Benefits of a New Rail Wheel Profile

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Presentation Agenda

- ❑ BART System Overview – Facts, Fleets, Rails
- ❑ Why Choose a Cylindrical Wheel Profile?
- ❑ What's Wrong with a Cylindrical Wheel Profile?
- ❑ Opportunity for Change
- ❑ Evaluation of the Change Opportunity
- ❑ Benefits of the New BT-3 Modified Tapered Profile

BART Overview – System

- Operation began in 1972, 450 Rohr cars
- 110 miles (168 km) mainline
- 46 stations
- Commuter and urban operation
- 430,000 weekday riders
- 3 – 10 car consists
- Full ATC operation
- 80 mph (129 km/h) top speed
- 1000 VDC 3rd rail
- 5.5 ft (1676 mm) wide gauge track
- Full dedicated right-of-way
- 3 miles (4.8 km) dedicated test track

BART Overview – Existing Fleet

- 669 heavy rail cars
  - *Lead Cars – 289*
    - 59 A2 Rohr cars
    - 150 C1 Alsthom cars
    - 80 C2 Morrison Knudsen cars
  - *Mid consist cars – 380*
    - 380 B2 Rohr cars
- 2 door openings per side
- 60 & 56 seats per car
- 615 ft^2 (57 m^2) & 655 ft^2 (61 m^2) interior area
- 70 ft (21.3 m) x 10 ft (3.2 m)
- 63k lb (28.6 t) empty car – super light weight
- 110k lb (49.9 t) max car weight – civil limited

Unique Vehicle Characteristics

- Full lightweight Aluminum carbody structure
- Wide gauge for improved ride and roll stiffness
- Low roof line for compact frontal area
- Lightweight Aluminum wheels for low rotational inertia
- 1k Vdc operation for lower operating currents
- Full regeneration capability for maximum efficiency
- Stringent fire, smoke, toxicity requirements
- Advanced crash energy management design

"Fleet of the Future" – Fleet Replacement

- Contract with Bombardier Transportation, May 30, 2012
- 775 cars, includes 310 "D" cab cars and 465 "E" mid consist cars
- 10 pilot cars currently in non-revenue testing, production cars in 2017
- Transition phase with both fleets in operation – approximately 10 years
- Each car will have 3 doors per side, advanced passenger information system, AC propulsion, robust HVAC, TCMS with advanced diagnostics, etc.
- Performance specification – optimize car without constraint to existing fleet

Existing Rail System Statistics

- 110 route miles of main track
  - 235 mainline track miles
  - 28% aerial direct fixation (36" fastener spacing)
  - 27% subway direct fixation (36" fastener spacing)
  - 45% at-grade ballasted concrete ties (30" Tie spacing)
- 29 interlockings / 289 mainline turnouts
- 119RE continuous welded rail
- Custom trackwork for cylindrical profile

Why Choose a Cylindrical Wheel Profile?

- Not entirely uncommon when District began operation – SF Muni, CTA, PATH
- District has mostly tangent track
- District operates at high speed – 80 mph
- No hunting at high speed on tangent track
- Ride quality with new wheels and rails is generally good
- Typical 1,000,000 mile wheel life when originally condemned at #8 flange and use of wheel lathes to minimally reprofile worn wheels

What's Wrong with a Cylindrical Profile?

- No inherent wheelset steering through curves
- 2-point contact prevalent as wheel and rail profiles become worn
- Systemic issues with corrugation growth in tunnels and elevated track, accentuated in curves
- Areas with corrugation are unbearably noisy – mostly direct fixation
  - Reverberation in tunnels results in a resonating howling noise inside the cars
  - Noise from elevated tracks floods surrounding neighborhoods with noise
- Severe wheel flange wear and rail head wear in sharp curves – difficult to grind
- Expense to maintain wheels and rails has become excessive

Opportunity for Change – Bombardier

- Collected data:
  - Laser measurements of the BART mainline – rail profiles new and worn
  - Measured wheel profiles new and worn
  - Ran two instrumented wheelsets and truck over entire system to understand ride quality requirements and dynamic characteristics of rail network
- Analyzed the data and confirmed poor wheel/rail interaction with pervasive 2-point contact resulting in excessive noise and severe wear
- Bombardier experts walked various track sections to confirm severity of rail conditions
- Optimized simulations to develop custom tapered wheel profile

