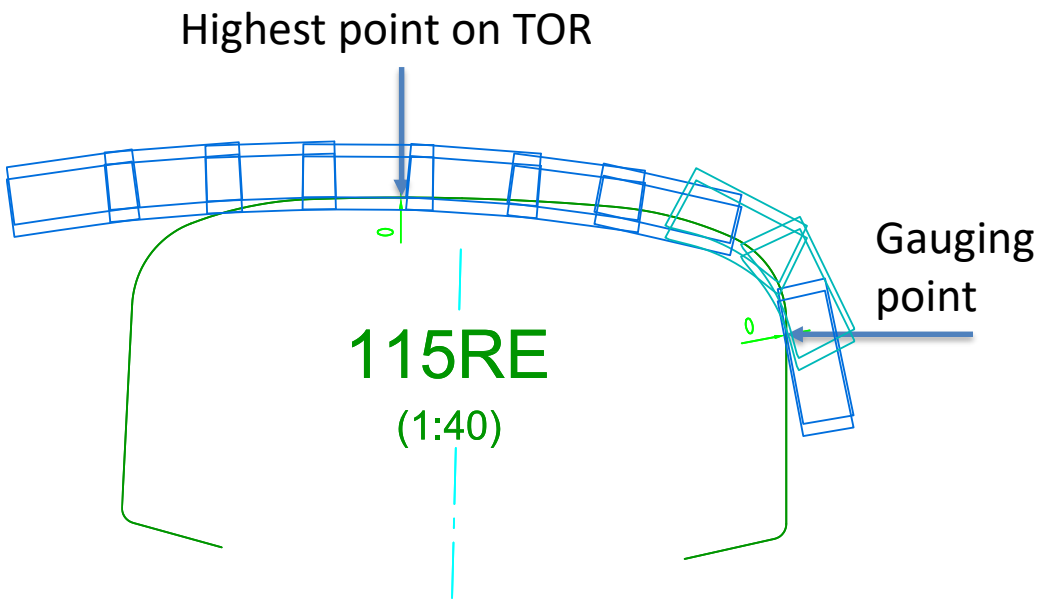
- Closest conformity between cutter head and profile template





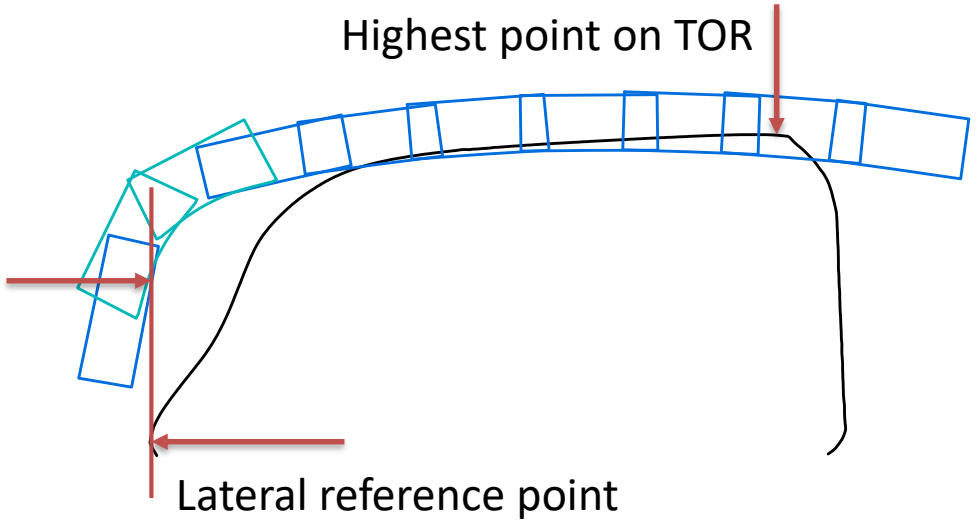
Cutter Head Alignment

- Determine (by sensor):
  - highest point on TOR
  - gauging point
- Align profile in reference to these points
- Cutting depth in reference to highest point on TOR



