Integrated Wheel/Rail Characterization through Advanced Monitoring and Analytics – an Overview

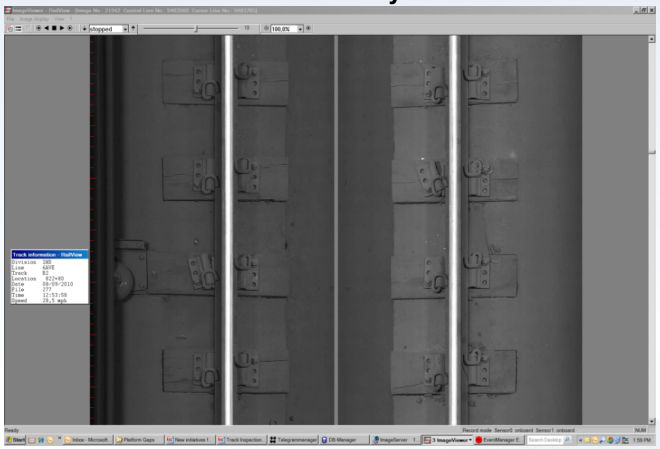
Antonio Cabrera – Assistant Chief Officer, Track Engineering, MTA-NYCT

Eric Magel – Principal Research Officer, National Research Council, Canada

Outline

- Automated track inspection pilot
- Wheel/rail analytics project
  - team, technologies
  - objectives
  - analytics

