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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

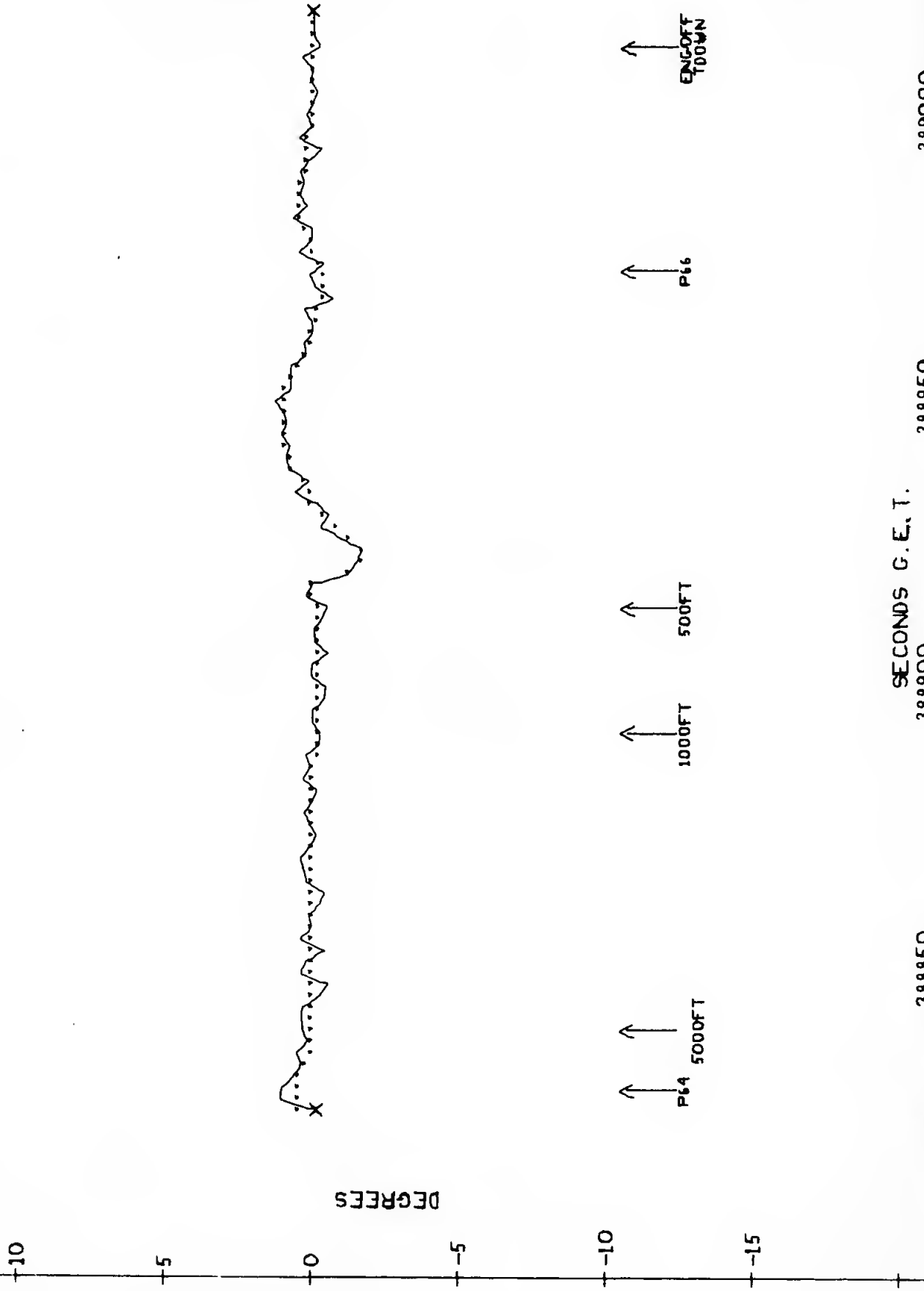
In these tests lateral velocity spikes were abruptly incorporated into the LM state vector and vehicle reaction observed. The magnitude of the spikes upon incorporation was 45 cm/s in the direction of the stable-member y-axis. This is about 1.5 ft/s - the maximum one-pass change in the velocity vector 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



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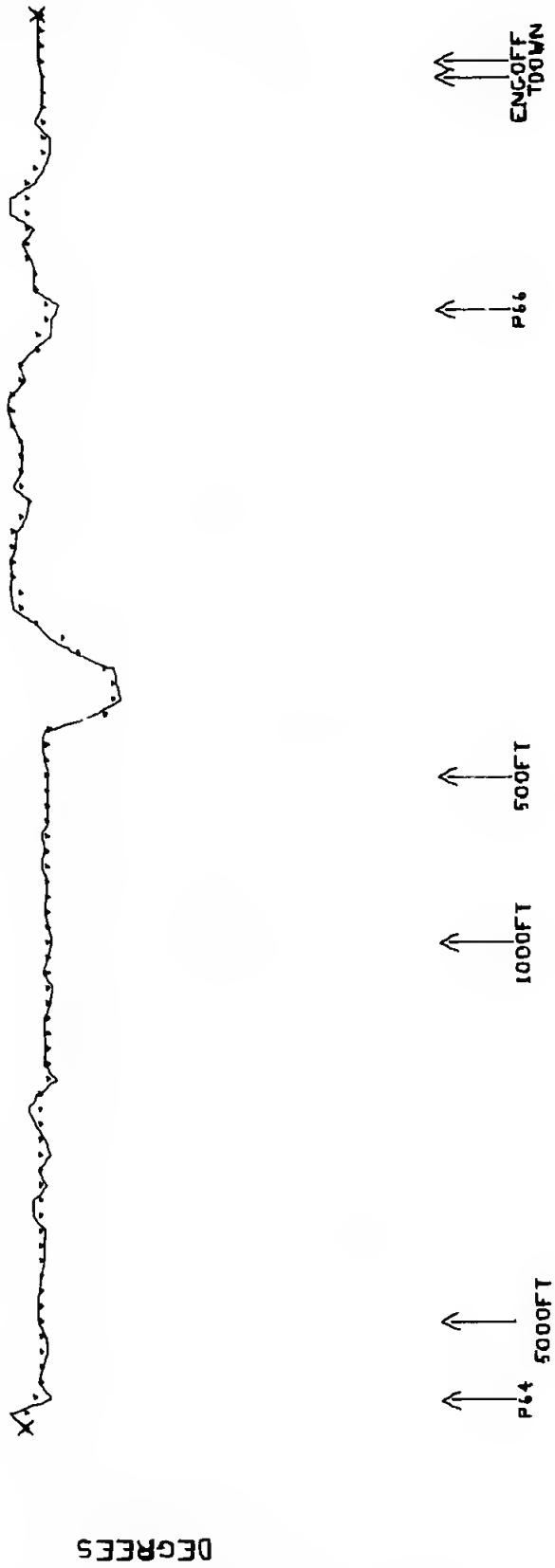
SECONDS G. E. T.