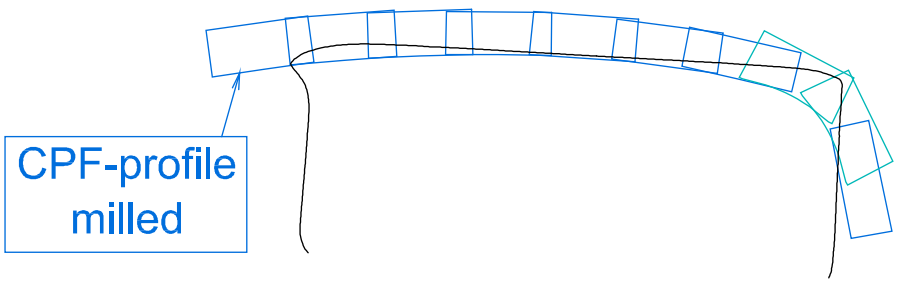
Cutter Head Alignment - Wear

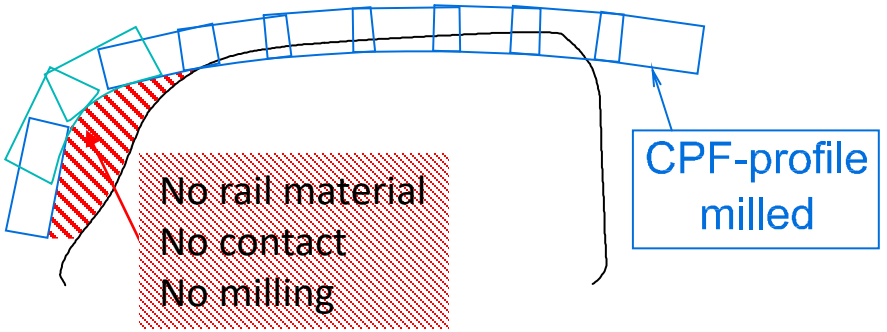
- Severely worn rail
  - GF lip
- Alignment:
  - Cutting depth
  - GF lip
- Prevent
  - damage of cutter head
  - gauge widening



Profile correction

- High wear condition
- No rail – no cutting





Exemplary cuts

Milling Program Development

- Optical rail measurement data
- US measurement data
- Eddy Current data
- Other damage data
- Data about prev. maintenance
- Network data/configuration
- Customer requirements

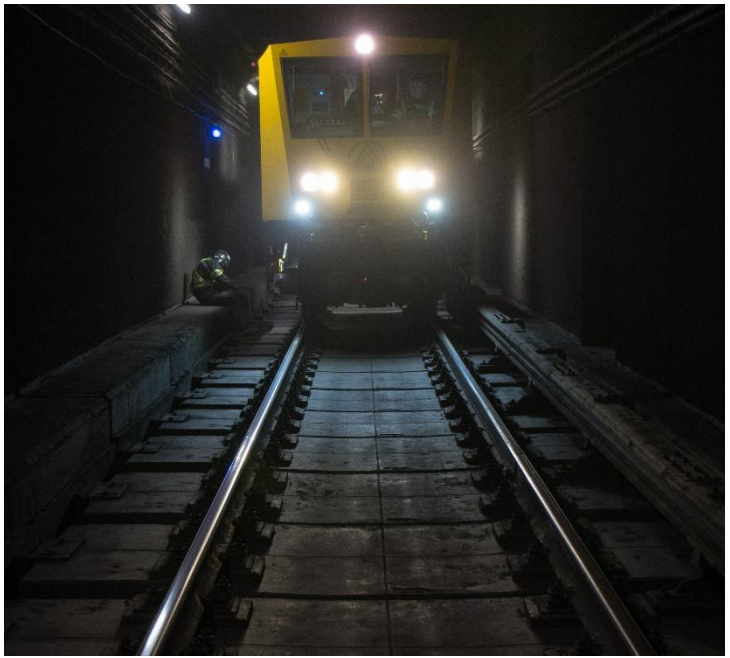
- Determine locations to be milled / not to be milled