NYCT's Track Geometry Car - TGC4

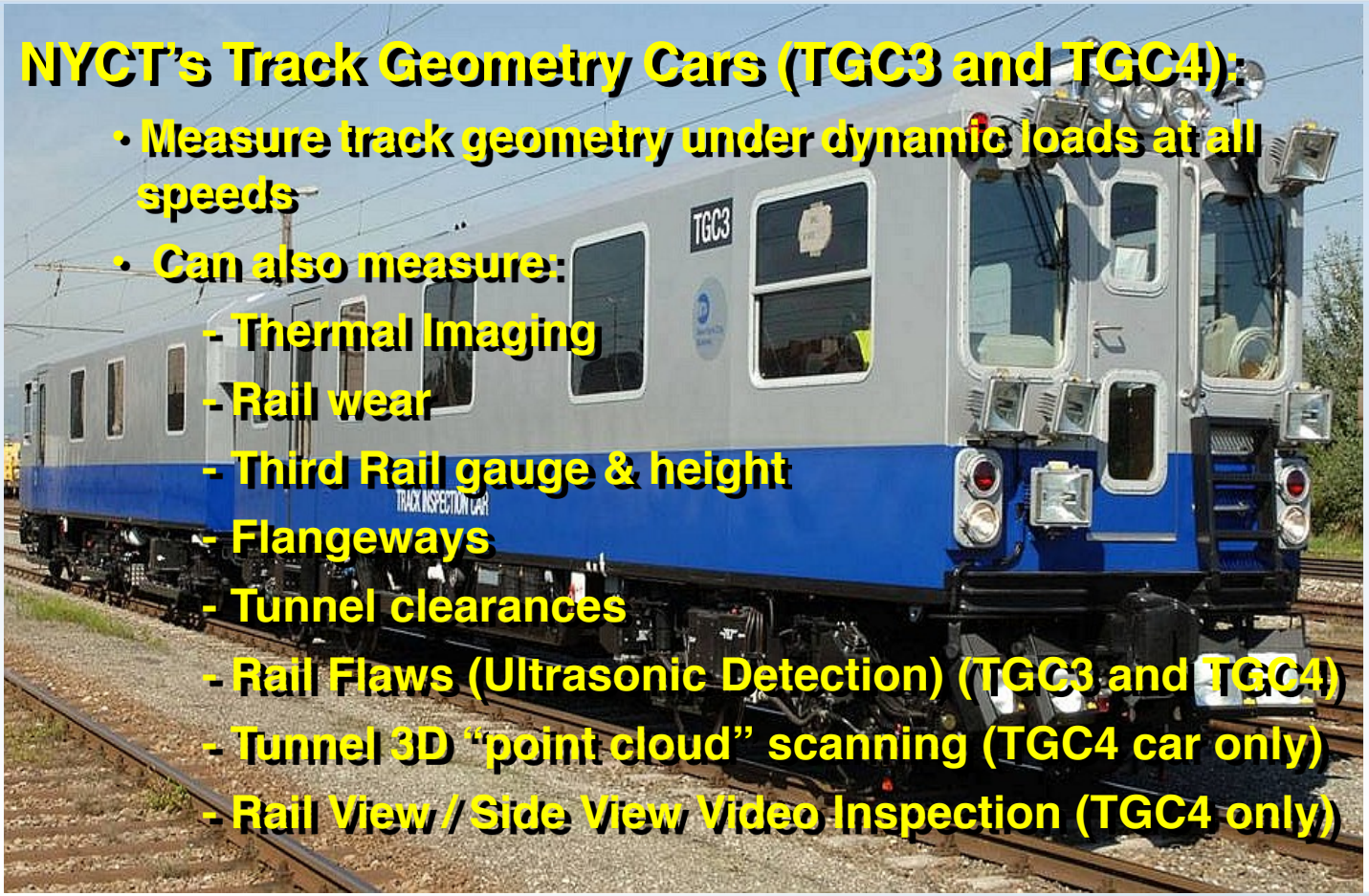


TGC4's Rail View Video System

FTA Office of Research Project NY-26-7112

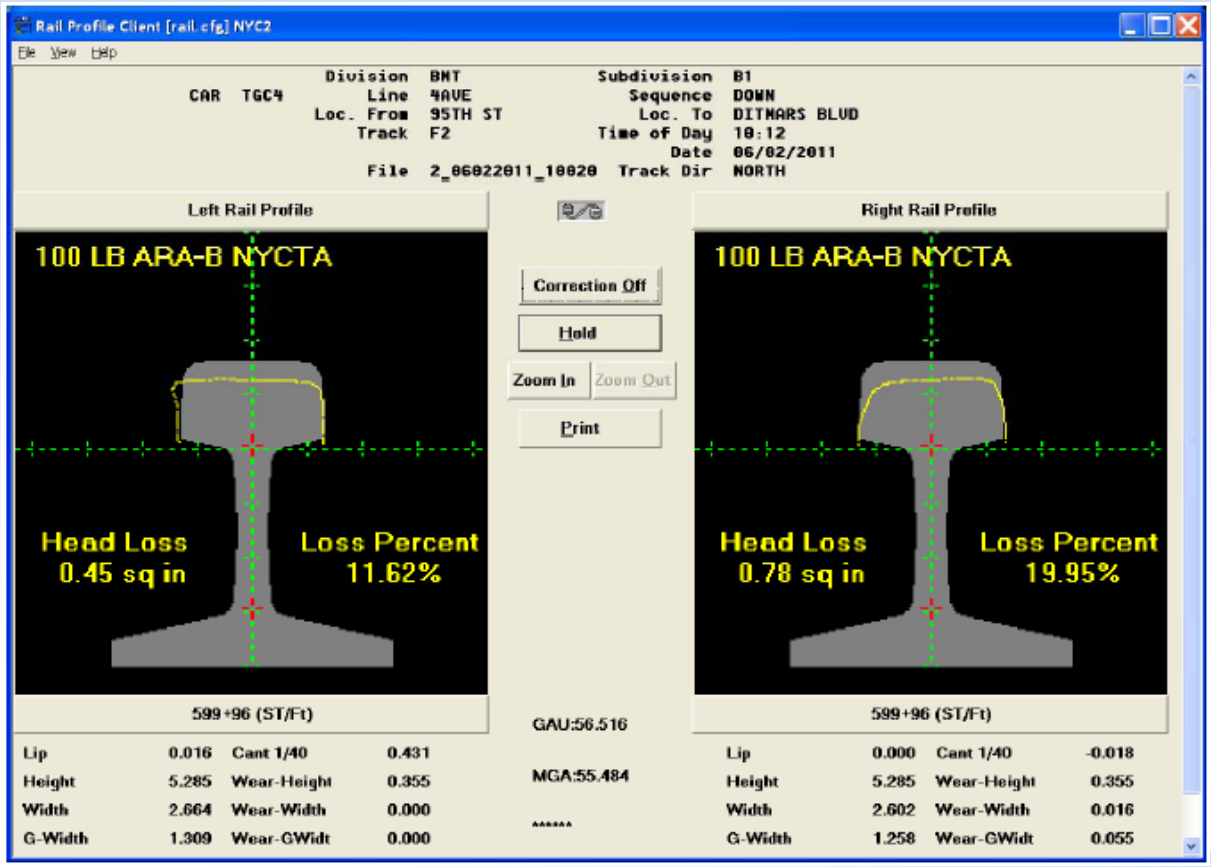
Demonstration of Machine Vision Assisted Automated Track Inspection Pilot

NYCT's Track Geometry Cars (TGC3 and TGC4):

