

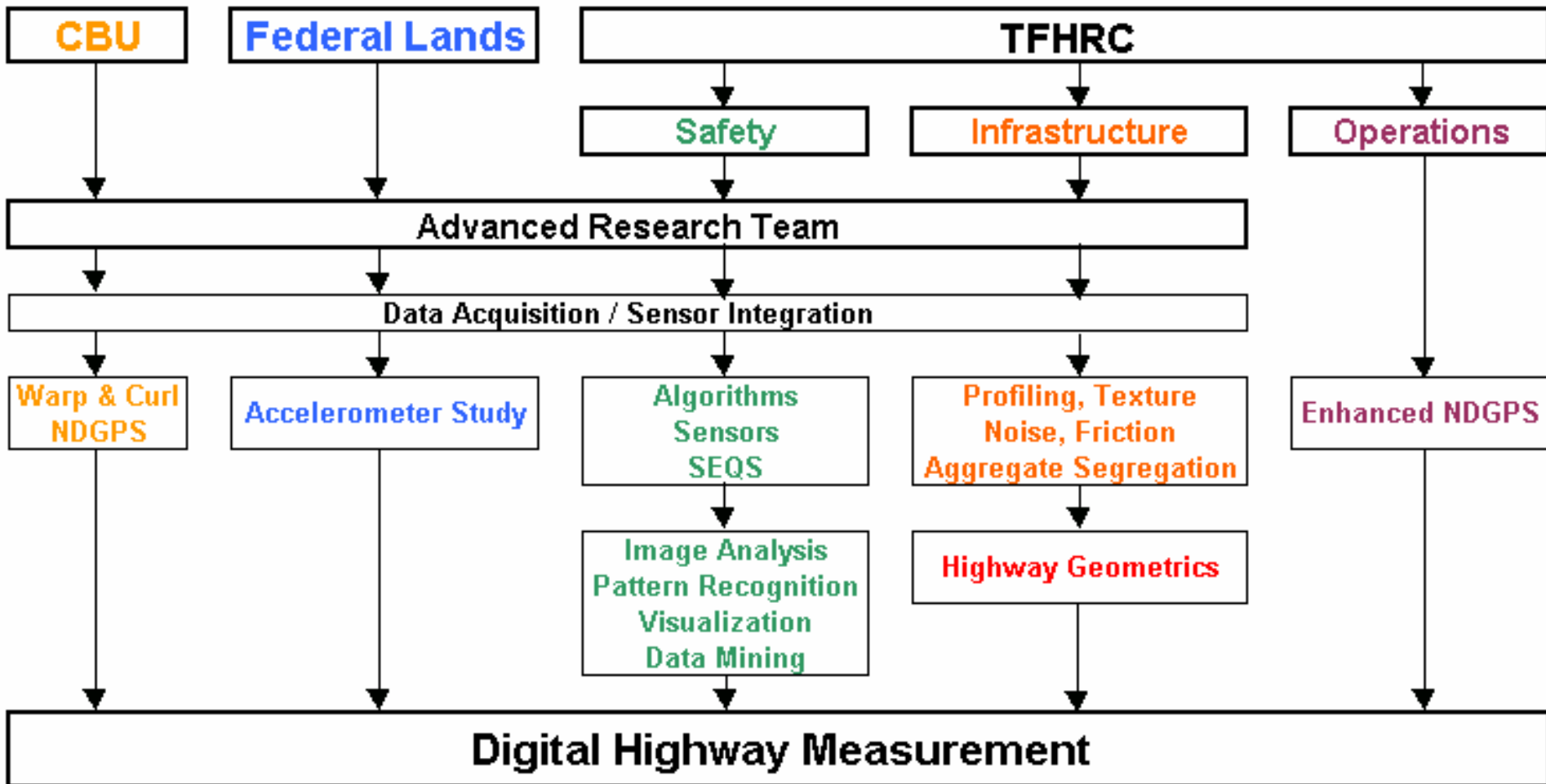


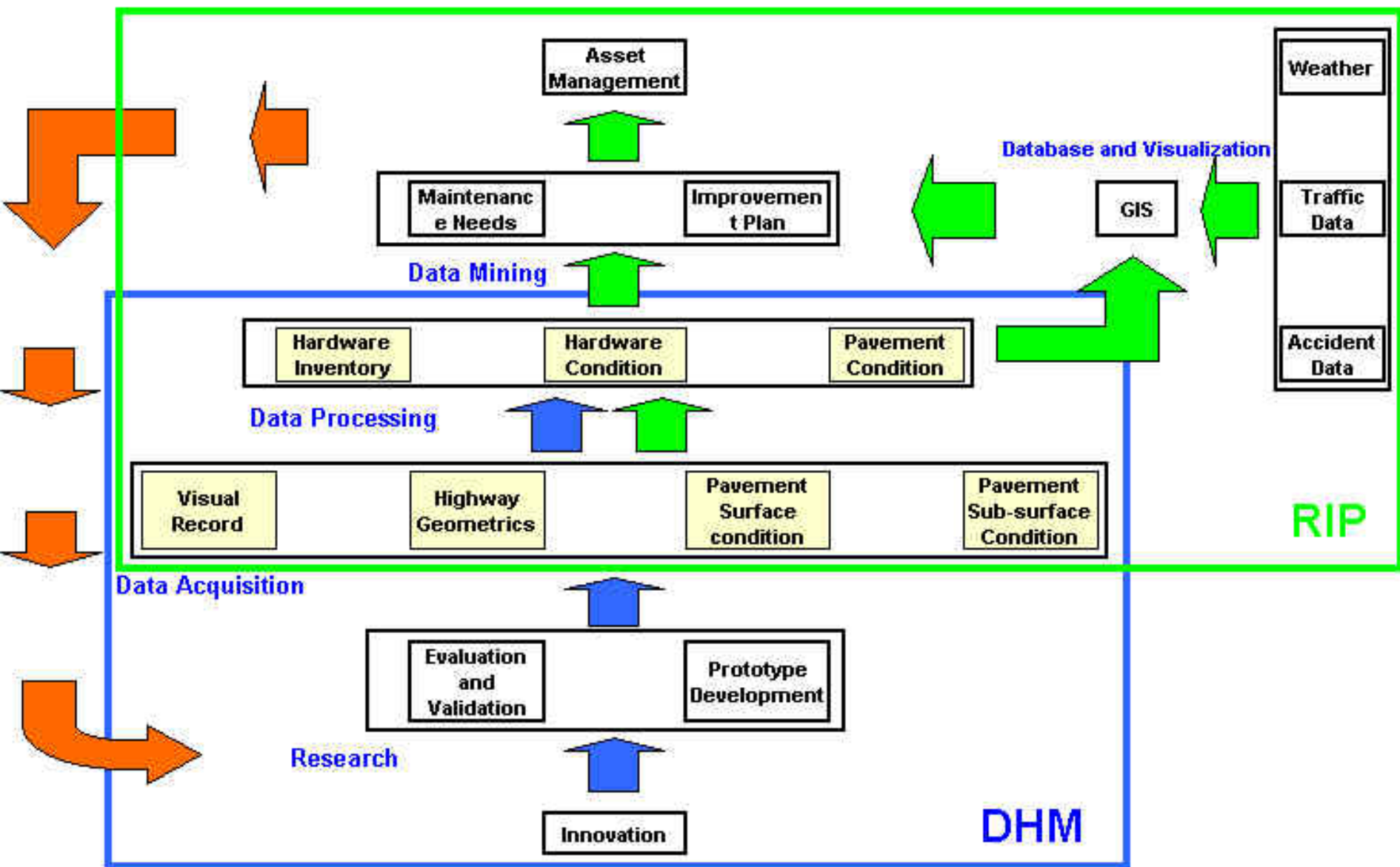
AN OVERVIEW OF THE COLONIAL PARKWAY DHM PROJECT

**TURNER-FAIRBANK HIGHWAY RESEARCH CENTER
ADVANCED RESEARCH TEAM
AND
EASTERN FEDERAL LANDS HIGHWAY DIVISION**

APRIL 19, 2005

DHM-Background





DHM = Digital Highway Measurement

RIP = Federal Lands Road Inventory Program

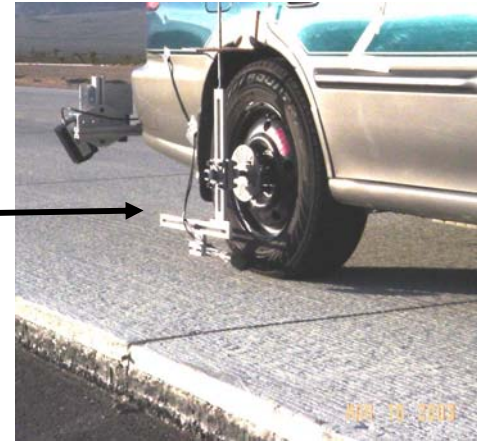
Vehicle and Phase I Sensors



DHM-Potential Additions



GPR Antenna



Sound
Intensity
Pressure
Device

OTHERS.....

DHM-Components

Operational Considerations:

- Data collected at traffic speeds

- Vehicle lane wander removed from data

- Traffic control not needed

- Data not affected by stop-and-go operations in urban and rural environments where continuous GPS coverage is not available.

Geometry:

- Horizontal alignment

- Vertical alignment

- Cross-slope

- Lane width/Lane Markings/Edge of pavement

- Roadside profile

DHM-Accuracy

Parameter	Accuracy								
Centerline	function of length of site -- see table of results in appendices B and C								
Pavement marking	less than one inch								
Edge of pavement	less than six inches								
Vehicle wander	less than one inch when pavement markings are available								
Stationing	function of continuity of reference line used for centerline -- see table of results in appendices B and C								
Cross-slope	0.01%								
Roadside profile	<table border="1"> <caption>Roadside profile Accuracy Data</caption> <thead> <tr> <th>Range in feet</th> <th>Accuracy in inches</th> </tr> </thead> <tbody> <tr> <td>5</td> <td>0.04</td> </tr> <tr> <td>30</td> <td>0.14</td> </tr> <tr> <td>50</td> <td>0.24</td> </tr> </tbody> </table>	Range in feet	Accuracy in inches	5	0.04	30	0.14	50	0.24
Range in feet	Accuracy in inches								
5	0.04								
30	0.14								
50	0.24								
Alignment extraction									
Horizontal	less than two feet								
Vertical	0.01%								
Macrotexture	within standards specifications								
Roughness	within standards specifications								

DHM-Components (continued)

Video Analysis

3-D reconstruction using stereoscopic cameras based on automated feature recognition and matching

Feature recognition and classification, including off-the-road Optical Character Recognition (OCR) for classification of features

Pavement surface

Roughness/Smoothness/Macrotexture

Joint recognition (longitudinal and transverse)

Faulting/Rutting/Surface temperature

Pavement sub-surface

Pavement thickness

Base and sub-base geometry

Bridge deck/Culverts and utilities/Voids

Tire-pavement interaction noise

DHM-Documentation

- Phase I Research Report (in Preparation)
- Executive Summary (Final Draft)
- TRB 2005 Brochure
- Task Report – Ground Penetrating Radar
- Executive Summary – Image Processing (in Preparation)

DHM Field Collection

Preparing DHM

Site Information

- Determine site and data storage requirements
- Prepare Log sheets

Vehicle Preparation

- Check vehicle
- Check computer and sensors
- System check
- Test collection
- Data check using Log file and DHM Data Viewers

Calibration (see Appendix A)

Starting DHM

Optional reflective markers

Power Startup

Primary Computer

- Boot
- DHM2 DAQ program start
- Dummy collection to initialize DLLs
- Sensor power switches / connections check

Secondary Computer

- Boot
- Scanning laser power check
- DHM2_SYS2 program start, scan laser spin-up
- Dummy collection to initialize DLLs

Inertial Navigation Unit

- Frequency convertor start
- Initialize via INU console
- Set to Navigate after ~10 minute initialization

GPS

- Reset GPS receivers if needed via clear buttons
- Boot notebook computer
- Set HA beacon communications
- Start GPS programs in correct sequence

Collecting Data with DHM

Data Collection

- Enter Casename and initialize
- Verify initialization
- Update Log
- Collect data
- Monitor operation

- Check Log file after collection

Data Transfer

- Transfer files to external hard disks

DHM-Field Procedures

DHM-Data Collection at Colonial Parkway



21 MARCH 2005

DHM-Data Collection at Colonial Parkway

Run	Direction	Scan	Field QC/QA	Comments	Length
1	west	1000rpm	scanning laser stopped halfway	Checked connections, rebooted.	23 miles
2	east	1000rpm	ok		23 miles
2	west	1000rpm	ok		23 miles
3	east	1000rpm	ok		23 miles
3	west	1000rpm	ok		23 miles
4	east	1000rpm	ok		23 miles
4	west	1000rpm	ok		23 miles
5	east	1000rpm	ok	Centerlane	23 miles
6	west	1000rpm	ok		23 miles
6	east	1000rpm	ok		23 miles
7	west	2600rpm	ok		23 miles
James	east	1000rpm	ok	Entrance divided area	5 miles
Tunnel	east	1000rpm	ok		10 miles

Total:

268 miles

DHM- New Analysis Modules

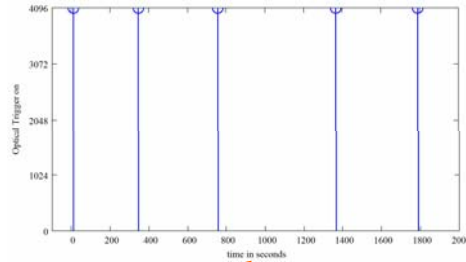
- Longitudinal Joint Recognition
- Quality Control for Scanning Laser
- Edge Low Point using Scanning Laser
- Guard Rail Recognition, Position, and Location using Scanning Laser
- Cross-section without vehicle motion using Scanning Laser

DHM-Fusion

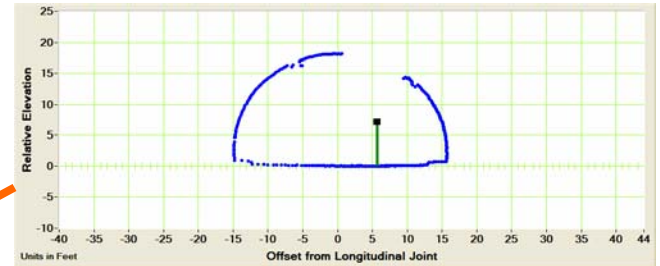
Digital Images



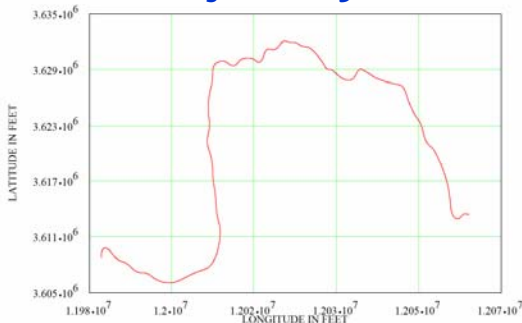
Optical Triggers



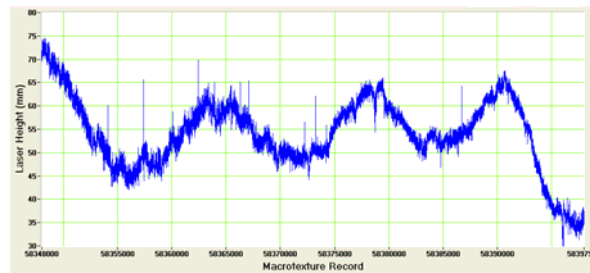
Digital Laser Scans



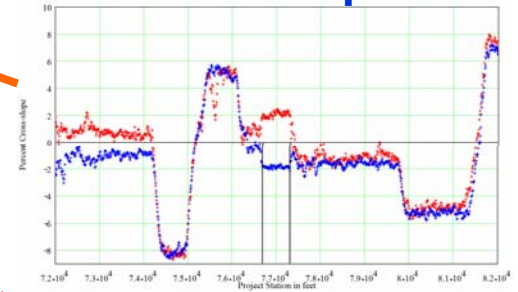
Trajectory



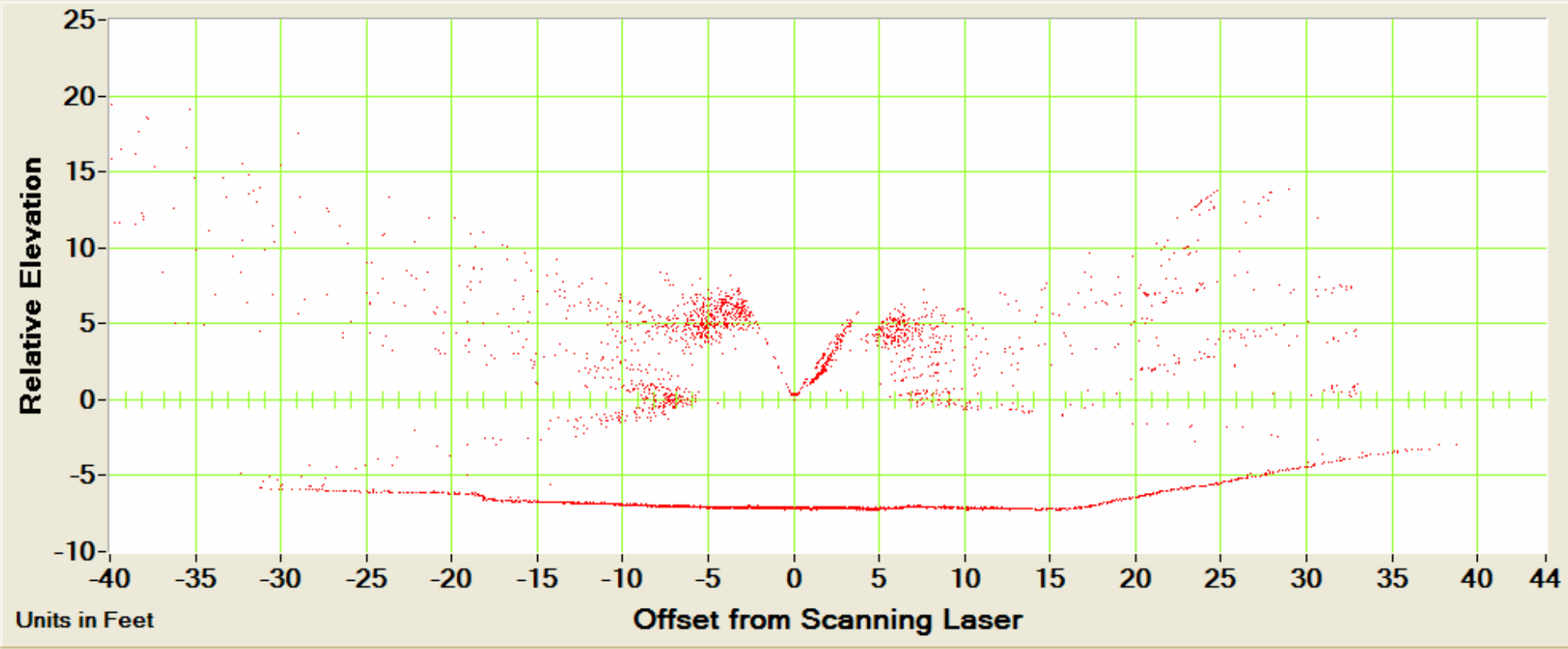
Macrotexture



Cross-Slope

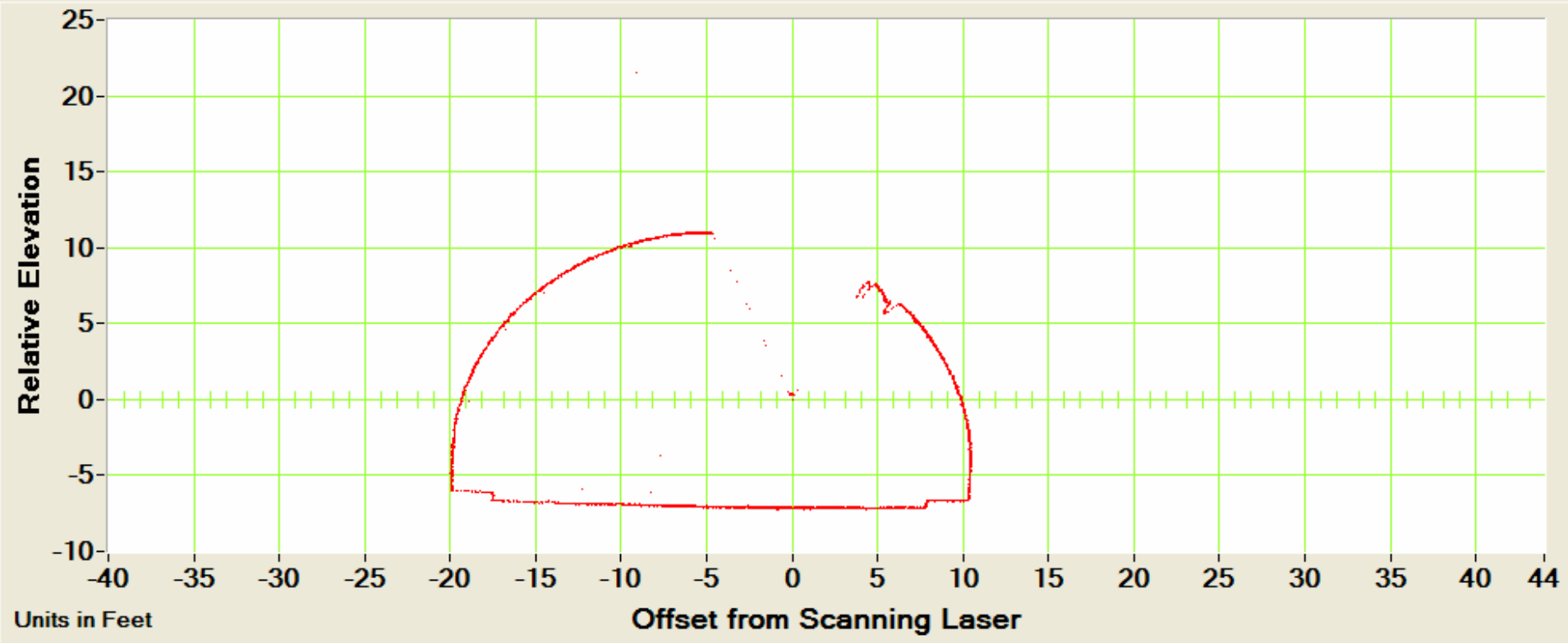


Scans



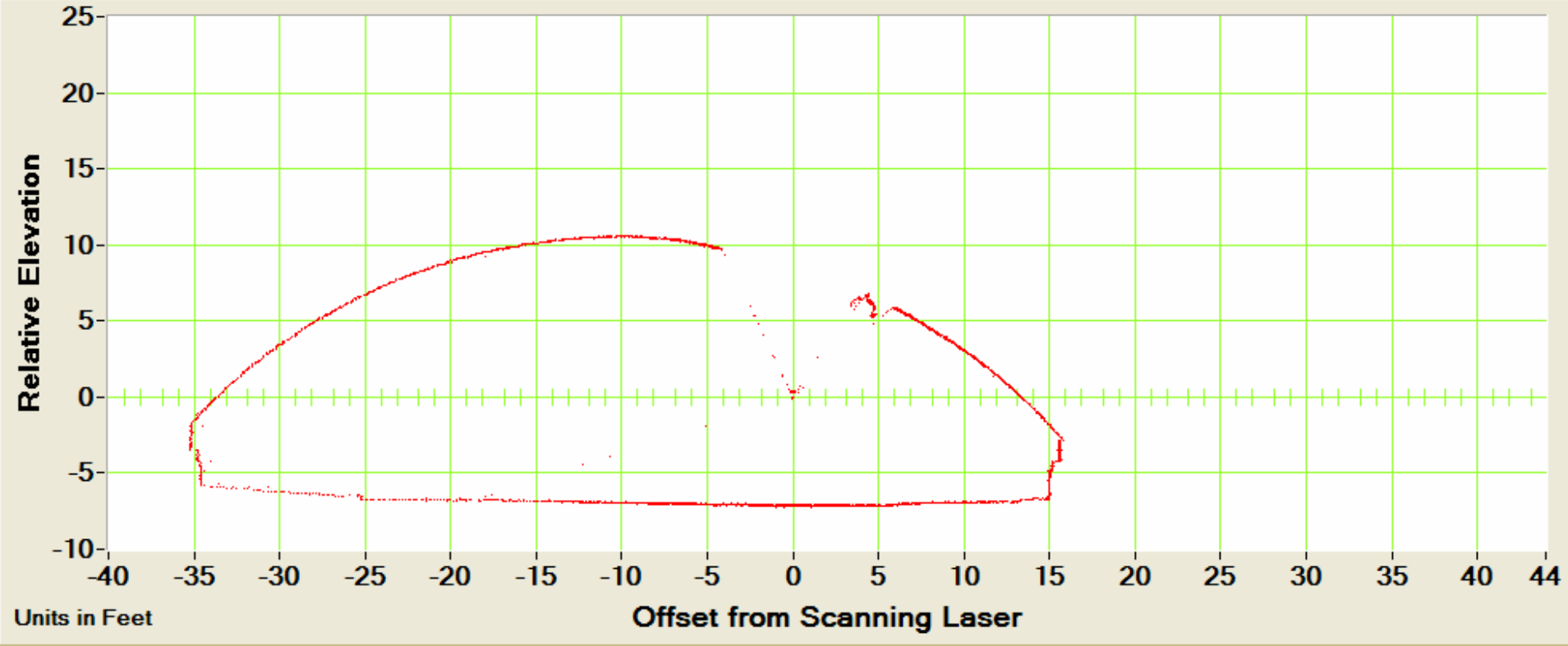
RAW DATA FOR ONE SCAN – NO FILTERS APPLIED

