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Cambridge, Massachusetts

LUMINARY Memo #149

To: Distribution  
From: D. Eyles  
Date: 13 May 1970  
Subject: Further Tests of ZERLINA

Along with the tests of the Variable Servicer version ZERLINA which were described in Luminary Memo #144 I ran tests designed (1) to further verify that in zero TLOSS cases ZERLINA performs like LUMINARY, and (2) to reveal any latent instability that may lurk in ZERLINA at high TLOSS. This memo, mostly plots, presents the results of these runs.

Velocity Spike Cases

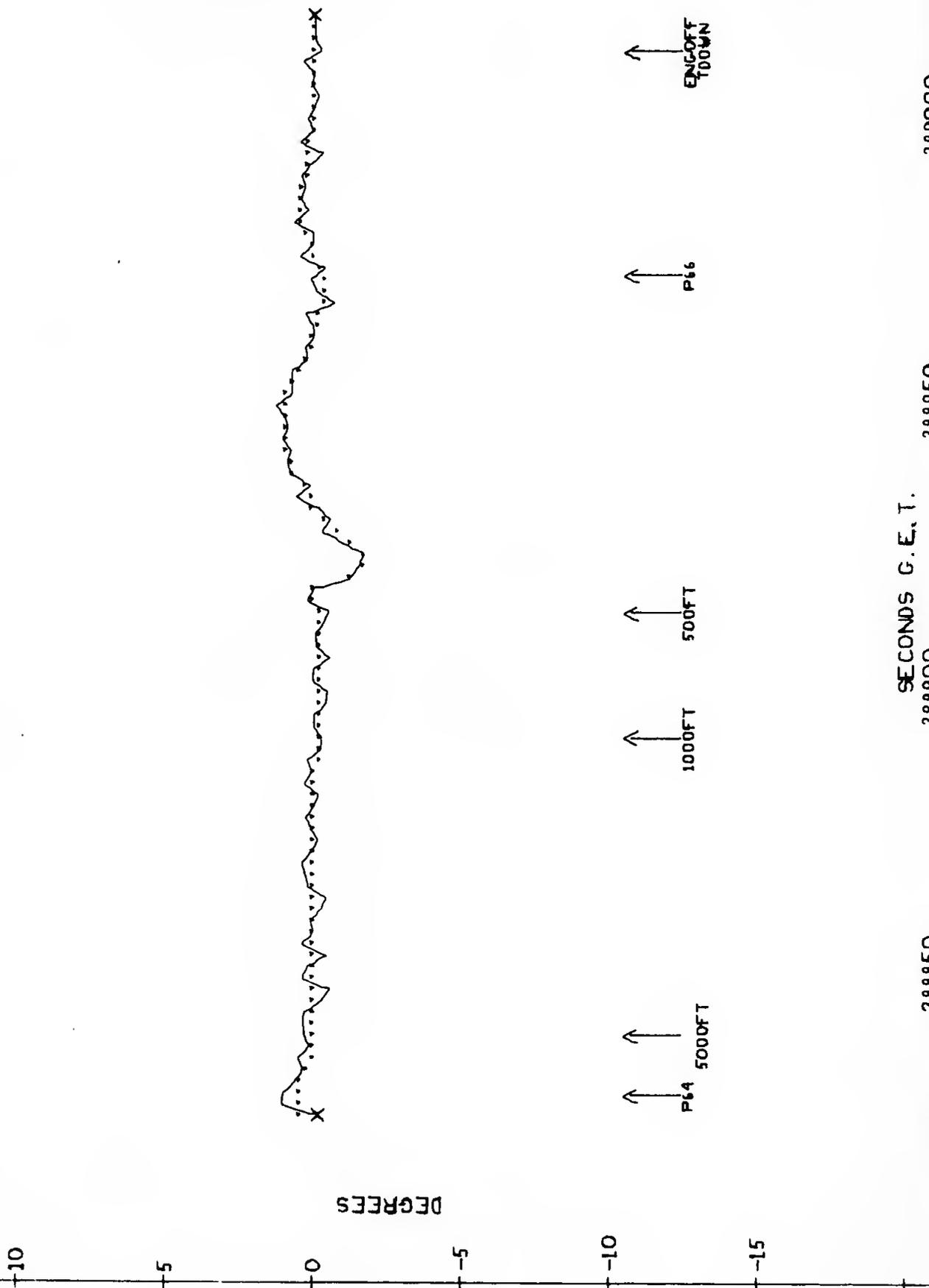
In these tests lateral velocity spikes were abruptly incorporated into the LM state vector and vehicle reaction observed. The magnitude of the spikes upon incorporation was 45 cm/s in the direction of the stable-member y-axis. This is about 1.5 ft/s - the maximum one-pass change in the velocity vector for a radar weighting factor of .2 and a velocity reasonableness test limit of 7.5 ft/s. In fact the reasonableness test limit for Apollo 13 was 2.5 ft/s and the lower value will probably be kept, so the spikes used were impossibly big by a factor of 3. Each spike was input by an astronaut action conditional on the display of LPD time in noun 64 and actually enters the state vector a few seconds after the time at which TGO is the indicated -70 or -50 seconds. The spike cases run were these:

1. LUM 154. Spike at TGO -70.
2. ZER 16. Spike at TGO -70.
3. ZER 16. Spike at TGO -70. TLOSS 20%.
4. ZER 16. Spike at TGO -70. TLOSS 20%. LEADTIME 3 seconds.
5. LUM 154. Spike at TGO -50.
6. ZER 16. Spike at TGO -50.
7. ZER 16. Spike at TGO -50. TLOSS 20%.
8. ZER 16. Spike at TGO -50. TLOSS 20%. LEADTIME 3 seconds.

Unless otherwise indicated TLOSS is zero and LEADTIME is 2.2 seconds. The plots for CDUZ for these tests are on the following pages. Note that the ZERLINA and LUMINARY cases for zero TLOSS compare closely. The 20% TLOSS cases, especially for a spike at TGO -50, return to normalcy less quickly, due to a longer attitude control interval and slower correction of the velocity vector by the landing radar. Nevertheless the oscillations do not grow and instability is avoided. At this time in P64 with 20% TLOSS guidance period is around 2.6 seconds. The 20% TLOSS cases with LEADTIME set to 3 from the customary value of 2.2 seconds show little difference.

# CDUZ AND CDUZD

MARSROT NUMBER 08813545  
LUMINARY LANDING WITH NOISE SPIKE AT TGO -70



SECONDS G. E. T.