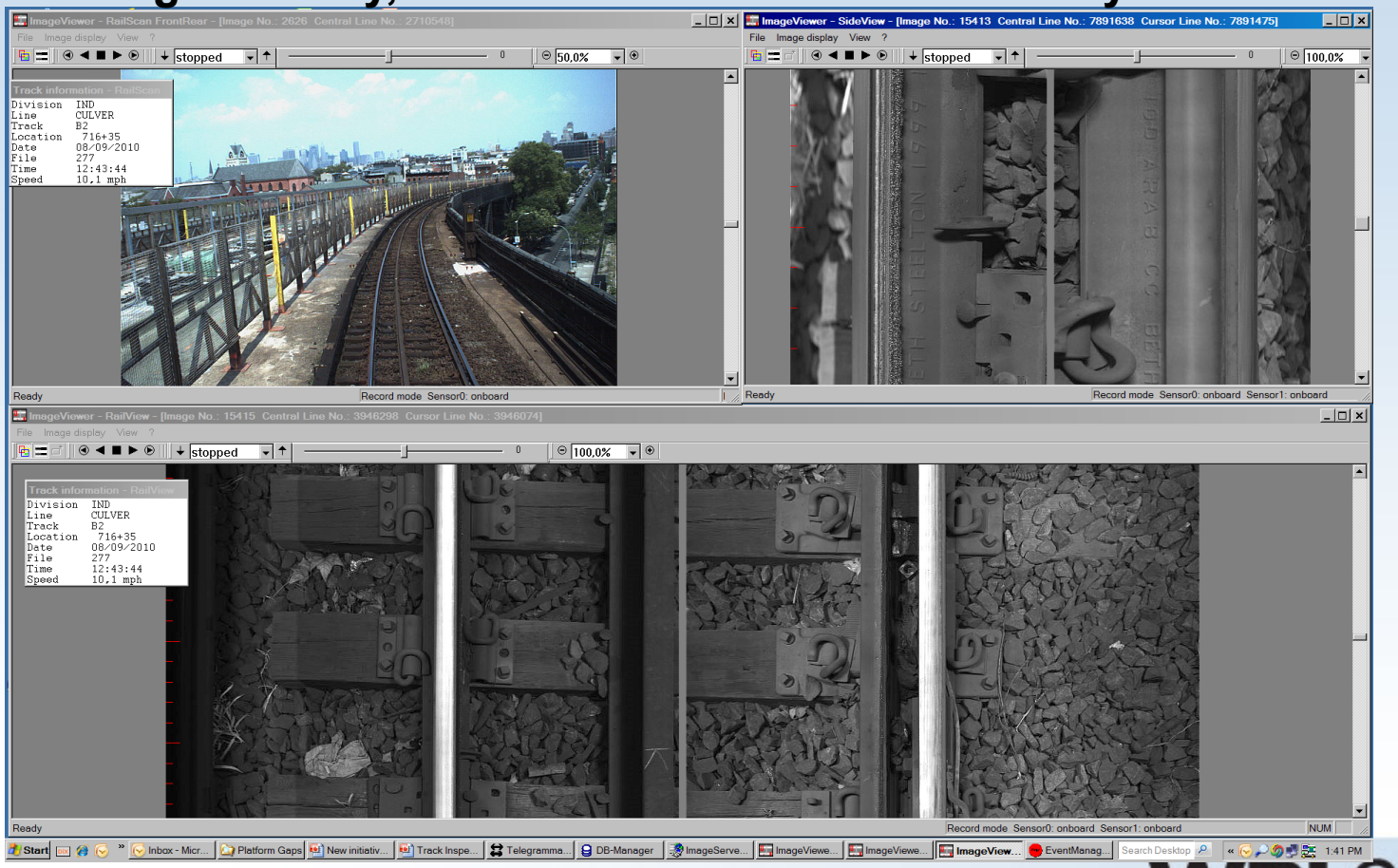


- Measure track geometry under dynamic loads at all speeds
- Can also measure:
  - Thermal Imaging
  - Rail wear
  - Third Rail gauge & height
  - Flangeways
  - Tunnel clearances
  - Rail Flaws (Ultrasonic Detection) (TGC3 and TGC4)
  - Tunnel 3D "point cloud" scanning (TGC4 car only)
  - Rail View / Side View Video Inspection (TGC4 only)

