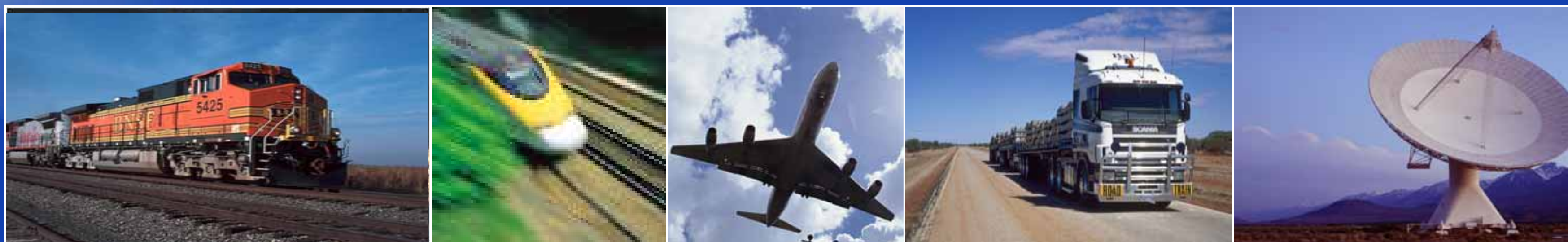
Status report: November 7, 2003

Test & Analysis support towards a vibration survey of subway structures



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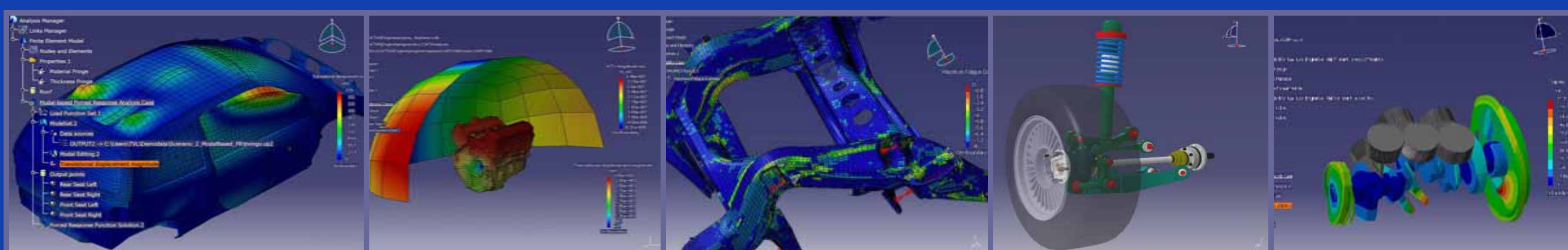

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Status Report Contents

- Process Overview
- Measurement overview
- Where to go from here
- Input needed for mission synthesis

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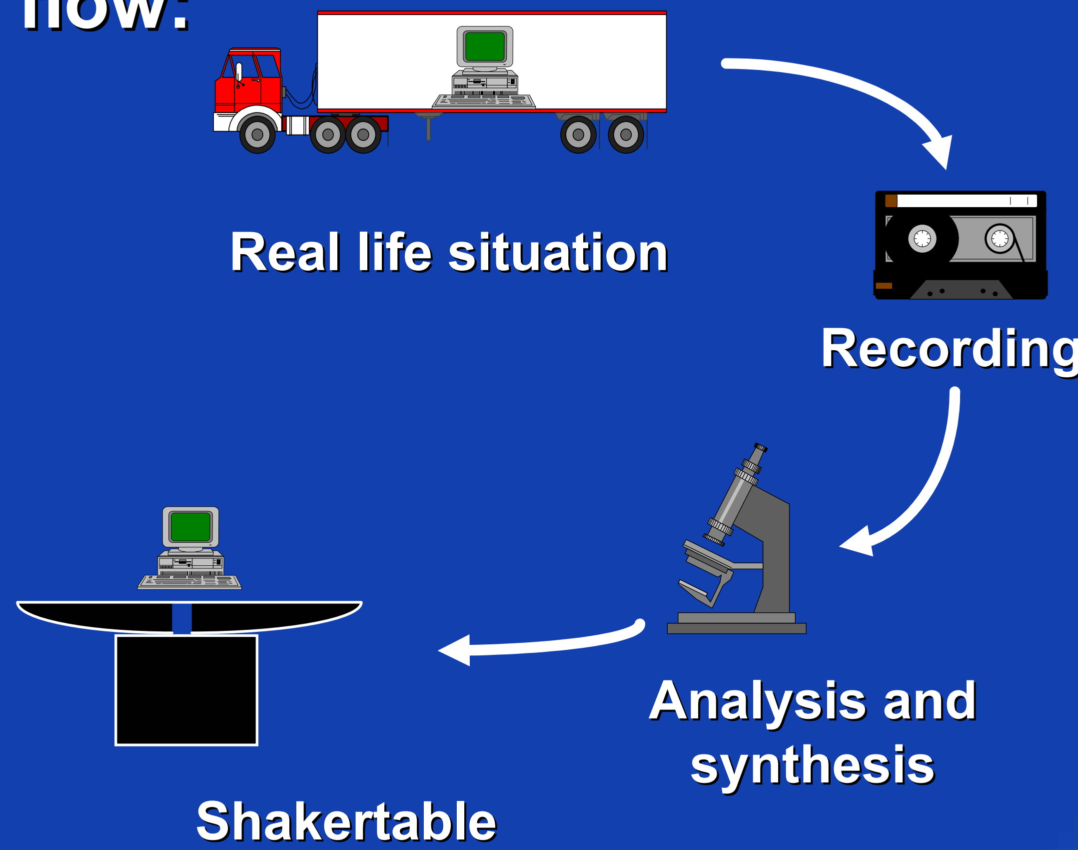
Goal of the project

Defining a uni-axial vibration test specification for vibration based durability qualification testing for rail equipment mounted near the tracks based on vibration data collected in real life situations.

Measure vibration levels at various locations assigned by the NYC Transit authority

Process overview

Simplified process flow:



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Process overview

- Define mission for the product:
  Identify different phases ("environments") during product life in terms of loads, different locations, track construction,…
- Quantify each phase by measuring data in real life situation
- Statistical analysis on the environments to assess the loading variability

Process overview

- Each of the environments gets analyzed for damage potential
  - Fatigue Damage Spectrum (FDS) for cumulative fatigue damage assessment:

    characterizes the vibration environment in terms of its propensity to cause fatigue failure
  - Maximum Response Spectrum (MRS) for limit load damage assessment:

    characterizes the vibration environment in terms of its propensity to overstress the part leading to failure

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Process overview

- Combine the environments appropriately according to the entire life profile (series and/or parallel events)
- Based on the life profile damage curves, a PSD or other type of profile will be synthesized
- This synthesis will be used to drive the shaker to submit the component to the desired vibration qualification test (equivalent to a life on the subway tracks)