Scans



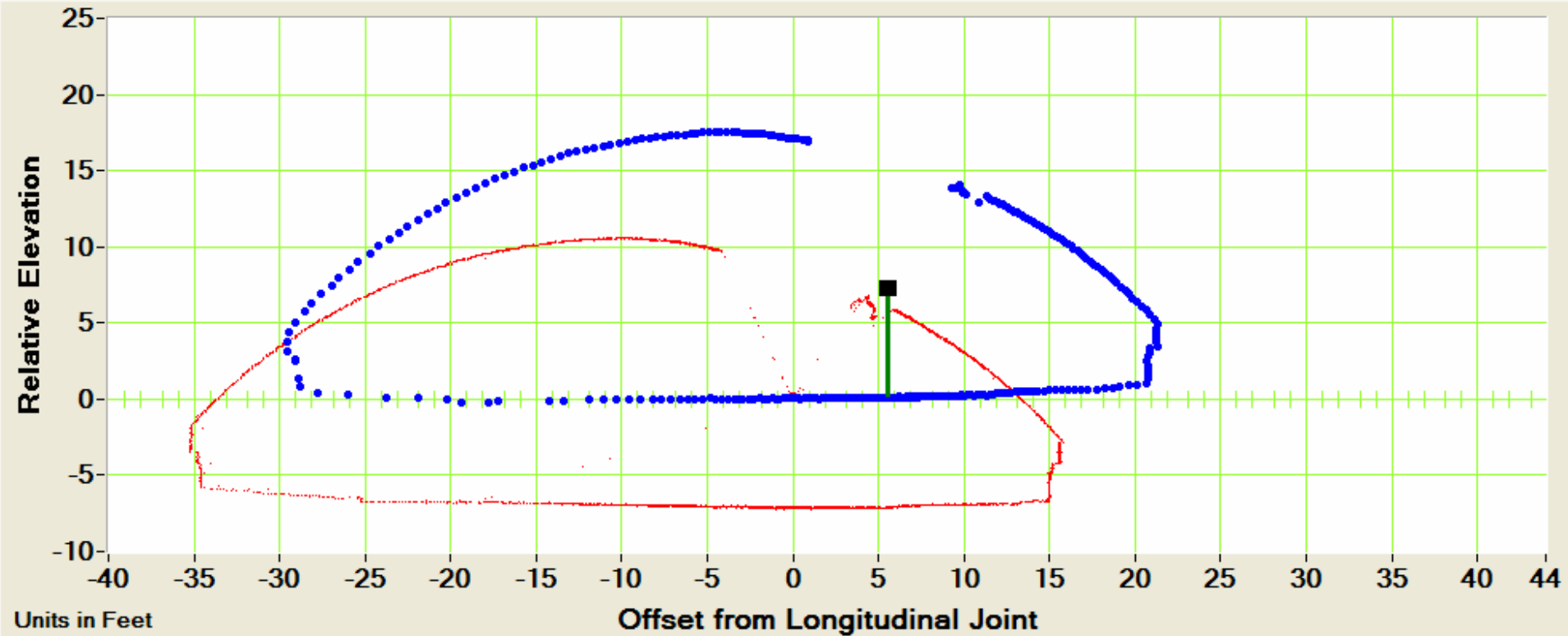
RAW DATA FOR ONE SCAN – NO FILTERS APPLIED

Scans



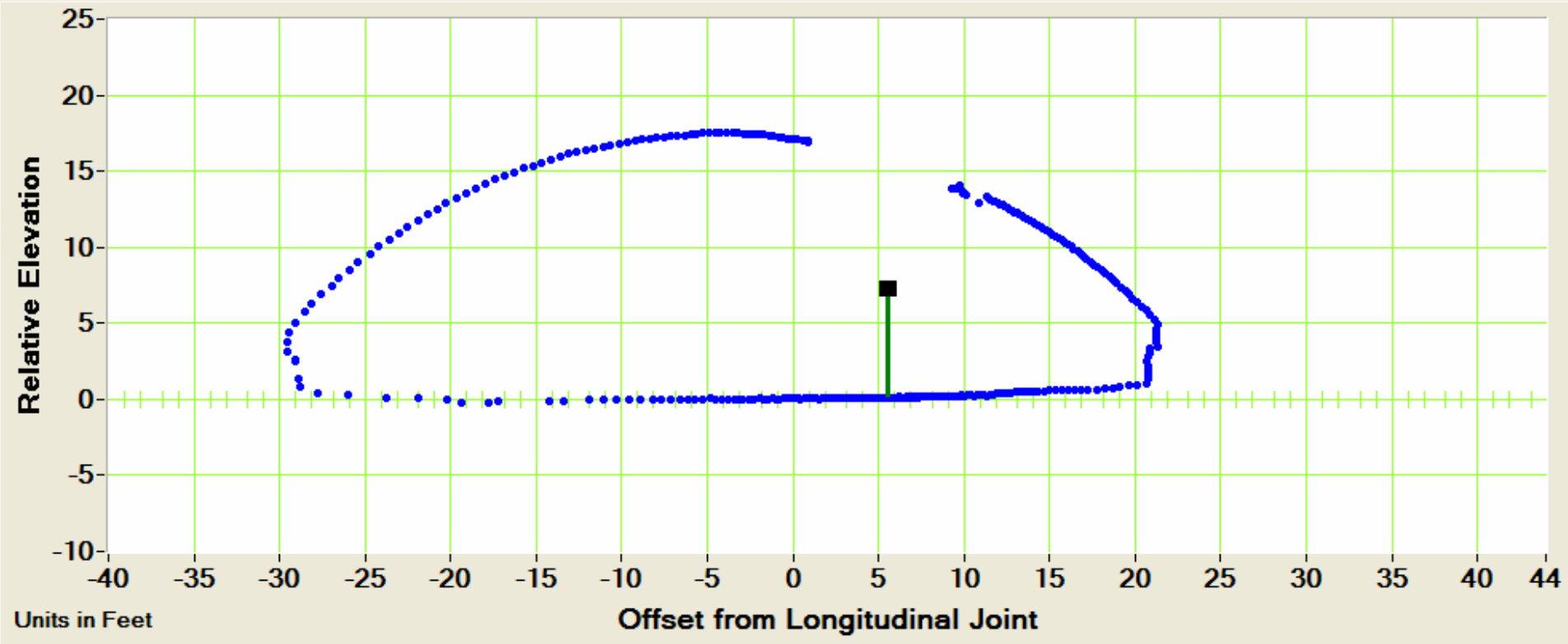
EASTBOUND, WESTBOUND –

Scans



PROCESS OF REMOVING VEHICLE ROLL MOTION, AND WANDER

Scans



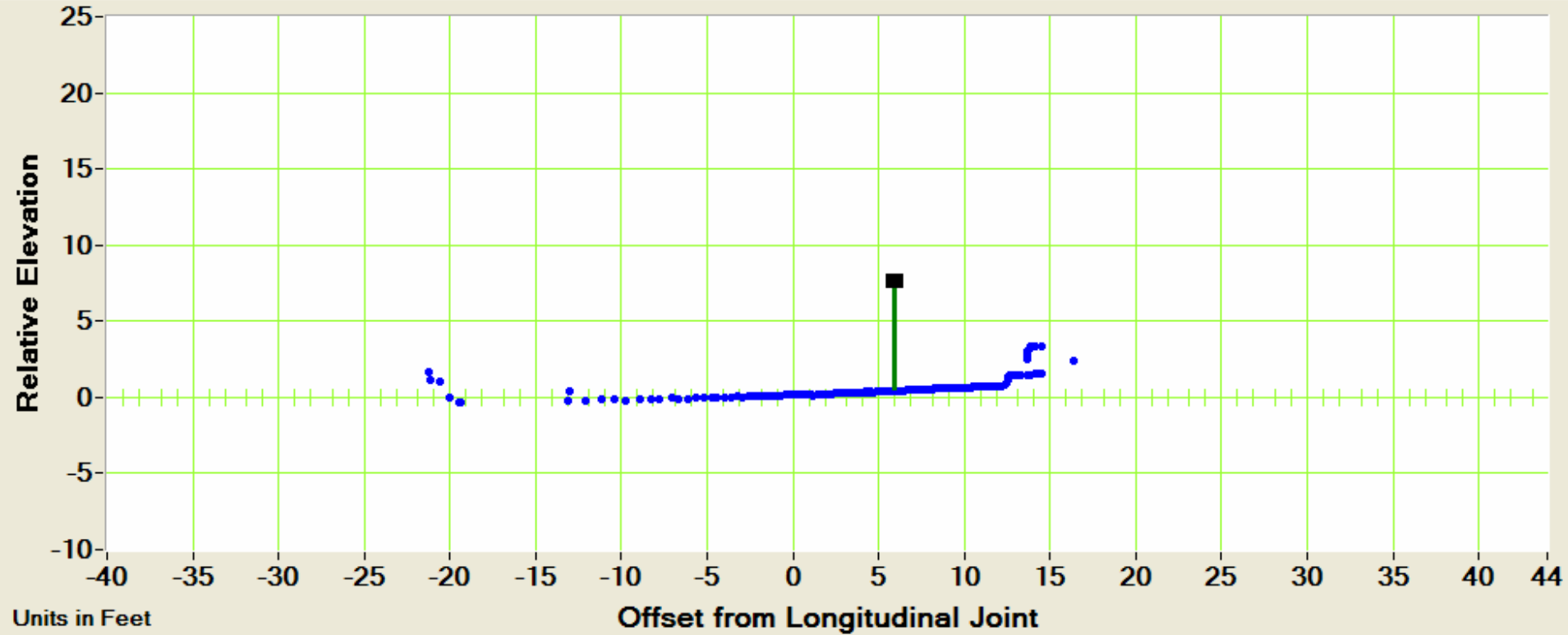
PROCESSED SCAN – ORIGIN IS PLACED AT CONTROL LINE – BRIDGE OVERPASS

Scans



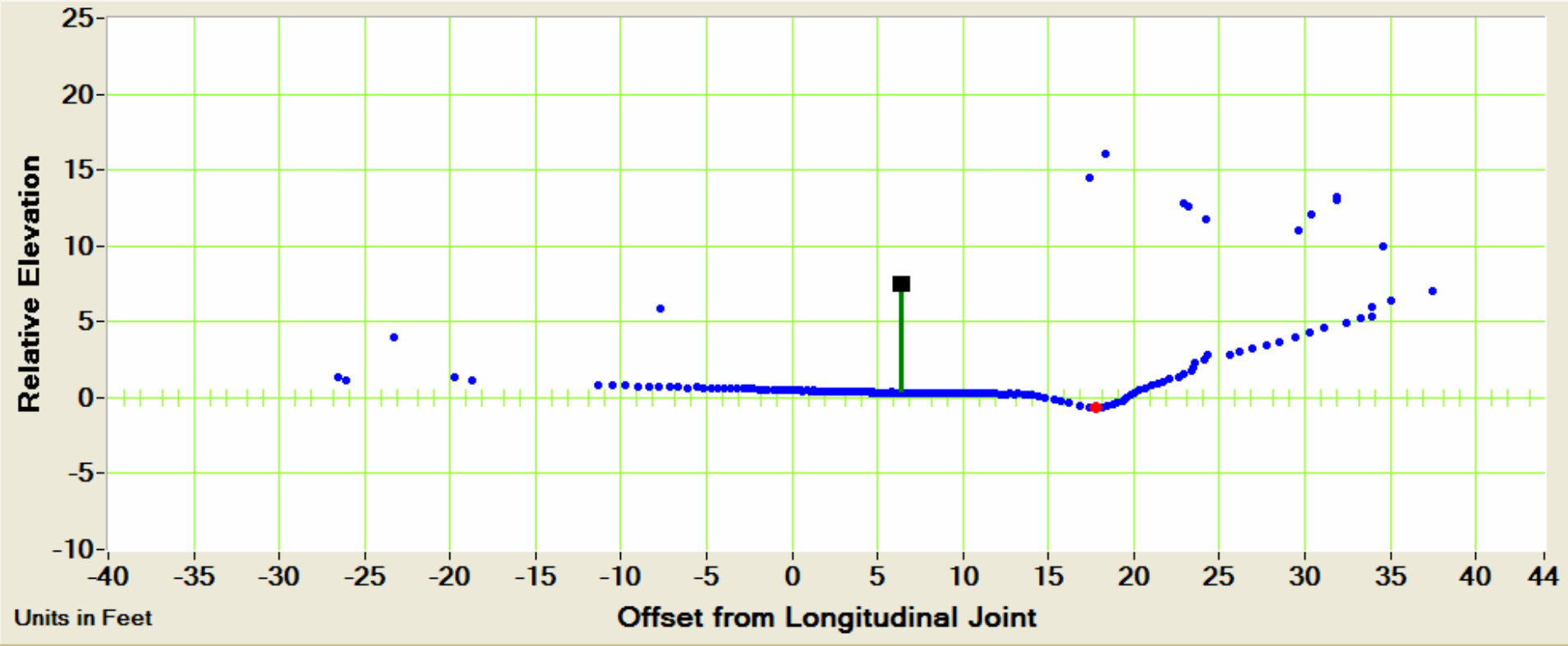
PROCESSED SCAN – ORIGIN IS PLACED AT CONTROL LINE – TUNNEL