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CDUZ AND CDUZD

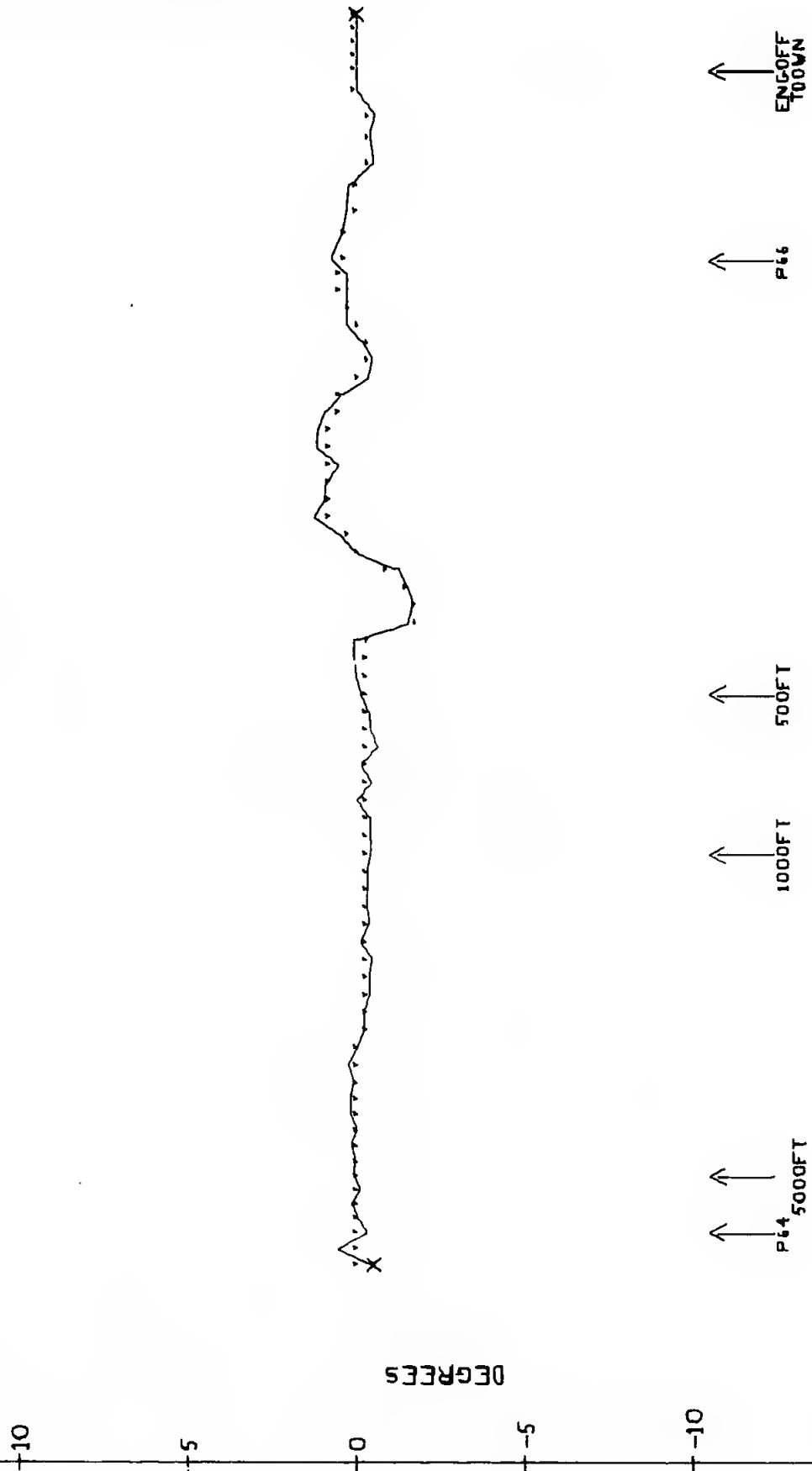
MARSROT NUMBER 08811494
ZERLINA 16 LANDING WITH NOISE SPIKE AT TGO -70



CDUZ AND CDUZD

MARSROT NUMBER 08803360

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

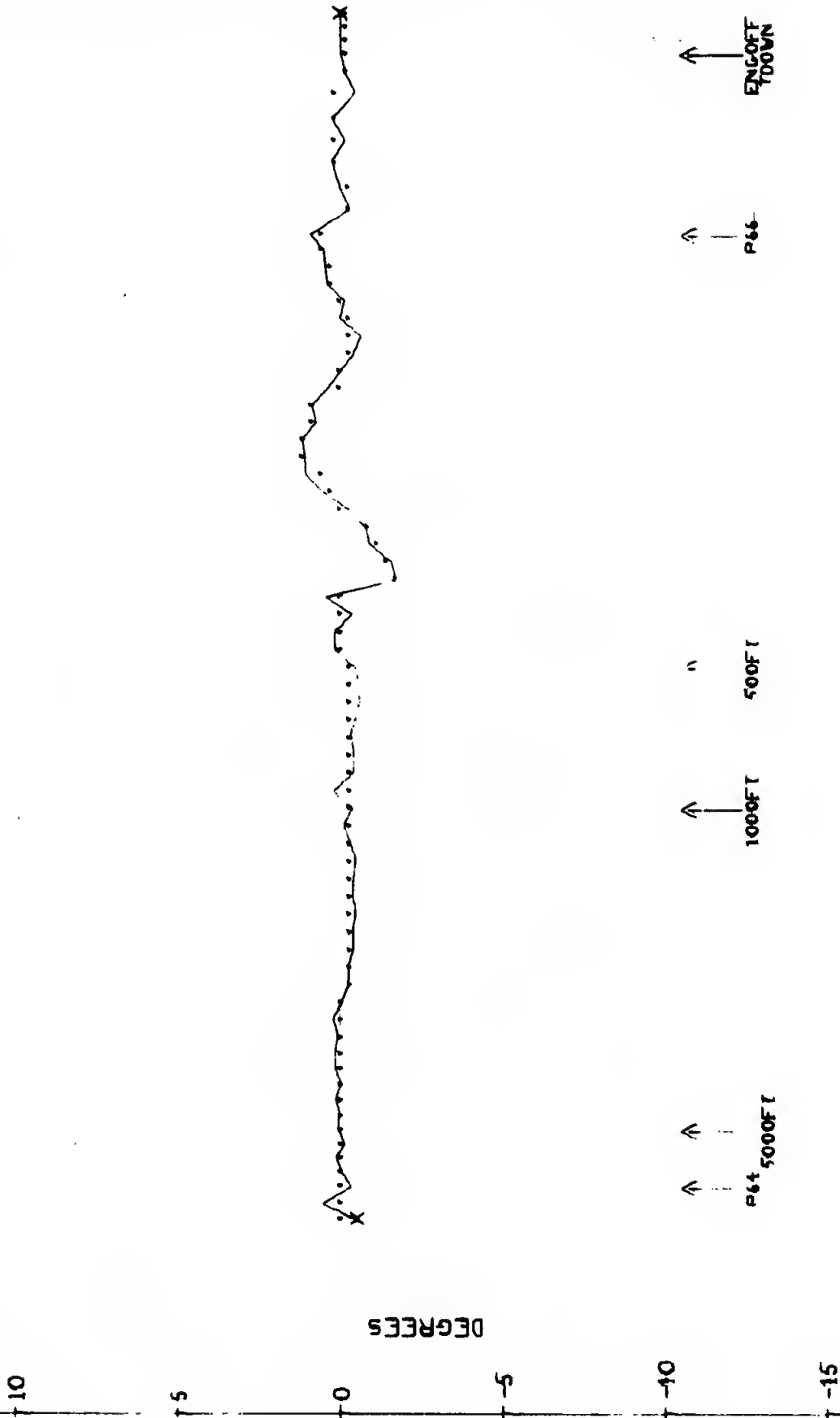


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CDUZ AND CDUZD

MARSROT NUMBER 08803360

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



SECONDS G.E.T.