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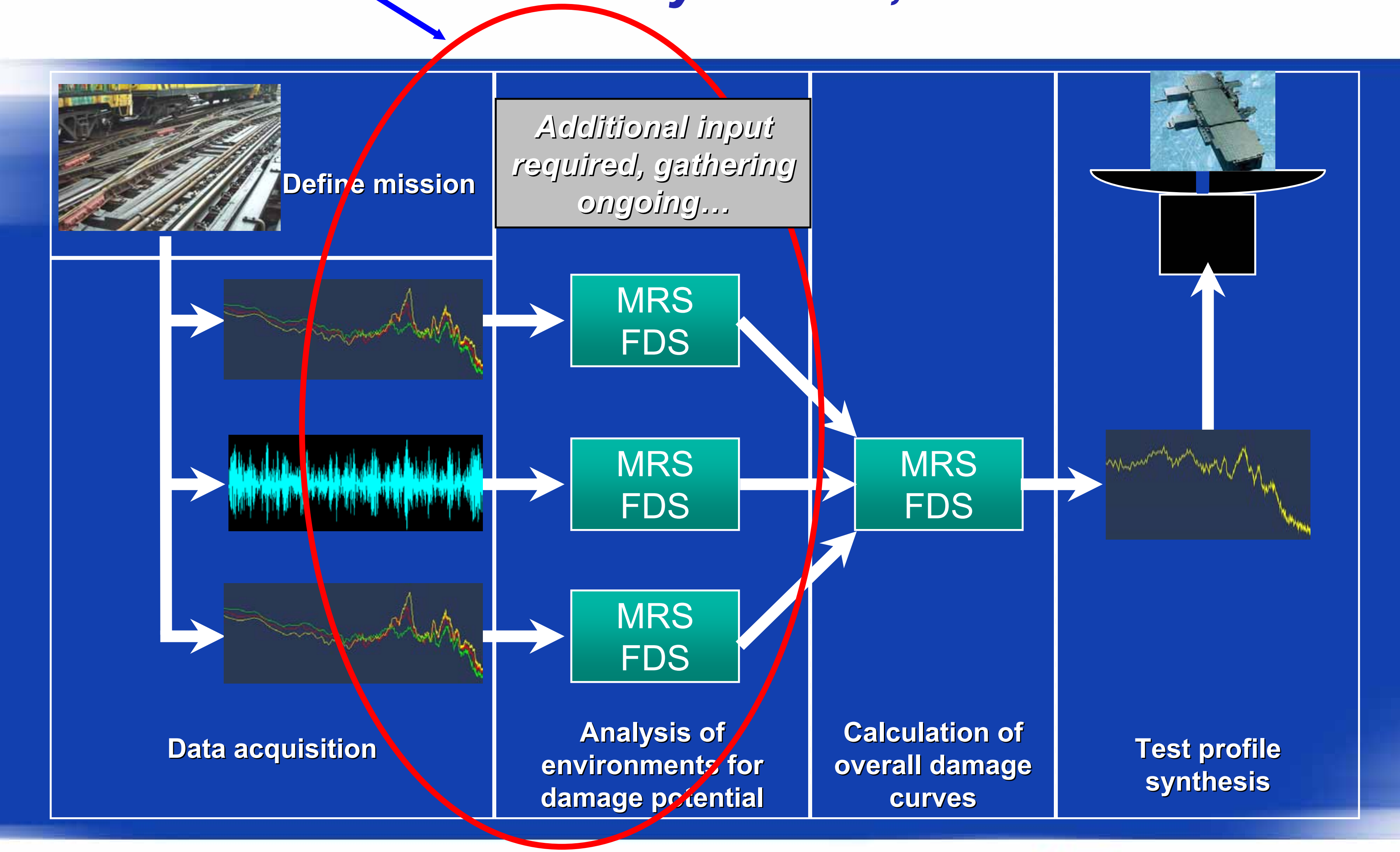
Mission Synthesis, where are we now

Current Activity



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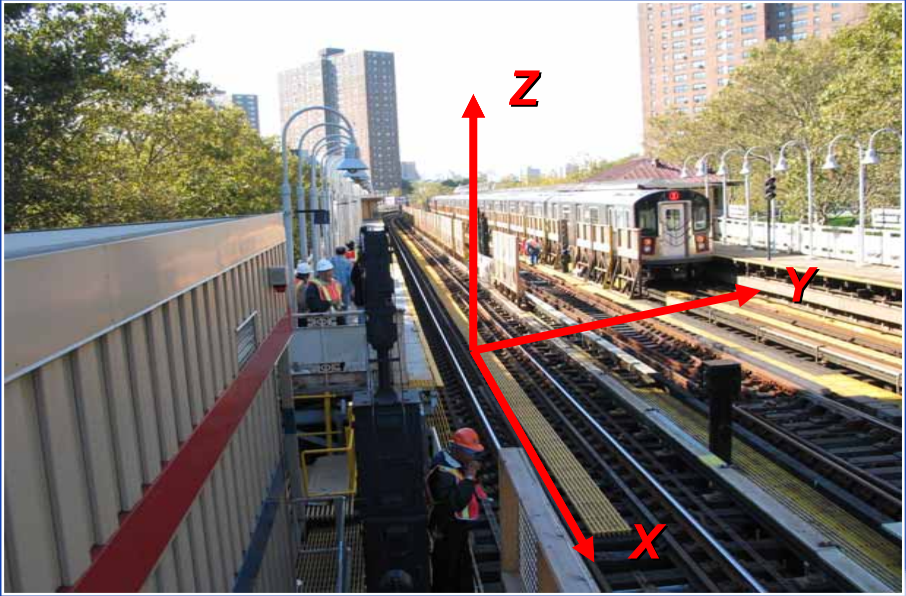
Site 1 details

Site 1 = Jackson avenue relay room on subwayline 2&5, (New York City, NY)

Site 1 axis system definition:

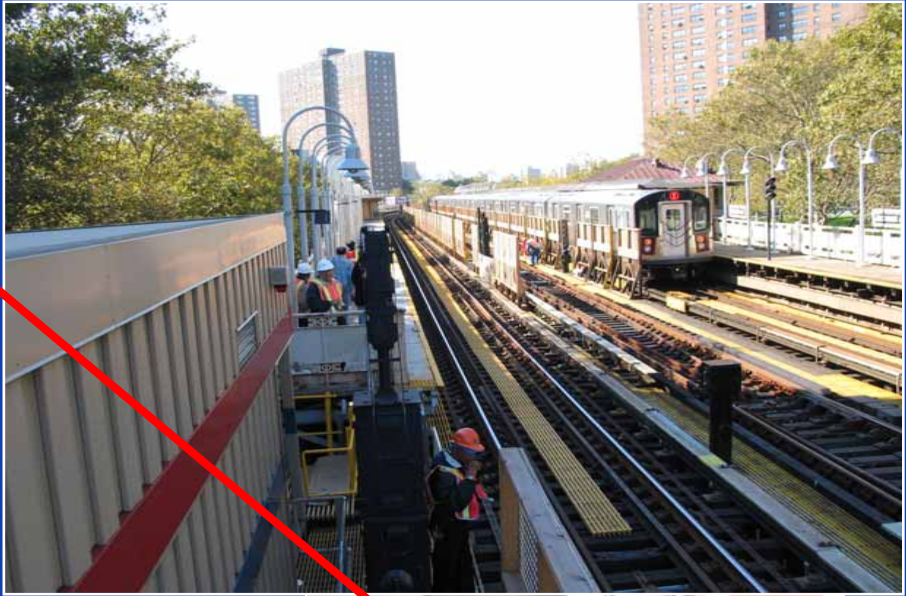
- X: parallel with rails, positive Northbound
- Y: transverse to rails, positive from Northbound to Southbound track
- Z: Vertical direction, positive upwards

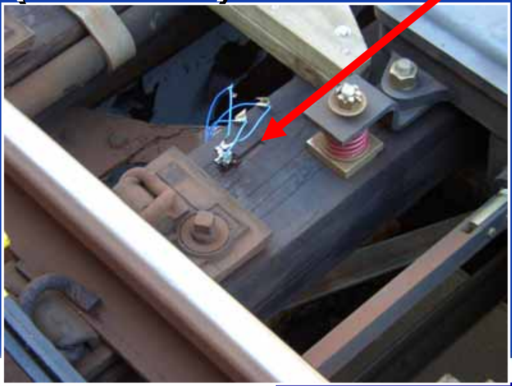


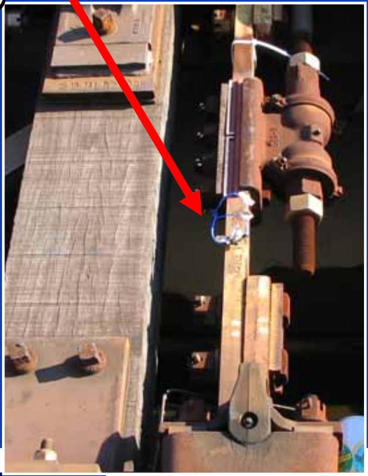
Site 1 details

Site 1 locations:

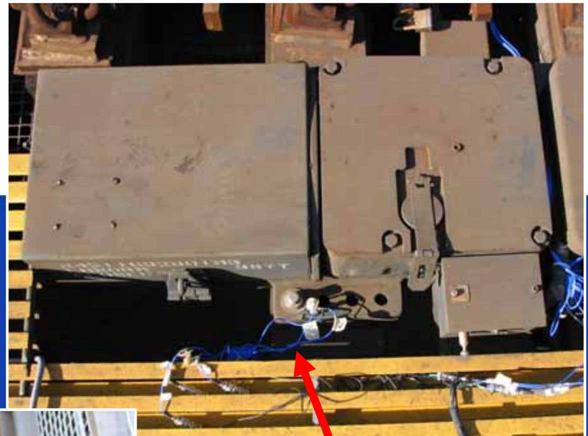
- On the doorway of relay room
- On the switch throw rod (257A)
- On the tie that is the southern mounting of the train stop for signal 2378 (track3)

