GBT MEMO 160

Laser Rangefinder Deflection Measurements of the GBT Derrick

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1 Introduction

Section B of the left horizontal feedarm was suspended for weighing and lifted into place on October 31 and November 1, 1996. With the recent addition of a retroreflector mounted 81 meters above the ground on the GBT derrick tower one of the four 140 Foot Telescope demonstration lasers gained the capability to measure one component of the tower's deflection under load. Picture 2 shows the derrick as seen by the laser rangefinder used in this experiment; a close-up of the retroreflector mounted on the derrick is in picture 3. Because both days were overcast and the temperature remained relatively constant, the laser rangefinder recorded stable survey data throughout the entire lift. The graphical data included with the memo represents the derrick's deflection under the 89,500 pound load of section B.

Note that the deflection measurements did not constitute an experiment in the strict sense of the word, but rather a field test exploring the capabilities of a production laser rangefinder. Refer to Laser Field Testing Recordbook Two for the complete contemporaneous record of the lift as monitored over the radio.

2 Summary of Graphical Data

In addition to measuring the retroreflector mounted on the crane tower, the laser unit also measured a reference cube and a previously surveyed stationary retroreflector located approximately one kilometer away on a mountain. The reference cube, which is installed on the laser unit, provides the laser ranging software with a means of removing electronic drift from the distance measurements of all other cubes.

The retroreflector on the mountain rests atop an abandoned microwave reflector panel and serves as a control cube, monitoring changes in the index of refraction. Picture 1 shows the retroreflector on the mountain from the laser rangefinder's point of view. As the index of refraction fluctuates, the apparent distance to any object seen by the laser rangefinder also changes. The distance measurements of the four graphs included in this memo have not been compensated for a changing index of refraction.

Figure 1 shows the distance data taken from the 140 Foot Telescope demonstration laser to the retroreflector mounted atop the derrick while weighing the load. At 15:50, the derrick and a mobile crane each supported about half of the entire load. Note a deflection of about 20 millimeters in the direction of the 140 Foot Telescope. Near the end of the data set, a series of downward spikes were generated when the mobile crane swung away from the derrick and the boom partially blocked the laser beam.

Figure 2 shows the uncorrected distance data taken from the laser unit to the retroreflector mounted one kilometer away on the microwave reflector panel. The apparent distance to the reflector remains stable throughout the experiment–varying only 3 millimeters over a 2 hour period. The stability of the data is a direct result of the ideal weather conditions. Had the distance readings been compensated for the fluctuating index of refraction, the graph would have shown a line with a slope of zero.

Figure 3 shows the distance data taken from the laser rangefinder to the derrick while the derrick lifts the full 45 ton load into place. Note that when the unaided derrick hoists the full load, the resulting deflection is about 35 millimeters in the direction of the 140 Foot Telescope. At 18:46, the boom of the crane raised. As the boom raised, the distance between the crane and the laser unit increased about 45 millimeters due to the reduced torque on the crane tower. At 19:10, the boom swung right, rotating the horizontal feedarm section into place. The distance between the laser and cube increased once more, due to the growing angle between the load and the instrument. Finally, the boom is raised, lowered, and swung left and right in order to orient the load into position. The remainder of the data in figure 1 shows various dips and peaks in distance as the crane maneuvered the load into its final location.

A corresponding set of data taken from the laser rangefinder to the microwave reflector within the same time frame as figure 3, comprises figure 4. Again, the measurement to the stationary cube is stable and reflects the excellent weather conditions during the lift; the data varies only 2 millimeters over a 2 hour period. The drift is less than on the previous day, shown in figure 2, indicating that the weather conditions were even more ideal. In fact, October 31 was only partially cloudy; whereas, November 1 was cloudy with occasional rainfall.

