MCDONNELL DOUGLAS TECHNICAL SERVICES CO.
HOUSTON ASTRONAUTICS DIVISION

SPACE SHUTTLE ENGINEERING AND OPERATIONS SUPPORT

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STUDY OF THE EFFECTS OF MULTIPLE GROUND UPDATES ON THE ACCURACY OF THE ONBOARD STATE VECTOR WITH IMU ONLY NAVIGATION

MISSION PLANNING, MISSION ANALYSIS, AND SOFTWARE FORMULATION

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1.0 SUMMARY

The purpose of this study is to determine the accuracy in the onboard state at separation as a function of the number of ground updates to the onboard state under conditions of IMU only navigation. Six cases are considered (1) no updates made during the flight, (2) one ground update in the vertical components only at the first practice separation minus 15 minutes, (3) one ground update in all components at the first practice separation minus 5 minutes, (4) updates 2 and 3 applied successively, (5) Case 4 plus an update in all components at the second separation attempt minus 3 minutes, and (6) one ground update at first separation attempt minus 5 minutes and a second update at second separation minus two minutes The mission control simulation program, GROPER, was run using as radar input a tape containing radar derived state vectors for the trajectory described as Captive Active 1, except for case 6 which was run using the Captive Active 2 trajectory. Each of six separate tapes containing simulated downlisted SSO telemetry was used to simulate the six cases enumerated above. Results show that two ground updates to the onboard state prior to the first separation (case 4) will insure that the accuracy in the onboard state at first separation is within the limits imposed in Reference 1. An additional update 3 minutes prior to the second separation will not insure that the accuracy in the onboard state is within these limits at the second separation attempt, however, the error limits are exceeded by only 300 feet in the Z component and 4.6 feet/second in Z dot for the case investigated in this study. A single update prior to each separation aitempt will not insure acceptable accuracy in the onboard state vector.

2.0 INTRODUCTION

The purpose of this study is to determine the accuracy of the onboard state vector under conditions of IMU only navigation with six different histories of ground update: (1) no updates to the onboard state, (2) a single ground update in the vertical components at first practice separation minus 15 minutes; (3) a single ground update in all components at first practice separation minus five minutes, (4) a ground update in the vertical components at the first practice separation minus 15 minutes and a ground update in all components at the first practice separation minus 5 minutes, (5) a ground update in the vertical components at the first practice separation minus 15 minutes, a ground update in all components at the first practice separation minus 5 minutes, and a ground update in all components at the second practice separation minus 3 minutes; (6) a ground update at the first practice separation minus 5 minutes and at the second practice separation minus two minutes in all components. The trajectory data used for this study is described as Captive Active 1 and is contained on tape number X11404. The Captive Active 2 trajectory was used for case (6), however, the two trajectories are nearly identical This analysis was performed using the Mission Control simulation program GROPER (Ground Operations Evaluations Routine)

3.0 DISCUSSION

GROPER requires as input two tapes, one containing simulated radar data and the other containing simulated downlisted telemetry as well as error free state vectors derived from the trajectory tape. The simulated radar data input to GROPER for the Captive Active 1 trajectory is contained on tape number X00263, produced by MPAD from the trajectory tape, number X11404. It contains simulated radar derived state vectors with refraction induced errors. The radar data input to GROPER for the Captive Active 2 trajectory is contained on tape number X01896 and contains refraction induced errors The tapes containing simulated onboard state vectors were produced by MPAD using the Navigation Analysis Program (NAP). They are the following·

Tape #	Description
X00477	CA1 updated at sep 1 - 15 min in Z, $\dot{Z}$
X12175	CA1 updated at sep 1 - 5 min, all components
X10248	CA1 updated at sep 1 - 15 min in Z, $\dot{Z}$, and sep 1 - 5 min in all components
X09254	CA1 updated at sep 1 - 15 min. in Z, $\dot{Z}$, sep 1 - 5 min in all components; sep 2 - 3 min in all components
X17777	CA1 IMU only, benchmark initialized after sep 1
X14386	CA2 updated at 1st separation minus 5 minutes and 2nd separation minus 2 minutes

Five GROPER runs were made, using the tape, X00263, to simulate radar derived data and using each of five Captive Active 1 shuttle tapes in turn to simulate downlisted SSO state vectors. An additional run was made using the tape, X01896, to simulate radar

derived data, and using the Captive Active 2 shuttle tape, X14386, to simulate downlisted SSO state vectors. These two trajectories are very similar. Using the data supplied on the tapes, GROPER computes the error in the onboard state vector, the error in the radar derived state vector, the update to be applied to the onboard state based on differences between the radar derived state and the onboard state, and errors in the update based on the truth model which is available on the shuttle tape.

A value of 120 was used for the parameter DTVEL, the minimum time difference between position differences, DRINT, used to compute the velocity updates, DVP. This is the currently baselined value, but the author has recently shown that the optimum value of DTVEL is 60 (Reference 2).

Errors in the onboard state at first separation are given in Table 1 for each of the four cases: no updates applied, update in Z and Z dot only at separation 1 minus 15 minutes, update in all components at separation 1 minus 5 minutes; and update at separation 1 minus 15 minutes in the vertical components and at separation 1 minus 5 minutes in all components. The difference in the errors in the X and Y components of the onboard state between the IMU only case and the case with an update in Z and Z dot only is due to the reinitialization of the covariance matrix at the time of the update. The errors in the onboard state at the time of second separation are given in Table 2 for the above four cases as well as the 2 cases having an additional update prior to the second separation attempt.

Maximum allowable errors in the updated state vector are 1100 feet in position and 4 feet/sec in velocity (in each component) (Reference 1, JSC Memo FM82 (75-67). The accuracy of the onboard state vector is within these limits at first separation attempt only for the case in which the onboard state was updated twice prior to separation. At the second practice separation, the accuracy of the onboard state was not within the prescribed limits for any case. For case 5, 2 updates prior to first separation attempt and an additional update 3 minutes prior to second separation attempt, the additional error is 300 feet in Z and 4.6 feet per second in Z dot.

A time history of errors in the radar state is provided in the Appendix. Plots of onboard errors versus time are provided for each of the six test cases. Time is given in seconds of day and errors in the state vectors are in feet and feet per second.

TABLE 1
CAPTIVE ACTIVE 1

Error in Onboard State at 55941 sec. 1st Sep

	IMU ONLY	UPDATE SEP1-15 Z, $\dot{Z}$	UPDATE SEP1-5 ALL COMP	UPDATE SEP1-15, SEP-5
X	-18438	-18419	-87.1	652.
Y	33866	34088	881.	851.
Z	13078	4120	3541.	1018
$\dot{X}$	-9.8	-9.8	-3.4	-2.1
$\dot{Y}$	15 9	16.6	6.4	7.9
$\dot{Z}$	24.5	9.0	9.3	3.1

NOTE: The run with a single update at "SEP-5" was updated 30 seconds later than the run with a double update.

TABLE 2
CAPTIVE ACTIVE 1, 2

Error in Onboard State at 57020.5 2nd Sep

	IMU ONLY	UPDATE AT SEP1-15 Z, $\dot{Z}$	UPDATE AT SEP1-5 Z, $\dot{Z}$	UPDATE AT SEP1-15 ALL COMP	UPDATE AT SEP1-15, SEP 1-5 SEP 2-3	UPDATE AT SEP 1-5, SEP 2-2
X	-413706.	-20369	-11506.	-10305.	-655.6	-289.8
Y	39100.	36810.	20943.	22783.	943 7	648.3
Z	-81634.	33116.	32412.	12426.	1404.0	5211.4
X	-344.	7.2	- 14.8	-15 5	- 4 2	-2.1
$\dot{Y}$	14 2	-13.2	23.7	25.8	4.4	0.2
$\dot{Z}$	-173.	58.6	58.8	23.6	8.6	30.0

4.0 CONCLUSIONS AND RECOMMENDATIONS

It has been shown that the accuracy of the onboard state vectors is within the allowable range at separation only for the case in which the onboard state is updated twice prior to separation, once in the vertical component only at separation minus 15 minutes and once in all components at separation minus 5 minutes. The accuracy of the onboard state at second separation is within the acceptable limits in X, X dot, Y, and Y dot for the case in which the onboard state was updated three times prior to second separation attempt; however, the errors in Z and Z dot are 1404 feet and 8.6 fps, respectively. It is recommended that an update be applied in the vertical component at separation minus fifteen minutes and in all components at separation minus five minutes for the first practice separation. This scenario should be repeated prior to the second separation attempt if possible; however, one additional update prior to the second separation attempt might be adequate if slightly reduced accuracy can be tolerated.

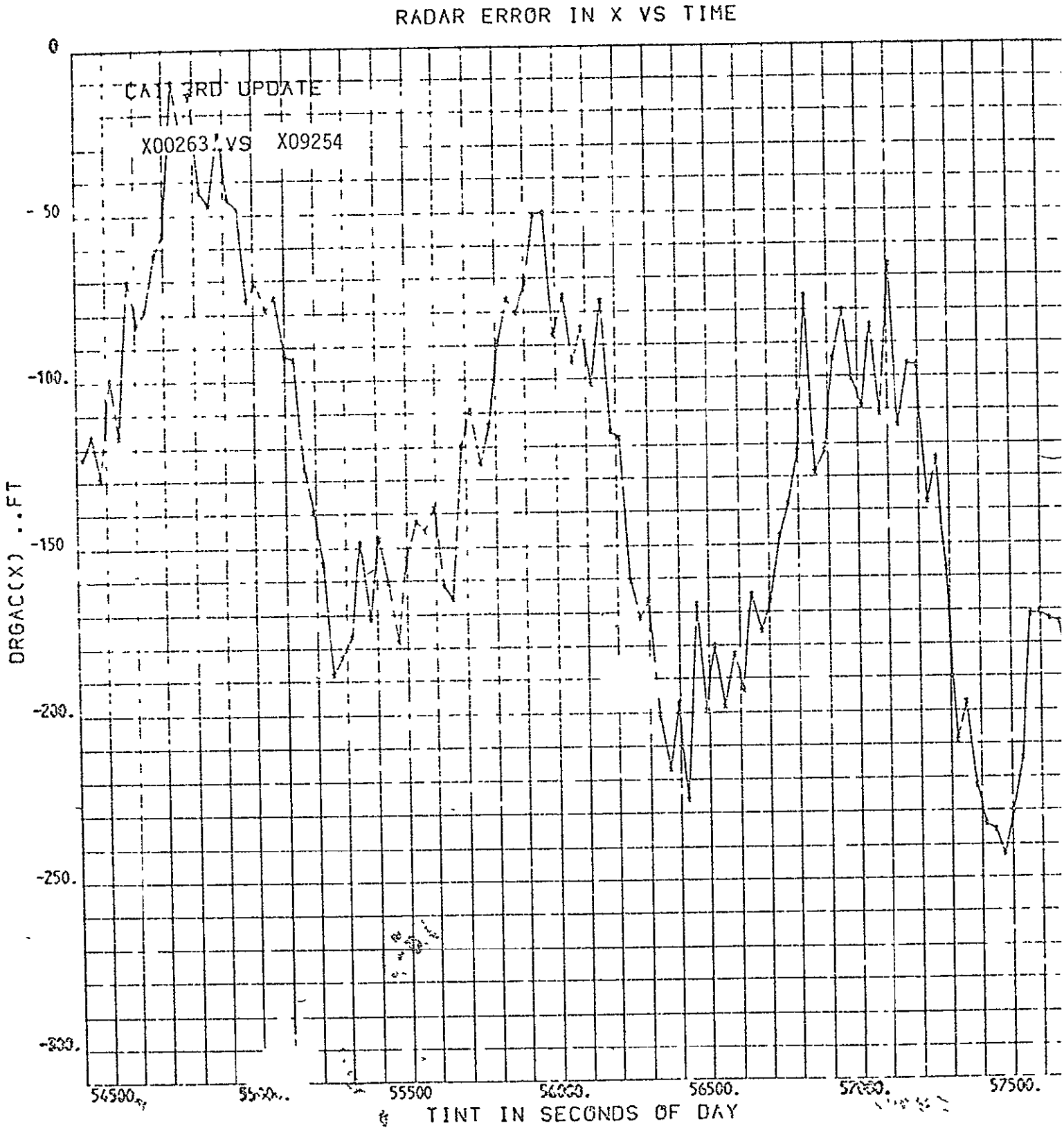
5.0 REFERENCES

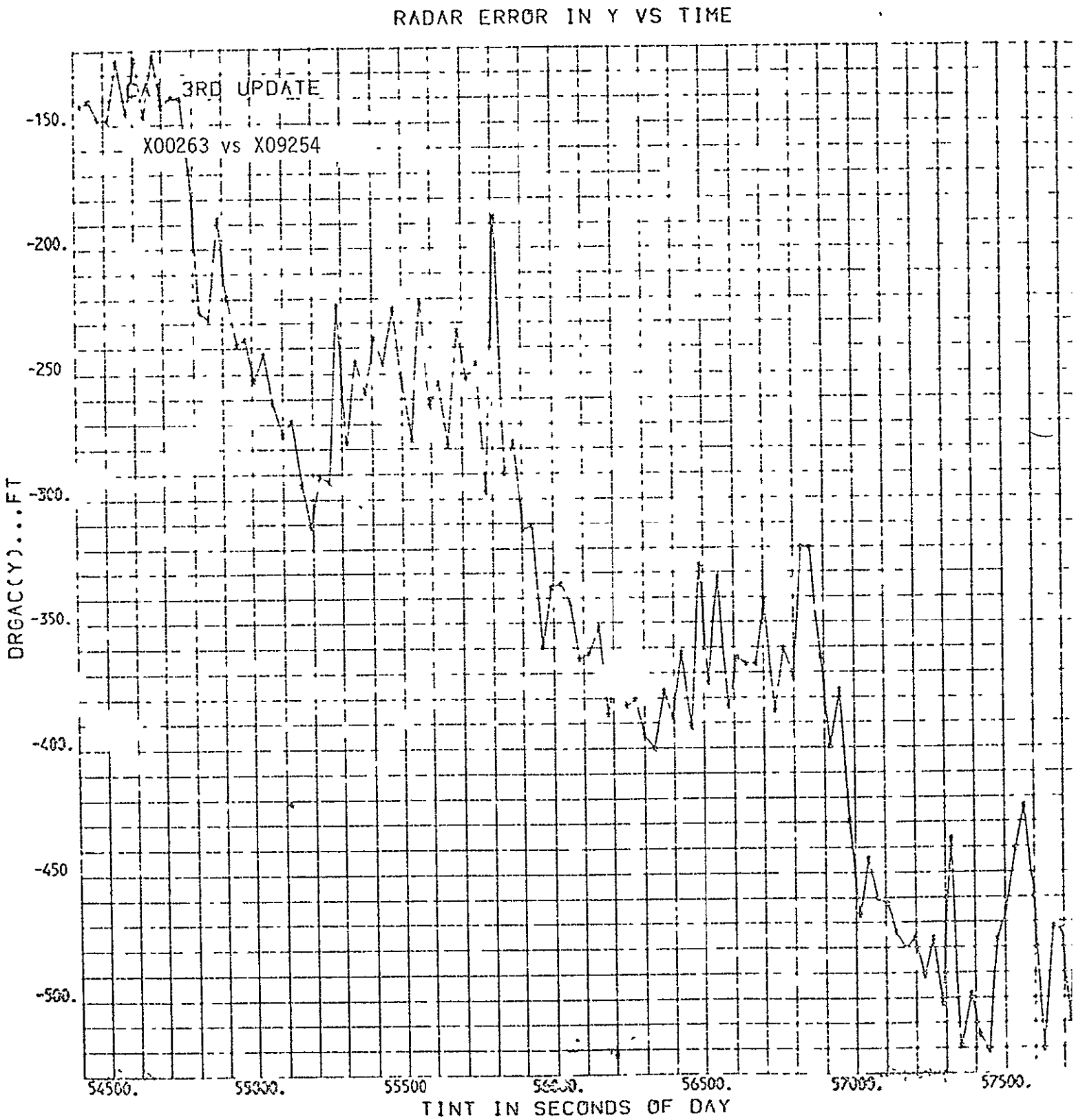
1 Bond, A. C., "Effect of Ground Updates on ALT Navigation Accuracies," JSC Memo FM82 (75-67), May 11, 1975.

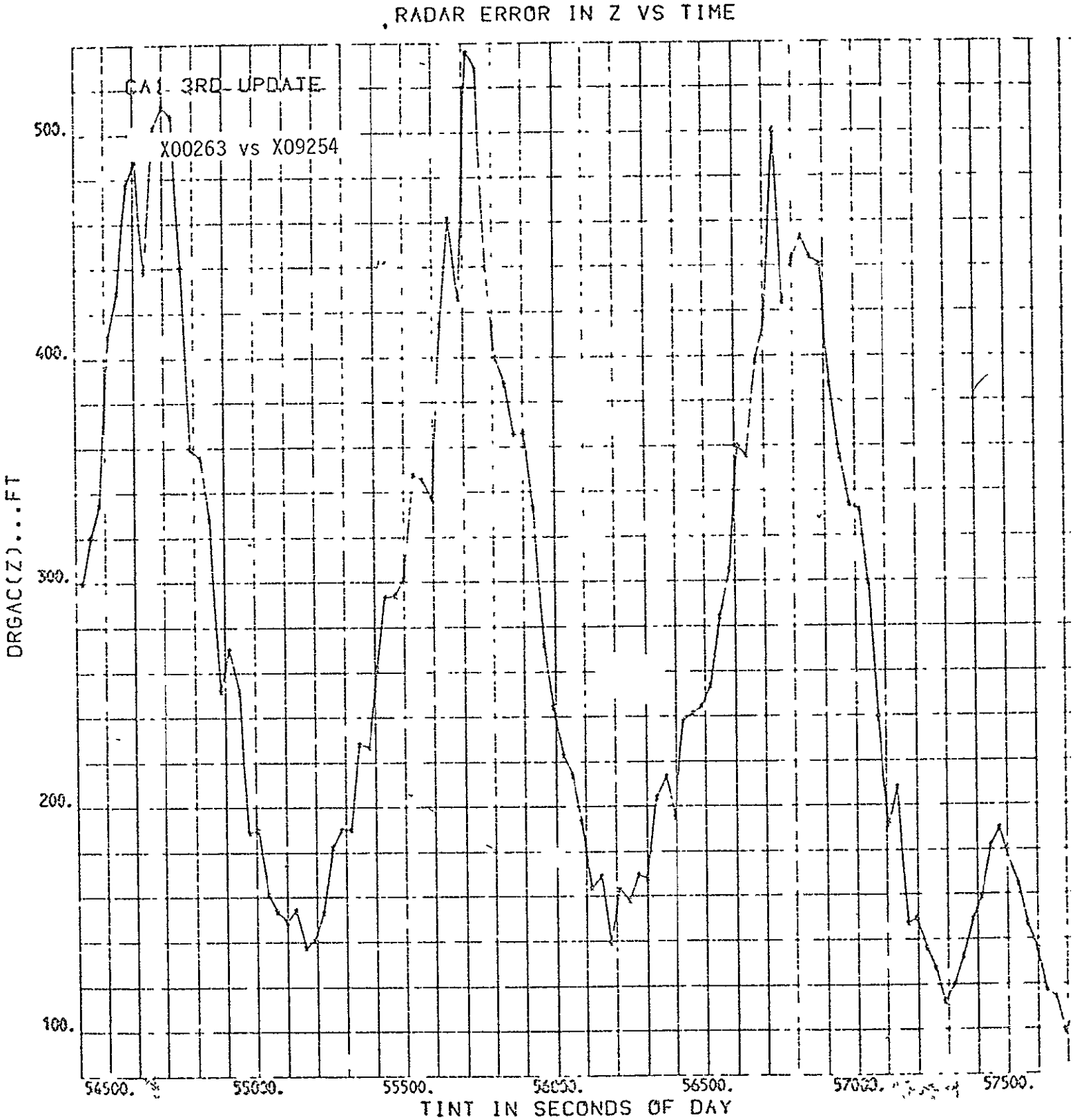
2. Killen, R. M., "Analysis of the Accuracy of the State Vector Update as a Function of the Parameter DTVEL," McDonnell Douglas Technical Services Co. Transmittal Memo 1.4-MPB-590, 14 February 1977.

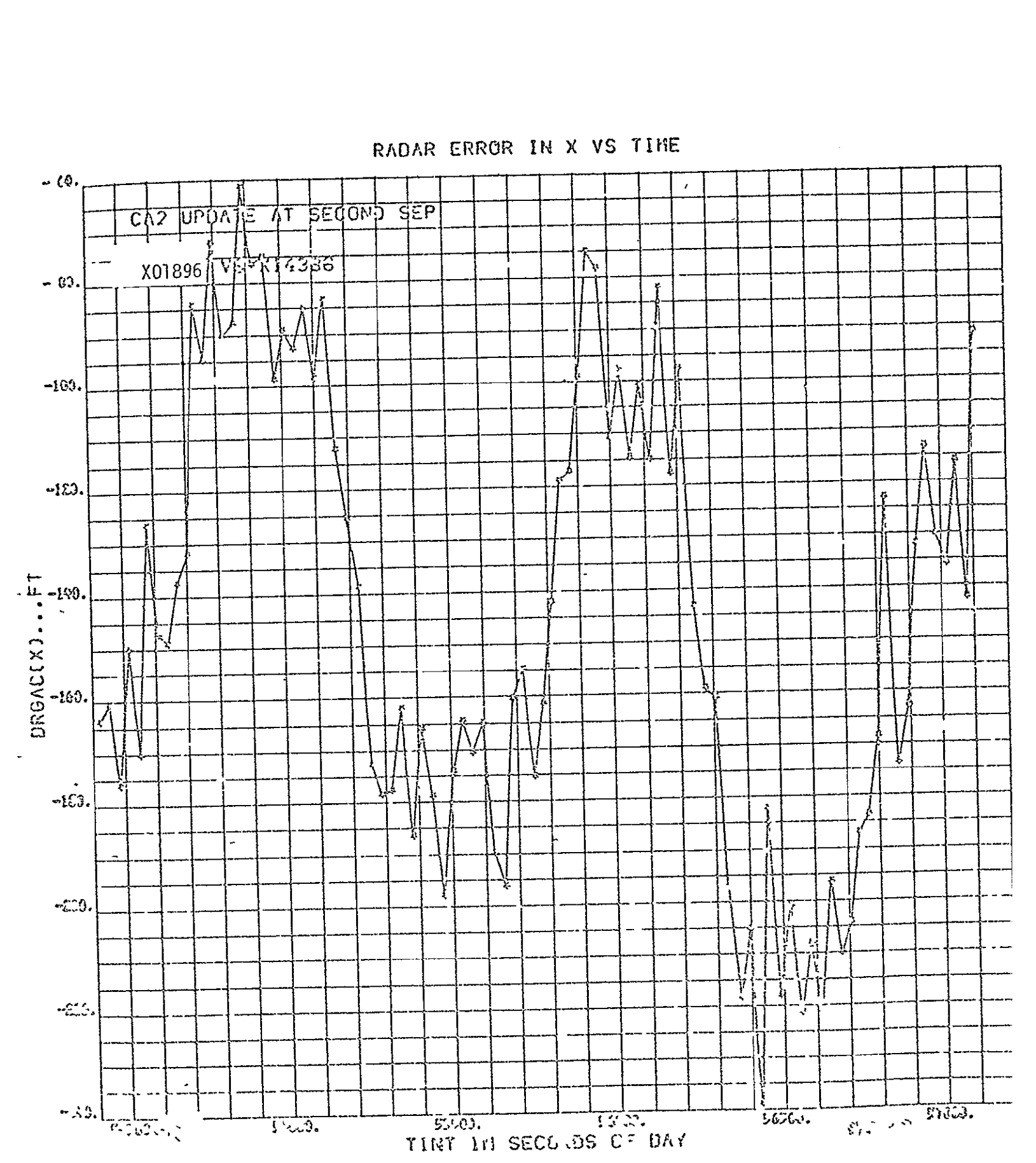
APPENDIX 1

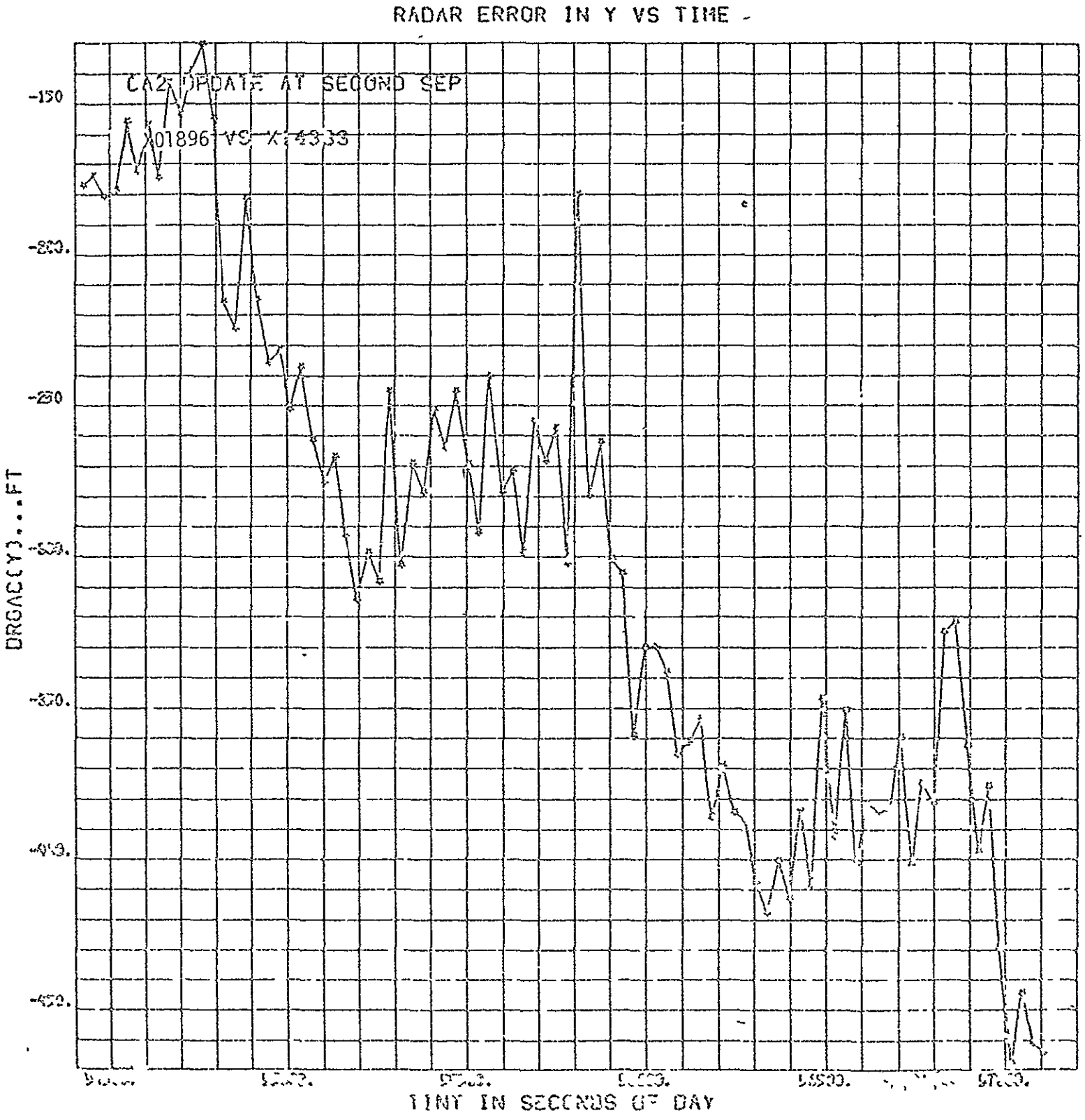
The following plots represent errors in the radar derived state vectors as a function of time for the trajectory described as Captive Active 1 with refraction induced errors. Radar position error is included for the Captive Active 2 trajectory

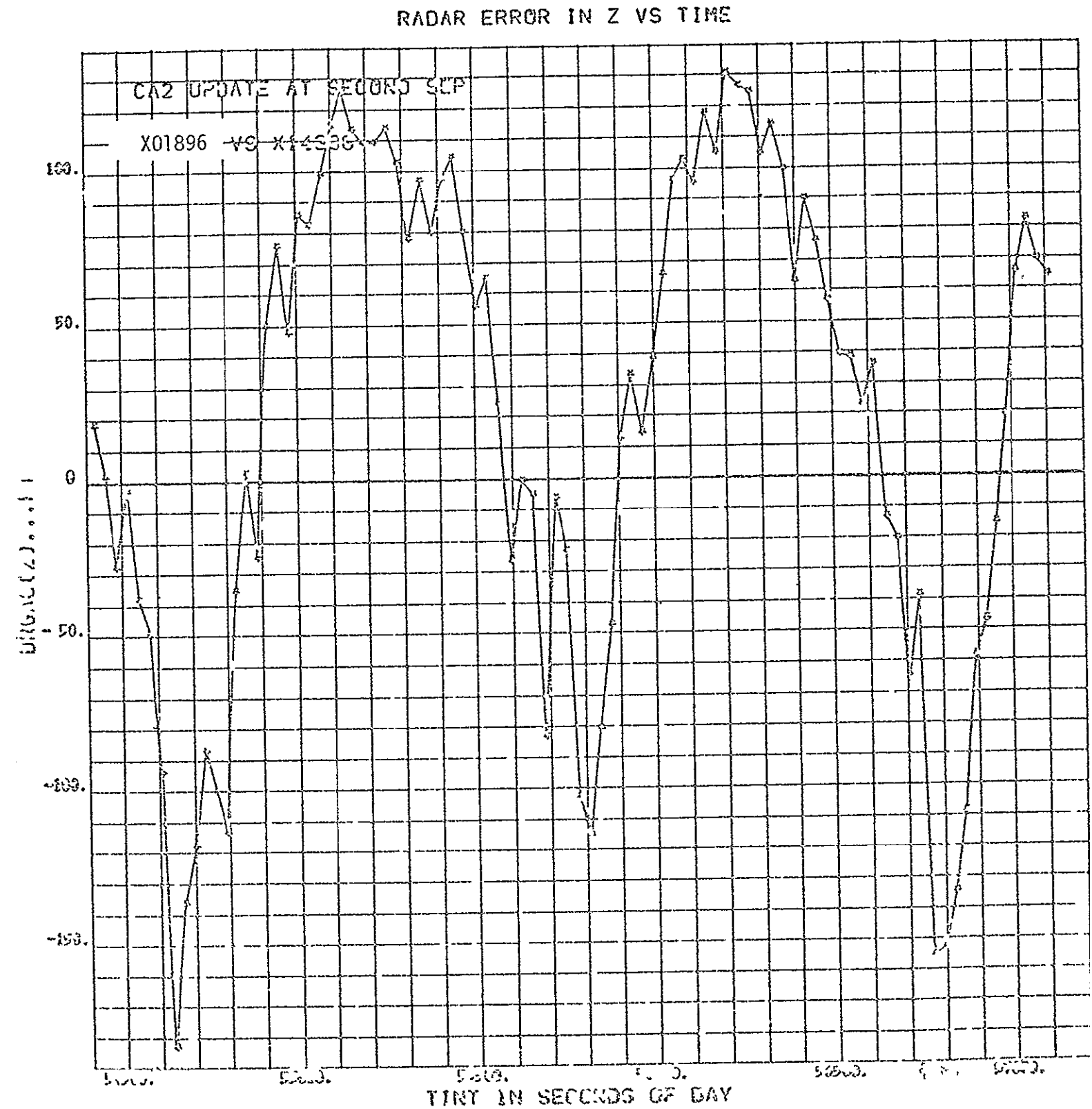

RADAR ERROR IN X VS TIME
CAT 3RD UPDATE
X00263 VS X09254
0
- 50
-100.
-150
-200.
-250.
-300.
DRGAC(X) ..FT
54500.
55000.
55500
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