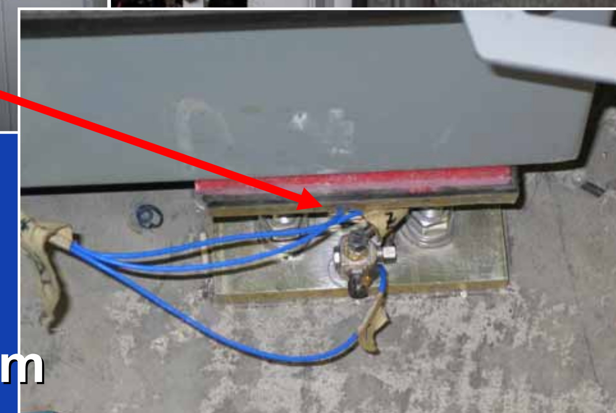






Site 1 details





- On the frame of switch machine 257A (track2)
- On top and base of PLC-code cabinet in relay room
- On SW-corners of top and base of signal 2378 (track3)
- On base of switch heater junction box (257A)

Site 1 measurement overview

- Instrumentation of 9 points in 3 directions on October 28
- Acquisition of data on evening rush of October 28:
  - Vibrations on code cabinet (2 points) were too low to be measured with available set of sensors,
  - Data recorded for local tracks (North- & South-bound) & express track,
  - About 20 local southbound trains recorded,
  - About 10 express trains recorded,
  - About 15 local northbound trains recorded,
- Logging of train traffic during measurements (time, track & direction)

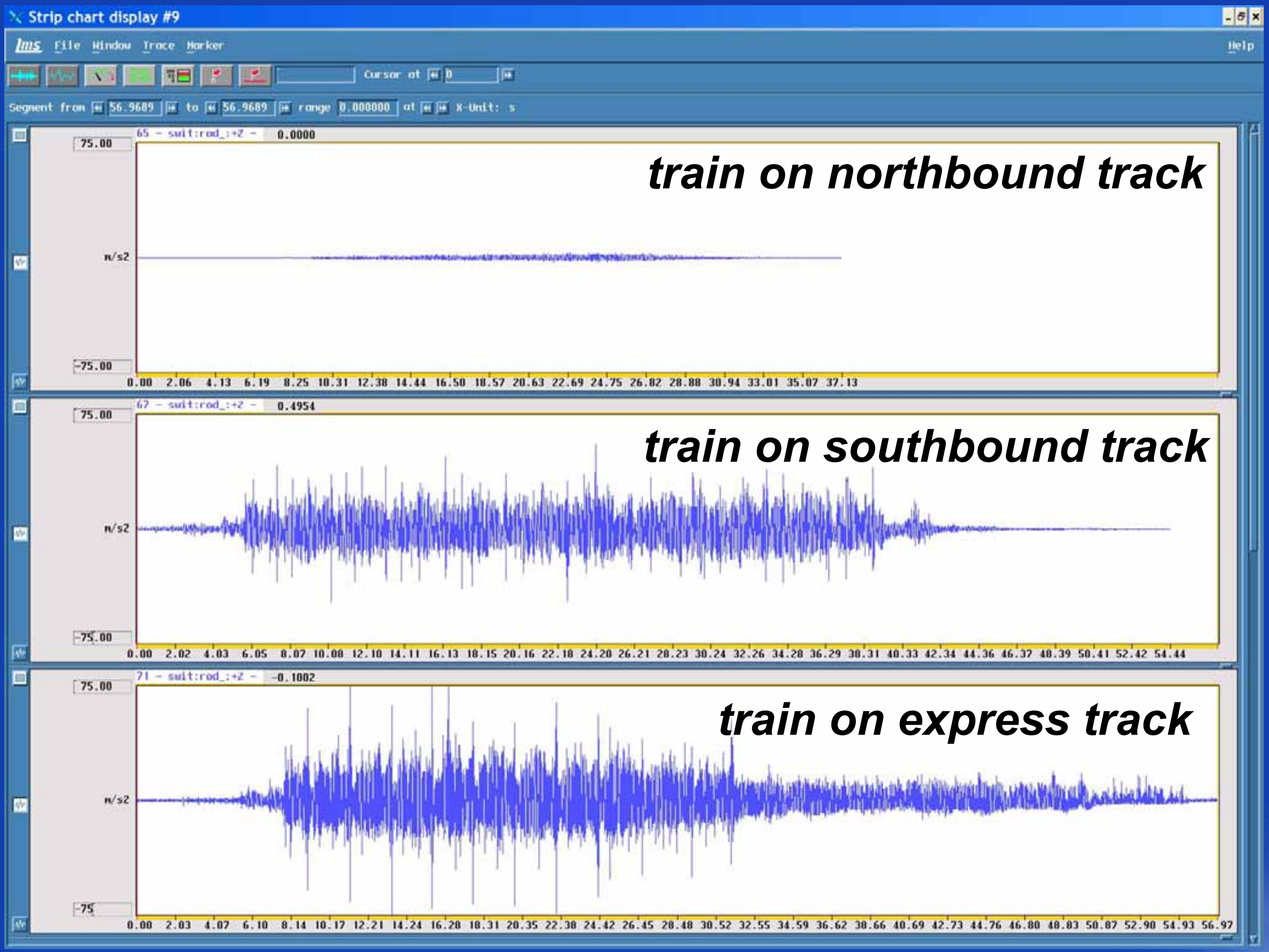
Site 1 measurement examples

Comparison between train passing on different tracks for vertical vibration at frame of switch machine:

(sensor mounted between S'bound & express track):

Limits: +/- 75 m/s²

Proximity of train is important towards vibration amplitude



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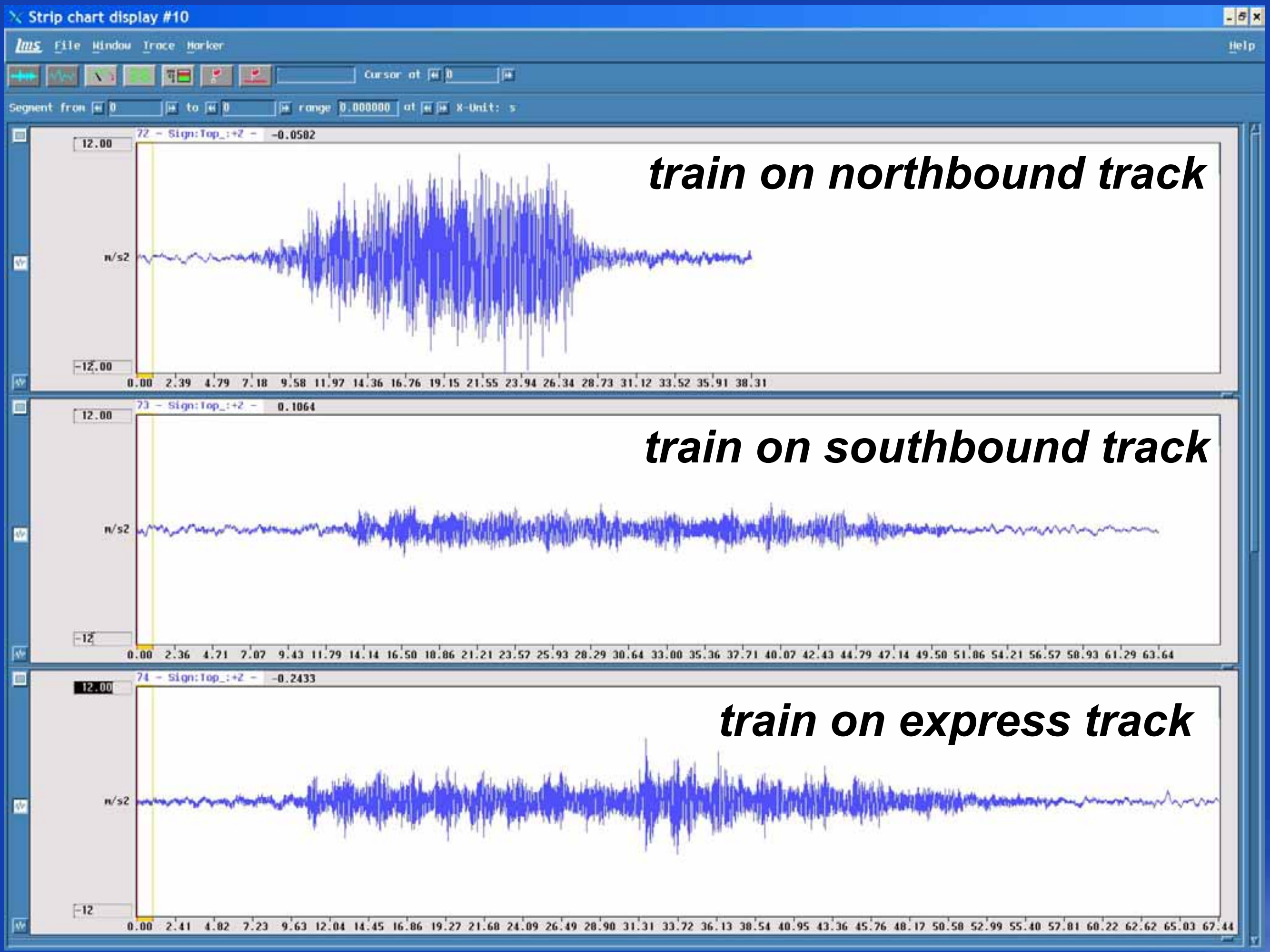
Site 1 measurement examples

