MCDONNELL DOUGLAS TECHNICAL SERVICES COMPANY, INC.
HOUSTON ASTRONAUTICS DIVISION
16915 El Camino Real, Suite 220, Houston, Texas 77058

CR 151580

17 November 1977
HAD-1.4-274

Subject: Contract NAS 9-14960, Task Order No. D0806, Task Assignment E, Transmittal of Design Note No. 1.4-4-33.

To: NASA/Lyndon B. Johnson Space Center
Attention: M. V. Jenkins, FM4
2101 NASA Road 1
Houston, Texas 77058

Enclosure: (1) Design Note No. 1.4-4-33, "Abort Region Determinator (ARD) Module Feasibility Report"

1. The enclosure presents a feasibility analysis of the OFT Mission Control Center (MCC) software formulation requirements for the Abort Region Determinator processor. This analysis demonstrates that the baselined ARD module meets all design objectives for MCC OFT launch/abort support.

Very truly yours,

W. E. Hayes

W. E. Hayes
Project Manager
Mission Planning, Mission Analysis
and Software Formulation

WEH:csc

EC: R. L. Berry/FM8
A. Bordano/FM7
R. O. Nobles/FM17
Distribution Operations (3)/JM86
J. D. Yencharis/FM4

(NASA-CR-151580) ABORT REGION DETERMINATOR (ARD) MODULE FEASIBILITY REPORT. MISSION PLANNING, MISSION ANALYSIS AND SOFTWARE FORMULATION (McDonnell-Douglas Technical Services) 77 p HC A05/MF A01 CSCL 22A G3/12
N78-15064
Unclas
55520

MCDONNELL DOUGLAS TECHNICAL SERVICES CO.
HOUSTON ASTRONAUTICS DIVISION

SPACE SHUTTLE ENGINEERING AND OPERATIONS SUPPORT

DESIGN NOTE. NO. 1.4-4-33

ABORT REGION DETERMINATOR (ARD) MODULE FEASIBILITY REPORT

MISSION PLANNING, MISSION ANALYSIS AND SOFTWARE FORMULATION

---

17 OCTOBER 1976

This Design Note is Submitted to NASA Under Task Order No. D0706, Task Assignment E, Contract NAS 9-14960.

PREPARED BY: B. G. Draeger
Engineer
Dept. E904, Ext. 243

PREPARED BY: J. A. Joyner
Task Manager - ARD
Dept. E904, Ext. 243

CONTRIBUTION BY: G. D. Venables
Senior Engineer
Dept. E904, Ext. 243

APPROVED BY: L. C. Winans
Integration Manager-
Intact Aborts
Dept. E904, Ext.243

APPROVED BY: W. W. Hinton
Technical Manager-Return
and Abort Analysis
Dept. E914, Ext. 240

APPROVED BY: W. E. Hayes
Project Manager
Mission Planning, Mission
Analysis and Software
Formulation
Dept. E914, Ext. 266

TABLE OF CONTENTS

TABLES

FIGURES

FIGURES (CONTINUED)

ACRONYMS AND SYMBOLS

Acronym or Symbol	Definition
AM	Actual Mode
AOA	Abort Once Around
ARD	Abort Region Determinator
ATO	Abort to Orbit
BRR	B Rid Review Board
CR	Change Request
CRT	Cathode Ray Tube
ET	External Tank
FAB	Flight Analysis Branch
FOD	Flight Operations Directorate
γ	Earth-Relative Flight Path Angle
HM	Hypothetical Mode
MC	Mission Completion
MCC	Mission Control Center
MECO	Main Engine Cutoff
MED	Manual Entry Device
MDTSCO	McDonnell Douglas Technical Services Company
MPAD	Mission Planning and Analysis Division
MPS	Main Propulsion System
NOM	Nominal
OFT	Orbiter Flight Test
PBI	Push Button Indicator
PET	Phase Elapsed Time From Liftoff

ACRONYMS AND SYMBOLS

Acronym or Symbol	Definition
RTLS	Return to Launch Site
SSME	Space Shuttle Main Engine
SSR	Staff Support Room
SVDS	Space Vehicle Dynamic Simulation
TLM	Telemetry
VE	Earth Relative Velocity Magnitude
$\overline{VE}$	Earth Relative Velocity Vector
VI	Inertial Velocity Magnitude
$\overline{VI}$	Inertial Velocity Vector
RI	Inertial Radius Magnitude
$\overline{RI}$	Inertial Radius Vector
$\dot{W}$	Total Vehicle Weight

1.0 SUMMARY

A software module feasibility study has been completed for the Mission Control Center (MCC) Abort Region Determinator (ARD) processor. This study addresses the feasibility of the basic ARD module function in support of single-failure launch aborts. The analysis here is generally restricted to the ARD Module independent of other MCC processors and interfaces. A complete study would also encompass ARD module function in an integrated MCC environment for both single-failure and multiple-failure aborts. Such an integrated scheme feasibility study will be conducted as a follow-on to this analysis.

This study provides a detailed performance evaluation of the present ARD module design in support of OFT-1 ascent and OFT-1 intact launch aborts. The evaluation method used is to compare ARD results against results obtained using the full-up Space Vehicle Dynamic Simulations (SVDS) program under the same conditions. Results are presented for each of the three major ARD math models (the Ascent Numerical Integrator, the Mass Model, and the Second Stage Predicator) as well as the total ARD module. These results demonstrate that the baselined ARD module meets all design objectives for MCC OFT launch/abort support.

In addition, this study does explore one aspect of ARD module function in an integrated MCC environment. The study includes an analysis of the ARD/Special-MPS-processor MCC interface and the adequacy of this interface for off-nominal conditions. While this is, strictly speaking, an integrated scheme feasibility consideration, this question is judged to be of fundamental importance and is included in this report.

As an additional feature, this study also addresses the adequacy of baselined ARD MCC displays. In MCC application the results of ARD processing will be used to update a digital CRT display on the flight dynamics consoles at six-second intervals. To facilitate evaluation of the ARD digital display design, ARD results are presented in this study exactly as they will appear in the MCC for nominal ascent and four launch abort scenarios. These results provide a good indication of the capabilities and limitations of the digital display.

2.0 INTRODUCTION

The Flight Analysis Branch (FAB) of the Mission Planning and Analysis Division (MPAD) at Johnson Space Center (JSC) is responsible for defining software formulation requirements for the Mission Control Center launch/abort processors that will be used to support Shuttle ascent operations. MPAD is also responsible for developing mission techniques and procedures required in the application of these processors by mission controllers in the MCC.

The Abort Region Determinator is the launch/abort monitor that will be used in the Mission Control Center to support Shuttle ascent operations. McDonnell Douglas Technical Services Company (MDTSCO) is charged with the MPAD development responsibilities for this MCC processor. This task is part of the Space Shuttle Engineering Operations Support Contract and is being conducted under the direction of Morris V. Jenkins, MPAD FAB Branch Chief.

Based on the level A requirements of reference 1 and the Flight Operations Directorate (FOD) statement of requirements (reference 2), initial formulation requirements for the ARD were developed and baselined in references 3 and 4. These requirements have been revised to date by two formal requirements change documents as a result of bench program development and ARD feasibility studies (references 5 and 6). First generic techniques and procedures for ARD application have been provided in reference 7. Currently, ARD task emphasis is shifting from the software requirements definition phase to review, testing and verification of the software for the first MCC build. A detailed test plan (reference 8) has been published that defines a procedure for verification of MCC software using the ARD bench program developed by MDTSCO and Lockheed Software Development Branch personnel. A trajectory test data base (references 9, 10, and 11) has also been established for use in this MCC software verification effort. Detailed MCC software implementation plans are presently under review by MDTSCO as part of the ARD Critical Design Review.

This study utilizes an ARD bench program as developed to 1 October 1977 (October 1977 ARD Milestone). This milestone includes all ARD bench-program-development change request (CR) items approved to 1 October 1977 by the level B requirements review board (BRR) (reference 12). The milestone also include a baselined third-order analytic predictor improvement CR item approved by the BRR on 17 October 1977.

The study also utilizes Milestone 3.7 of the SVDS program presently under development by Software Development Branch. The OFT-1 no-roll trajectories generated with this program are generally consistent with the reference flight profile (RFP) document of reference 13.

3.0 ARD MODULE FEASIBILITY-APPROACH AND ANALYSIS

ARD detailed formulation requirements have been implemented in a bench program simulation of ARD MCC software. In order to verify the feasibility of this formulation, the ARD bench program was run in simulated support of the following launch and launch/abort trajectories:

1) Nominal OFT-1 ascent from liftoff to MECO for mean April winds;
2) Nominal no-wind OFT-1 liftoff to MECO ascent;
3) AOA abort of the mean-wind OFT-1 ascent with center SSME failure at 213 seconds and abort enactment at 233 seconds after liftoff;
4) ATO abort of the no-wind OFT-1 ascent with center SSME out at 245 and abort enactment at 265 seconds after liftoff;
5) RTLS abort of the mean-wind OFT-1 ascent with center SSME failure at liftoff and abort enactment at 126 seconds after liftoff;
6) Mission completion of the mean-wind OFT-1 ascent following partial loss of center SSME thrust at 66 seconds after liftoff.

The approach in each of these simulations was to run the ARD bench program on a simulated telemetry (TLM) state vector file generated with the SVDS program. ARD/flight controller interfaces were simulated to approximate ARD MED and PBI control action that will be experienced in the MCC. For each trajectory, ARD results were then compared with results from the SVDS. This comparison provides for each case a detailed measure of ARD accuracy and ARD module support feasibility.

This section presents the results of the feasibility analysis for each of these trajectories. In each case ARD support is presented graphically as well as in terms of the flight controller's digital display. The ARD-support graphs demonstrate clearly the trends and characteristics of the ARD for the various support situations. Such graphs have been proposed by MDTSCO for MPAD flight dynamics SRR support and are currently being considered for MCC display. The digital displays of the figures that follow provide ARD results exactly as they will appear on the MCC consoles during ascent (see Reference 15). This display is presently the primary ARD flight controller tool and gives the granularity and ARD control parameters required for ARD support. A close scrutiny of the figures of this section, however, confirms that the digital display does not readily identify some important trends and characteristics of ARD support. (Note that displays are provided at selected points only. In the MCC, ARD displays will be updated at the end of each 6-second interval throughout ascent. Additional displays are available on request.) Detailed accuracy study results are also presented for each of the three major ARD math models.

The developmental status of the computer simulations used must be considered in reviewing the results of this section. In the MCC, margins for other abort modes will not be displayed once an abort mode PBI has been selected. The ARD bench program does not simulate this function and margins for the other modes are displayed in this section even after mode selection. These margins shold be disregarded. There is also an unresolved problem with the bench program display of the RCS DELV (see Reference 15). This display slot should also be disregarded. These items are due to the immaturity of the bench program and do not reflect on the ARD formulation.