3 Conclusions

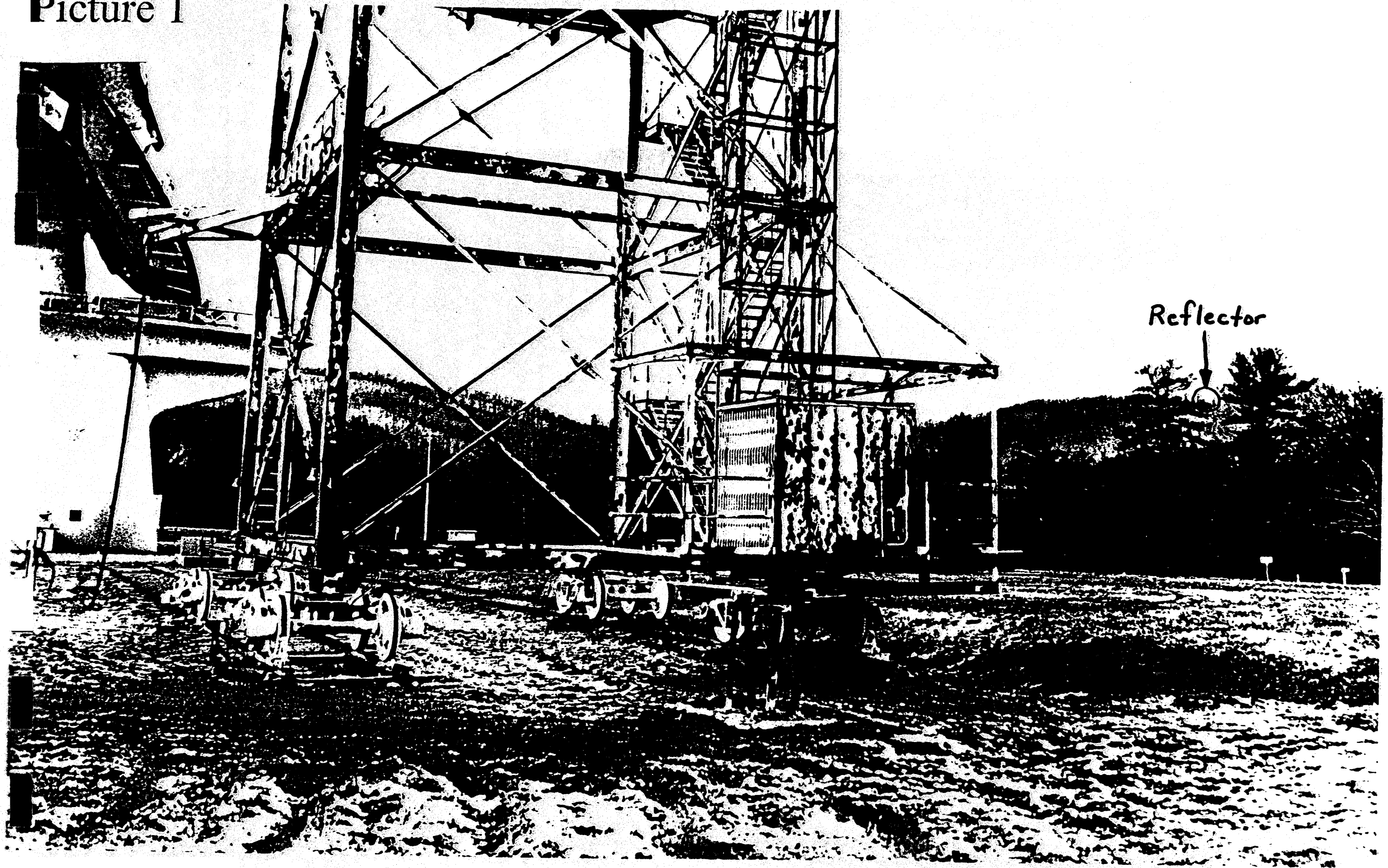
The graphs clearly demonstrate the capability of the laser rangefinder to resolve small mechanical deflections of a structure. While no attempt was made to compare the results to a deformation model, the results suggest that the instrument would be a valuable tool in verifying a variety of structural models (e.g. checking the margin of safety for heavy lifts and monitoring vertical feedarm motion during construction).

Utilizing additional rangefinders, the full three dimensional motion of a structure could be resolved. For example, if further GBT shaker experiments are performed (as described in GBT Memo 159), a set of laser rangefinders mounted around the GBT could measure actual telescope displacement. In the shaker experiment, the elevation bearing moved about 800 microns; such a small movement is detectable and points on the feedarm would probably yield much greater motions.

Acknowledgements

The GBT Antenna Metrology group would like to thank RSI for mounting the retroreflector on the crane tower and for providing data for the experiment.