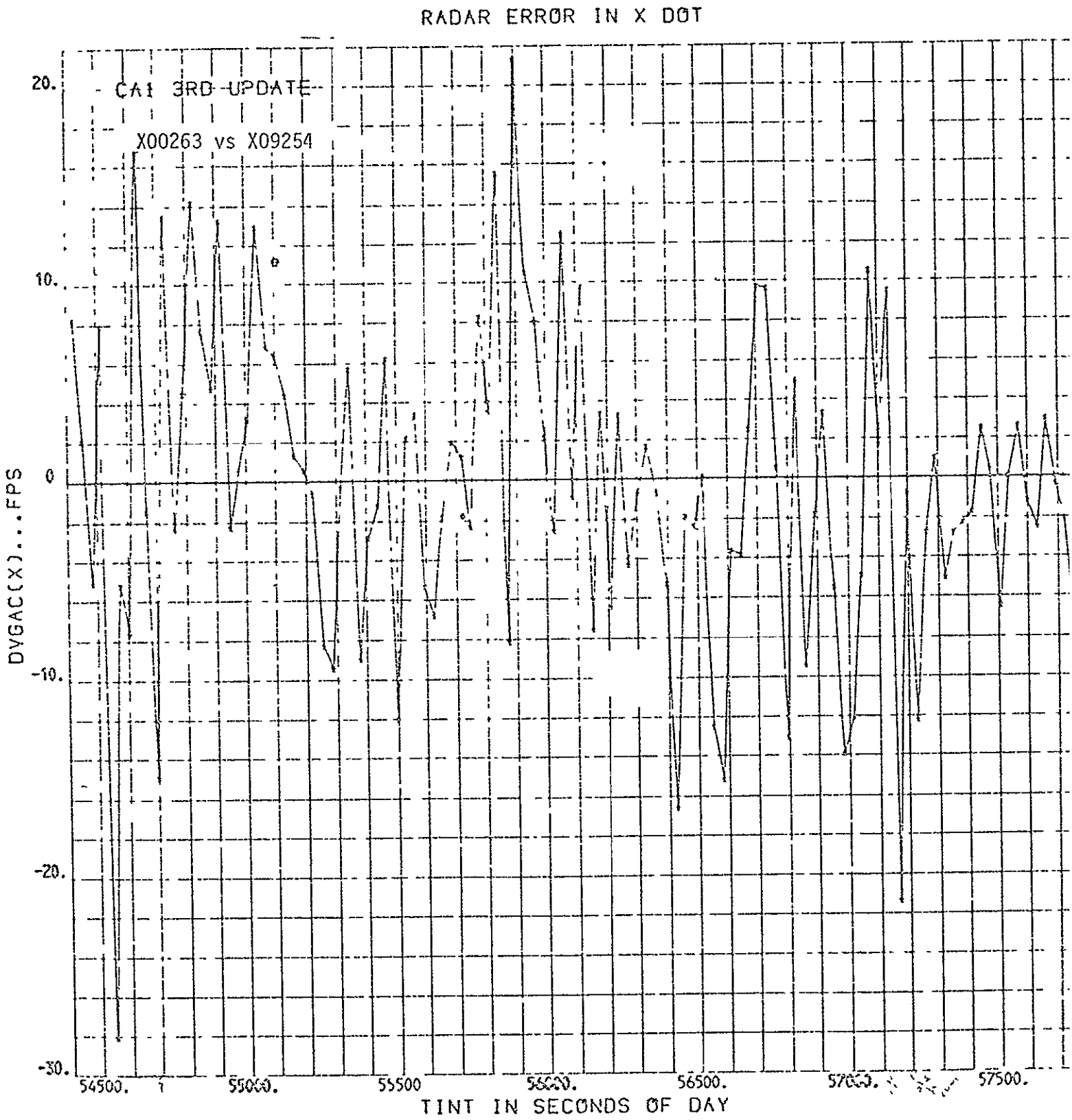

RADAR ERROR IN Y VS TIME
CAT 3RD UPDATE
X00263 vs X09254
-150.
-200.
-250
-300.
-350.
-400.
-450
-500.
DRGAC(Y)...FT
54500.
55000.
55500
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

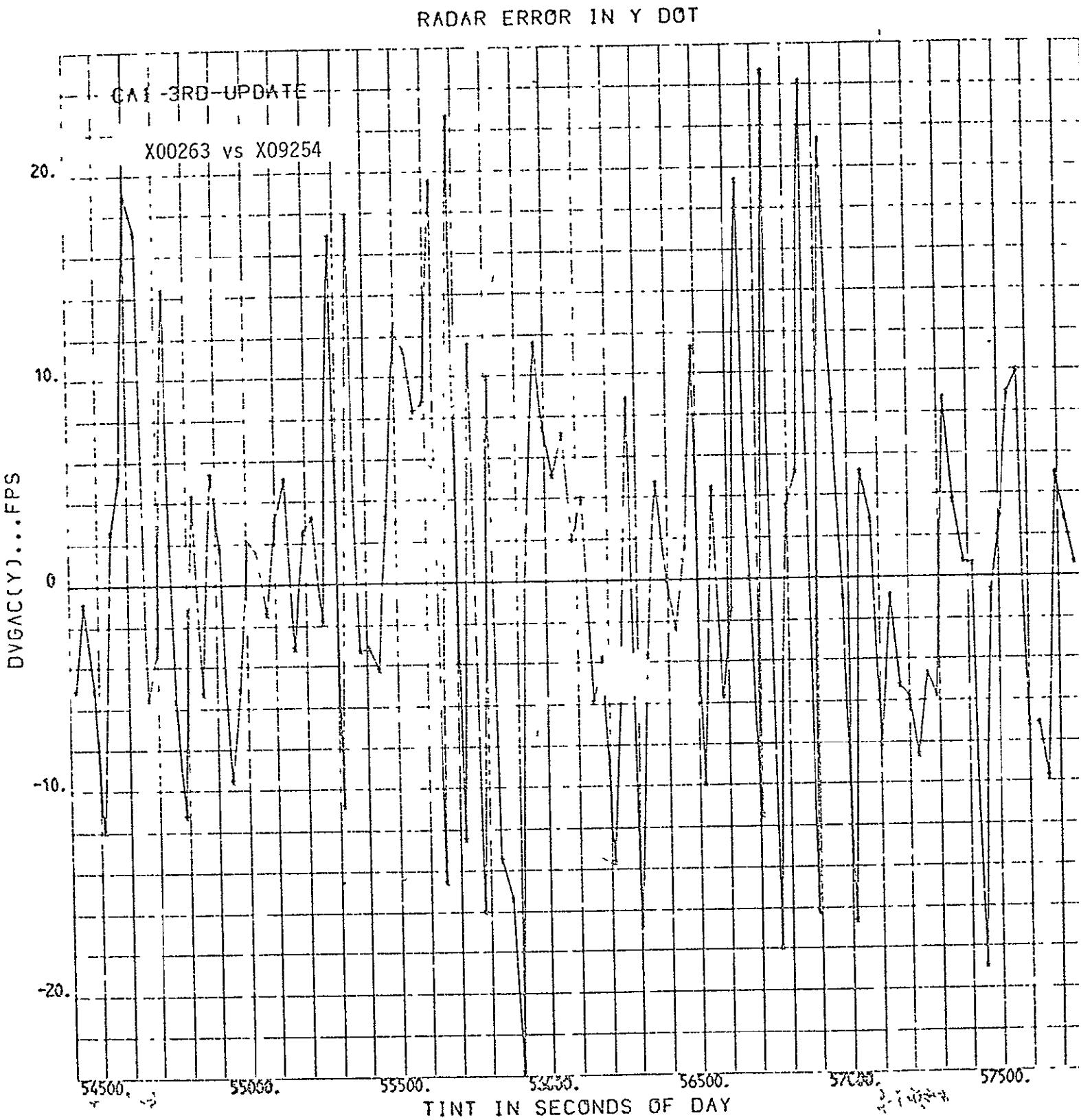

RADAR ERROR IN Z VS TIME
CA1 3RD UPDATE
X00263 vs X09254
500.
400.
300.
200.
100.
DRGAC(Z)...FT
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

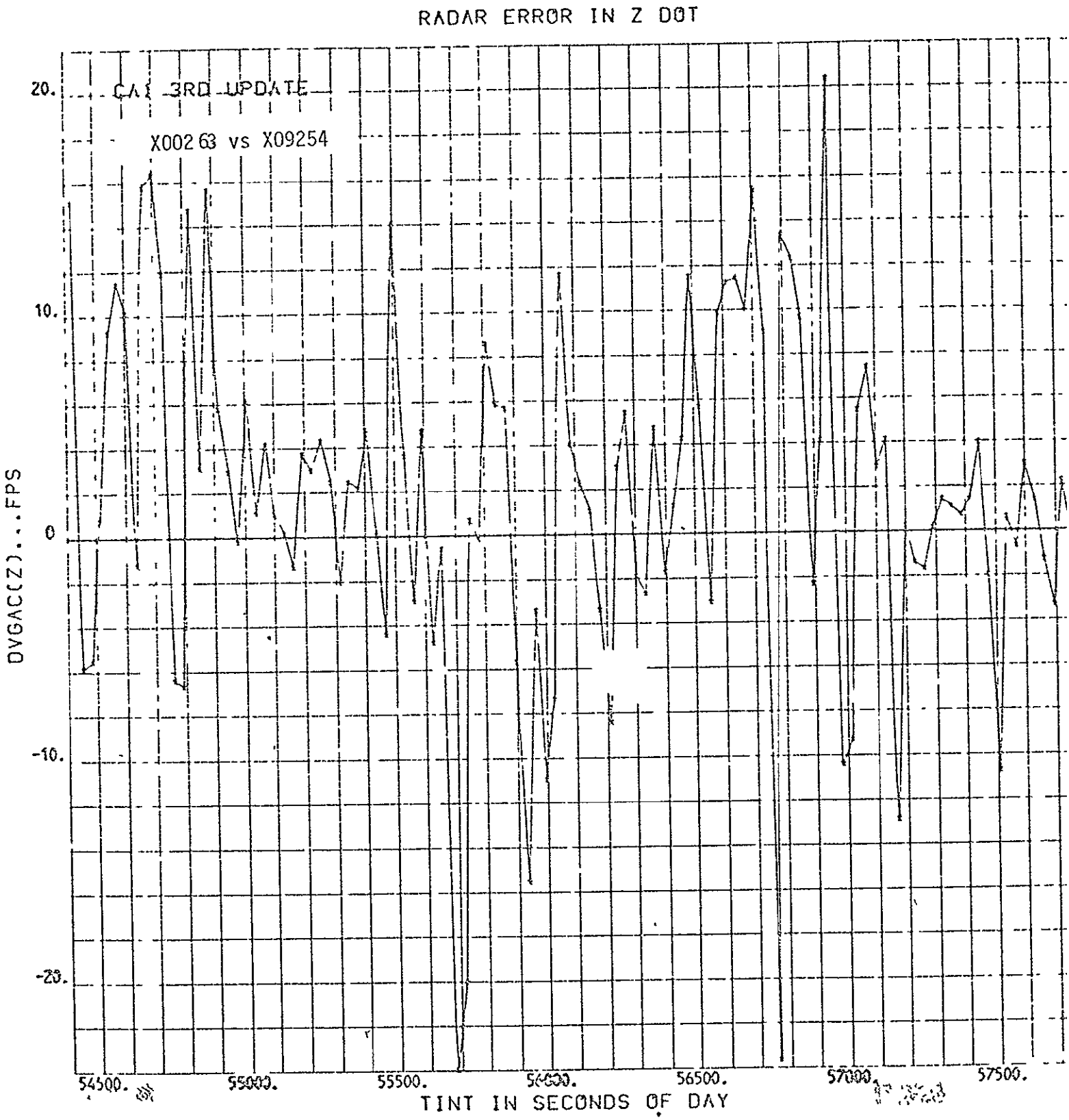






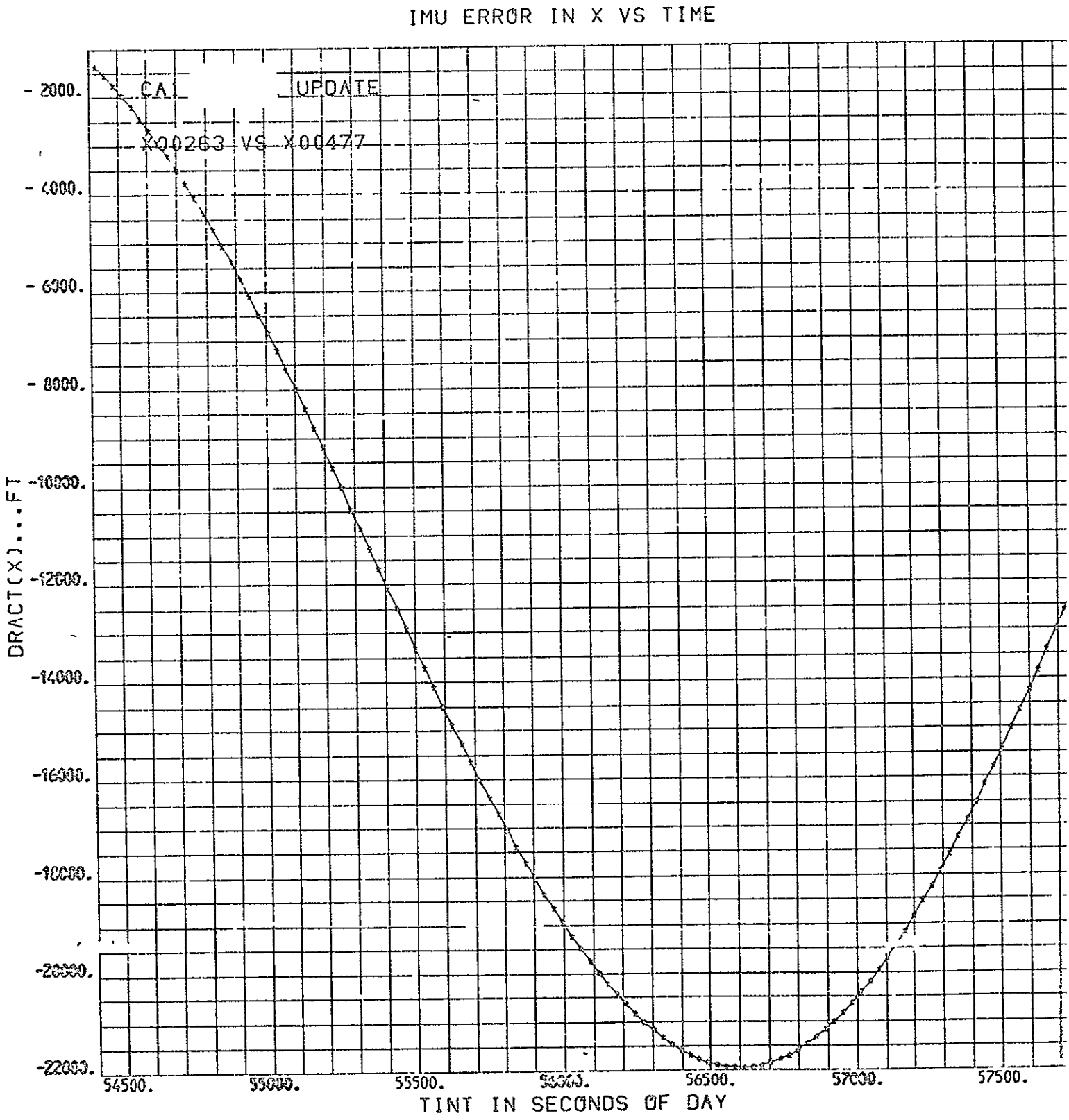


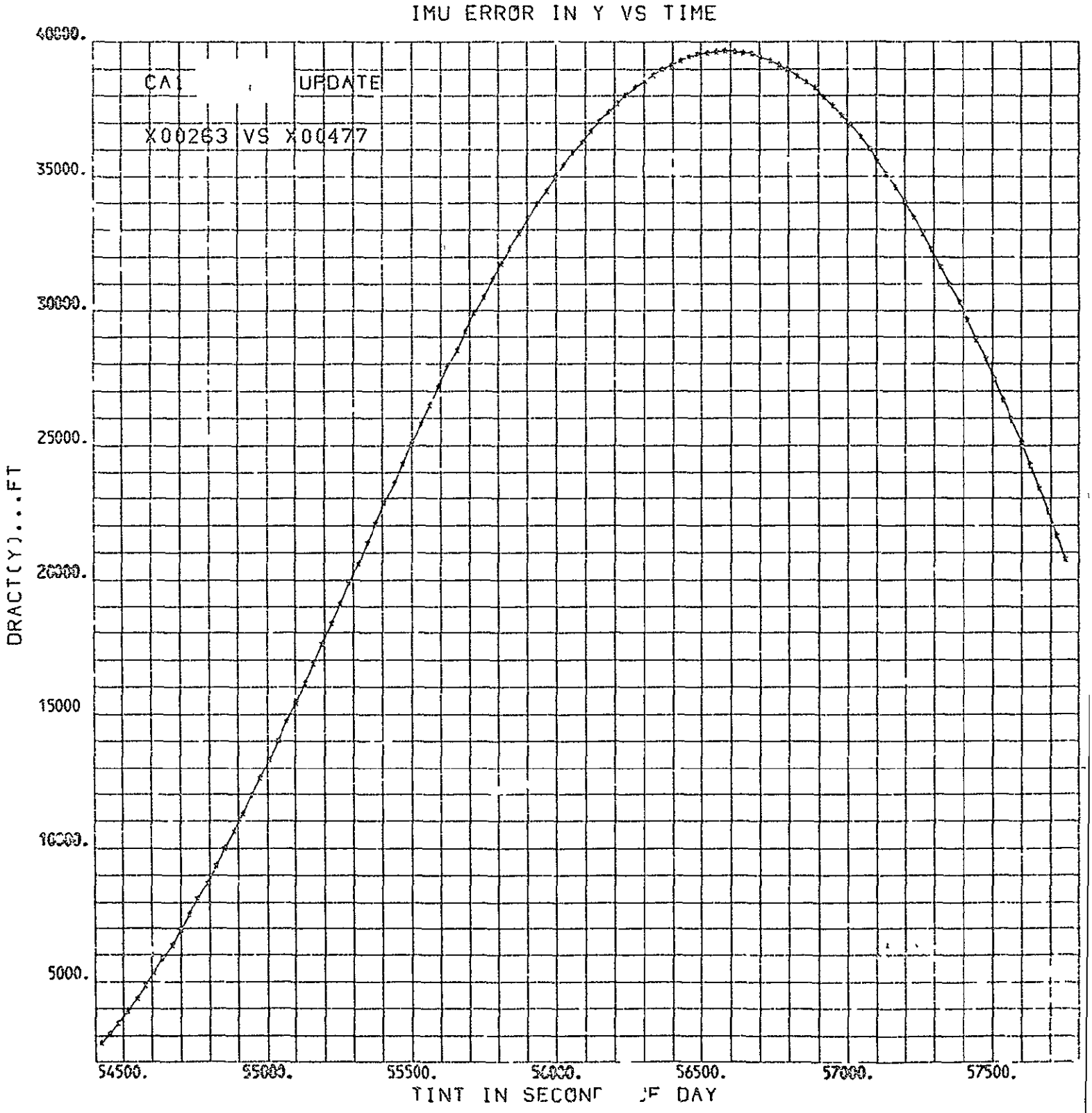

RADAR ERROR IN Y DOT
CAI -3RD-UPDATE
X00263 vs X09254
20.
10.
0
-10.
-20.
DVGAC(Y)...FPS
54500.
55000.
55500.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

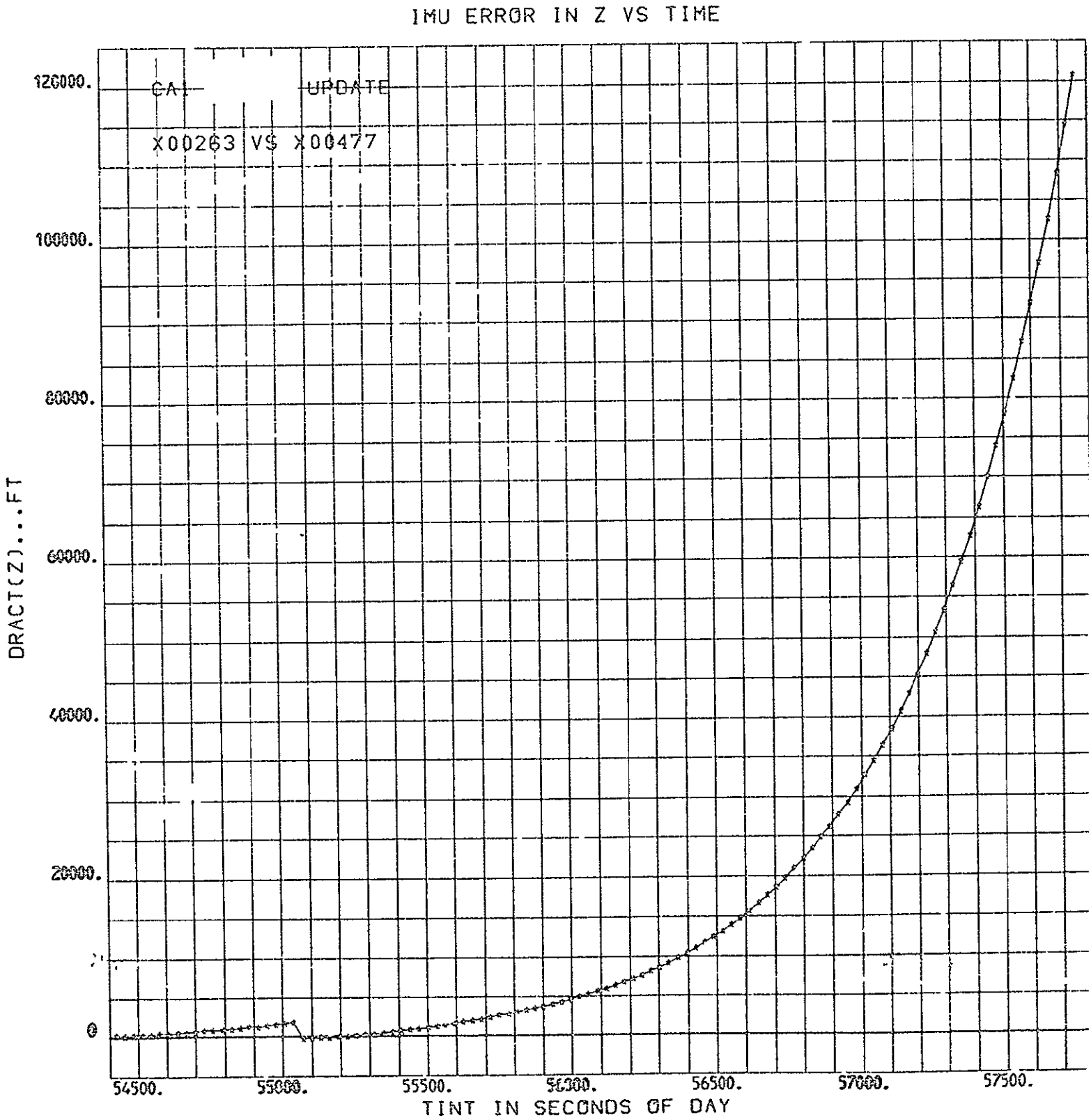

RADAR ERROR IN Z DOT
CAL 3RD UPDATE
X00263 vs X09254
20.
10.
0
-10.
-20.
DVGAC(Z)...FPS
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

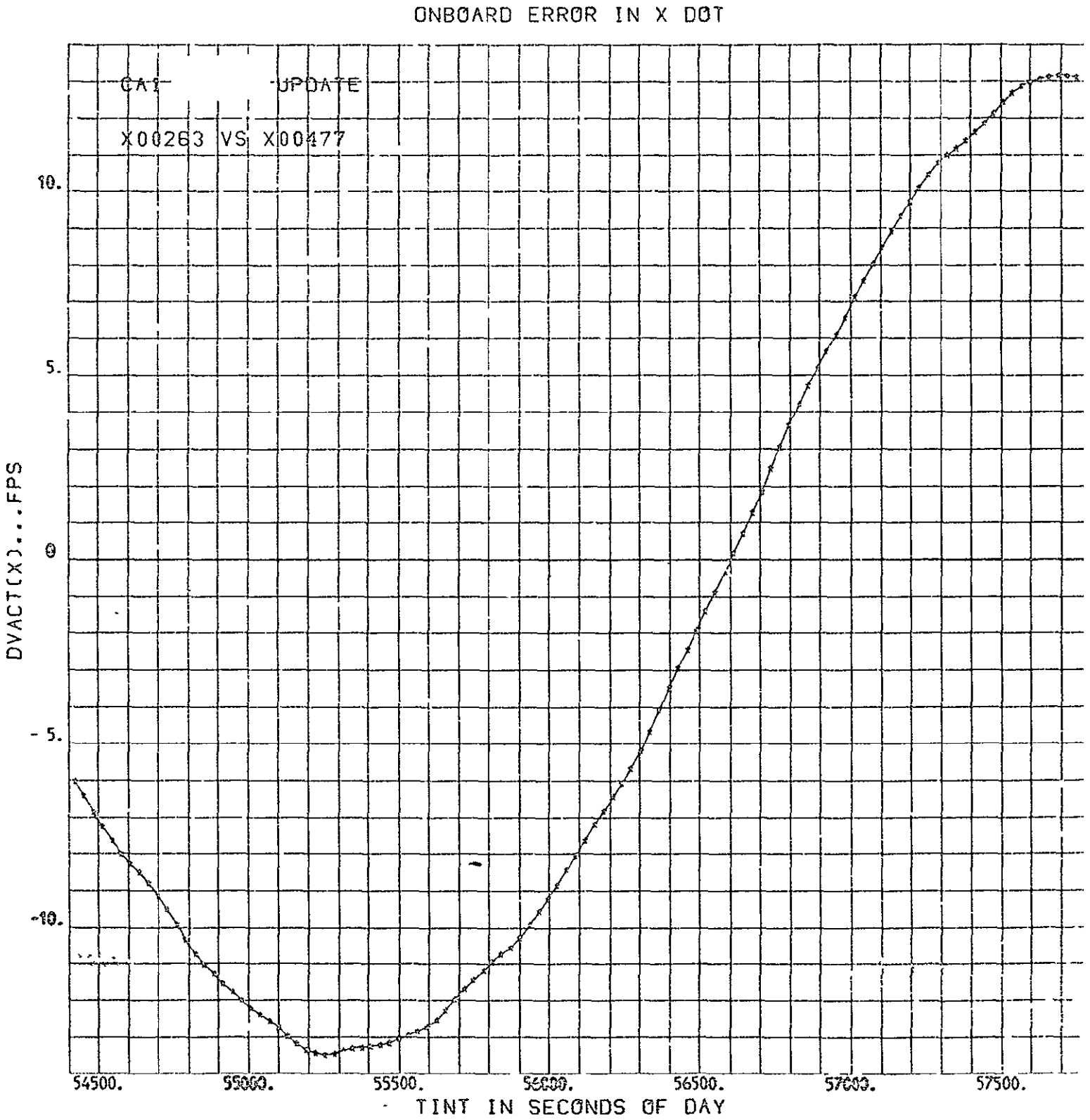
APPENDIX 2

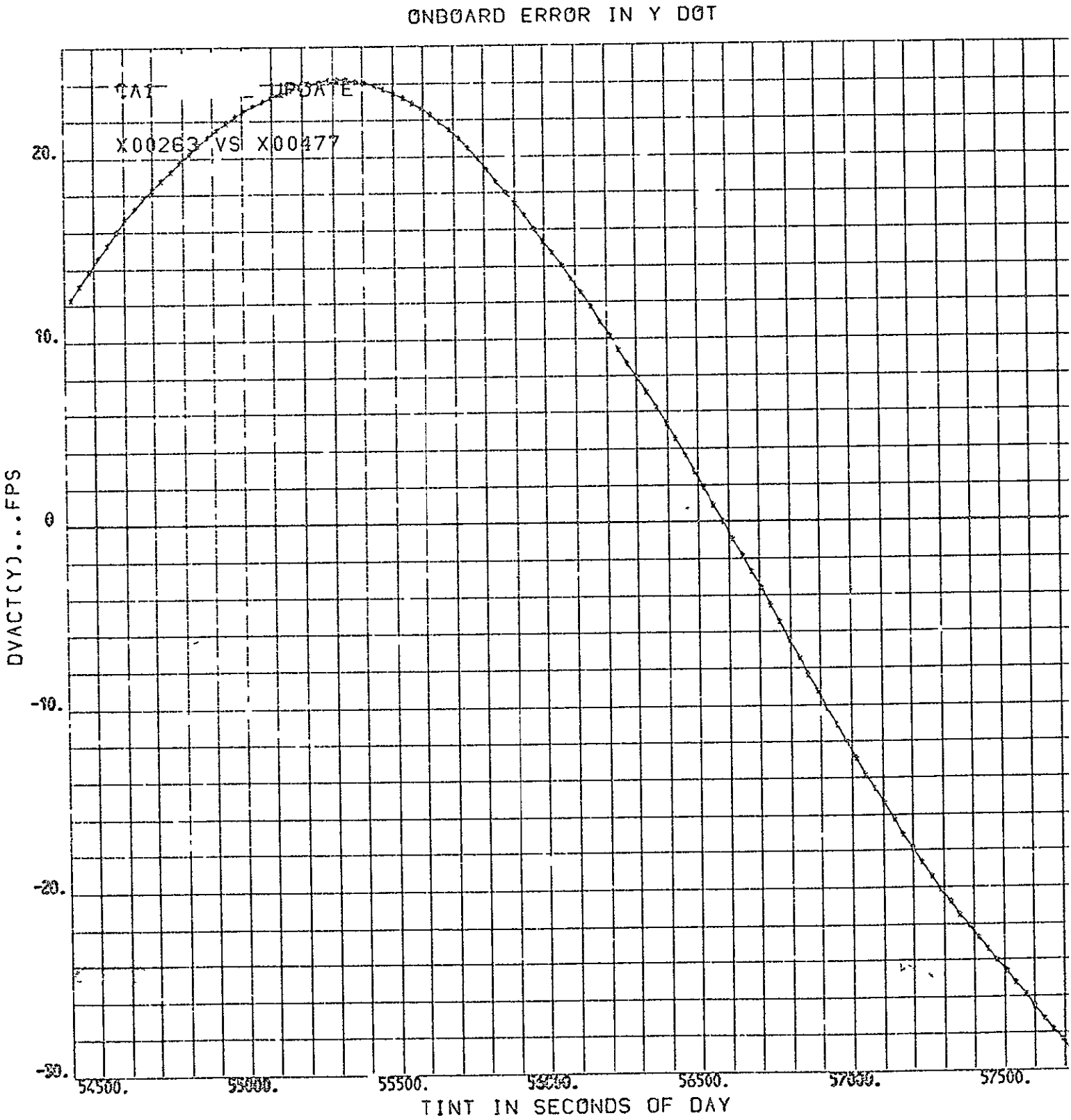
The following plots represent the case in which the onboard state was updated in the vertical components at the first practice separation minus fifteen minutes. Errors in the onboard state vectors and errors in the computed update are plotted as a function of time.