Note also that the SVDS program used has no model of the MECO standard-SSME shutdown procedure. This means that MECO results obtained with this program are somewhat optimistic. Real MECO velocity margins will be up to 5 feet per second less than those presented here. And actual MECO times will be 1 to 5 seconds later than those of this section. This inaccuracy does not compromise the validity of the ARD/SVDS comparison. In fact, the ideal MECO times of this program allow a direct comparison of ARD-predicted and SVDS-actual times that could not otherwise be made.

3.1 ARD Nominal Ascent Support

ARD nominal ascent support feasibility is assessed in this section for both mean April winds and a no-wind OFT-1 ascent trajectory. The mean-wind trajectory is representative of actual OFT-1 ARD support. The no-wind trajectory is required for detailed ARD math model accuracy analysis and provides a measure of the effect of winds of the day on ARD margin predictions.

Figures 1.1 and 1.2 provide a complete graphical summary of ARD support for mean-wind OFT-1 ascent. This information is also presented in digital display format in figure 1.3. Since this trajectory is consistent with reference 14, basic ARD feasibility for this case is assessed by comparing these results with the data of reference 14. Table 1 provides this comparison and illustrates the capability of the ARD to define abort boundaries for OFT-1. Note in all cases the good agreement of ARD bench program results and the independently-derived SVDS results of reference 14. Also note the comparison of ARD predicted nominal margins versus the SVDS results.

There are several important aspects of the figures 1.1-1.3 that should be pointed out:

1) the effect of using a wind-biased first-stage body axis command table in the no-wind ARD first-stage integrator is indicated by the difference in the AM margins for liftoff versus the margins at SRB staging (126 seconds after liftoff. Also refer to Table 5.1);
2) AM margins for nominal, ATO and AOA are identical since abort

and nominal targets are the same and since no pre-MECO OMS/RCS burns are scheduled in 3-SSME aborts for OFT-1;

3) The effect of the OFT-1 throttle bucket is apparent in the HM margins between 35 and 65 seconds after liftoff;
4) The mission completion design of the ATO pre-MECO OMS/RCS burns is reflected in the ATO margins after 250 seconds.

These trends are evident in all of the figures of the appendix.

Figures 1.4-1.6 summarize ARD support for no-wind OFT-1. Since the ARD is predicated on a no-wind ascent model, this trajectory affords the best opportunity for detailed comparison of the ARD against SVDS from liftoff to MECO. Table 2 presents such a comparison for a wide range of points selected from figures 1.4-1.6. Tables 3-5 provide a similar assessement of the performance of the major ARD component math models vs. the corresponding models of SVDS.

A comparison of the ARD results for the mean-wind ascent versus the no-wind ascent identifies one area of inaccuracy in the present ARD implementation. Present plans are now to use the onboard wind-biased first-stage guidance commands in the ARD for OFT support. Figure 1.1 and Table 1 clearly demonstrate the inaccuracy associated with use of wind biased commands in the no-wind ARD. Figure 1.4 illustrates the improvement possible if no-wind commands were used instead.

3.2 ARD Mission Completion Support

In addition to its primary task of providing abort region predictions in abort situations, the ARD is first required to identify the situations in which an abort is required. This section addresses the capability of the present baseline to perform this task.

Figures 2.1-2.3 summarize ARD support for an SSME-partial-loss-of-thrust failure occurring during the throttle-up portion of the OFT-1 throttle bucket. In this simulation, SSME-1 locked at 76% throttle 66 seconds after liftoff and remained at that level throughout ascent to MECO. All other aspects of this trajectory are identical to the mean-wind nominal ascent of section 3.1. Note that three applications of the ET fuel adjustment MED were required here to match ARD mass track results with those of the spline interpolators of SVDS. Figure 2.1 illustrates the affect of these MED's.

Table 6 summarizes ARD performance for this scenario. Immediately following the failure, the first question facing the flight team is whether an abort situation exists. For this situation the ARD margins of the figures indicate that it does not (i.e., no abort action is required). SVDS results in table 6 confirm the validity of the ARD prediction.

Figures 2.1-2.3 illustrate the capablity of the ARD to predict significant shifts in the abort regions. By comparing the HM 2-SSME boundaries of these figures with those of figures 1.1-1.3 (see table 6) the effect of the SSME-lock failure on 2-SSME abort posture is apparent. Note that while the downrange abort boundaries have been significantly perturbed, the region of RTLS capability remains relatively unaffected. ARD capability to predict this shift in the mode boundaries is very important here, since for hydraulic-lock-induced failures it is likely that the sick engine will fail entirely 1-2 minutes after the partial-loss-of-thrust failure.

3.3 ARD Abort-to-Orbit (ATO) Abort Support

This section details ARD capability to predict valid ATO abort regions and support a selected ATO abort. Figures 3.1-3.3 summarize ARD support for a typical ATO OFT-1 launch abort situation. In this case complete loss of center SSME thrust was experienced 245 seconds into a no-wind OFT-1 ascent. Following a 20 second abort decision delay, an ATO abort was enacted and completed. The ARD digital displays in Figure 3.3 are provided from the time of the failure. Displays prior to this time are identical to those of Figure 1.6.

Table 7 summarizes ARD performance in support of this launch abort. The agreement of ARD ATO abort predictions and SVDS results here confirms ARD feasibility for this case.

There are several features of figure 3.1 that should be observed:

1) Margins for this case are identical to the no-wind ascent margins of section 3.1 up to the time of engine failure;
2) ARD response to the center-SSME-out PBI is apparent in the AM at 245 seconds;
3) ARD auto-safing is confirmed on figure 3.3 at 245 seconds;
4) AM and HM reconfiguration following engine-out PBI is confirmed since AM & HM margins are identical following the failure;
5) The validity of HM application is confirmed by comparing HM margins just prior to the failure to the final result.

These effects are also evidenced in the AOA and RTLS results that follow.

3.4 ARD Abort Once Around (AOA) Abort Support

ARD module feasibility for AOA abort region definition and AOA abort support is assessed in this section. The failure simulated here is complete loss of center SSME thrust at 213 seconds after liftoff. Following a 20-second delay, an AOA abort is enacted and completed. Figures 4.1-4.3 provide a summary of ARD support for this case. Table 8 summarizes ARD performance in support of this abort. Note that digital display information in Figure 4.3 starts at time of engine failure. Displays prior to this time are identical to those of Figure 1.3.

3.5 ARD Return to Launch Site RTLS Abort Support

The ARD was run in simulated support of a worst-case-type RTLS abort. The trajectory simulated was for complete loss of center SSME thrust at liftoff with RTLS selected at the beginning of second stage ascent. Figures 5.1-5.3 detail ARD support for this case. Note that this simulation begins at SRB staging. Table 9 summarizes ARD performance for this support.

There are several unique features of figure 5.1 that should be observed for this case:

1) Start of RTLS pitcharound is clearly reflected in both the AM and HM at 411 seconds;
2) The difference in AM and HM margins reflects the difference in flyback capability with present throttles (96%) versus ultimate capability with maximum performance (109%);
3) The conservative onboard and ground RTLS turnaround extrapolation algorithm as evidenced in the HM between 411 and 423 seconds;
(4) The effect of the SSME-lock MED adjusting throttles from 100% to 95% is apparent in AM between 417 and 423 seconds.

These will be characteristic of ARD support of all RTLS aborts.

ARD/Special-Main Propulsion System (MPS)-Processor Interface Feasibility

The ARD functions based on the mass properties computations (i.e., total weight, MPS fuel remaining, OMS/RCS fuel remaining) of the ARD nominal mass track. The mass track assumes nominal main-engine performance based on input throttle settings. There are no provisions in the mass track for off-nominal performance or engine-to-engine performance dispersions for a given throttle setting. Moreover, with the present ARD control design, the flight team has no way of adjusting the mass track for the small throttle fluctuations about the nominal value that are considered likely to occur.

To account for these off-nominal performance conditions, a comparison interface has been established between the ARD and a special MPS processor. This processor computes mass properties based on detailed propulsion system status information (chamber pressures, temperatures, flow rates, etc.) downlinked via telemetry and is intended to provide an accurate comparison base for other MCC processors. Detailed requirements for this processor are given in reference 16. The established interface presently provides for the flight controller to maintain an accurate ARD mass track by periodic MED adjustments based on the output of this MPS processor.

A study was undertaken to evaluate the validity of this MCC interface. Based on the anticipated accuracy of the special MPS processor computations (reference 17) a set of worst-case special MPS processor errors were generated for OFT-1. These errors are summarized in figure 6.1. ARD support was then simulated for no-wind OFT-1 ascent using these errors as MPS-fuel-remaining-adjustment MEDS to simulate the

APD/special-MPS-processor interface. Figure 6.2 and 6.3 summarize ARD support for this case. By comparing the results of figures 6.2 and 6.3 to the nominal results of figures 1.4 and 1.5, worst-case ARD errors resulting from the worst-case special MPS processor errors were derived. (Note that this study was conducted for second stage ascent only. The first stage was judged to be very insensitive to weight errors. The results obtained confirm this assessment.)

Figure 6.4 presents these results for both positive and negative worst-case errors. From this figure it is apparent that while the ARD is very insensitive to special MPS processor errors early in ascent, it becomes progressively more sensitive as ascent progresses. In view of the magnitude of the OFT-1 FPR (roughly 260 fps), in fact, the errors near MECO must be regarded as totally unacceptable. (Note in figure 6.4 the error-damping effect of the ARD constant acceleration mass track after 460 seconds.) These errors are particularly serious in view of current proposals for ARD to support intact contingency (i.e., multiple SSME-out) aborts near MECO.

There are a number of alternative solutions to this difficulty. In order to provide an indication of the improvement possible, comparable worst-case mass properties errors were assessed for one of these. The alternative investigated is the simple sensed-thrust-velocity algorithm presented in reference 18. This algorithm is only valid for exoatmospheric flight. Therefore, for this evaluation it was assumed that the present special MPS processor was used until SRB staging. The sensed-thrust-velocity algorithm was then used to provide comparison weights from staging to MECO . (Note that the input weight error to the algorithm is in fact, a conservative 1000 pounds worse that the observed MPS processor error.). Figure 6.5 presents worst-case weight errors using this algorithm versus those of the present special MPS processor. Now the sensed-acceleration algorithm errors of this figure are somewhat over-optimistic. There is a 3800 pound uncertainty in the dry weight of the vehicle that defines a lower limit on achievable weight uncertainties. Also there may be, depending on the implementation, errors associated with the sensed-velocity input to the algorithm in the MCC, but even with these considerations, the errors of Figure 6.5 offer a significant improvement over the present scheme. Based on these errors, it is judged that there are alternative comparison bases that could reduce attendant ARD margin uncertainties to well within FPR level.