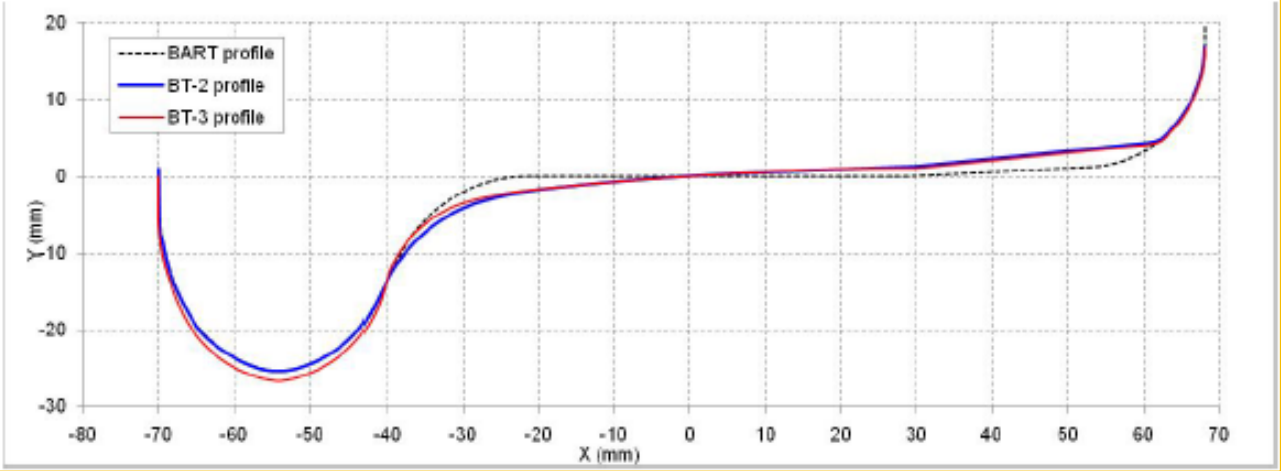
Opportunity for Change – Bombardier

Several iterations to settle on custom BT-3 modified tapered wheel profile

Special trackwork difficult to simulate; requested BART to verify compatibility

BT-3 Wheel Profile

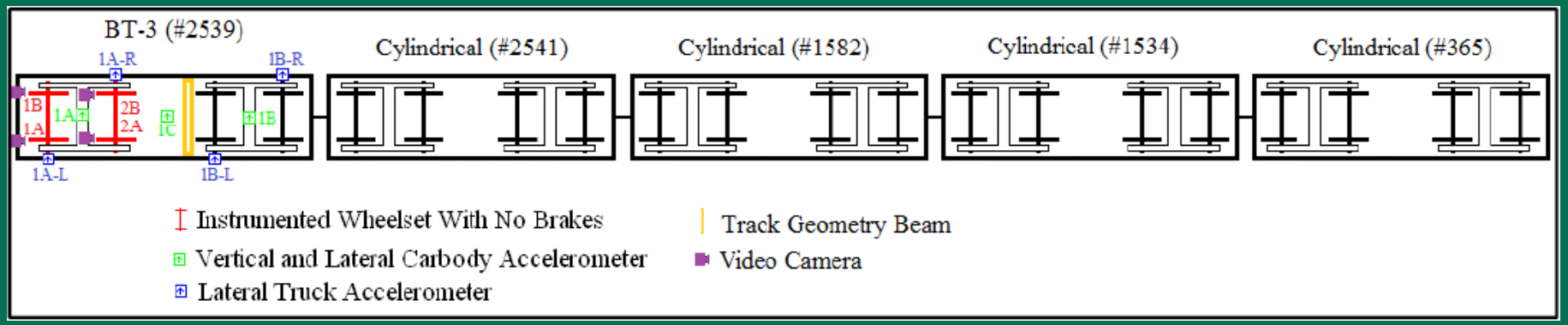
- New profile to integrate APTA minimum flange angle requirement:
  - 73.5 degree over 0.075 inch
  - 72 degree over 0.11 inch
- Increased flange height to allow for steeper flange angle
- Curving performance equivalent to BT-2 profile



Evaluation of the Change Opportunity

BART tasked ENSCO through LTK to evaluate BT-3 profile compatibility with special trackwork and to confirm acceptability system wide

- ***Dynamic mainline tests using the 2 IWS modified with BT-3 profile***
- ***Track geometry and rail profile map of BART rail network***
- ***Special trackwork compatibility analysis***
- ***Computer simulation analysis to corroborate Bombardier analysis***