Scans



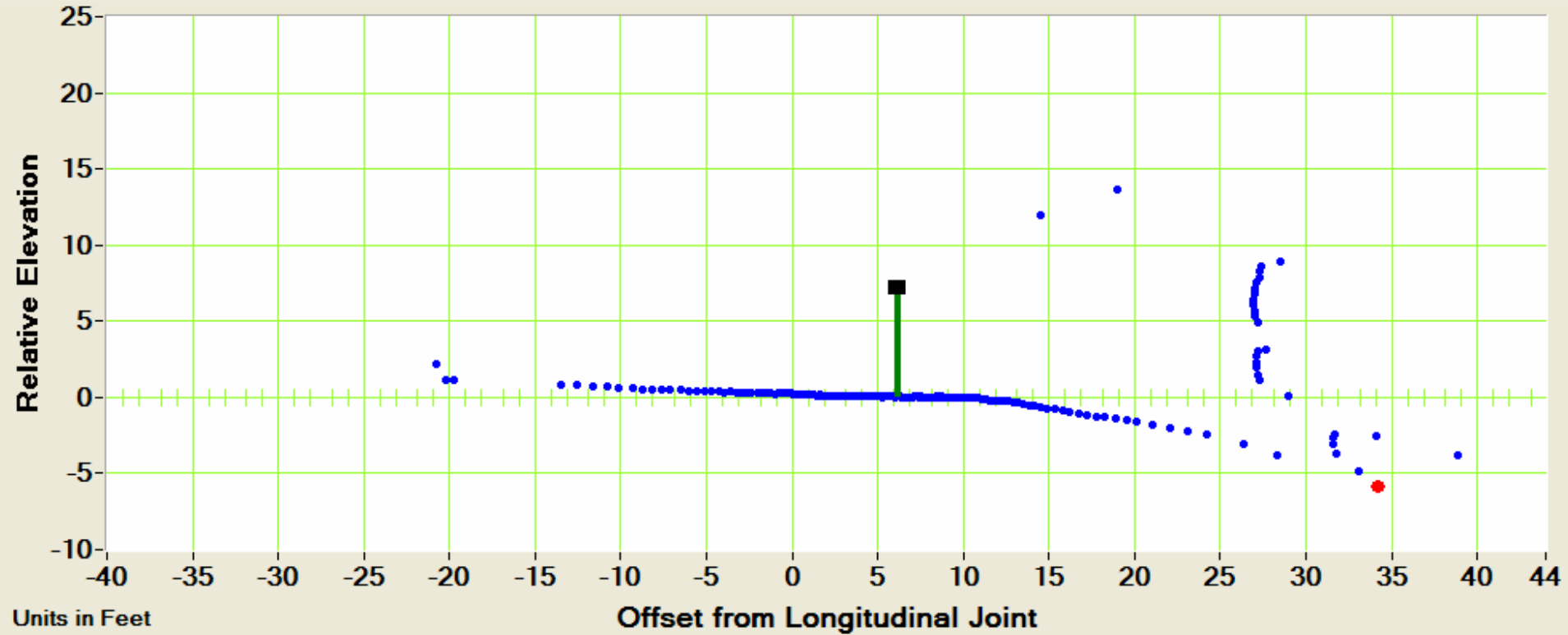
PROCESSED SCAN – ORIGIN IS PLACED AT CONTROL LINE – BRIDGE DECK

Scans



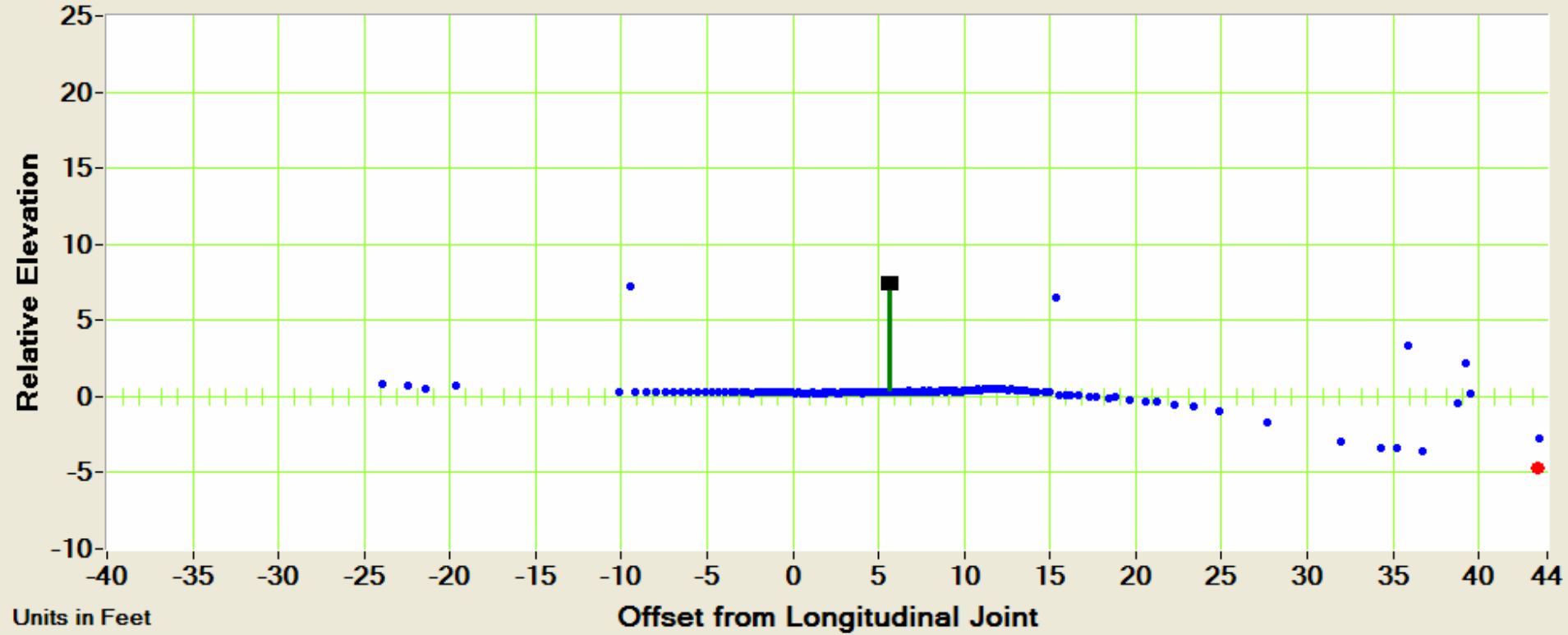
LOW POINTS

Scans



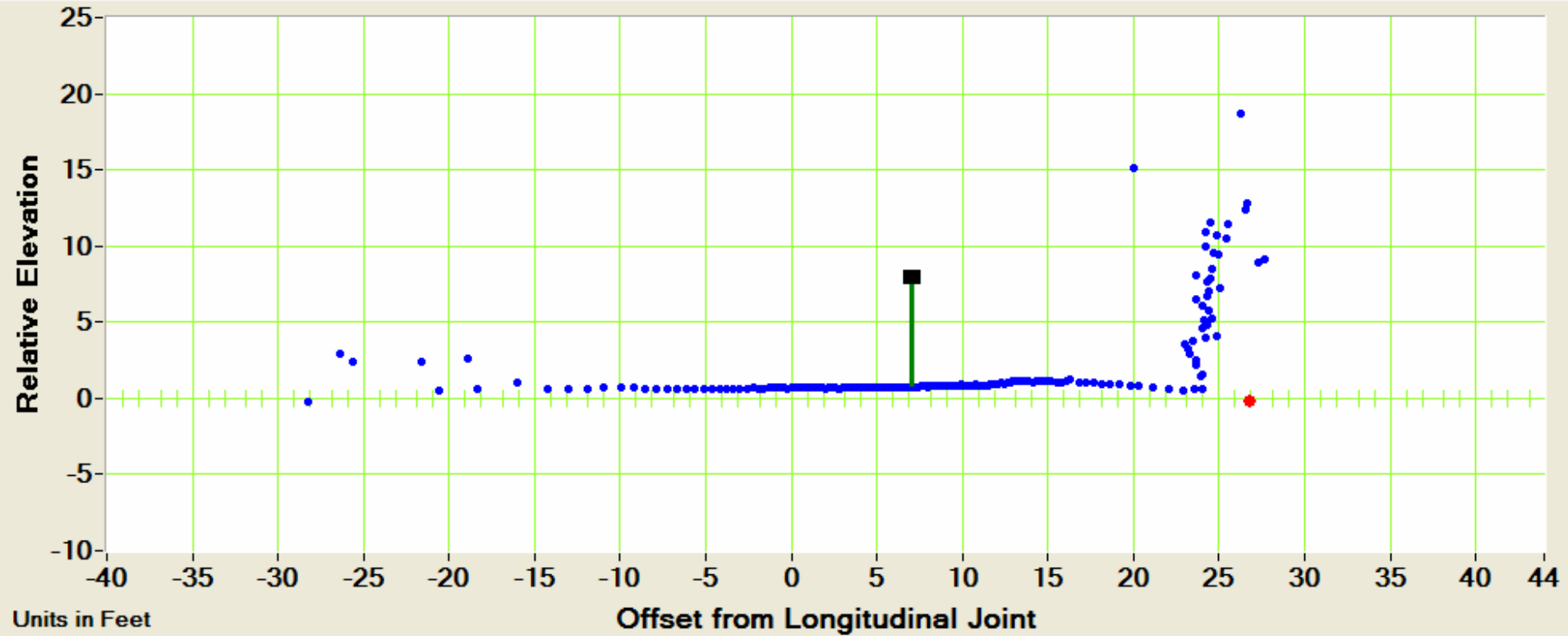
LOW POINTS

Scans



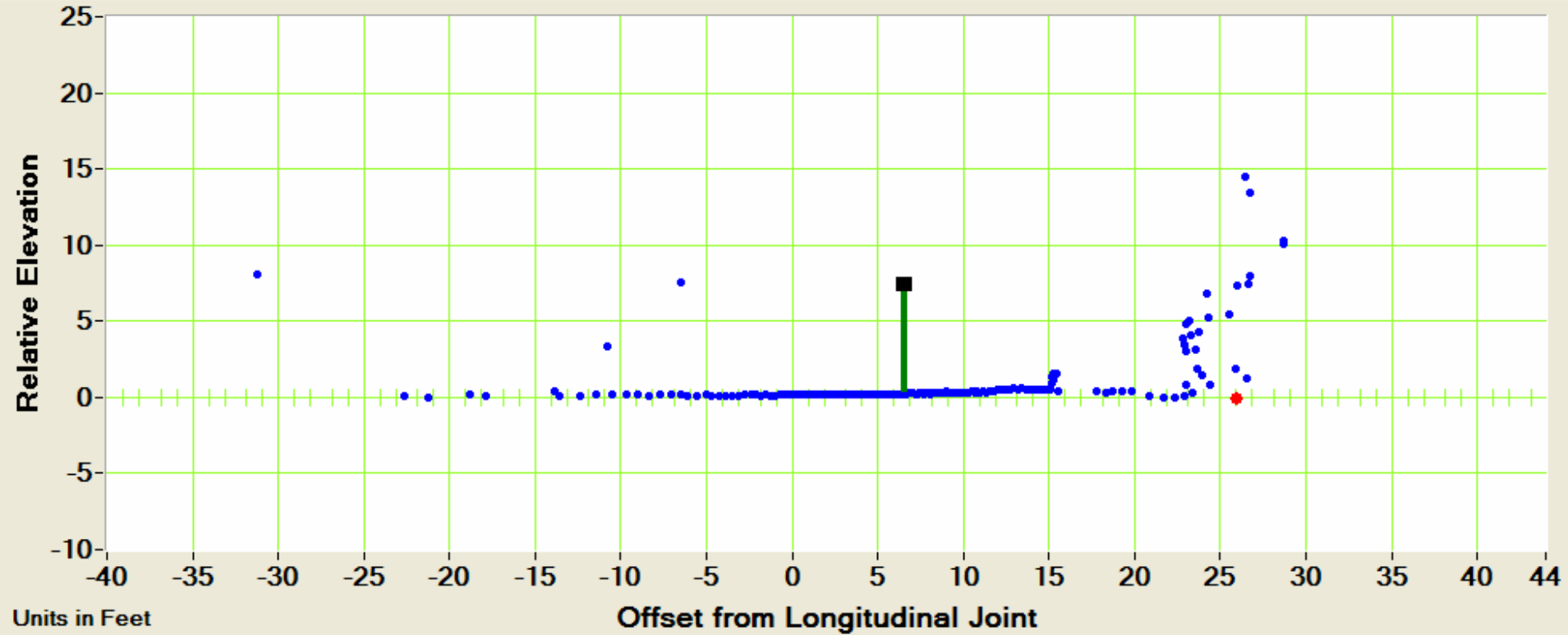
LOW POINTS

Scans



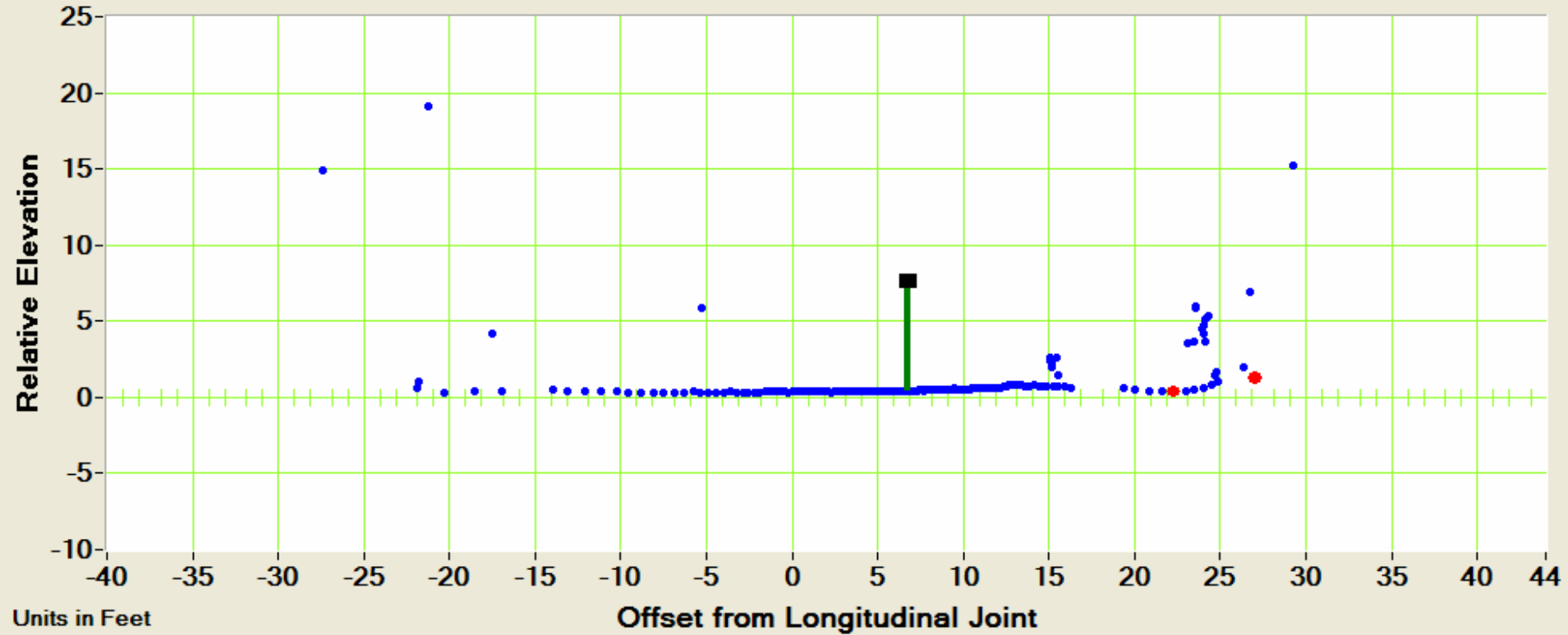
LOW POINTS, GUARD RAIL

Scans



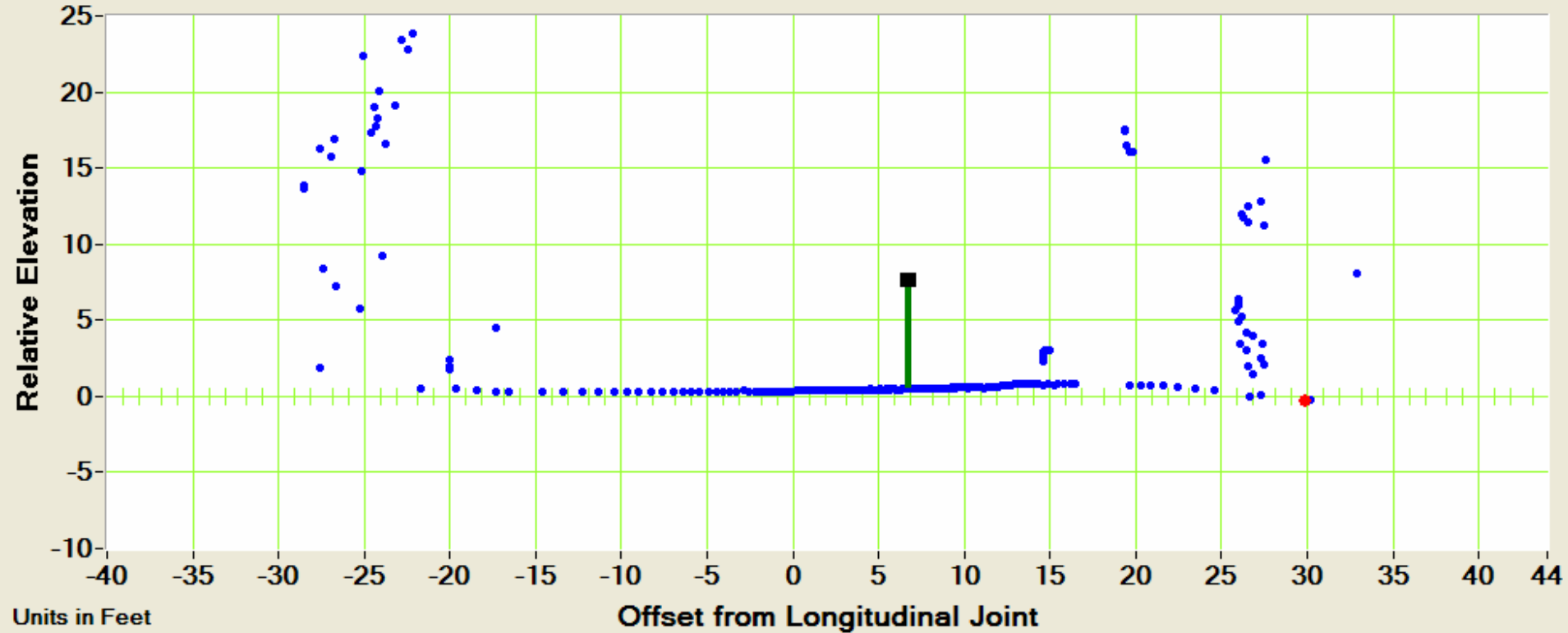
LOW POINTS, GUARD RAIL

Scans



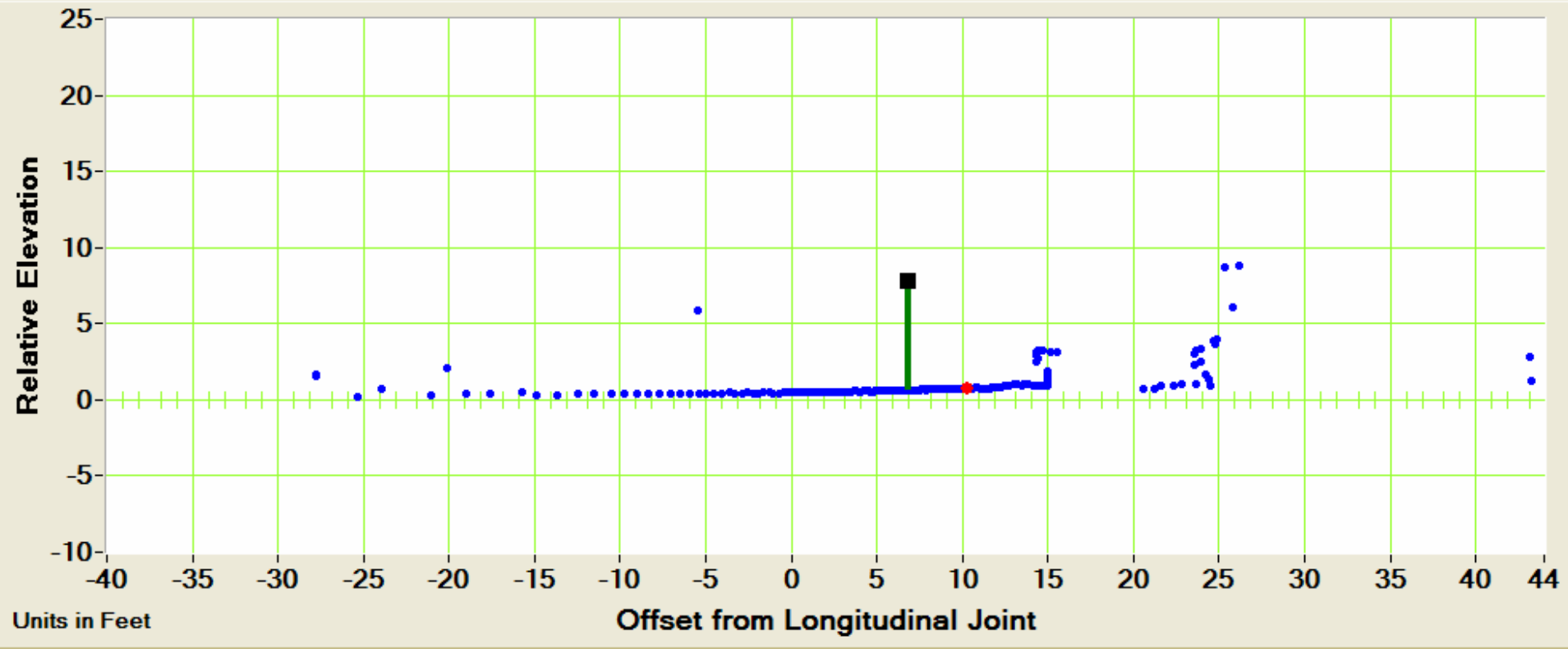
LOW POINTS, GUARD RAIL

Scans



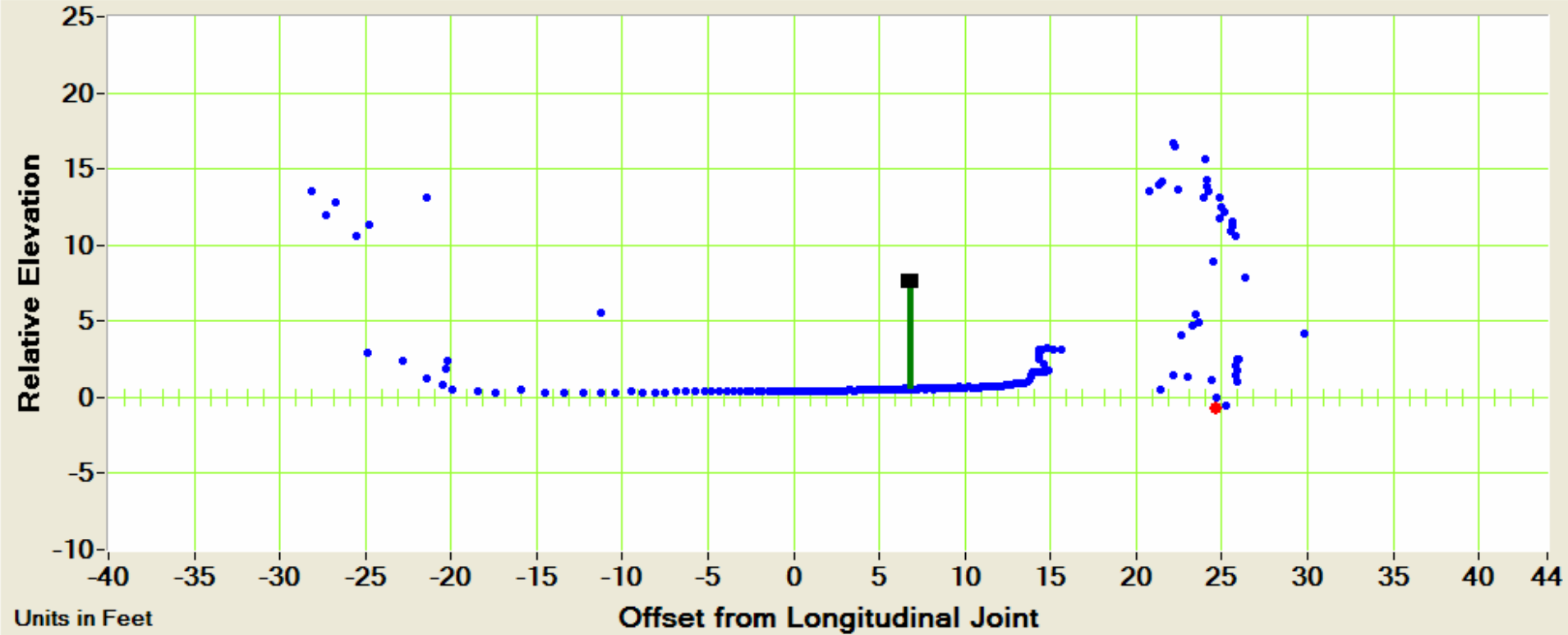
LOW POINTS, GUARD RAIL

Scans



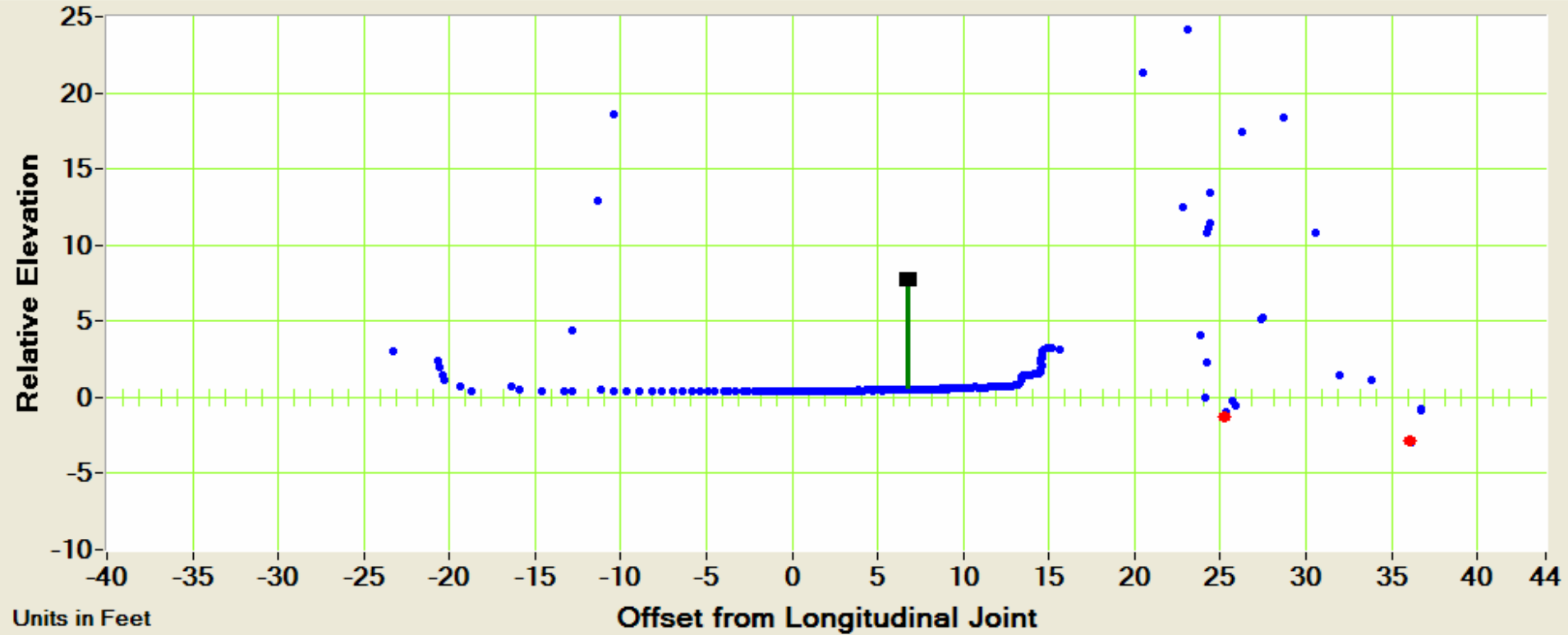
LOW POINTS, GUARD RAIL

Scans



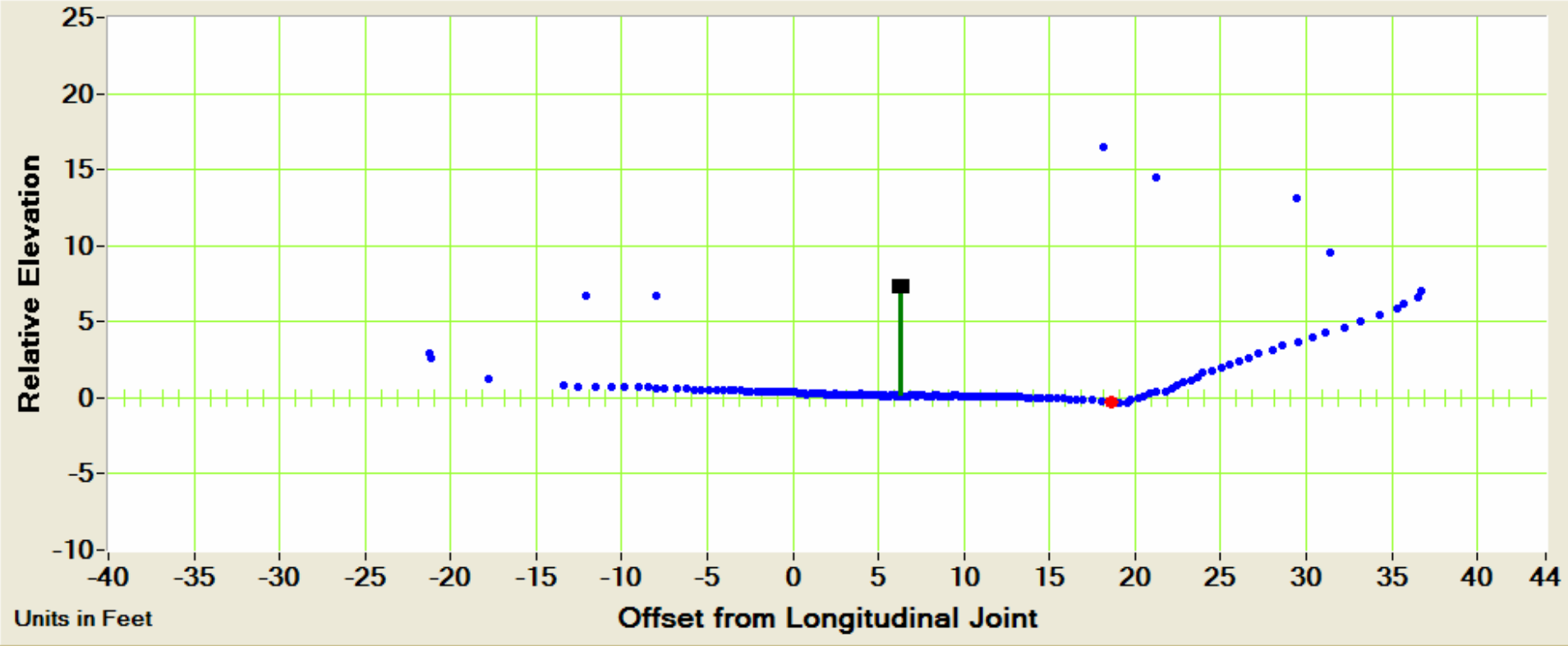
LOW POINTS, GUARD RAIL

Scans



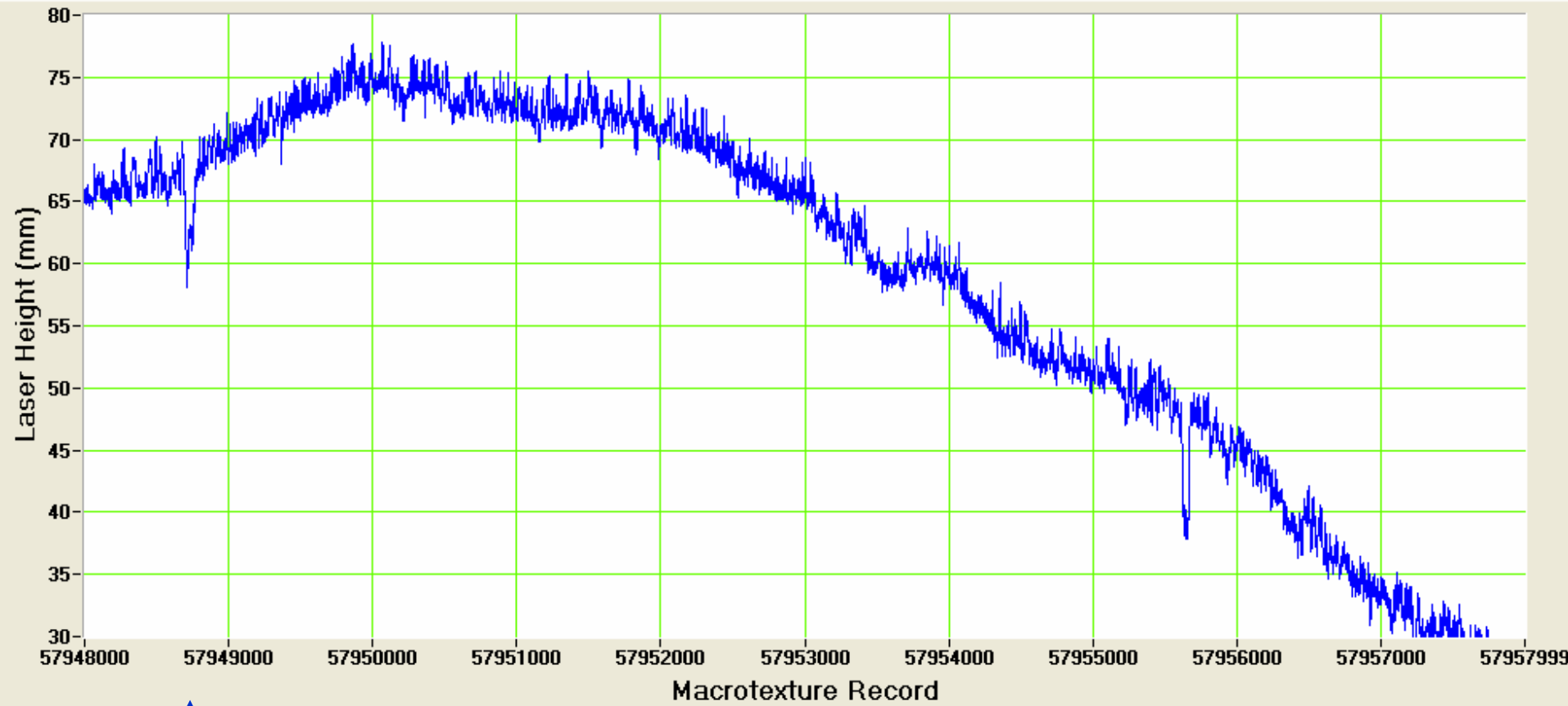
LOW POINTS, GUARD RAIL

Scans



LOW POINTS, HILL SIDE