Comparison between train passing on different tracks for vertical vibration on top of signal 2378:

(sensor mounted on Westside of N'bound track)

Limits: +/- 12 m/s²

Proximity of train is important towards vibration amplitude



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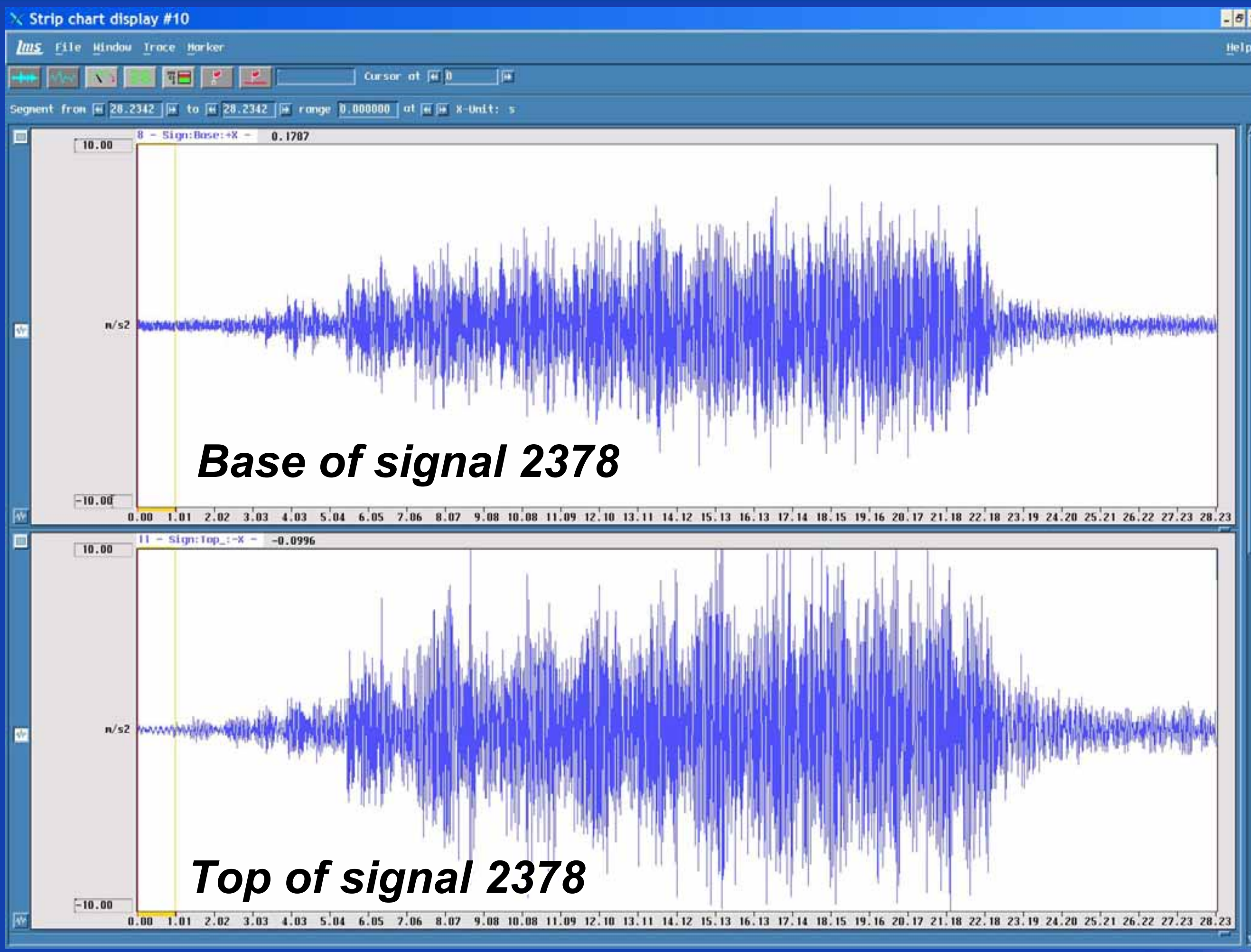
Site 1 measurement examples

Comparison between base & top of signal 2378 for train on northbound tracks (parallel direction, X):

Limits: +/- 10 m/s^2



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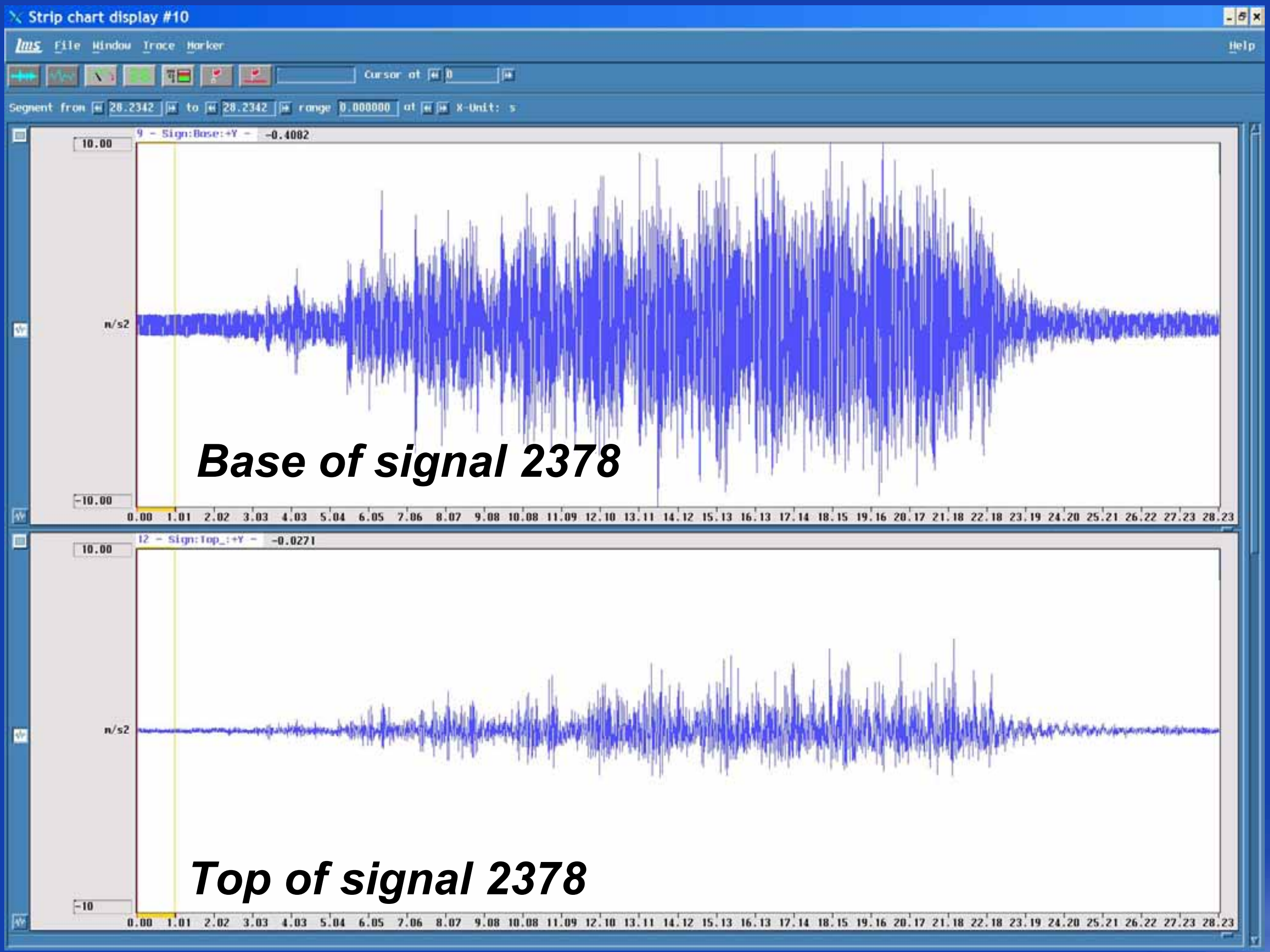
Site 1 measurement examples