5.0 Conclusions and Recommendations

This paper demonstrates the basic feasibility of the baselined ARD formulation in MCC support of shuttle OFT ascents and intact launch aborts. ARD OFT-1 design characteristics identified in this analysis are summarized in Table 10. The only significant module discrepancy identified by this analysis is the useage of wind-biased first stage guidance commands in the no-wind first stage ARD model. While the present baseline is in full compliance with Level A and B ARD design requirements, these studies indicate that the wind-biased command set may not be the best one for ARD application. It appears that a no-wind profile might provide better ARD first stage predictions. There is presently, however, no source of such a profile, since MPAD ascent design is only being conducted for ascents with winds. Moreover, ARD inaccuracies due to this effect are only significant for the first one to one-and-one-half minutes of ascent. It is recommended that this issue be addressed by MPAD and an MPAD position determined at the earliest possible date.

The figures of this document illustrate the limitations of the present ARD digital display in readily identifying important ARD characteristics and trends. The figures also demonstrate the utility of ARD margin history plots in readily identifying such trends. While these plots are of interest to the flight team as a whole, they are judged to be essential for MPAD flight dynamics SSR support of ARD applications. Margin history plots have been proposed but not yet baselined for implementation in the MCC common display system. It is recommended that MPAD press for baselining of these MCC plots at the earliest opportunity.

This document also identifies significant problems with one of the planned ARD external interfaces in the MCC. The special MPS processor as presently formulated by FOD appears inadequate for use as an ARD mass track comparison base. It is recommended that alternatives be evaluated by FOD and either the special MPS processor be revised or another comparison base of sufficient accuracy be provided in the MCC.

6.0 References

1) "MCC Level A Requirements for Shuttle, Volume 1: OFT, Revision 2 Change 1", 19 December 1975, JSC 10852

2) "Launch Subsystem-Level B Overview", 30 January 1976, GSR-64, W. A. Stoval

3) "Orbital Flight Test Abort Region Determinator Level B Formulation", 23 September 1976, JSC Internal Note 76-FM-49

4) "Abort Region Determinator Level C Formulation Requirements", 17 February 1977, JSC Internal Note 77-FM-12

5) "Change Request 1 to ARD Level C Formulation Requirements", 18 April 1977

6) "Change Request 2 to ARD Level C Formulation Requirements", October 1977

7) "OFT Baseline Abort Plan", October 1977, JSC Internal Note 77-FM-53

8) "Abort Region Determinator/RTLS Event Predictor Mission Control Center Software Verification Test Plan", 9 September 1977, TM No. 1.4-6E-27

9) "ARD Processor Test Data Base-Ascent Guidance Table", 15 July 1977, TM No. 1.4-6E-22

10) "ARD Processor Test Data Base-MED Inputs Table", 29 July 1977, TM No. 1.4-6E-23

11) "OFT ARD Processor Test Data Base Systems Constants", 11 October 1977, TM 1.4-6E-29

12) "ARD Changes 5 and 6", 28 September 1977, TM No. 1.4-6E-28

13) "Ascent Reference Flight Profile for OFT-1", 7 March 1977, JSC Internal Note 77-FM-14

14) "RTLS OFT 1 Performance Studies", TM No. 1.4-610-16, 22 July 1977

15) "Abort Region Determinator (ARD) Display", GSR-217, 3 February 1977

16) "Level C Requirements-Formulation for the MPS Special Computations", 8 October 1976, GSR-144

17) "MPAD Accuracy and Formulation Verification of ET Depletion Time-to-GO Predictions", 14 December 1976, JSC Memorardum FM4(76-160)

18) "Acceleration and Mass Estimation", 5 August 1975, C. S. Draper Lab-John P. Higgins

TABLE (1): ARD Module Performance for Mean Wind OFT-1

1a) Abort Mode Boundary Prediction

Hypothetical Abort Type	Mode Boundary ARD	Mode Boundary *RFP	Difference ARD-*RFP Sec
AOA	211	213.	-2.
ATO	245.	245.	0.
MC	295.	300.	-5.
RTLS	291.	** 290.	1.

*RFP - Values listed in the Ascent Reference Flight Profile for OFT-1; March 7, 1977; JSC Internal Note No. 77-FM-14

** - RFP consistent results for 12 degree/second pitch rate from Reference 14

1b) Nominal Margin Prediction

Elapsed Time From Liftoff (Sec)	ARD Predicted Nom AM Margin	Error ARD-*RFP
0.0	343	-203
52	385	-161
100	510	-36
126	535	-11
176	547	1
227	537	-9
277	543	-3
327	551	5
377	551	5
427	552	6
477	545	-1
512	537	-9

* RFP margin from Reference 13 is 11205 lbs or 546 feet per second

TABLE (2): ARD MODULE PERFORMANCE FOR NO WIND OFT-1

2a) ARD Nominal AM Prediction Versus SVDS Results

PET SEC	ARD NOM AM MARGIN FT/S	SVDS FT/S	ERROR ARD-SVDS FT/S	ARD PREDICTED MECO TIME SEC	ACTUAL MECO SVDS SEC	ERROR MECO SVDS SEC
0.0	607.7	647.2	-39.5	523.4	522.9	.5
49.0	634.9	647.2	-12.3	522.1	522.9	.2
98.0	673.6	647.2	26.4	522.7	522.9	-0.2
126.7	684.5	647.2	37.3	522.6	522.9	-0.3
152.7	671.8	647.2	24.6	522.7	522.9	-0.2
200.7	662.4	647.2	15.2	522.7	522.9	-0.2
213.0	659.8	647.2	12.6	522.8	522.9	-0.1
243.0	655.9	647.2	8.7	522.9	522.9	0.0
249.0	655.8	647.2	8.6	522.9	522.9	0.0
297.0	653.3	647.2	6.1	522.9	522.9	0.0
351.0	653.6	647.2	6.4	522.9	522.9	0.0
369.0	654.5	647.2	7.3	522.9	522.9	0.0
399.0	648.8	647.2	1.62	523.0	522.9	0.1
417.0	656.3	647.2	9.1	522.9	522.9	0.0
453.0	656.3	647.2	9.1	522.9	522.9	0.0
519.0	640.4	647.2	-6.8	523.0	522.9	0.1

TABLE (2): ARD MODULE PERFORMANCE FOR NO WIND OFT-1 (CONTINUED)

2b) ARD Abort Availability Predictions Versus SVDS Results

ABORT MODE	PET SEC	ARD HM MARGIN FPS	SVDS RESULT FPS	ARD ERROR FPS
AOA	213	132.3	116.0	16.3
AOA	369	882.1	859.6	22.5
ATO	243	139.6	150.0	-10.4
ATO	417	581.4	568.4	13.0
MC	297	196.9	194.0	2.9
MC	417	581.6	568.6	13.0
RTLS	171	9243.	9337	7
RTLS	249	3481	3521	-40
RTLS	267	1861	1866	-5
RTLS	300	-1563	-1551	12

TABLE (3): ARD Second Stage Predictor Accuracy

P.E.T (seconds)	ARD Predicted MECO Time sec.	*Error SEC (ARD - SVDS)
126.7	522.61	-.33
152.7	522.74	-.20
200.7	522.70	-.24
249.0	522.88	-.06
297.0	522.93	-.01
351.0	522.92	-.02
399.0	522.97	+.03
447.0	522.91	-.03
501.0	522.96	+.02
519	522.97	+.03

* SVDS results: TMECO=522.94

TABLE (4): Ascent Numerical Integrator Accuracy

PARA METER	SDVS	ANI INTEGRATING FROM 0 SECONDS	ANI-SDVS	ANI INTEGRATING FROM 24 SECONDS	ANI-SDVS	ANI INTEGRATING FROM 49 SECONDS	ANI-SDVS	ANI INTEGRATING FROM 75 SECONDS	ANI-SDVS	ANI INTEGRATING FROM 98 SECONDS	ANI-SDVS	ANI INTEGRATING FROM 122 SECONDS	ANI-SDVS
γ (degrees)	26.9515	27.163	-.211	27.198	.246	27.191	.239	27.009	.0575	26.958	-.0065	27.083	-.13
V_E fps	4243.9	4249.8	5.9	4243.6	-.3	4241.0	-2.9	4241.5	-2.4	4240.3	-3.6	4244.4	.5
V_i fps	5244.5	5293.4	48.9	5282.9	38.4	5272.7	28.2	5263.7	19.2	5250.3	5.8	5246.4	1.9
$\bar{V}_i$ fps	164.4 -4225.1 3102.6	65.4 -4409.2 2928.3	-99 -184.1 -174.3	70.4 -4386.6 29434.2	-94 -161.5 -159.4	84.4 -4352.4 2975.0	-80 -127.3 -127.6	115.4 -4311.0 3018.0	-49 -85.9 -84.6	139.0 -4258.8 3067.4	-25.4 -33.7 -35.2	140.9 -4230.2 3100.1	-23.5 -5.1 -2.5
R_i ft	21052207.	21054256.	2048.	+21054009	1801.	21053721	1513.	21052676	468.	21052292	84.	21052238	30.
$\bar{R}_i$ ft	-18236443. -2861585. 10121212	-18242971. -2872055. 10110739.	6528. -10470. -10473	-18242024. -2869546. 10112645.	5581. -7961. -8567	-18240500. -2866703. 10115599.	4057. -5118 -5613	-18238044. -2864339. 10118522.	1601. -2754 -2690.	-18236815. -2862170. 120120552.	372. -585 -660	-18236491 -2861599. 10121191.	48. 6 -21
W lbs	1499227	1499244	17.0	1499243	16.0	1499377.6	150.6	1499319.5	92.5	1499318.1	91.1	1499316.7	89.7
ET lbs FUEL	1204422.1	1204439.	16.9	1204437.8	15.7	1204572.6	150.5	1204514.5	92.4	1204513.1	91.0	1204511.7	89.6
NOM VAM fps	647.2	607.7	-40.0	614.8	-32.4	635.0	-12.2	655.0	7.8	673.6	26.4	691.6	44.4

TABLE (5): ARD Mass Track Accuracy

PET	SVDS WT.	ARD WT.	ARD-SVDS	ET SVDS WT	ET ARD WT	ARD-SVDS
0	4439479.9	4439486.	6.1	1558092.0	1558093.	0
49.0	3245948.0	3246040.	92.	1424375.2	1424453.	78.
98.0	2206437.4	2206328.	-109.	1293280.3	1293358.	78.
152.7	1418682.3	1418759.	77.	1123877.3	1123954.	77.
200	1269984.3	1270061.	76.	975179.31	975256.	76.
249	1120306.3	1120384.	77.	825501.3	825579.	77.
303	953021.03	953099.	77.	658216.05	658294.	77.
351	804323.03	804400.	77.	509518.05	509595.	76.
399	652527.15	655702.	31	357722.1	360897.	31.
447	506927.04	507004.	77	212122.05	212199.	76.
501	356192.58	356128	-64	61387.59	61323.	-64.
519	316316.46	316206.	-110	21511.476	21401.	-110

TABLE (6): ARD Module Performance for MC (76% Partial Trust)