ω

38850

38890

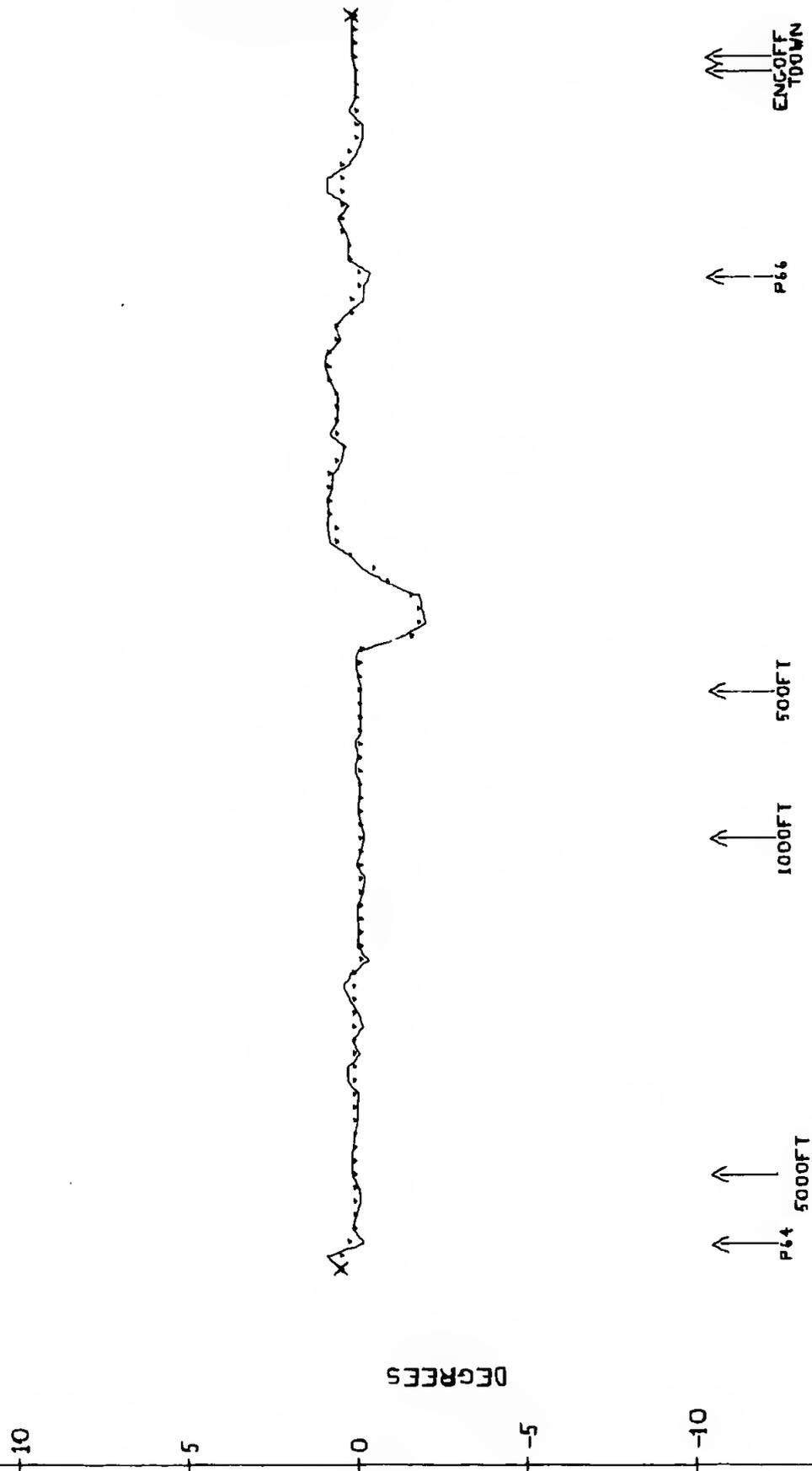
388950

389000

⊕

# CDUZ AND CDUZD

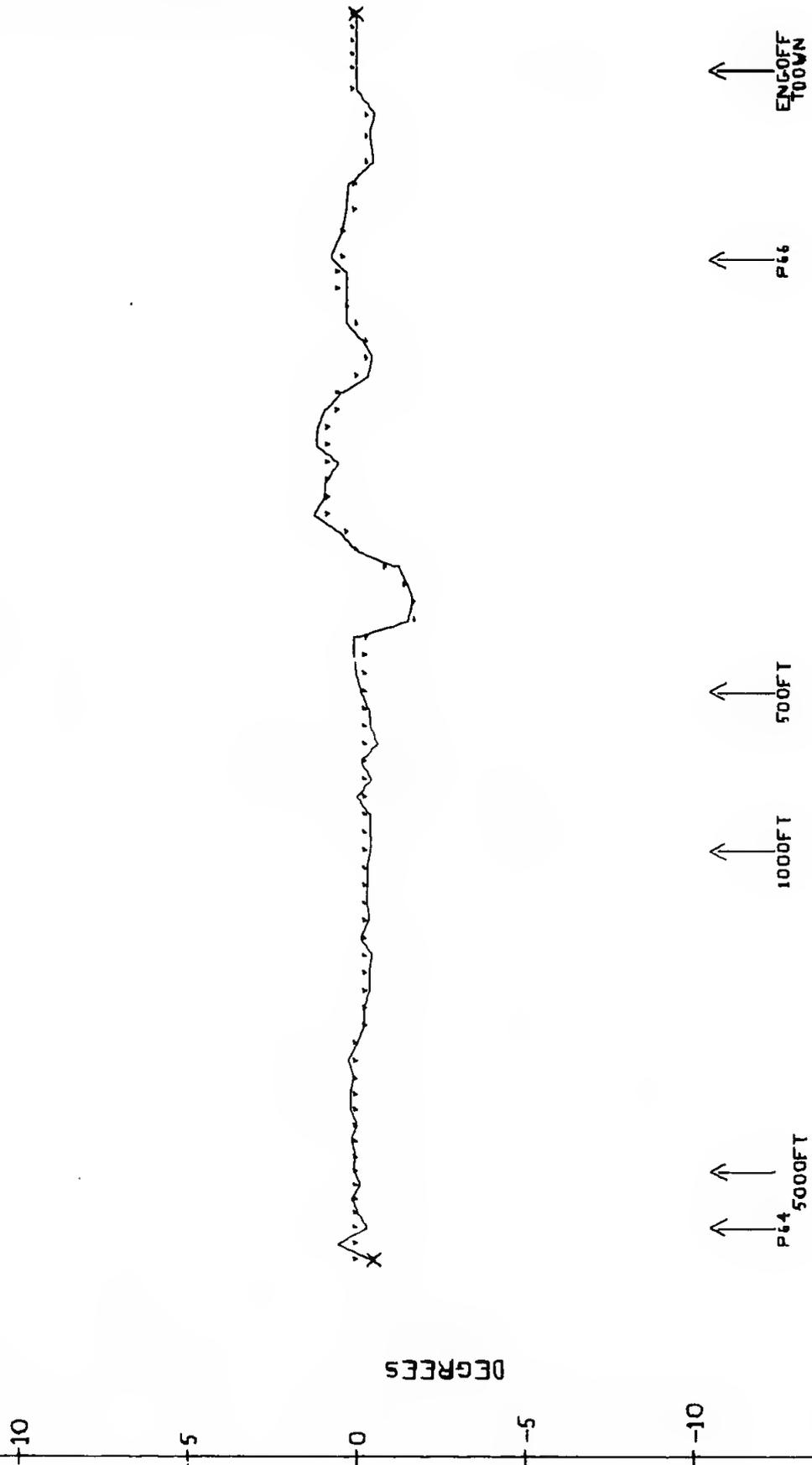
MARSROT NUMBER 08811494  
ZERLINA 16 LANDING WITH NOISE SPIKE AT TGO -70



# CDUZ AND CDUZD

MARSROT NUMBER 08803360