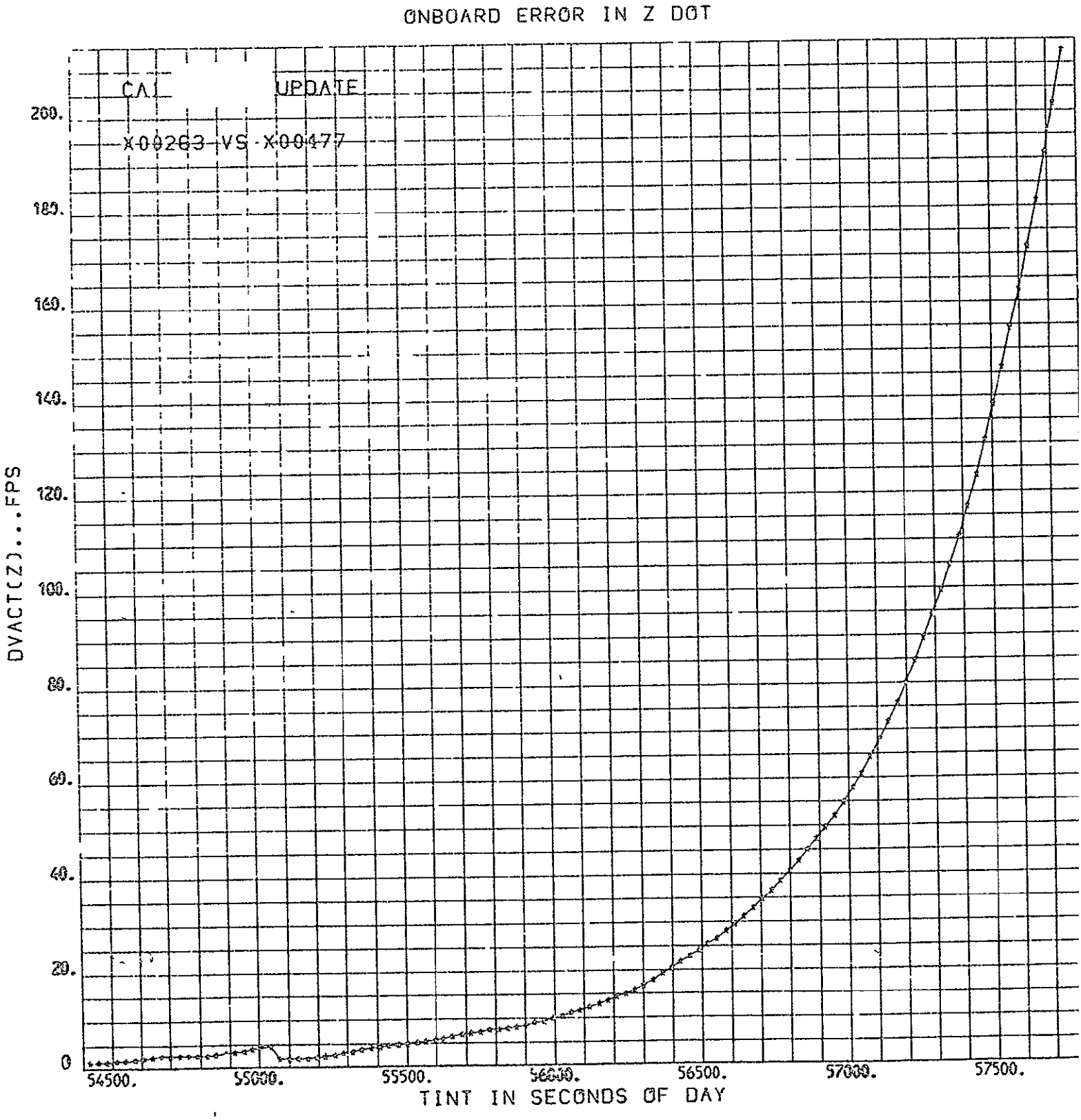

IMU ERROR IN X VS TIME
CAL UPDATE
X00263 VS X00477
- 2000.
- 4000.
- 6000.
- 8000.
-10000.
-12000.
-14000.
-16000.
-18000.
-20000.
-22000.
DRACT(X)...FT
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

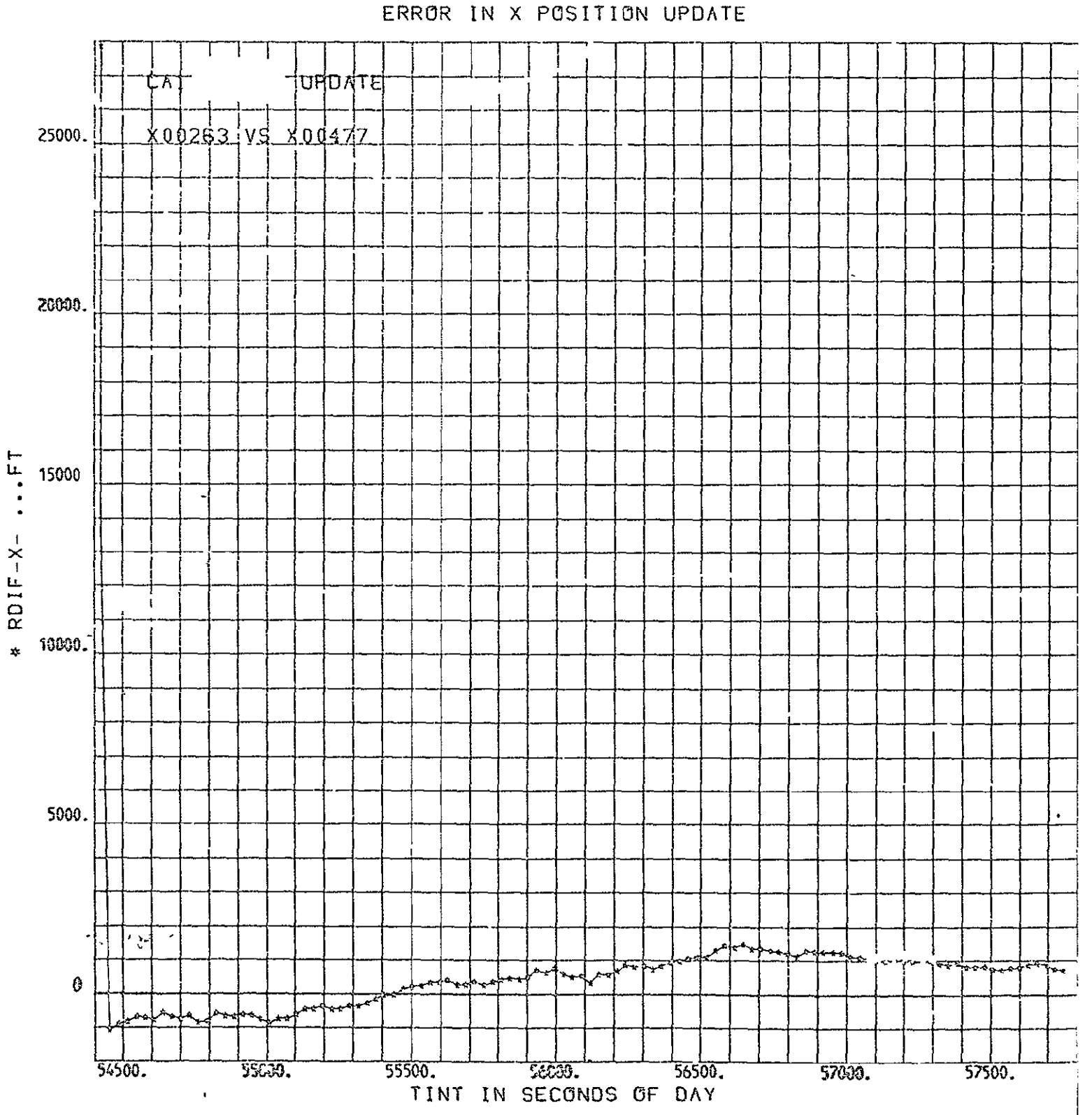

IMU ERROR IN Y VS TIME
CA UPDATE
X00263 VS X00477
40000.
35000.
30000.
25000.
20000.
15000
10000.
5000.
DRACT(Y)...FT
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONF OF DAY

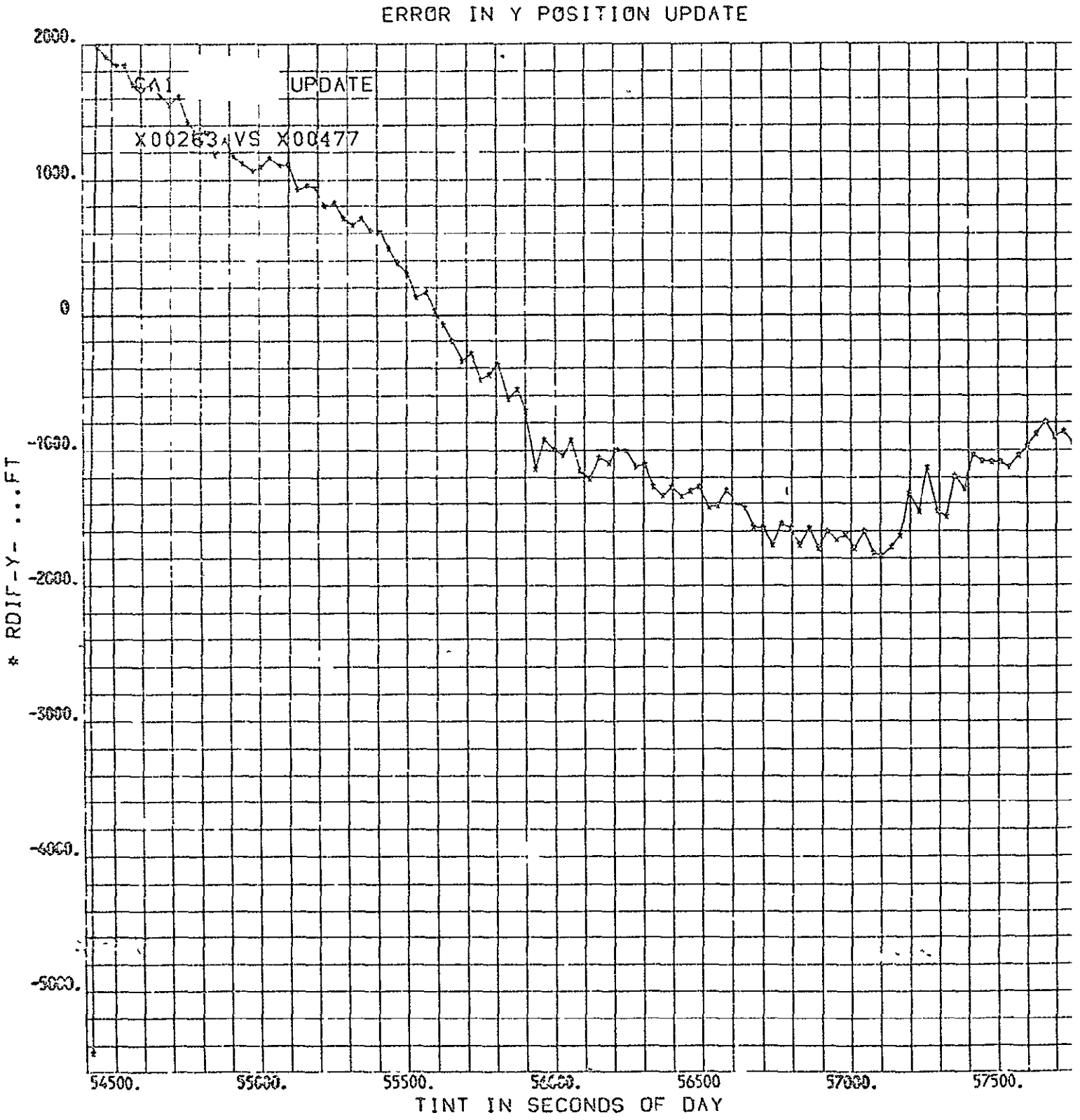

IMU ERROR IN Z VS TIME
CAL
UPDATE
X00263 VS X00477
120000.
100000.
80000.
60000.
40000.
20000.
0
DRACT(Z)...FT
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

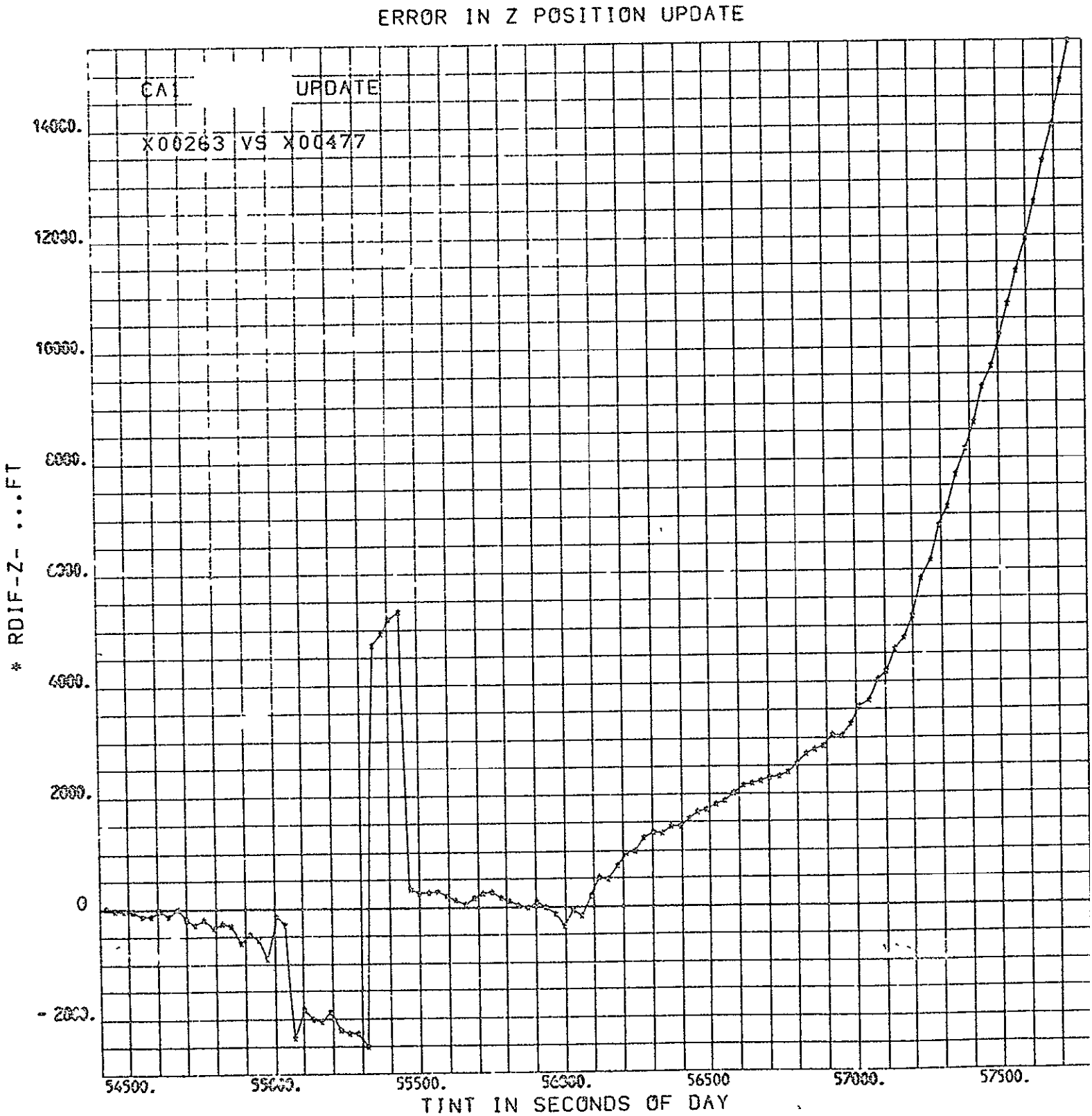

ONBOARD ERROR IN X DOT
CA1 UPDATE
X00263 VS X00477
10.
5.
0
- 5.
-10.
DVACT(X)...FPS
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

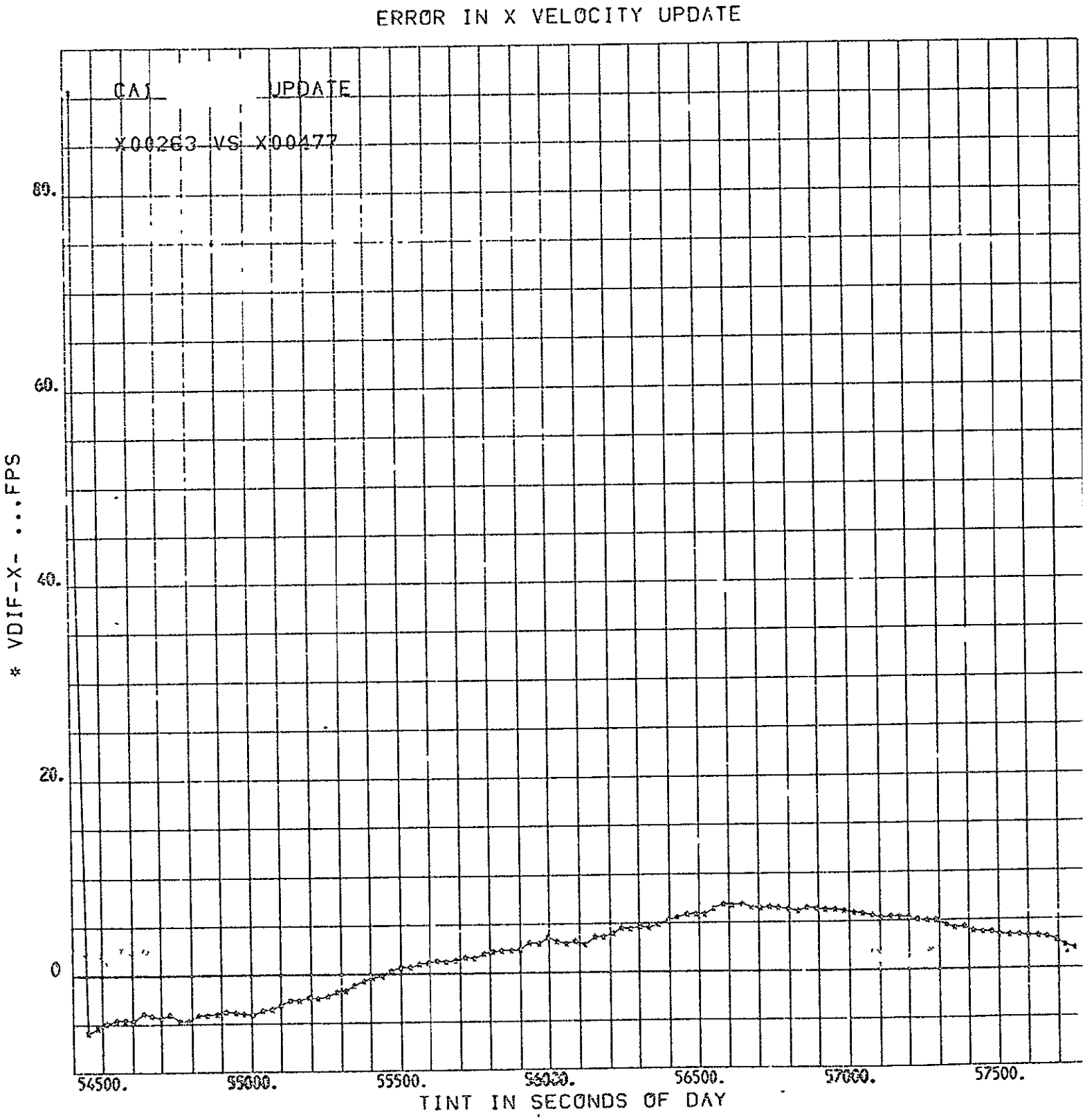

ONBOARD ERROR IN Y DOT
TAI
UPDATE
X00263 VS X00477
20.
10.
0
-10.
-20.
-30.
DVACT(Y)...FPS
52500.
55000.
55500.
56500.
57500.
TINT IN SECONDS OF DAY

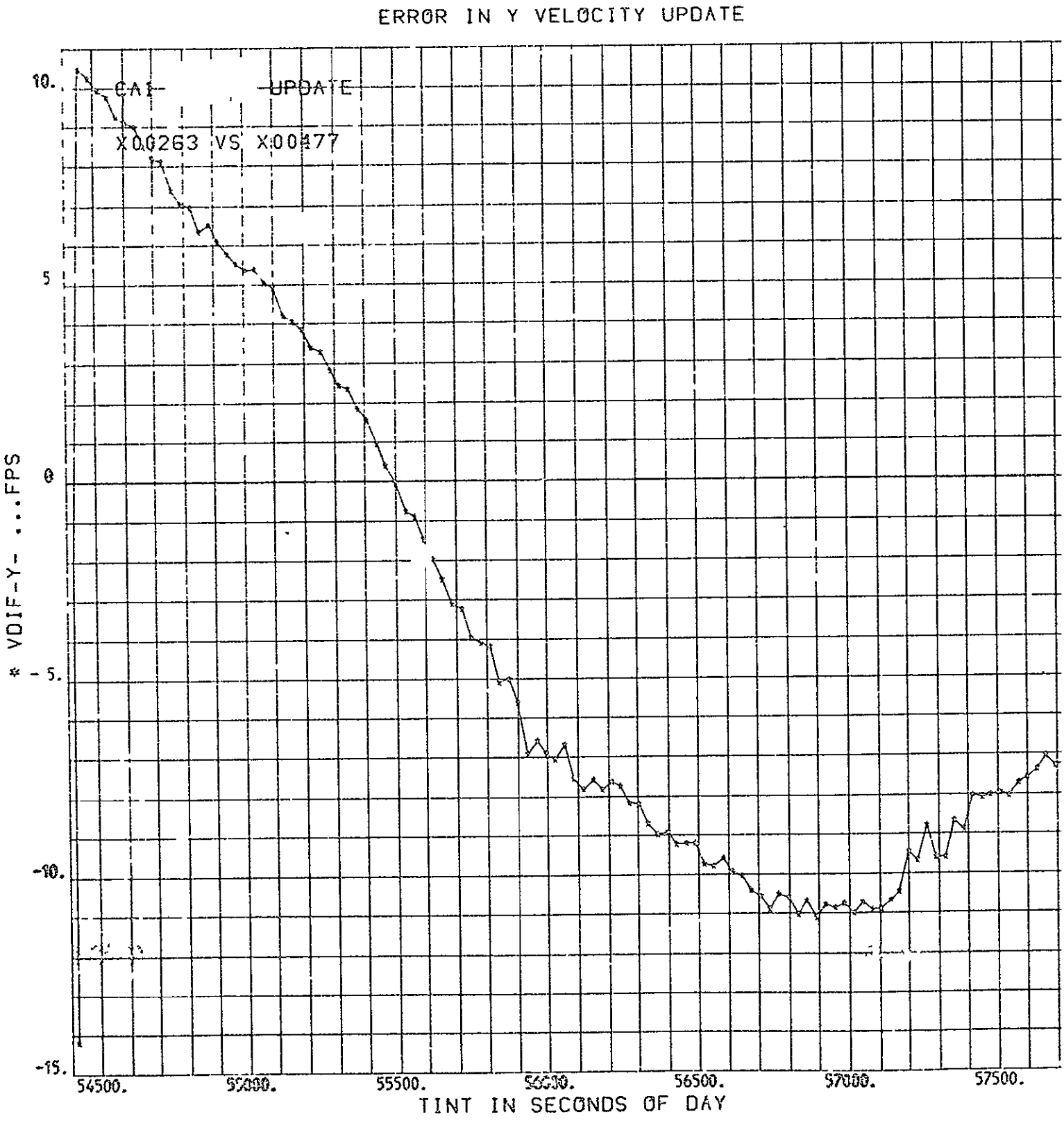

ONBOARD ERROR IN Z DOT
CAL UPDATE
X00263 VS X00477
200.
180.
160.
140.
120.
100.
80.
60.
40.
20.
0
DVACT(Z)...FPS
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

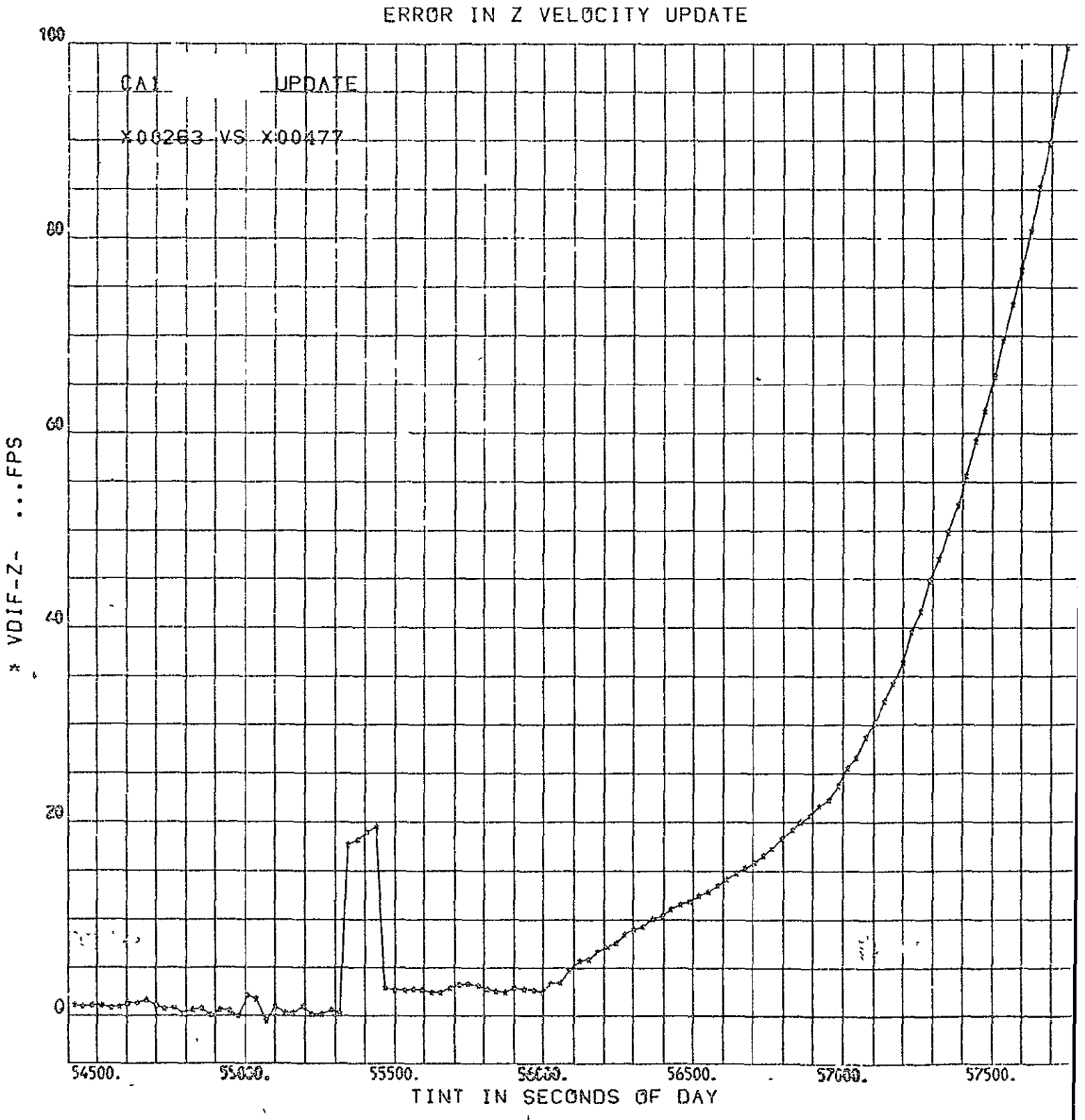

ERROR IN X POSITION UPDATE
CA UPDATE
X00263 VS X00477
25000.
20000.
15000
10000.
5000.
0
* RDIF-X- ...FT
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY


ERROR IN Y POSITION UPDATE
2000.
1000.
0
-1000.
-2000.
-3000.
-4000.
-5000.
C11
UPDATE
X00263 VS X00477
* RDIF-Y- ...FT
54500.
55000.
55500.
56000.
56500
57000.
57500.
TINT IN SECONDS OF DAY


ERROR IN Z POSITION UPDATE
CA1 UPDATE
X00263 VS X00477
14000.
12000.
10000.
8000.
6000.
4000.
2000.
0
- 2000.
* RDIF-Z- ...FT
54500.
55000.
55500.
56000.
56500
57000.
57500.
TINT IN SECONDS OF DAY

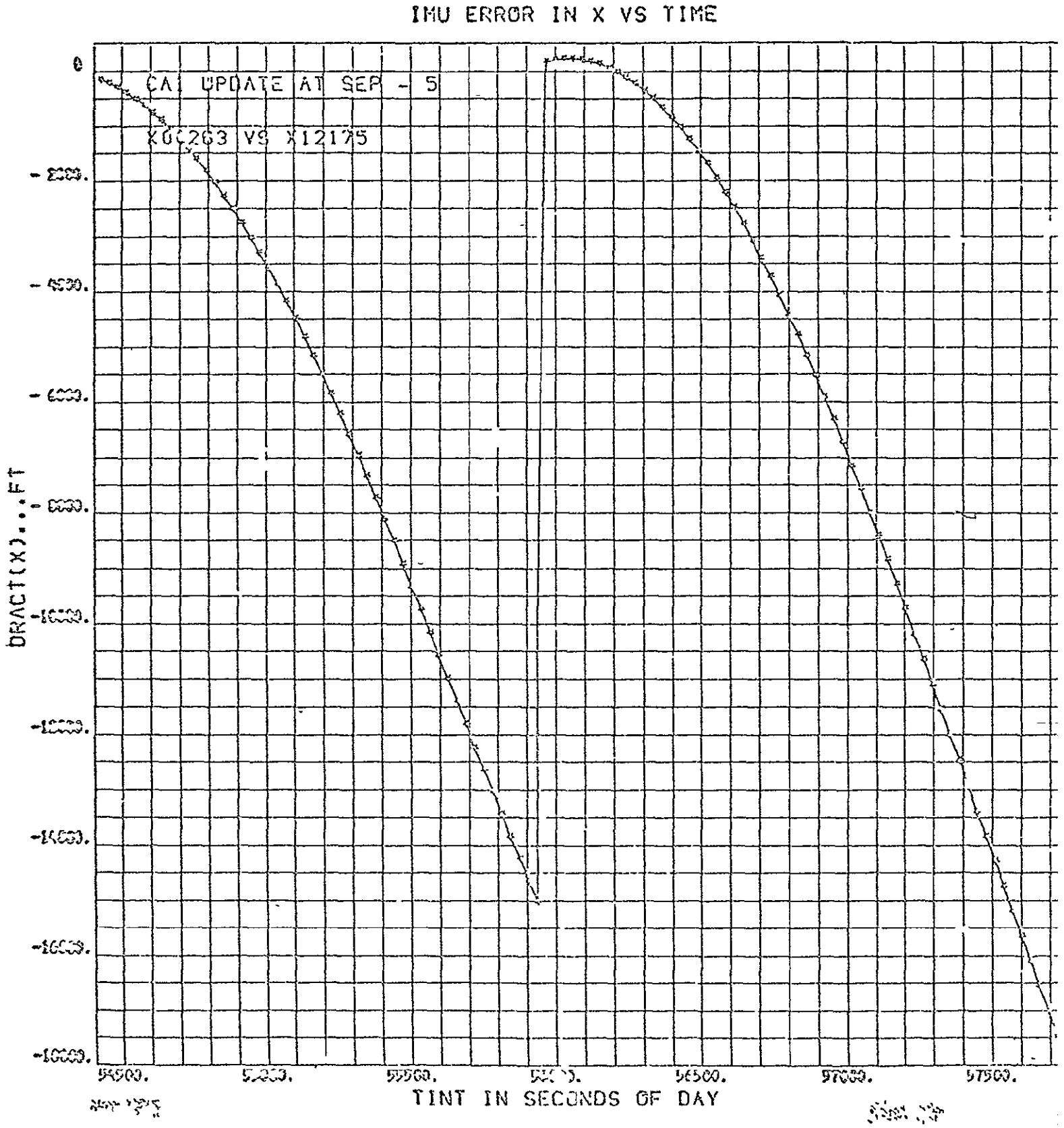

ERROR IN X VELOCITY UPDATE
CA1 UPDATE
X00263 VS X00477
80.
60.
40.
20.
0
* VDIF-X- ...FPS
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

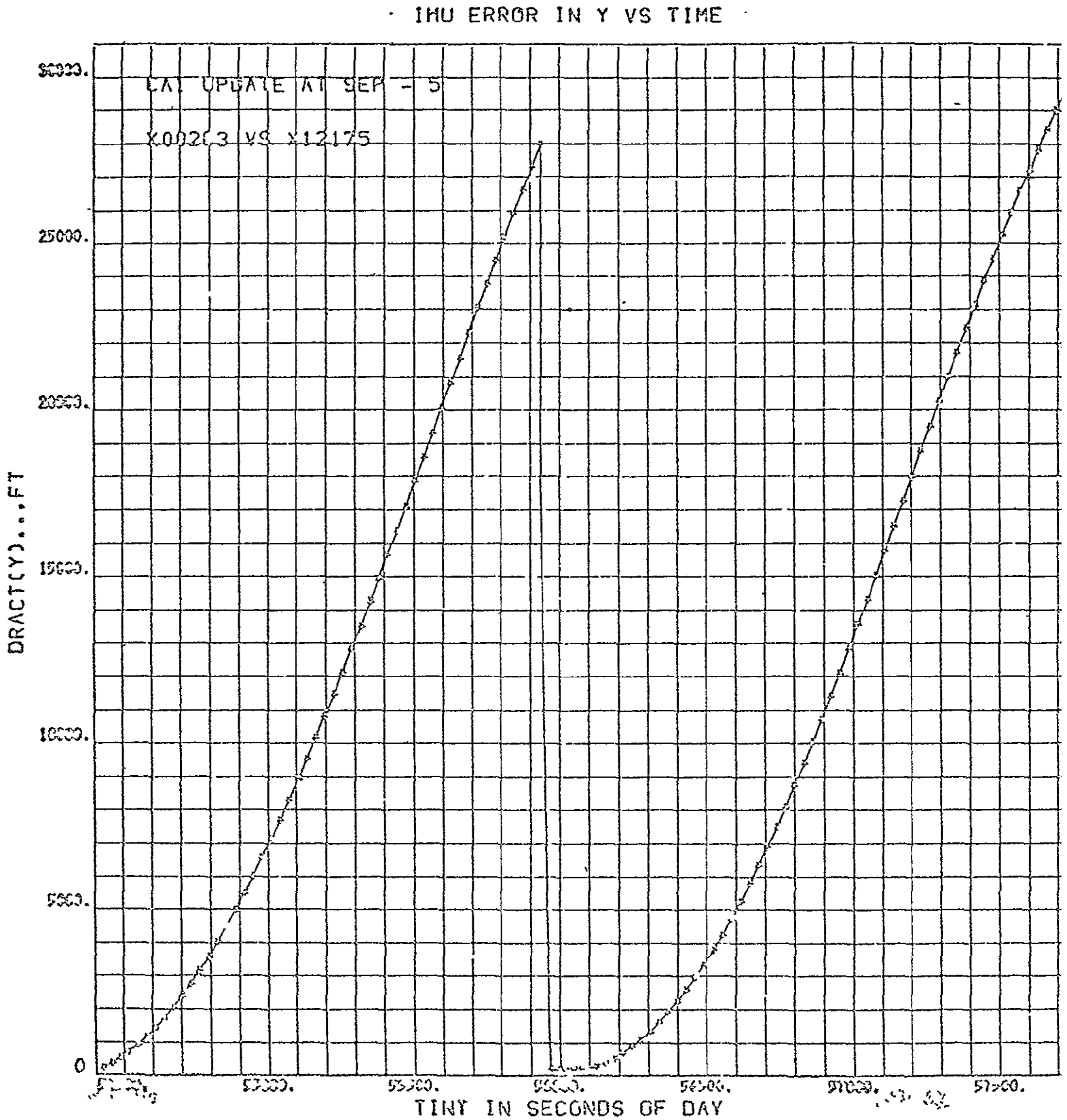

ERROR IN Y VELOCITY UPDATE
CAI UPDATE
X00263 VS X00477
10.
5
0
-5.
-10.
-15.
* VDIF-Y- ...FPS
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