Rail Profile and Rail Wear



Right-of-Way, Side View and Rail View Video systems



Demonstration of Machine Vision Assisted Automated Track Inspection Pilot

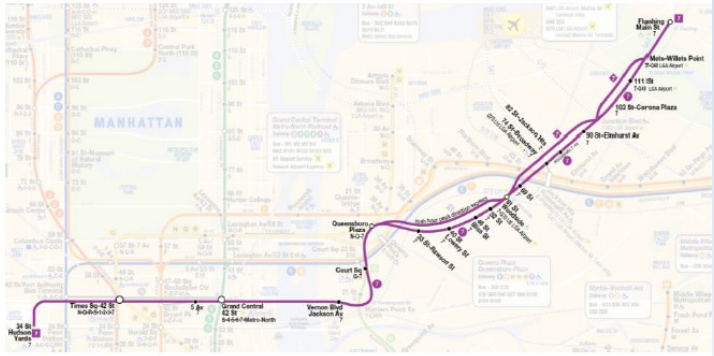
- FTA Office of Research Project NY-26-7112 Granted to NYCT $500 K on March 2012
- FTA Objectives:
  - Improve right-of-way safety of Track Inspectors through advanced track inspection techniques limiting the Inspectors' exposure on live tracks
  - Enhance the quality of the track inspections and reporting of defects
- Use of NYCT's TGC4, already equipped with Rail Top View, Gauge Side Rail View and Right-of-Way Video Systems, coupled with the other existing measuring systems, was found to be ideally positioned to accomplish the research objectives.
- Plasser American Corp. (manufacturer of the TGC4 and its measuring systems) agreed to be a partner to this Project.
- Project was performed in four Phases, starting in April 2012.

Automated Visual Track Inspections - Summary

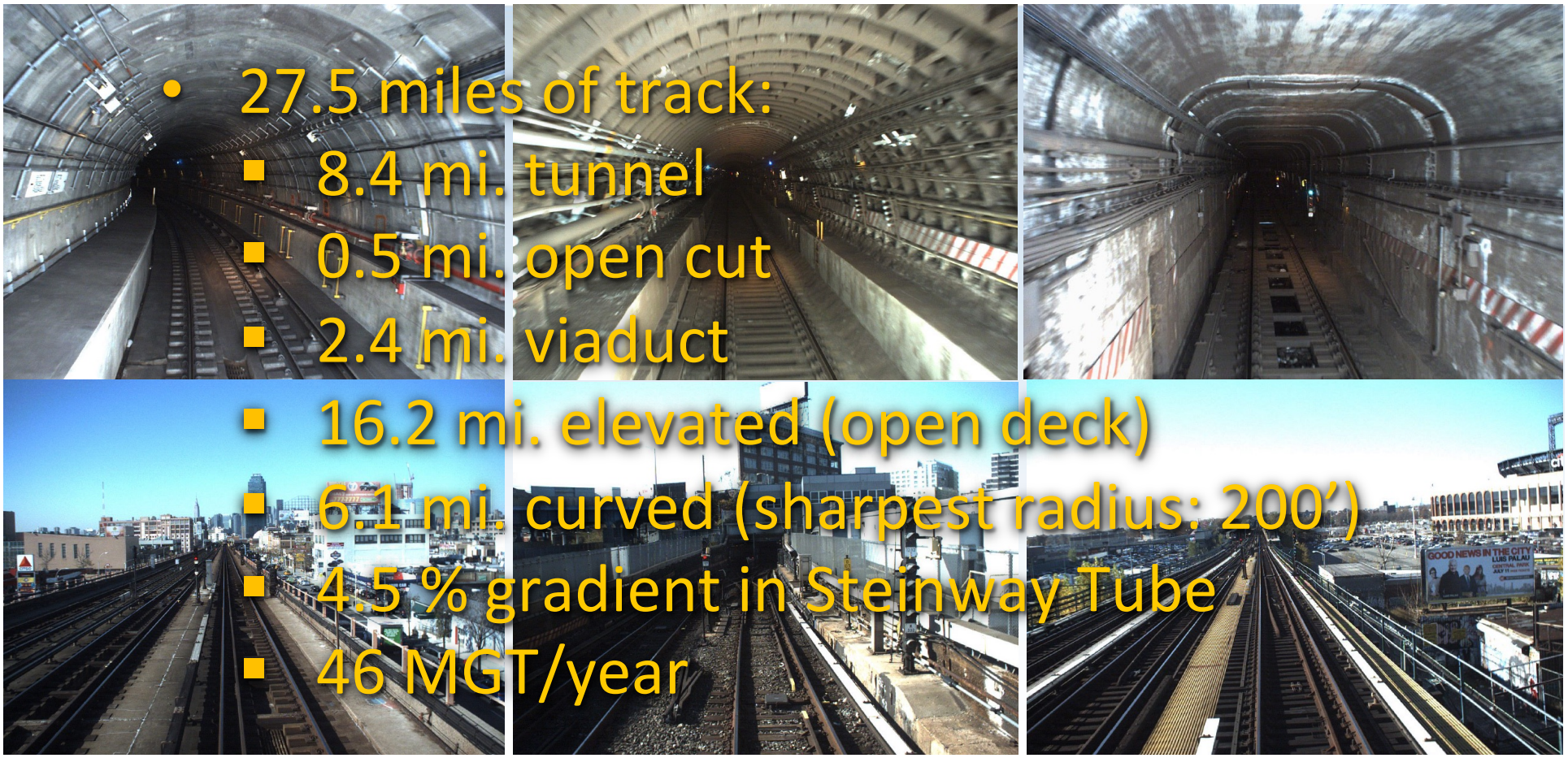
- Inspection from vehicle (TGC4)
- Assure safety of track inspectors
- High-speed video cameras with good lighting provide for higher quality inspections
- Permanent objective record of inspection
- Defects found can be correlated with geometry or other defects
- No degradation of on-time train performance