ZERLINA 16 LANDING WITH NOISE SPIKE AT TGO -70 AND 20x TLOSS



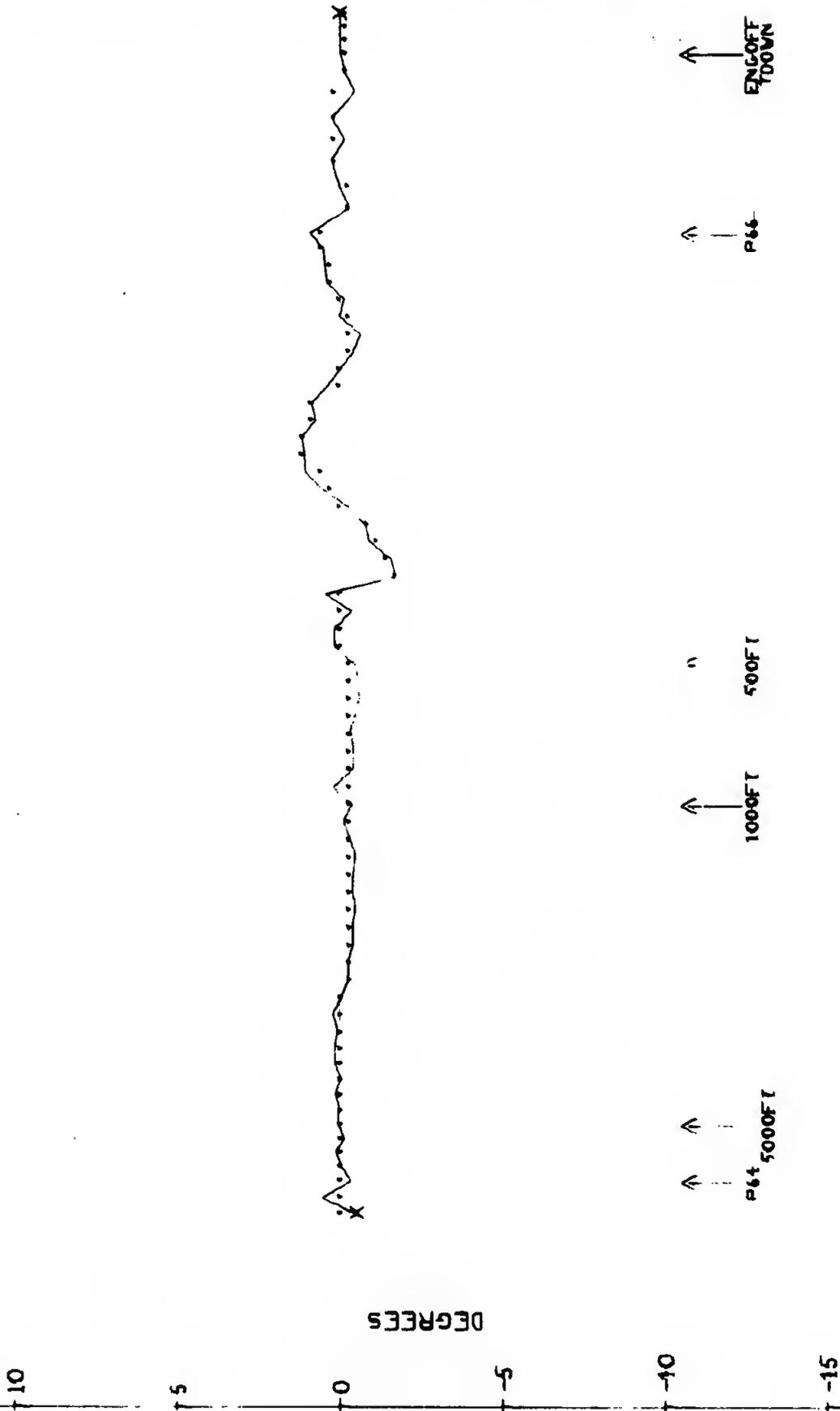
SECONDS G.E.T.

CE

# CDUZ AND CDUZD

MARSROT NUMBER 08803360

ZERLINA 16 LANDING WITH NOISE SPIKE AT TGO -70, 20\* TLOSS, LEADTIME 3



SECONDS G.E.T.