Macrotexture



↑
JOINT

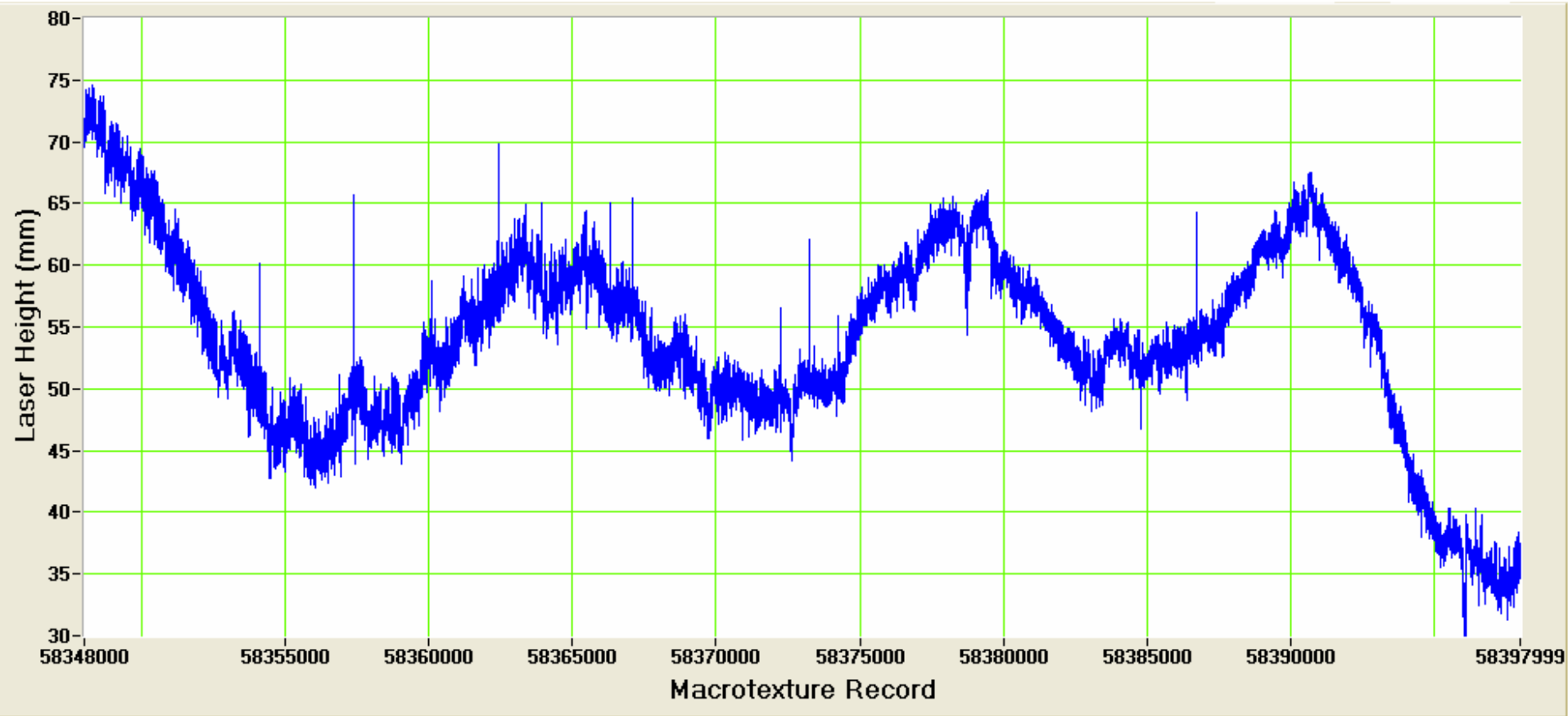
SLAB

↑
JOINT



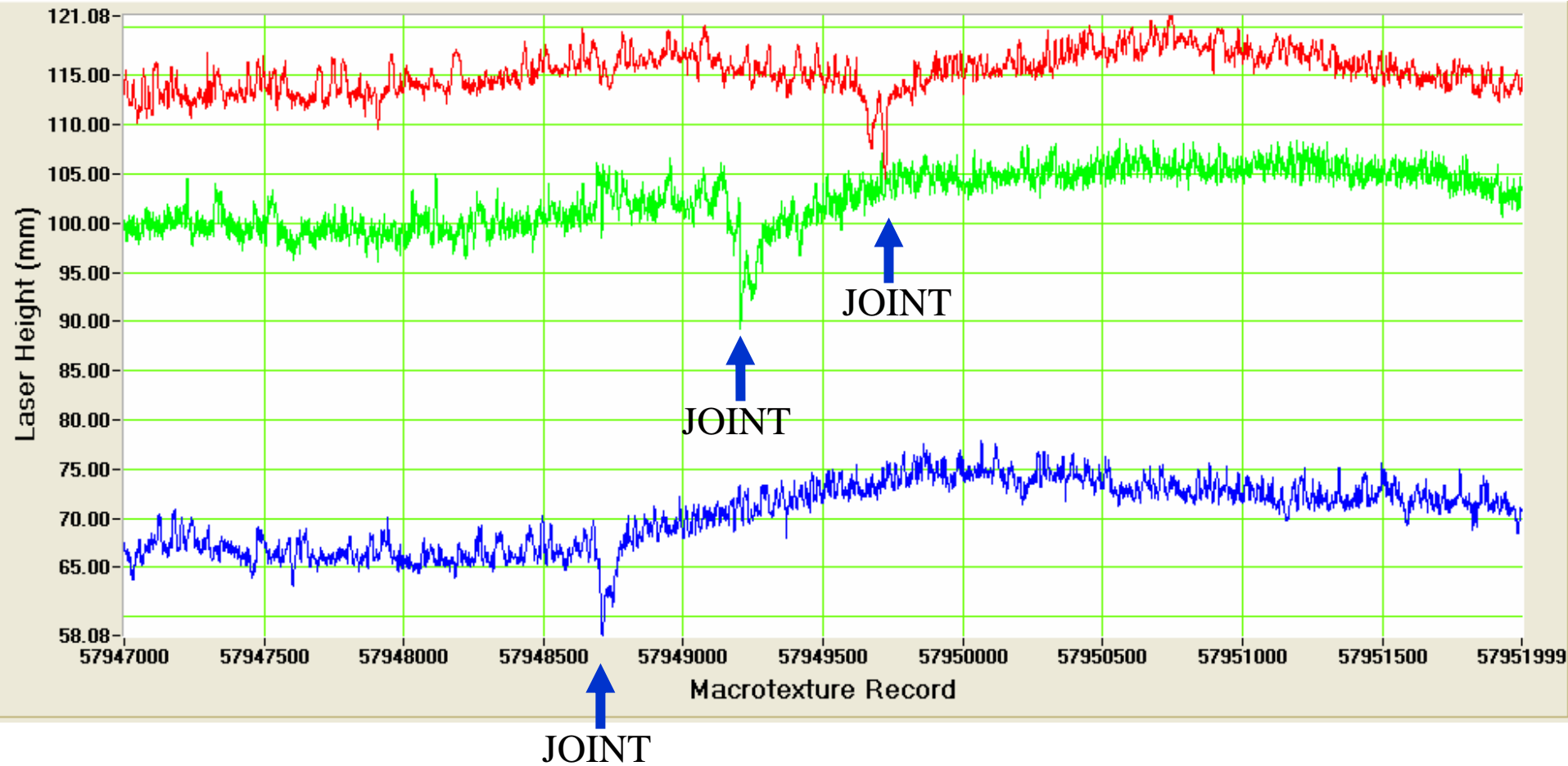
TRANSVERSE JOINT RECOGNITION

Macrotexture



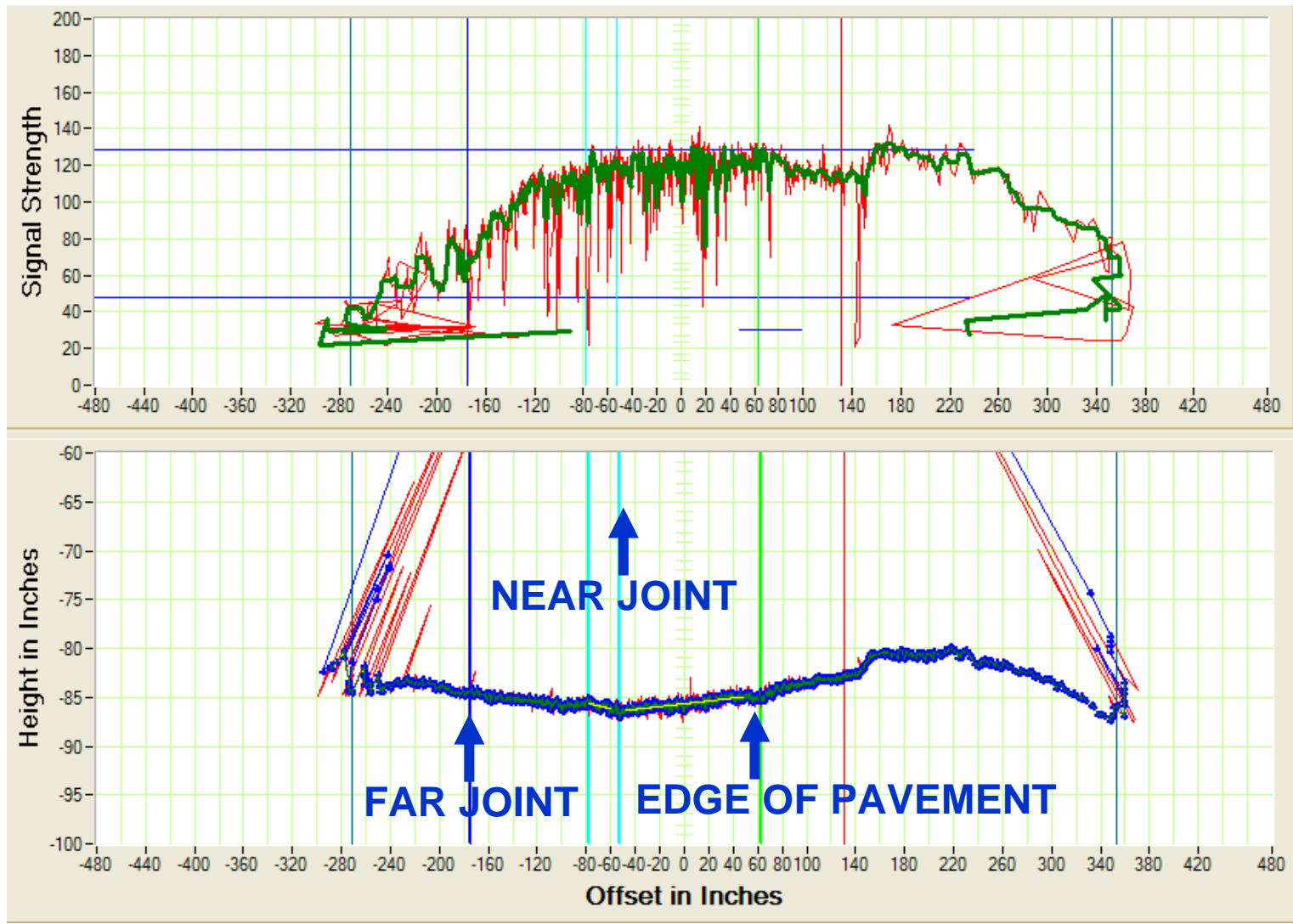
WARP AND CURL OF SLABS -- ROUGHNESS

Macrotexture



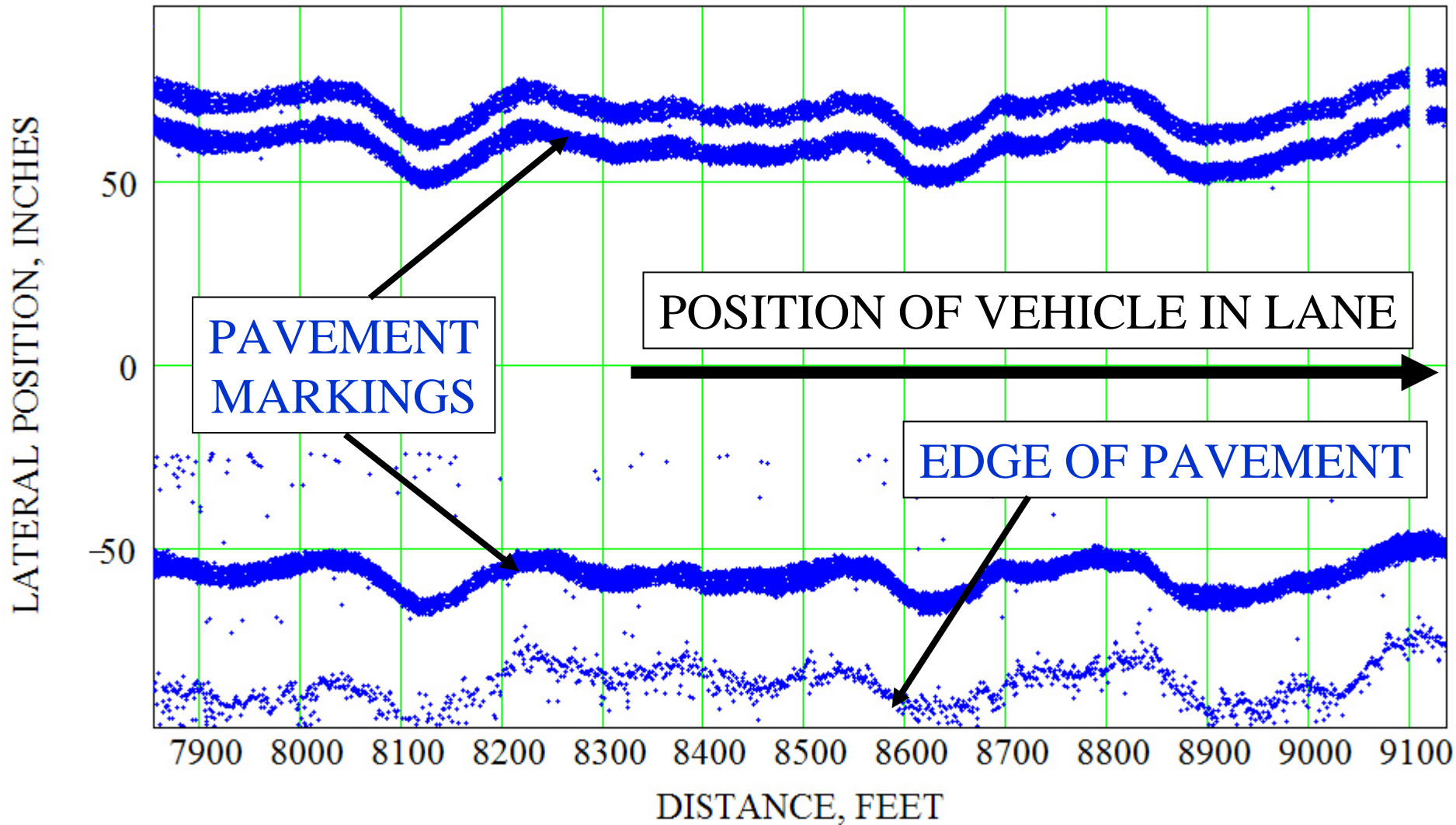
SKEWED TRANSVERSE JOINT – LASERS: RIGHT = blue, CENTER = green, LEFT = red

Joint and Edge Recognition

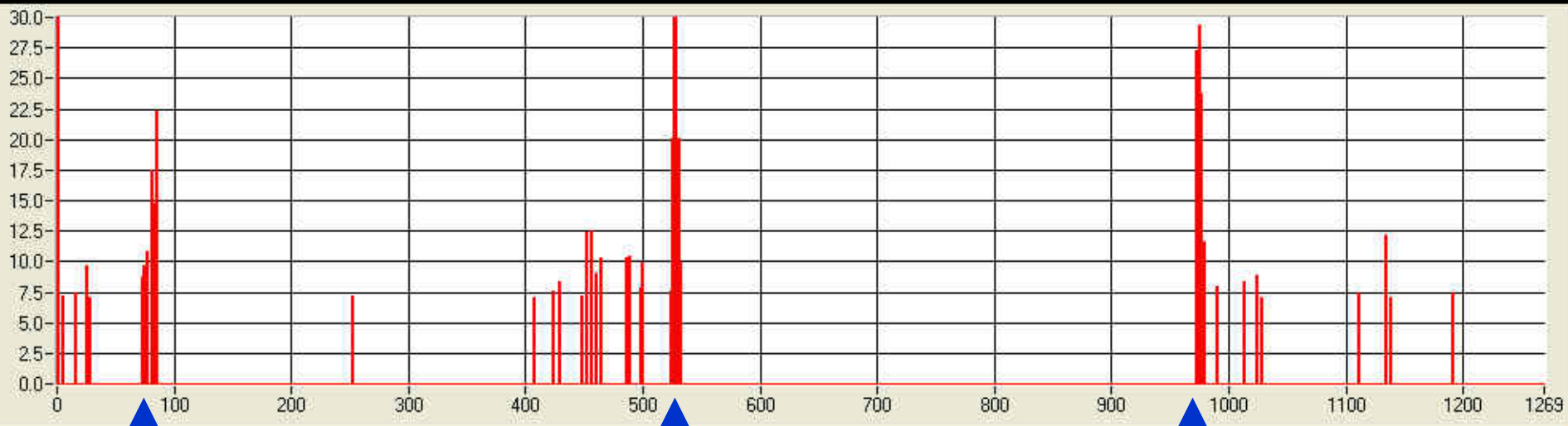


LONGITUDINAL JOINT RECOGNITION USING LASER SCANS

Pavement Markings



Joint and Edge Recognition



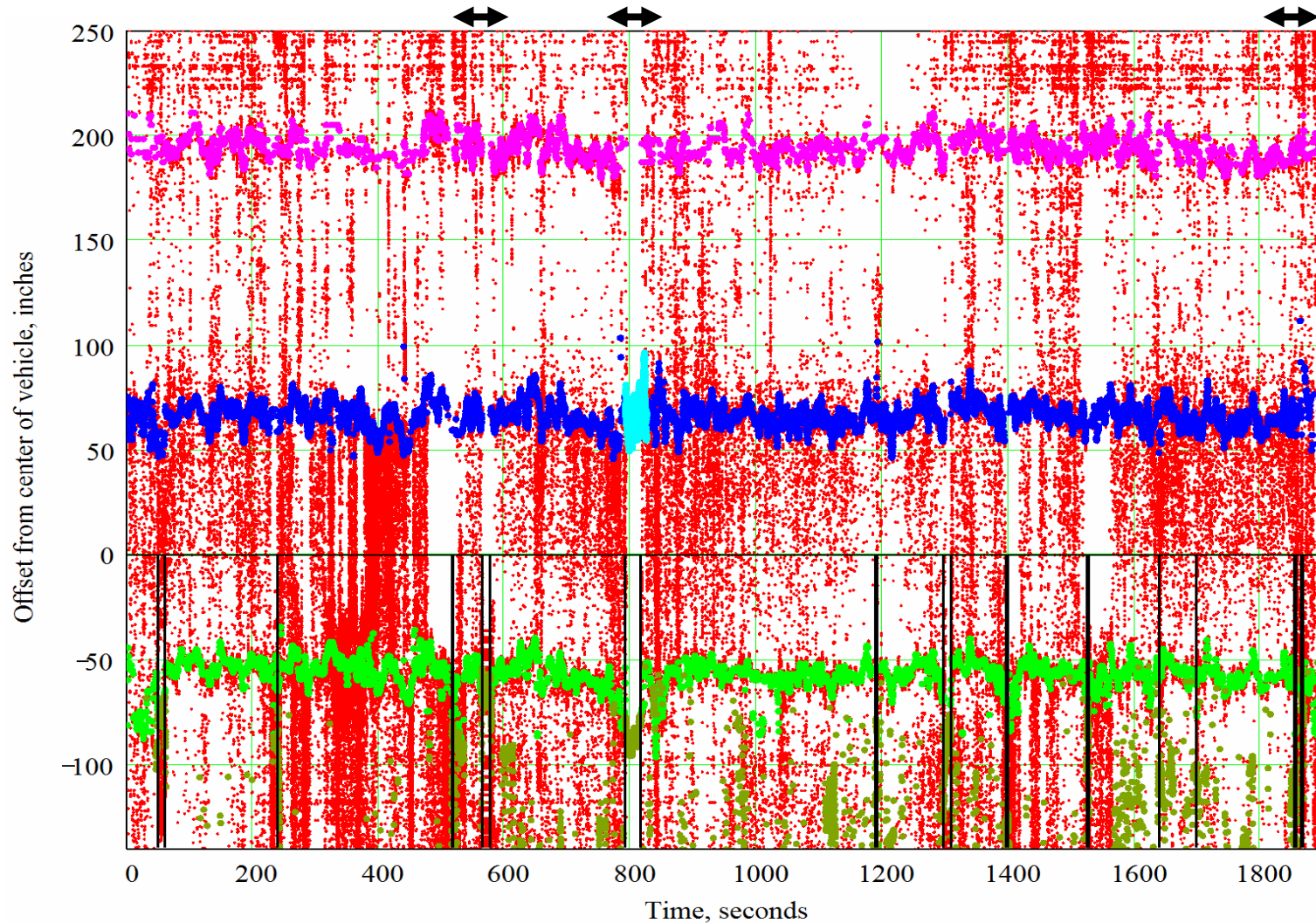
FAR JOINT

NEAR JOINT

EDGE OF PAVEMENT

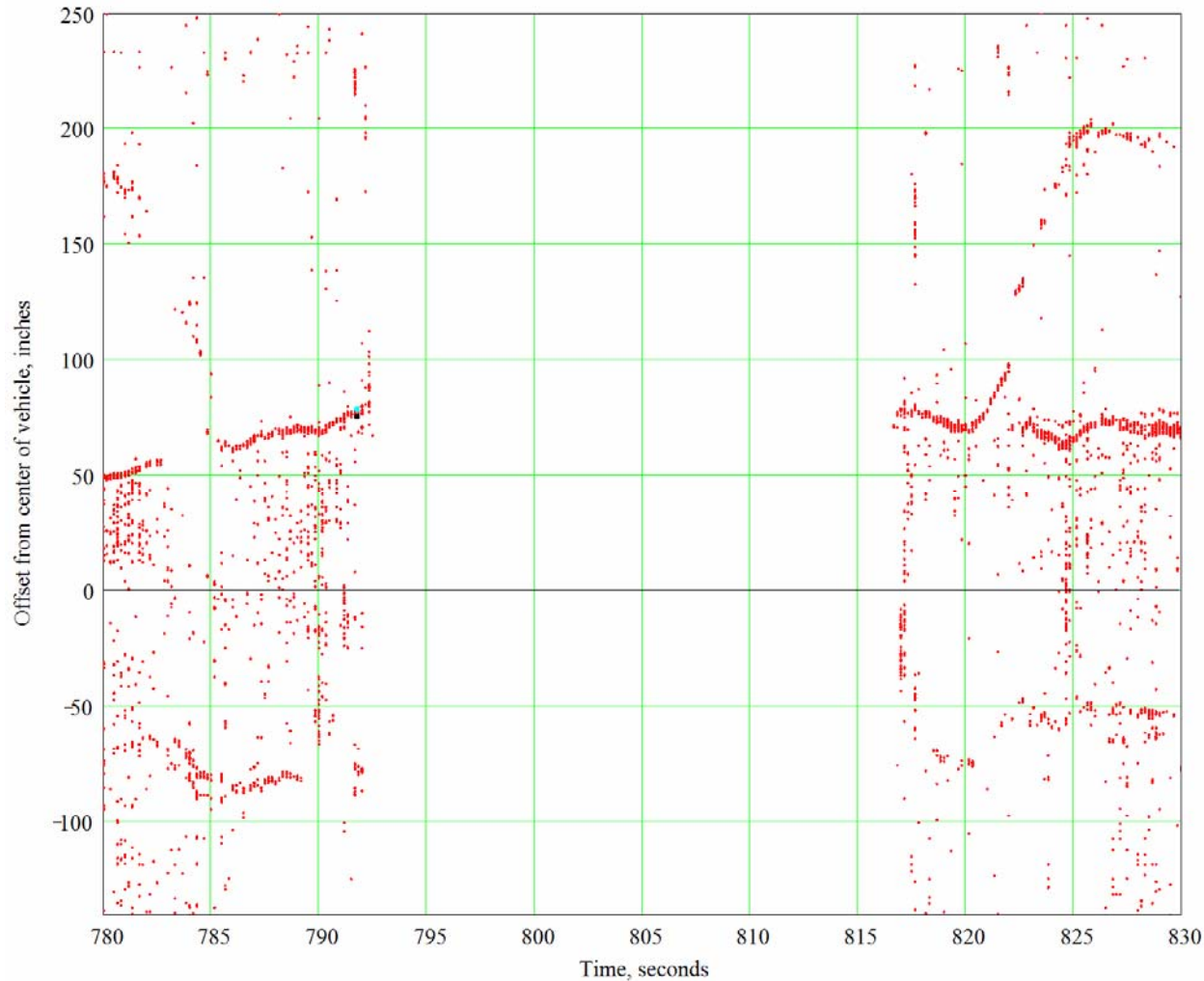
LONGITUDINAL JOINT RECOGNITION USING DIGITAL VIDEO

Joint and Edge Recognition



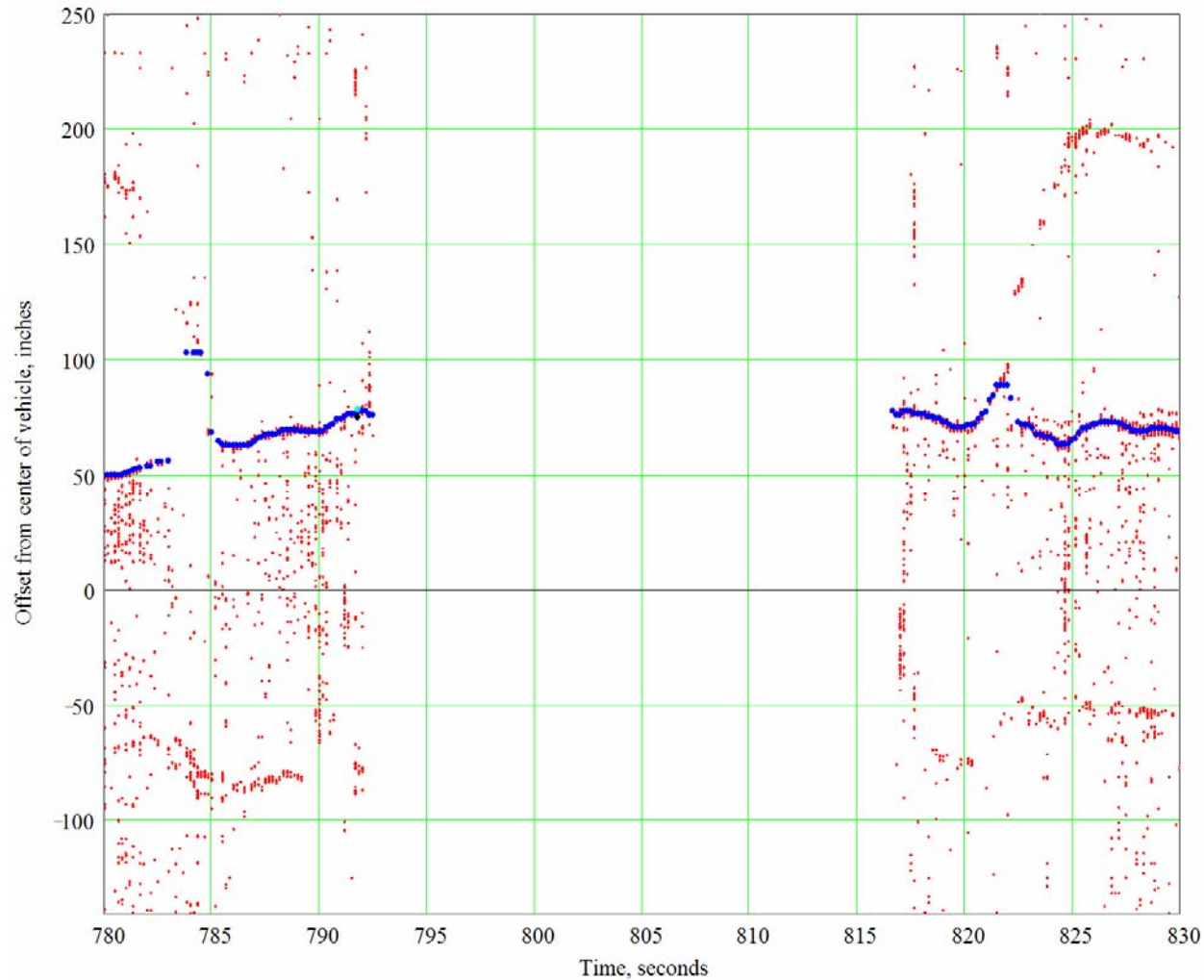
ALL FEATURES FROM SCANNING LASER AND DIGITAL VIDEO