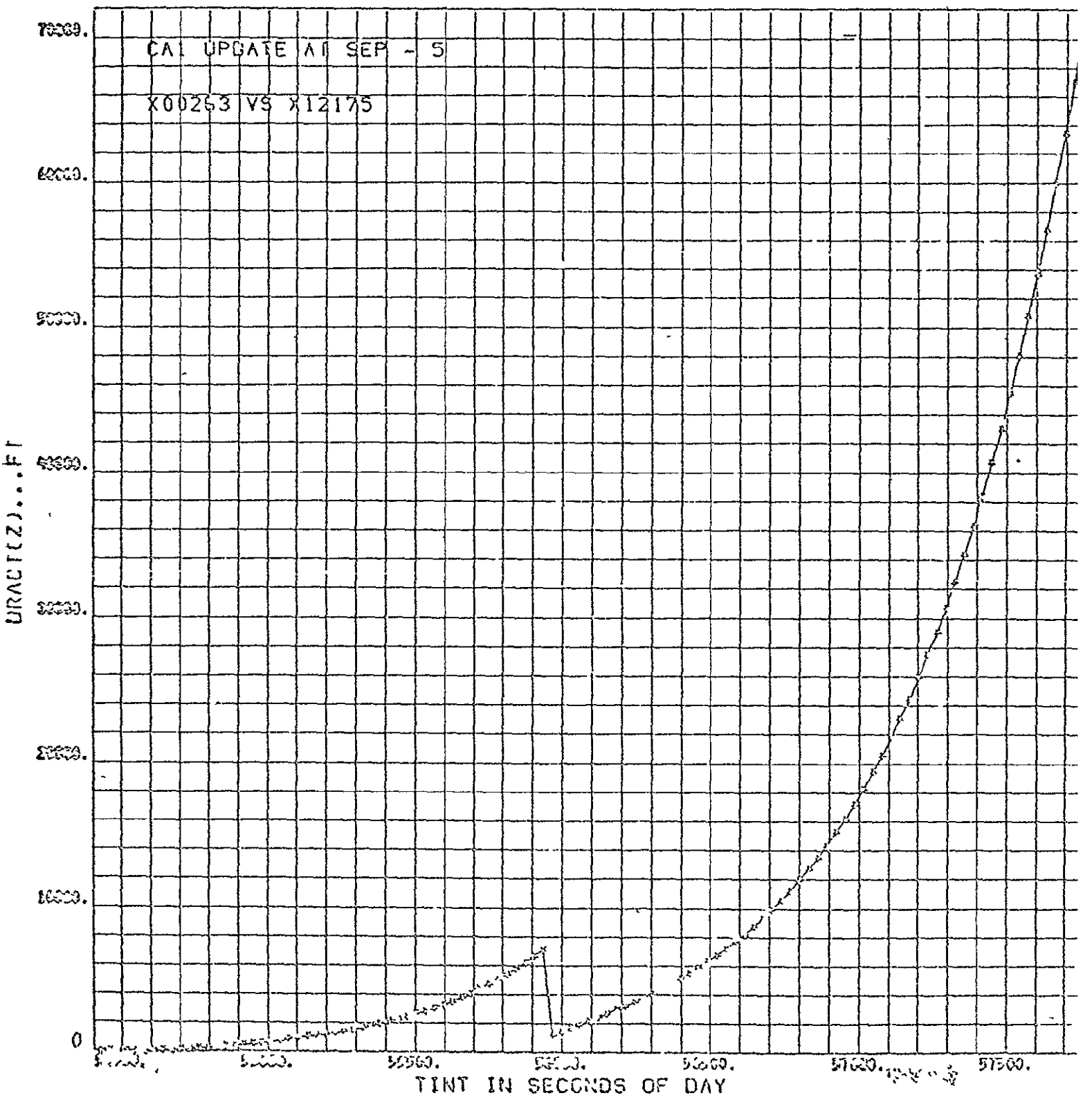

ERROR IN Z VELOCITY UPDATE
CAL UPDATE
X00263 VS X00477
100
80
60
40
20
0
* VDIF-Z- ...FPS
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

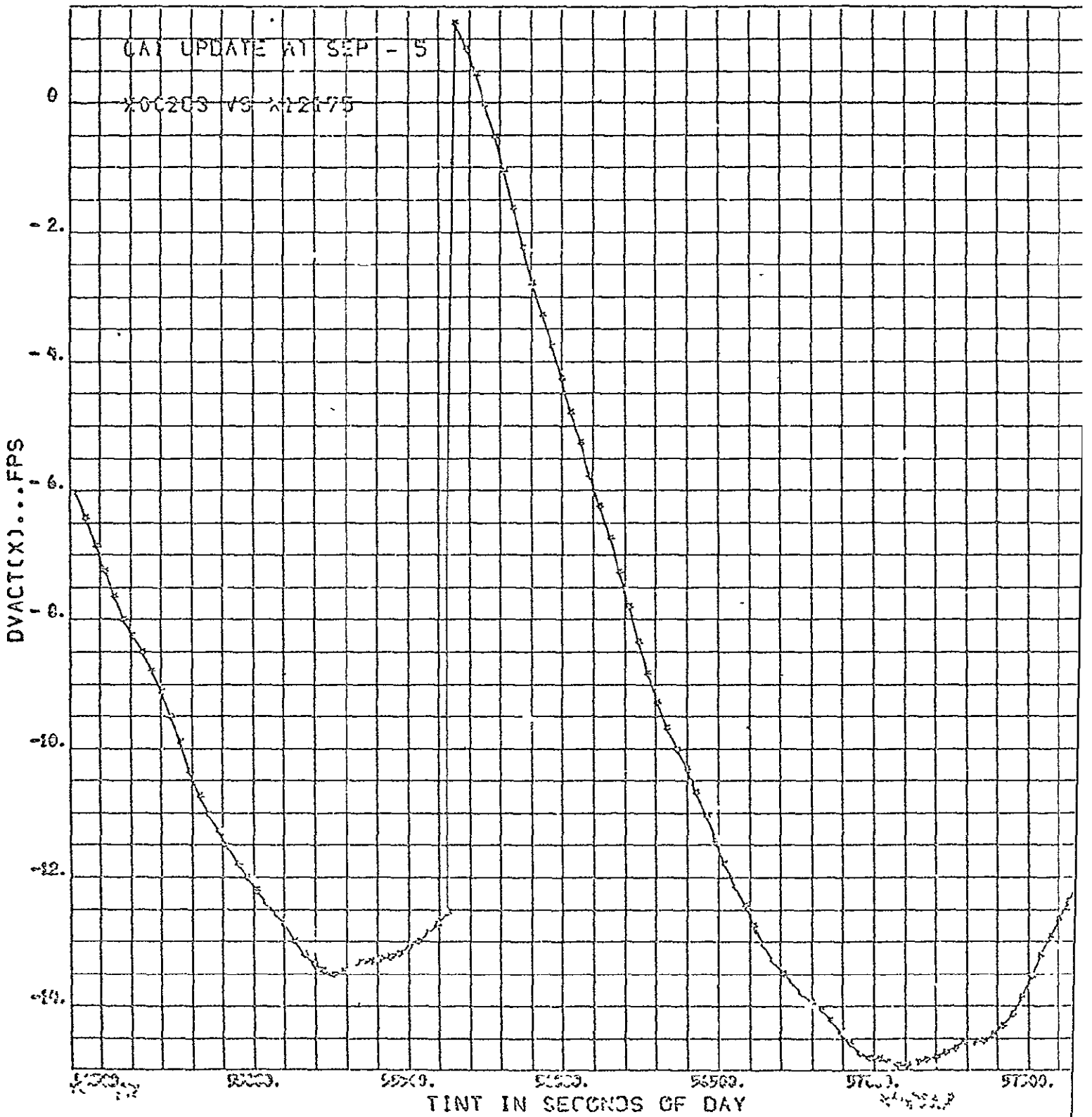
APPENDIX 3

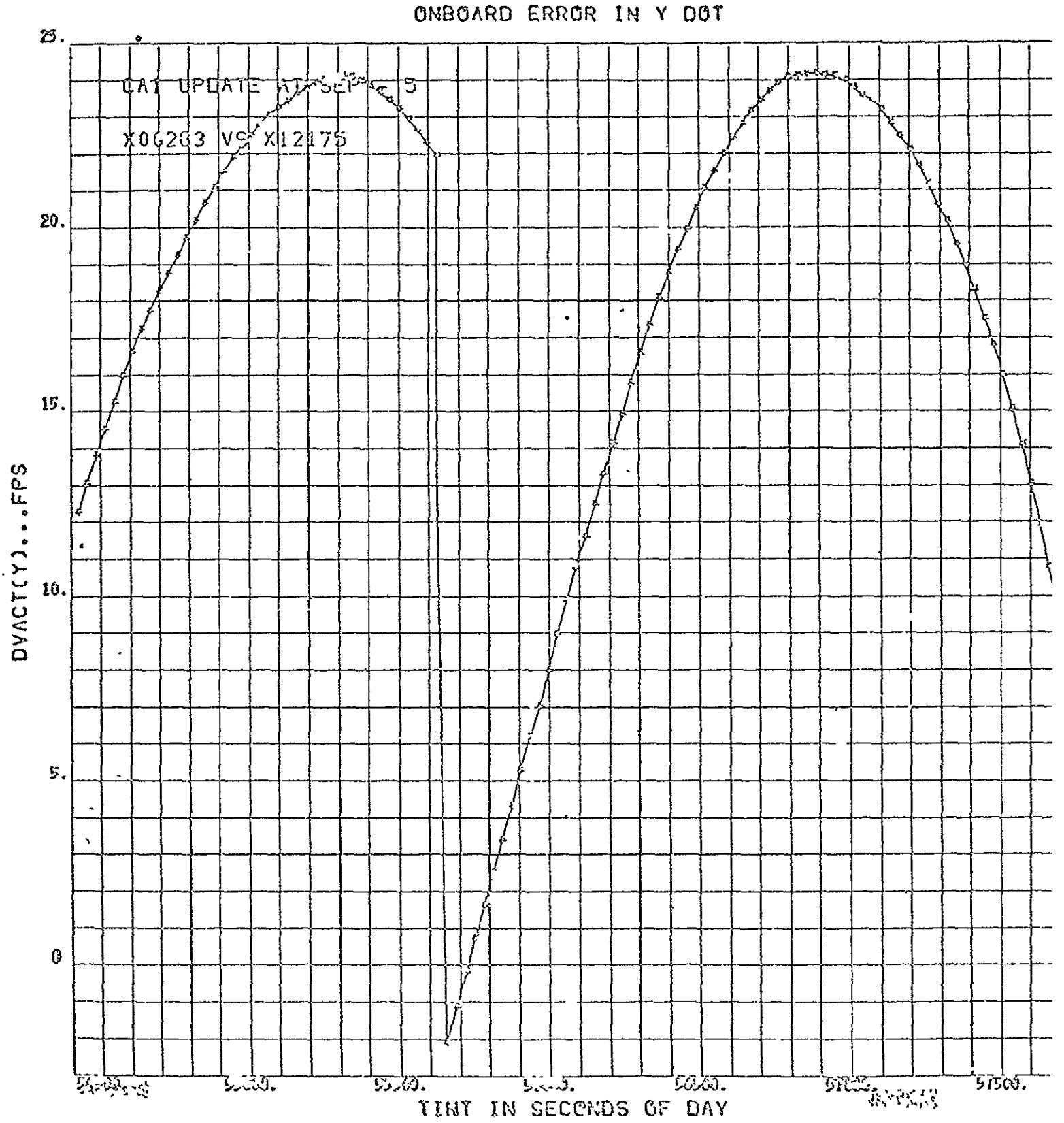
The following plots represent the case in which the onboard state was updated at the first practice separation minus five minutes. Errors in the onboard state and errors in the computed update are plotted as a function of time.

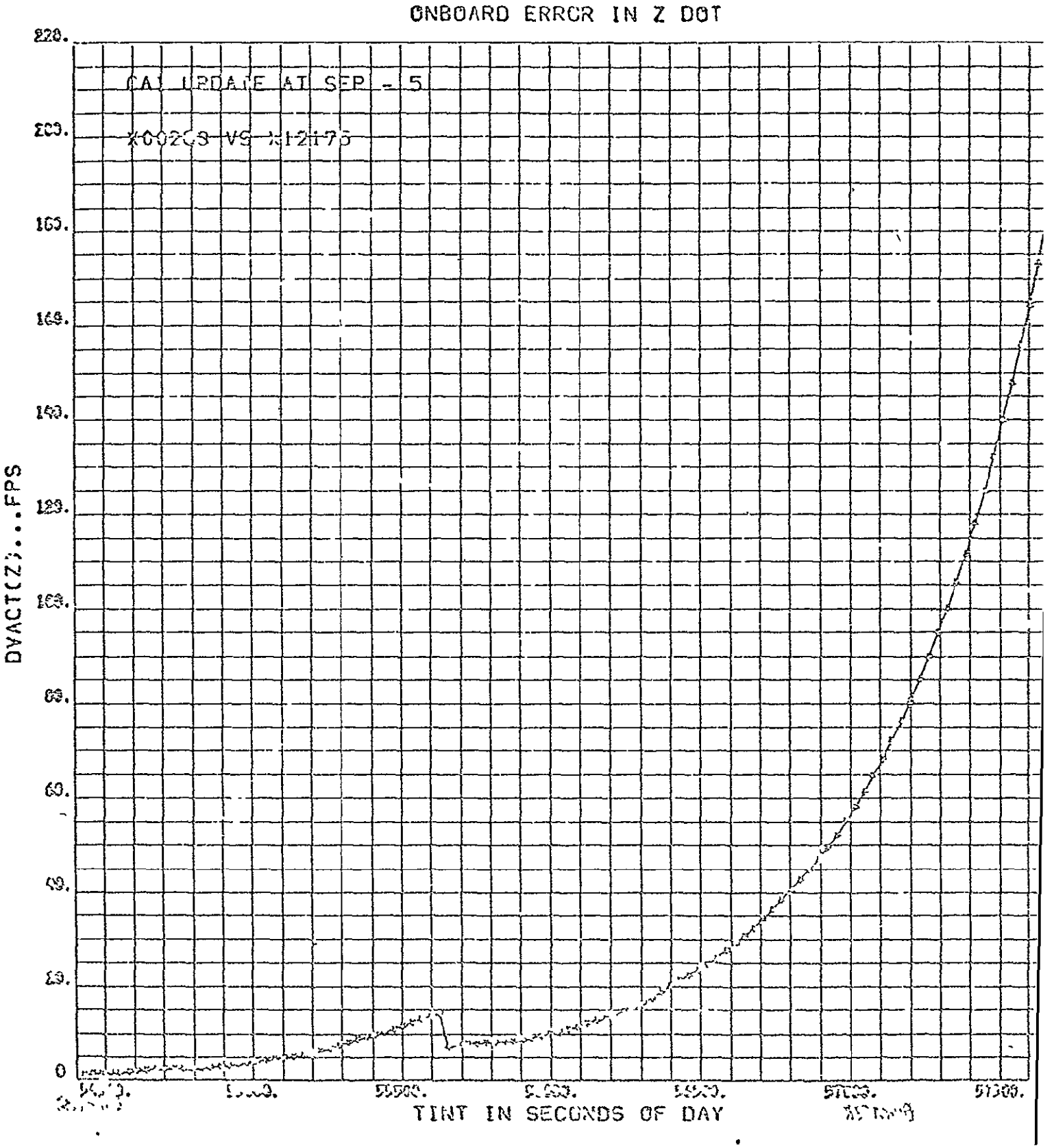



IMU ERROR IN Y VS TIME
LAT UPDATE AT SEP - 5
X00203 VS X12175
25000.
20000.
15000.
10000.
0
DRACT(Y)...FT
TINT IN SECONDS OF DAY


IMU ERROR IN Z VS TIME
CAL UPDATE AT SEP - 5
X00263 VS X12175
0
TINT IN SECONDS OF DAY

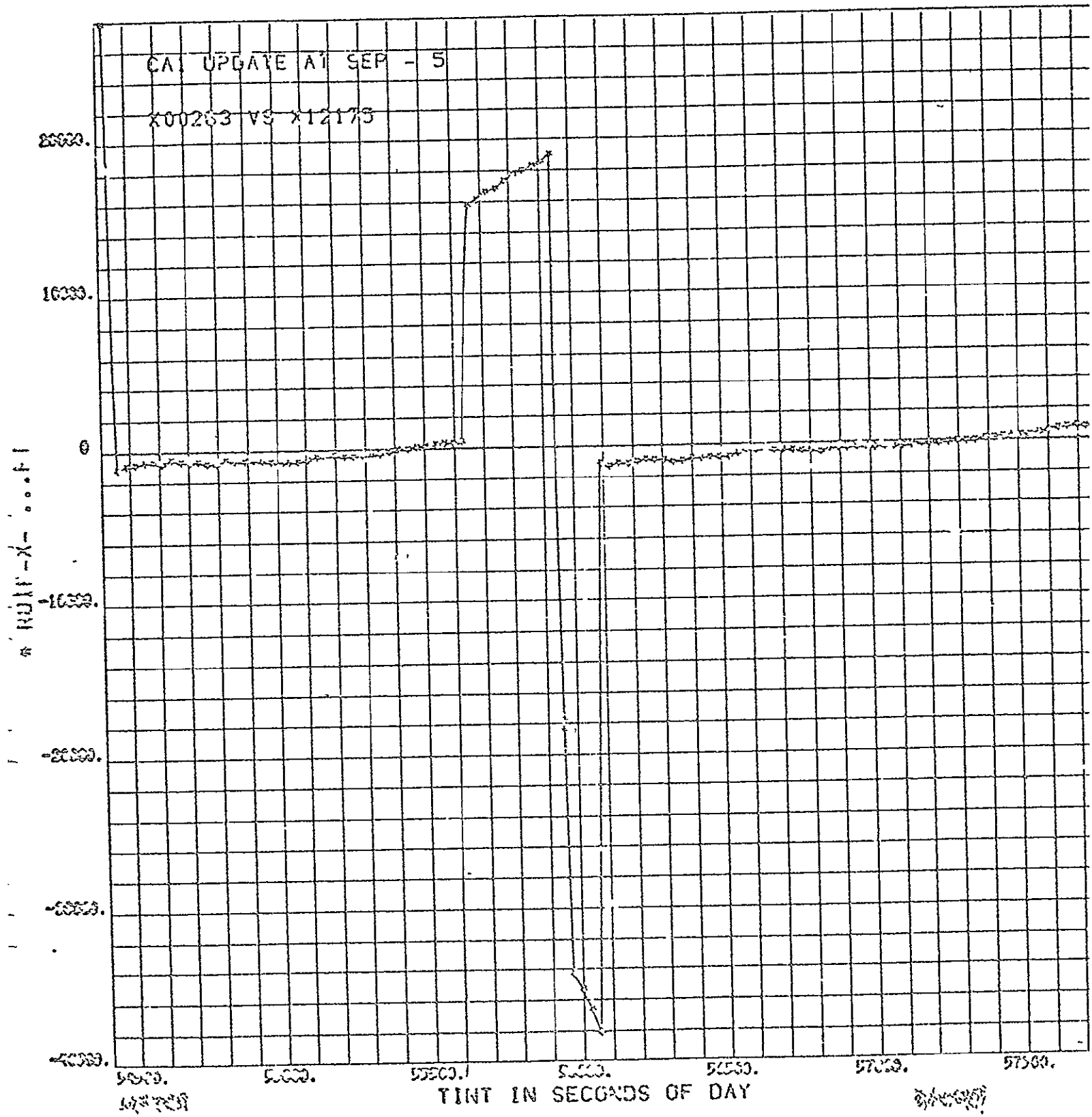



ONBOARD ERROR IN Y DOT
CAT UPDATE AT SEP = 3
X0G2G3 VS X12175
25.
20.
15.
10.
5.
0
DVACT(Y)...FPS
TINT IN SECONDS OF DAY



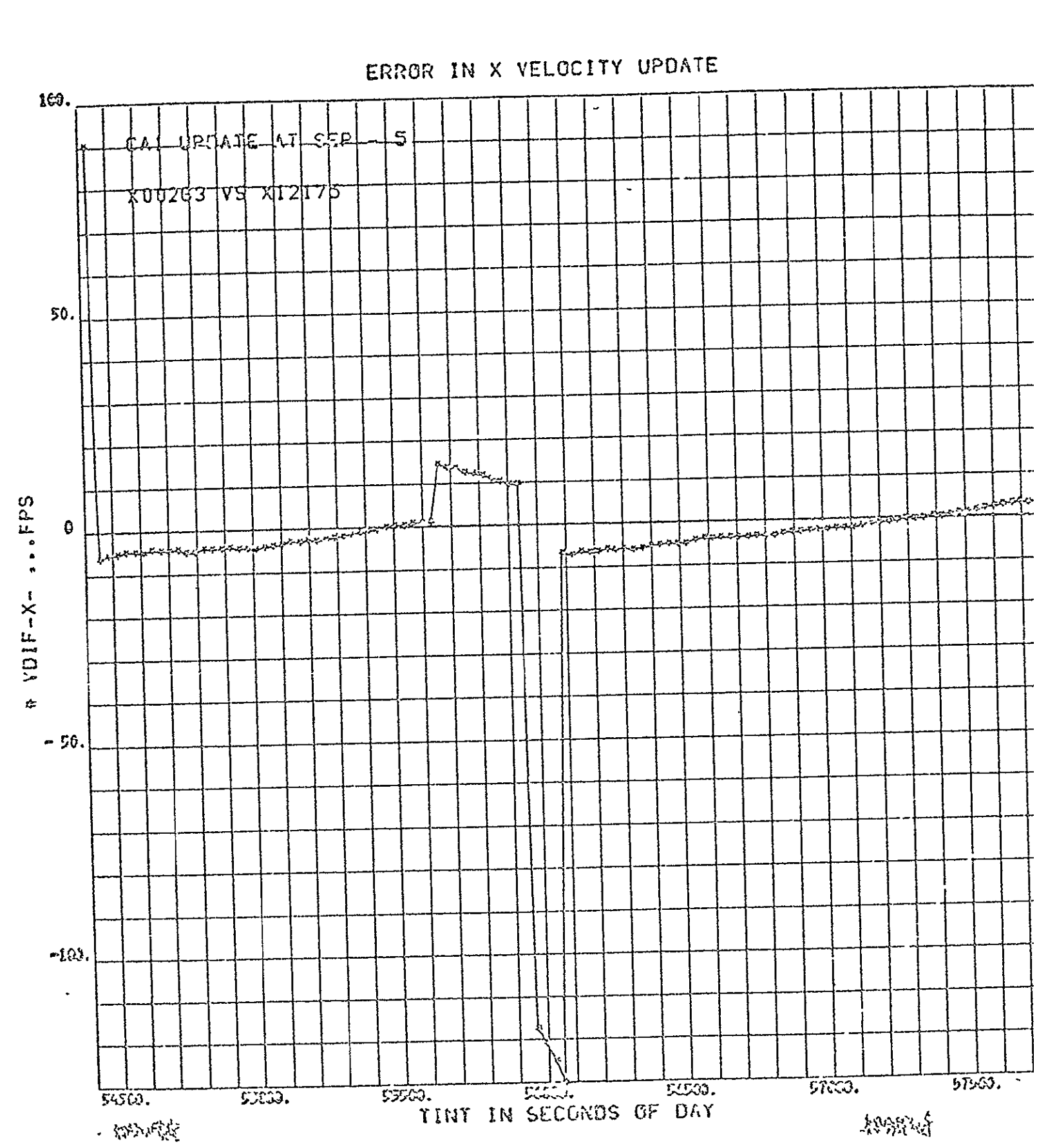
ORIGINAL PAGE IS
OF POOR QUALITY

ERROR IN X POSITION UPDATE

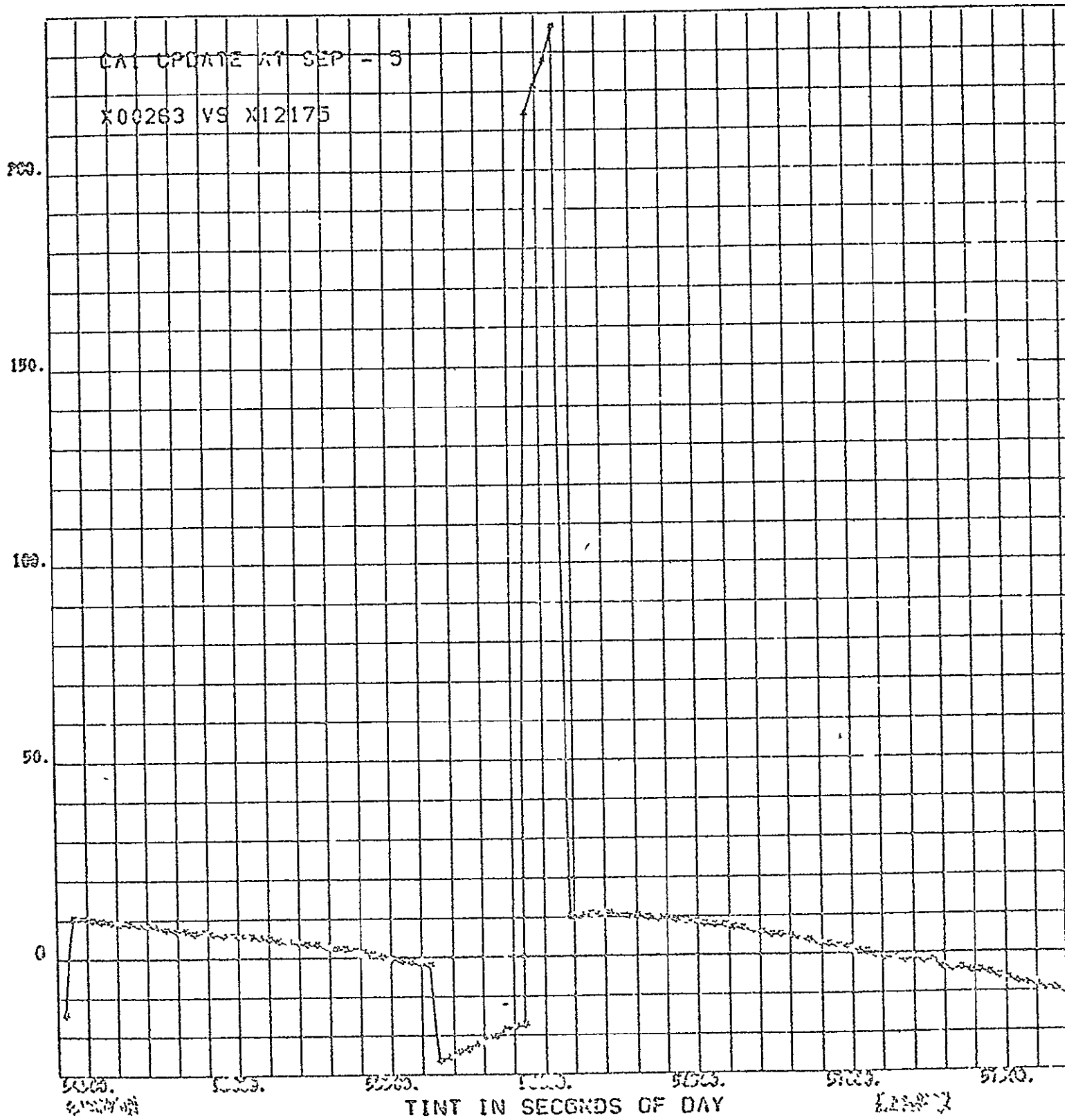


ERROR IN Y POSITION UPDATE
CA UPDATE AT SEP - 5
K00203 VS X12175
* RDIF-Y- ...FT
0
TINY IN SECONDS OF DAY

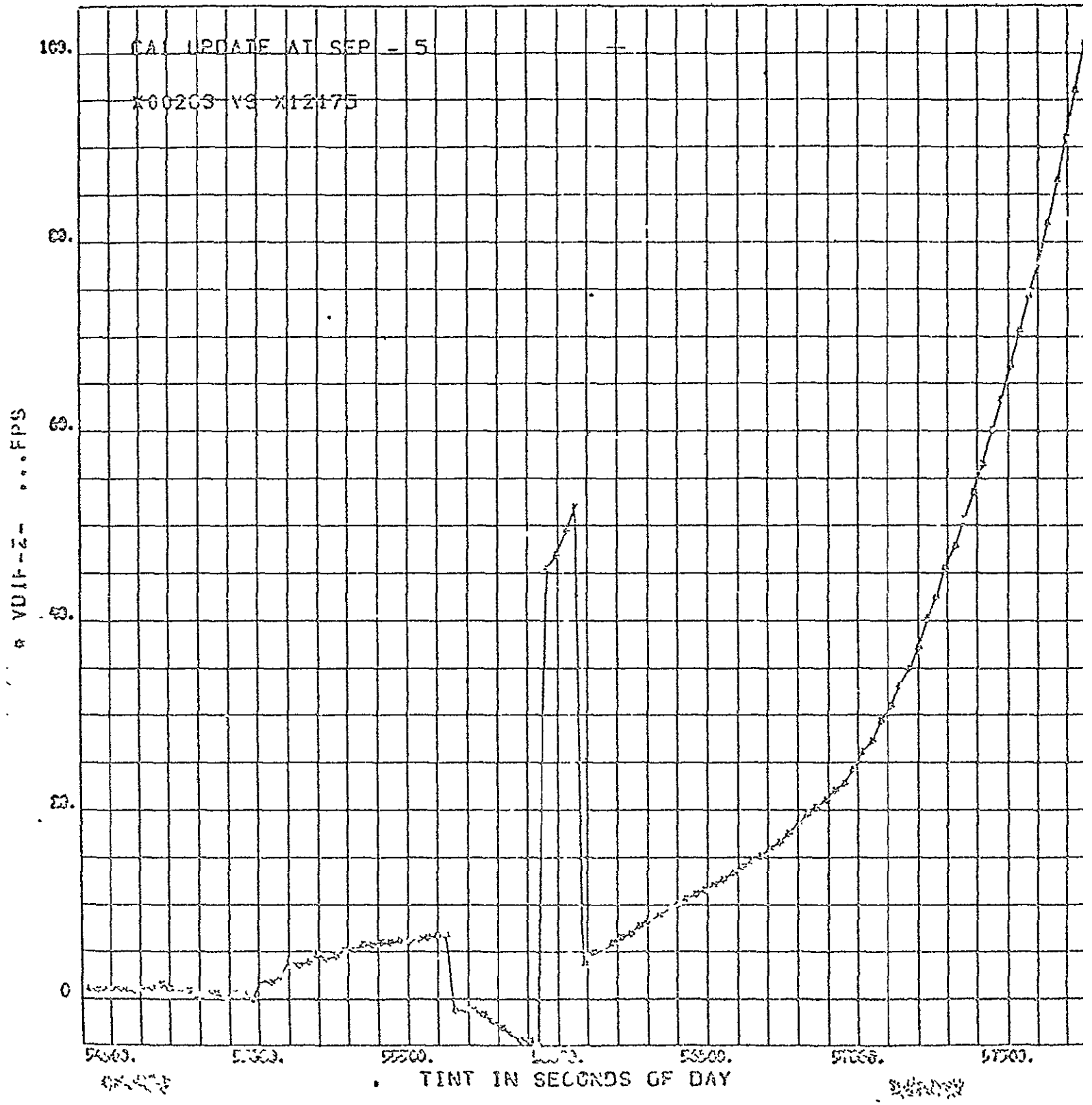
ERROR IN Z POSITION UPDATE
CAL UPDATE AT SEP - 5
X002C3 VS X12175
15000.
10000.
5000.
0
- 5000.
* RDIF-Z- ...FT
TINT IN SECONDS OF DAY


ERROR IN X VELOCITY UPDATE
CAL UPDATE AT SEP -- 5
X00263 VS XI2175
160.
50.
0
-50.
-100.
YDIF-X- ...FPS
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

ERROR IN Y VELOCITY UPDATE.