6a) Nominal Margin Prediction

PET SEC	ARD NOMINAL MARGIN FT/SEC	SVDS FT/SEC	ERROR (ARD-SDVS) FT/SEC	MECO TIME ARD SEC	MECO SVDS SEC	ERROR ARD-SDVS SEC
74.0	136.3	143.4	-7.1	562.5	561.7	.08
152.7	157.3	143.4	13.9	561.8	561.7	.1
200.7	172.1	143.4	28.7	561.5	561.7	-.2
248.7	172.5	143.4	29.1	561.6	561.7	-.1
303.0	163.9	143.4	20.5	561.6	561.7	-.1
399.0	155.8	143.4	12.4	561.6	561.7	-.1
453.0	152.4	143.4	9.0	561.7	561.7	.0
501.0	123.61	143.4	-19.8	561.7	561.7	.0
549.0	122.7	143.4	-20.7	561.7	561.7	.0
561.0	111.1	143.4	-32.3	561.9	561.7	.2

6b) ARD-Predicted Mode Boundary Shift

ABORT TYPE	BOUNDARY AFTER FAILURE (SEC)	*RFP BOUNDARY (SEC)	BOUNDARY SHIFT (SEC)
AOA	283	213	70
ATO	426	245	181
MC	426	300	126
RTLS	309	290	19

* Reference 13

TABLE (7): ARD Module Performance for ATO Abort of No-Wind OFT-1

PET SEC	ARD ATO MARGIN FT/SEC	SVDS RESULT FT/SEC	ARD ERROR ARD-SDVS FT/SEC	ARD PREDICTED TIME SEC	ACTUAL MECO SVDS SEC	ERROR ARD-SDVS SEC
249.6	167.5	152.1	15.3	-	617.8	-
255.0	164.5	152.1	12.4	-	617.8	-
261.0	163.3	152.1	11.2	618.8	617.8	1.0
267.0	158.3	152.1	6.2	618.8	617.8	1.0
273.0	128.4	152.1	-23.7	618.0	617.8	.2
303.0	126.6	152.1	-25.4	618.0	617.8	.2
327.0	124.6	152.1	-27.5	618.0	617.8	.2
351.0	125.5	152.1	-26.6	618.0	617.8	.2
399.0	123.3	152.1	-28.8	617.4	617.8	-.4
453.0	128.5	152.1	-23.6	617.9	617.8	.1
501.	134.5	152.1	-17.6	617.8	617.8	0.0
549.	145.4	152.1	-6.7	617.8	617.8	0.0
615.	150.2	152.1	-1.9	617.8	617.8	0.0

TABLE (8): ARD Module Performance for AOA Abort of Mean-Wind OFT-1

PET SEC	ARD AOA MARGIN FT/SEC	SVDS RESULT FT/SEC	ERROR ARD-SDVS FT/SEC	ARD PREDICTED MECO TIME SEC	ACTUAL MECO SVDS SEC	ERROR MECO ARD-SDVS SEC
237.0	4.0	42.9	-38.9	632.1	631.4	.7
243.0	6.7	42.9	-36.2	632.1	631.4	.7
273.0	3.8	42.9	-39.1	631.7	631.4	.3
303.0	9.5	42.9	-33.4	631.7	631.4	.3
351.0	19.2	42.9	-23.0	631.6	631.4	.2
399.0	23.7	42.9	-19.2	631.5	631.4	.1
447.0	29.9	42.9	-13.0	631.6	631.4	.2
519.	34.0	42.9	-8.9	631.5	631.4	.1

TABLE (9): ARD Module Performance For RTLS Abort of Mean-Wind OFT-1

PET SEC	ARD RTLS MARGIN FT/SEC	SVDS RESULT FT/SEC	ERROR (ARD-SVDS) FT/SEC
459	370*	298	72*
507	317	298	19
555	301	298	3
603	303	298	5
651	303	298	5
705	298	298	0

* Reflects vehicle performance if 96% throttle had been maintained from end of turn to start of powered pitchdown. Ground and onboard throttle were adjusted to 95% throttle at 505 seconds.

TABLE (10): ARD Characteristics Table

PARAMETER	PARAMETER DESCRIPTION	VALUE
M_{NOMHM}	Nominal 2-SSME HM margin slope at mode boundry	7.17 ft/s^2
M_{ATOHM}	ATO 2-SSME HM margin slope at mode boundry	8.91 ft/s^2
M_{AOAHM}	AOA2-SSME HM margin	11.14 ft/s^2
M_{QTLSHM}	RTLS margin slope at mode boundary	103.16 ft/s^2
$V_{NOMAM\ MEAN\ WIND}$	Non-dispersed second stage nominal AM margin for mean first stage winds	546.0 ft/sec
$V_{NOMAM\ NO\ WIND}$	Non-dispersed nominal AM margin for no winds	684.5 ft/sec
$V_{L/O\ NOM\ HM}$	Liftoff nominal 2-SSME HM margin	-2799.2 ft/s
$V_{L/O\ ATO\ HM}$	Liftoff ATO 2-SSME HM margin	-2486.5 ft/s
$V_{L/O\ AOA\ HM}$	Lfitoff AOA 2-SSME HM margin	-2204.1 ft/s
$V_{L/O\ RTLS\ HM}$	Liftoff RTLS 2-SSME HM margin	12203.0 ft/s
$V_{EAOA\ DELAY}$	Early AOA abort enactment delay penalty	-.55 ft/sec
$V_{AOA\ SWITCH}$	AOA target switch velocity	7292 ft/sec
$V_{ATO\ SWITCH}$	ATO target switch velocity	9230. ft/sec
FPR	Mission FPR not considered in ARD margins	262.1 ft/sec
TOLERANCE	ARD module worst case margin uncertainty	40 ft/sec