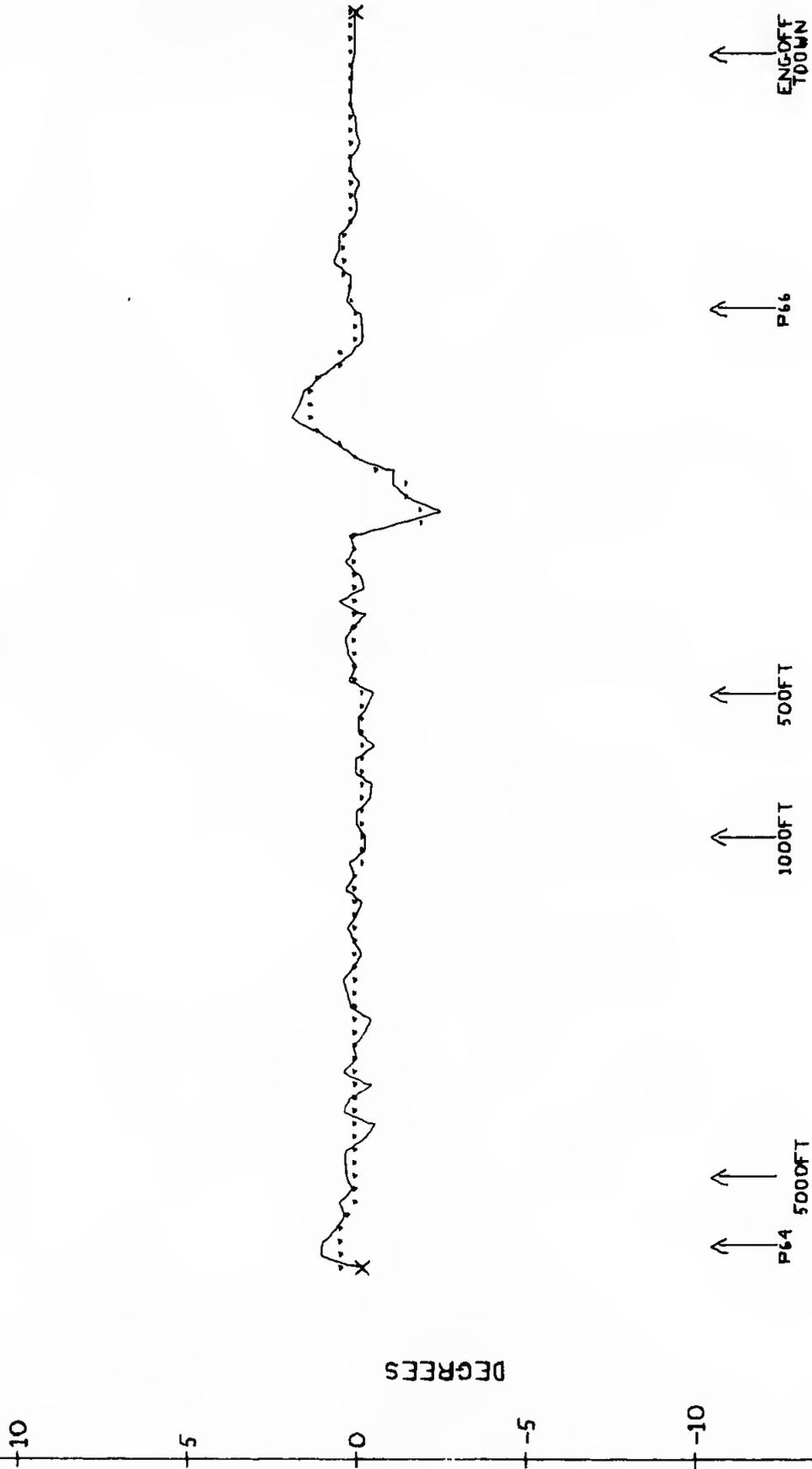
388950

389000

CE

# CDUZ AND CDUZD

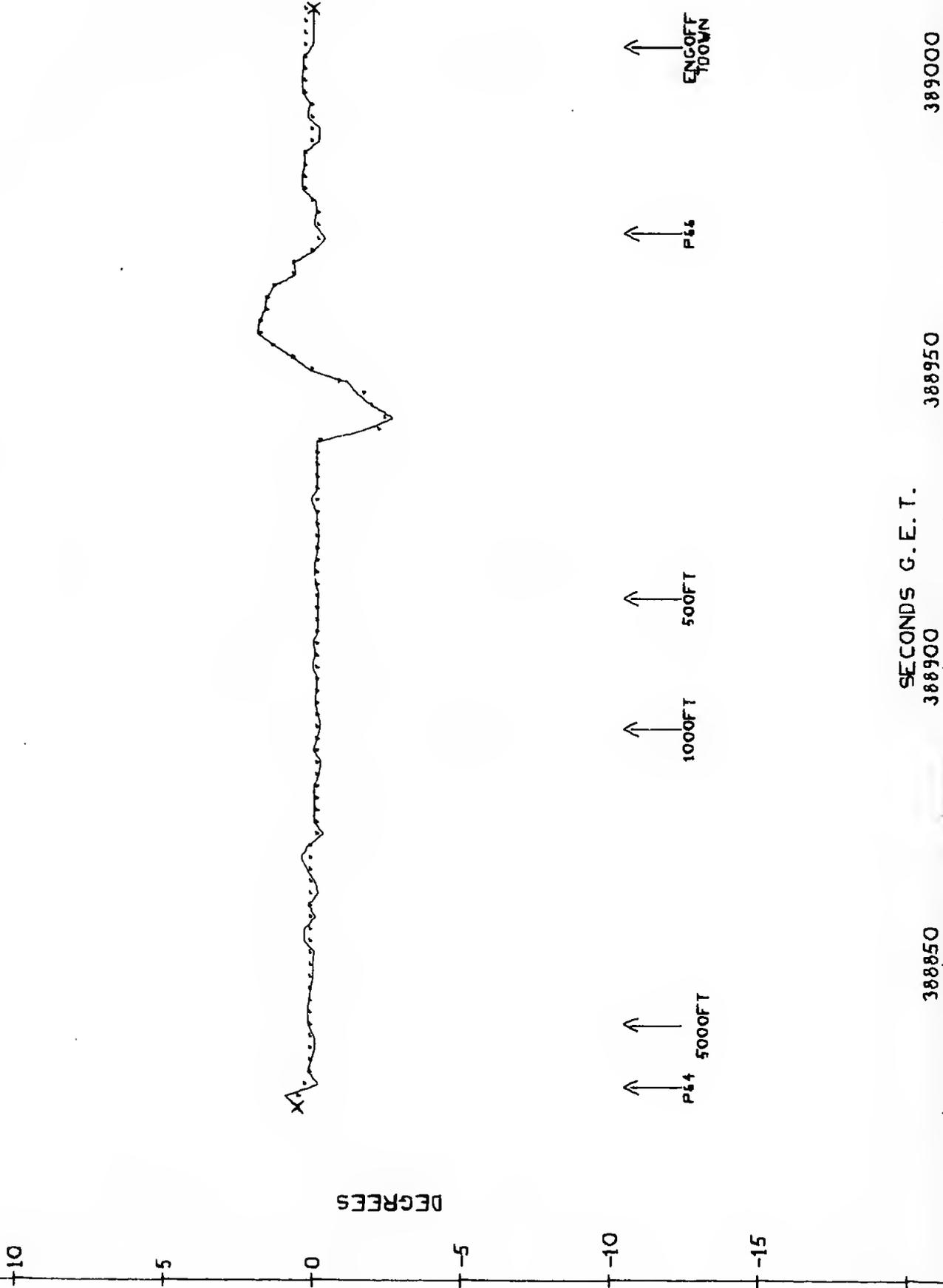
MARSROT NUMBER 06723183  
LUMINARY LANDING WITH NOISE SPIKE AT TGO -50



SECONDS G.E.T. 388850 388900 388950 389000

# CDUZ AND CDUZD

MARSROT NUMBER 08810425  
ZERLINA 16 LANDING WITH NOISE SPIKE AT TGO -50

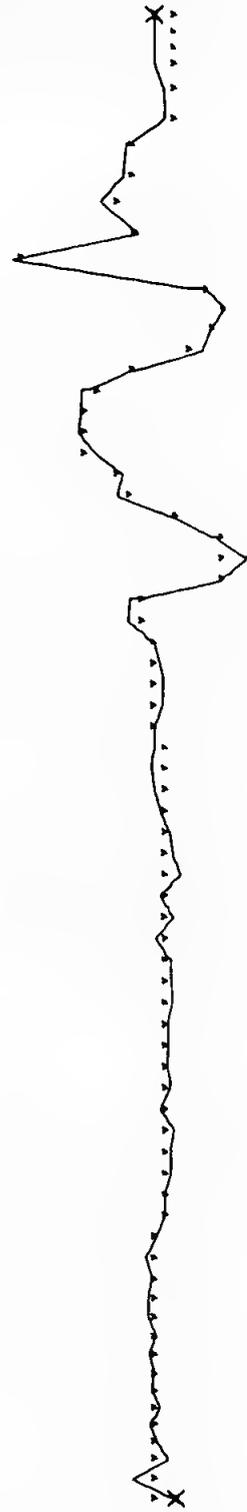


# CDUZ AND CDUZD

MARSROT NUMBER 08802313  
ZERLINA 16 LANDING WITH NOISE SPIKE AT TGO -50 AND 20\* TLOSS

DEGREES

-10  
-5  
0  
-5  
-10  
-15



P64 5000FT

1000FT

500FT

P66

ENG OFF  
1000W

# CDUZ AND CDUZD

MARSROT NUMBER 08802313

ZERLINA 16 LANDING WITH NOISE SPIKE AT TGO -50, 20x TLOSS, LEADTIME 3

DEGREES

10

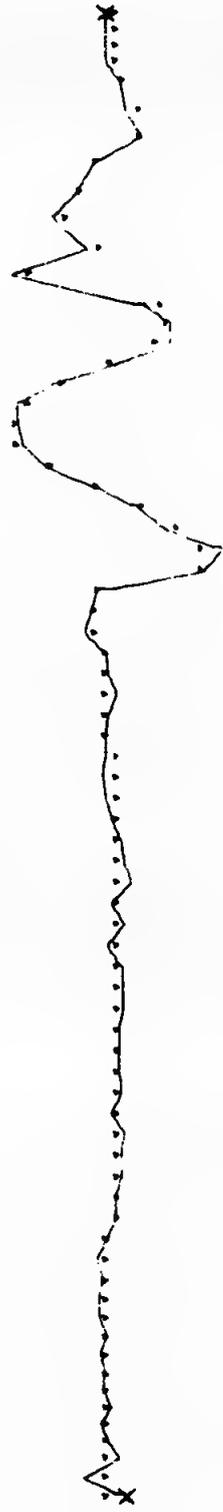
5

0

-5

-10

-15



↑ P64 5000FT

↑ 1000FT

↑ 500FT

↑ P66

↑ ENG-OFF 7000M

01

388850

388900

96LONDS G.E. T.

388950

389000

0E

### Redesignation Cases

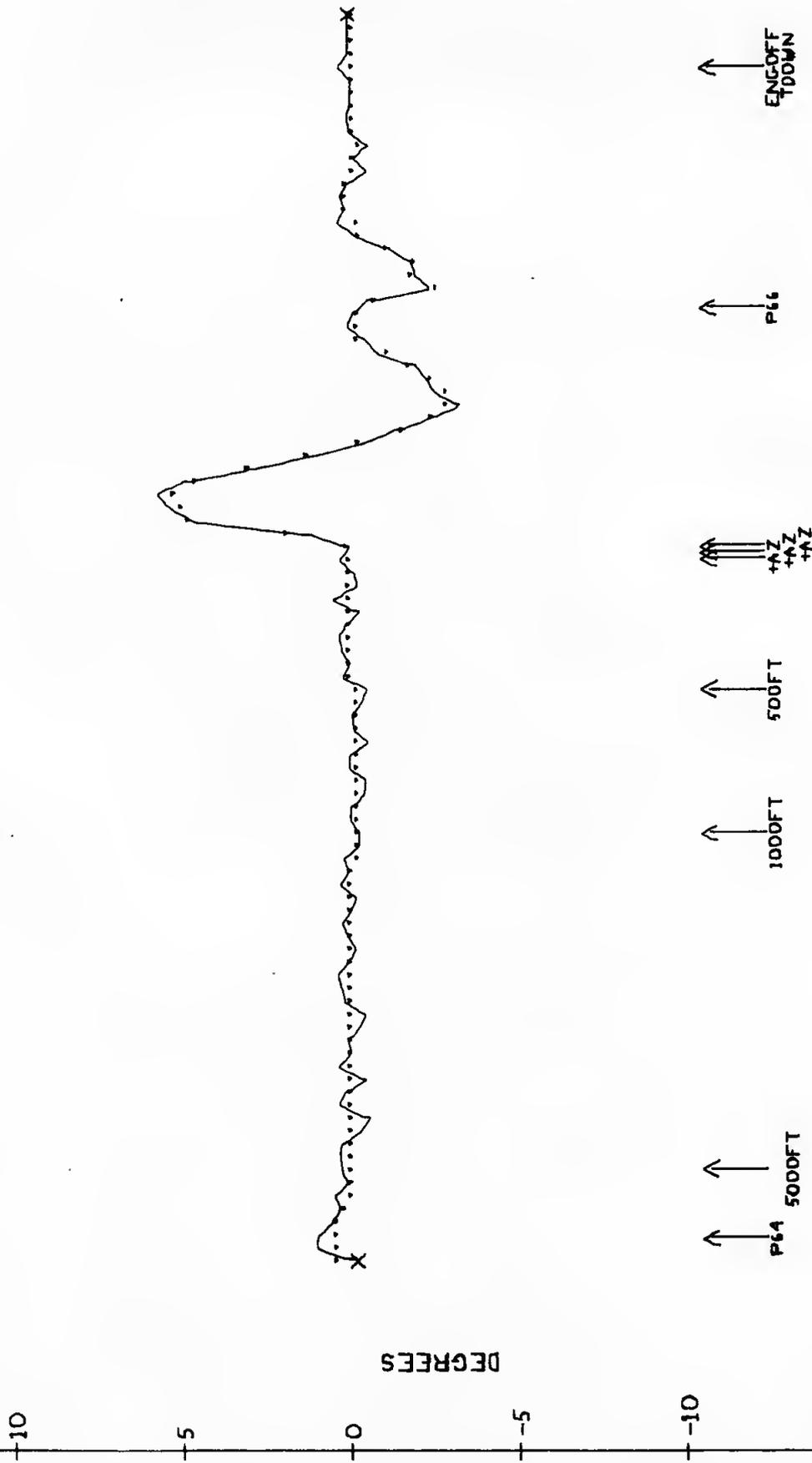
In these runs 3 rightward (+ azimuth) redesignations were input at about TGO -50 seconds. The earlier cases perturb the velocity vector. These redesignation cases in effect perturb the position vector by shifting the landing site. The redesignation cases are these:

1. LUM 154. Redesignations at TGO -50.
2. ZER 16. Redesignations at TGO -50.
3. ZER 16. Redesignations at TGO -50. TLOSS 20%.
4. ZER 16. Redesignations at TGO -50. TLOSS 20%. LEADTIME  
3 seconds.

The reactions to these position "spikes" are shown in the CDUZ plots on the next pages. Again note that at zero TLOSS the LUMINARY and ZERLINA cases compare closely, and that unbounded behavior never results. Increasing LEADTIME from 2.2 seconds to 3 seconds somewhat improves the 20% TLOSS case. Possibly we may wish to increase LEADTIME to improve performance in very high TLOSS situations.

# CDUZ AND CDUZD

MARSROT NUMBER 08809394  
LUMINARY LANDING WITH REDESIGNATIONS AT TGO -50



SECONDS G. E. T.