Picture 1



Picture 2

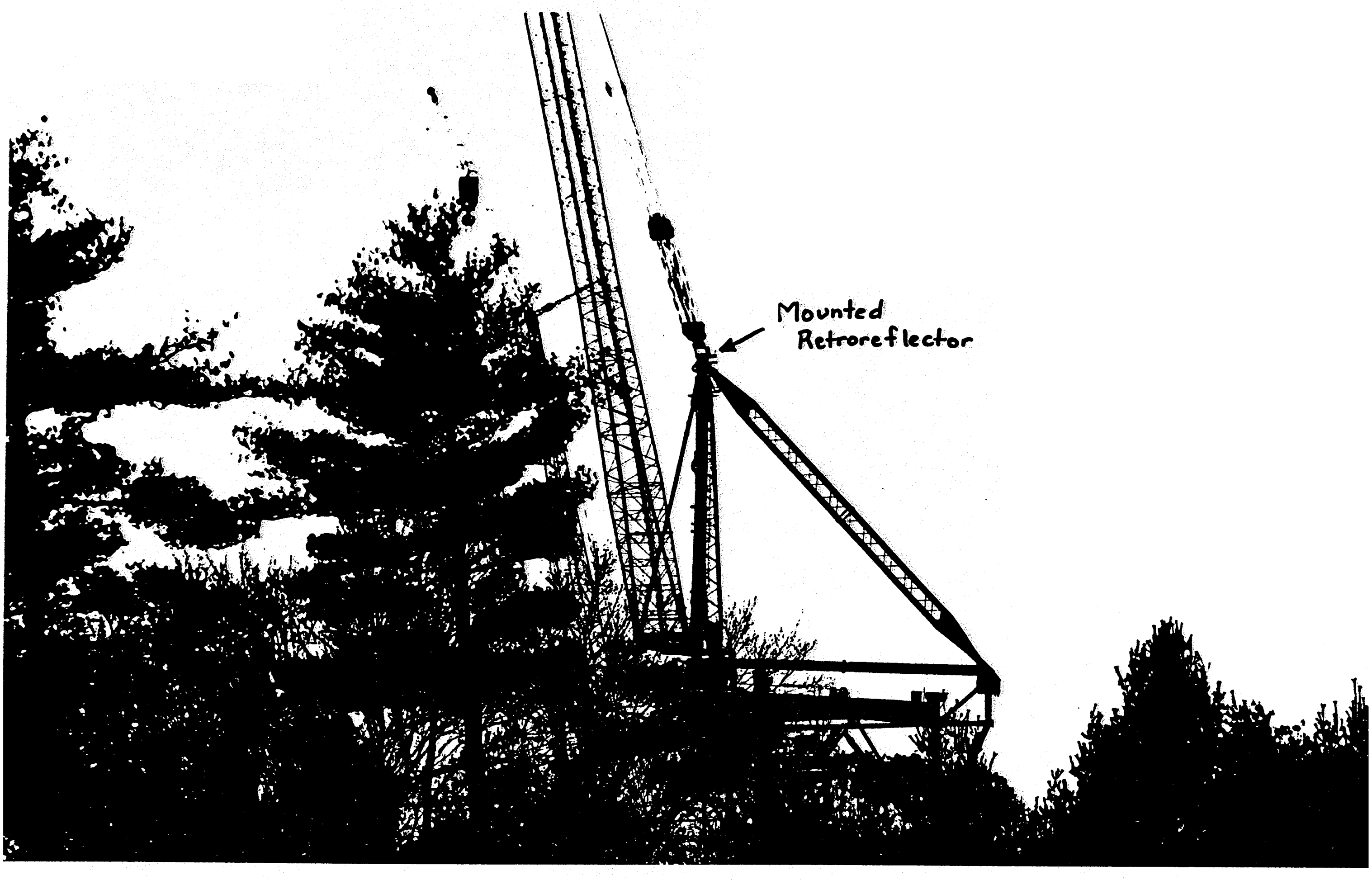
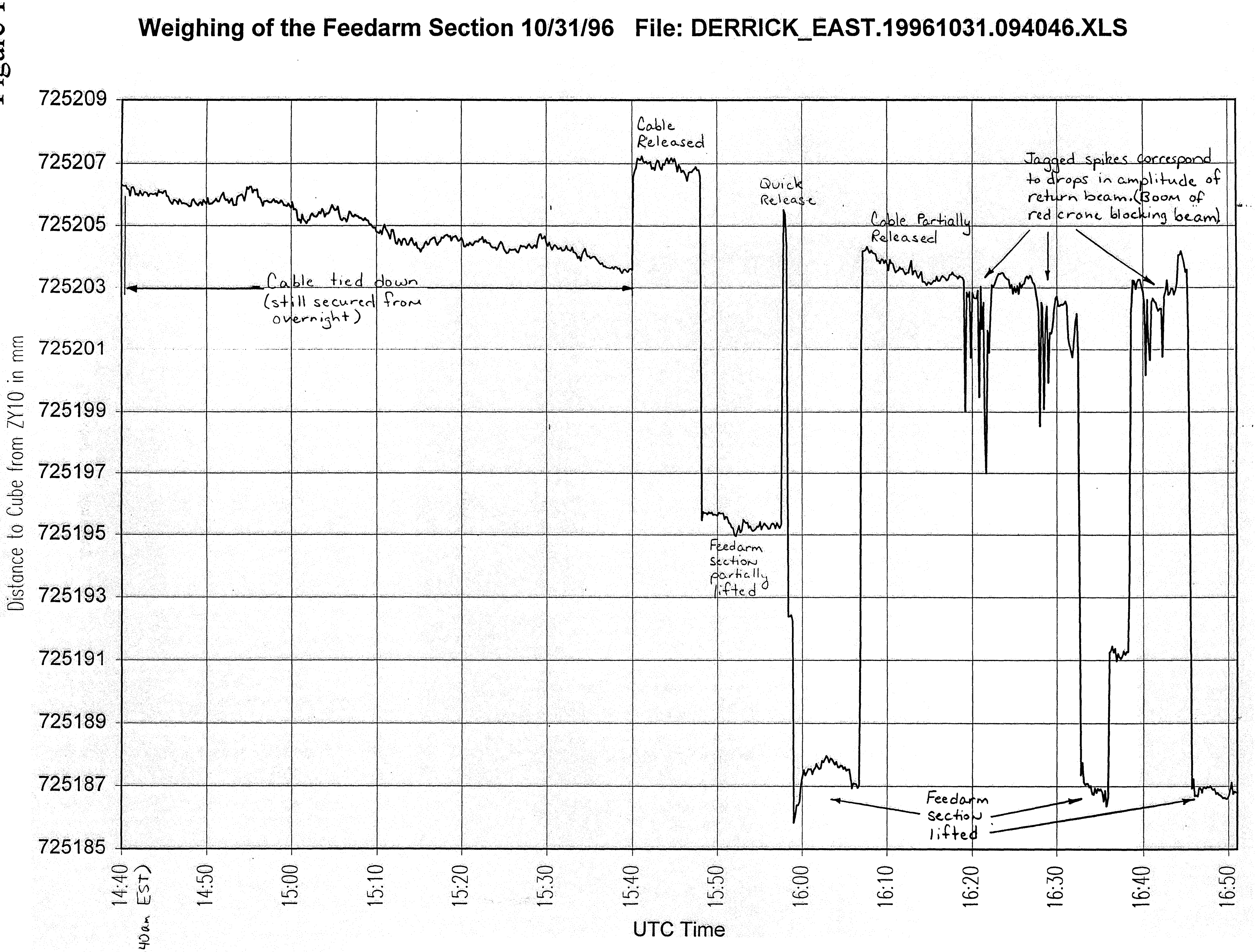