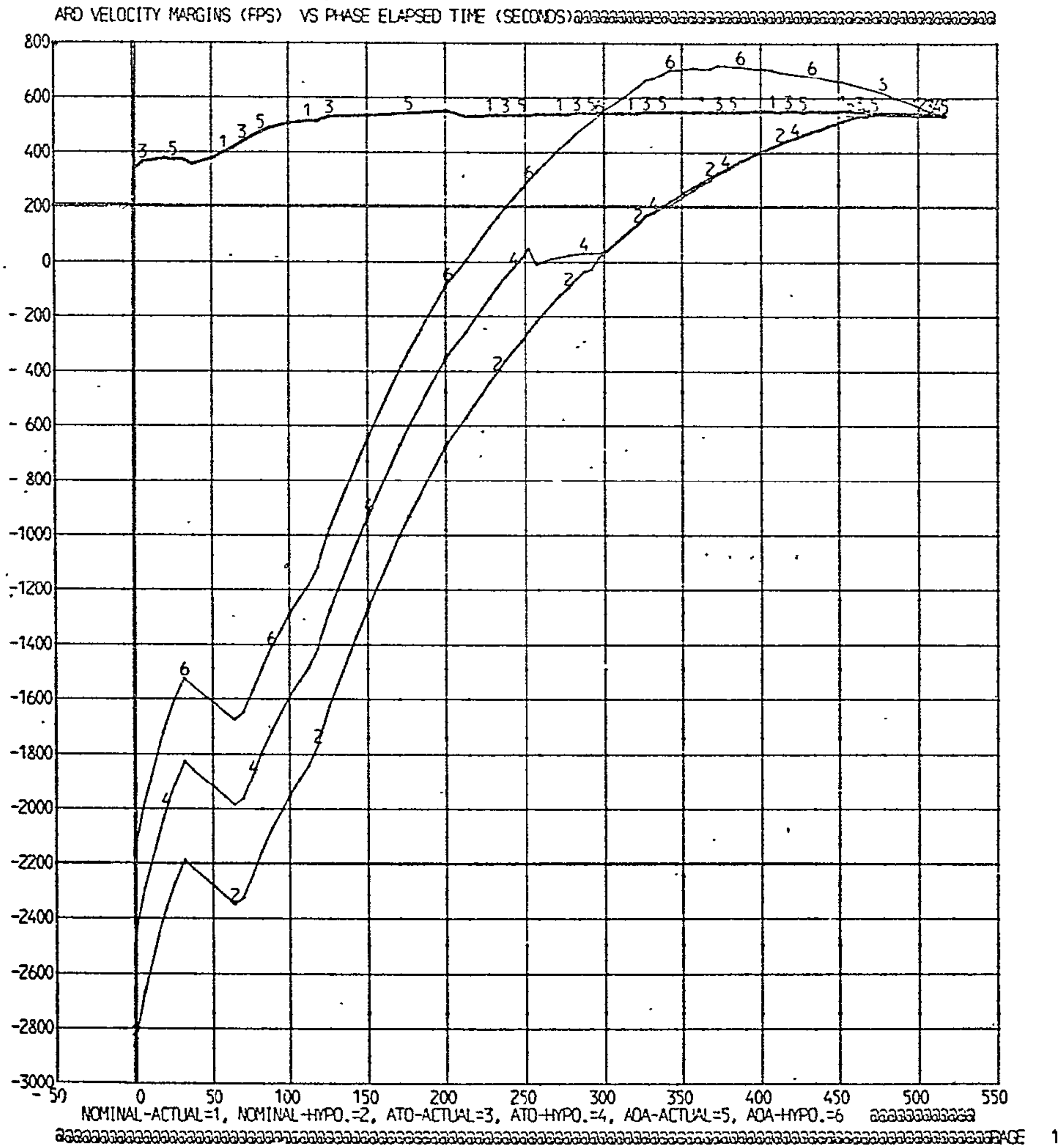


FIGURE 1.1: Mean-Wind OFT-1 Ascent - ARD Downrange Margin Histories

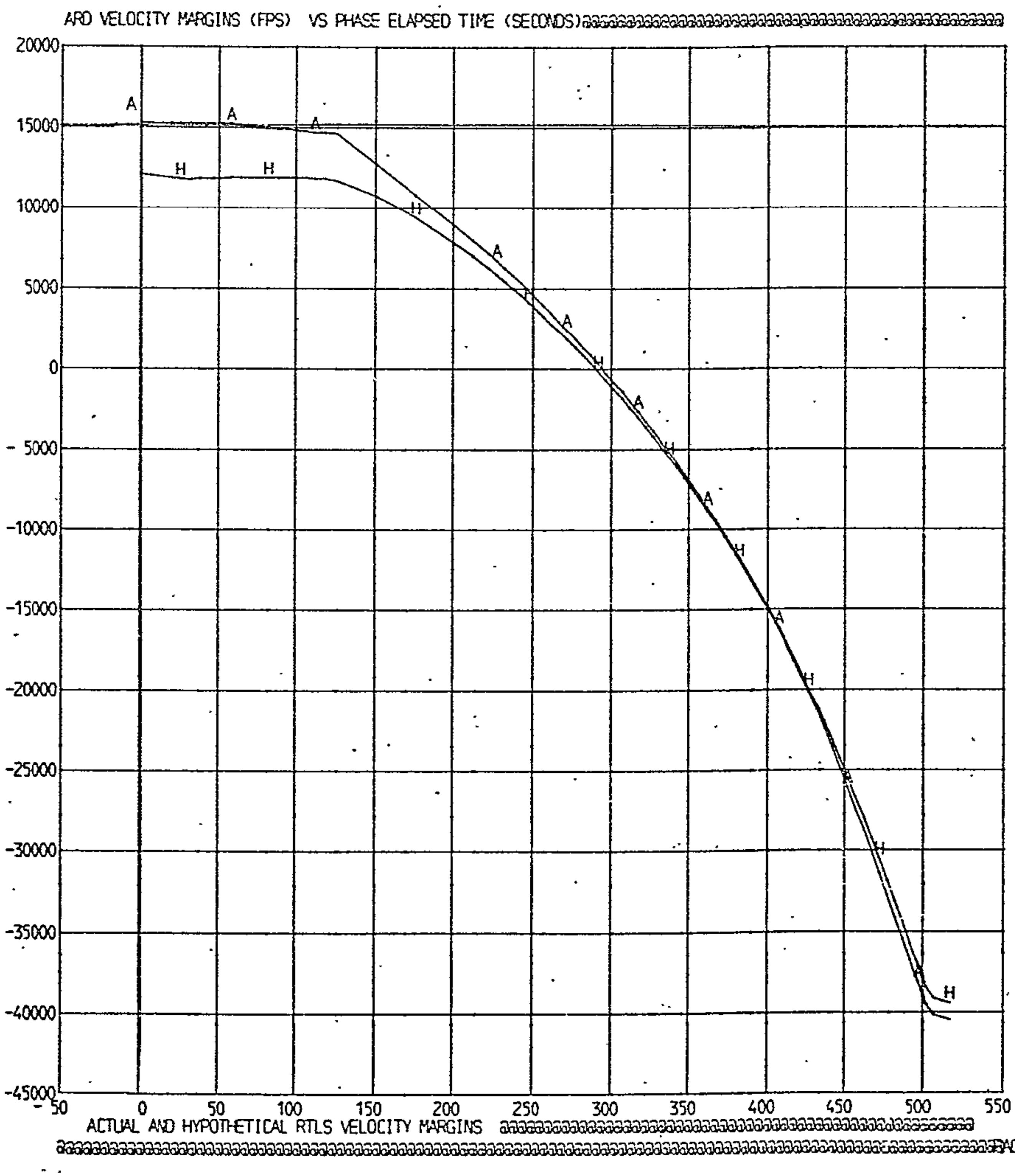


FIGURE 1.2: Mean-Wind OFT-1 Ascent - ARD RTLS Margin Histories

```
                 ABORT REGION DETERMINATOR

      PET    58.0       SELECTED SOURCETLM       GMT L/045000.0
                                     I
           ACTUAL MODE               I       HYPOTHETICAL MODE
            THROTTLES                I          THROTTLES
  COMMANDED  .0          ABORT       I
       L      C      R    SEL        I
   TLM   .00    .00    .00    NOM    I                          L      C      R
   ARD   .63    .63    .63           I      HYPOTHETICAL      .00   1.09   1.09
           VEL MARGINS               I          VEL MARGINS
  REGION    MPROP    XOMS      SUM   I REGION    MPROP     XOMS       SUM
                                     I
   NOM    400.37      .00      .00   I NOM -2317.80         .00        .00
                                     I
  RTLS15283.81            15283.81   I RTLS11938.37              11938.37
                                     I
   AOA    400.55      .00      .00   I AOA -1646.25         .00        .00
                                     I
   ATO    400.55      .00      .00   I ATO  -1955.54        .00        .00
       EVENT   TLM     ARD           I    RTLS EVENT PREDICTION
       TGO       .0   467.5          I       DELO DISS        .0  TMECO      .0
       MECO     .00  525.55          I   TIME TO TURN        .00  RMECO      .0
       TMECO     .0      .0          I        PET TURN       .00  VMECO      .0
       VMECO     0.  25668.          I TIME END TURN         .00  GMECO      .0

  PRPLT    OMS     RCS   CURRENT WT  I       DELTHT PITCH       .0
  LBS   17584.   3797.    VEH3067720.I       MECO-IS        .0
  DELV     58.   [illegible]    ETP1406745.I       PITCHDOWN Z        .0
```


FIGURE 1.3 CONTINUED

```
                    ABORT REGION DETERMINATOR

        PET  126.0        SELECTED SOURCETLM        GMT L/045000.0
                                                I
             ACTUAL MODE                        I      HYPOTHETICAL MODE
     ---------------------------------------------------------------------
               THROTTLES                        I         THROTTLES
     COMMANDED  .0                ABORT         I
               L      C      R     SEL          I
        TLM    .00    .00    .00       NOM      I                          L      C      R
        ARD   1.00   1.00   1.00                I     HYPOTHETICAL      .00   1.09   1.09
     ---------------------------------------------------------------------
              VEL MARGINS                       I        VEL MARGINS
     REGION   MPROP      XOMS       SUM         I REGION    MPROP       XOMS       SUM
                                                I
      NOM     535.29      .00        .00        I NOM -1625.73           .00        .00
                                                I
      RTLS14722.08             14722.08         I RTLS11779.76            11779.76
                                                I
      AOA     535.09      .00        .00        I AOA   -979.74          .00        .00
                                                I
      ATO     535.09      .00        .00        I ATO  -1277.47          .00        .00
     ---------------------------------------------------------------------
           EVENT   TLM     ARD                  I      RTLS EVENT PREDICTION

             TGO       .0   398.1               I       DELO DISS        .0 TMECO       .0
             MECO     .00  524.12               I   TIME TO TURN       .00 RMECO       .0
             TMEO      .0      .0               I       PET TURN       .00 VMECO       .0
             VMEO      0.  25668.               I TIME END TURN       .00 GMECO       .0

     PRPLT    OMS     RCS    CURRENT WT         I     DELTHT PITCH          .0
     LBS   17584.    3797.    VEH1501343.       I     MECO-IS           .0
     DELV    119.  [illegible]    ETP1206538.   I     PITCHDOWN Z           .0
```


FIGURE 1.3 CONTINUED

```
                ABORT REGION DETERMINATOR

     PET  212.0       SELECTED SOURCETLM        GMT L/045000.0
                                      I
          ACTUAL MODE                 I      HYPOTHETICAL MODE
          THROTTLES                   I         THROTTLES
COMMANDED  .0              ABORT      I
        L     C     R       SEL       I
  TLM    .00   .00   .00        NOM   I                     L     C     R
  ARD   1.00  1.00  1.00              I    HYPOTHETICAL    .00  1.09  1.09

       VEL MARGINS                    I        VEL MARGINS
REGION   MPROP    XOMS      SUM       I REGION   MPROP    XOMS     SUM
                                      I
 NOM    534.39     .00    534.39      I NOM   -571.86      .00 -571.86
                                      I
 RTLS 8072.83            8072.83      I RTLS 7065.88           7065.88
                                      I
 AOA    533.90  319.32    853.22      I AOA      5.07      .00    5.07
                                      I
 ATO    533.90  145.10    679.00      I ATO   -257.28      .00 -257.28

     EVENT   TLM     ARD              I    RTLS EVENT PREDICTION

      TGO       .0   312.1            I    DELO DISS      .0 TMECO      .0
     MECO      .00  524.09            I  TIME TO TURN    .00 RMECO      .0
     TMEO       .0      .0            I      PET TURN    .00 VMECO      .0
     VMEO       0.  25668.            I TIME END TURN    .00 GMECO      .0

PRPLT    OMS    RCS   CURRENT WT   I    DELTHT PITCH      .0
LBS   17584.  3797.   VEH1234926.I      MECO-IS       .0
DELV    145.  [redacted]  ETP 940121.I      PITCHDOWN Z       .0
```

FIGURE 1.3 CONTINUED

```
                    ABORT REGION DETERMINATOR

     PET  247.0       SELECTED SOURCETLM       GMT L/045000.0
                                            I
             ACTUAL MODE                    I      HYPOTHETICAL MODE

               THROTTLES                    I         THROTTLES
     COMMANDED  .0              ABORT       I
             L       C     R     SEL        I
       TLM     .00     .00    .00     NOM   I                        L      C      R
       ARD   1.00   1.00   1.00             I     HYPOTHETICAL     .00   1.09   1.09

             VEL MARGINS                    I        VEL MARGINS
     REGION     MPROP     XOMS      SUM     I REGION     MPROP     XOMS      SUM
                                            I
      NOM    538.76       .00    538.76     I NOM    -290.12       .00  -290.12
                                            I
      RTLS  4970.63              4970.63    I RTLS  4230.78              4230.78
                                            I
      AOA    538.94    319.32    858.26     I AOA     265.11       .00    265.11
                                            I
      ATO    538.94    145.10    684.04     I ATO      14.97       .00     14.97

          EVENT   TLM      ARD              I      RTLS EVENT PREDICTION

            TGO      .0    277.1            I      DELO DISS       .0  TMECO       .0
           MECO     .00   524.07            I    TIME TO TURN     .00  RMECO       .0
           TMEO      .0       .0            I         PET TURN    .00  VMECO       .0
           VMEO      0.   25668.            I   TIME END TURN     .00  GMECO       .0

     PRPLT    OMS    RCS    CURRENT WT  I      DELTHT PITCH       .0
     LBS   17584.   3797.   VEH1126500.I      MECO-IS        .0
     DELV    159.   [redacted]   ETP 831695.I      PITCHDOWN Z        .0
```

FIGURE 1.3 CONTINUED

```
                 ABORT REGION DETERMINATOR

  PET  292.0       SELECTED SOURCETLM       GMT L/045000.0
                                     I
          ACTUAL MODE                I      HYPOTHETICAL MODE
  -----------------------------------------------------------
            THROTTLES                I         THROTTLES
  COMMANDED  .0            ABORT     I
         L       C      R   SEL      I
     TLM   .00    .00    .00   NOM   I                    L     C     R
     ARD  1.00   1.00   1.00         I     HYPOTHETICAL  .00  1.09  1.09
  -----------------------------------------------------------
         VEL MARGINS                 I         VEL MARGINS
  REGION   MPROP   XOMS     SUM      I REGION   MPROP   XOMS     SUM
                                     I
   NOM   544.11     .00   544.11     I NOM    -25.28     .00   -25.28
                                     I
   RTLS  347.59           347.59     I RTLS  -112.63          -112.63
                                     I
   AOA   544.10  319.32   863.42     I AOA    515.53     .00   515.53
                                     I
   ATO   544.10  145.10   689.20     I ATO     34.32  116.90   151.22
  -----------------------------------------------------------
       EVENT   TLM      ARD          I      RTLS EVENT PREDICTION

          TGO      .0   232.2        I      DELQ DISS      .0 TMECO    .0
         MECO     .00  524.20        I   TIME TO TURN     .00 RMECO    .0
         TMEO      .0      .0        I        PET TURN    .00 VMECO    .0
         VMEO      0.  25668.        I TIME END TURN      .00 GMECO    .0

  PRPLT    OMS    RCS   CURRENT WT   I     DELTHT PITCH     .0
  LBS   17584.   3797.   VEH 987096.I      MECO-IS      .0
  DELV    181.   [redacted]   ETP 692291.I      PITCHDOWN Z      .0
```