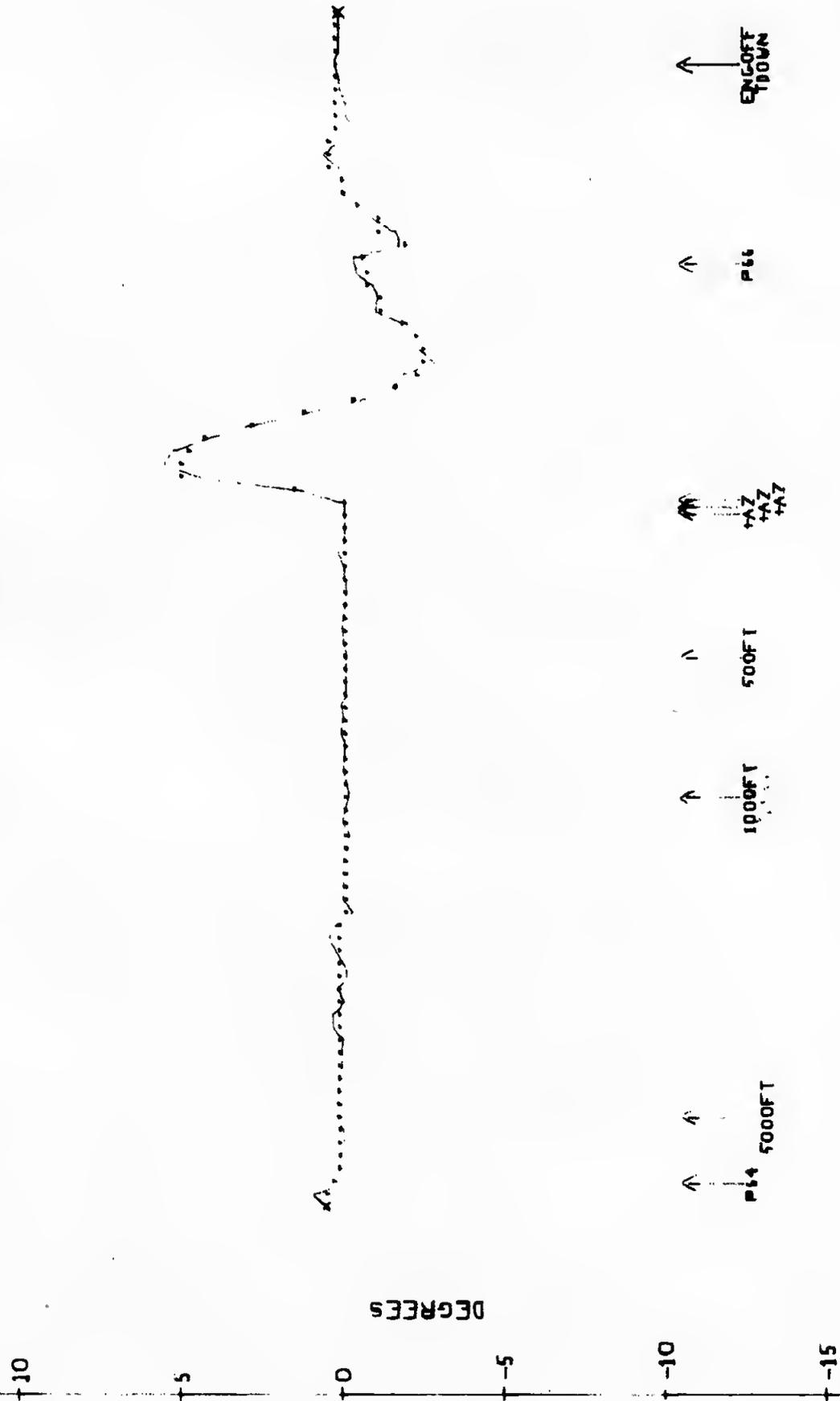
388950

389000

CE

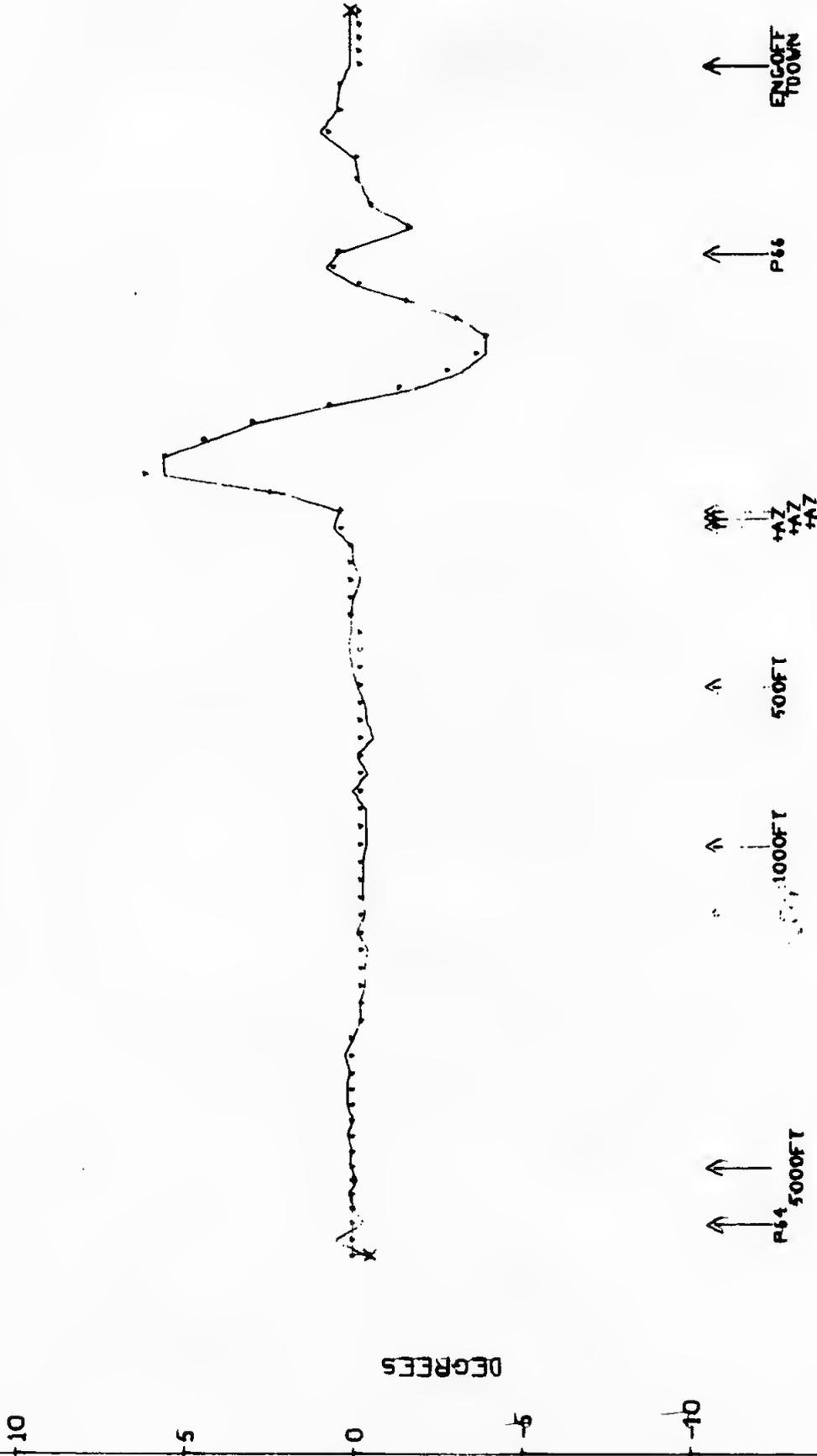
# CDUZ AND CDUZD

MARSROT NUMBER 08900462  
ZERLINA 16 LANDING WITH REDESIGNATIONS AT TGO -50



# CDUZ AND CDUZD

MARSROT NUMBER 08810032  
ZERLINA 16 LANDING WITH REDES AT TGO -50, 20\* TLOSS, LEADTIME 3



SECONDS G.E.T.