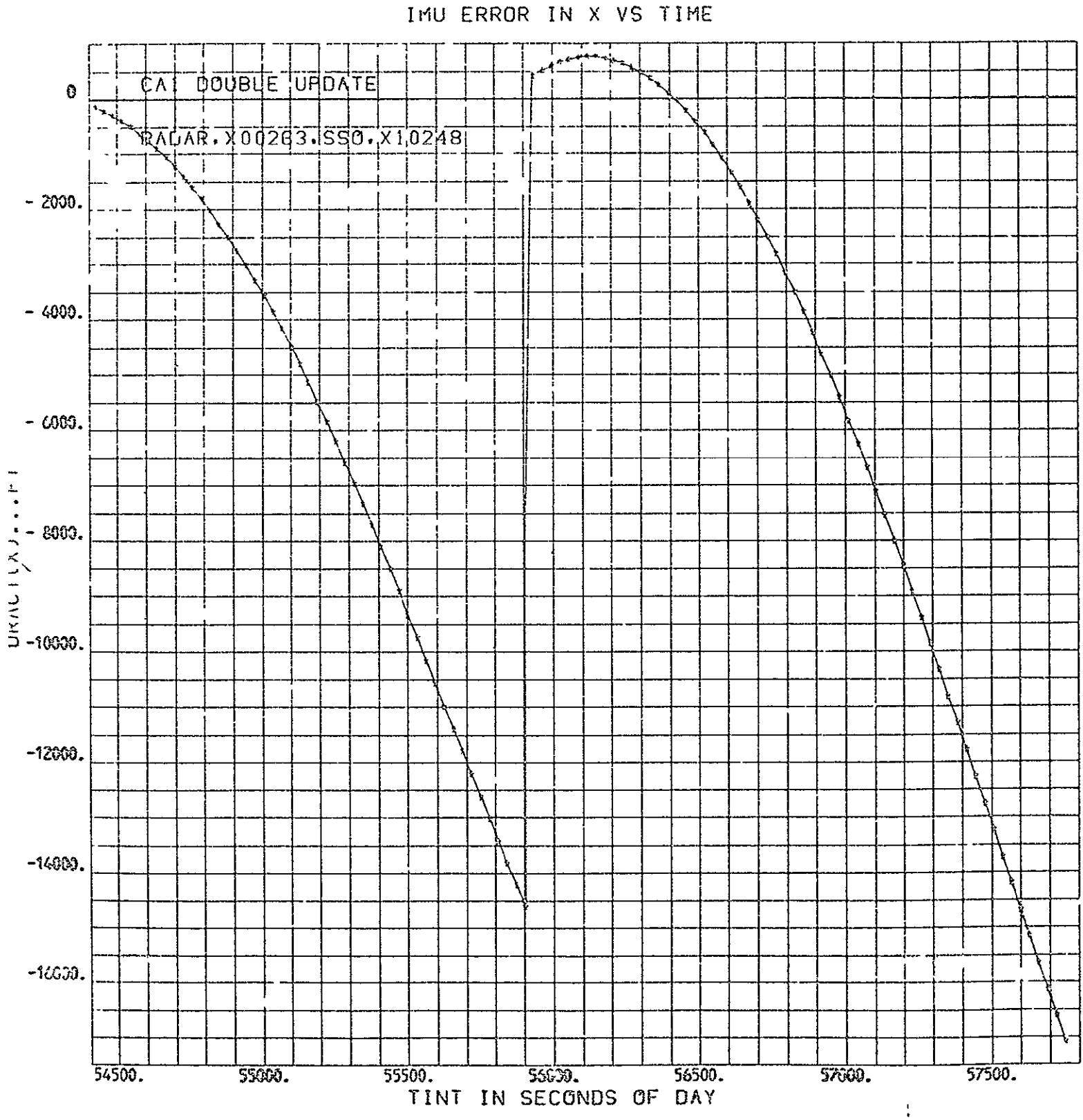


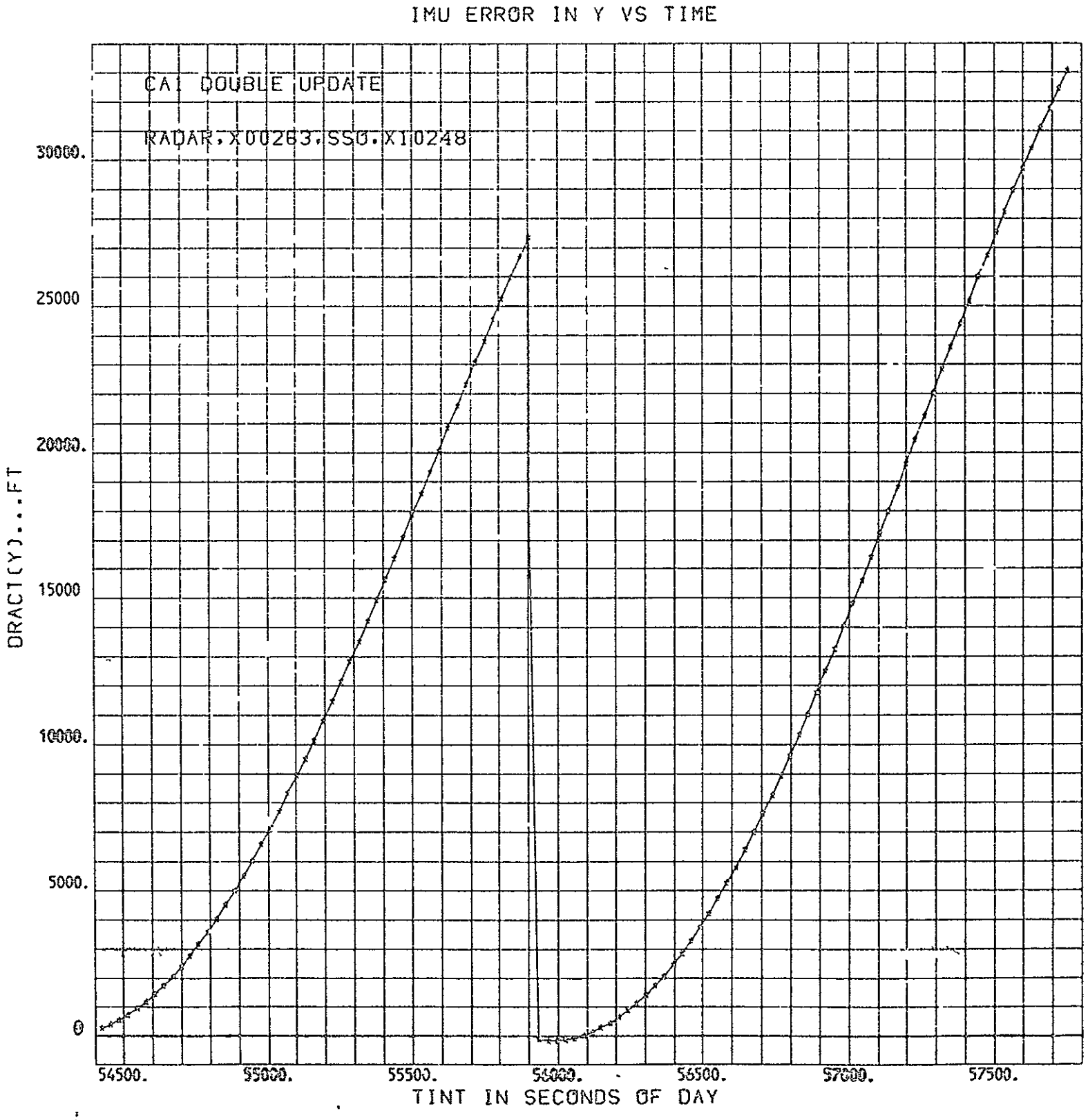
ERROR IN Z VELOCITY UPDATE

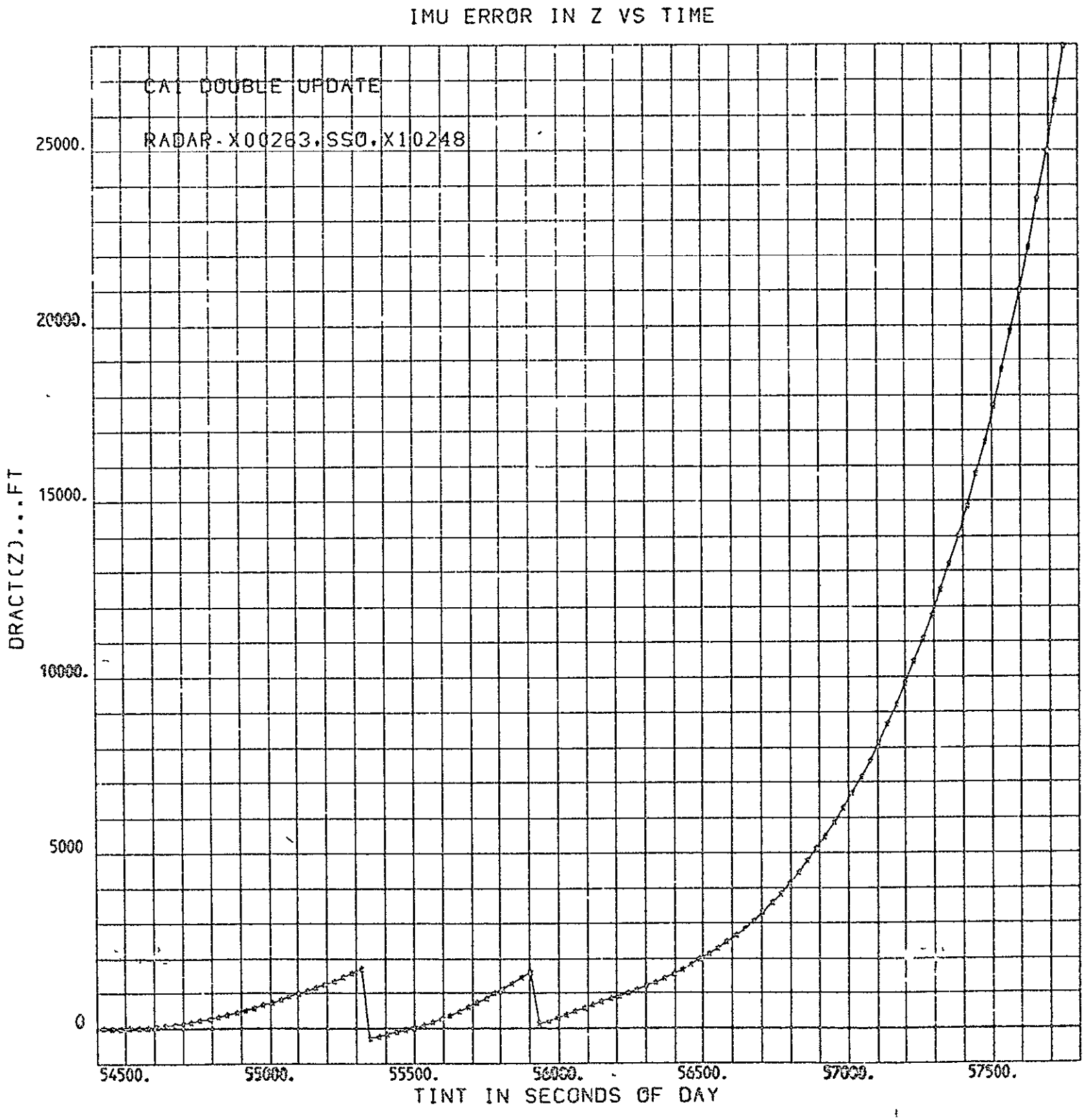


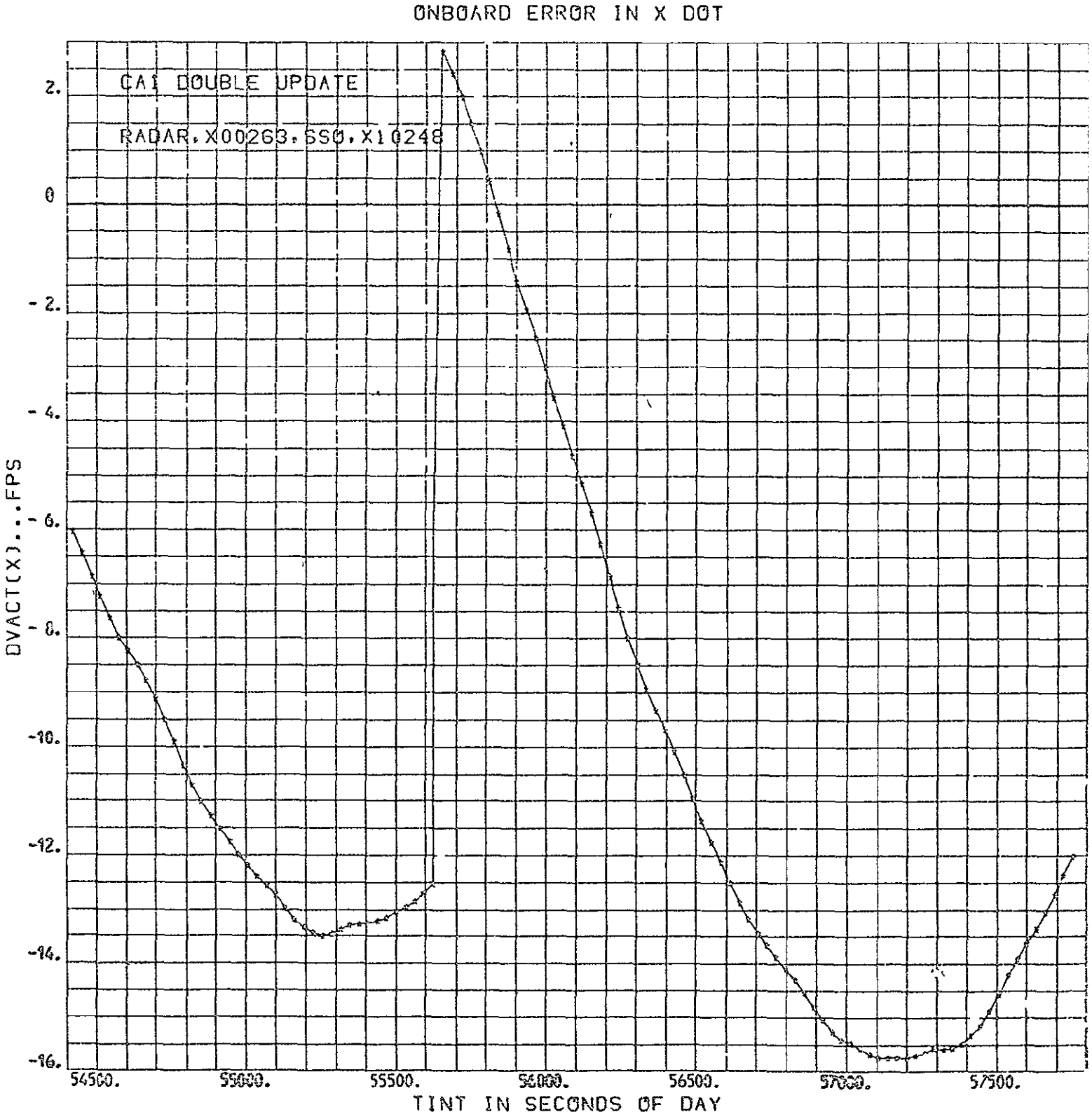
APPENDIX 4

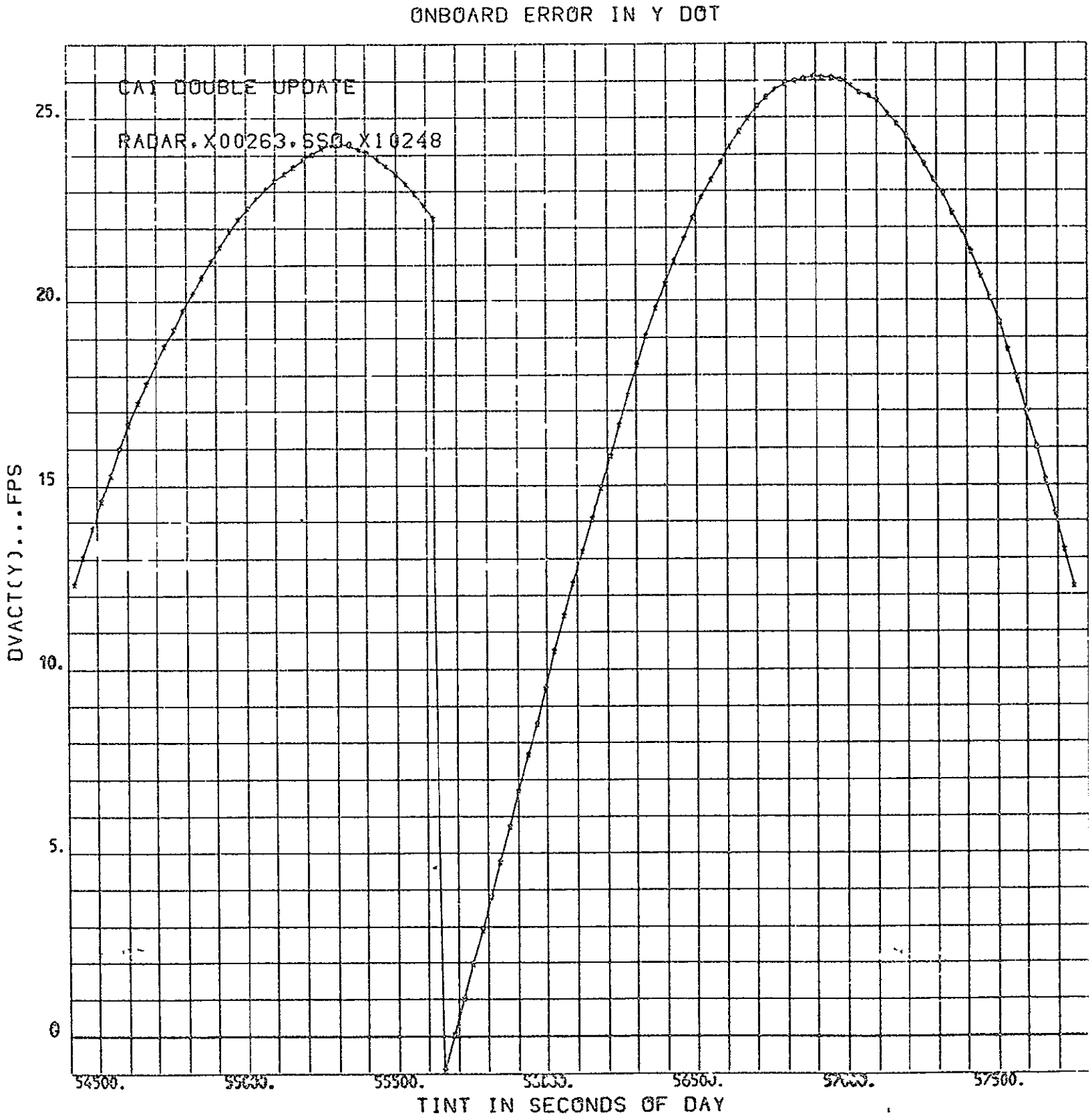
The following plots represent the case in which the state vectors were updated at the first practice separation minus 15 minutes in the vertical components only, and at first separation minus 5 minutes in all components. Errors in the onboard state and errors in the computed update are plotted as a function of time.

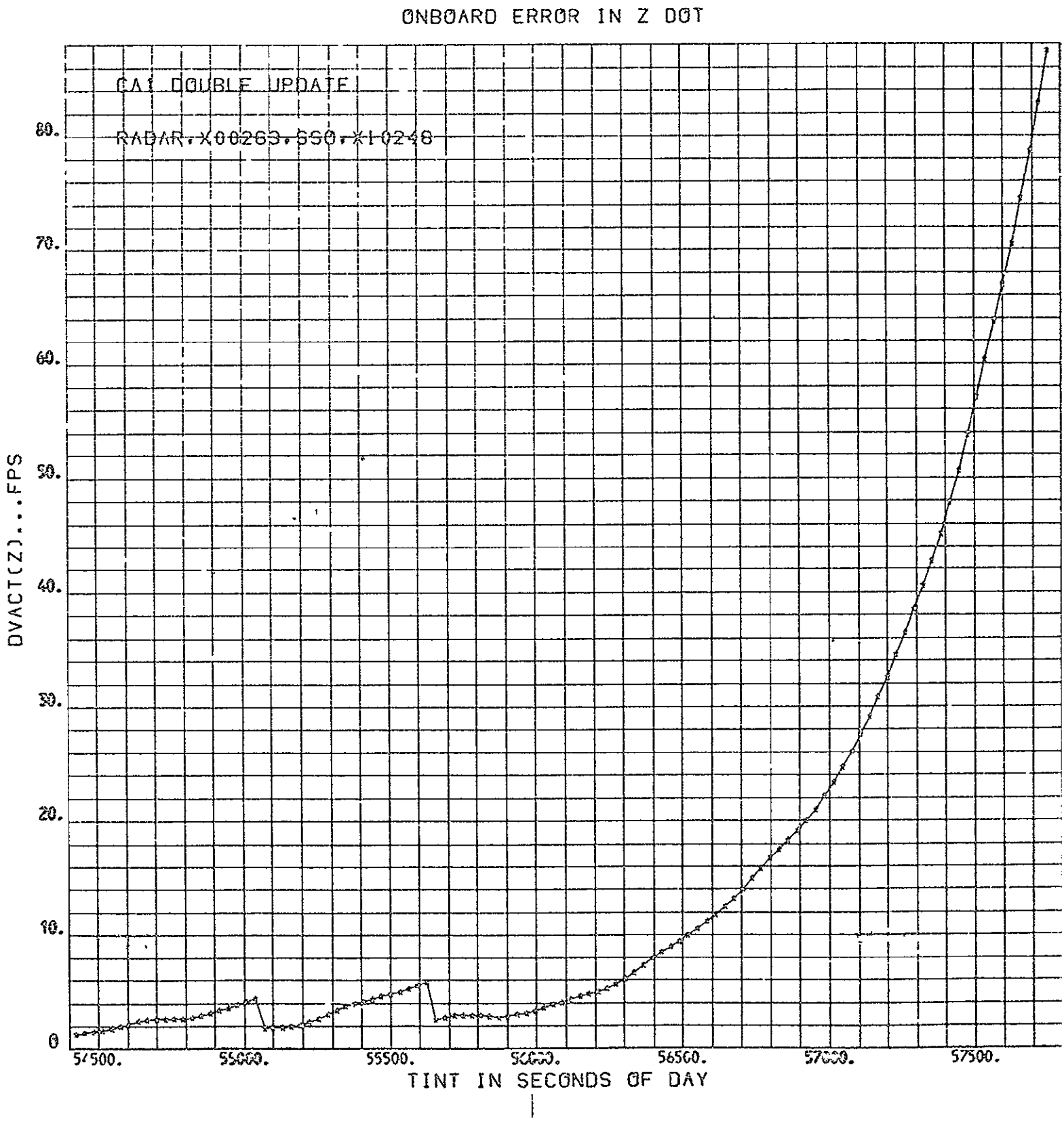

IMU ERROR IN X VS TIME
CAT DOUBLE UPDATE
RADAR.X00263.SS0.X1.0248
0
- 2000.
- 4000.
- 6000.
- 8000.
-10000.
-12000.
-14000.
-16000.
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

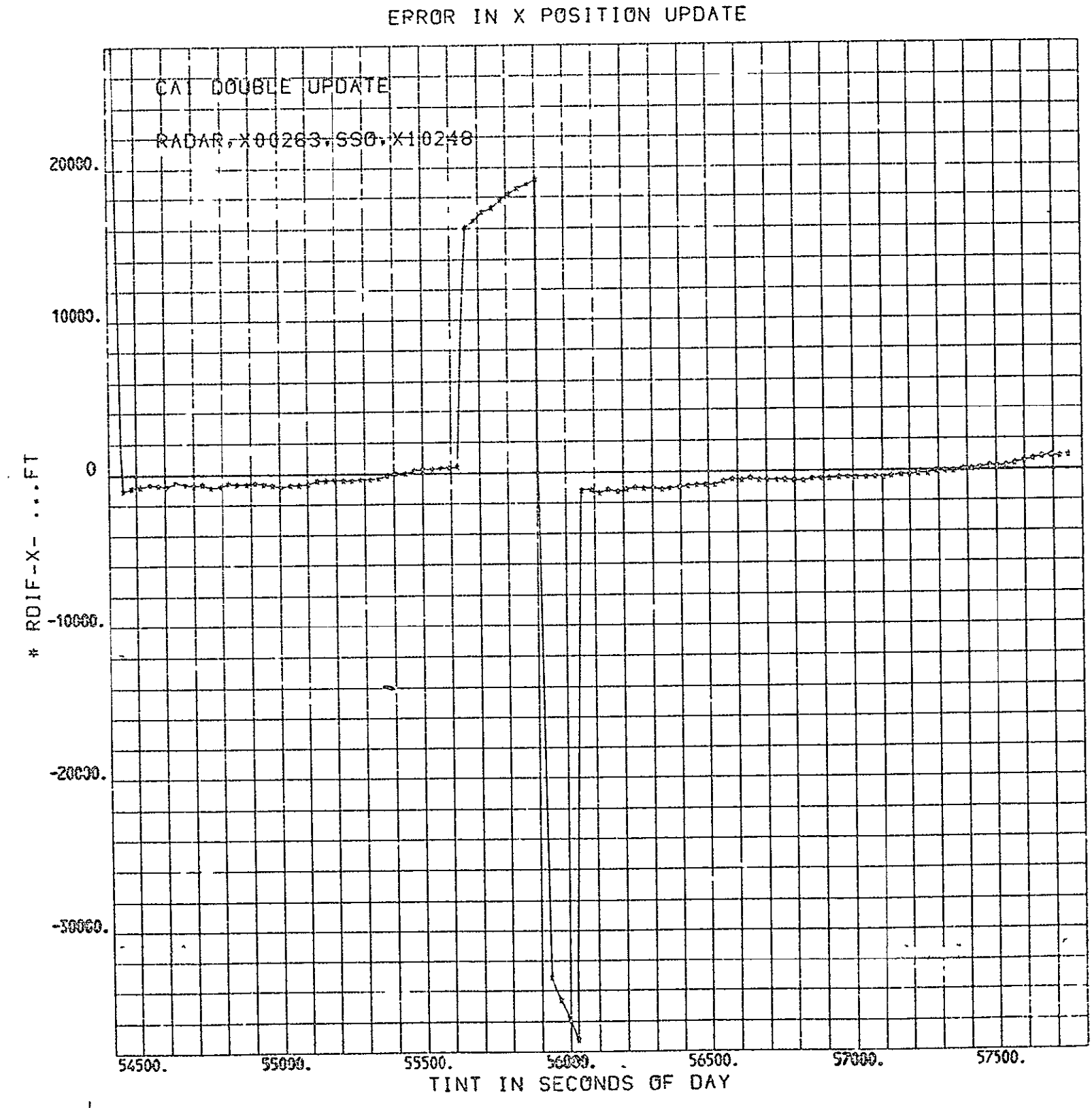

IMU ERROR IN Y VS TIME
CA1 DOUBLE UPDATE
RADAR,X00263,SS0,XI0248
30000.
25000
20000.
15000
10000.
5000.
0
DRACT(Y)...FT
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

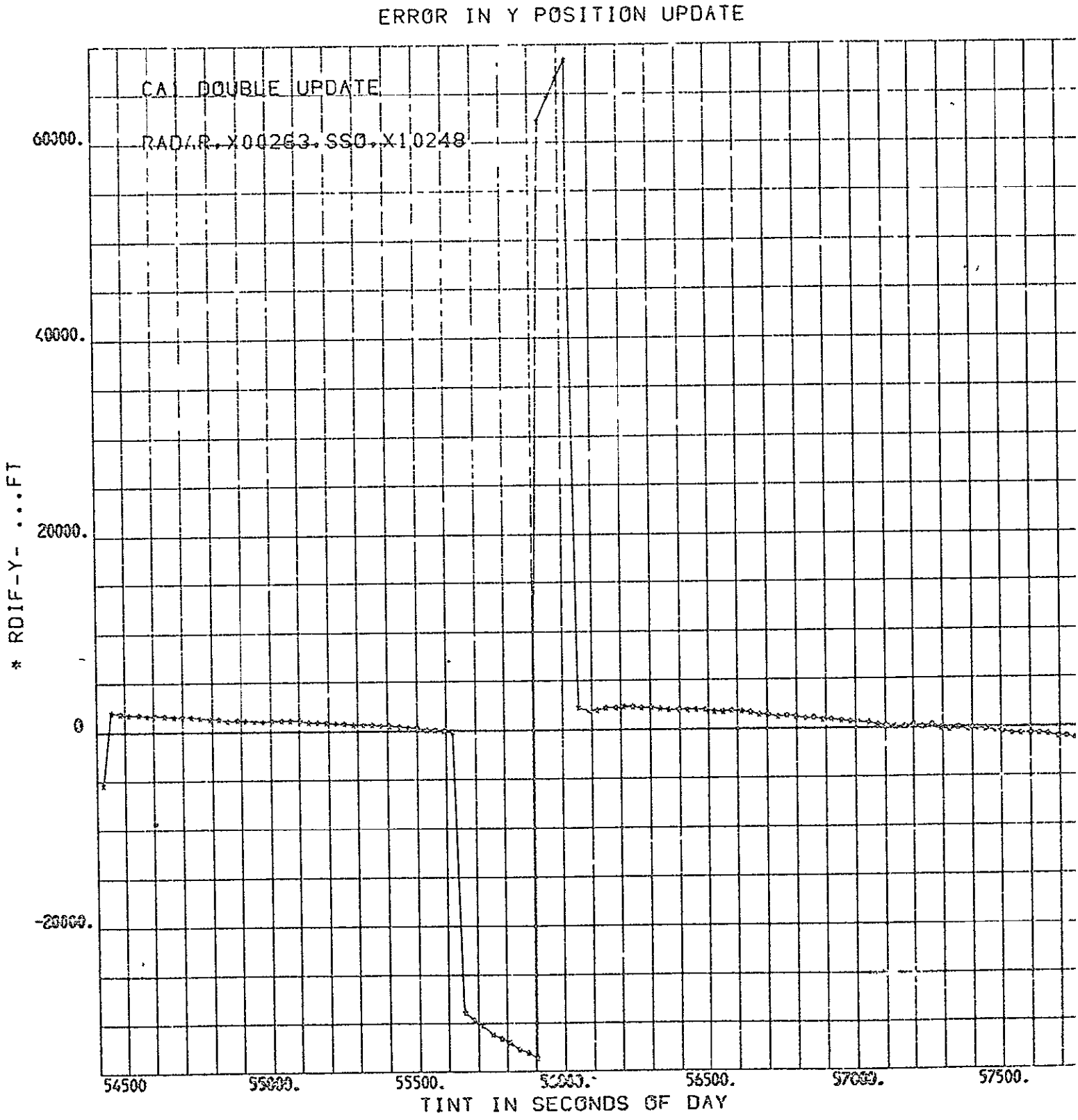

IMU ERROR IN Z VS TIME
CAT DOUBLE UPDATE
RADAR-X00263,SS0,X10248
25000.
20000.
15000.
10000.
5000
0
DRACT(Z)...FT
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

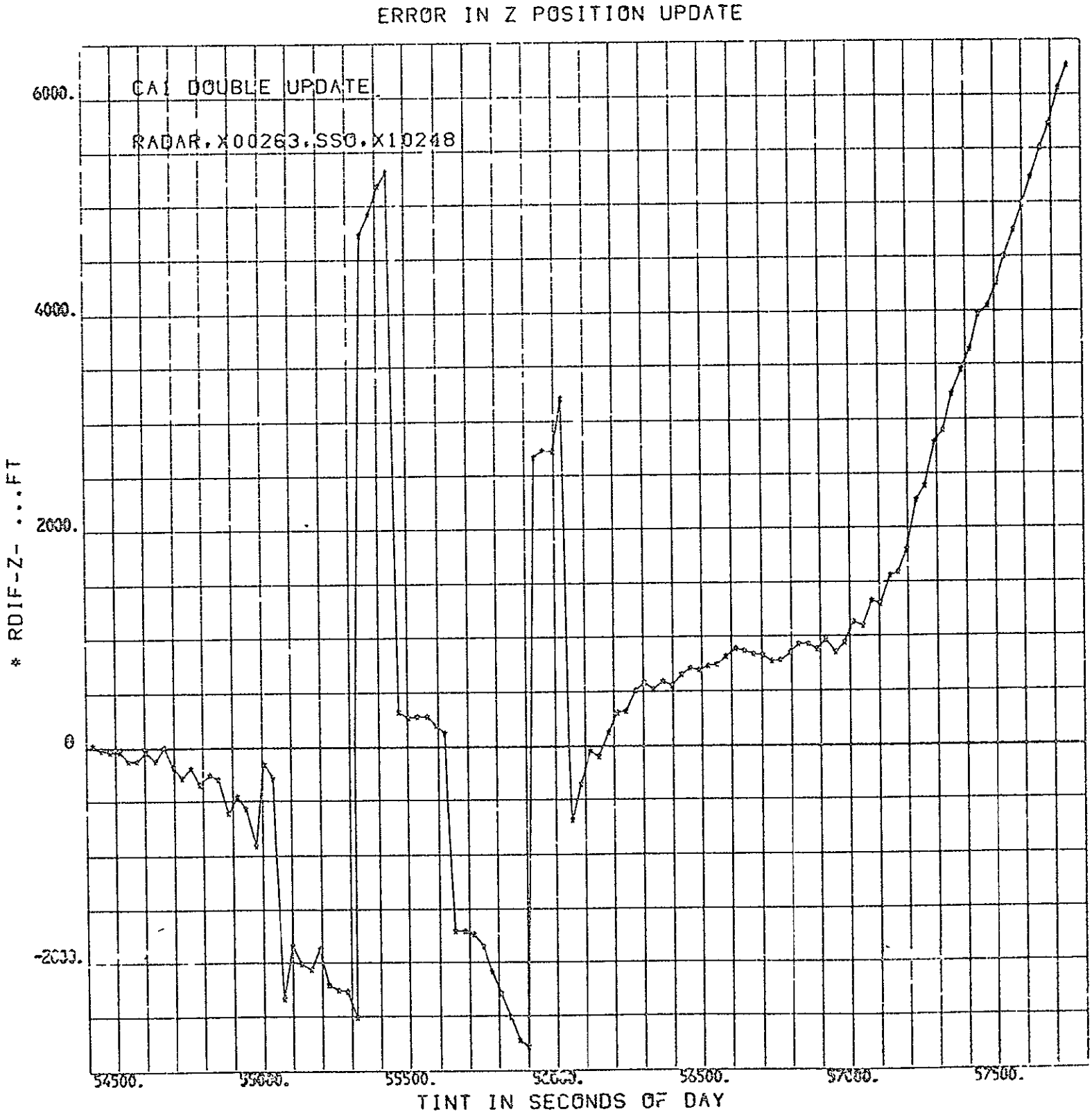

ONBOARD ERROR IN X DOT
CAI DOUBLE UPDATE
RADAR.X00263.SS0.X10248
2.
0
-2.
-4.
-6.
-8.
-10.
-12.
-14.
-16.
DVACT(X)...FPS
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