FIGURE 1.3 CONTINUED

```
                 ABORT REGION DETERMINATOR

     PET  502.0       SELECTED SOURCETLM       GMT L/045000.0
                                     I
         ACTUAL MODE                 I      HYPOTHETICAL MODE
------------------------------------------------------------------
              THROTTLES              I        THROTTLES
COMMANDED  .0              ABORT     I
         L      C      R    SEL      I
   TLM    .00    .00    .00     NOM  I                         L      C      R
   ARD    .75    .75    .75          I     HYPOTHETICAL       .00   1.09   1.09
------------------------------------------------------------------
        VEL MARGINS                  I      VEL MARGINS
REGION   MPROP    XOMS      SUM      I REGION   MPROP     XOMS     SUM
                                     I
 NOM   539.15      .00   539.15      I NOM    544.80      .00   544.80
                                     I
 RTLS********          -39506.11     I RTLS********           -38437.32
                                     I
 AOA   539.07   319.32   858.38      I AOA    566.52   290.55   857.08
                                     I
 ATO   539.06   145.10   684.16      I ATO    544.70   145.10   689.80
------------------------------------------------------------------
       EVENT   TLM      ARD          I     RTLS EVENT PREDICTION

       TGO      .0     22.0          I     DELO DISS        .0 TMECO      .0
       MECO    .00  524.01           I   TIME TO TURN      .00 RMECO      .0
       TMEO     .0      .0           I        PET TURN     .00 VMECO      .0
       VMEO     0.  25668.           I TIME END TURN       .00 GMECO      .0

PRPLT    OMS    RCS   CURRENT WT  I      DELTHT PITCH       .0
LBS   17584.   3797.   VEH 353723.I      MECO-IS       .0
DELV    514.  [illegible]  ETP  58918.I      PITCHDOWN Z        .0
```

FIGURE 1.3 CONTINUED

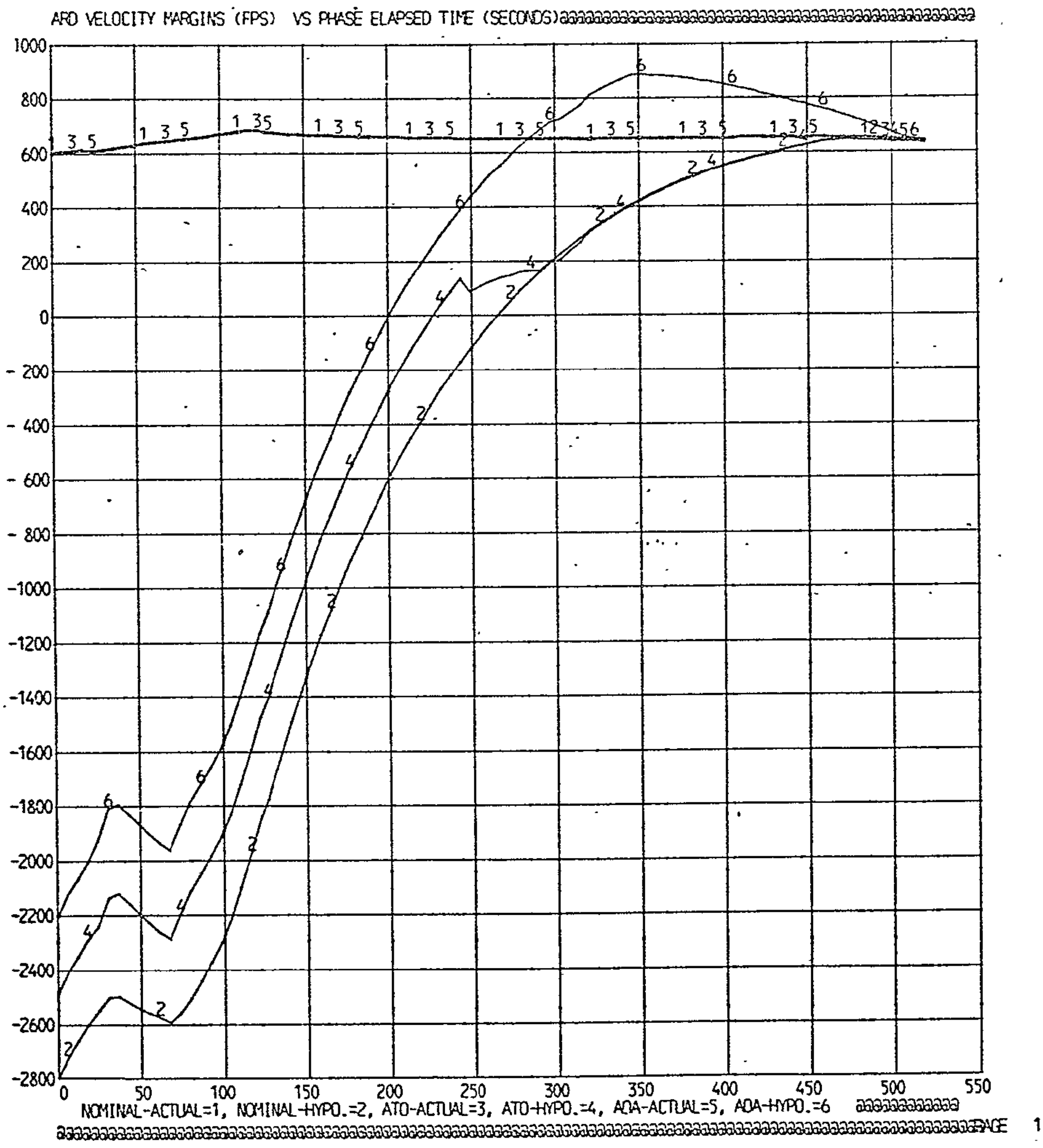


FIGURE 1.4: No-Wind OFT-1 Ascent - ARD Downrange Margin Histories

ORIGINAL PAGE IS
OF POOR QUALITY

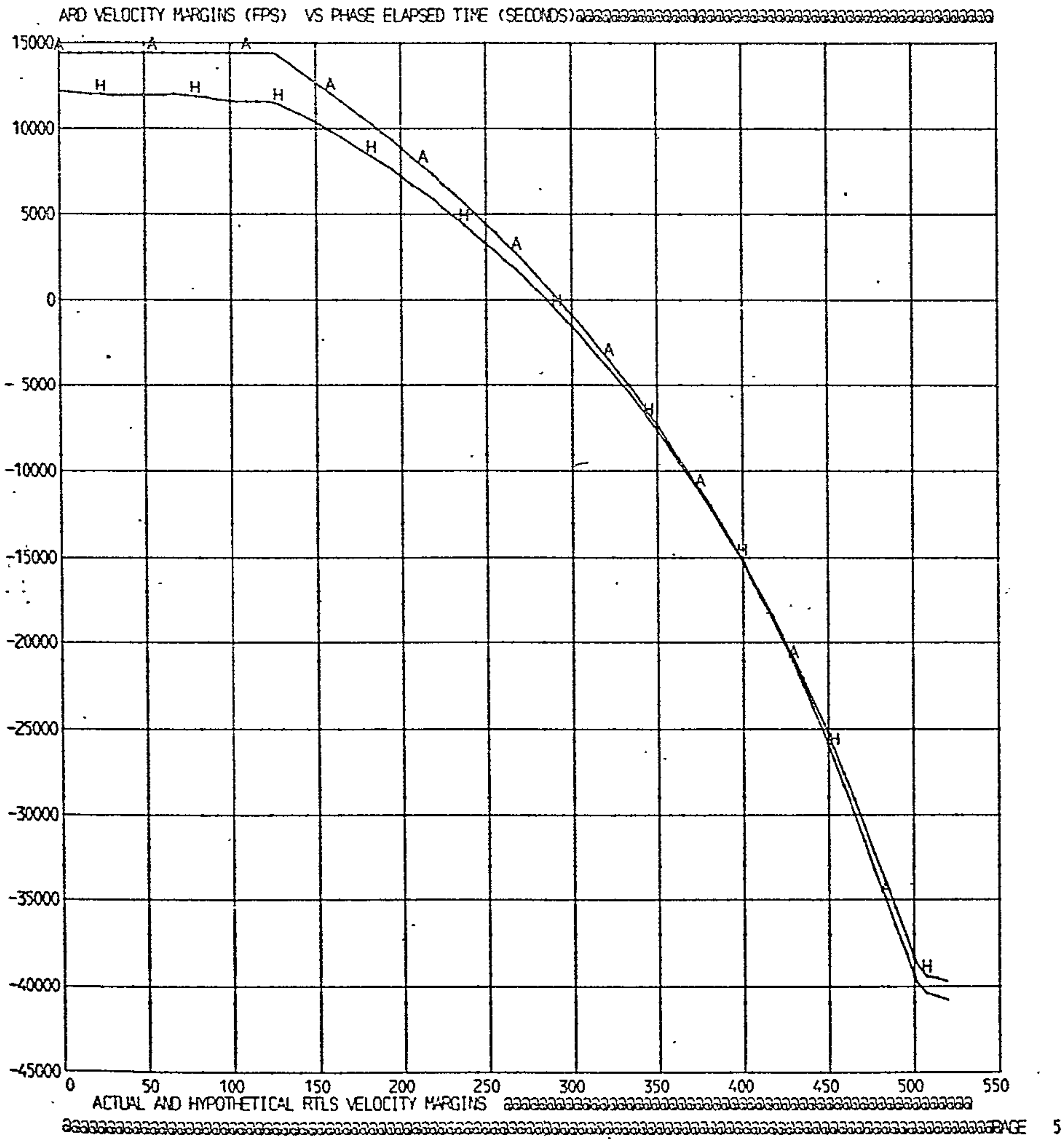


FIGURE 1.5: No-Wind OFT-1 - ARD RTLS Margin Histories

```
                      ABORT REGION DETERMINATOR
       PET      .0      SELECTED SOURCETLM          GMT L7045000.0
                                     I
           ACTUAL MODE               I      HYPOTHETICAL MODE
------------------------------------------------------------------------
              THROTTLES              I          THROTTLES
COMMANDED  .0              ABORT     I
         L     C     R      SEL      I
  TLM   .00   .00   .00     NOM      I
  ARD  1.00  1.00  1.00              I     HYPOTHETICAL      .00   1.09   1.09
------------------------------------------------------------------------
          VEL MARGINS                I          VEL MARGINS
REGION   MPROP    XOMS      SUM      I REGION    MPROP     XOMS     SUM
                                     I
 NOM    607.71     .00      .00      I NOM  -2799.20       .00      .00
                                     I
 RTLS14398.49          14398.49      I RTLS12203.08           12203.08
                                     I
 AOA    607.75     .0C      .00      I AOA  -2204.14       .00      .00
                                     I
 ATO    607.75     .00      .00      I ATO  -2486.53       .00      .00
------------------------------------------------------------------------
     EVENT    TLM     ARD            I    RTLS EVENT PREDICTION
                                     I
       TGO      .0   523.4           I     DELO DISS      .0 TMECO      .0
      MECO     .00   523.39          I  TIME TO TURN     .00 RMECO      .0
      TMEO      .0      .0           I      PET TURN     .00 VMECO      .0
      VMEO      0.  25668.           I TIME END TURN     .00 GMECO      .0

PRPLT     OMS    RCS   CURRENT WT    I     DELTHT PITCH       .0
LBS   17584.   3797.   VEH4439486.I        MECO-IS      .0
DELV      40.  [illegible]  ETP1558093.I   PITCHDOWN Z        .0
```