Edge and Joint Recognition



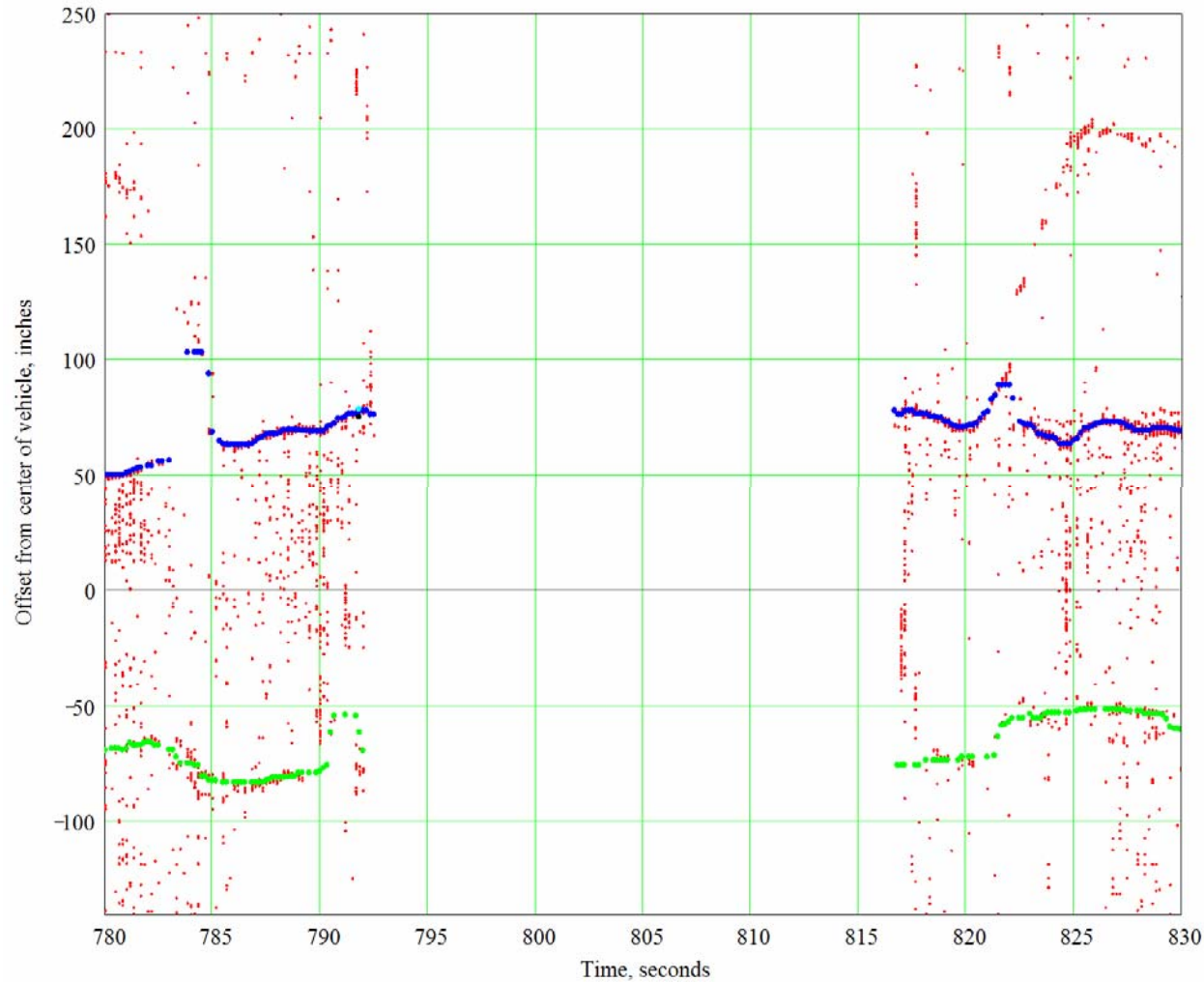
DETAIL NEAR TUNNEL -- DIGITAL VIDEO FEATURES

Edge and Joint Recognition



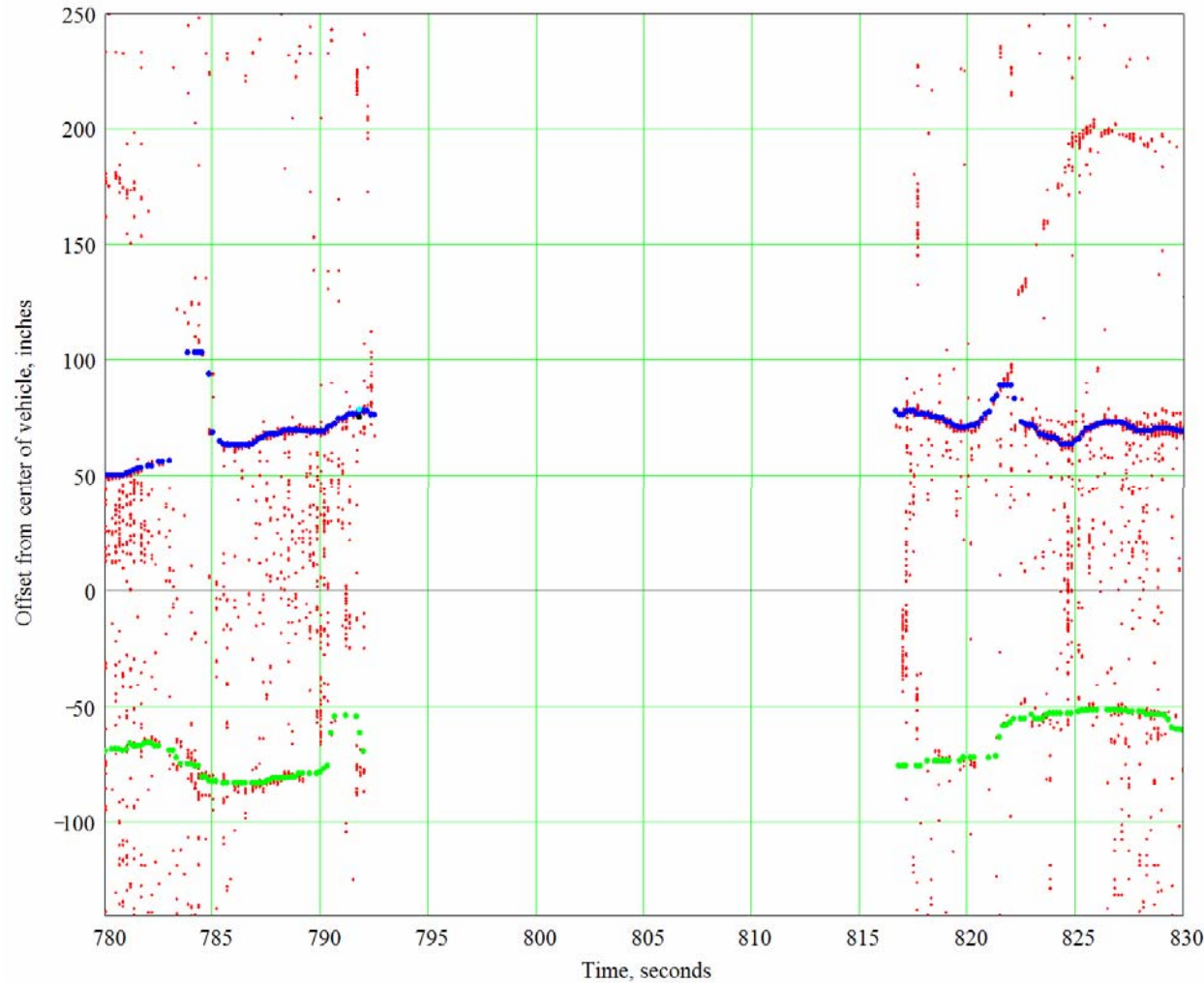
DETAIL NEAR TUNNEL – NEAR LONGITUDINAL JOINT RECOGNITION

Edge and Joint Recognition



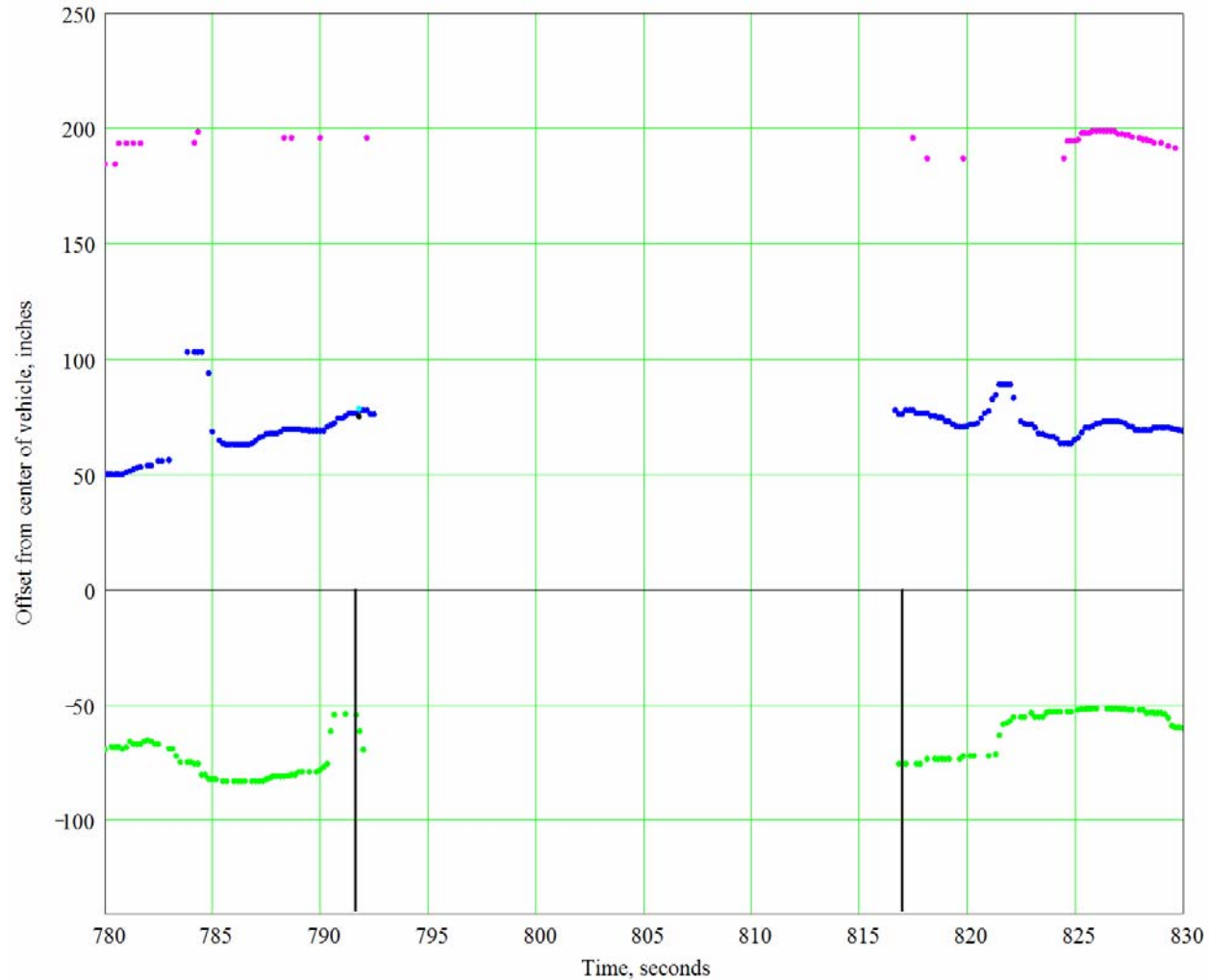
DETAIL NEAR TUNNEL – EDGE OF PAVEMENT RECOGNITION