Flushing Line At A Glance

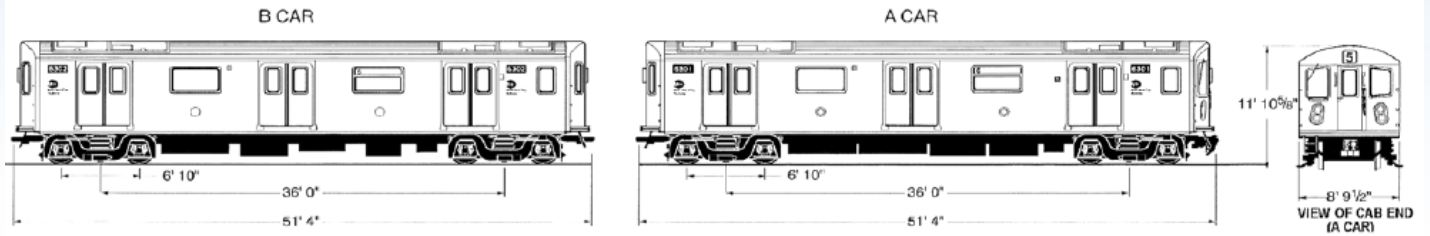
- 27.5 Miles of Track
- 22 Stations
  - 34th Street-Hudson Yards opened in September, 2015
- Average Daily Ridership:
  - Weekday = 525,000
  - Saturday = 350,000
  - Sunday = 300,000



- 7 line (tied with the 6 line) has the most frequency of service in the entire system.
- 27 Trains per hour in each direction during Weekday Peak



- 27.5 miles of track:
  - 8.4 mi. tunnel
  - 0.5 mi. open cut
  - 2.4 mi. viaduct
  - 16.2 mi. elevated (open deck)
  - 6.1 mi. curved (sharpest radius: 200’)
  - 4.5 % gradient in Steinway Tube
  - 46 MGT/year



WEIGHT & CAPACITY	
CAR WEIGHT (EMPTY)	
A CAR	72,000 LBS
B CAR	66,300 LBS
CAR WEIGHT (LOADED)	
A CAR (AW3)	100,000 LBS
B CAR (AW3)	94,300 LBS

W/R Analytics project

- leverage NYCT/FRA Automated Track Inspection Research efforts.
- address concepts to enhance Operational Safety and strengthen the Resiliency of Transit Rail Systems.

Approach

- SOA, automated, machine based
- wheel, track and truck data
- characterize and perform automated data collection and analytics
  - safety, resiliency + economics

Introducing…

THE TEAM

KLD WheelScan

Automated Wheel Profile Measurement

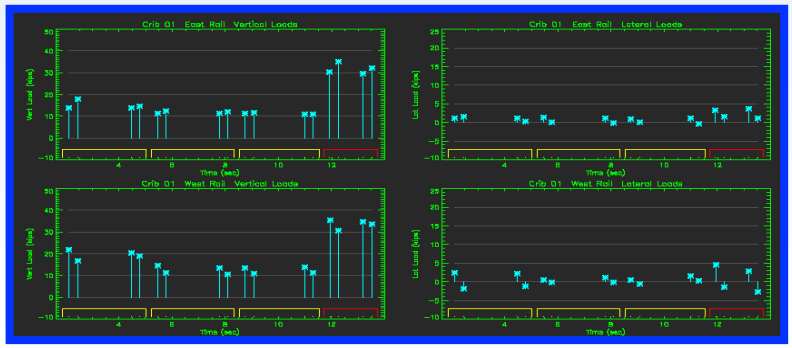
- **Being installed at Corona Yard**
- **Will capture, measure, store and report the condition of the entire Flushing Line R188 Fleet wheels**
- **Providing a web interface for access to data and TrainBase tools as required by participants**
- **Enabling categorization of fleet wheel wear patterns for input to wheel/rail analytics**

WheelScan to be installed at Corona Yard

Near 111th Street station

ISI – L/V Measurement System

- Remote Data System installed in 3rd Rail environment
  - Acquires lateral and vertical forces for each passing train
  - Characterizes vehicle performance: steering, wheel climb, effect of wheel profile, friction management, etc.
- Data is automatically transferred to KLD's central data warehouse