FIGURE 1.6: No-Wind OFT-1 ARD Digital Displays

```
                ABORT REGION DETERMINATOR
   PET  128.7       SELECTED SOURCETLM        GMT L7045000.0
                                      I
          ACTUAL MODE                 I     HYPOTHETICAL MODE
-------------------------------------------------------------------
            THROTTLES                 I         THROTTLES
COMMANDED   .0              ABORT     I
         L       C      R    SEL      I
  TLM   .00     .00     .00      NOM  I                       L      C      R
  ARD  1.00    1.00    1.00           I     HYPOTHETICAL     .00   1.09   1.09
-------------------------------------------------------------------
         VEL MARGINS                  I          VEL MARGINS
REGION   MPROP    XOMS      SUM       I REGION   MPROP      XOMS      SUM
                                      I
 NOM    682.66      .00   682.66      I NOM -1734.70        .00-1734.70
                                      I
 RTLS14264.70           14264.70      I RTLS11403.53           11403.53
                                      I
 AOA    682.13   319.33 1001.46       I AOA -1056.31        .01-1056.30
                                      I
 ATO    682.13   145.10  827.23       I ATO -1365.36        .00-1365.35
-------------------------------------------------------------------
      EVENT   TLM     ARD             I       RTLS EVENT PREDICTION

        TGO        .0   393.9         I      DELO DISS      .0 TMECO      .0
       MECO       .00  522.62         I  TIME TO TURN      .00 RMECO      .0
       TMEO        .0      .0         I      PET TURN      .00 VMECO      .0
       VMEO        0.  25668.         I TIME END TURN      .00 GMECO      .0

PRPLT    OMS    RCS   CURRENT WT   I      DELTHT PITCH        .0
LBS   17584.   3797.   VEH1493108.I      MECO-IS       .0
DELV    119.  [illegible]  ETP1198303.I      PITCHDOWN Z         .0
```


FIGURE 1.6 CONTINUED

```
                    ABORT REGION DETERMINATOR
      PET  200.7        SELECTED SOURCETLM          GMT L7045000.0
                                           I
           ACTUAL MODE                     I      HYPOTHETICAL MODE
   ------------------------------------------------------------------
                 THROTTLES                 I          THROTTLES
   COMMANDED  .0               ABORT       I
           L       C      R     SEL        I
     TLM     .00     .00     .00      NOM  I                      L      C      R
     ARD   1.00    1.00    1.00            I     HYPOTHETICAL    .00   1.09   1.09
   ------------------------------------------------------------------
            VEL MARGINS                    I           VEL MARGINS
   REGION    MPROP      XOMS       SUM     I REGION    MPROP      XOMS      SUM
                                           I
    NOM     662.39       .00    662.39     I NOM     -586.98       .00  -586.98
                                           I
    RTLS   8821.28             8821.28     I RTLS    7178.18             7178.18
                                           I
    AOA     661.62    319.33    980.95     I AOA        6.12       .01     6.13
                                           I
    ATO     661.62    145.10    806.73     I ATO     -262.60       .00  -262.60
   ------------------------------------------------------------------
          EVENT   TLM     ARD              I    RTLS EVENT PREDICTION

             TGO       .0    322.0         I       DELO DISS       .0  TMECO      .0
            MECO      .00    522.70        I   TIME TO TURN       .00  RMECO      .0
            TMEO       .0        .0        I       PET TURN       .00  VMECO      .0
            VMEO       0.    25668.        I TIME END TURN        .00  GMECO      .0

   PRPLT     OMS      RCS     CURRENT WT   I       DELTHT PITCH      .0
   LBS    17584.     3797.    VEH1270061.  I       MECO-IS         .0
   DELV     140.   [redacted] ETP  975256. I       PITCHDOWN Z       .0
```

FIGURE 1.6 CONTINUED

ABORT REGION DETERMINATOR

```
PET  225.0        SELECTED SOURCETLM         GMT L/045000.0
                                  I
         ACTUAL MODE              I      HYPOTHETICAL MODE
----------------------------------------------------------------------
           THROTTLES              I           THROTTLES
COMMANDED  .0              ABORT  I
      L       C      R      SEL   I
  TLM   .00     .00     .00     NOM I                        L       C       R
  ARD  1.00   1.00   1.00         I      HYPOTHETICAL     .00   1.09   1.09
----------------------------------------------------------------------
          VEL MARGINS             I           VEL MARGINS
REGION    MPROP     XOMS     SUM  I REGION    MPROP     XOMS      SUM
                                  I
 NOM    658.66       .00   658.66 I NOM    -330.19       .00  -330.19
                                  I
 RTLS 6756.43             6756.43 I RTLS 5368.36               5368.36
                                  I
 AOA    658.45   319.33   977.78  I AOA     243.97       .01   243.98
                                  I
 ATO    658.45   145.10   803.56  I ATO     -14.15       .00   -14.15
----------------------------------------------------------------------
      EVENT   TLM      ARD        I      RTLS EVENT PREDICTION

        TGO      .0   297.8       I        DELO DISS        .0 TMECO      .0
        MECO    .00  522.80       I  TIME TO TURN         .00 RMECO      .0
        TMEO     .0      .0       I         PET TURN       .00 VMECO      .0
        VMEO     0.  25668.       I TIME END TURN          .00 GMECO      .0

PRPLT    OMS    RCS    CURRENT WT   I     DELTHT PITCH       .0
LBS   17584.  3797.    VEH1194733.I     MECO-IS          .0
DELV    149.  [redacted]  ETP 899928.I     PITCHDOWN Z        .0
```

FIGURE 1.6 CONTINUED

```
                    ABORT REGION DETERMINATOR
        PET  285.0        SELECTED SOURCETLM          GMT L7045000.0
                                       I
              ACTUAL MODE              I      HYPOTHETICAL MODE
      ------------------------------------------------------------------
                THROTTLES              I          THROTTLES
      COMMANDED  .0           ABORT    I
             L      C     R    SEL     I
        TLM  .00   .00   .00      NOM  I                     L     C     R
        ARD 1.00  1.00  1.00           I     HYPOTHETICAL   .00  1.09  1.09
      ------------------------------------------------------------------
              VEL MARGINS              I      VEL MARGINS
      REGION   MPROP   XOMS     SUM    I REGION   MPROP     XOMS     SUM
                                       I
       NOM   653.76      .00  653.76   I NOM    128.92      .00   128.92
                                       I
       RTLS  803.32           803.32   I RTLS    19.71             19.71
                                       I
       AOA   653.76  319.33   973.09   I AOA    656.43      .01   656.44
                                       I
       ATO   653.76  145.10   798.86   I ATO    167.26   120.27   287.54
      ------------------------------------------------------------------
            EVENT   TLM    ARD         I    RTLS EVENT PREDICTION

             TGO      .0   237.9       I      DELO DISS      .0 TMECO      .0
            MECO     .00  522.93       I   TIME TO TURN     .00 RMECO      .0
            THEO      .0      .0       I       PET TURN     .00 VMECO      .0
            VMEO      0.  25668.       I TIME END TURN      .00 GMECO      .0

      PRPLT   OMS    RCS   CURRENT WT  I     DELTHT PITCH       .0
      LBS  17584.   3797.  VEH1008860.I      MECO-IS        .0
      DELV   177.  [illegible]  ETP 714055.I      PITCHDOWN Z        .0
```

FIGURE 1.6 CONTINUED

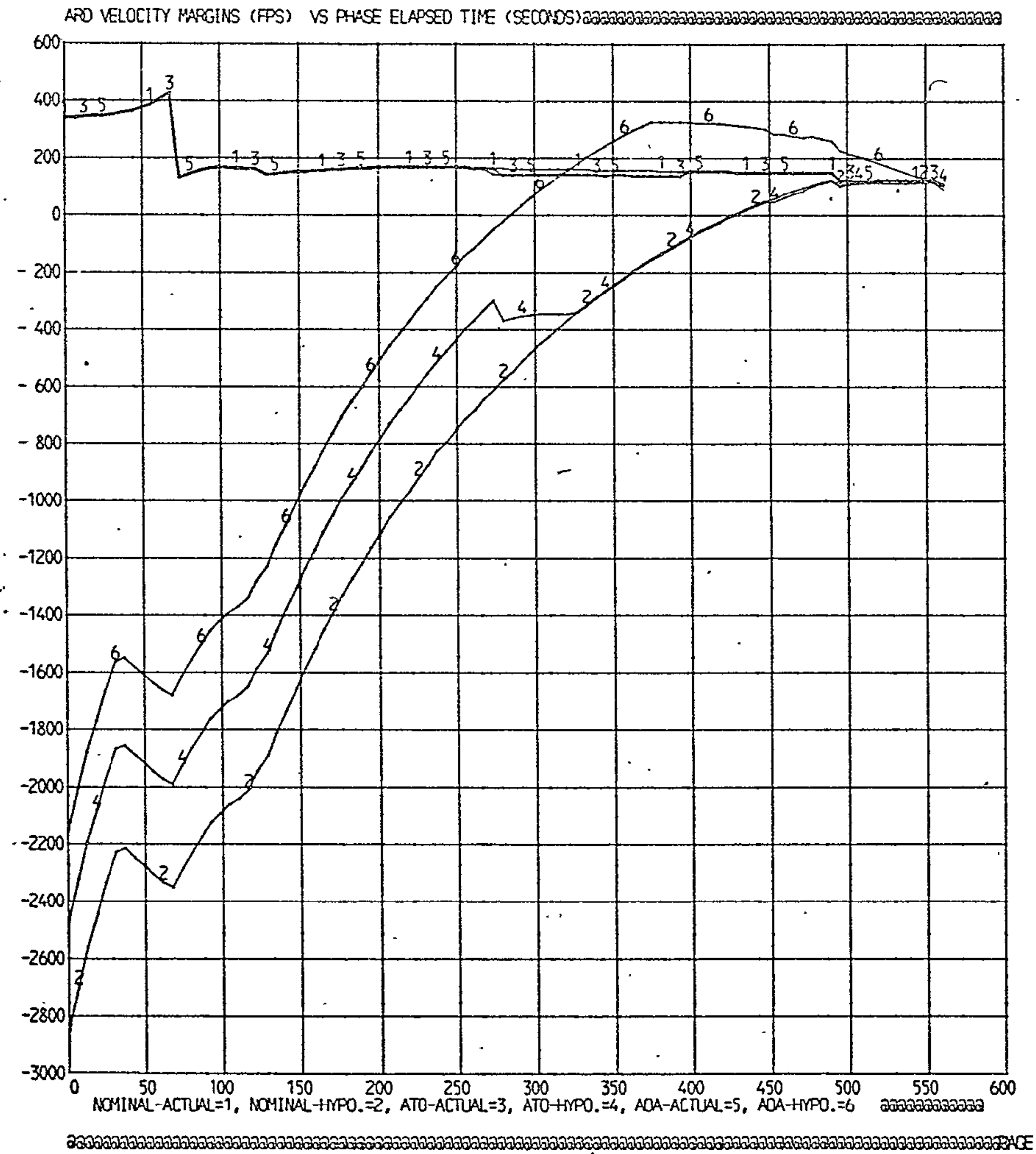


FIGURE 2.1: Mean-Wind OFT1 MC - Downrange Margin Histories for SSME-Partial-Loss-of-Thrust Failure