Edge and Joint Recognition



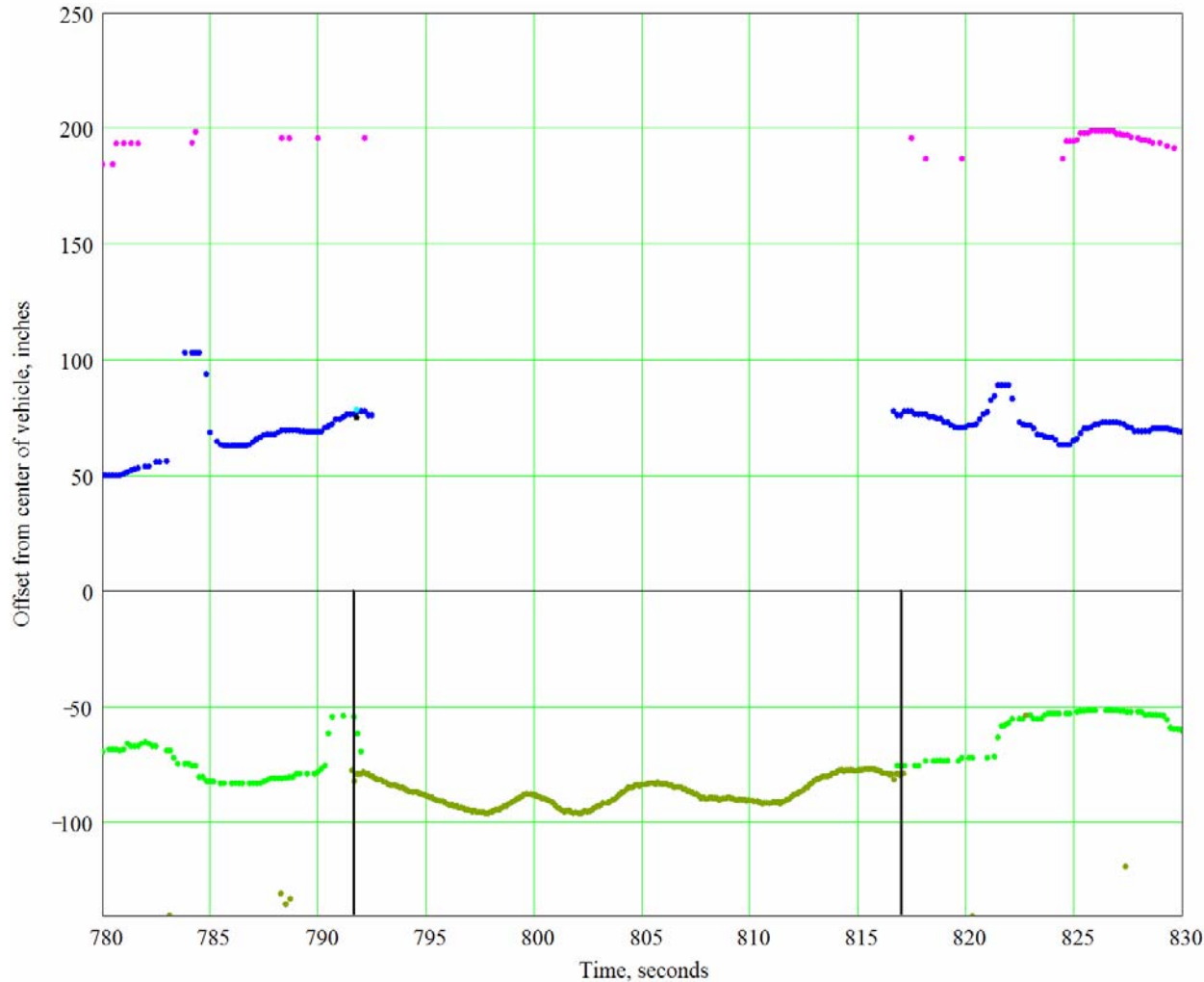
DETAIL NEAR TUNNEL – FAR LONGITUDINAL JOINT RECOGNITION

Edge and Joint Recognition



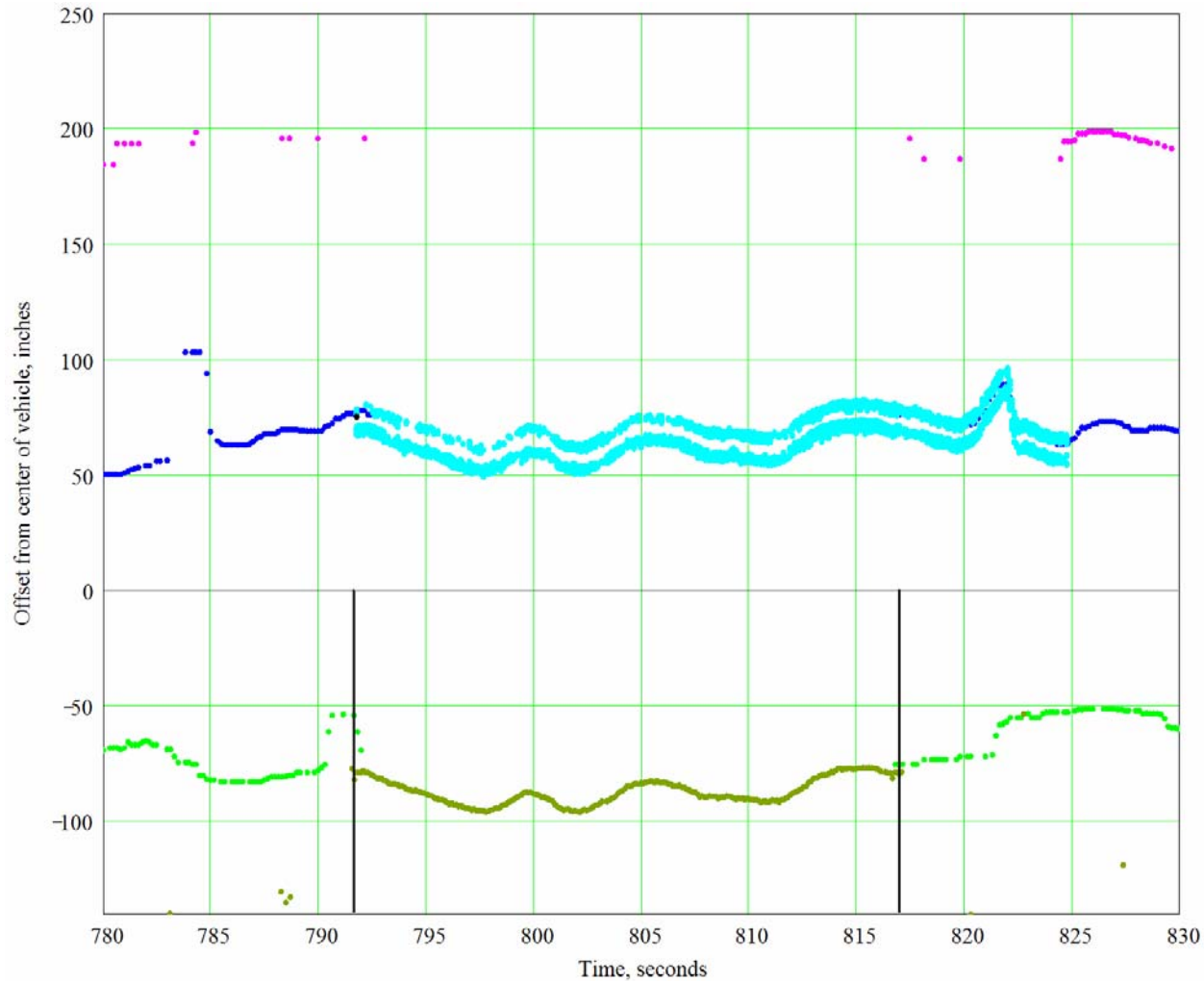
DETAIL NEAR TUNNEL – TRANSVERSE BRIDGE JOINT USING MACROTEXTURE

Edge and Joint Recognition



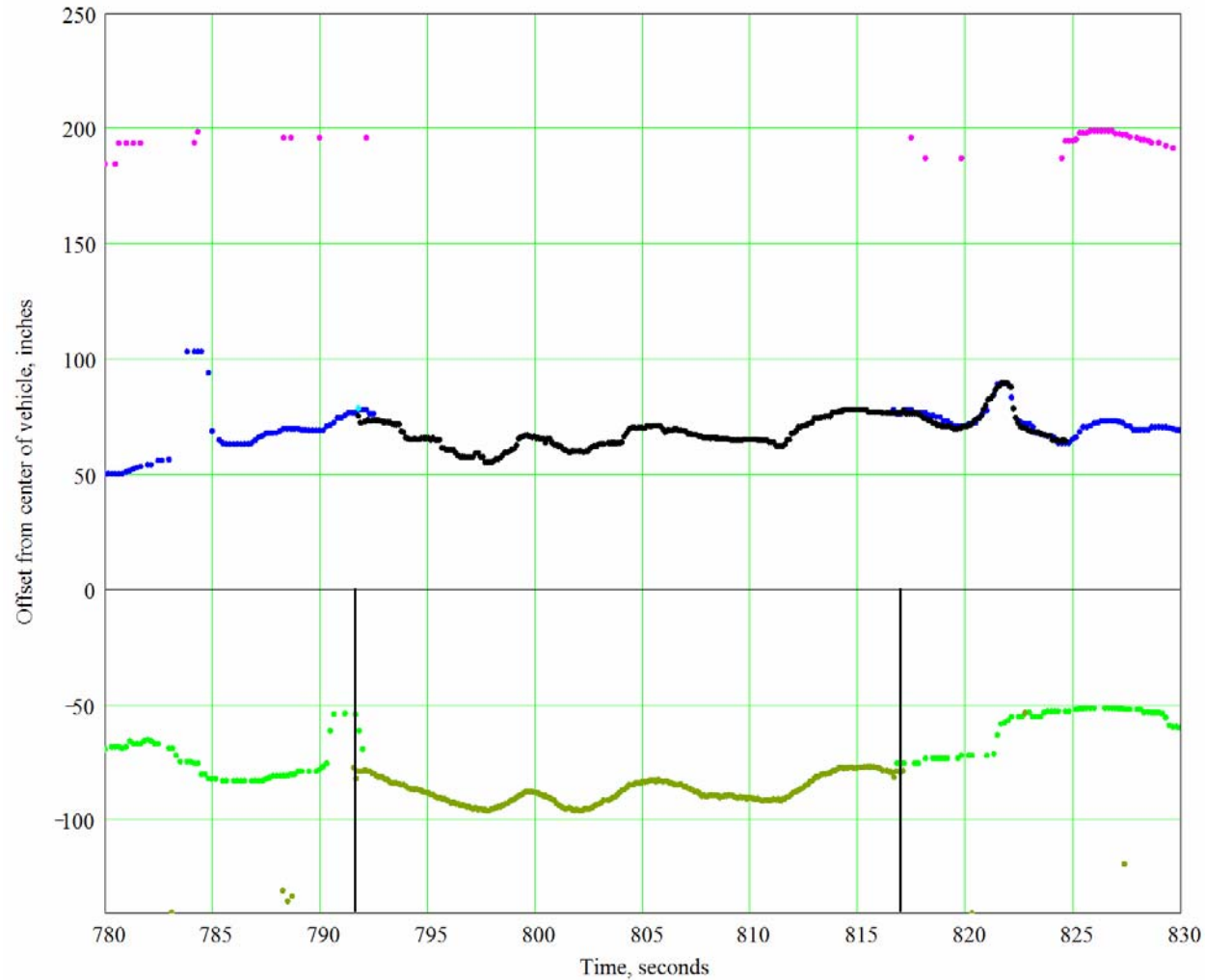
DETAIL NEAR TUNNEL – CURB RECOGNITION USING SCANNING LASER

Edge and Joint Recognition



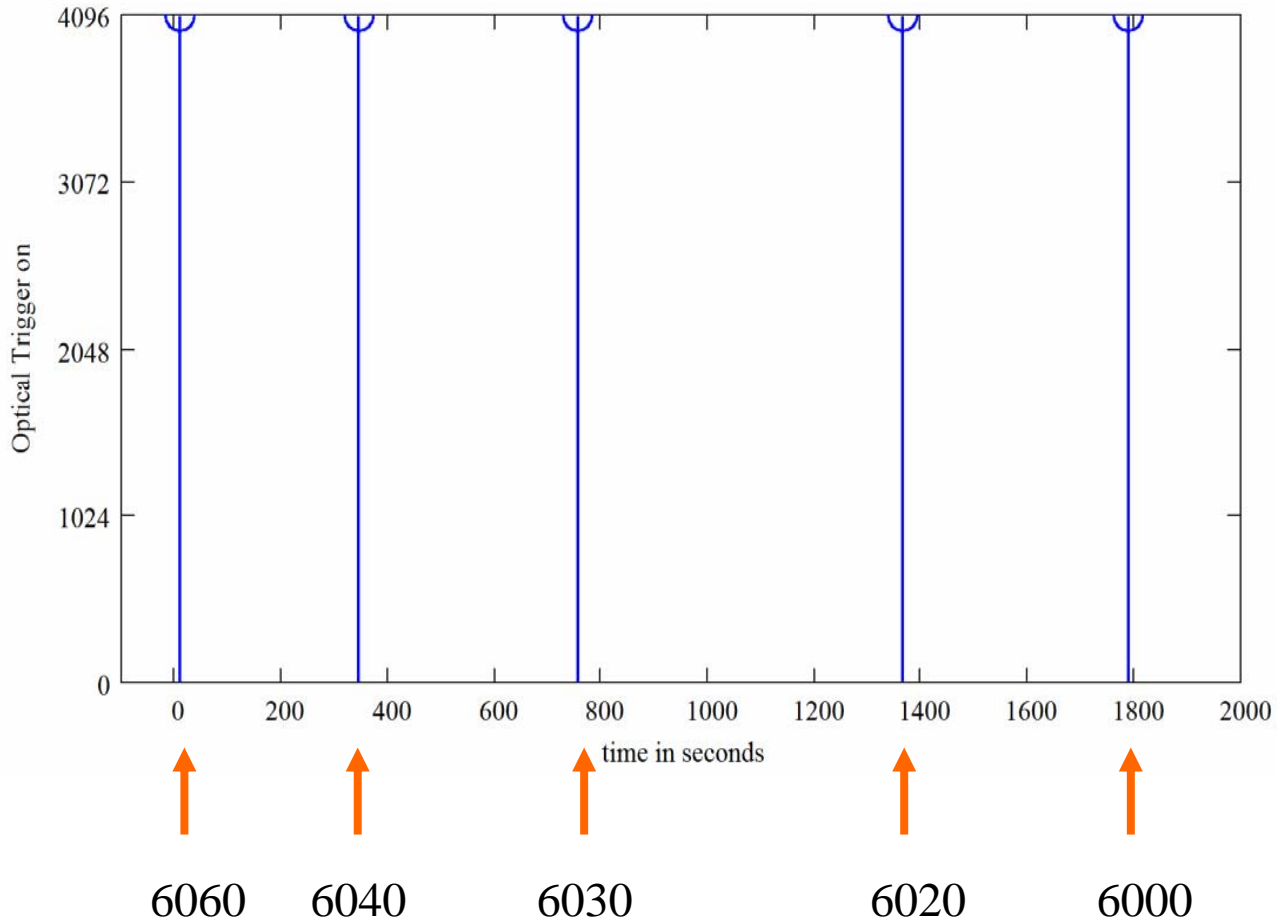
DETAIL NEAR TUNNEL – PAVEMENT MARKINGS USING SCANNING LASER

Edge and Joint Recognition



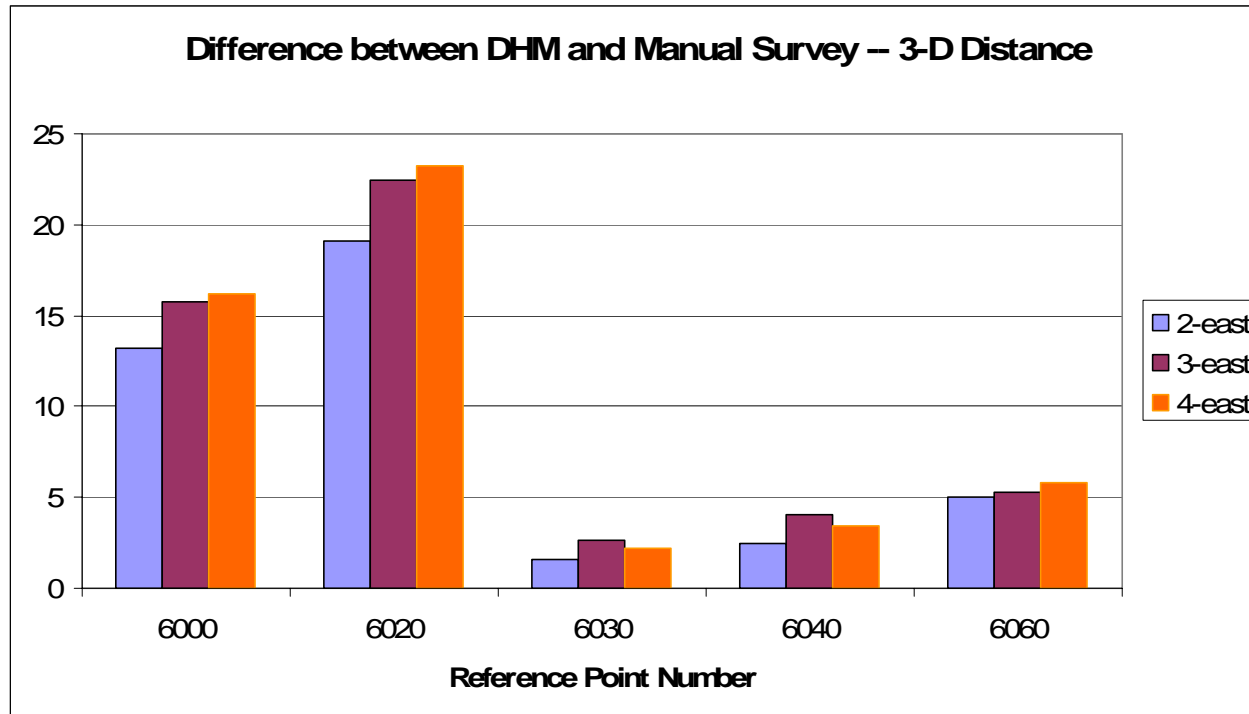
DETAIL NEAR TUNNEL – CONTROL LINE USING PAVEMENT MARKINGS

Electronic Markers using Optical Triggers



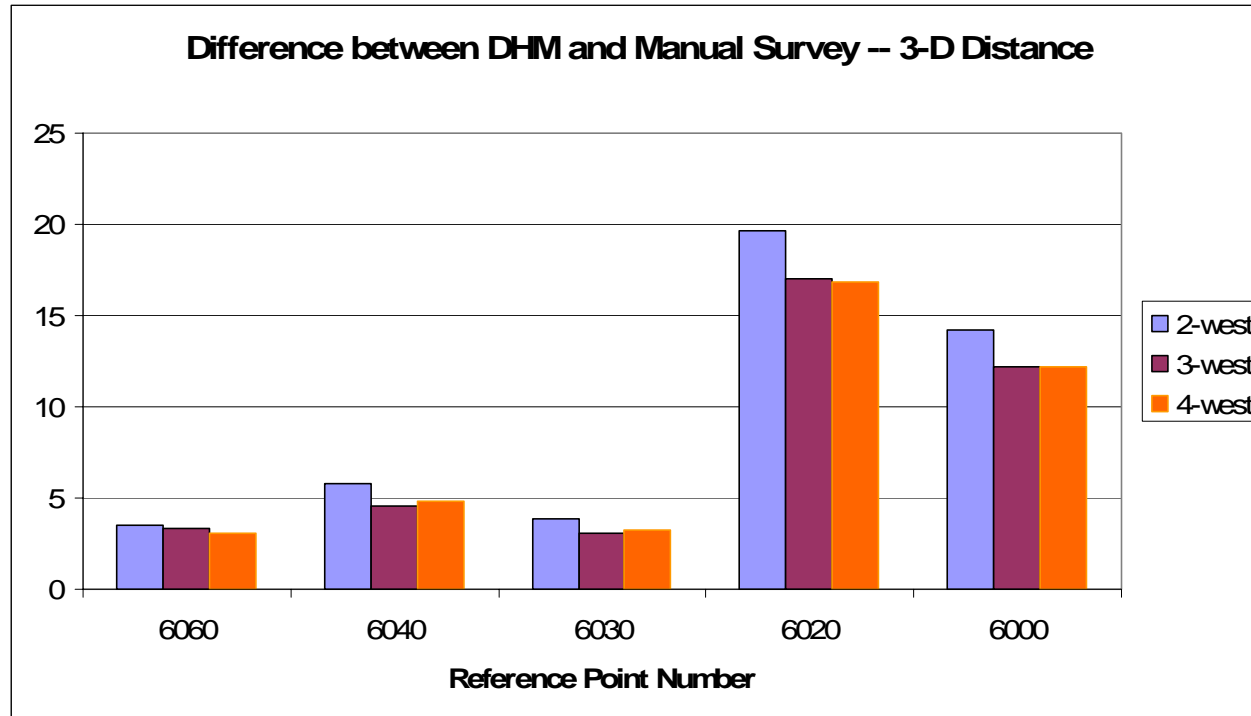
CAPTURING POINTS ON THE EDGE OF THE ROAD

Mapping of DHM on Manual Survey



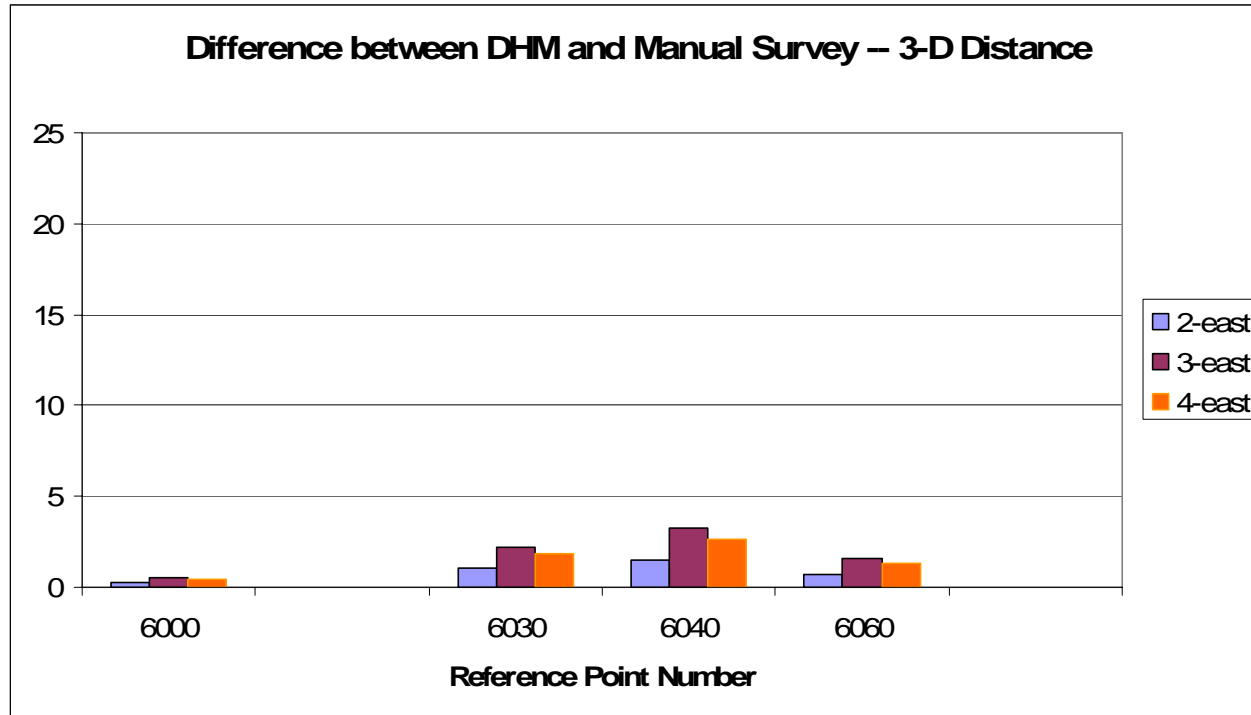
USING ALL REFERENCE POINTS

Mapping of DHM on Manual Survey



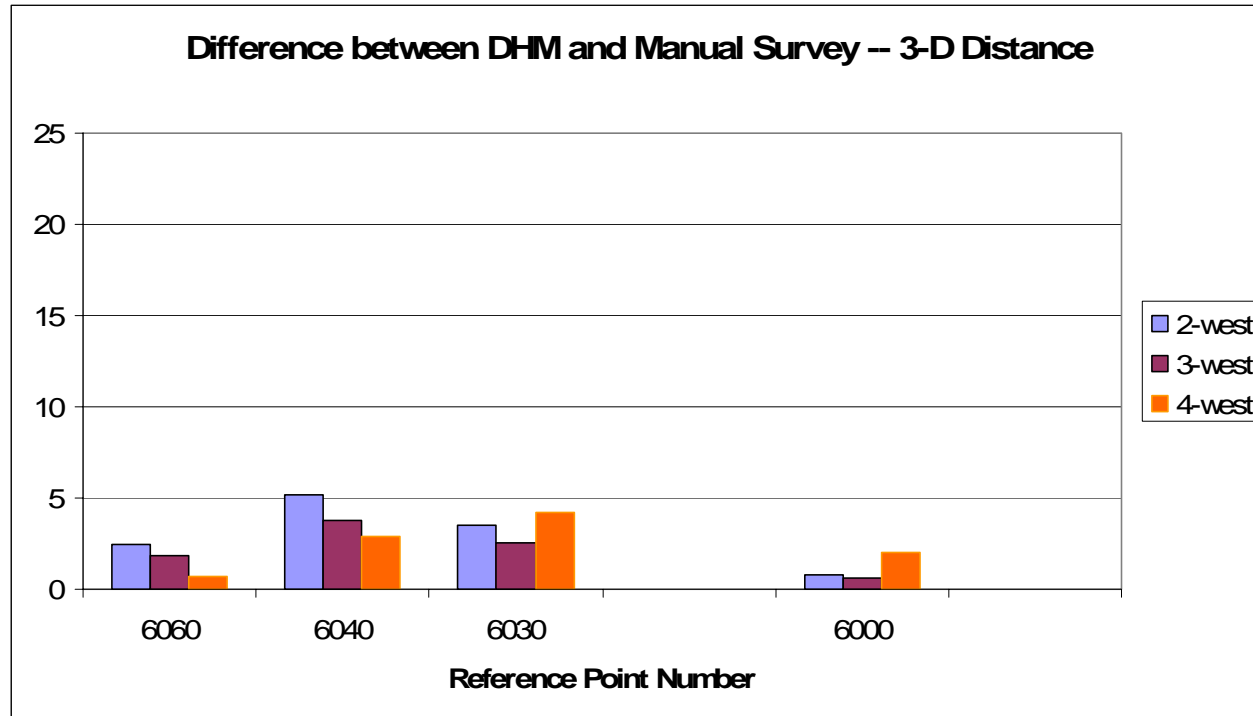
USING ALL REFERENCE POINTS

Mapping of DHM on Manual Survey



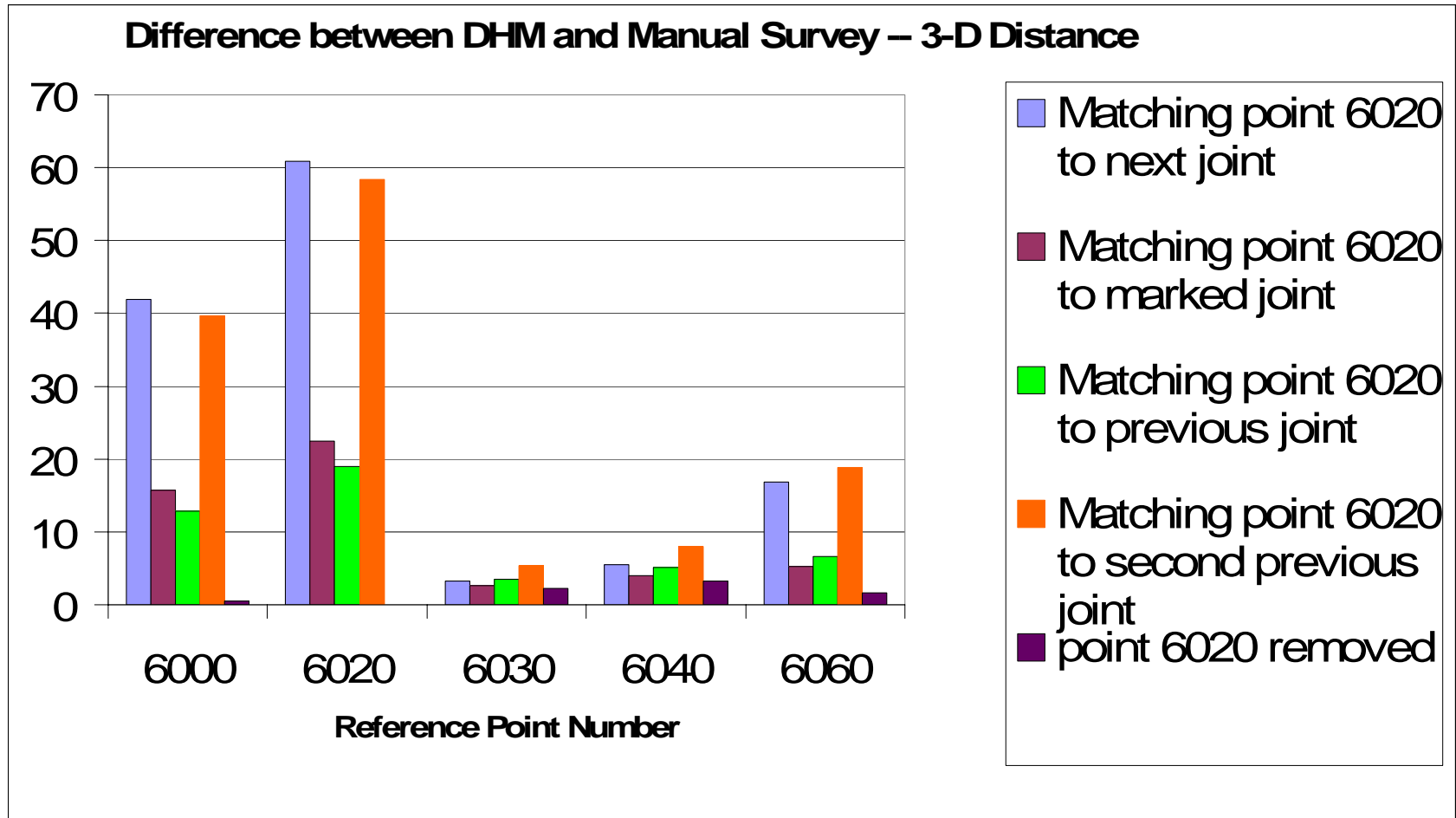
USING FOUR OF THE FIVE REFERENCE POINTS (6020 NOT USED IN MAPPING)

Mapping of DHM on Manual Survey



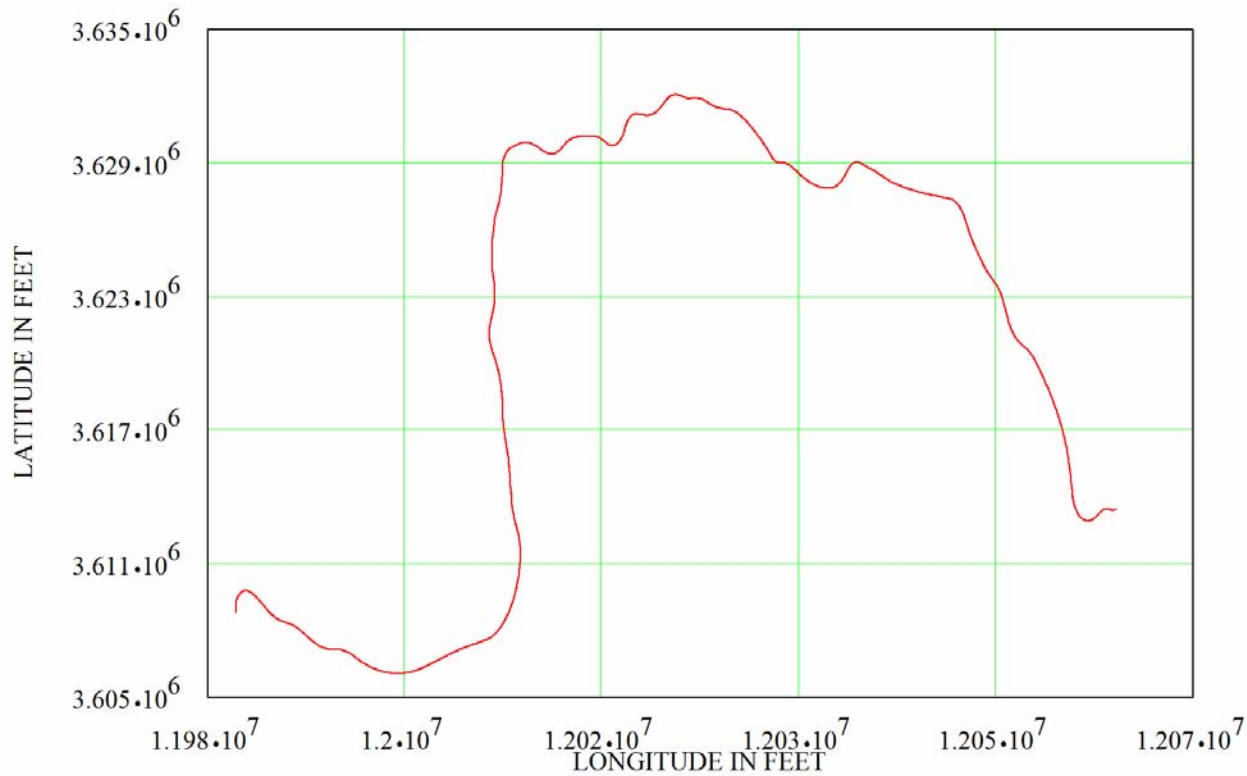
USING FOUR OF THE FIVE REFERENCE POINTS (6020 NOT USED IN MAPPING)