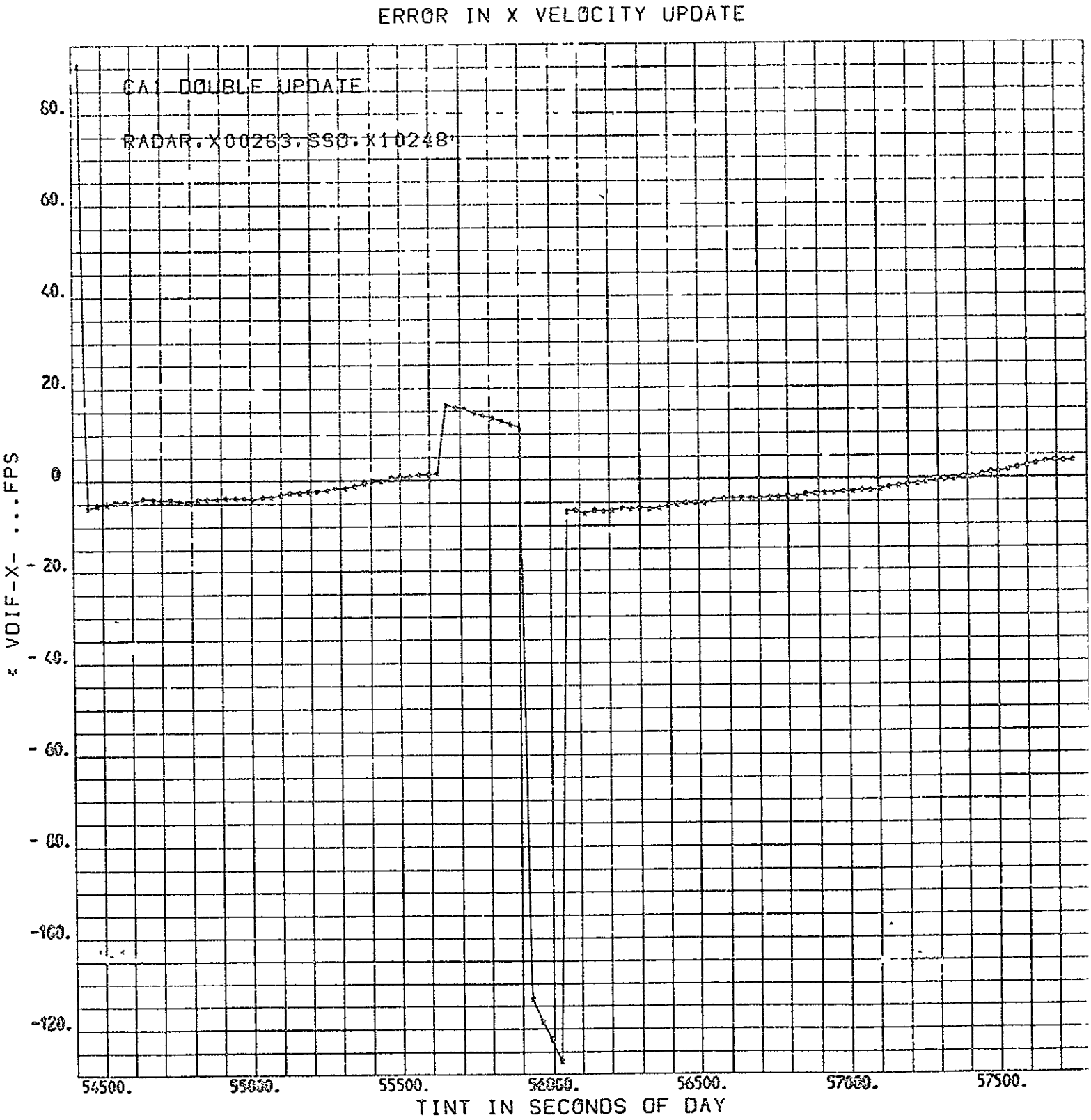

ONBOARD ERROR IN Y DOT
CAI DOUBLE UPDATE
RADAR.X00263.SSO.X10248
25.
20.
15
10.
5.
0
DVACT(Y)...FPS
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

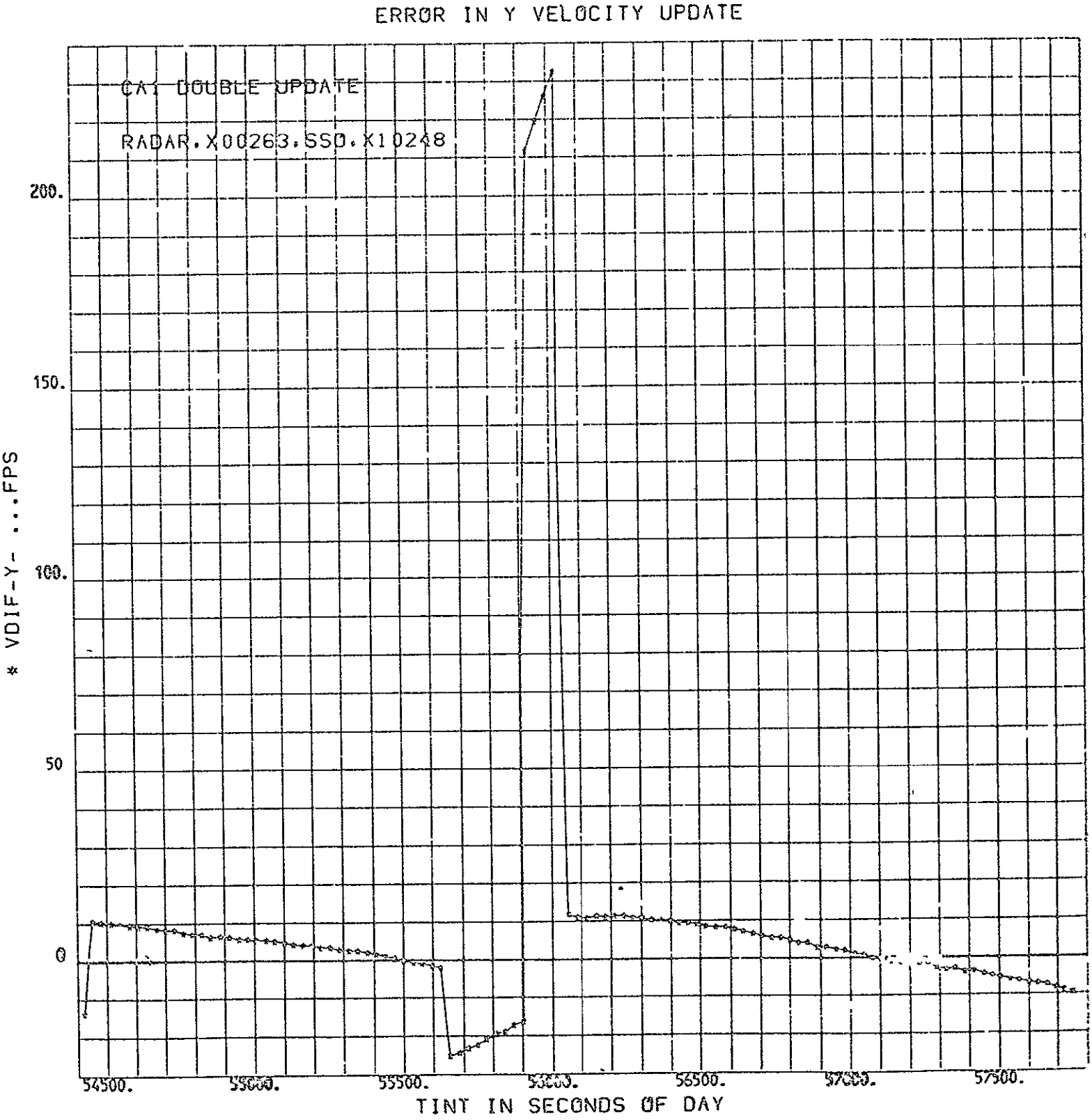

ONBOARD ERROR IN Z DOT
CAI DOUBLE UPDATE
RADAR,X00263,SS0,*I0248
80.
70.
60.
50.
40.
30.
20.
10.
0
DVACT(Z)...FPS
55000.
55500.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

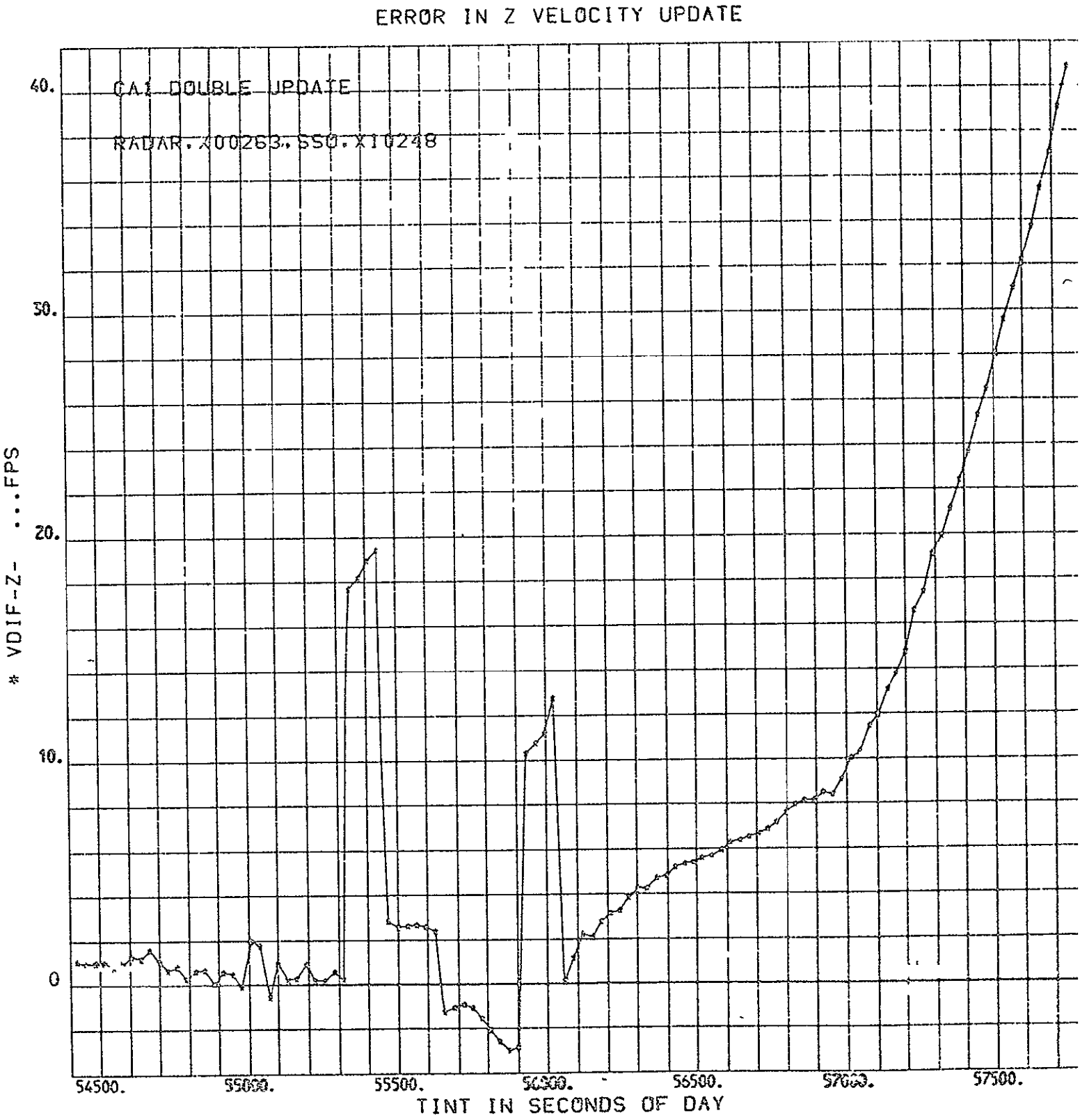

ERROR IN X POSITION UPDATE
CAT DOUBLE UPDATE
RADAR,X00263,SS0,X10248
20000.
10000.
0
-10000.
-20000.
-30000.
* RDIF-X- ...FT
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY


ERROR IN Y POSITION UPDATE
CA1 DOUBLE UPDATE
RADAR,X00263,SS0,X10248
60000.
40000.
20000.
0
-20000.
* RDIF-Y- ...FT
54500
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY


ERROR IN Z POSITION UPDATE
CAI DOUBLE UPDATE
RADAR,X00263,SSO,X10248
6000.
4000.
2000.
0
-2000.
* RDIF-Z- ...FT
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

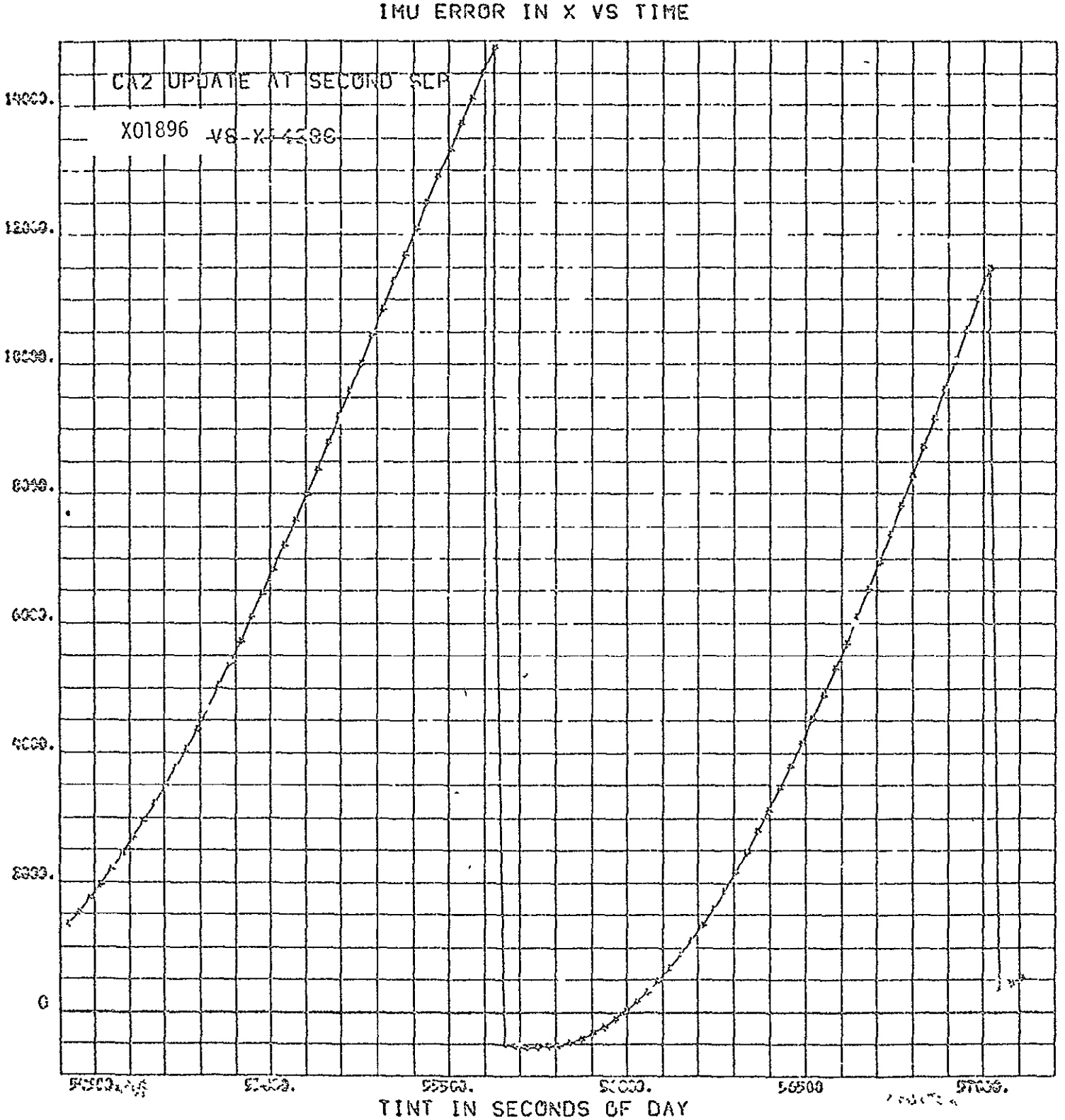

ERROR IN X VELOCITY UPDATE
CA1 DOUBLE UPDATE
RADAR,X00263,SSD,X10248
60.
40.
20.
0
- 20.
- 40.
- 60.
- 80.
-100.
-120.
* VDIF-X- ...FPS
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

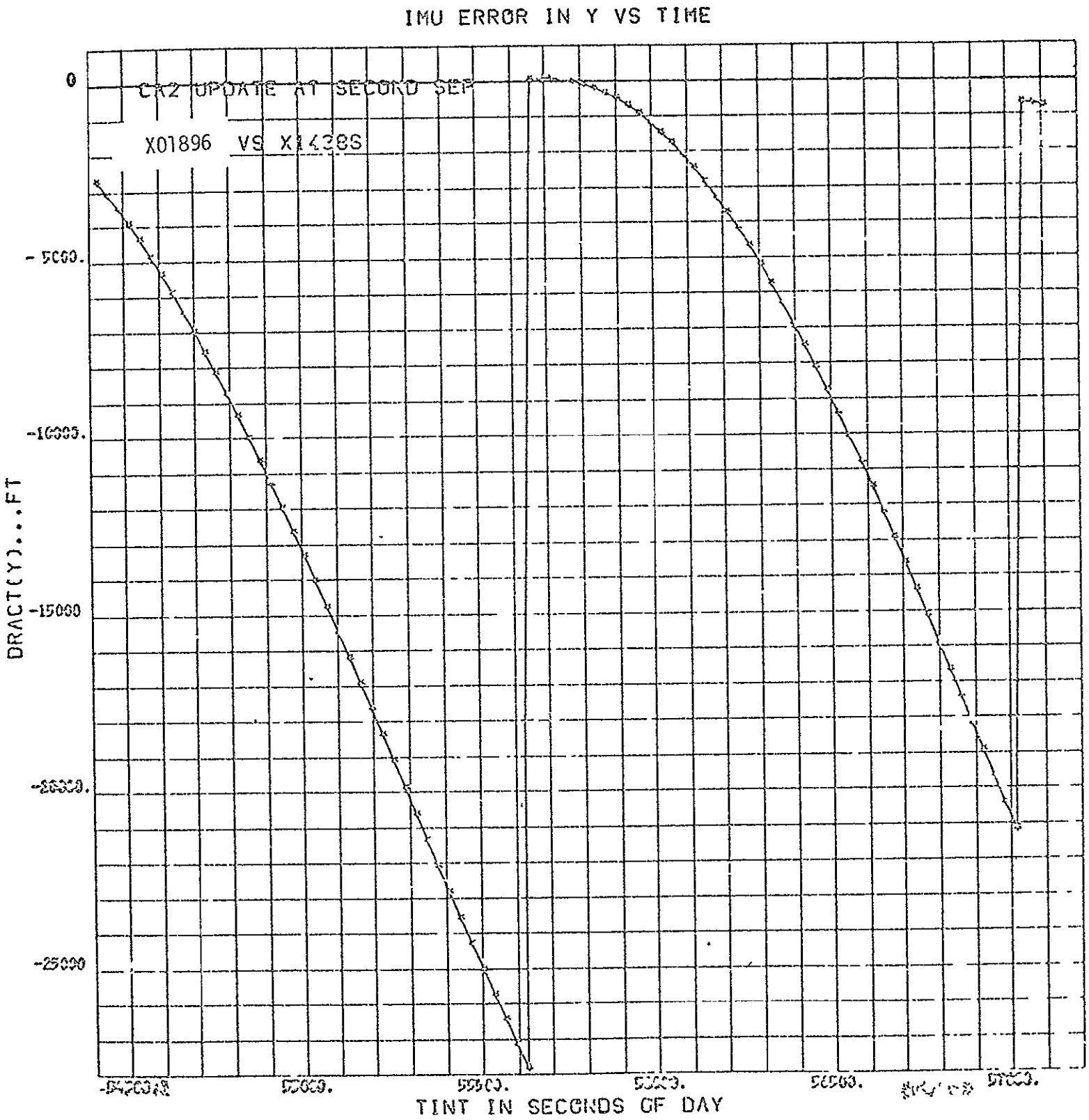

ERROR IN Y VELOCITY UPDATE
CAI DOUBLE UPDATE
RADAR.X00263.SSD.X10248
200.
150.
100.
50
0
* VDIF-Y- ...FPS
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

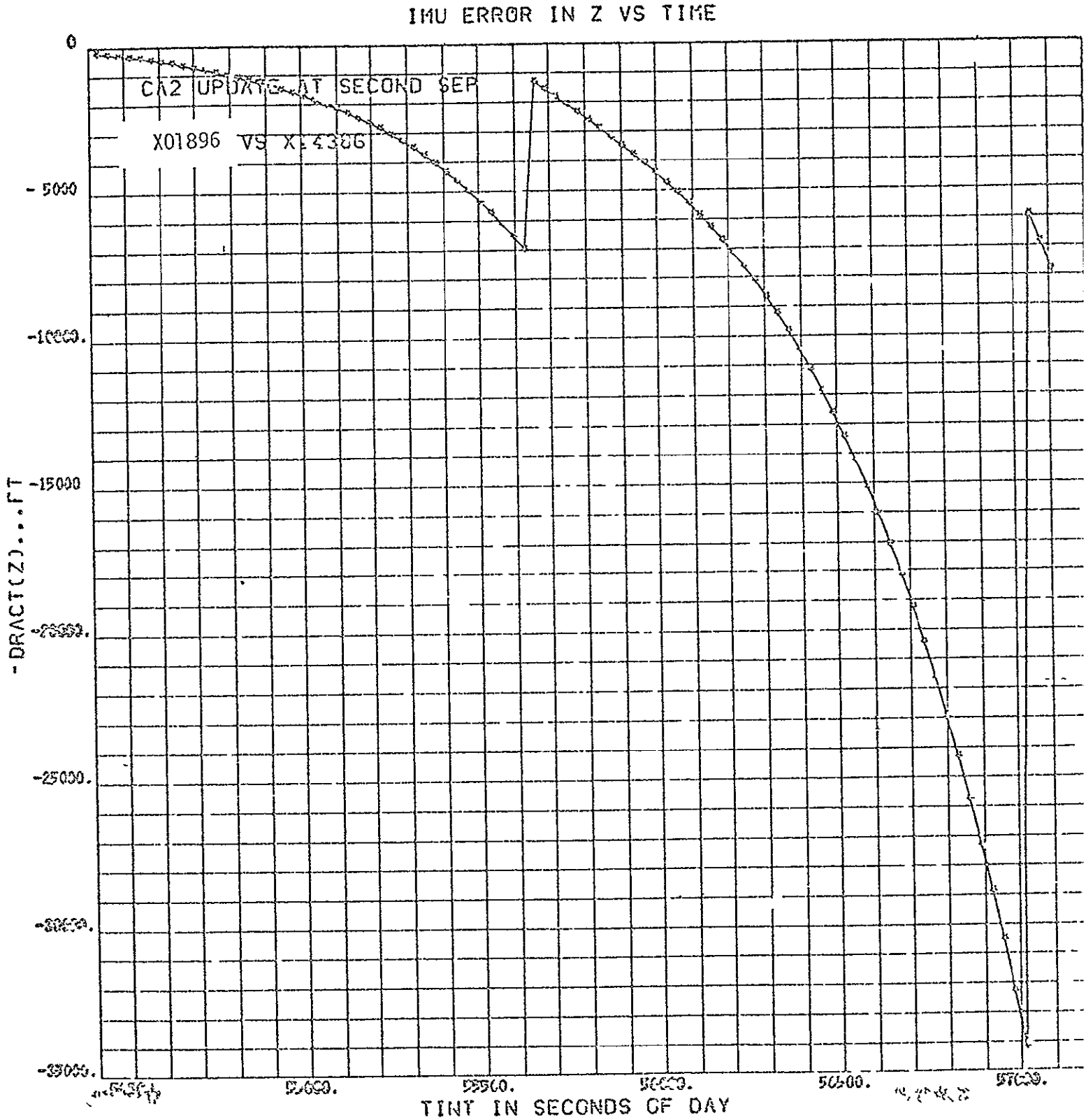

ERROR IN Z VELOCITY UPDATE
CAI DOUBLE UPDATE
RADAR.X00263.SS0.X10248
40.
30.
20.
10.
0
* VDIF-Z- ...FPS
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

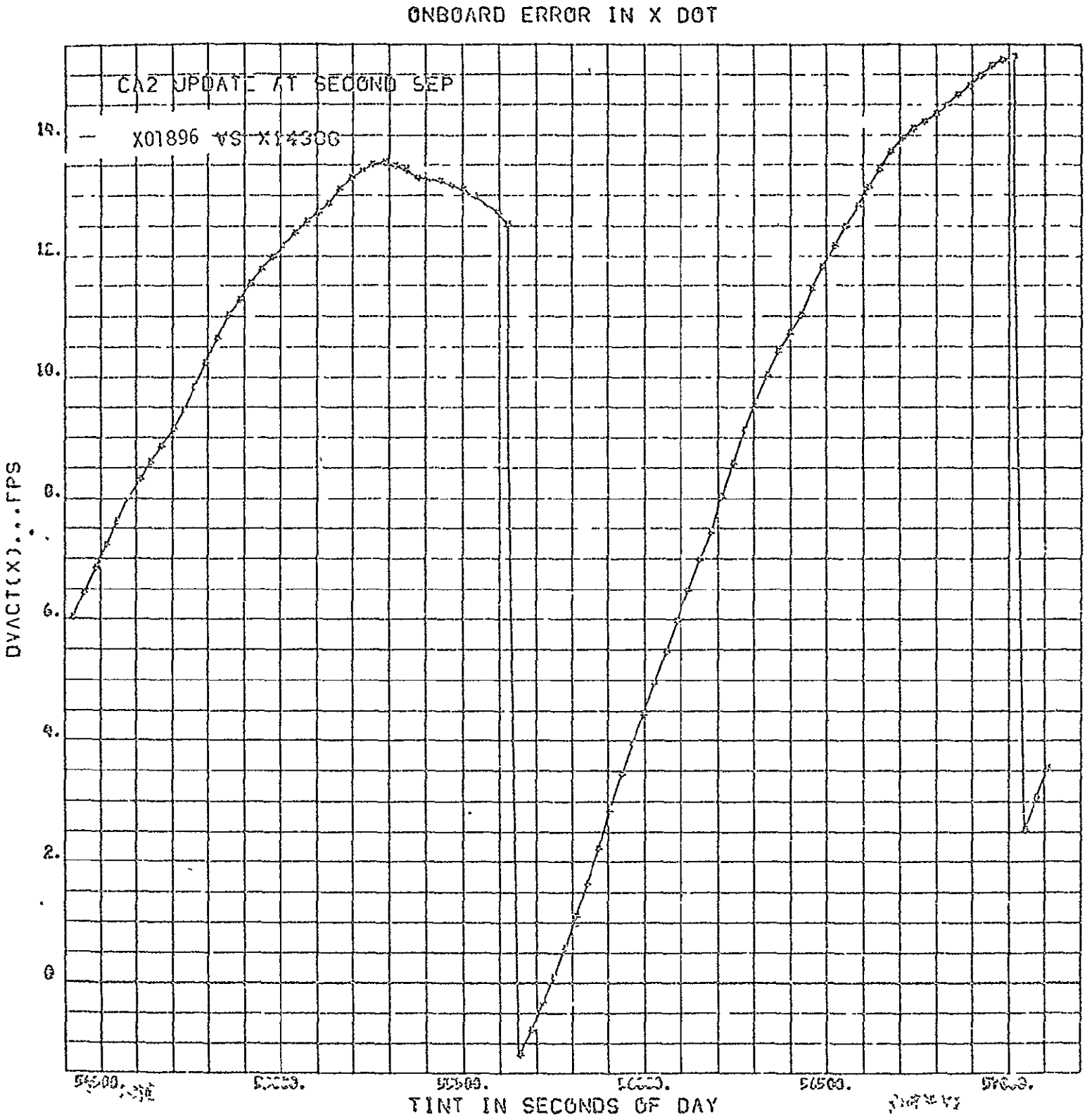
APPENDIX 5

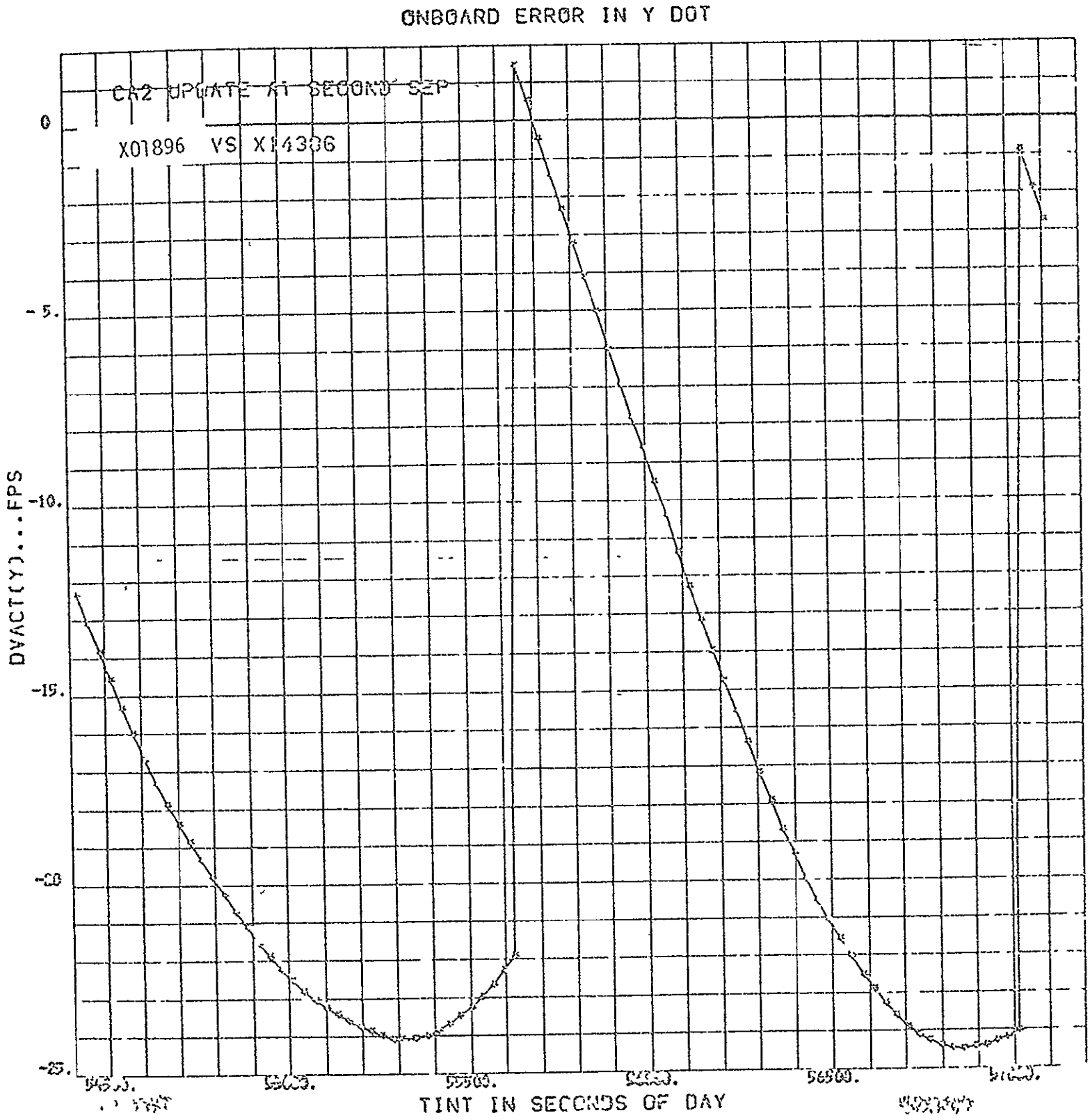
The following plots represent the case in which the state vectors were updated at first practice separation minus five minutes in all components and at second practice separation minus two minutes in all components. The trajectory is described as Captive Active 2, Revision 2. Errors in the onboard state and errors in the computed update are plotted as a function of time.