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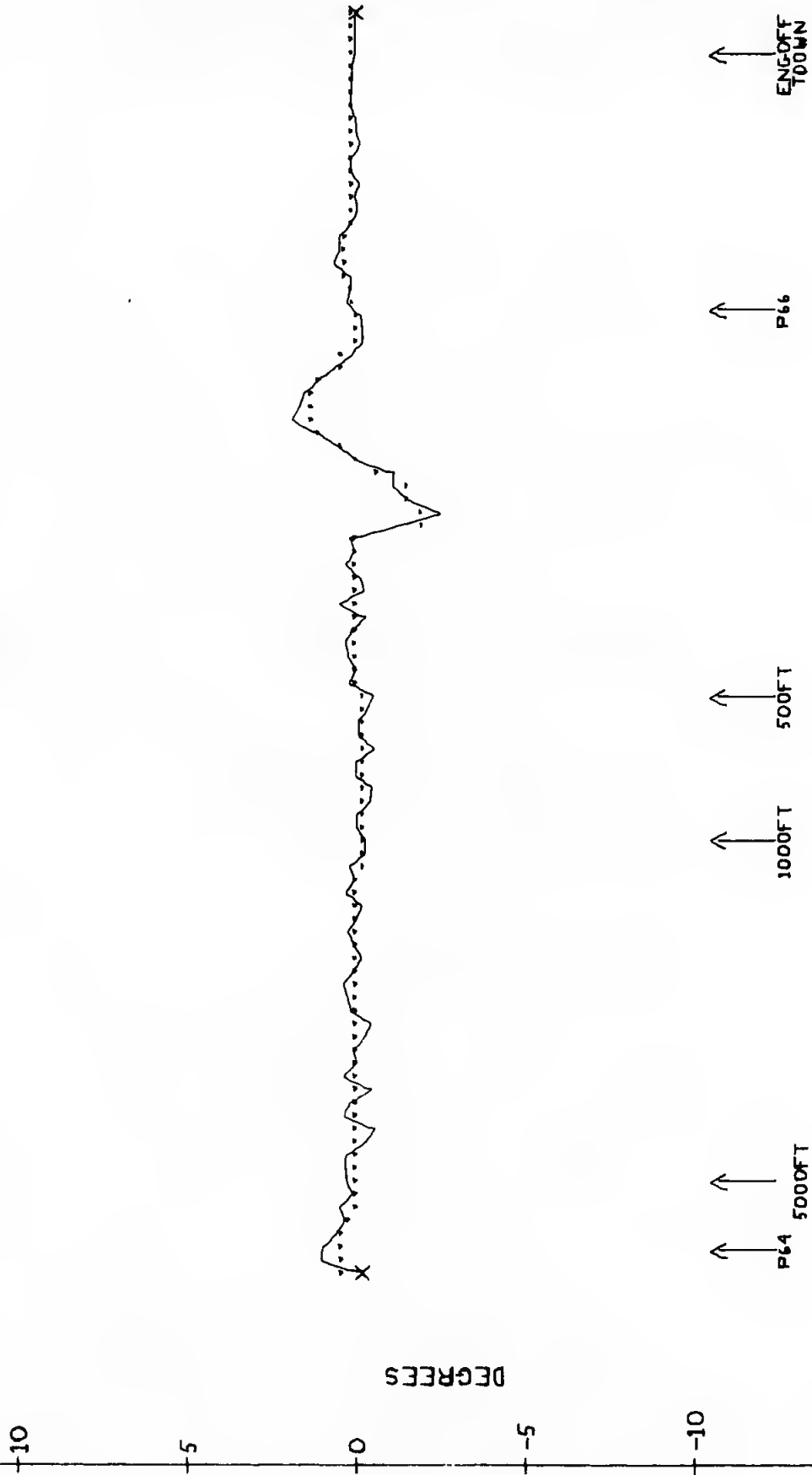
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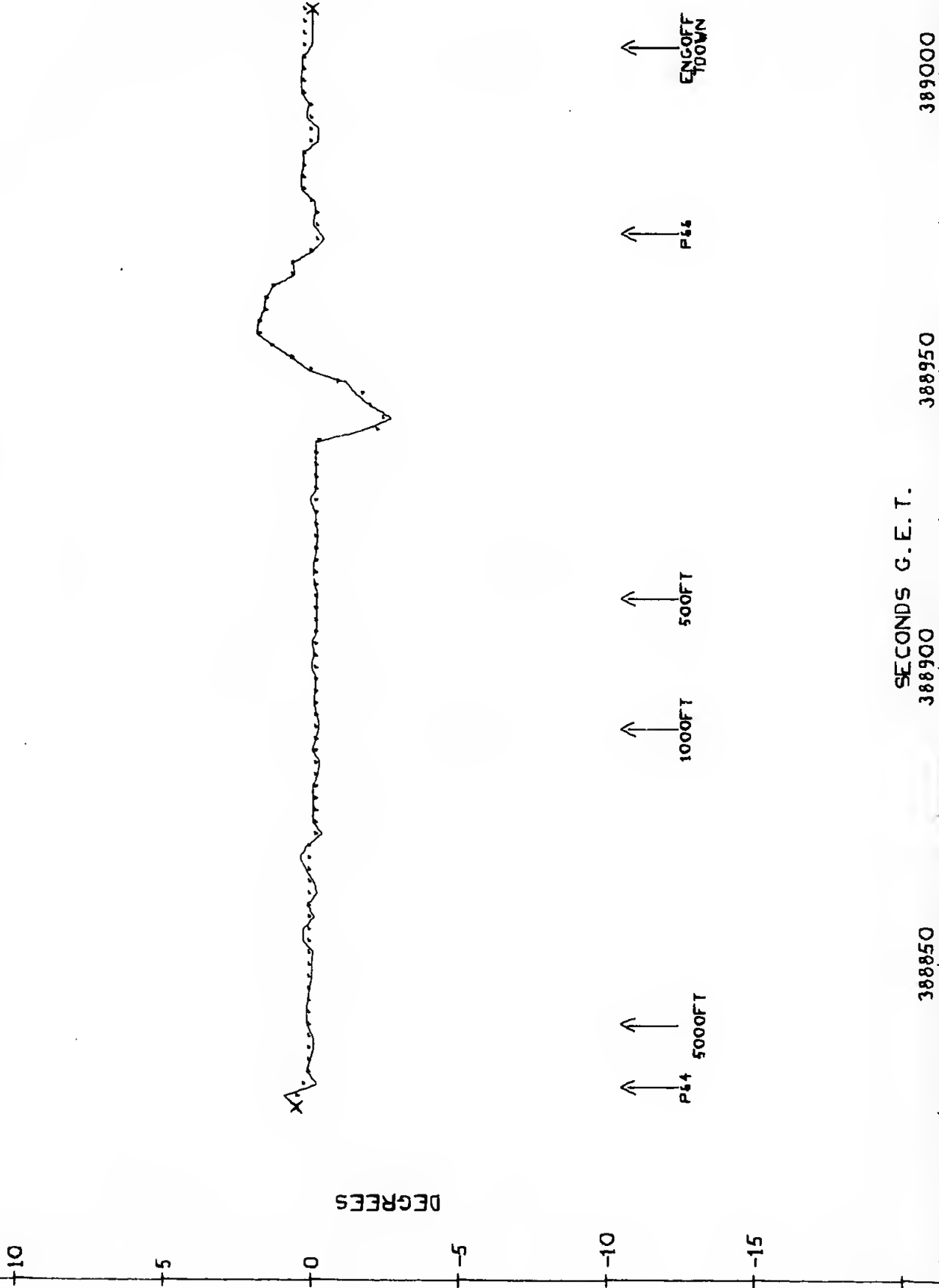
CDUZ AND CDUZD

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



CDUZ AND CDUZD