Mapping of DHM on Manual Survey

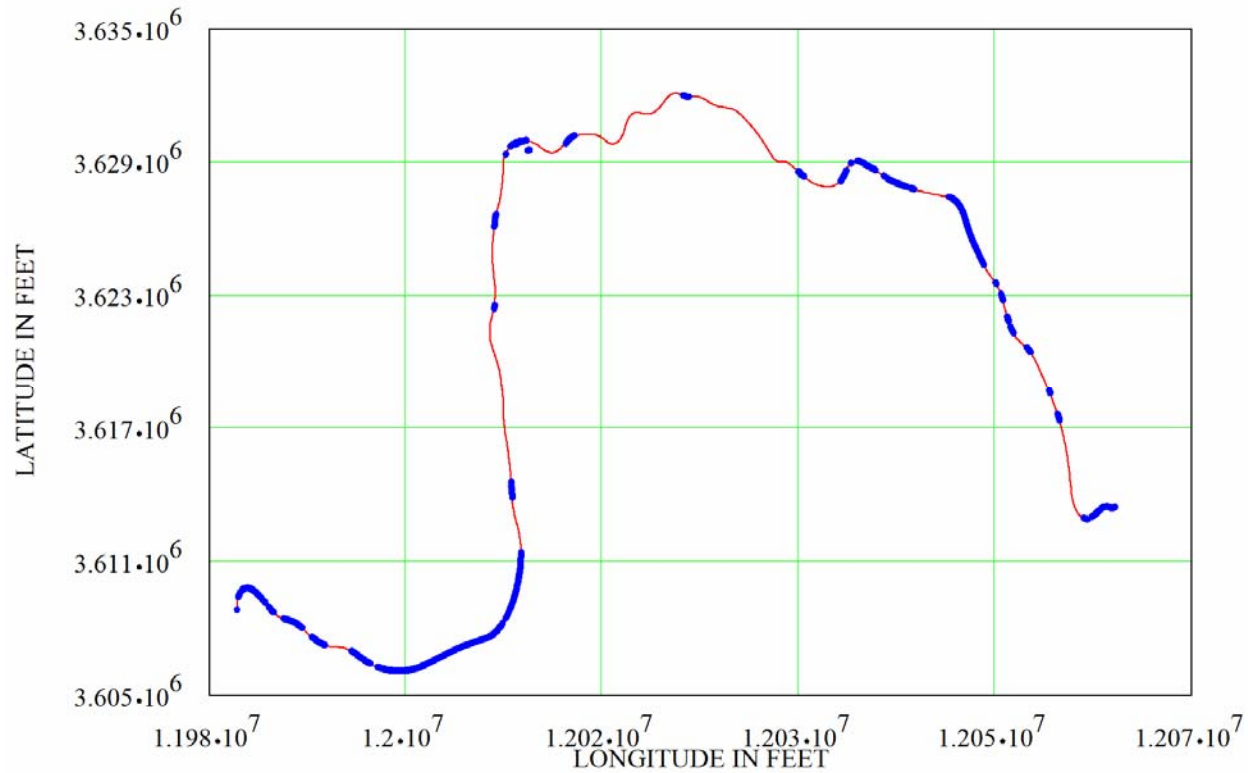


MOVING DHM POINT FOR REFERENCE POINT NUMBER 6020 TO NEARBY JOINTS

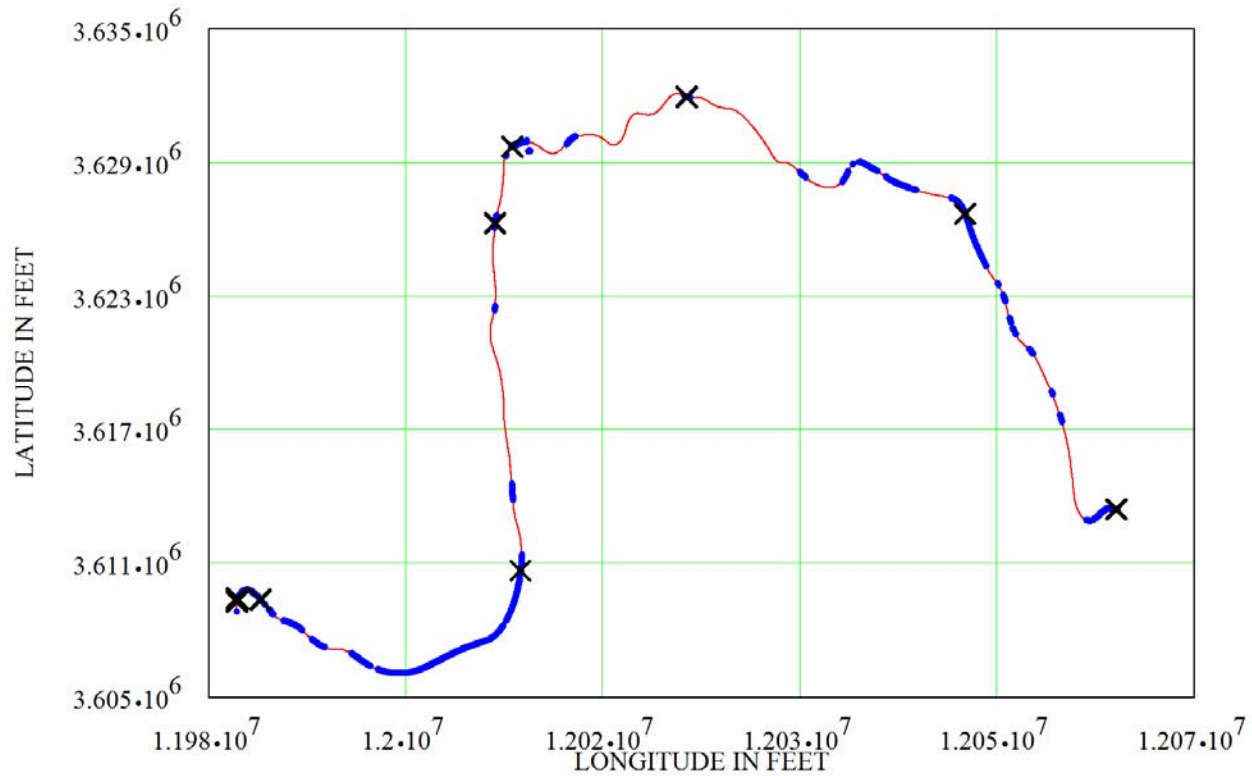
Trajectories



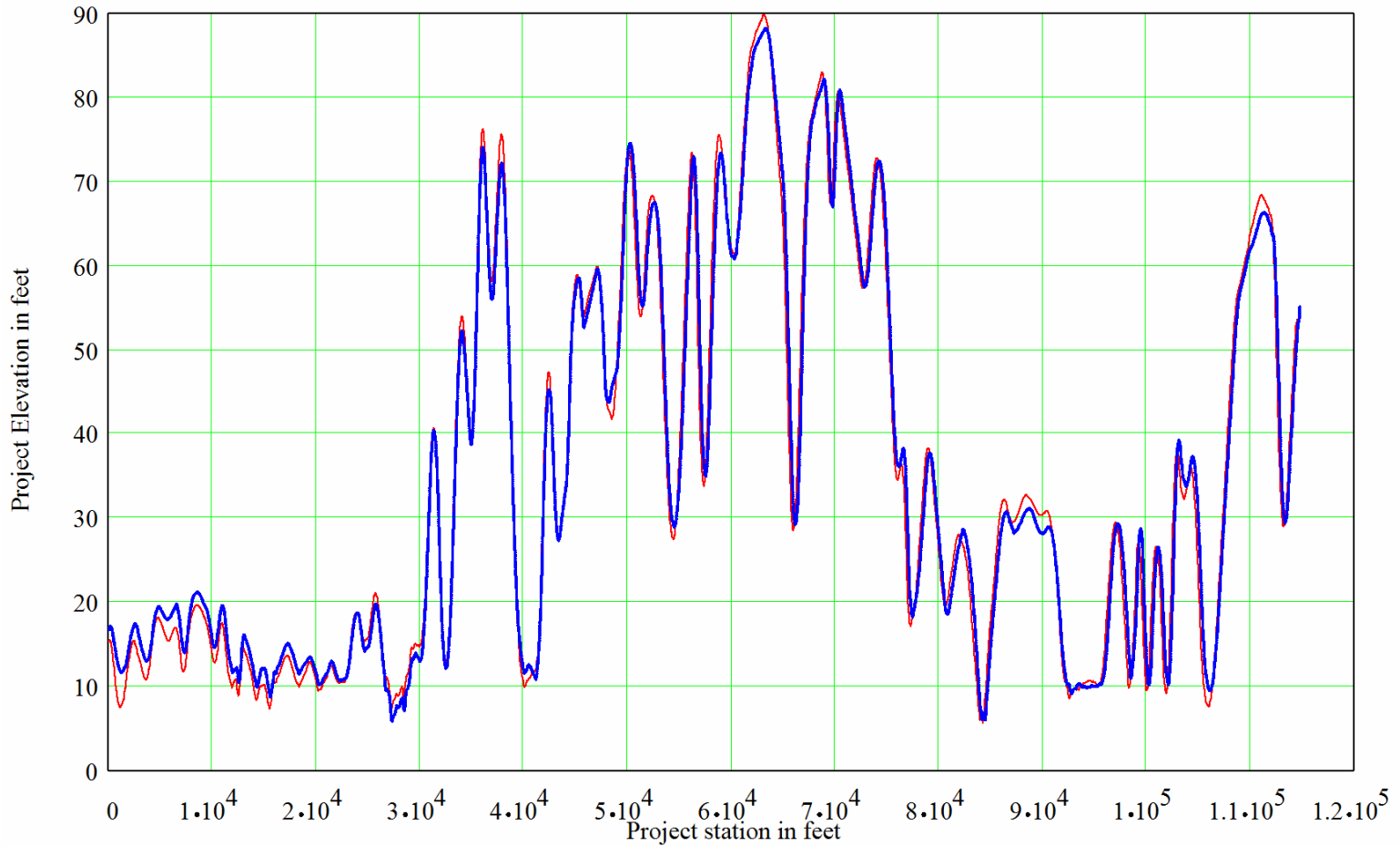
Trajectories



Trajectories

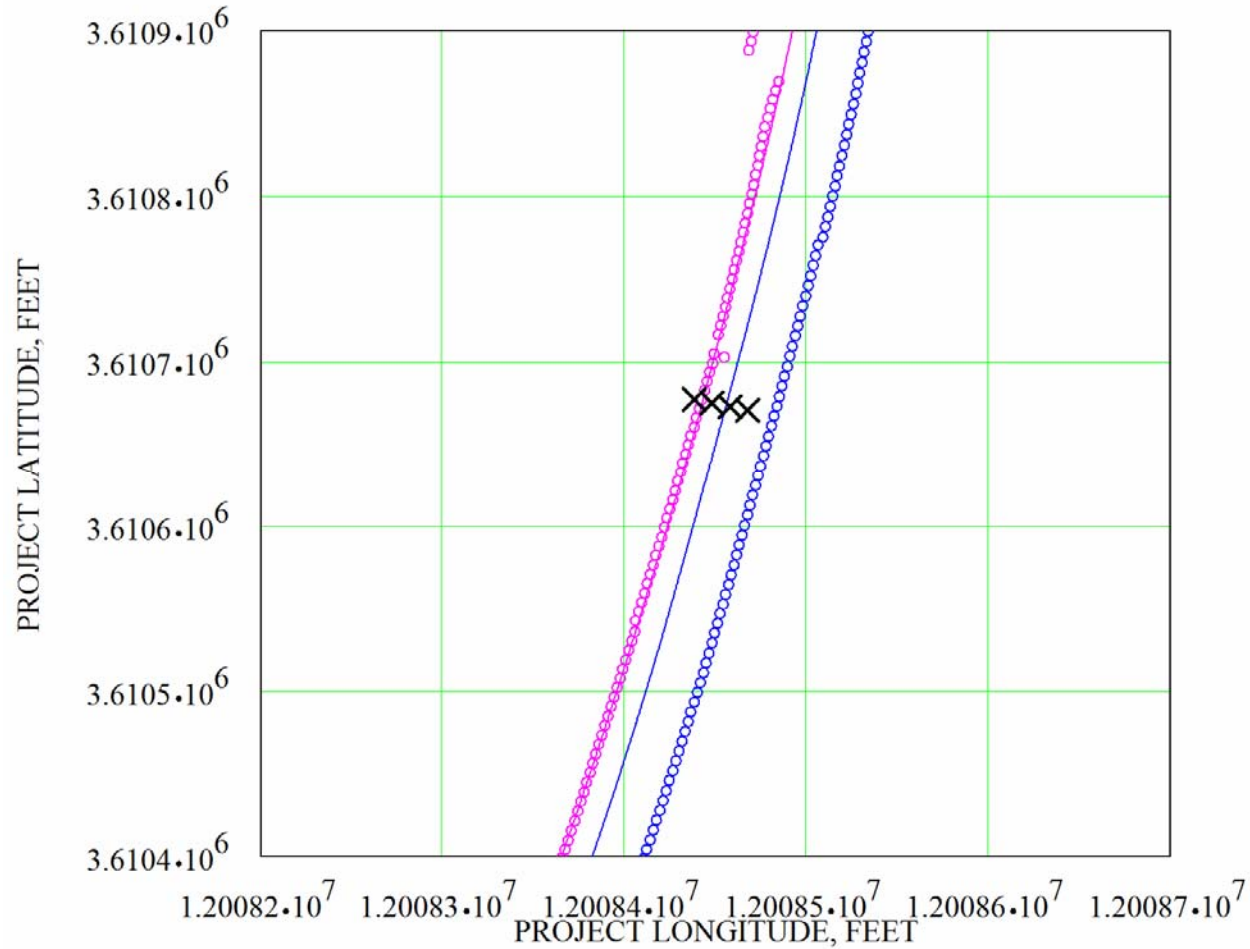


Trajectories



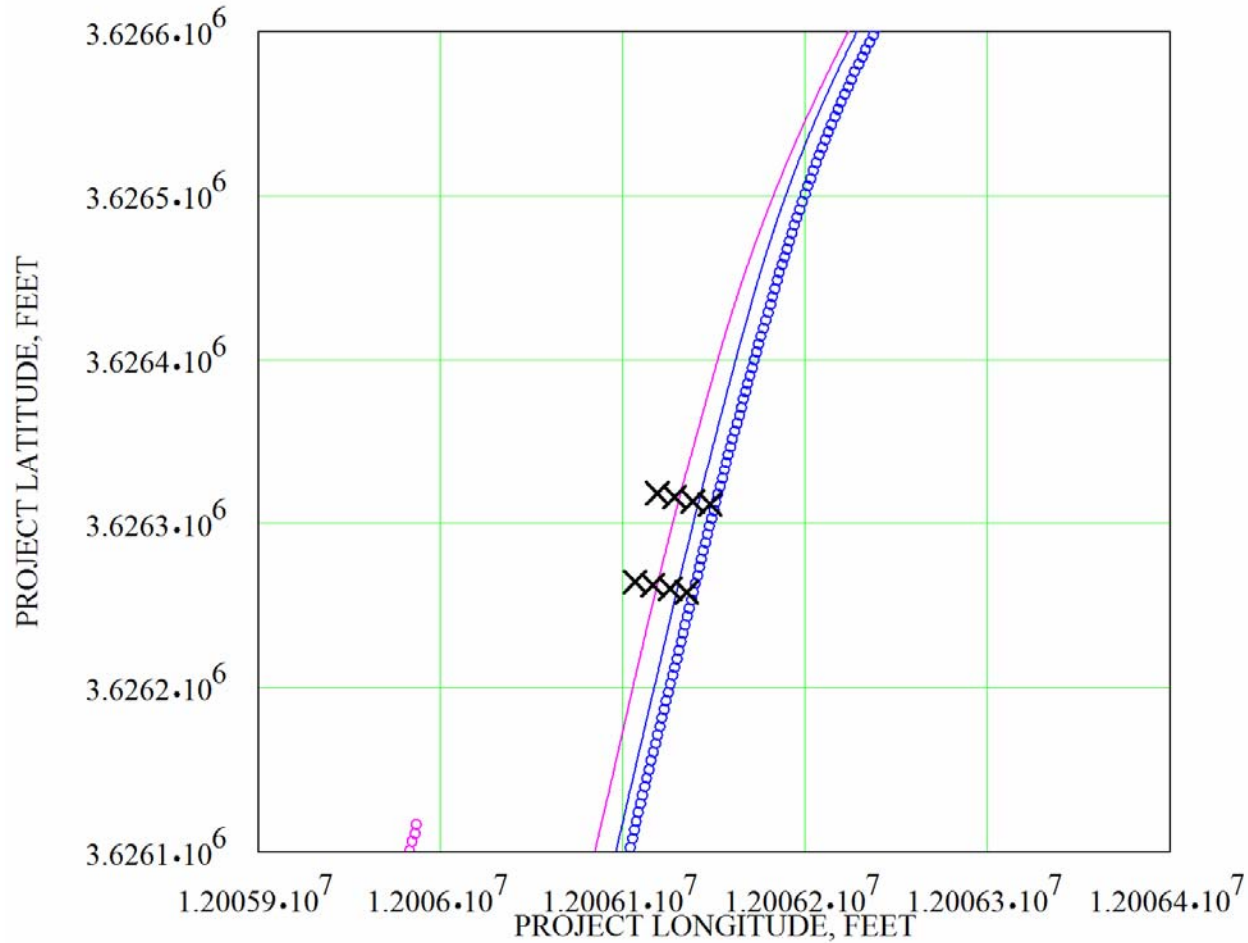
DHM – EASTBOUND, WESTBOUND – ELEVATION VS. STATION

Trajectories



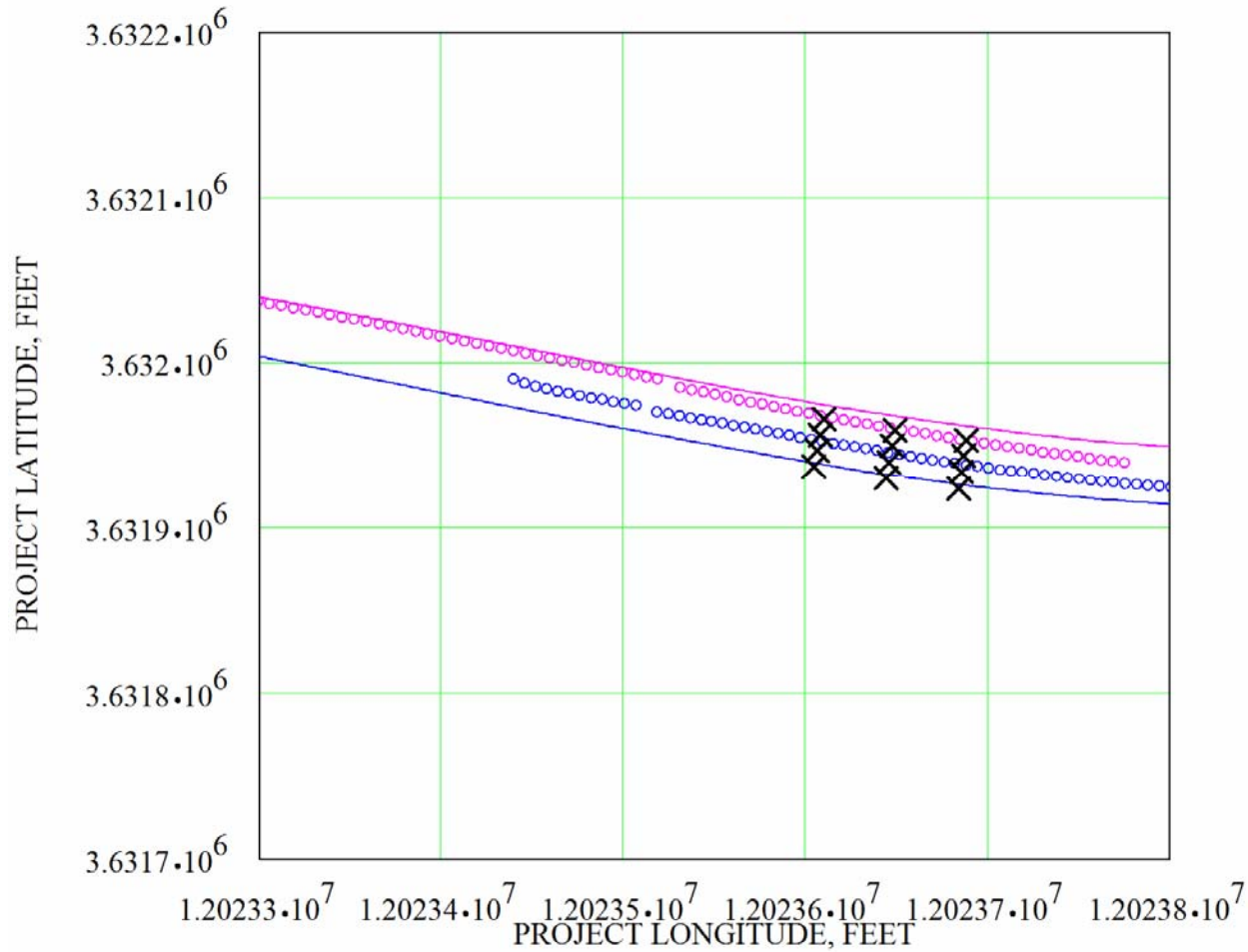
EASTBOUND, WESTBOUND – DHM, DGPS, AND SURVEY – BM2

Trajectories



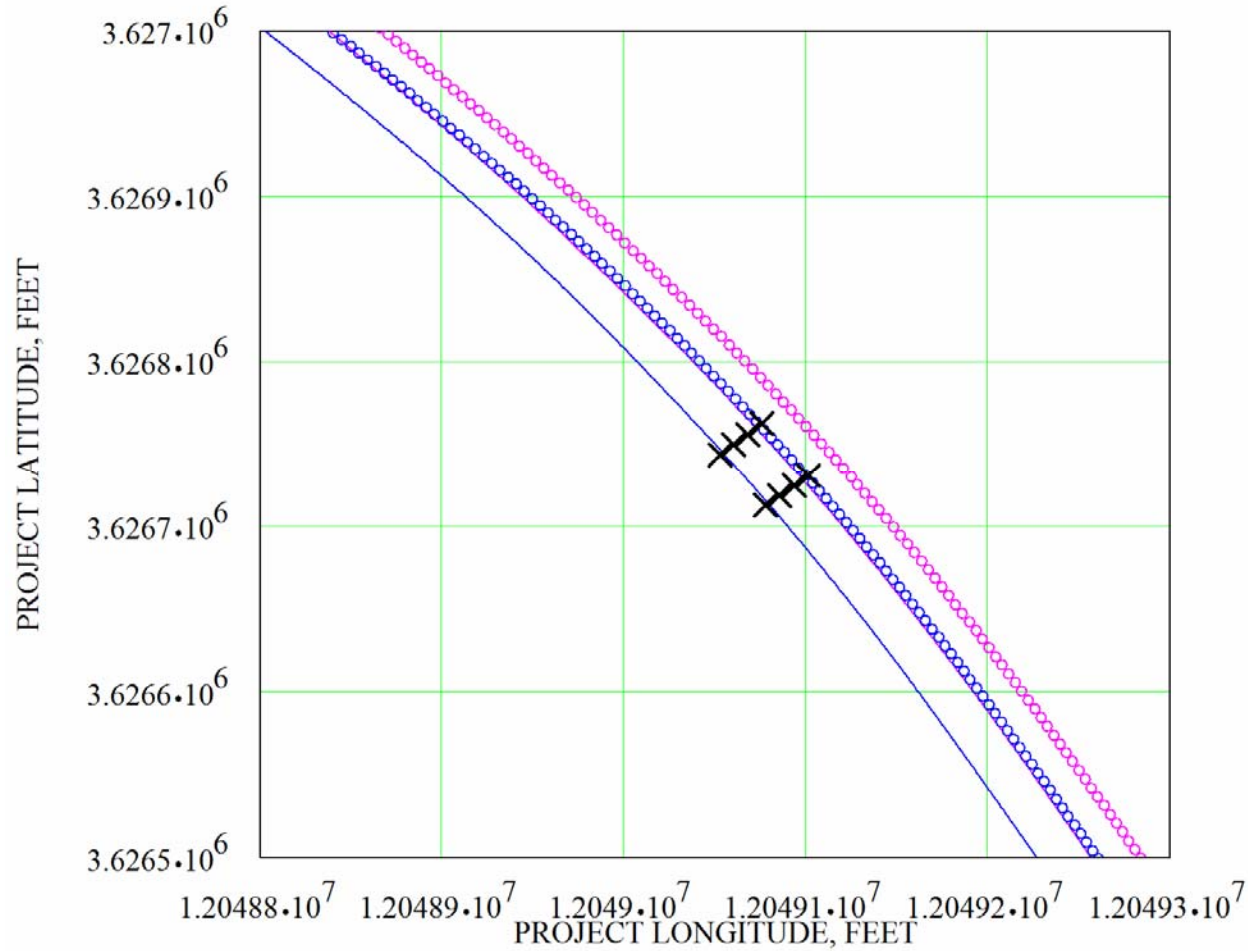
EASTBOUND, WESTBOUND – DHM, DGPS, AND SURVEY – BM3

Trajectories



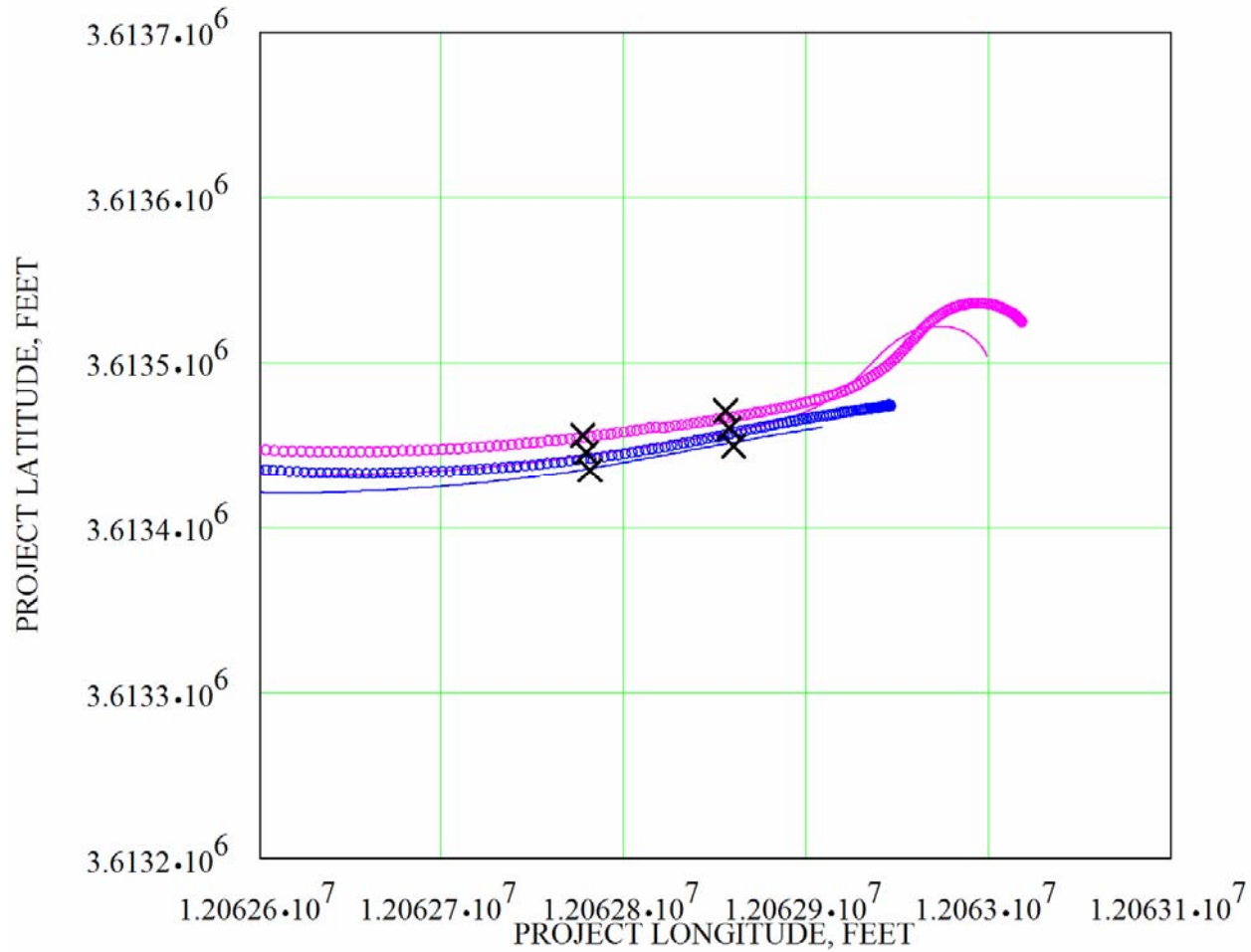
EASTBOUND, WESTBOUND – DHM, DGPS, AND SURVEY – BM4

Trajectories



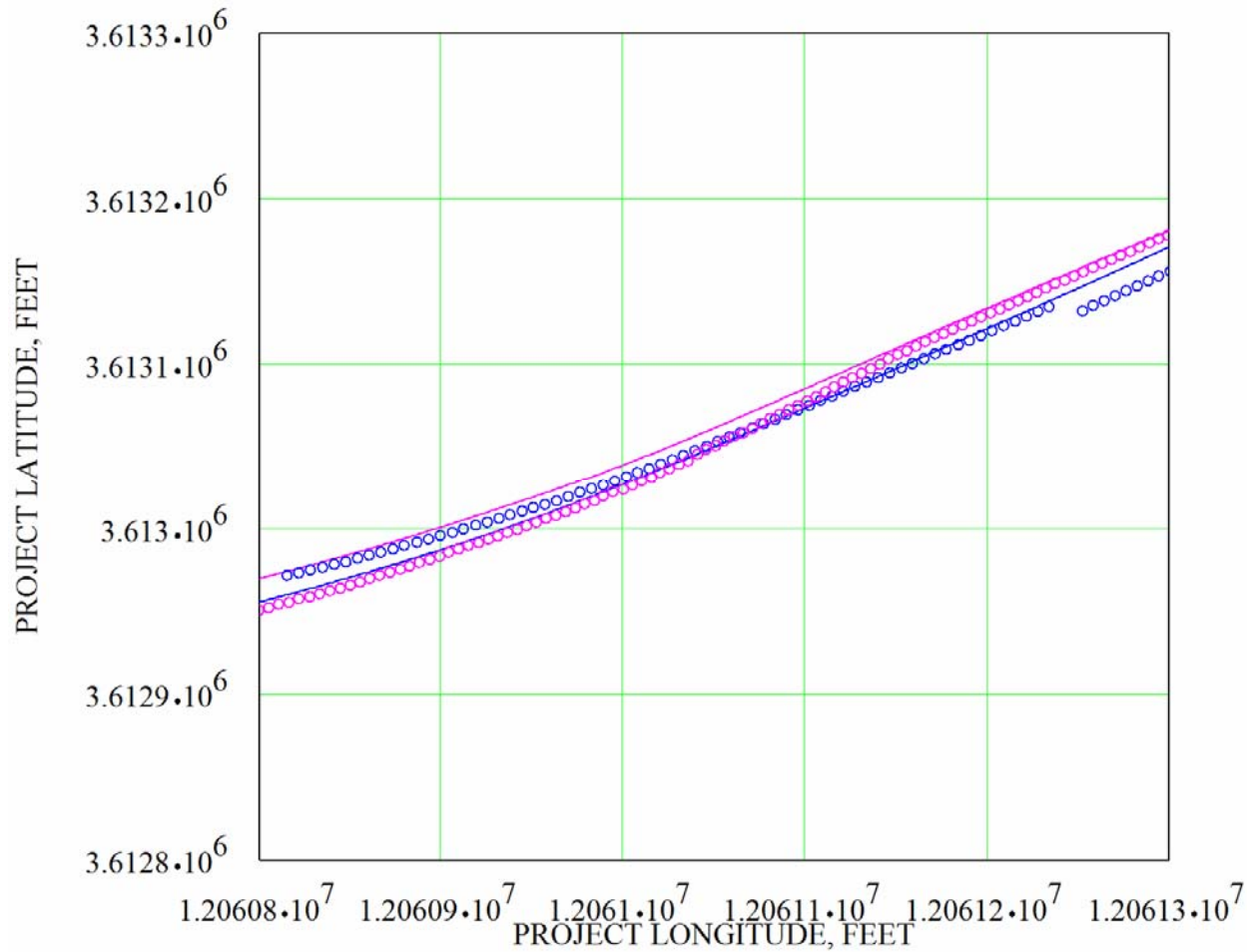
EASTBOUND, WESTBOUND – DHM, DGPS, AND SURVEY – BM5