- Milling locations:
  - Rail templates
  - Metal removal
  - No. of passes

Milling Program

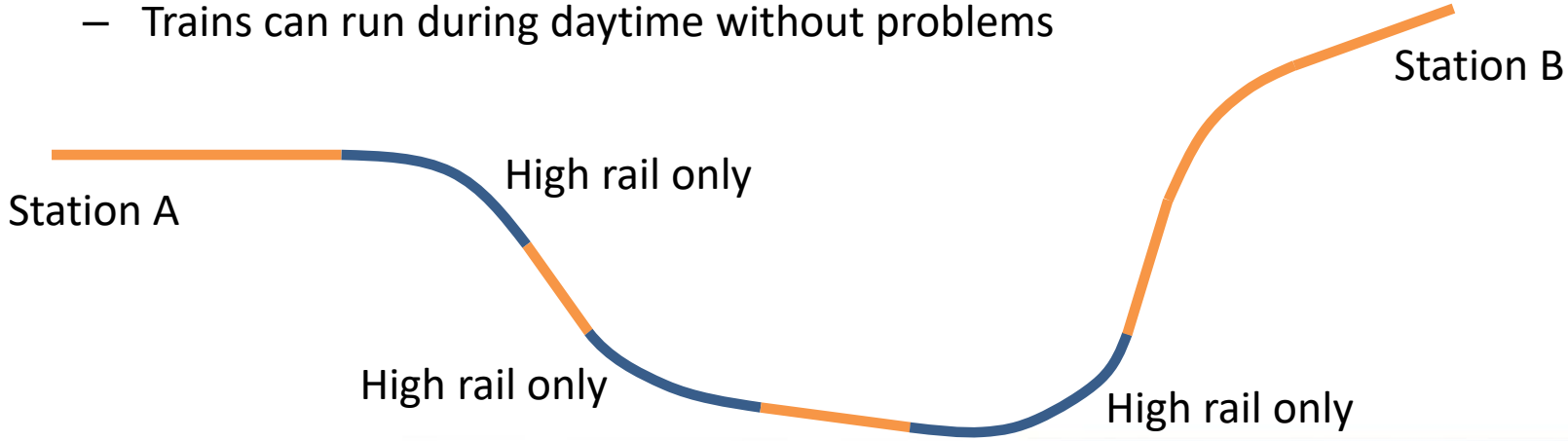
Milling Program at TTC

- Focus: profile degradation
- Milling from station A to B
- CPC and CPF profile
- One pass operation
- Metal removal on TOR:
  - 0.8 mm / 0.031 in
- Weekly planning of program