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

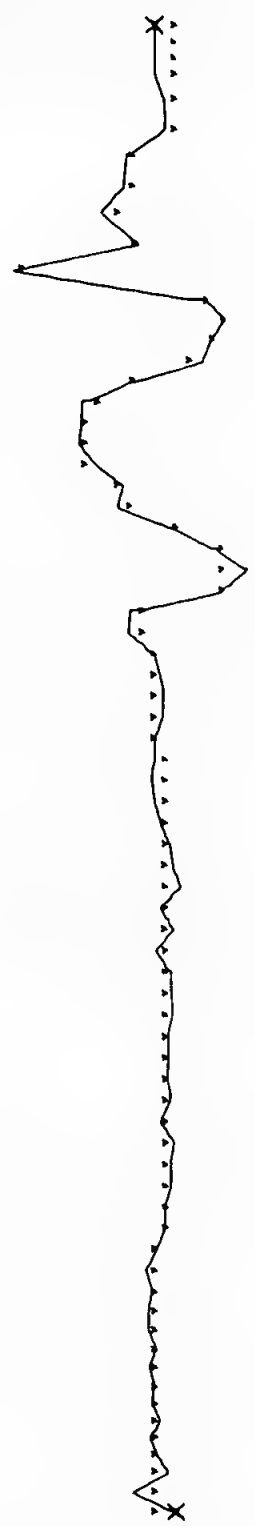


CDUZ AND CDUZD

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

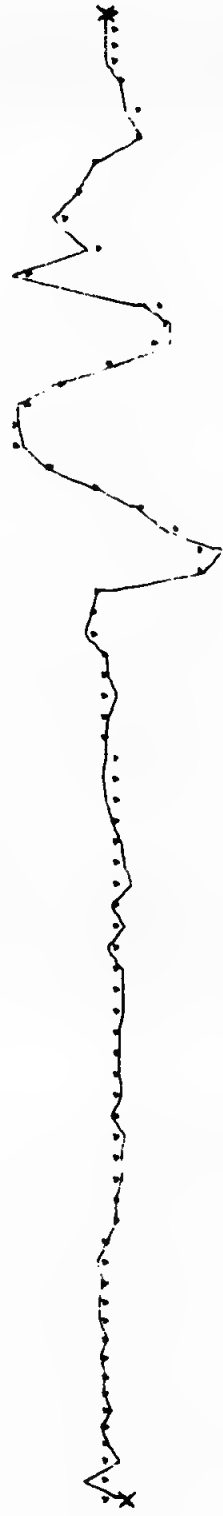
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0