Comparison between base & top of signal 2378 for train on northbound tracks (transverse direction, Y):

Limits: +/- 10 m/s²



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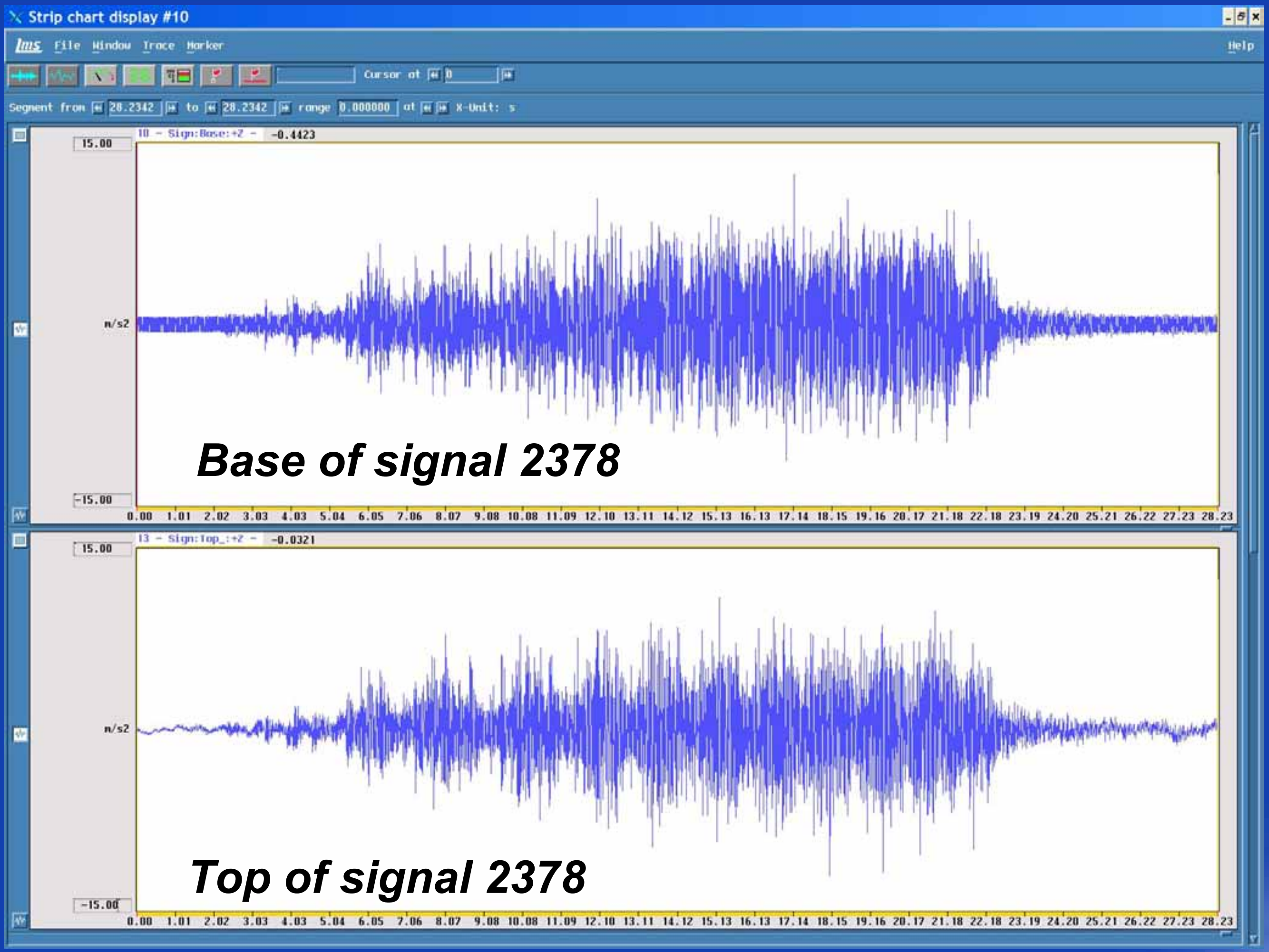
Site 1 measurement examples

Comparison between base & top of signal 2378 for train on northbound tracks (vertical direction, Z):

Limits: +/- 10 m/s^2



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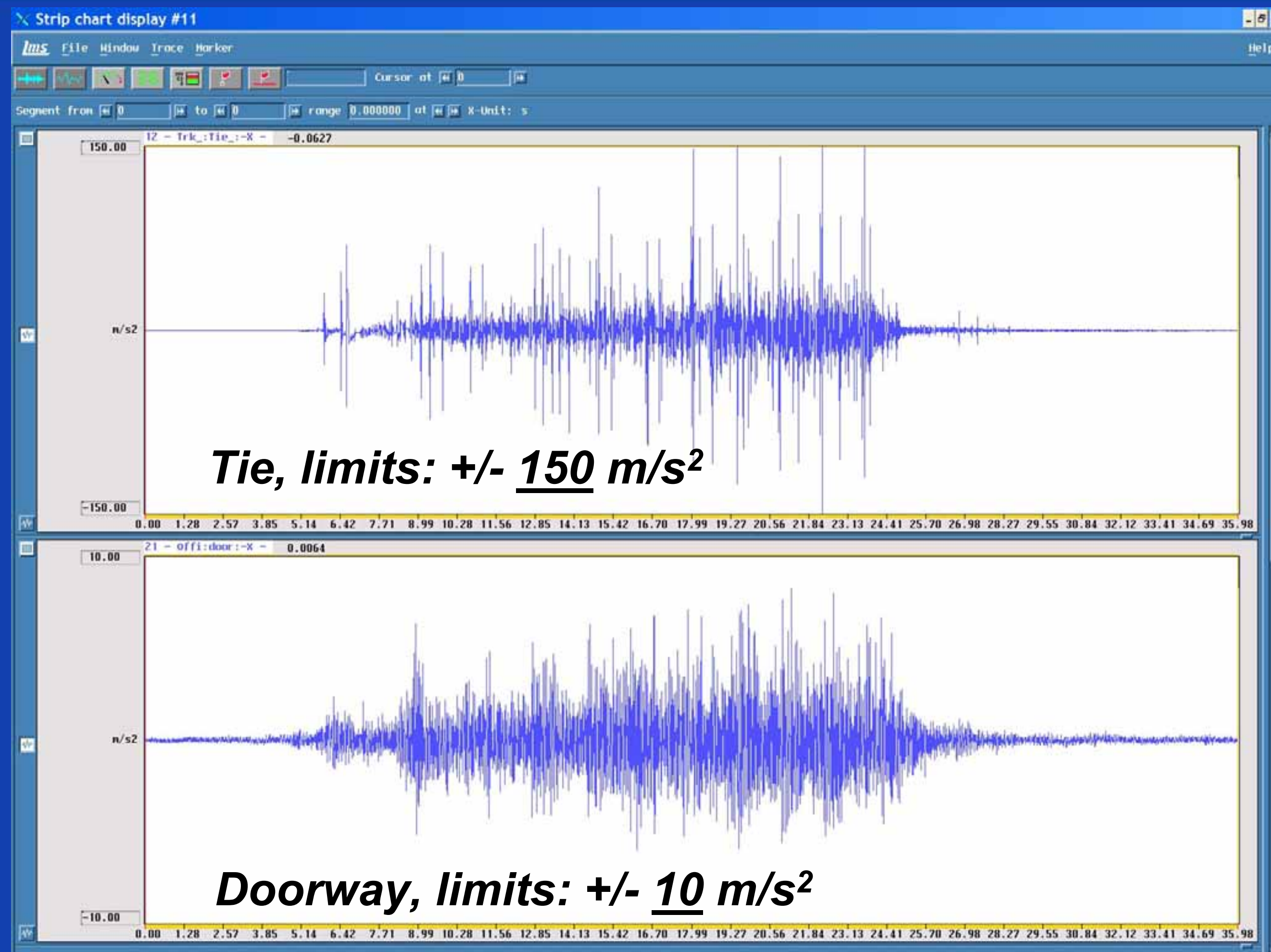
Site 1 measurement examples