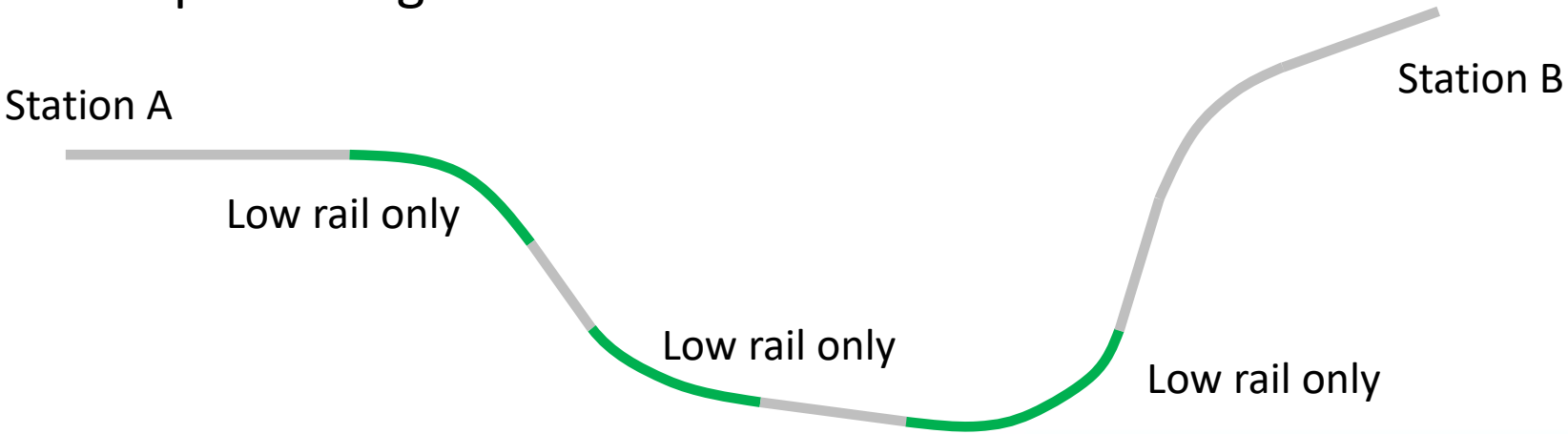
Milling Program Execution

- First run: use only one profile (e.g. CPC)
- Milling through whole segment from A to B
- Focus: Restore profile
  - One pass operation even if profile was not 100% restored
  - Trains can run during daytime without problems



Milling Program Execution

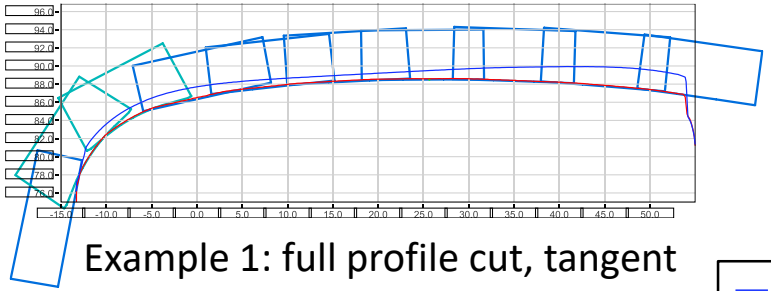
- Second run: apply the remaining target profile in curves
  - Skip the tangent sections in between



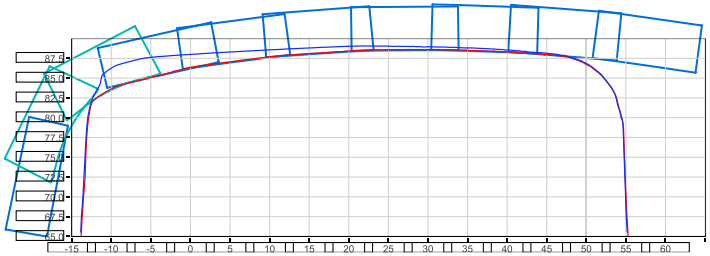
Profile Measurement Device

- Hand measurements at TTC
  - Truck was not equipped with on-board technology
- RailMonitor laser device
  - Accuracy 0.05mm / 0.002in
- Measure before/after milling at selected locations
- SF02T – fully automated on board pre-post profile measurement