-5

-10

-15



↑ P64 5000FT

↑ 1000FT

↑ 500FT

↑ P66

↑ ENG-OFF 7000M

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Redesignation Cases

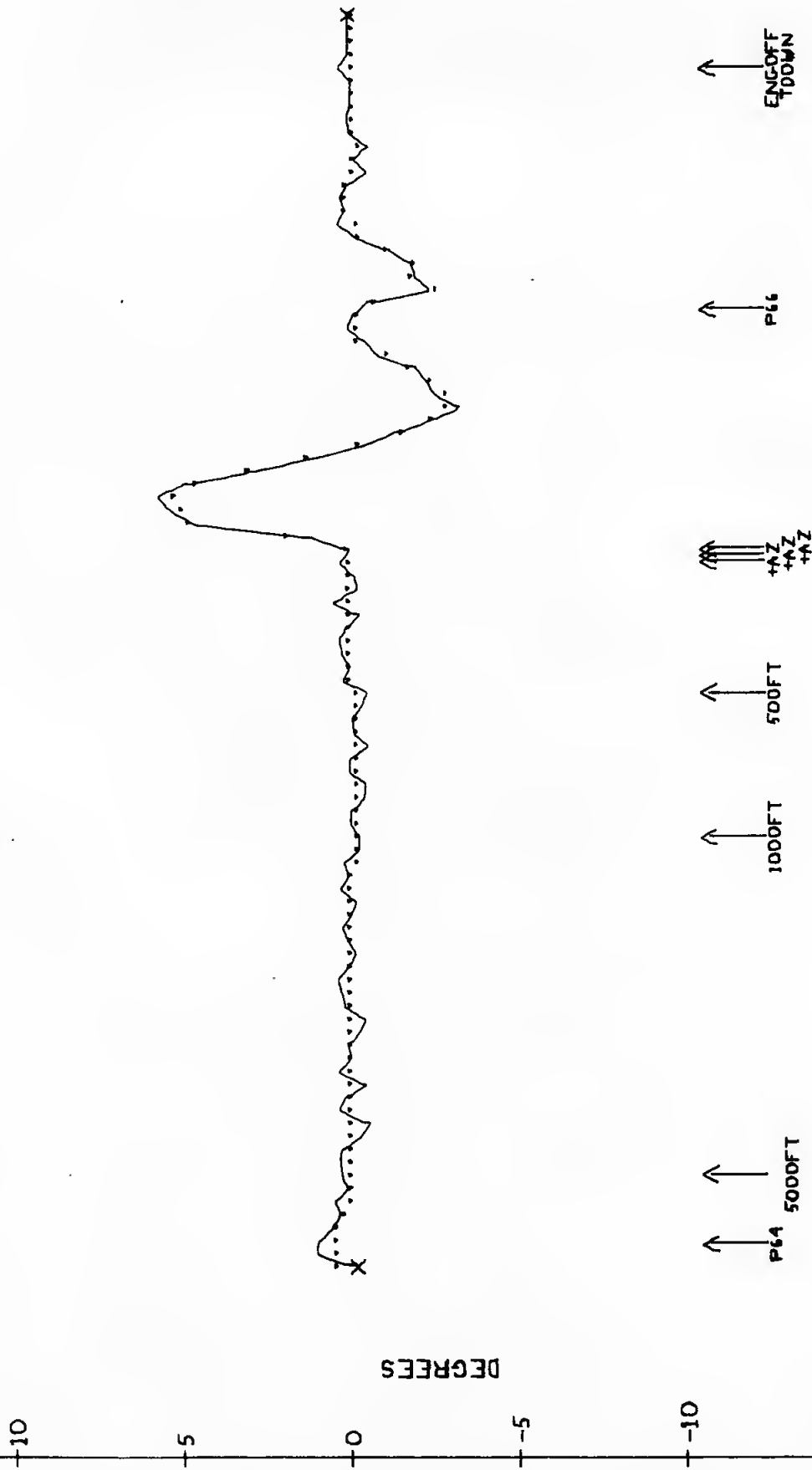
In these runs 3 rightward (+ azimuth) redesignations were input at about TGO -50 seconds. The earlier cases perturb the velocity vector. These redesignation cases in effect perturb the position vector by shifting the landing site. The redesignation cases are these:

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.