Comparison between vibration on tie & doorway for train on northbound tracks (parallel direction, X):

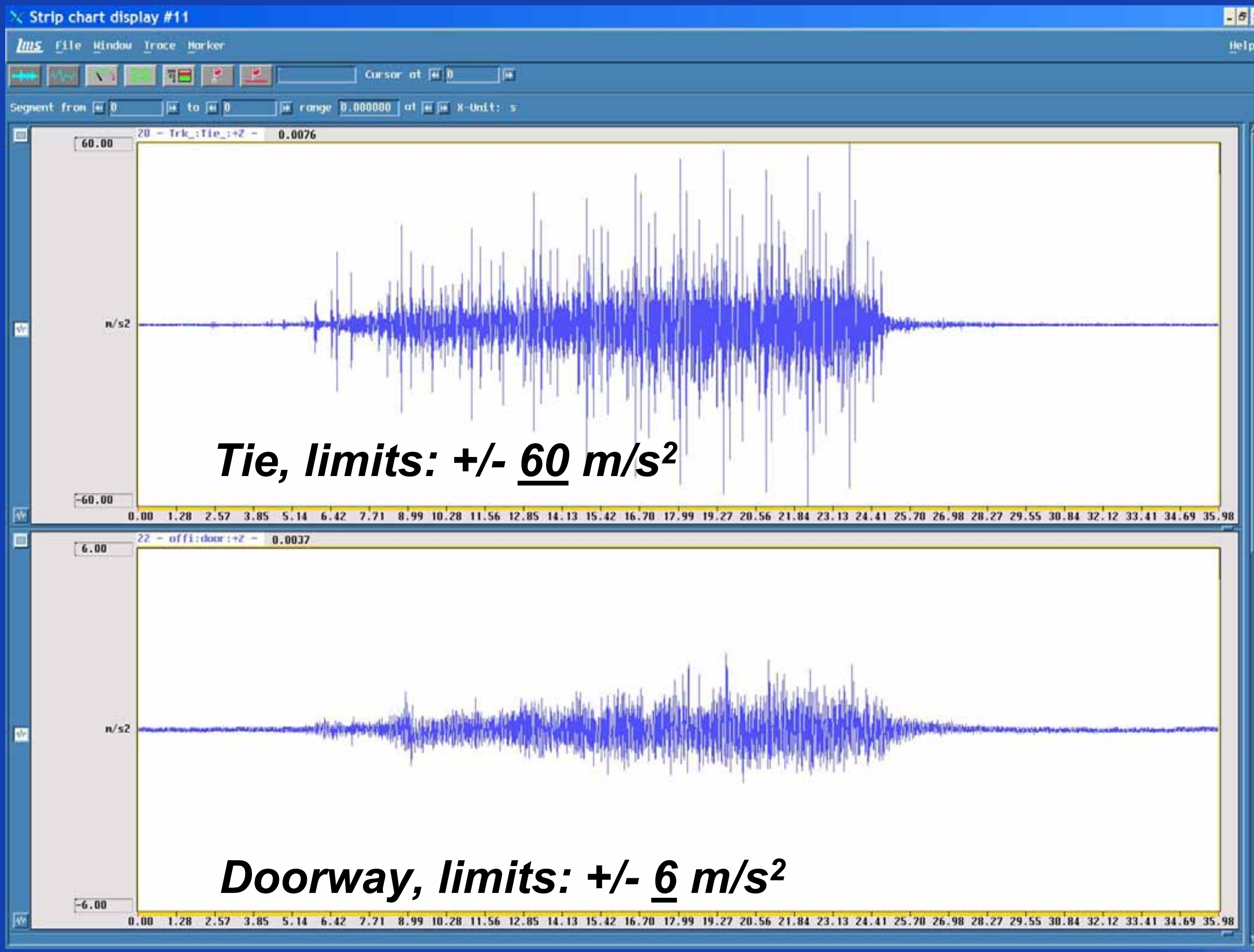
Closest & furthest measurement location



Site 1 measurement examples

Comparison between vibration on tie & doorway for train on northbound tracks (vertical direction, Z):

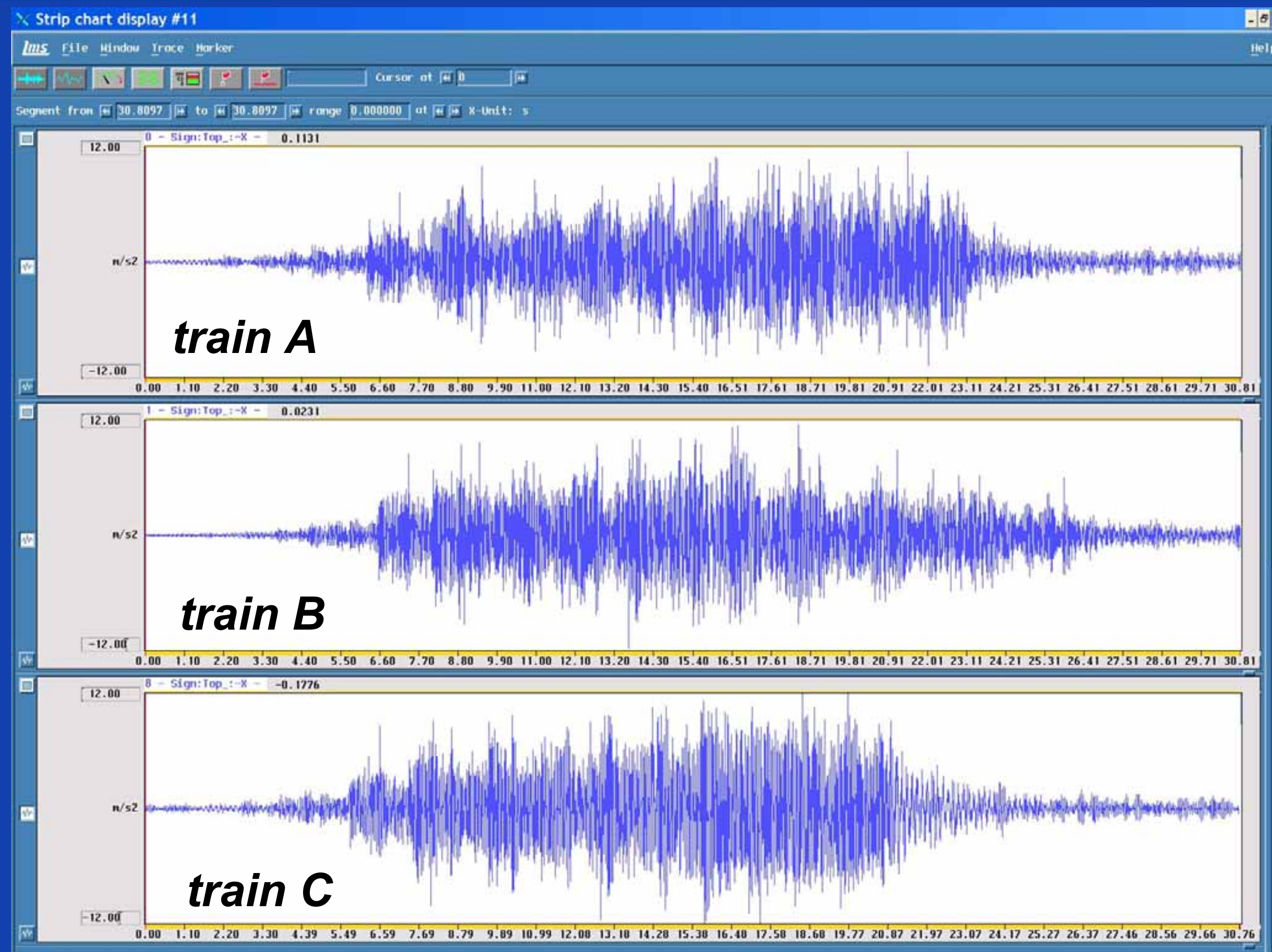
Closest & furthest measurement location



Site 1 measurement examples

Comparison between vibrations on top of signal 2378 between different trains on northbound tracks (parallel direction, X):