Profile examples

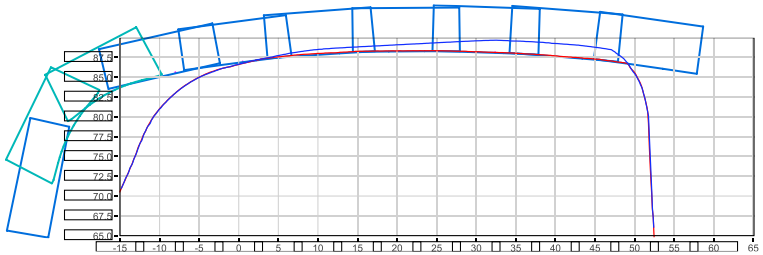


Example 1: full profile cut, tangent

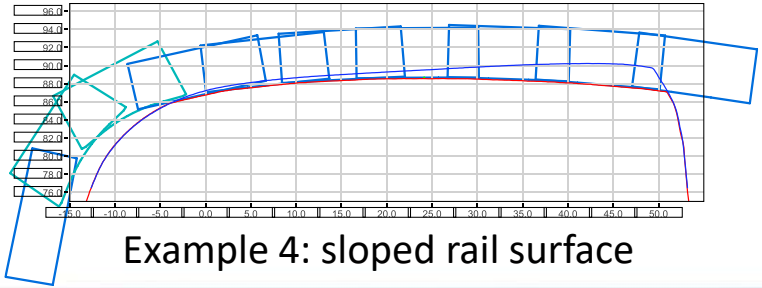


Example 2: flat rail cut, tangent

Pre-measurement
Post-measurement

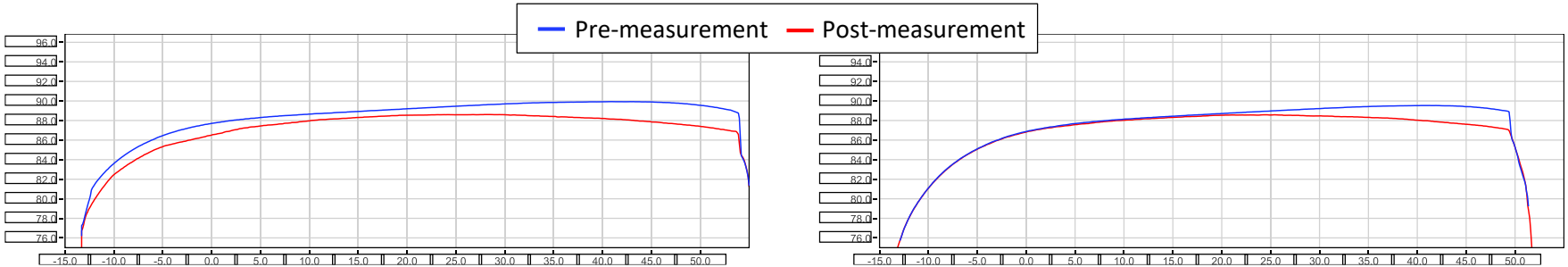


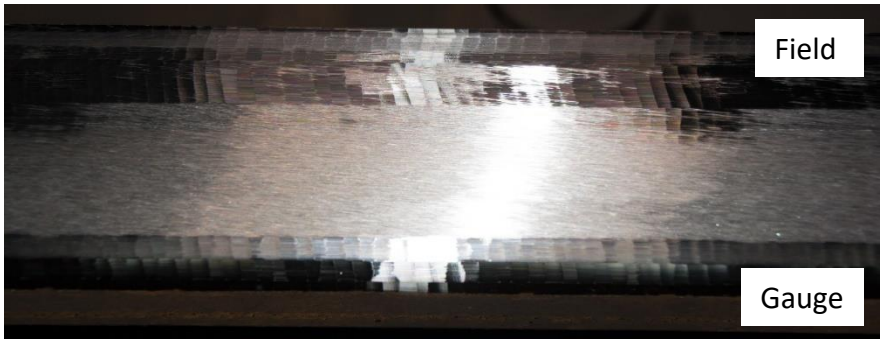
Example 3: high wear situation



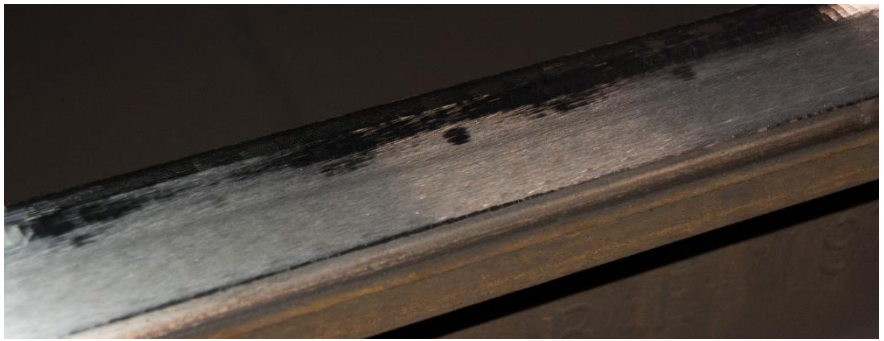