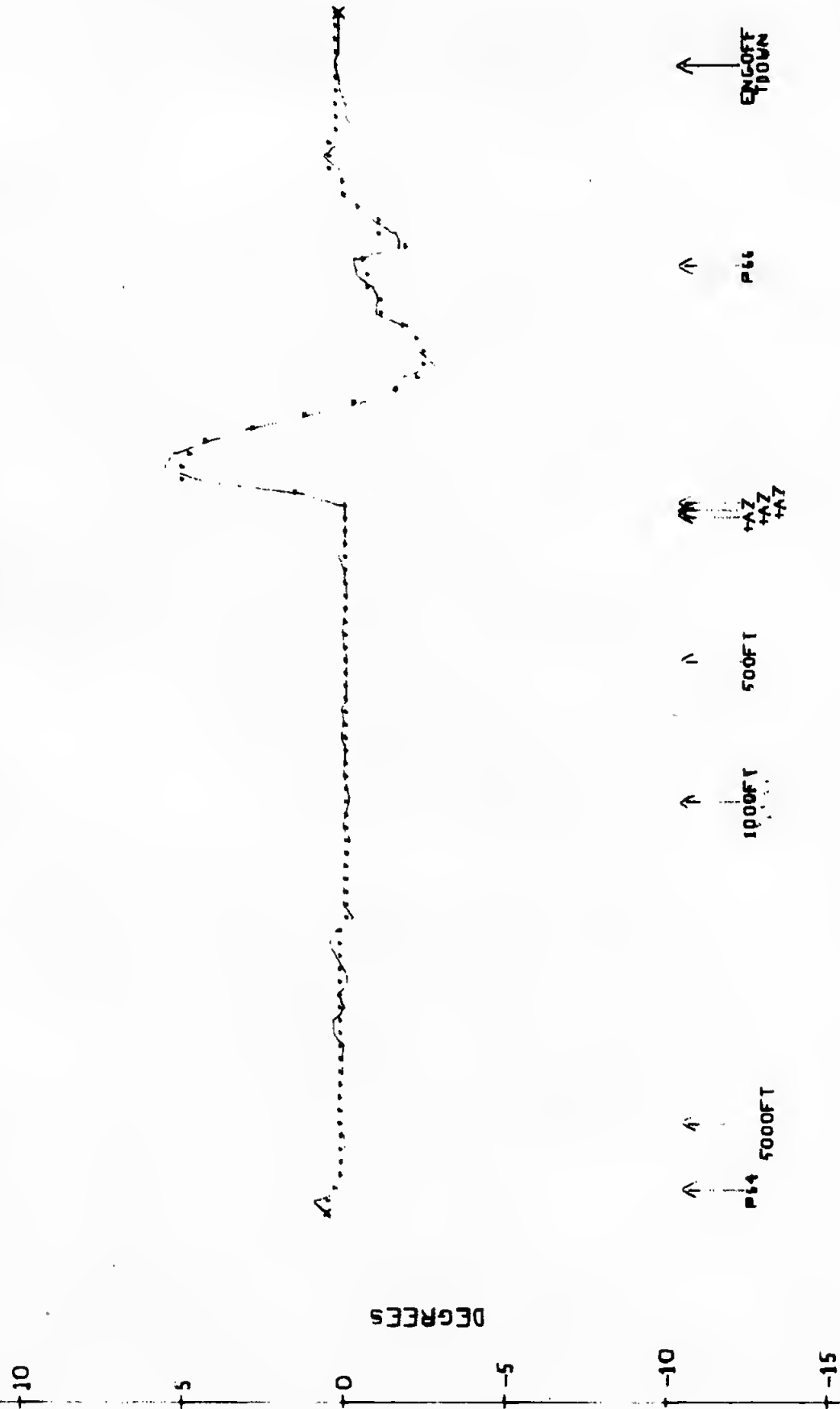
CDUZ AND CDUZD

MARSROT NUMBER 08809394
LUMINARY LANDING WITH REDESIGNATIONS AT TGO -50



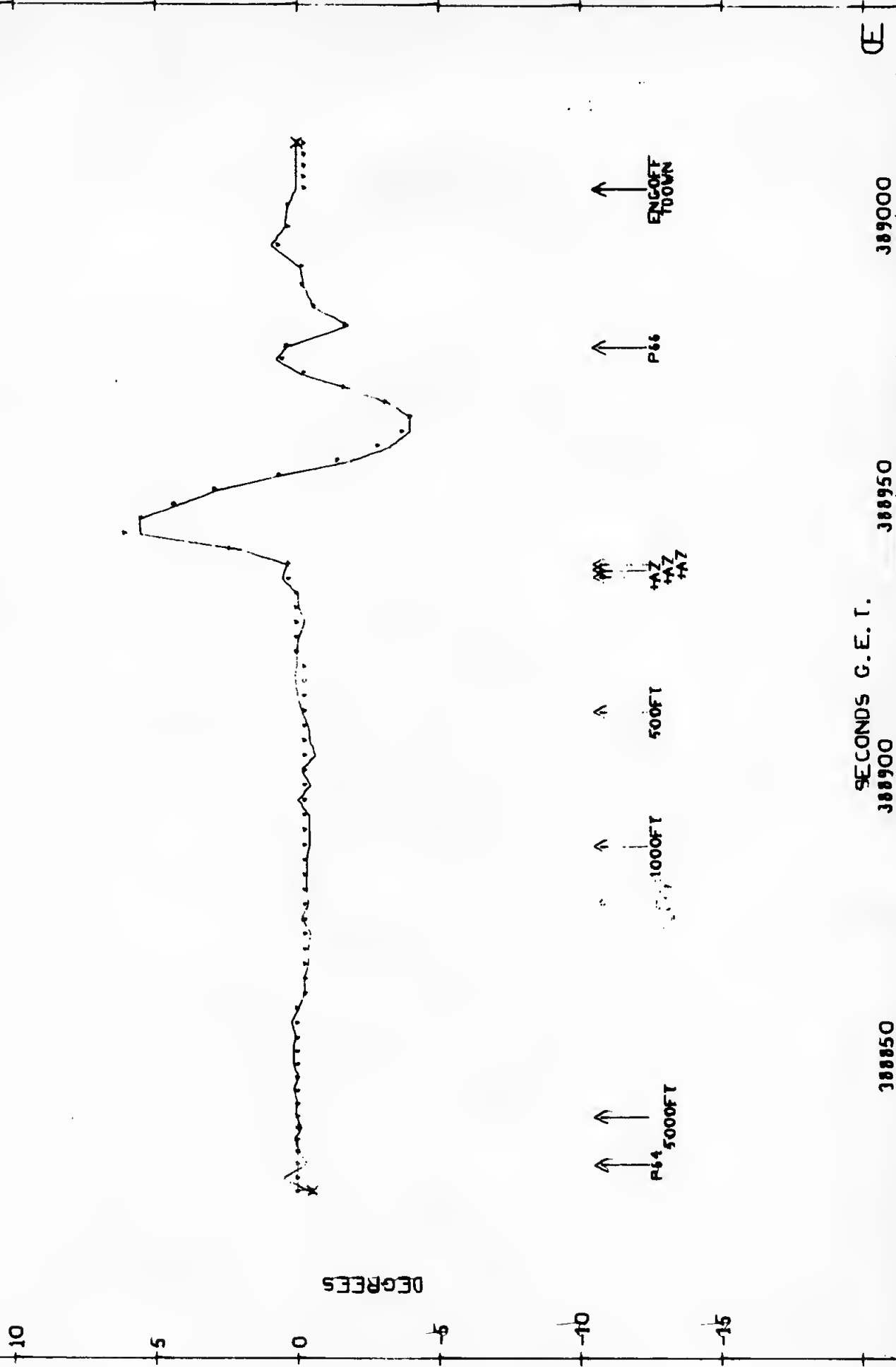
CDUZ AND CDUZD

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



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P66 Exercise Cases

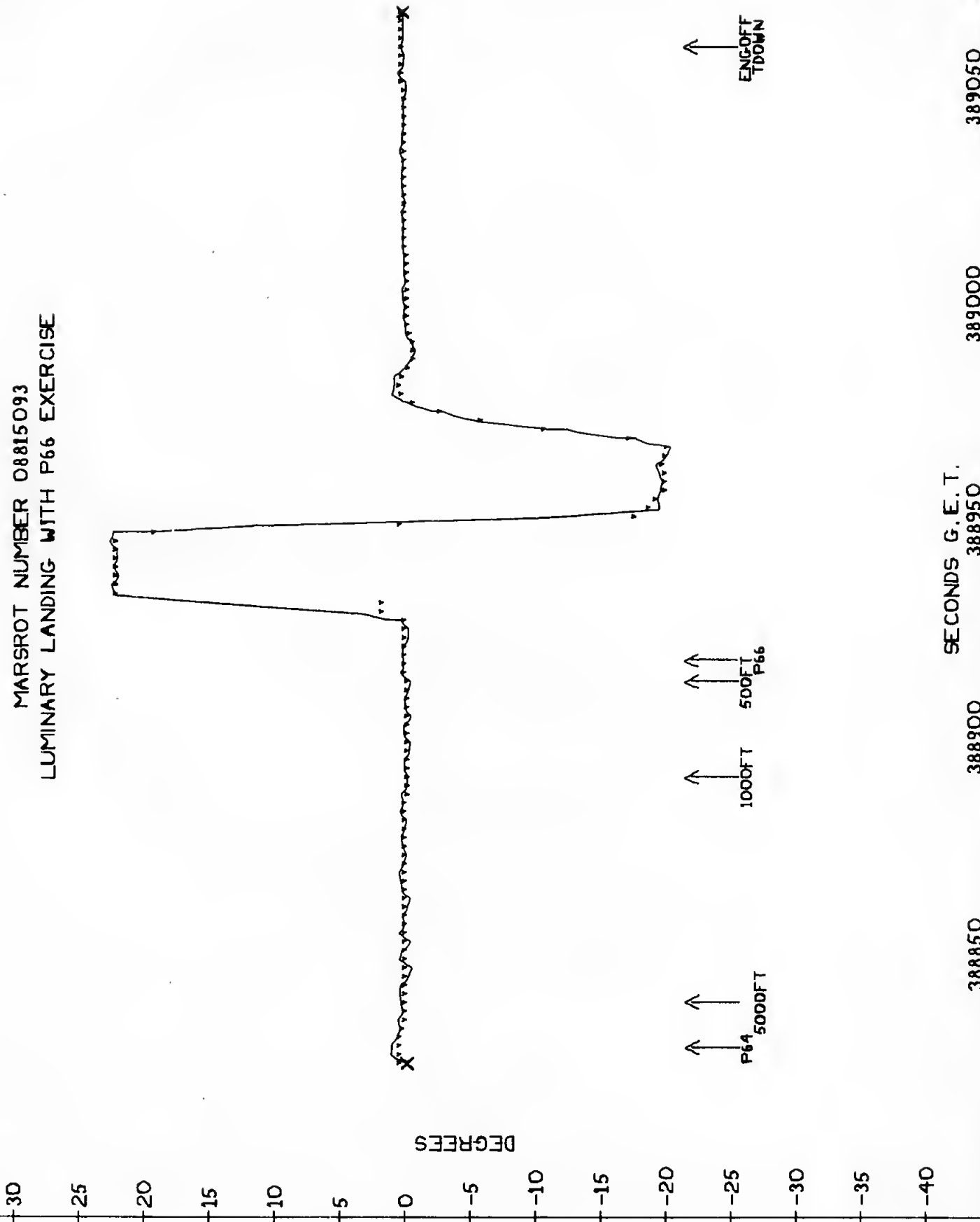
In these runs at around 350 feet with a sink rate of about 3 ft/s and DAP mode in attitude-hold the ACA is used to give the vehicle about 20° positive roll. This attitude is held for 10 seconds, then mode is returned to Auto and the vehicle maneuvers to correct the lateral velocity (about 40 ft/s) that 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° 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