Limits: +/- 12 m/s2



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Site 2 details

Site 2 = 277 Central instrument room, on subwayline 2&5, (New York City, NY)

Site 2 axis system definition:

- X: parallel with rails, positive Northbound
- Y: transverse to rails, positive from N to S'bound track
- Z: Vertical direction, positive upwards

Site 2 locations:

- On top & bottom of PLC-cabinet rack 17

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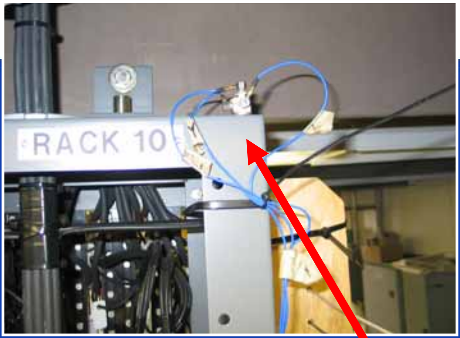
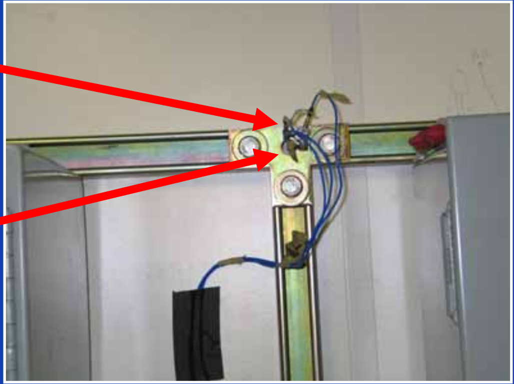
Site 2 details

Site 2 locations:

- On top & bottom of relay rack 10,
- On wall near automatic transfer panel
- On floor near automatic transfer panel





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Site 2 measurement overview

- Instrumentation of 6 points in 3 directions on October 29
- Acquisition of data on evening rush of October 29:
  - Vibrations in instrument room were too low to be measured with available set of sensors,
  - Nevertheless, data was recorded for local southbound, northbound & express traffic,
- Logging of train traffic during measurements (time, track & direction)

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Site 3 details

Site 3 = 322 Central instrument house, on subwayline 2&5, (New York City, NY)

Site 3 axis system definition:

- X: parallel with rails, positive Northbound
- Y: transverse to rails, positive from N to S'bound track
- Z: Vertical direction, positive upwards

Site 3 locations:

- On top & bottom of CIH
- On support structure of CIH

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Site 3 measurement overview

- Instrumentation of 3 points in 3 directions on October 29
- Acquisition of data on morning rush of October 30:
  - Vibrations are higher than in CIR,
  - Data recorded for local tracks (North- & South-bound) & express track,
  - About 15 local southbound trains recorded,
  - About 3 express trains recorded,
  - About 20 local northbound trains recorded,
- Logging of train traffic during measurements (time, track & direction)

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Site 4 details

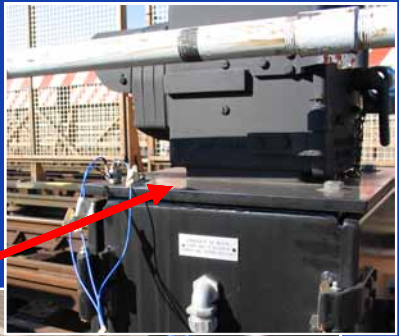
Site 4 = Signal 3293 on track 3 (near column 293) on subwayline 2&5, (New York City, NY)

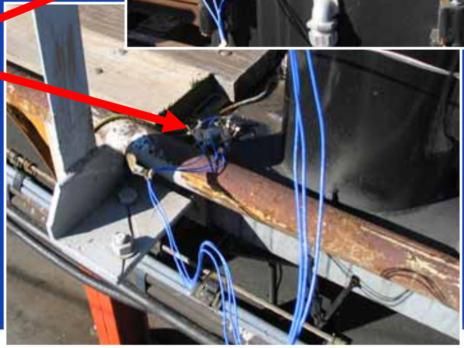
Site 4 axis system definition:

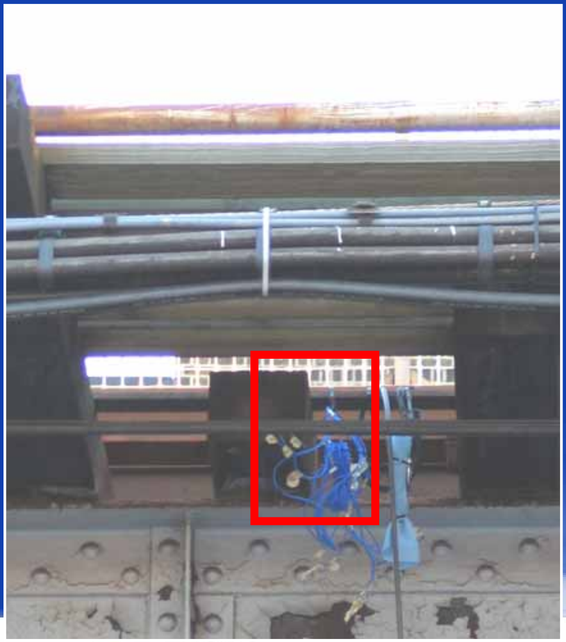
- X: parallel with rails, positive Northbound
- Y: transverse to rails, positive from N to S'bound track
- Z: Vertical direction, positive upwards

Site 4 locations:

- On top & bottom of signal
- On rail & tie near rail joint







Site 4 measurement overview

- Instrumentation of 4 points in 3 directions on October 30
- Acquisition of data on evening rush of October 30:
  - Data recorded for local tracks (North- & South-bound) & express track,
  - About 22 local southbound trains recorded,
  - About 9 express trains recorded,
  - About 15 local northbound trains recorded,
- Logging of train traffic during measurements (time, track & direction)

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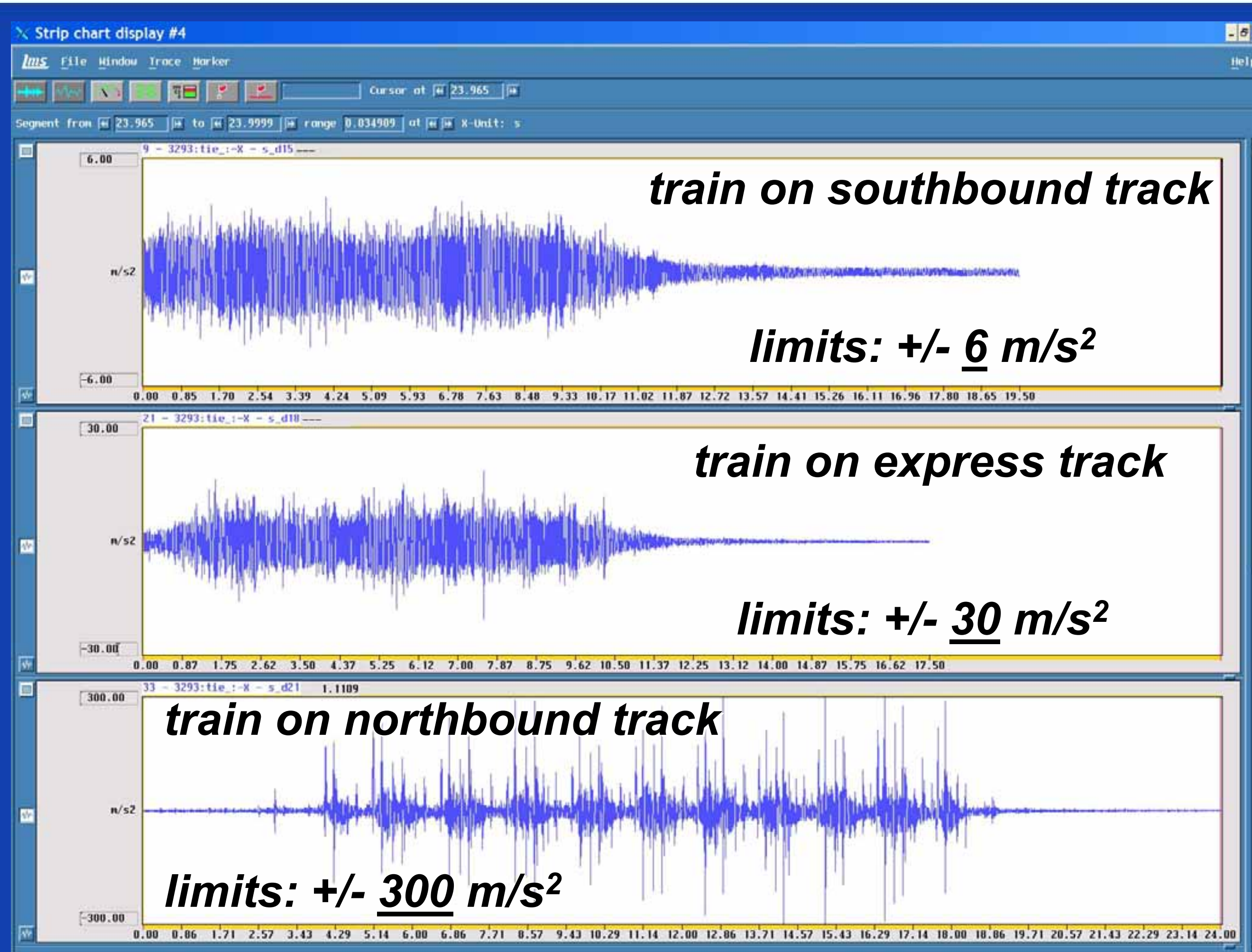
Site 4 measurement examples