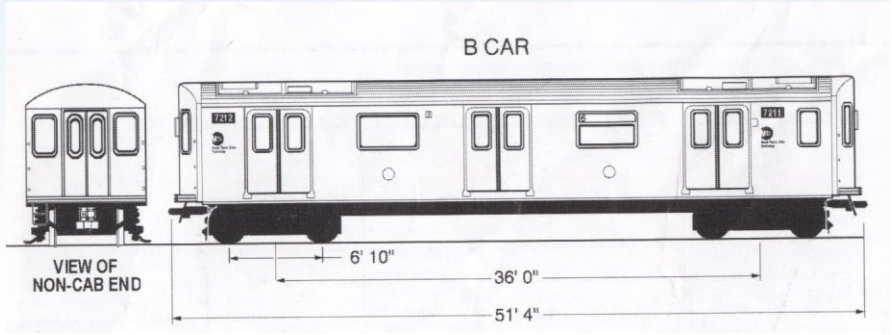
WID - TBOGI

Bogie Geometry Measurement System

- **Measures the tracking behavior of bogies. Identify bogies with steering issues.**
  - **Operates in 3rd rail environment.**
  - **Measures the AOA and TP of each passing wheelset, and more…**
  - **Data pushed to TBOGI-DB web database and central data warehouse.**

DCC – Data Collection Car

- instrumented wheel sets, accelerometers, acoustic recording equipment and propulsion energy recording equipment
- Part of an 11 car consist

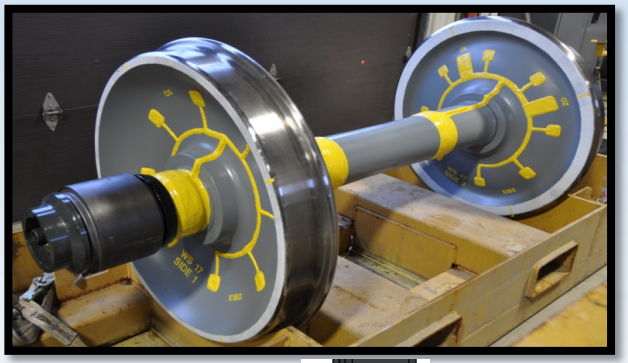


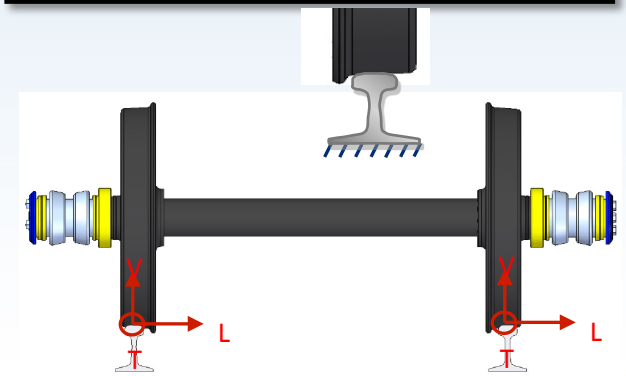
DTB – Instrumentation of Train Consist

- Design/develop/integrate data acquisition system for Research Consist and Data Collection Car (DCC)
- Measure propulsion energy consumption of Research Consist
- Measure vibration and acoustics on DCC in vicinity of Instrumented Wheel Set (IWS)
- Determine train location utilizing GPS aided Inertial Measurement Unit (IMU)
- Correlate acquired data to train location and time

NRC Instrumented Wheelsets

- Regular wheelset instrumented with strain gauges and turned into dynamic load cells
- Gives accurate measurements of wheel/rail contact forces in all three axes
- Characterizes track performance: steering, wheel climb, effect of rail profile, friction management, etc.