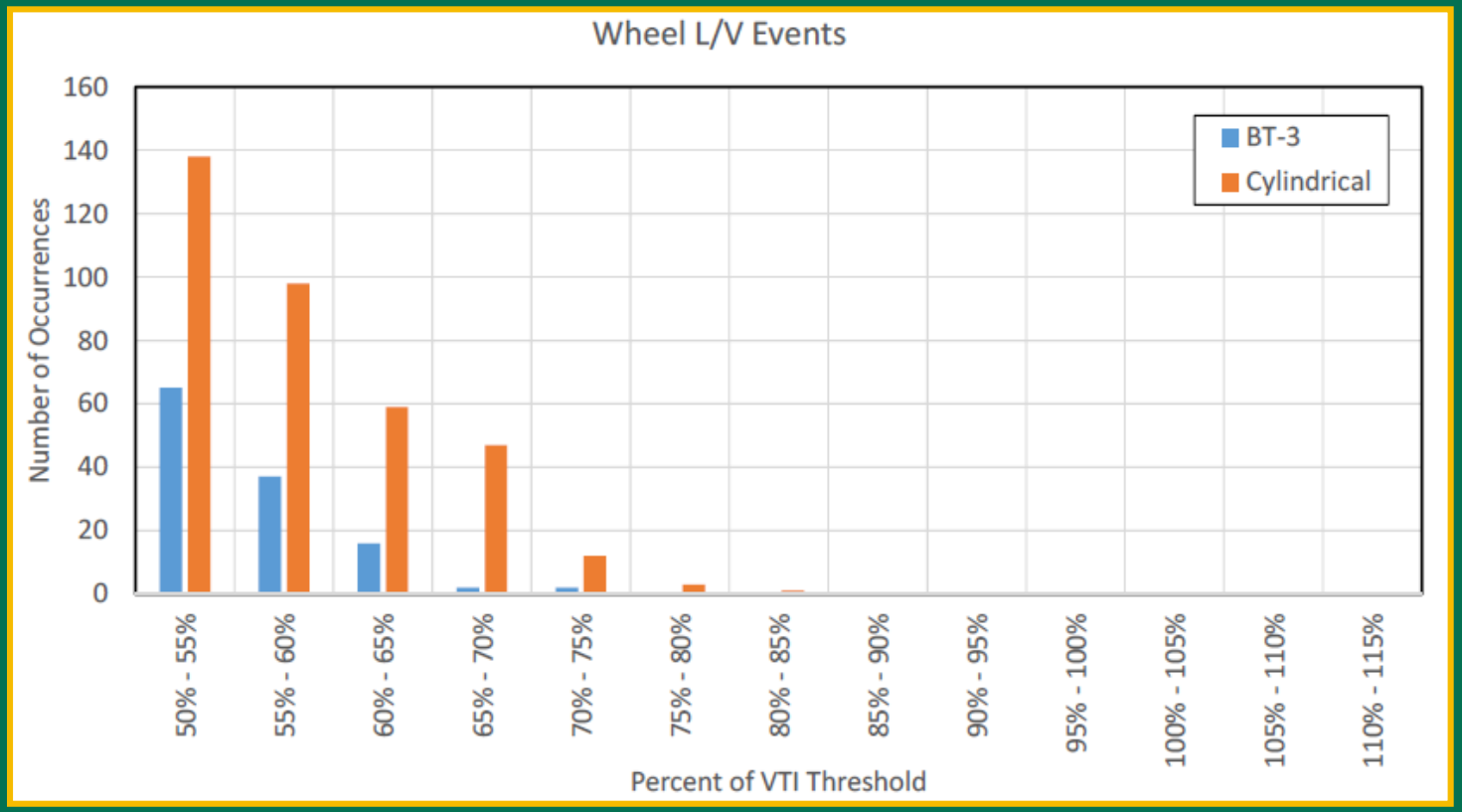


Evaluation of the Change Opportunity

BT-3 profile, tangent track

Cylindrical profile, tangent track

Evaluation of the Change Opportunity



Benefits of the New BT-3 Modified Tapered Profile

- ENSCO and LTK confirmed definite operational improvements
  - Safe
  - Compatible with special track work
  - Good stability and ride quality
- Confirmed long term expectations
  - slower corrugation growth
  - reduced wheel/rail wear
  - lower noise

Bombardier, ENSCO and LTK helped BART refine transition strategy

- 6 years to reach steady state wear – need to monitor wheels / rails
- OK to convert fleet within 1 year
- 2-step grinding program: sharp gauge points first, then rest of rails

Conclusion: LOWER NOISE and LOWER MAINTENANCE COSTS!

THANK YOU!

Q&A?