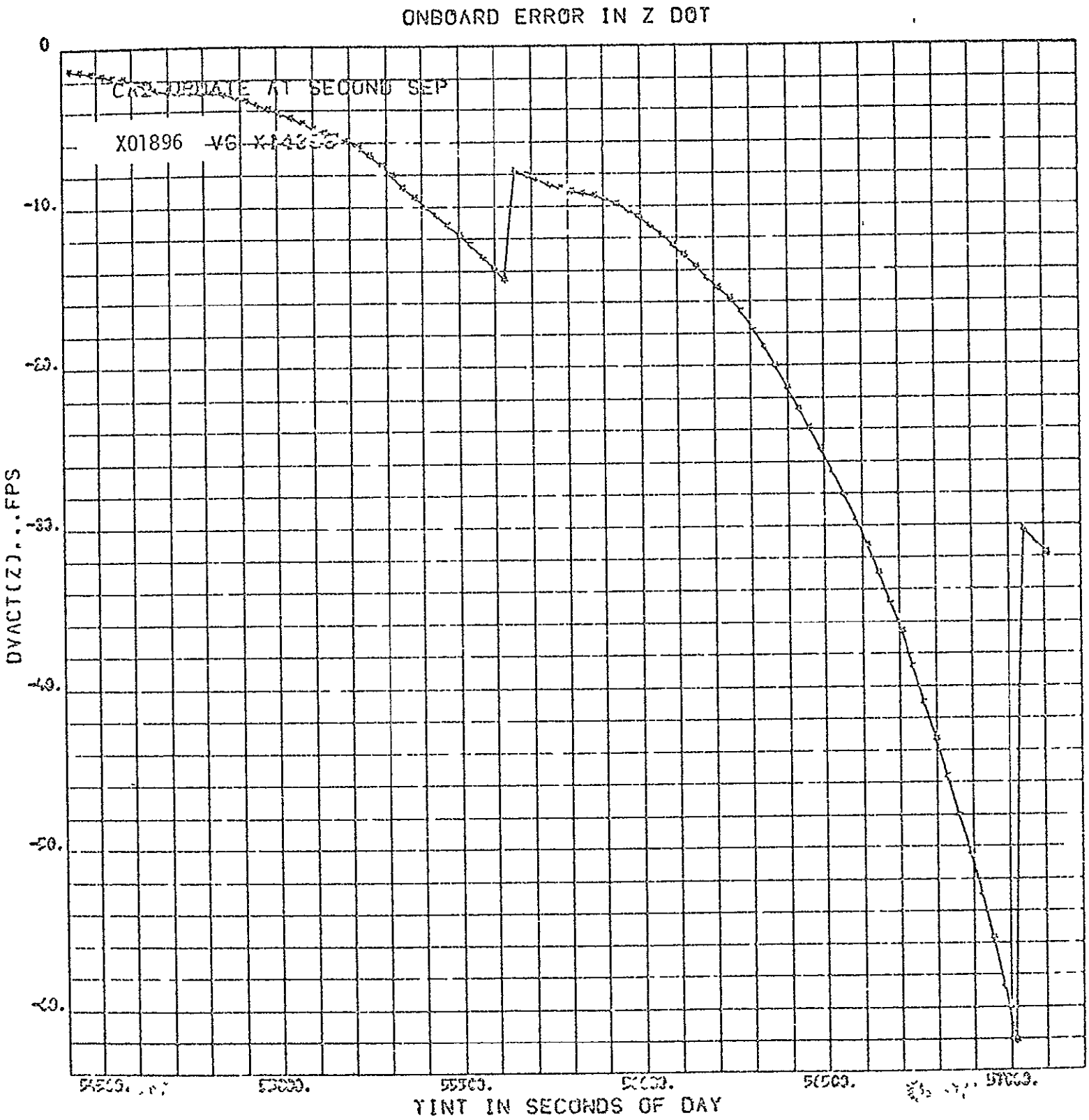

IMU ERROR IN X VS TIME
CA2 UPDATE AT SECOND SCP
X01896 VS X
14000.
12000.
10000.
8000.
6000.
4000.
2000.
0
55500.
56000.
56500
TINT IN SECONDS OF DAY

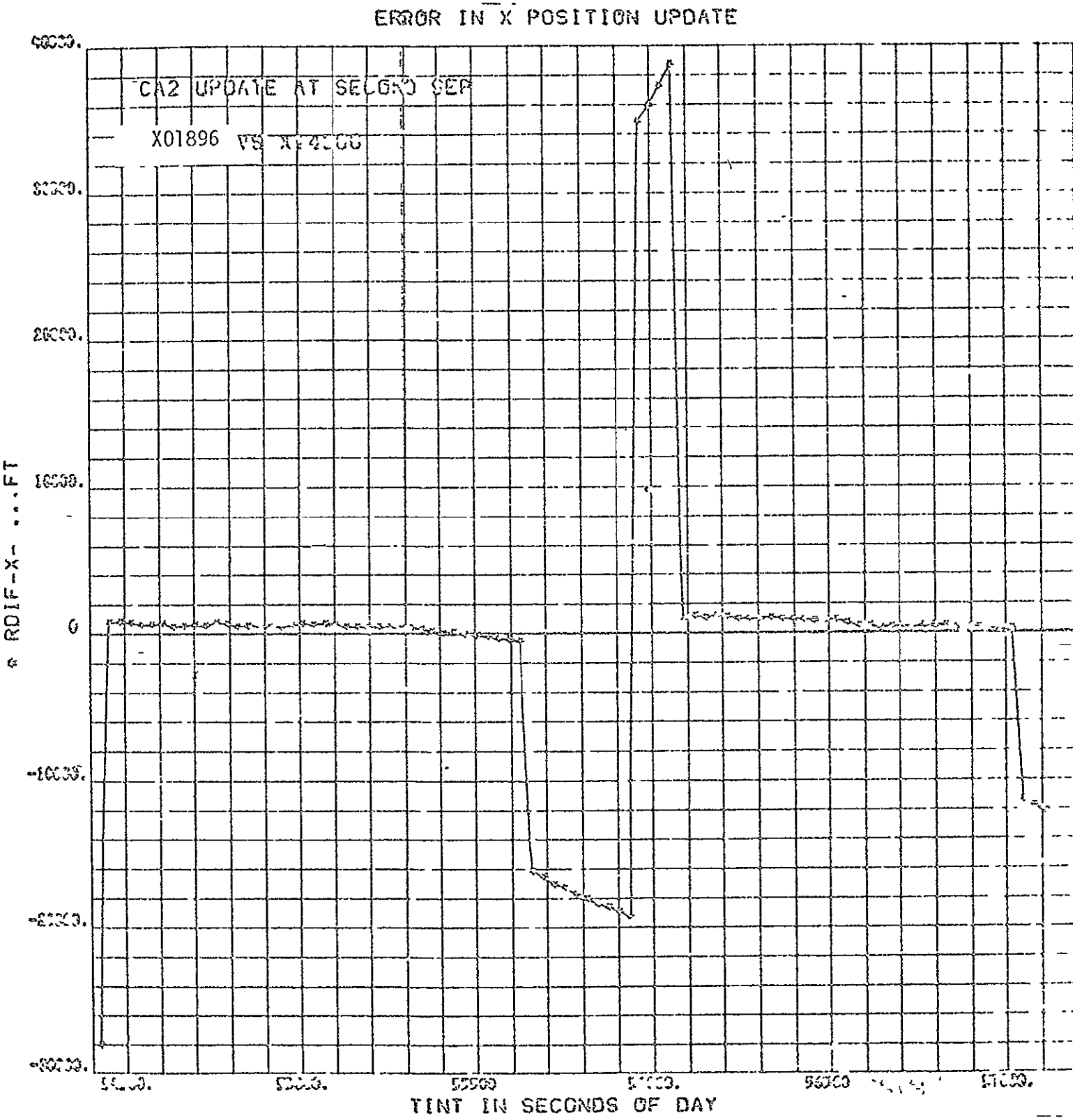

IMU ERROR IN Y VS TIME
CR2 UPDATE AT SECOND SEP
X01896 VS X14388
0
-5000.
-10000.
-15000
-20000.
-25000
DRACT(Y)...FT
55000.
55500.
56000.
TINT IN SECONDS OF DAY

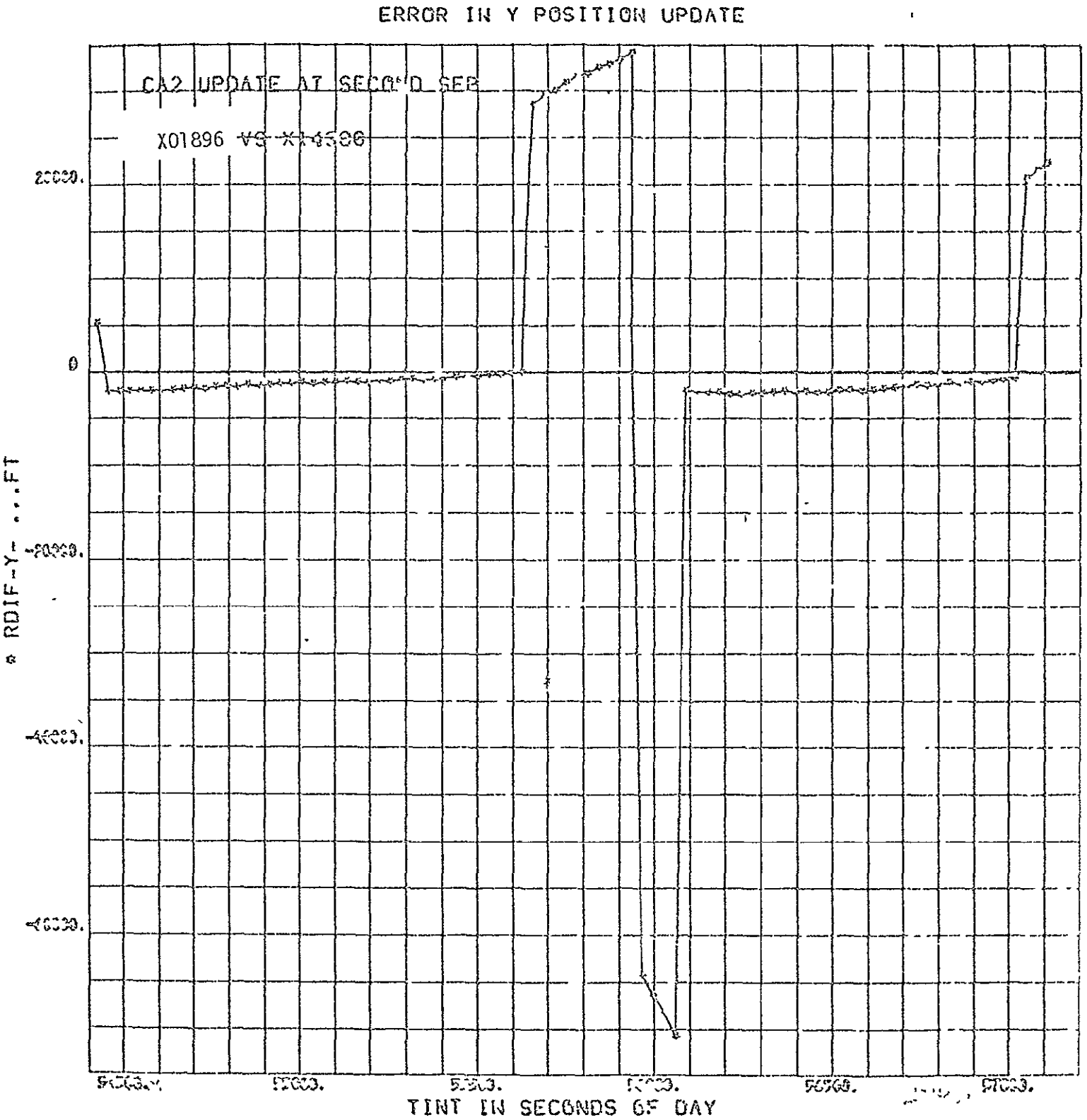

IMU ERROR IN Z VS TIME
CA2 UPDATE AT SECOND SEP
X01896 VS X
0
- 5000
-10000.
-15000
-25000.
-DRACT(Z)...FT
TINT IN SECONDS OF DAY

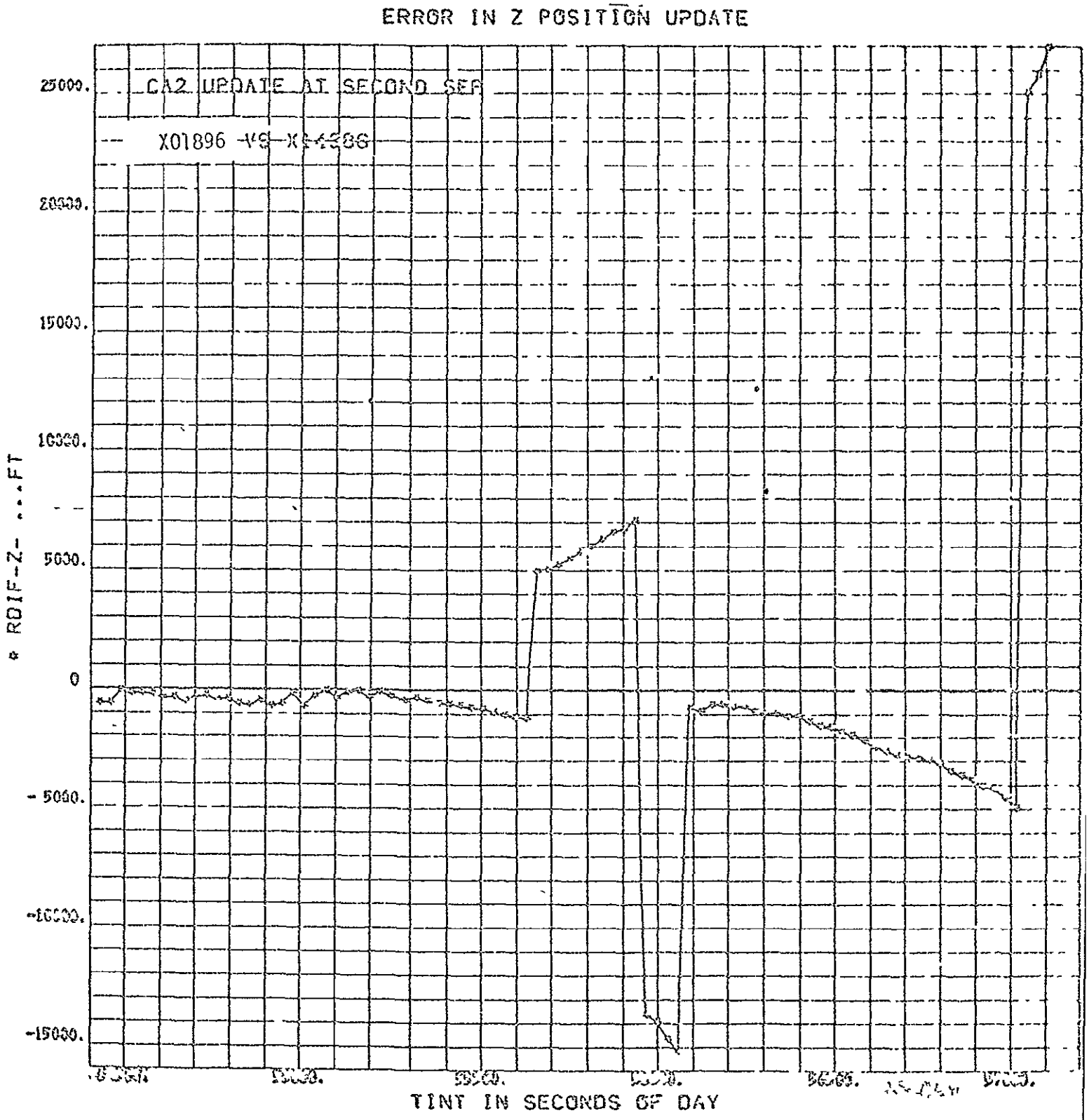

ONBOARD ERROR IN X DOT
CA2 UPDATE AT SECOND SEP
X01896 VS X1*300
14.
12.
10.
8.
6.
4.
2.
0
DVACT(X)...FPS
TINT IN SECONDS OF DAY


ONBOARD ERROR IN Y DOT
CR2 UPDATE AT SECOND SEP
X01896 VS X14306
0
-5.
-10.
-15.
-20
-25.
DVACT(Y)...FPS
55500.
56000.
TINT IN SECONDS OF DAY

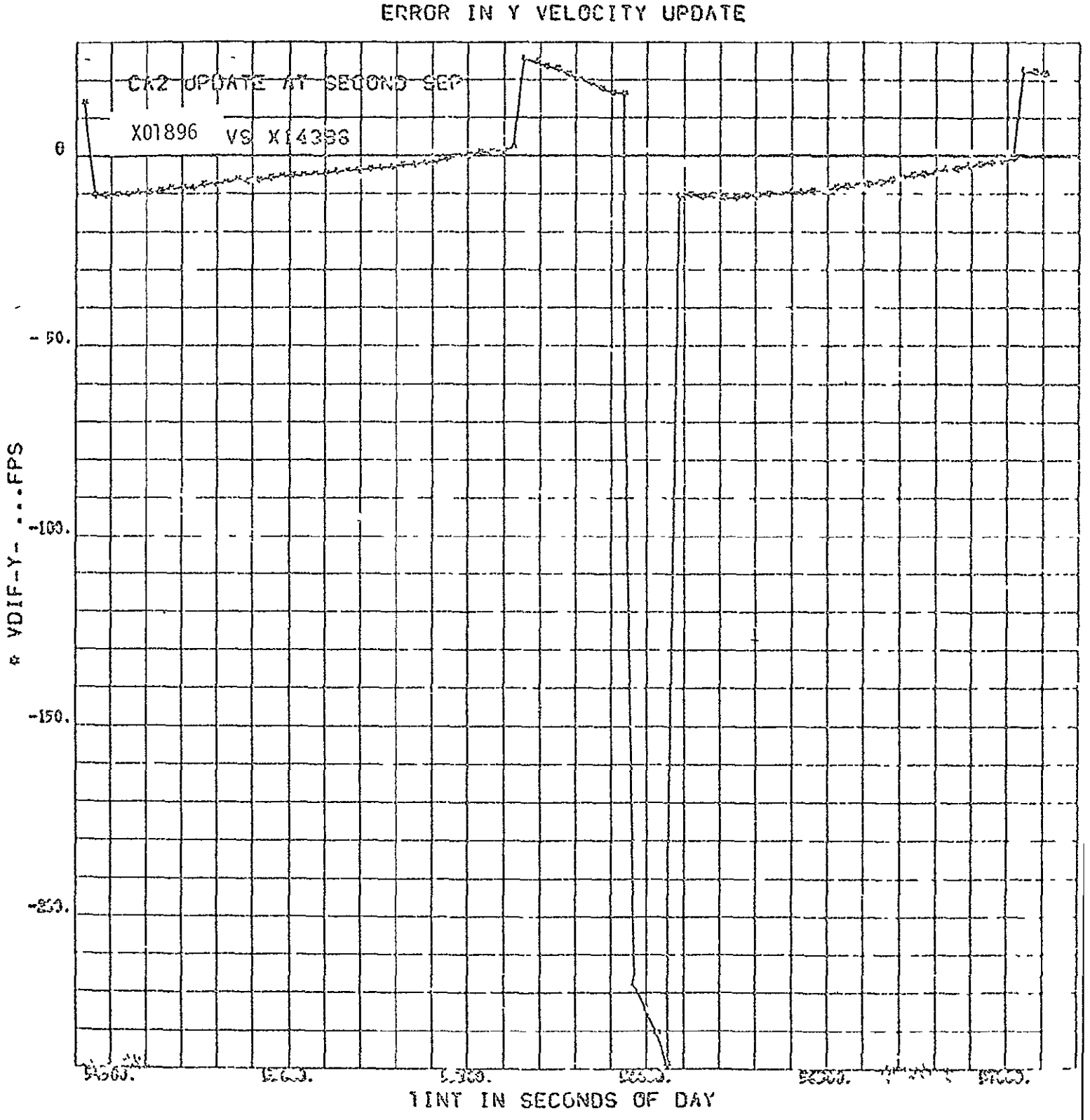

ONBOARD ERROR IN Z DOT
CR-ORBIATE AT SECOND SEP
X01896 V6
0
-10.
-20.
-30.
-40.
-50.
-60.
DVACT(Z)...FPS
5500.
5000.
5500.
5000.
5500.
5700.
TINT IN SECONDS OF DAY

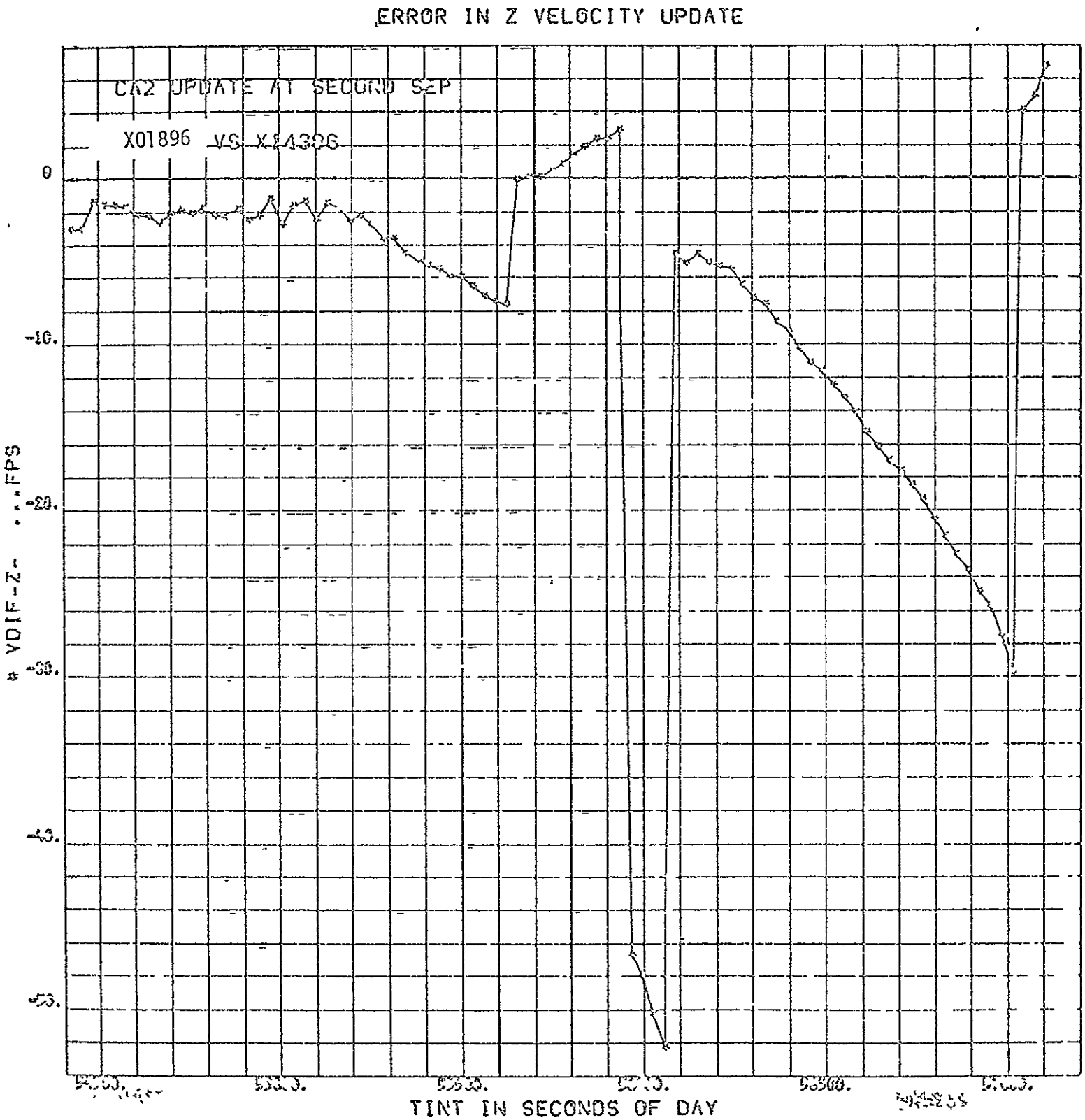

ERROR IN X POSITION UPDATE
CA2 UPDATE AT SECOND SEP
X01896 VS X=4200
* RDIF-X- ...FT
0
TINT IN SECONDS OF DAY


ERROR IN Y POSITION UPDATE
CA2 UPDATE AT SECOND SEB
X01896 VS X-4596
20000.
0
-20000.
-40000.
-60000.
* RDIF-Y- ...FT
TINT IN SECONDS OF DAY


ERROR IN Z POSITION UPDATE
CA2 UPDATE AT SECOND SEP
X01896
25000.
20000.
15000.
10000.
5000.
0
-5000.
-10000.
-15000.
* RDIF-Z- ...FT
TINT IN SECONDS OF DAY

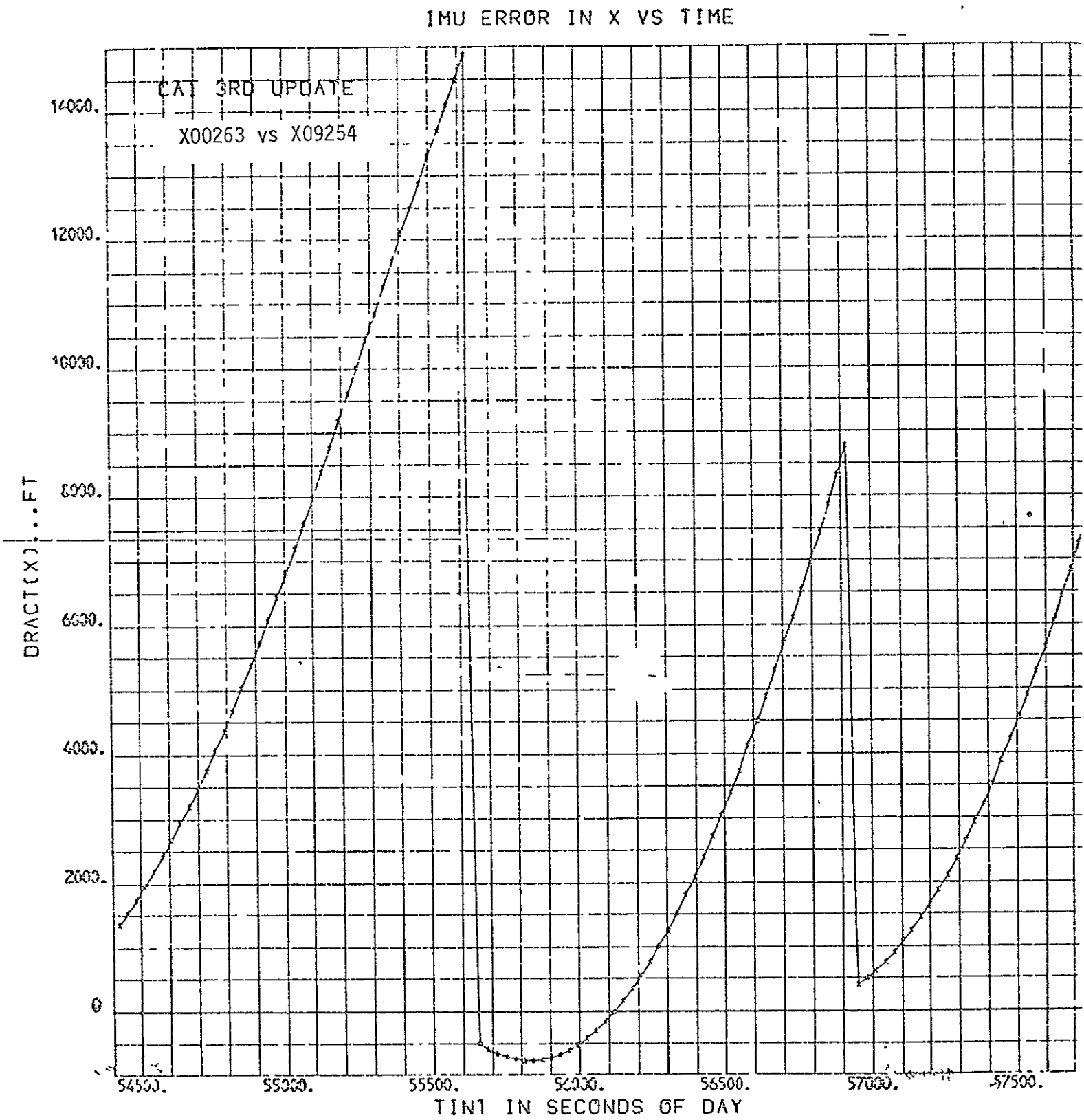
ERROR IN X VELOCITY UPDATE
C.2 UPDATE AT SECOND SEP
X01896 VS X14376
100.
50.
0
-50.
-100.
* VDIF-X - ...FPS
TINT IN SECONDS OF DAY

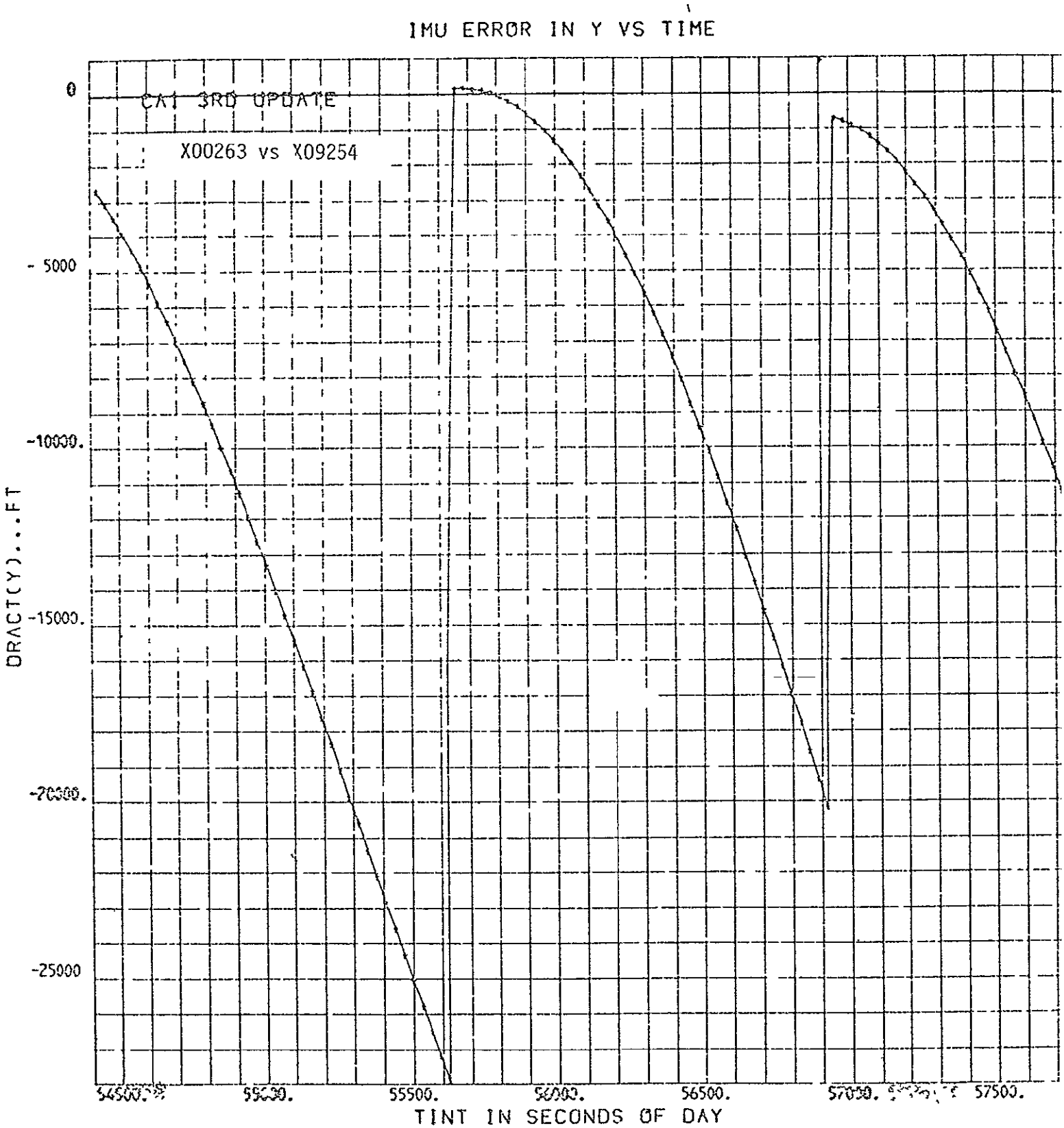

ERROR IN Y VELOCITY UPDATE
CR2 UPDATE AT SECOND SEP
X01896 VS X14396
0
-50.
-100.
-150.
-200.
* VDIF-Y- ...FPS
TINT IN SECONDS OF DAY

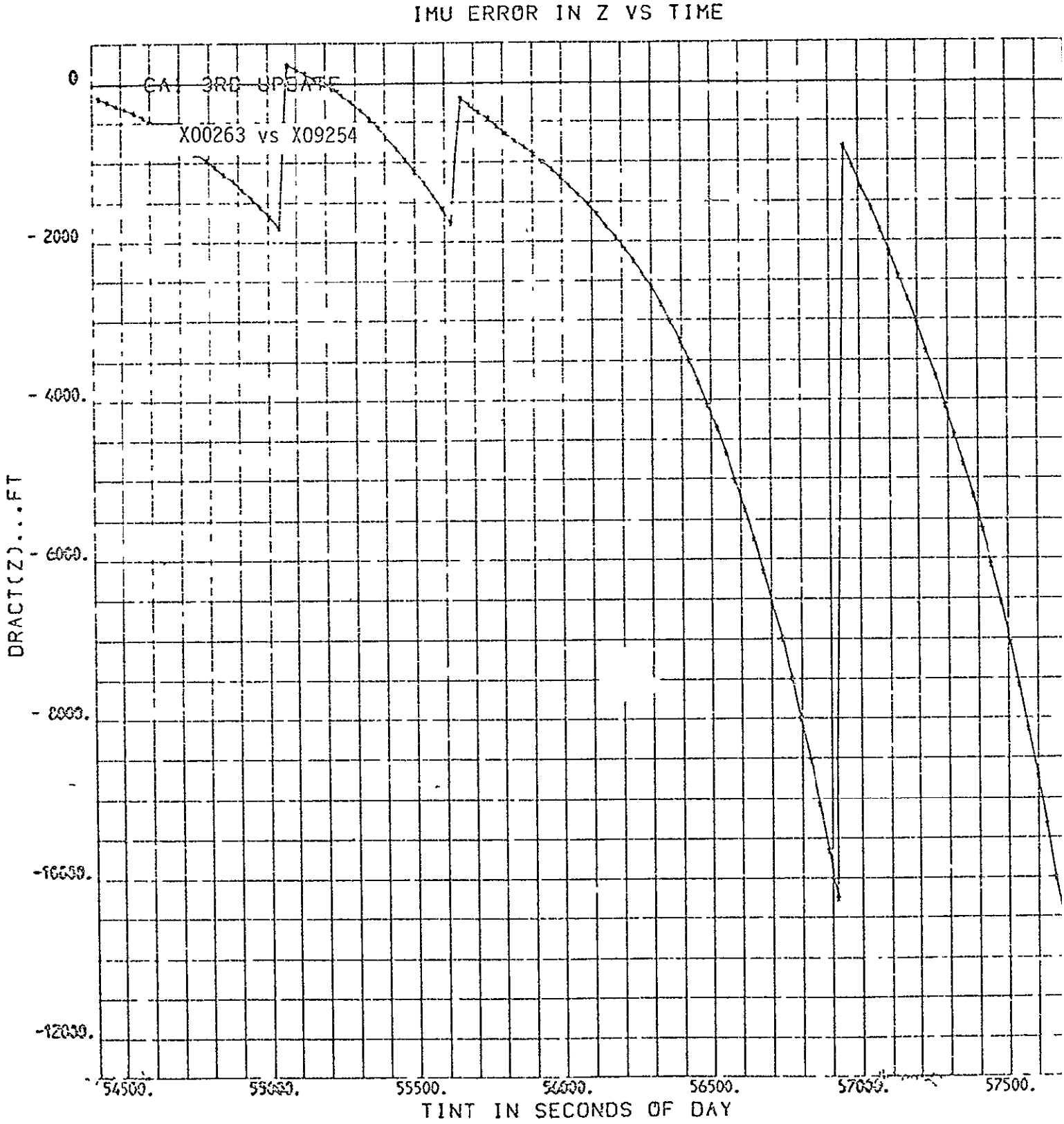

ERROR IN Z VELOCITY UPDATE
CA2 UPDATE AT SECOND SEP
X01896 VS XA4396
0
-10.
-20.
-30.
-40.
-50.
Δ VDIF-Z- ...FPS
TINT IN SECONDS OF DAY