DE

## P66 Exercise Cases

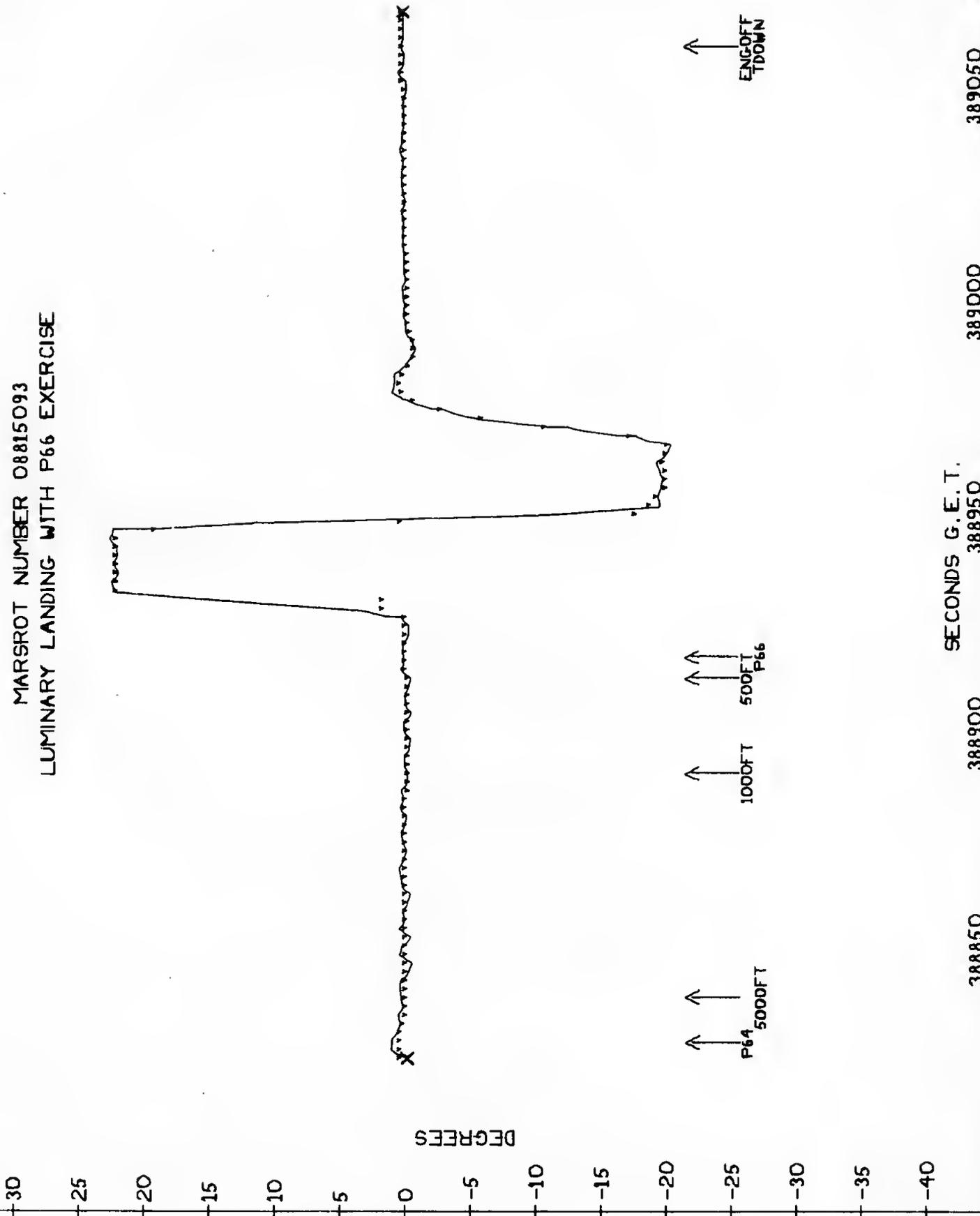
In these runs at around 350 feet with a sink rate of about 3 ft/s and DAP mode in attitude-hold the ACA is used to give the vehicle about  $20^{\circ}$  positive roll. This attitude is held for 10 seconds, then mode is returned to Auto and the vehicle maneuvers to correct the lateral velocity (about 40 ft/s) that has built up. The P66 exercise cases were:

1. LUM 154. P66 exercise.
2. ZER 16. P66 exercise.
3. ZER 16. P66 exercise. 20% TLOSS.

The CDUZ plots follow. Note that in responding to the lateral velocity the attitude excursion limit (AHZLIM) built into P66 Auto prevents the vehicle from maneuvering more than  $20^{\circ}$  in the other direction, giving the plots a certain symmetry. The zero TLOSS cases perform the same. The 20% TLOSS case shows a slight overshoot when it maneuvers back to the vertical.