Plasser American – Ec Analytics

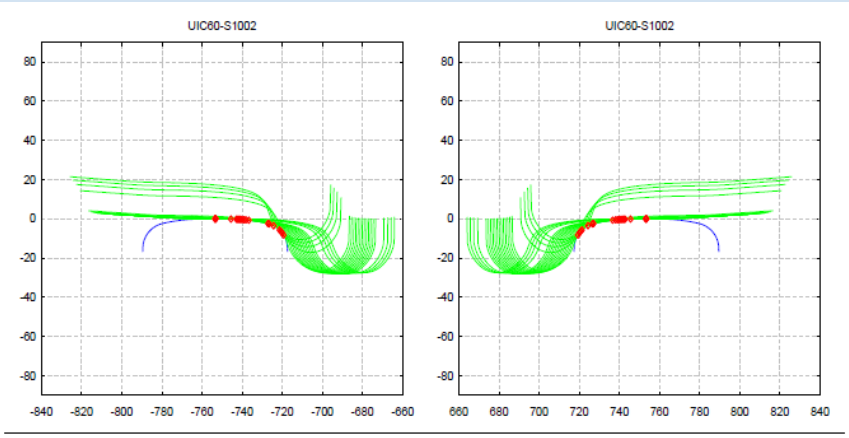
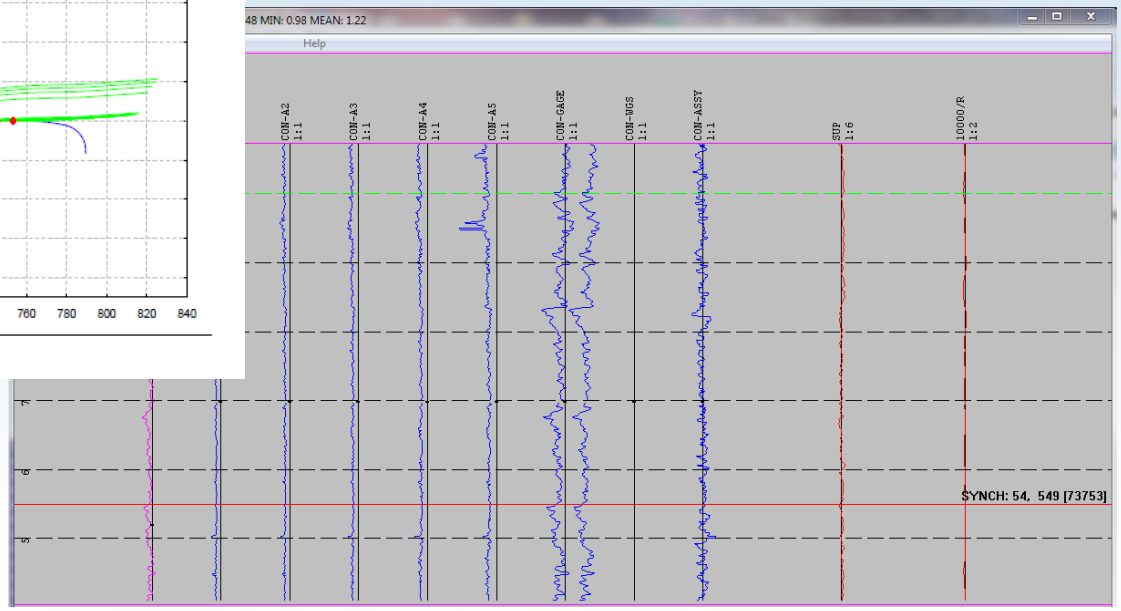


Figure 1.3. Contact between wheel and rail



Objectives

- Decision Making
- Operational Safety
- System Resiliency
- Post Event System Service Recovery
- Condition based maintenance
- Optimized Propulsion Energy

Decision Making

- wheel profile
- rail profiles
- friction management practices
- track maintenance prioritization
- train speeds, super-elevation

Operational Safety

- Slow speed derailments
  - lateral forces
  - wheel unloading
- hunting, poor ride quality
- equipment failure

System Resiliency

- asset condition monitoring and documentation
  - facilitate risk management
  - accelerate recovery/repair prioritization and speed a system's safe return to service

Condition-based maintenance

- Wheel retruing
- Rail grinding (including reprofiling)
- Track geometry
- Vehicles (wheels/axles/trucks)

Optimized Propulsion Energy

- measure against
  - wheel profiles
  - rail profiles
  - curvature
  - friction conditions