Mounted
Retroreflector

Figure 1



Weighing of the Feedarm Section 10/31/96 File: DERRICK_EAST.19961031.094046.XLS
Distance to Cube from ZY10 in mm
725209
725207
725205
725203
725201
725199
725197
725195
725193
725191
725189
725187
725185
UTC Time
14:40
40am EST)
14:50
15:00
15:10
15:20
15:30
15:40
15:50
16:00
16:10
16:20
16:30
16:40
16:50
Cable tied down (still secured from overnight)
Cable Released
Feedarm section partially lifted
Quick Release
Cable Partially Released
Jagged spikes correspond to drops in amplitude of return beam. (Boom of red crane blocking beam)
Feedarm section lifted

Figure 2

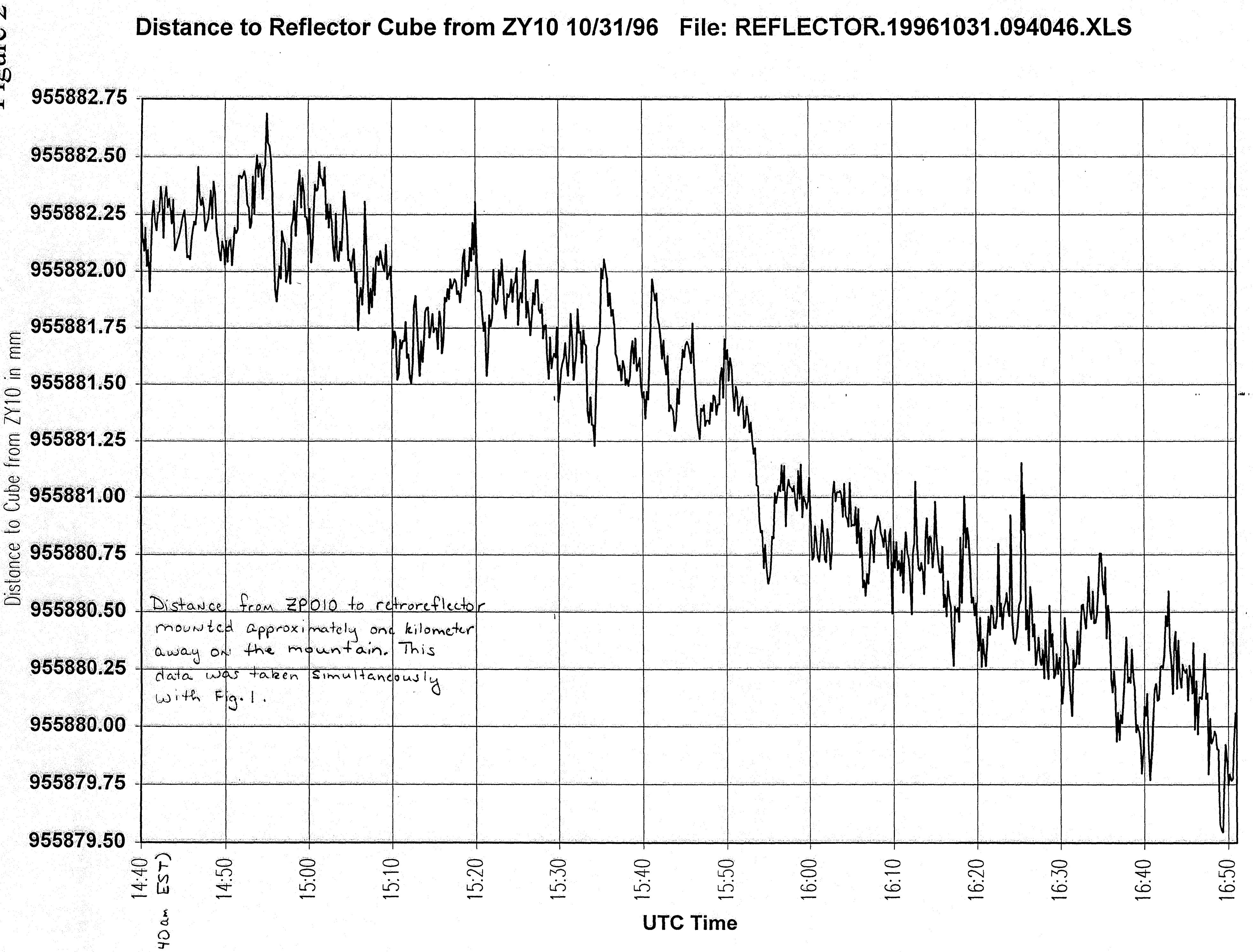
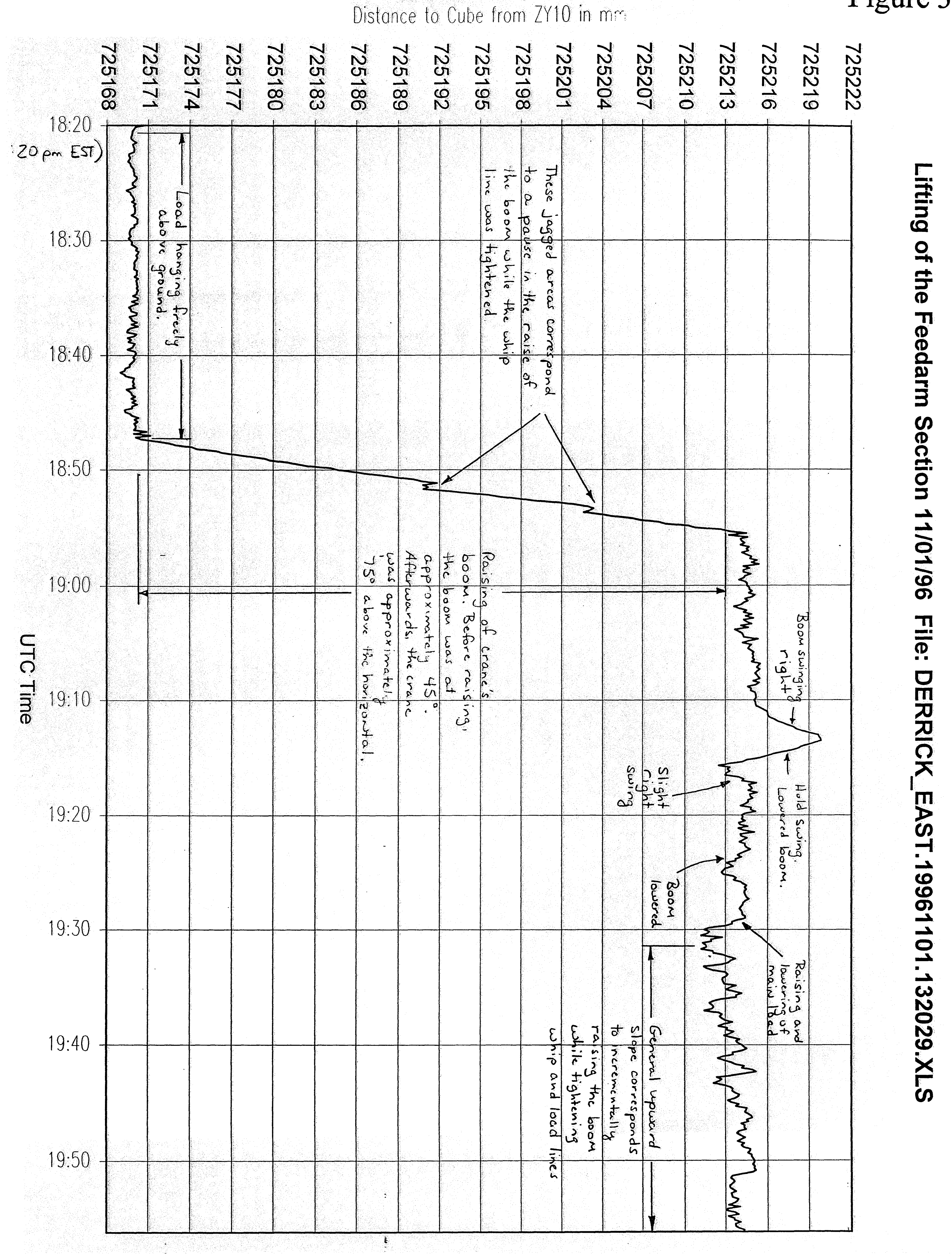
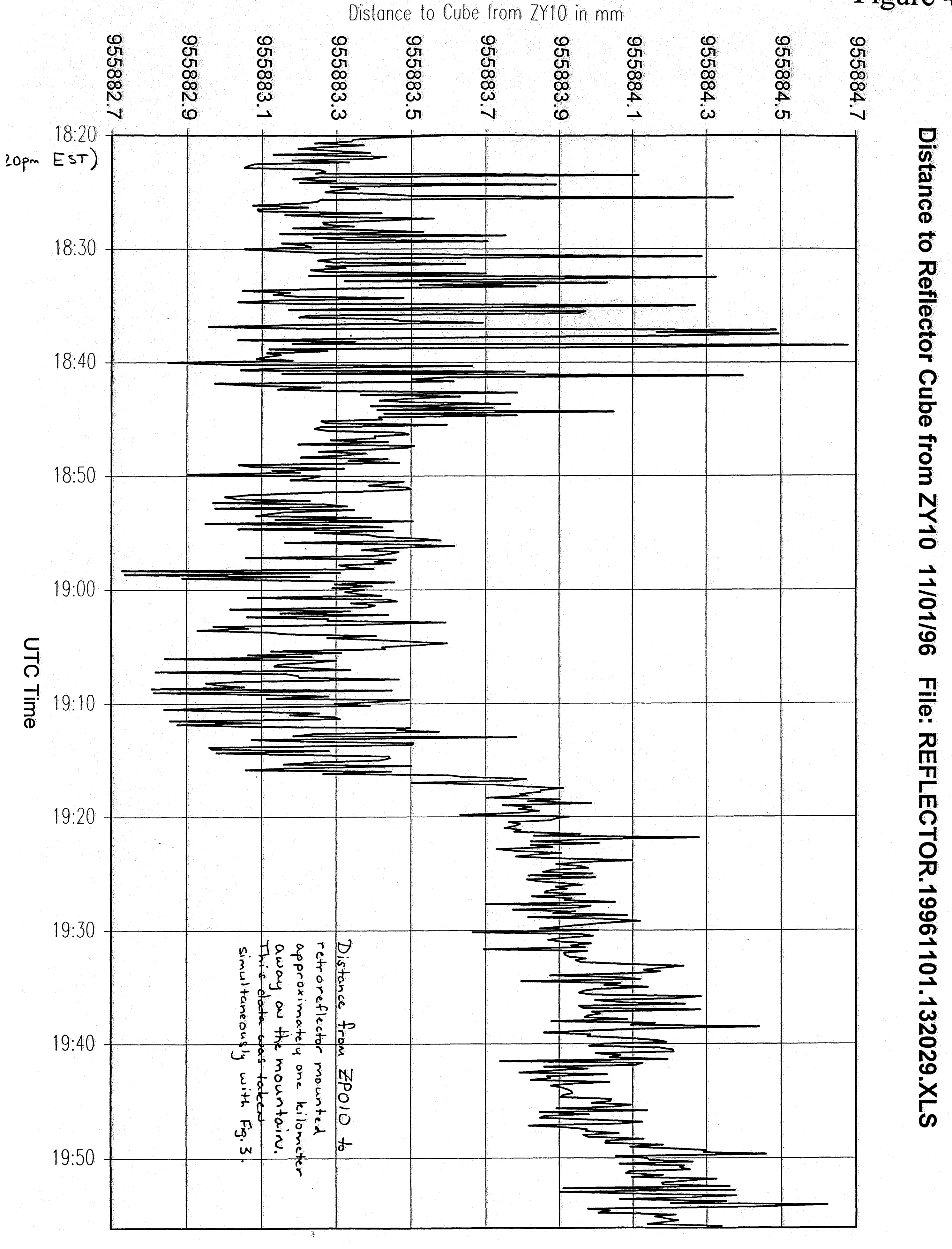