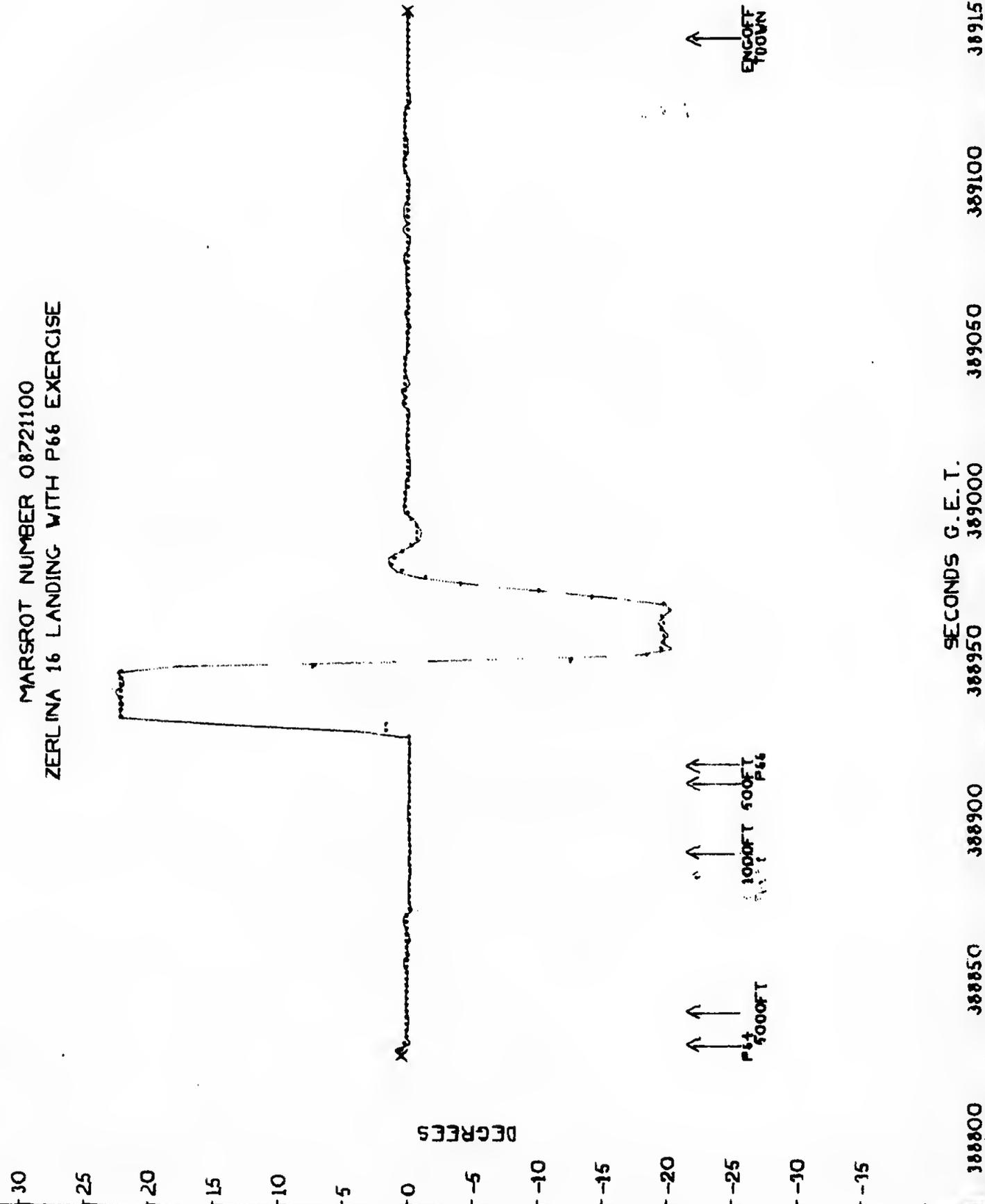
# CDUZ AND CDUZD

MARSROT NUMBER 08815093  
LUMINARY LANDING WITH P66 EXERCISE



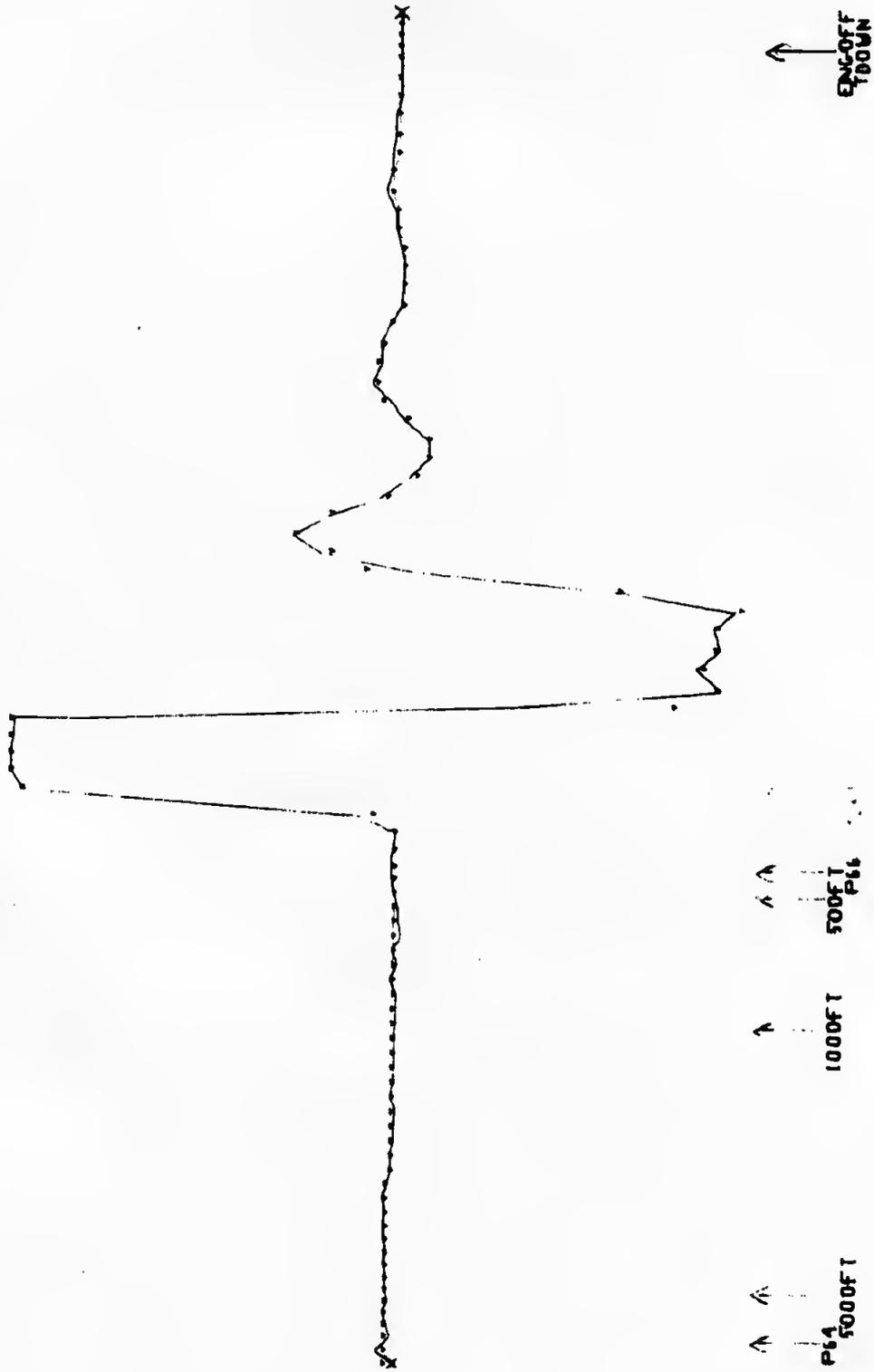
# CDUZ AND CDUZD

MARSROT NUMBER 08721100  
ZERLINA 16 LANDING WITH P66 EXERCISE



# CDUZ AND CDUZD

MARSROT NUMBER 08804071  
ZERLINA 16 LANDING WITH P66 EXERCISE AND 20x TLOSS



SECONDS C.E. T.  
388950

389000

389050

389100

389150

389200

389250

389300

389350

389400

389450

389500

389550

389600

389650

389700

389750

389800

389850

389900

389950

390000

390050

390100

390150

390200

390250

390300

390350

390400

390450

390500

390550

390600

390650

390700

390750

390800

390850

390900

390950

391000

391050

391100

391150

391200

391250

391300

391350

391400

391450

391500

391550

391600

391650

391700

391750

391800

391850

391900

391950

392000

392050

392100

392150

392200

392250

392300

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392500

392550

392600

392650

392700

392750

392800

392850

392900

392950

393000