Trajectories



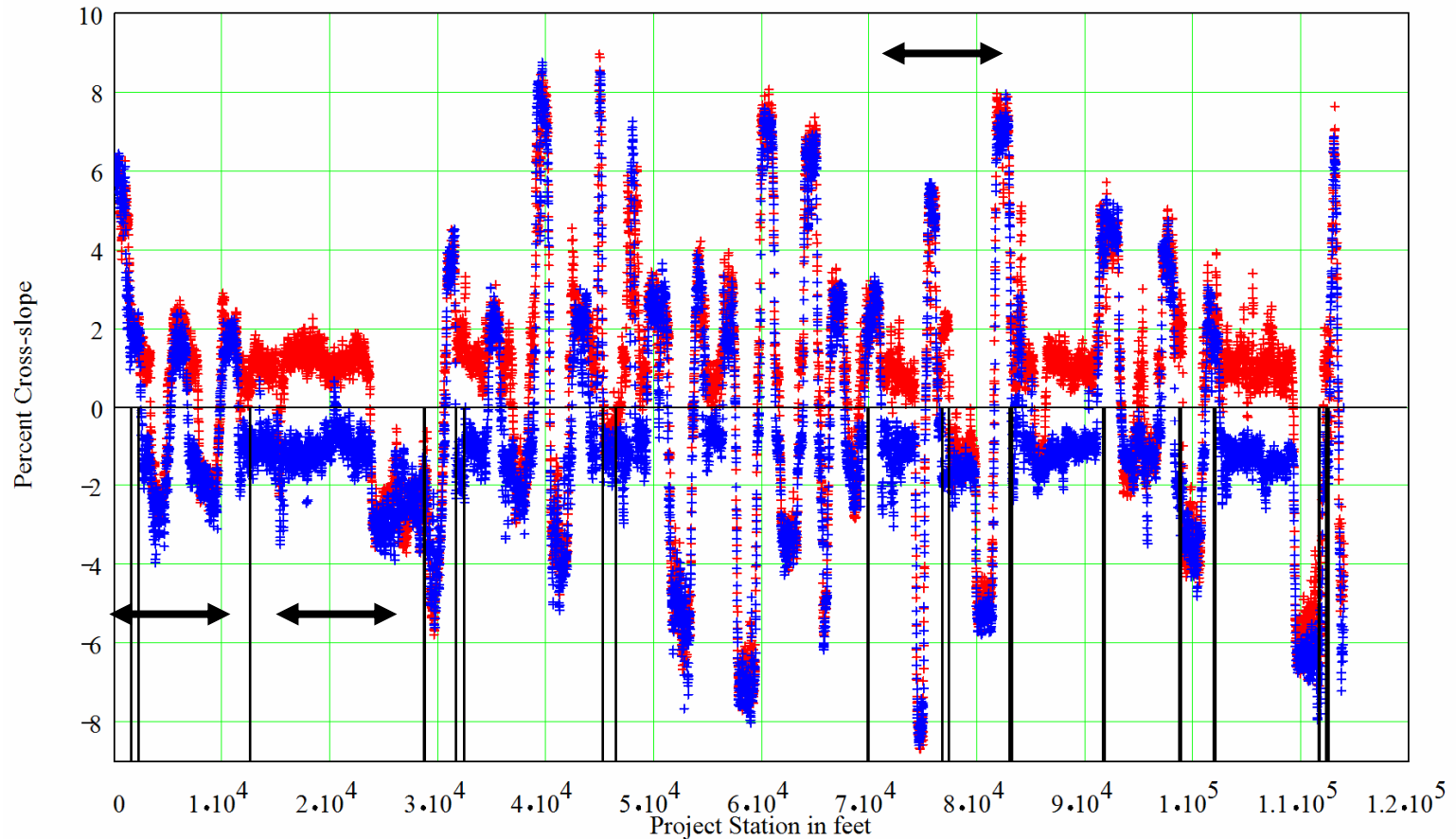
EASTBOUND, WESTBOUND – DHM, DGPS, AND SURVEY – BM6

Trajectories



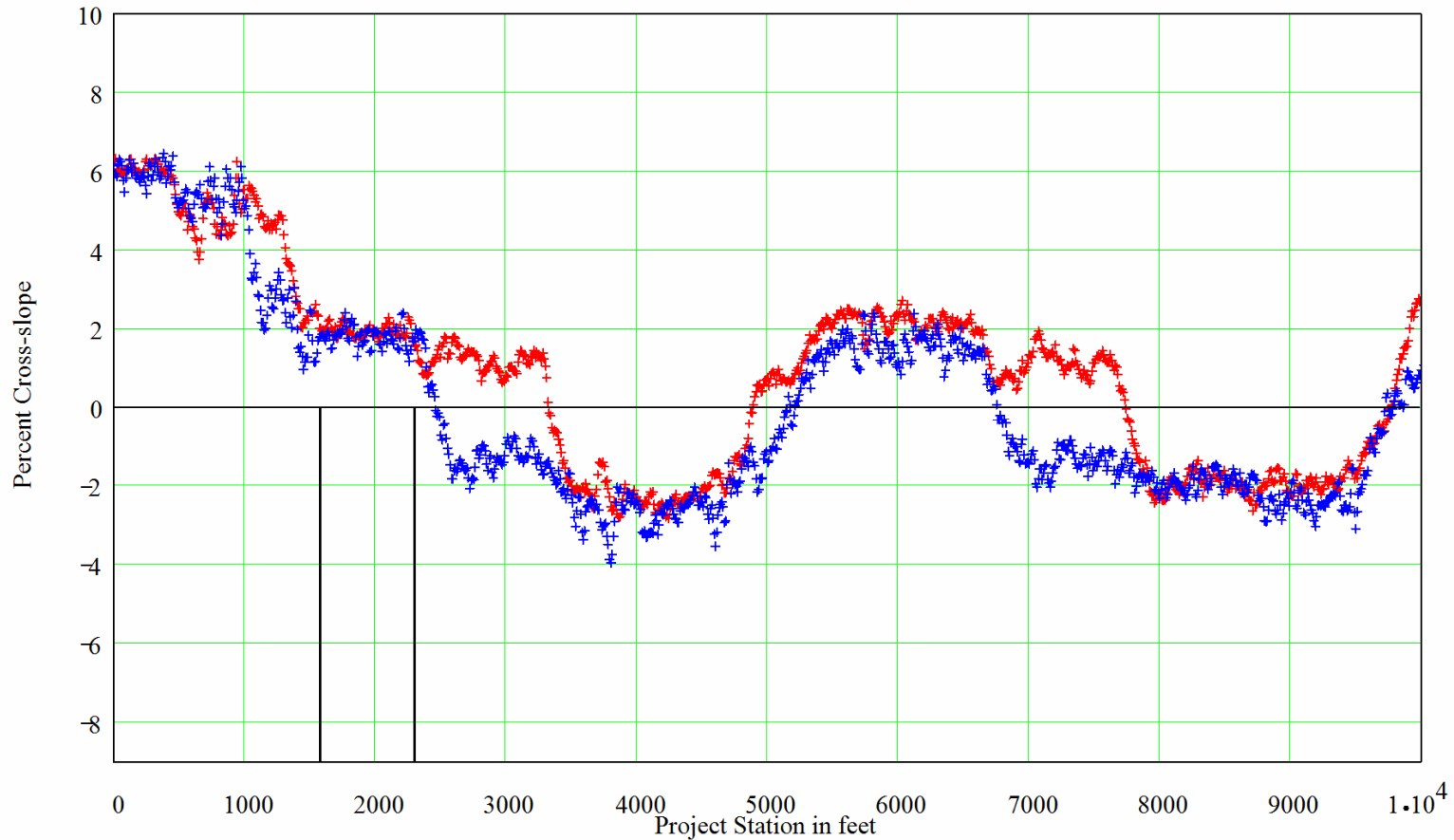
EASTBOUND, WESTBOUND – DGPS?????

Cross-Slope



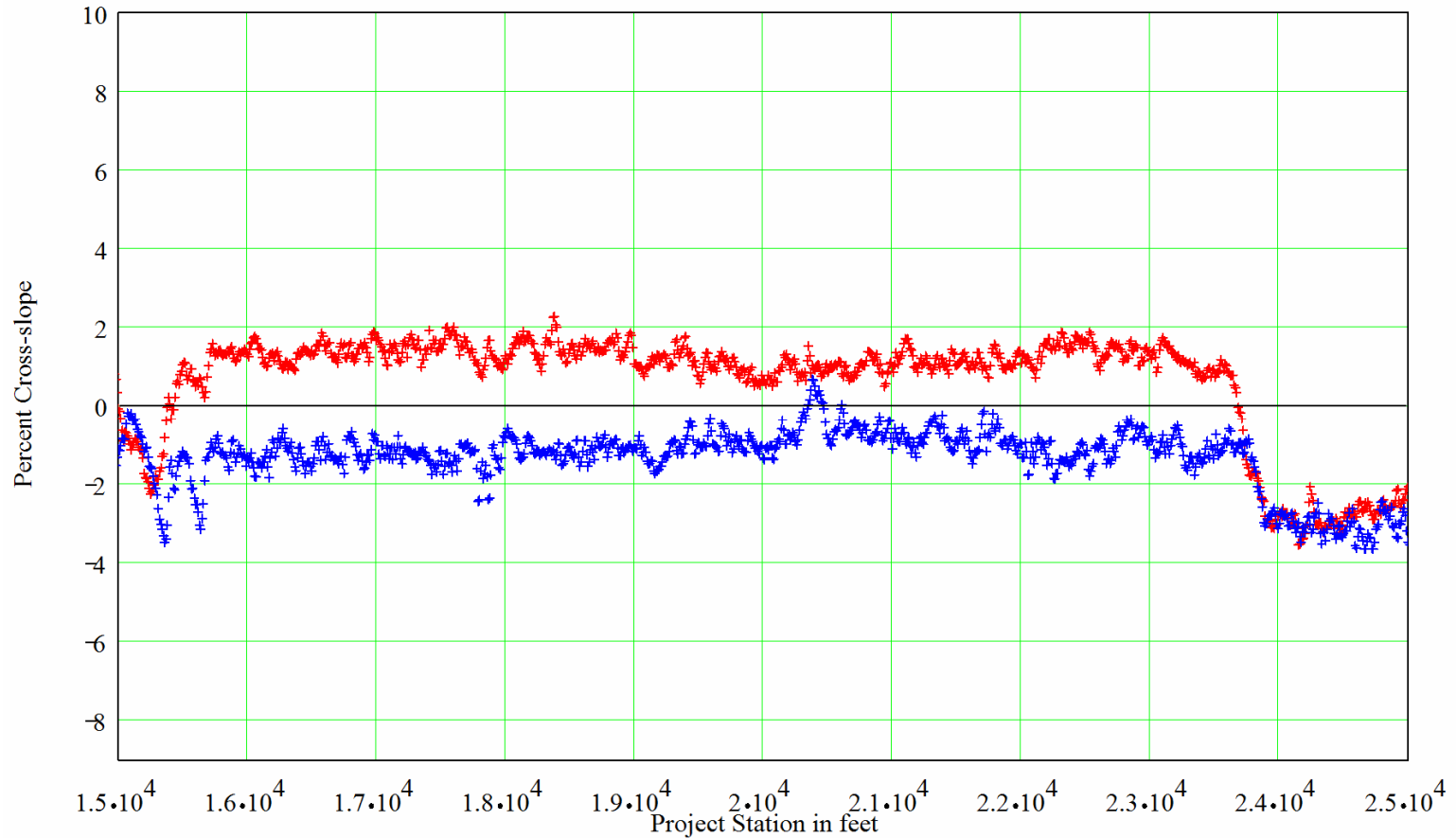
EASTBOUND in red , WESTBOUND in blue – ENTIRE PROJECT

Cross-Slope



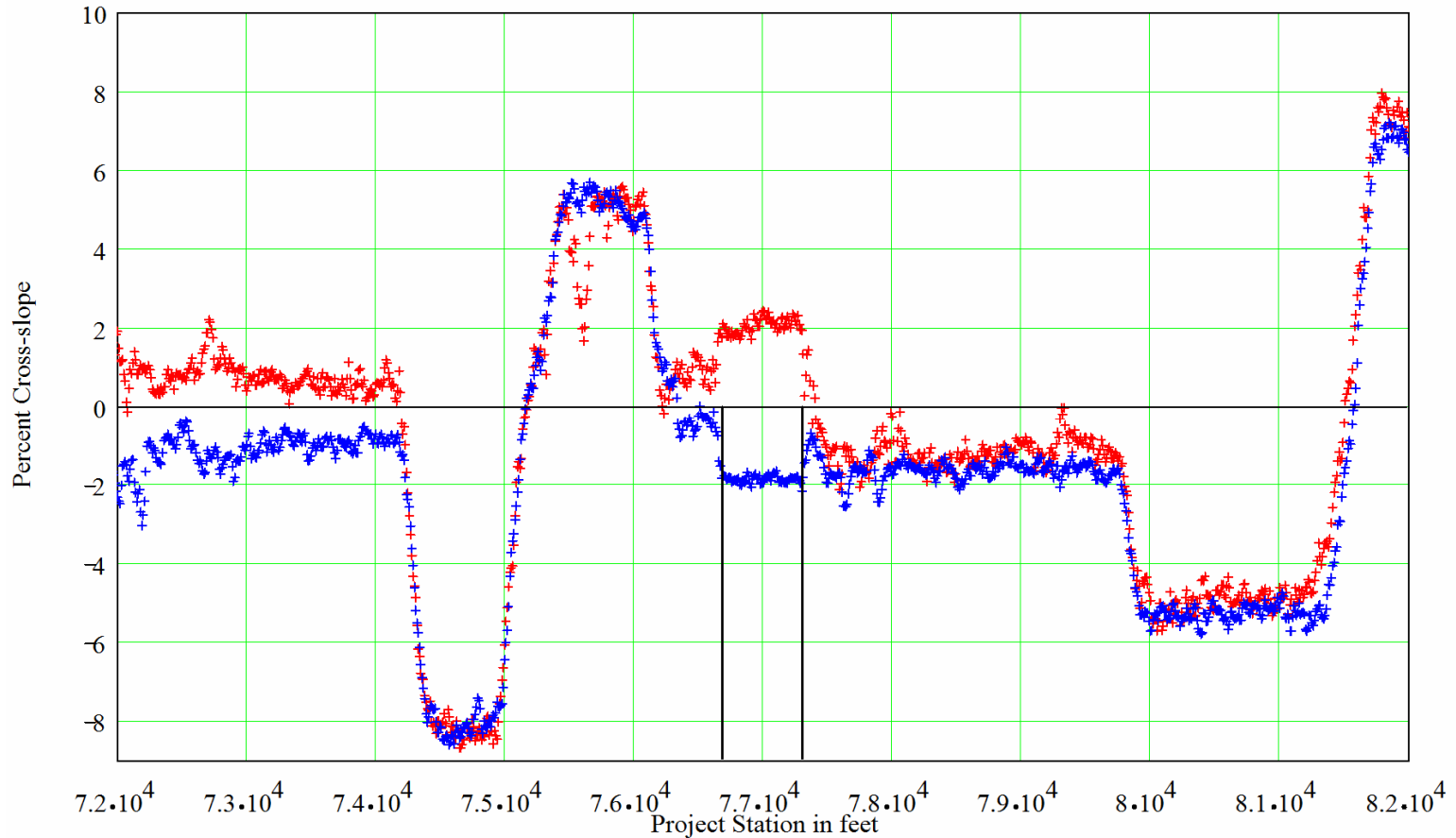
EASTBOUND in red , WESTBOUND in blue – DETAIL 1

Cross-Slope



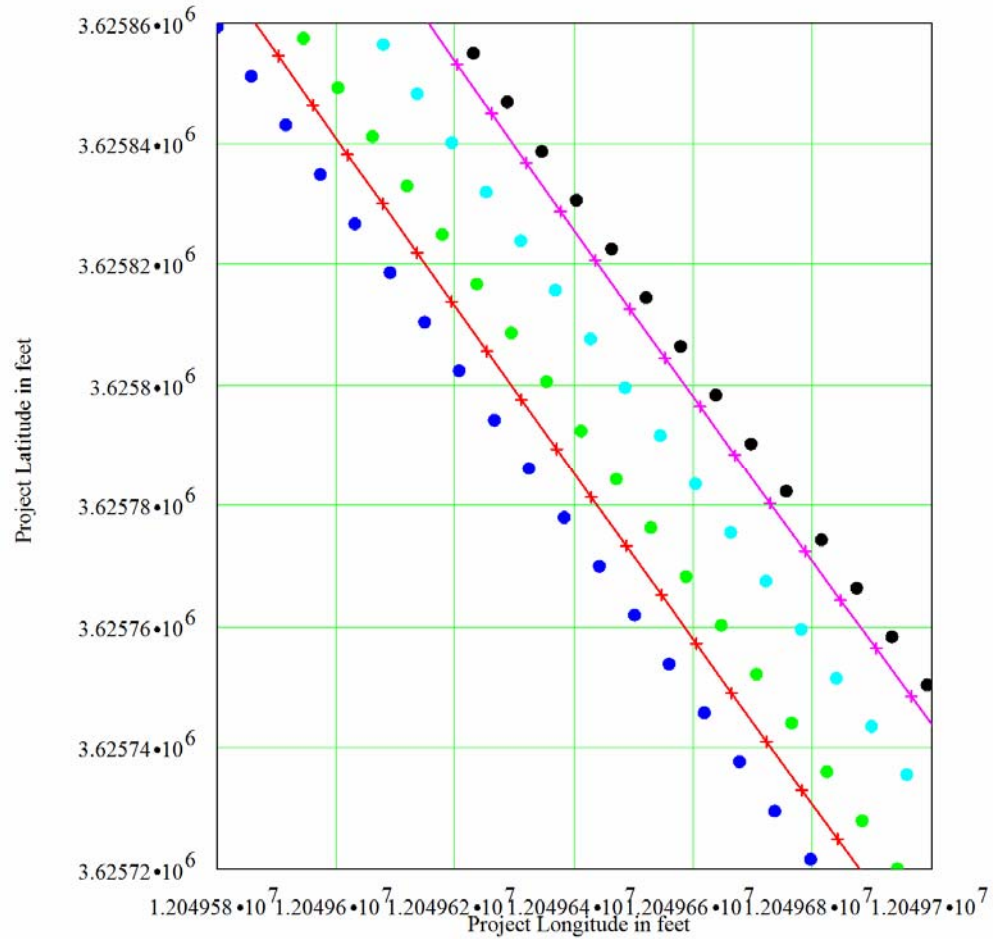
EASTBOUND in red , WESTBOUND in blue – DETAIL 2

Cross-Slope



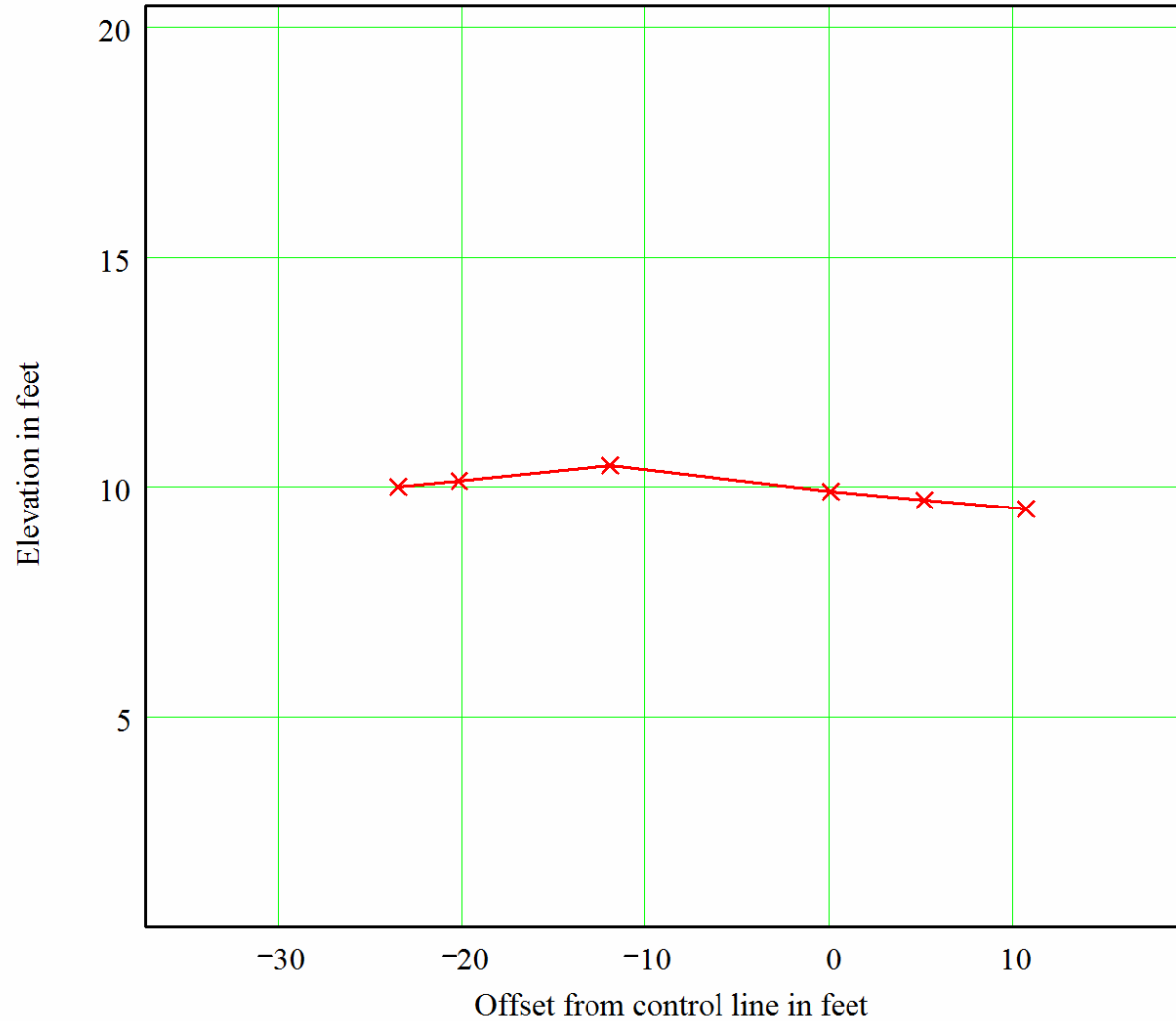
EASTBOUND in red , WESTBOUND in blue – DETAIL 3

Cross-Section



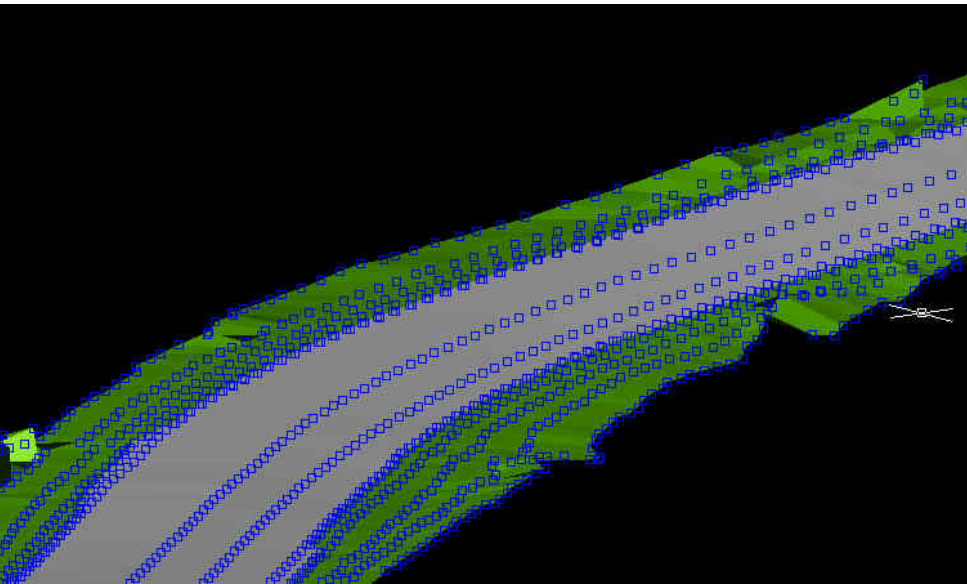
PLAN VIEW- TRAJECTORIES, JOINTS, EDGE OF PAVEMENT – DETAIL

Cross-Section



CROSS-SECTION- TRAJECTORIES, JOINTS, EDGE OF PAVEMENT

DHM-Visualization



AUTOCAD RENDERING

MOVIE OF CROSS-SECTIONS
IN .AVI FORMAT