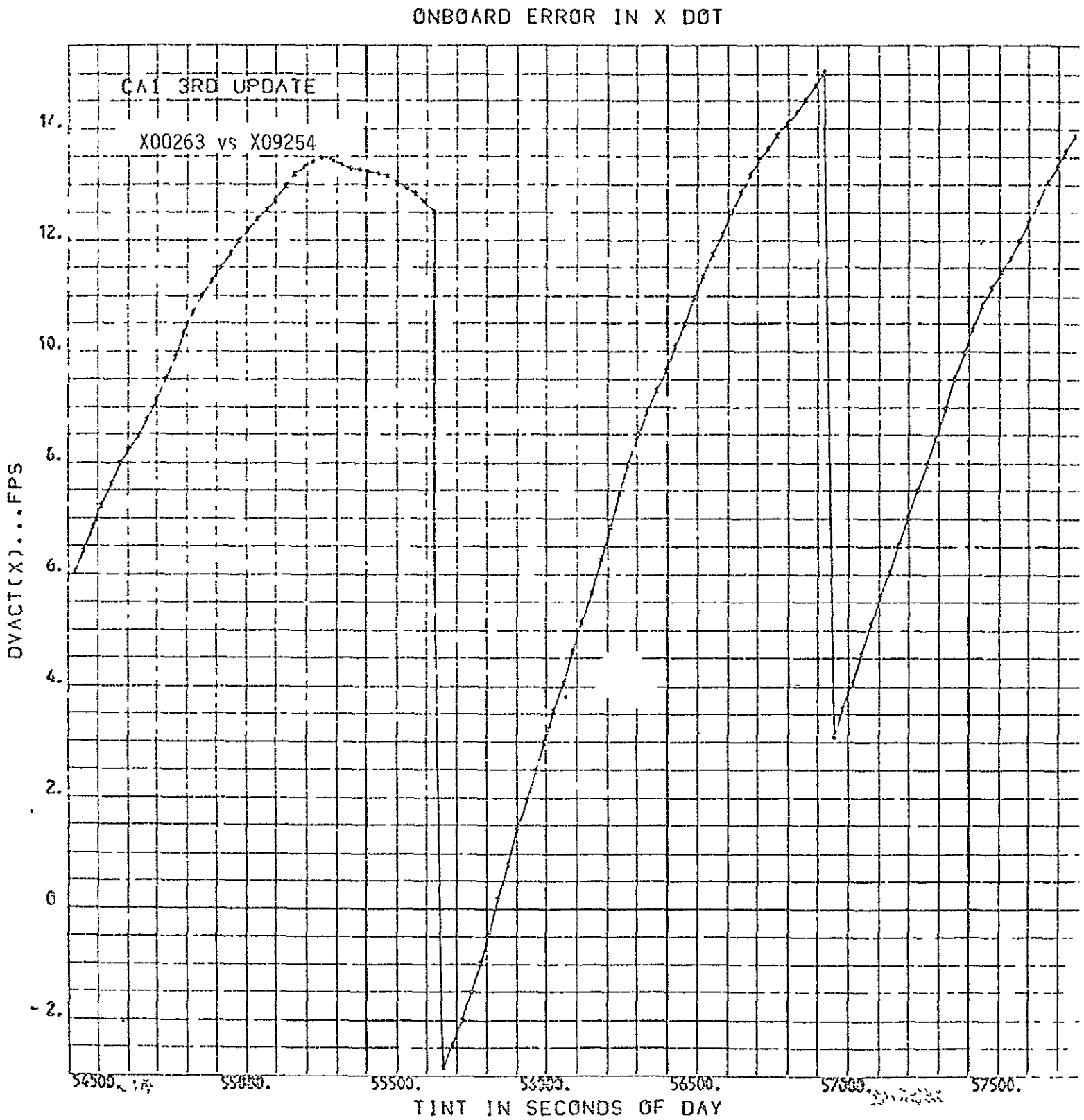
APPENDIX 6

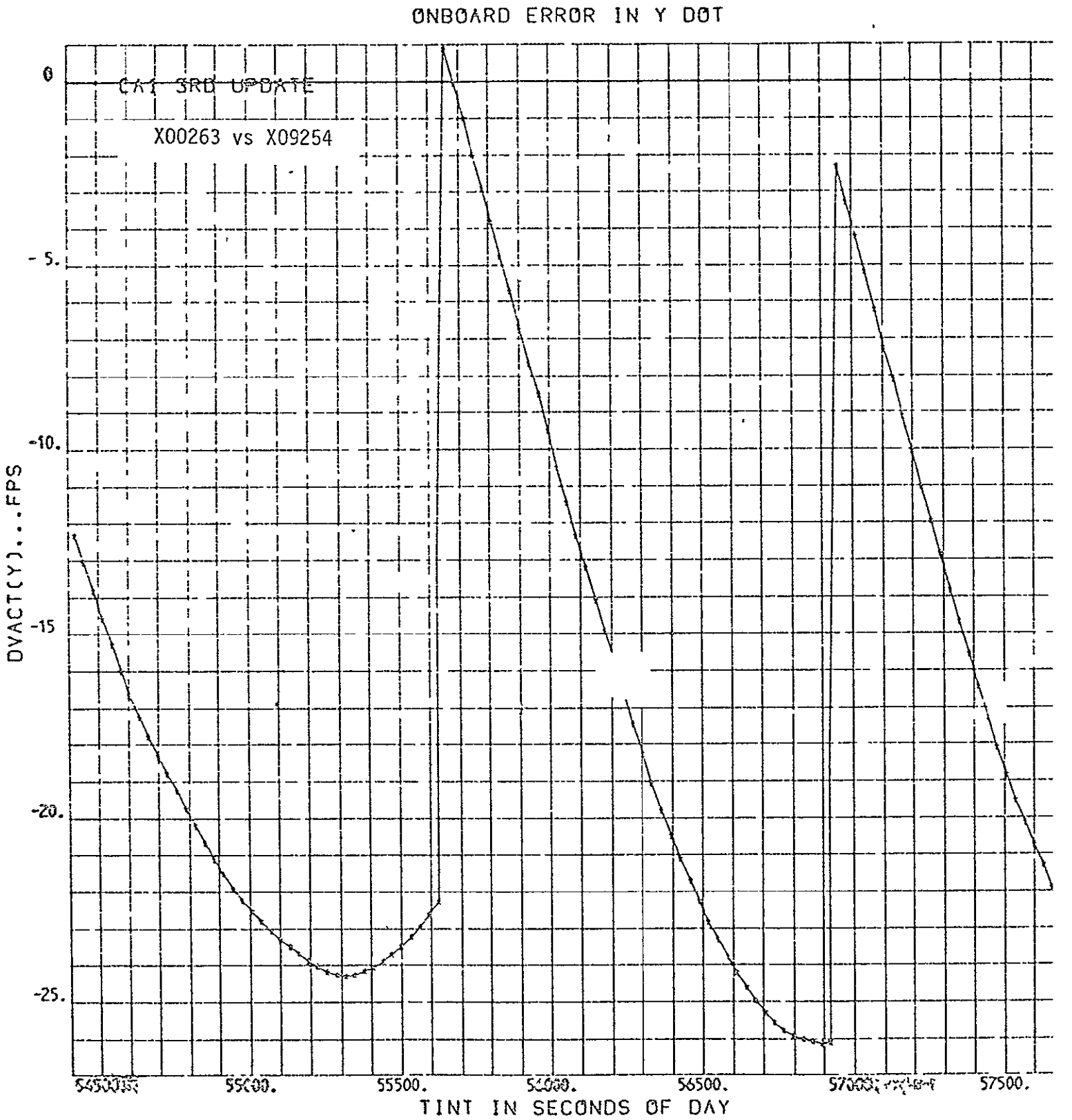
The following plots represent the case in which the onboard state was updated in the vertical components only at the first practice separation minus fifteen minutes, at the first practice separation minus five minutes in all components, and at the second practice separation minus two minutes in all components. Errors in the onboard state and errors in the computed updates are plotted as a function of time.

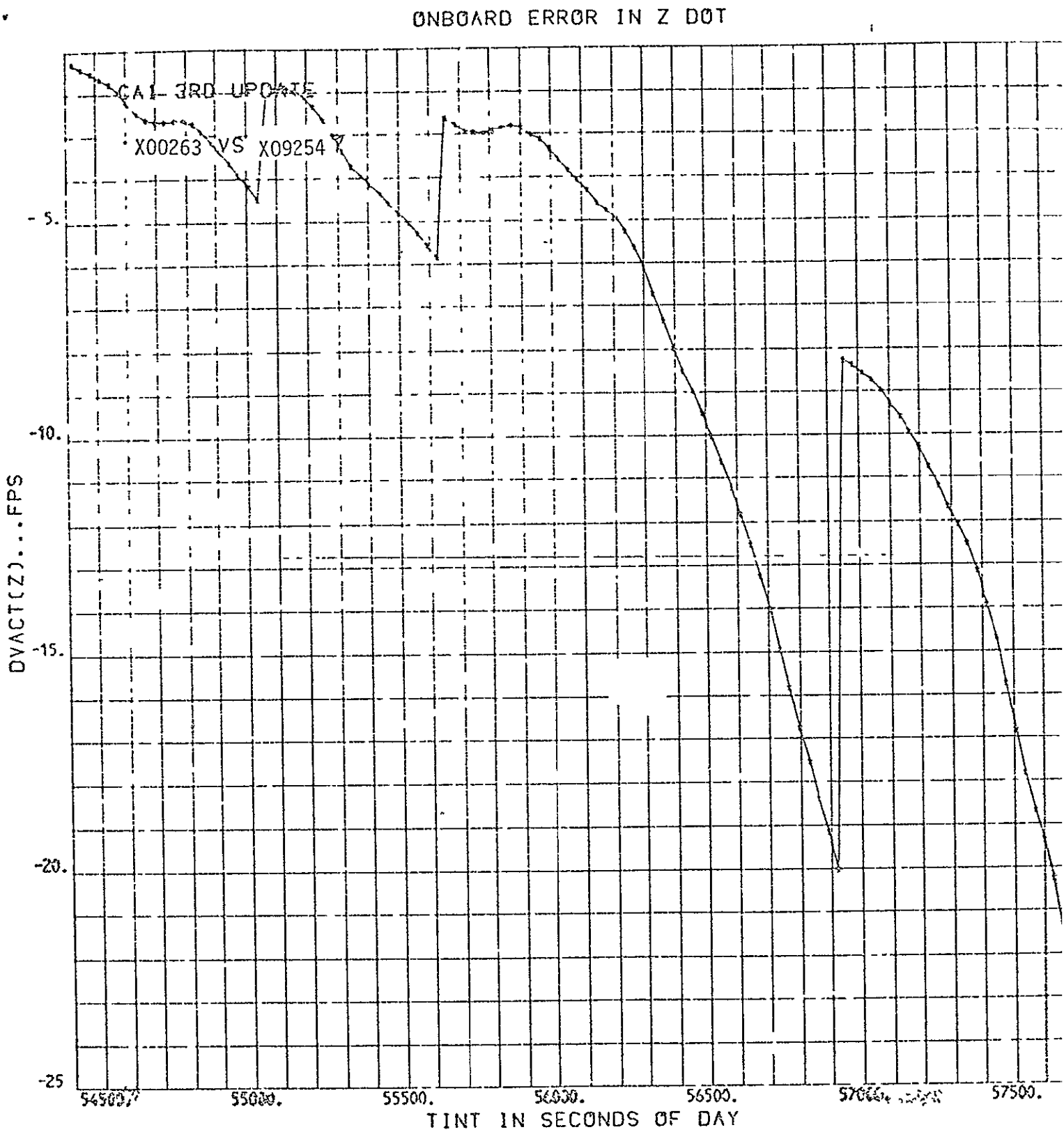

IMU ERROR IN X VS TIME
CAT 3RD UPDATE
X00263 vs X09254
14000.
12000.
10000.
8000.
6000.
4000.
2000.
0
DRACT(X)...FT
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

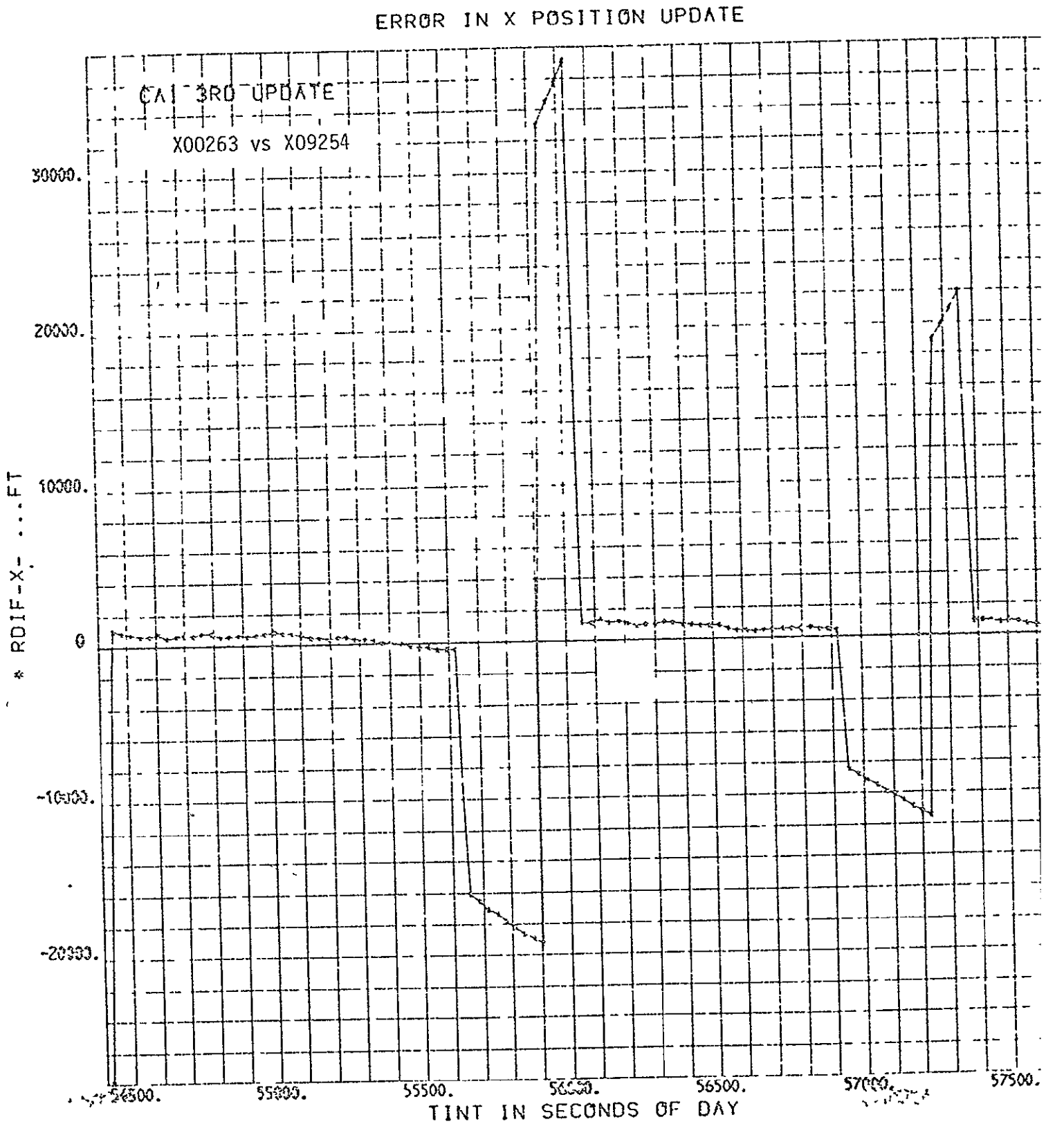

IMU ERROR IN Y VS TIME
CAT 3RD UPDATE
X00263 vs X09254
0
- 5000
-10000.
-15000.
-20000.
-25000
DRACT(Y)...FT
55500.
56000.
56500.
57500.
TINT IN SECONDS OF DAY

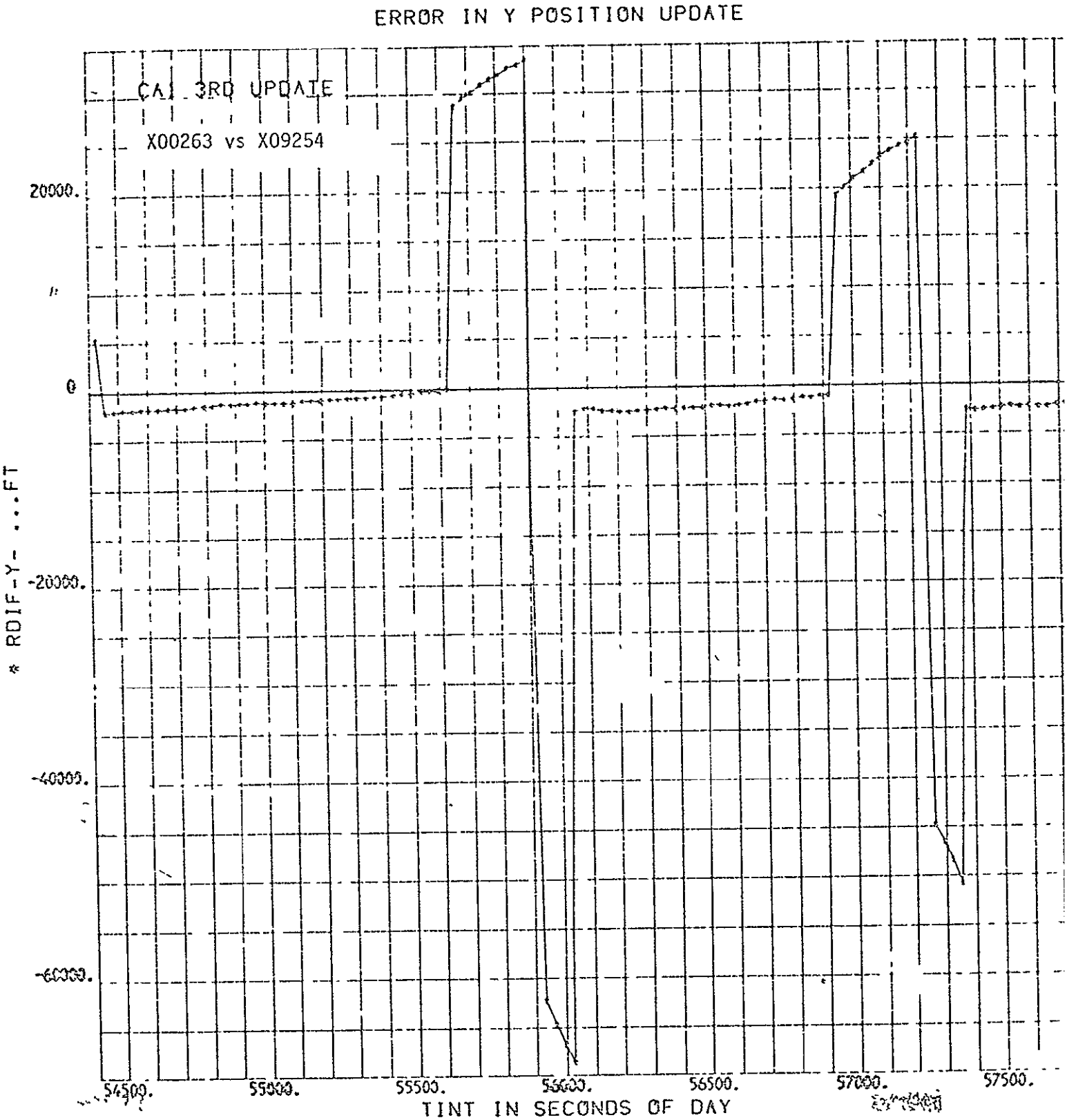

IMU ERROR IN Z VS TIME
0
CA: 3RD UPDATE
X00263 vs X09254
- 2000
- 4000.
- 6000.
- 8000.
-10000.
-12000.
DRACT(Z)...FT
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

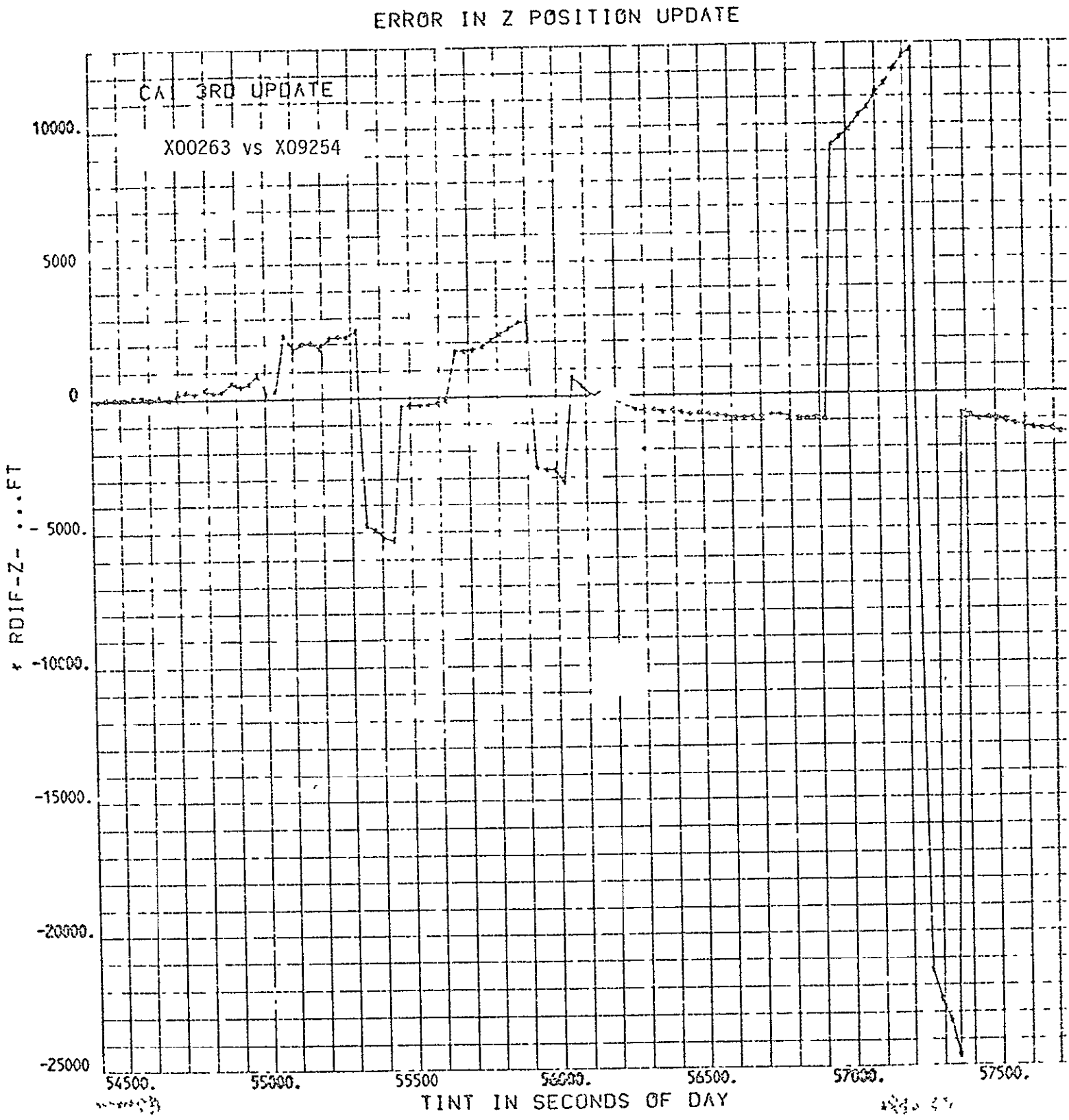

ONBOARD ERROR IN X DOT
CA1 3RD UPDATE
X00263 vs X09254
14.
12.
10.
8.
6.
4.
2.
0
-2.
DVACT(X)...FPS
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY

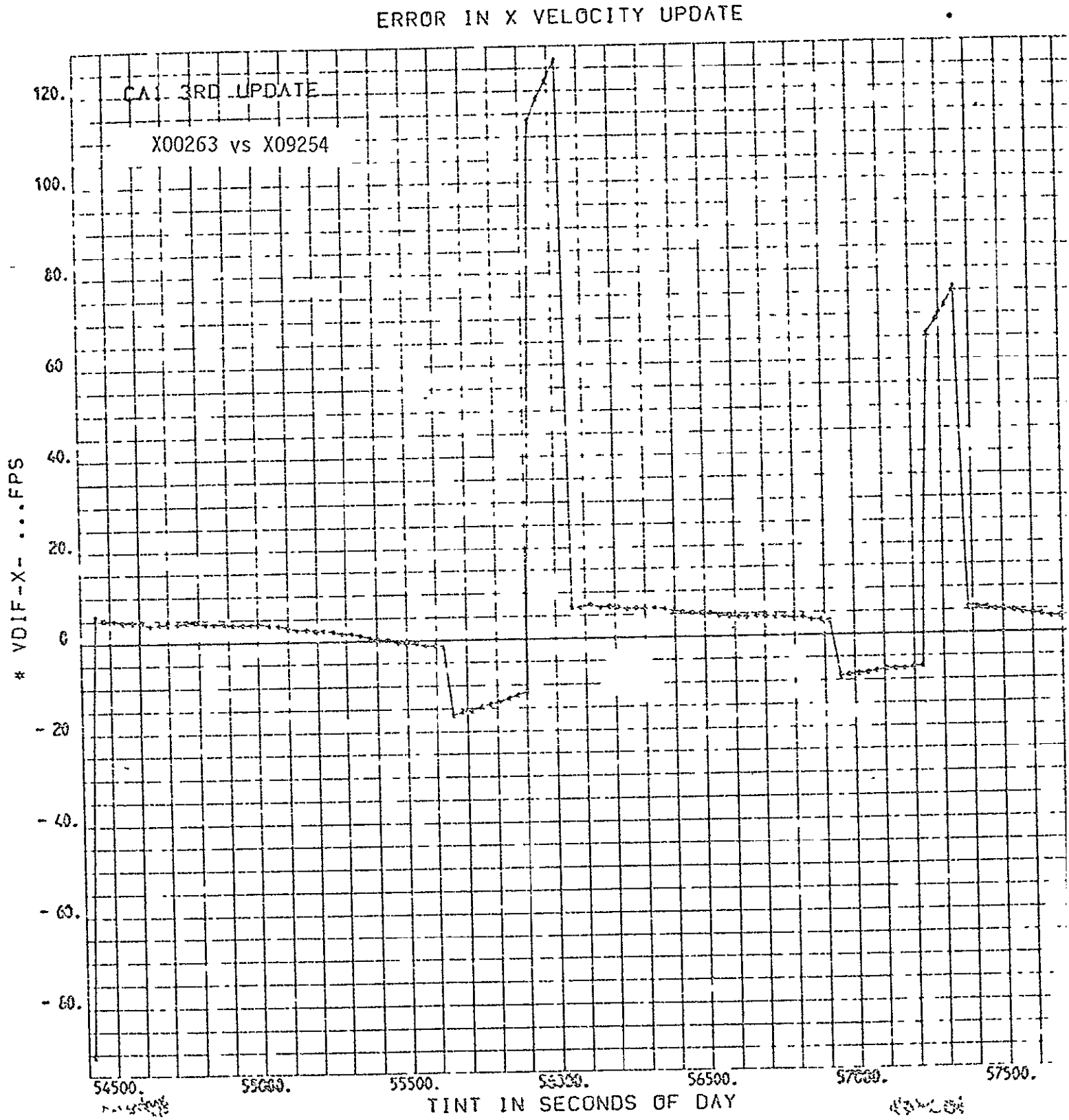

ONBOARD ERROR IN Y DOT
CAT SRB UPDATE
X00263 vs X09254
0
- 5.
-10.
-15
-20.
-25.
DVACT(Y)...FPS
55000.
55500.
56500.
57500.
TINT IN SECONDS OF DAY

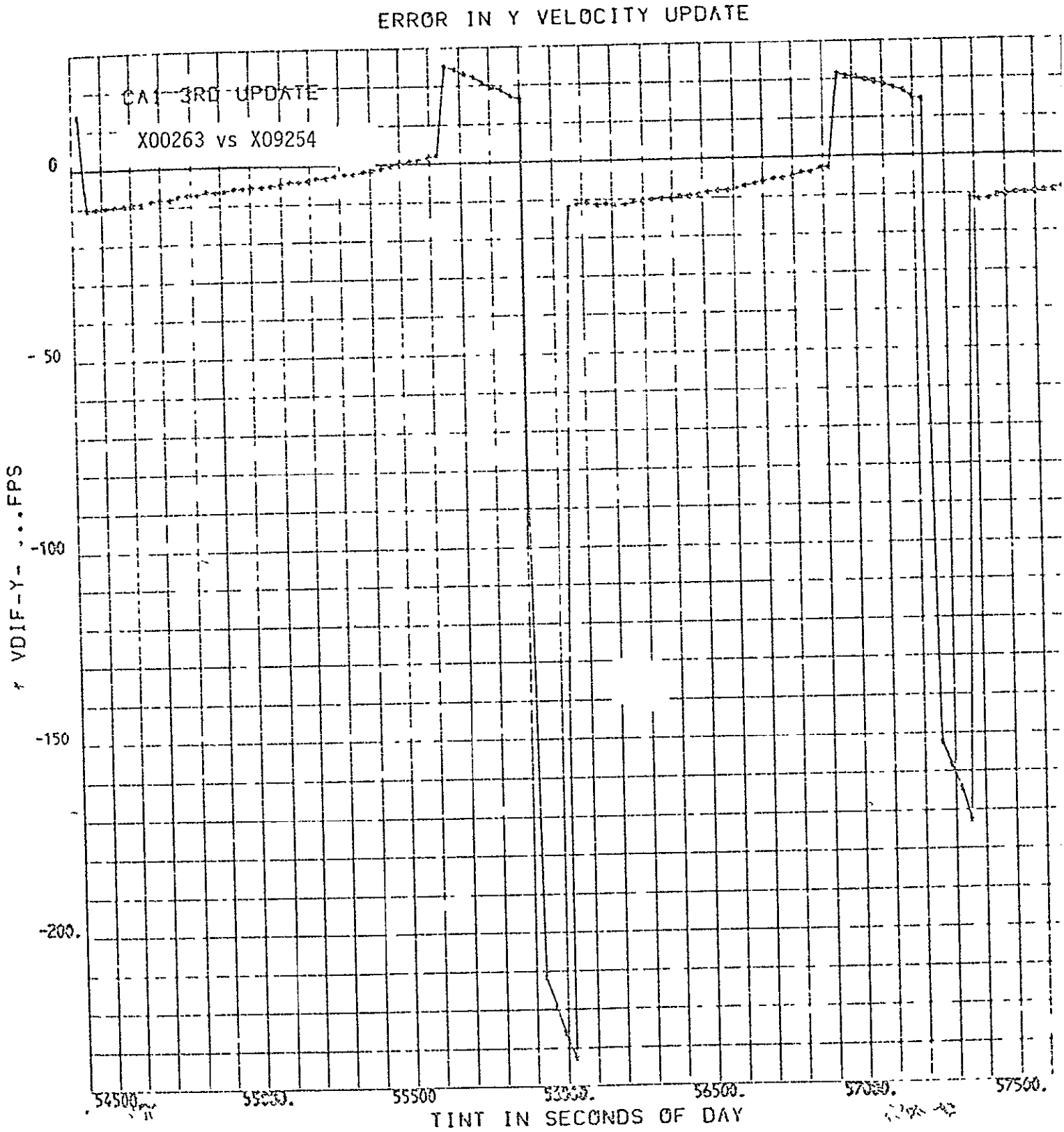

ONBOARD ERROR IN Z DOT
CAL 3RD UPDATE
X00263 VS X09254
- 5.
-10.
-15.
-20.
-25
DVACT(Z)...FPS
54500.
55000.
55500.
56000.
56500.
57500.
TINT IN SECONDS OF DAY


ERROR IN X POSITION UPDATE
CA1 3RD UPDATE
X00263 vs X09254
30000.
20000.
10000.
0
-10000.
-20000.
* RDIF-X- ...FT
55000.
55500.
56500.
57500.
TINT IN SECONDS OF DAY


ERROR IN Y POSITION UPDATE
CAL 3RD UPDATE
X00263 vs X09254
20000.
0
-20000.
-40000.
-60000.
* RDIF-Y- ...FT
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY


ERROR IN Z POSITION UPDATE
CA 3RD UPDATE
X00263 vs X09254
10000.
5000
0
- 5000.
-10000.
-15000.
-20000.
-25000
* RDIF-Z- ...FT
54500.
55000.
55500
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY


ERROR IN X VELOCITY UPDATE
CA 3RD UPDATE
X00263 vs X09254
120.
100.
80.
60
40.
20.
0
- 20
- 40.
- 60.
- 80.
* VDIF-X- ...FPS
54500.
55000.
55500.
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY


ERROR IN Y VELOCITY UPDATE
CA1 3RD UPDATE
X00263 vs X09254
0
- 50
-100
-150
-200.
VDIF-Y- ...FPS
54500.
55000.
55500
56000.
56500.
57000.
57500.
TINT IN SECONDS OF DAY


ERROR IN Z VELOCITY UPDATE
CAL 3RD UPDATE
X00263 vs X09254
0
-20.
-40.
-60.
-80.
* VDIF-Z- ...FPS
54500.
55000.
55500.
56500.
57500.
TINT IN SECONDS OF DAY