Distance to Reflector Cube from ZY10 10/31/96 File: REFLECTOR.19961031.094046.XLS
Distance to Cube from ZY10 in mm
955882.75
955882.50
955882.25
955882.00
955881.75
955881.50
955881.25
955881.00
955880.75
955880.50
955880.25
955880.00
955879.75
955879.50
14:40
40am EST)
14:50
15:00
15:10
15:20
15:30
15:40
15:50
16:00
16:10
16:20
16:30
16:40
16:50
UTC Time
Distance from ZP010 to retroreflector mounted approximately one kilometer away on the mountain. This data was taken simultaneously with Fig. 1.

Figure 3



Lifting of the Feedarm Section 11/01/96 File: DERRICK_EAST.19961101.132029.XLS
Distance to Cube from ZY10 in mm
725222
725219
725216
725213
725210
725207
725204
725201
725198
725195
725192
725189
725186
725183
725180
725177
725174
725171
725168
18:20
18:30
18:40
18:50
19:00
19:10
19:20
19:30
19:40
19:50
UTC Time
:20 pm EST)
Load hanging freely above ground.
These jagged areas correspond to a pause in the raise of the boom while the whip line was tightened.
Raising of crane's boom. Before raising, the boom was at approximately 45°. Afterwards, the crane was approximately 75° above the horizontal.
Boom swinging right
Hold swing. Lowered boom.
Slight right swing
Boom lowered
Raising and lowering of main load
General upward slope corresponds to incrementally raising the boom while tightening whip and load lines

Figure 4



Distance to Reflector Cube from ZY10 11/01/96 File: REFLECTOR.19961101.132029.XLS
Distance to Cube from ZY10 in mm
955882.7
955882.9
955883.1
955883.3
955883.5
955883.7
955883.9
955884.1
955884.3
955884.5
955884.7
UTC Time
18:20
20pm EST)
18:30
18:40
18:50
19:00
19:10
19:20
19:30
19:40
19:50
Distance from ZP010 to retroreflector mounted approximately one kilometer away on the mountain. This data was taken simultaneously with Fig. 3.