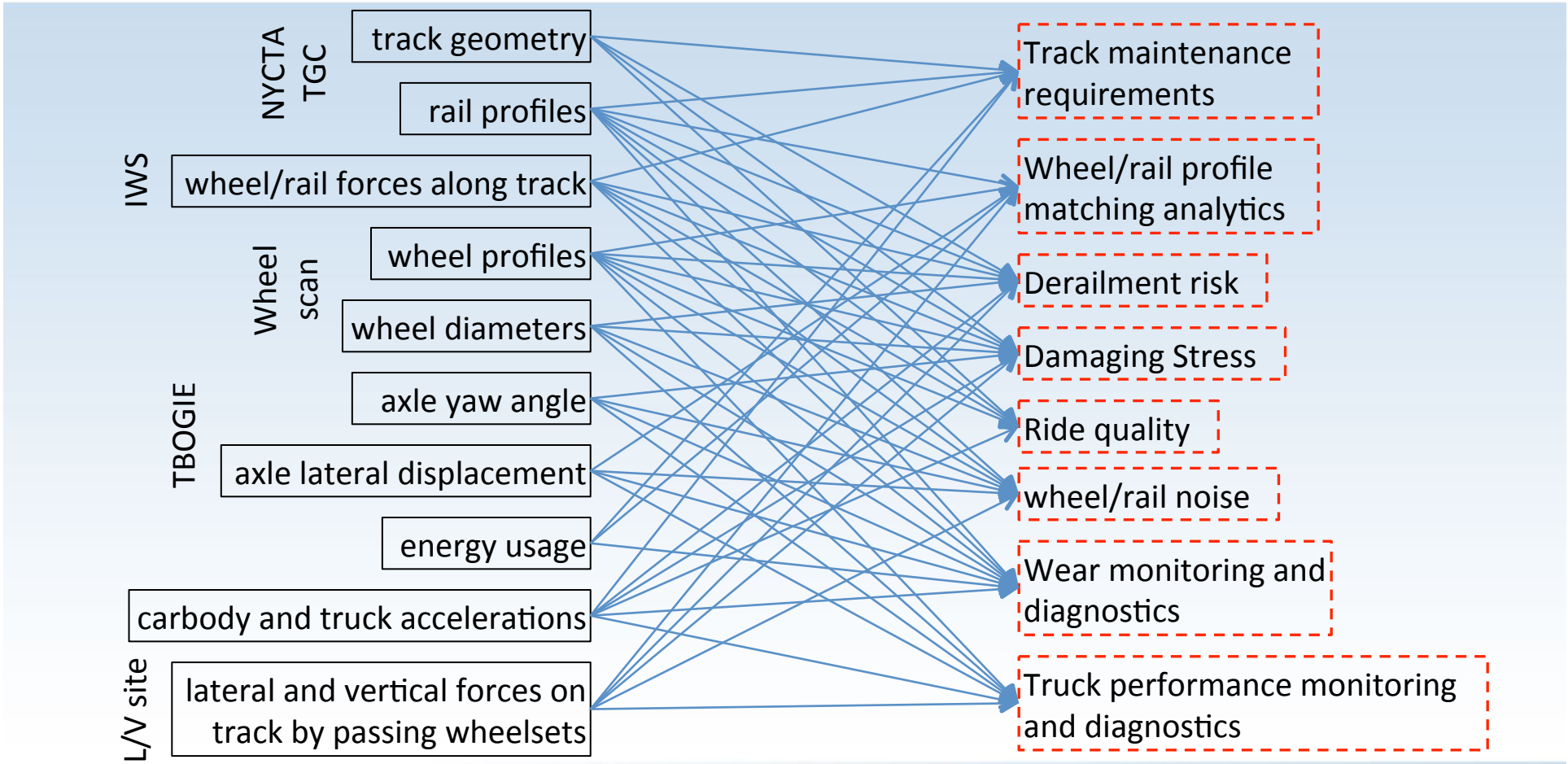
Improve Customer Service and Customer Experience

1. Reduce Wheel/Rail Noise
2. Improve vehicle ride characteristics (wheels, track and trucks)
3. Improve Vehicle Safety / system resiliency
4. Improving availability, avoid unplanned maintenance

WHEEL/RAIL ANALYTICS

Safety, comfort and economic parameters

- Lateral and vertical forces
- Wheel unloading
- Accelerations
- Wheel/rail noise
- Wheel angle of attack and lateral position
- Wheel and rail profiles
- Wheel/rail contact position
- L/V force ratio
- Contact Stress
- High Rail Conformality
- Rolling Radius Difference
- Effective Conicity


NYCTA
TGC
track geometry
rail profiles
IWS
wheel/rail forces along track
Wheel
scan
wheel profiles
wheel diameters
TBOGIE
axle yaw angle
axle lateral displacement
energy usage
carbody and truck accelerations
L/V site
lateral and vertical forces on track by passing wheelsets
Track maintenance requirements
Wheel/rail profile matching analytics
Derailment risk
Damaging Stress
Ride quality
wheel/rail noise
Wear monitoring and diagnostics
Truck performance monitoring and diagnostics

Timeline

- Phase 1 (18 months): Instrumentation of vehicles and track and collection of “as-is” (baseline) vehicle and track data and performance.
- Phase 2 (2 months): Develop and optimize analytics capability of the system.
- Phase 3 (4 months):In-track demonstrations of improved performance.

Next Years

- all technologies functional
- baseline performance data
- findings from early analytics
- One system change implemented and validated

Phase 1

Phase 2

Phase 3

WRI 2017?

WRI 2018?

THANK YOU!

Antonio Cabrera: Antonio.Cabrera@nyct.com

Eric Magel: Eric.Magel@nrc.ca