Example 4: sloped rail surface

Profile cut and surface finish





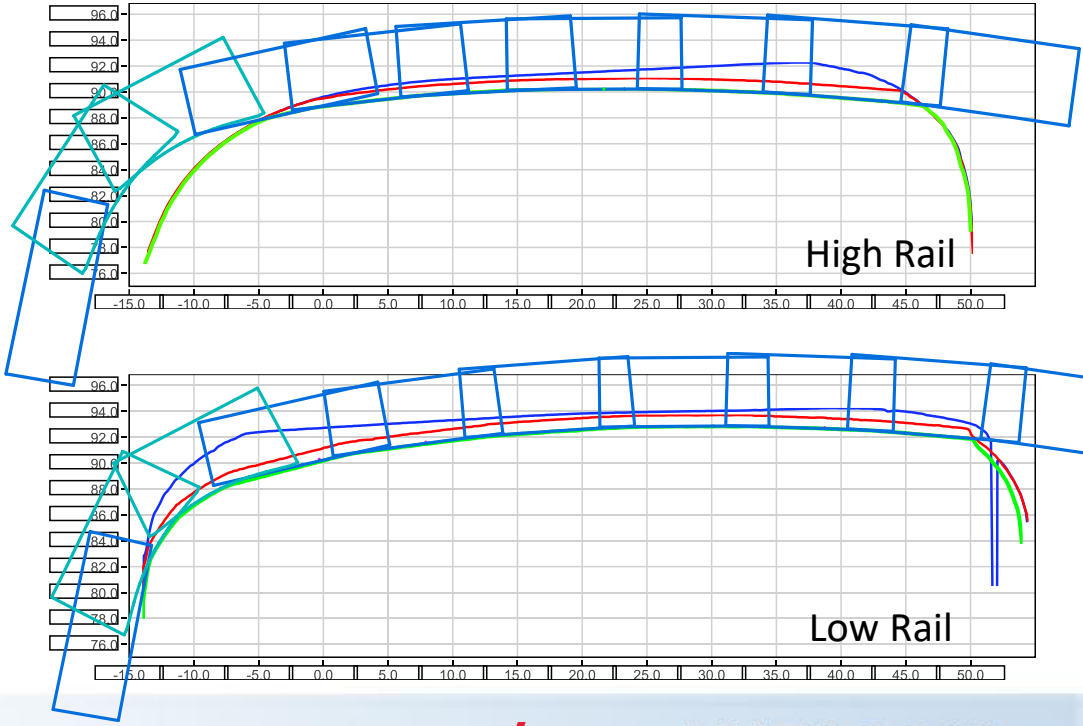
Full profile cut



Partial profile cut

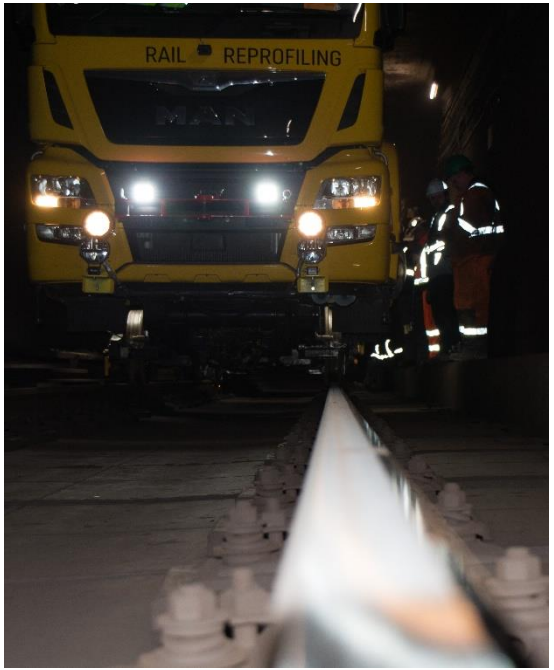
Two pass milling

- Pass 1: profile corrections
- Pass 2: removal of remaining damage
- Second milling pass during next night shift
- Measurement locations differ about 100 ft.