Comparison of vibration on the tie in parallel direction between trains passing on different tracks:

Proximity of train is important towards vibration amplitude



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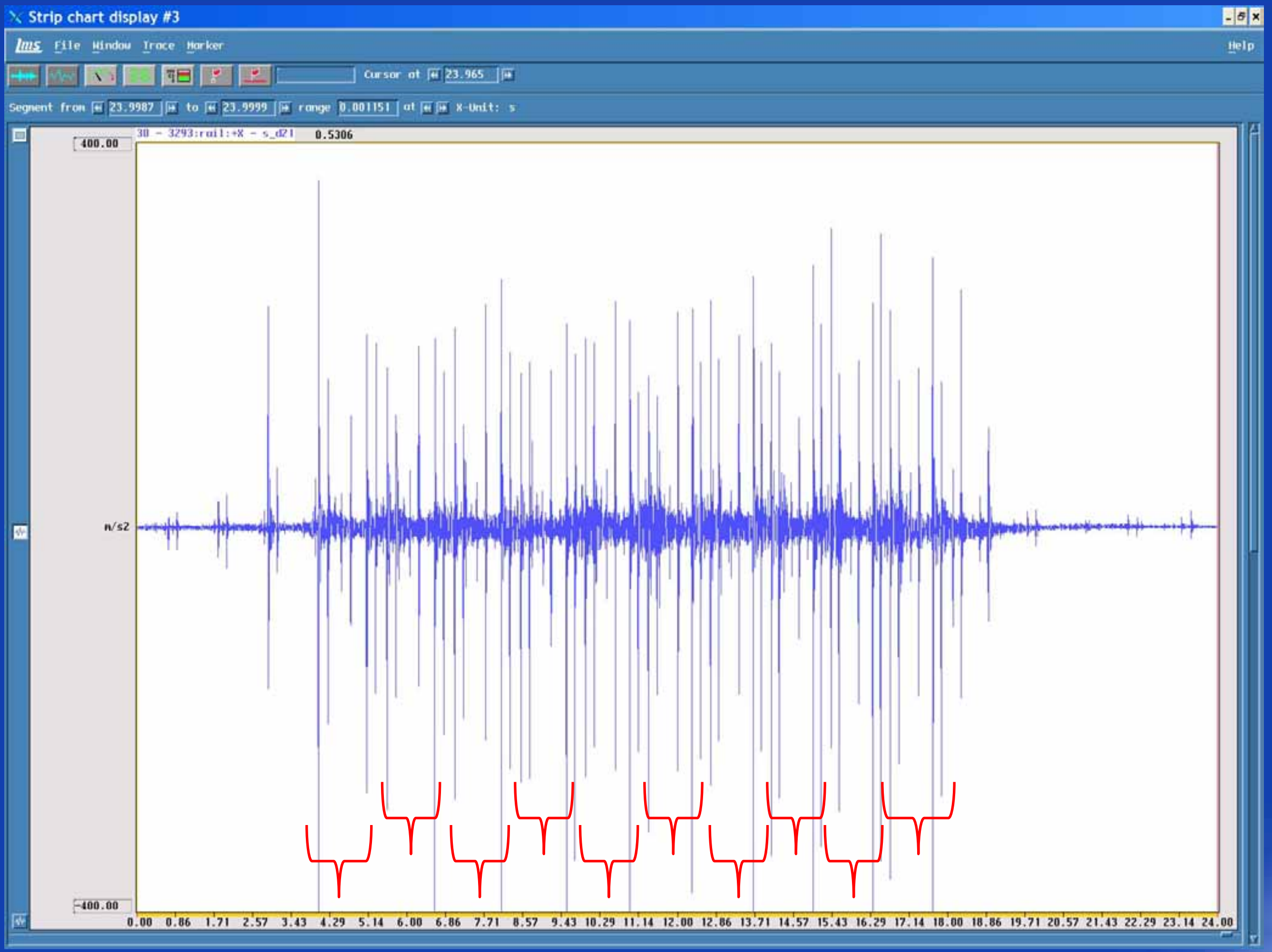
Site 4 measurement examples

Vibration on rail in parallel direction for northbound train:

Limits: +/- 400 m/s²

Identification of cars passing is possible



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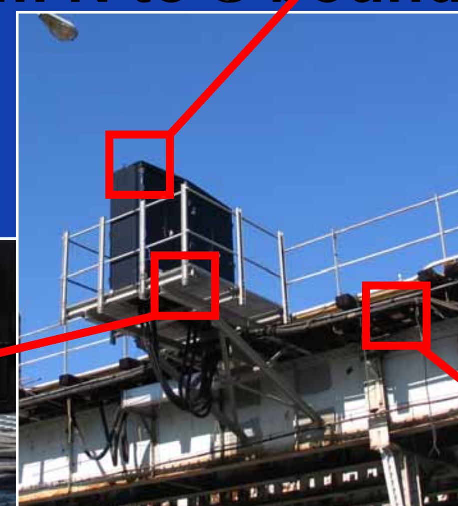
Site 5 details

Site 5 = 350 Central Instrument House on subwayline 2&5, (New York City, NY)

Site 5 axis system definition:

- X: parallel with rails, positive Northbound
- Y: transverse to rails, positive from N to S'bound track
- Z: Vertica, positive upwards



Site 5 locations:

- On top & base of CIH
- On tie near CIH

Site 5 measurement overview

- Instrumentation of 3 points in 3 directions on October 30
- Acquisition of data on morning rush of October 31:
  - Some problems with overnight humidity in cables and sensors, solved by adding other sensors in parallel from previous site,
  - Data recorded for local tracks (North- & South-bound) & express track,
  - About 15 local southbound trains recorded (only 7 for added channels),
  - About 6 express trains recorded (none for added channels),
  - About 20 local northbound trains recorded (only 7 for added channels),
- Logging of train traffic during measurements (time, track & direction)

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Processing (ongoing & planned)

- **Comparison between measurements at different locations**
- **Comparison between different trains**
- **Regrouping of acquired data for life profiles based on location & vibration levels**
- **Setup of data structure & processing tools for profile synthesis calculations**

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Input necessary for mission synthesis

- Acceleration data for all possible situations:
  - time series for isolated shock phenomena, measured on tracks (for instance bad wheel passing)
  - frequency spectra for stationary segments of data (for instance regular vibrations caused by train passing)

  - Time recordings taken during the measurements will be selected (for the isolated phenomena if present) & processed (into spectra for “regular” vibrations) to be used as input for the mission synthesis

Input necessary for mission synthesis

- **Statistical data on the vibrations:**

A typical life cycle will be built up based on the measured situations, therefore it will be necessary to have information on their frequency of occurrence:

- **number of passing trains per unit of time (day/week/…) will be derived from train schedule**
- **number of special occurrences (like bad wheel passing) will be included with frequency of presence in the acquired data**

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Input necessary for mission synthesis

- **Material properties:**

Despite the independency of the calculation from the product design (geometry, weight, layout,…), there must be a basic idea of the material properties of the components that will be used in the mounted equipment:

  - **Information source: Alstom**
  - **Assistance: LMS**
  - **Ongoing**

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