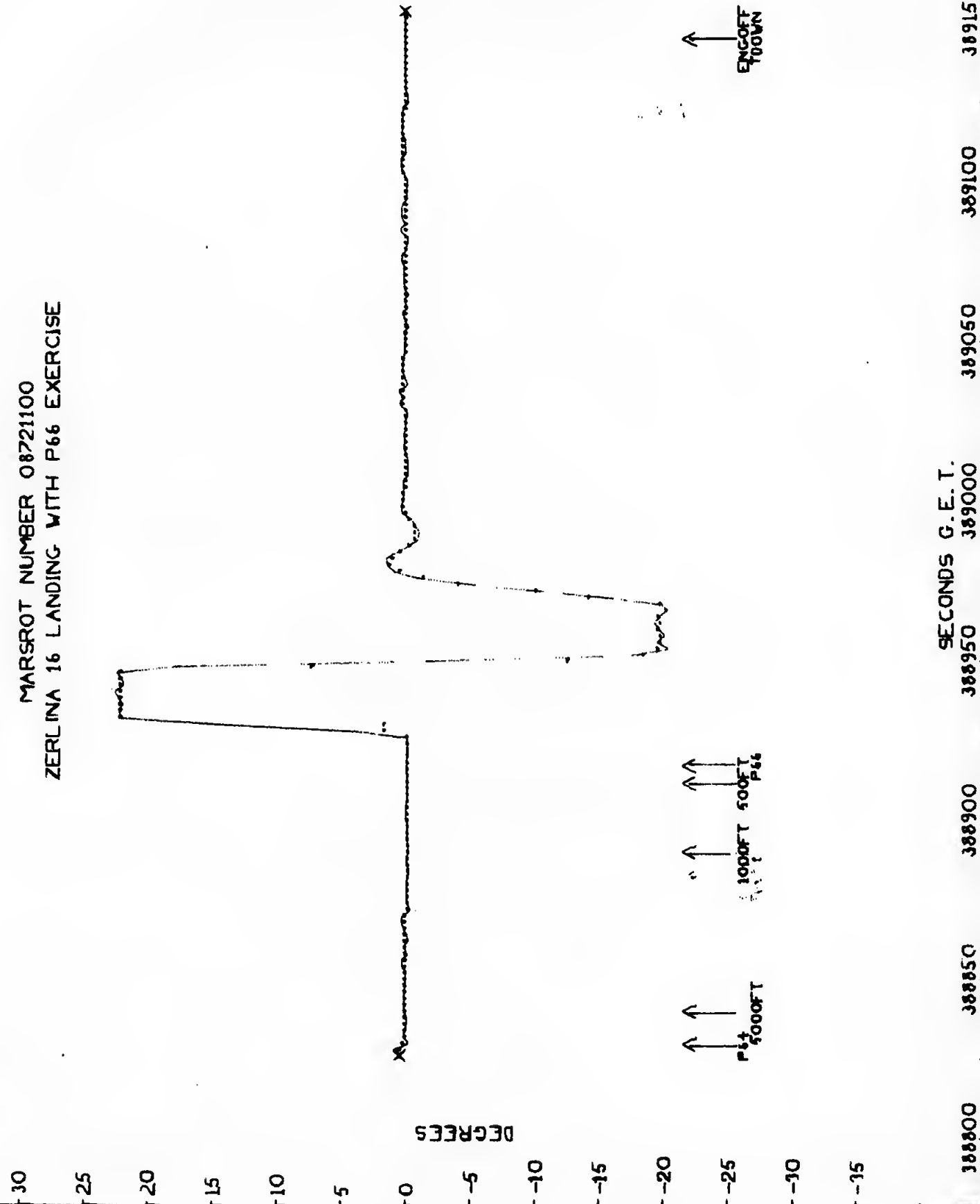
MARSROT NUMBER 08815093
LUMINARY LANDING WITH P66 EXERCISE



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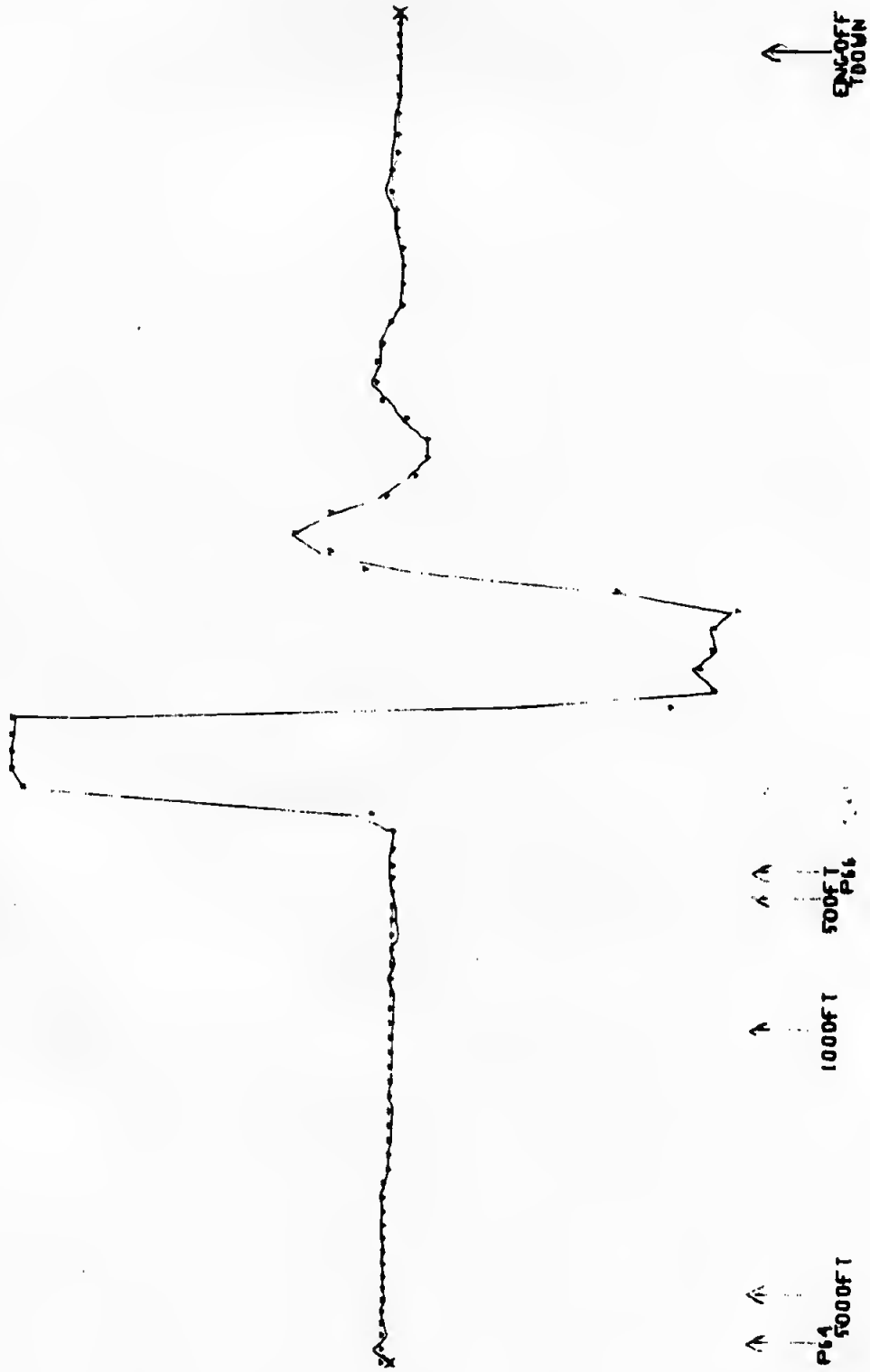
CDUZ AND CDUZD

MARSROT NUMBER 08721100
ZERLINA 16 LANDING WITH P66 EXERCISE



CDUZ AND CDUZD

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



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