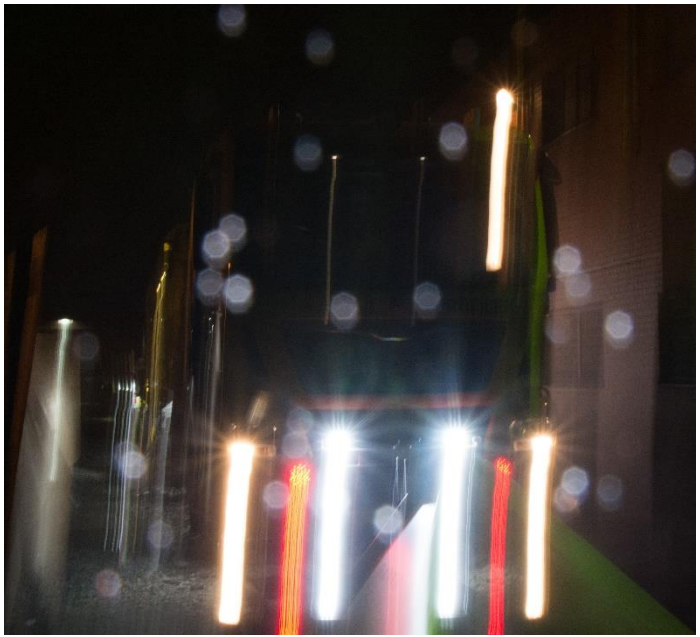
Night Shift

- 22:00 Crew arrival at yard
  - Milling location confirmation
  - Machine preparation and maintenance
- 02:05 leaving yard
- 02:35 arrive at station – wait for power cut
- 03:20 travel to work zone
- 03:30 milling start
  - Three quick location changes
- 04:50 milling stop and return to yard
  - 1602ft milled in 70 min: 1373ft/h



Real Life can be Different

- Delays due to
  - Technical, operational and organisational challenges
  - Cold weather influence
- Exceptionally well-working shifts
- Production rate:
  - 670 ft/h up to 1644 ft/h



Challenges and Solutions

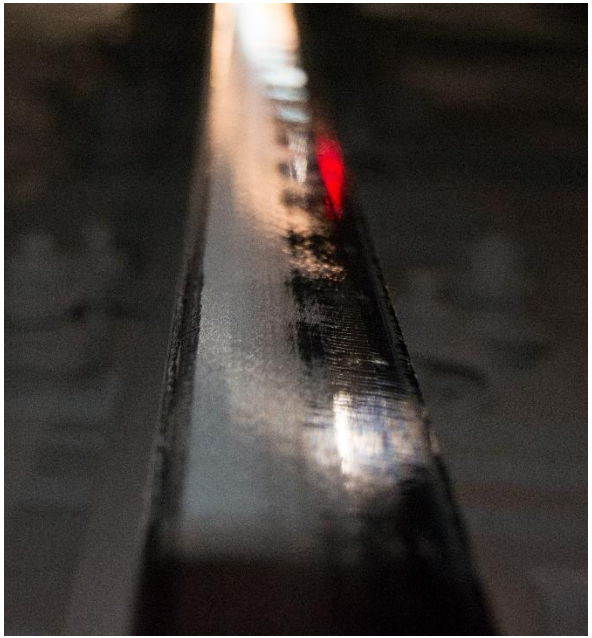
- Milling is **NOT** grinding – fundamentally different technologies
  - Think “milling”
- Uni-directional process
- Deep temperature conditions
- Milling program planning
  - Last minute changes
  - Not just hot spot treatment

The first year

- First milling operation in North America
- 36 shifts finished in year one
  - Worked on Line 1 and Line 2
  - Some shifts lost due to cold weather
- About 17.2km / 11.1mi of track treated
  - Spark and dust free

Next Steps

- Year 2:
  - Program optimisation
  - Damage removal / profile restoration
- Year 3:
  - focus on full system treatment
- SF02T-FS
  - Higher milling capacity
  - Full automated profile, metal removal and damage measurement



Thank you for your attention

RHOMBERG SERSA NORTH AMERICA

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