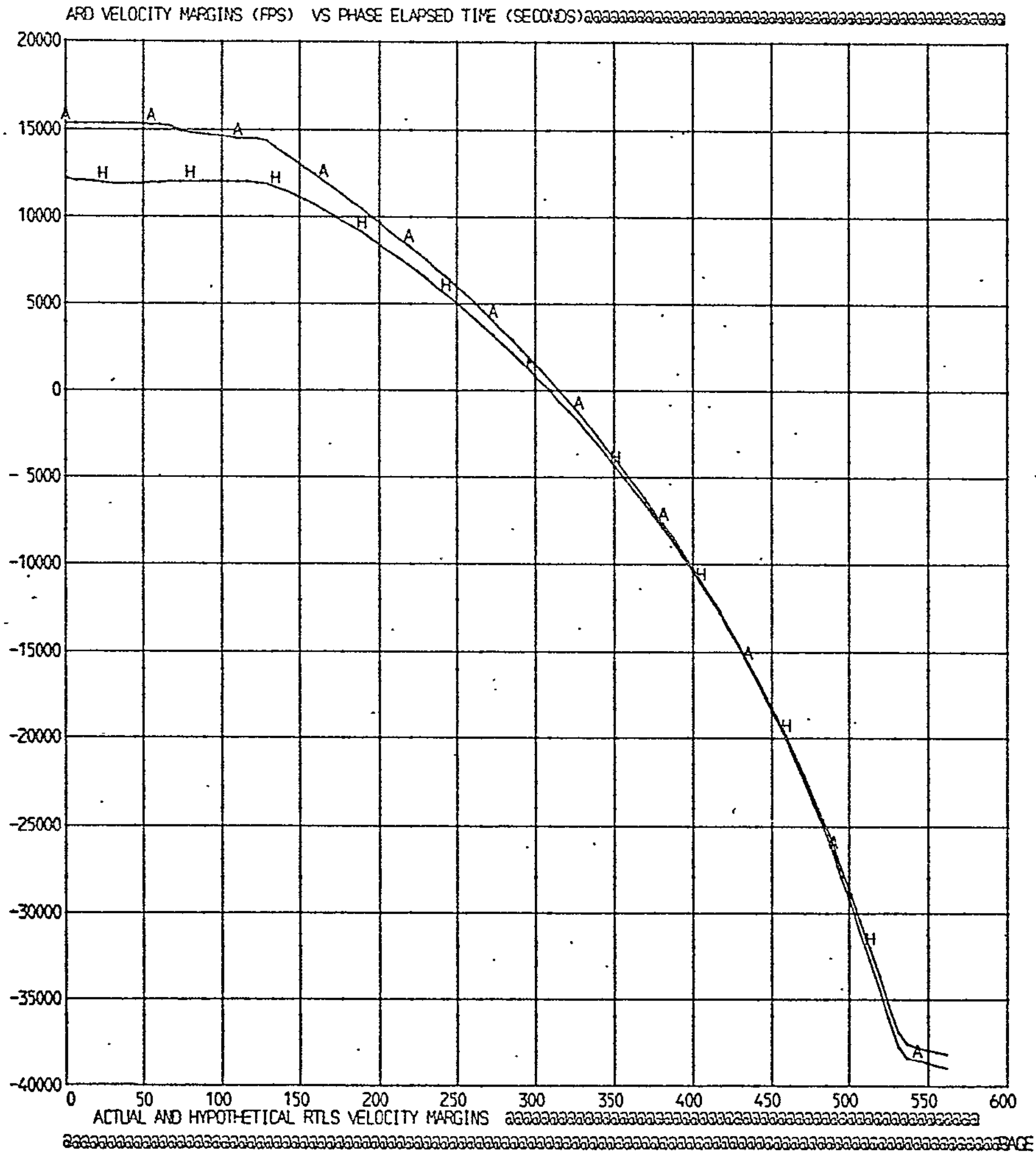


FIGURE 2.2: Mean-Wind OFT-1 MC - RTLS Margin Histories For SSME-Partial-Loss-Of-Thrust

```
                    ABORT REGION DETERMINATOR

     PET   74.0      SELECTED SOURCE TLM        GMT L/045000.0
                                     I
            ACTUAL MODE              I     HYPOTHETICAL MODE
-----------------------------------------------------------------
            THROTTLES                I        THROTTLES
  COMMANDED  .C          ABORT       I
        L      C     R    SEL        I
    TLM    .00   .00   .00   NOM     I                        L     C     R
    ARD    .76  1.00  1.00           I   HYPOTHETICAL       .00  1.09  1.09
-----------------------------------------------------------------
          VEL MARGINS                I       VEL MARGINS
  REGION   MPROP    XOMS      SUM    I REGION   MPROP     XOMS      SUM
                                     I
   NOM   136.32      .00       .00   I NOM  -2296.18       .00      .00
                                     I
   RTLS14951.27            14951.27  I RTLS11971.13            11971.13
                                     I
   AOA   135.95      .00       .00   I AOA  -1613.78       .00      .00
                                     I
   ATO   135.95      .00       .00   I ATO  -1923.51       .00      .00
-----------------------------------------------------------------
         EVENT   TLM      ARD        I      RTLS EVENT PREDICTION

          TGO      .0   486.5        I     DELO DISS    .0  TMECO     .0
          MECO   .00  562.53         I   TIME TO TURN   .00 RMECO     .0
          TMEO    .0       .0        1       PET TURN   .00 VMECO     .0
          VMEO    0.  25668.         I TIME END TURN    .00 GMECO     .0

  PRPLT    OMS    RCS   CURRENT WT   I      DELTHT PITCH       .0
  LBS  17584.   3797.   VEH2727558.I        MECO-IS       .0
  DELV     65.  [redacted]  ETP1369121.I    PITCHDOWN Z        .0
```


FIGURE 2.3: ARD Digital Displays for OFT-1 MC with SSME Partial Loss of Thrust

ABORT REGION DETERMINATOR

```
PET  285.0       SELECTED SOURCETLM       GMT L/045000.0
                                    I
        ACTUAL MODE                 I     HYPOTHETICAL MODE
------------------------------------------------------------------
          THROTTLES                 I         THROTTLES
COMMANDED  .0            ABORT      I
       L      C     R     SEL       I
 TLM  .00    .00   .00        NOM   I                        L     C     R
 ARD  .76   1.00   1.00             I     HYPOTHETICAL      .00  1.09  1.09
------------------------------------------------------------------
        VEL MARGINS                 I        VEL MARGINS
REGION  MPROP    XOMS     SUM       I REGION   MPROP     XOMS     SUM
                                    I
 NOM   165.25     .00   165.25      I NOM   -542.71       .00  -542.71
                                    I
 RTLS 2921.73          2921.73      I RTLS  2172.07            2172.07
                                    I
 AOA   144.93  319.32   464.25      I AOA      8.61       .00     8.61
                                    I
 ATO   145.21  145.10   290.31      I ATO   -359.11     27.71  -331.41
------------------------------------------------------------------
    EVENT  TLM     ARD              I     RTLS EVENT PREDICTION
                                    I
     TGO      .0   270.6            I        DELO DISS       .0 TMECO      .0
     MECO    .00  561.58            I   TIME TO TURN        .00 RMECO      .0
     TMEO     .0      .0            I        PET TURN       .00 VMECO      .0
     VMEO     0.  25068.            I TIME END TURN         .00 GMECO      .0

PRPLT    OMS     PCS     CURRENT WT I      DELTHT PITCH       .0
LBS   17584.   3797.   VEH100234.   I      MECO-IS          .0
DELV    169.   [illegible]   ETP 765429.  I      PITCHDOWN Z        .0
```

FIGURE 2.3 CONTINUED

```
                    ABORT REGION DETERMINATOR

    PET  309.0       SELECTED SOURCETLM       GMT L/045000.0
                                   I
           ACTUAL MODE             I      HYPOTHETICAL MODE
------------------------------------------------------------------
            THROTTLES              I        THROTTLES
  COMMANDED  .0          ABORT     I
          L     C     R   SEL      I
     TLM  .00   .00   .00    NOM   I                         L     C     R
     ARD  .76  1.00  1.07          I   HYPOTHETICAL         .00  1.09  1.09
------------------------------------------------------------------
            VFL MARGINS            I        VEL MARGINS
  REGION  MPROP    XOMS     SUM    I REGION  MPROP     XOMS    SUM
                                   I
  NOM    164.14     .00   164.14   I NOM    -419.91     .00  -419.91
                                   I
  RTLS   610.83           610.83   I RTLS      1.40              1.40
                                   I
  AOA    144.90  319.32   464.22   I AOA     114.54     .00   114.54
                                   I
  ATO    145.15  145.10   290.25   I ATO    -343.78   96.52  -247.26
------------------------------------------------------------------
      EVENT   TLM      ARD         I      RTLS EVENT PREDICTION

       TGO     .0    252.7         I      DELQ GISS       .0 TMECO     .0
      MECO    .00    561.71        I  TIME TO TURN       .00 RMECO     .0
      TMEO    .0        .0         I       PET TURN      .00 VMECO     .0
      VMEO    0.  25668.           I TIME END TURN       .00 GMECO     .0

  PRPLT    OMS    RCS   CURRENT WT I    DELTHT PITCH      .0
  LBS   17584.  3797.   VEH 991798.I    MLCG-IS        .0
  DELV    180.  3140.   ETP 696993.I    PITCHDOWN Z       .0
```

FIGURE 2.3 CONTINUED

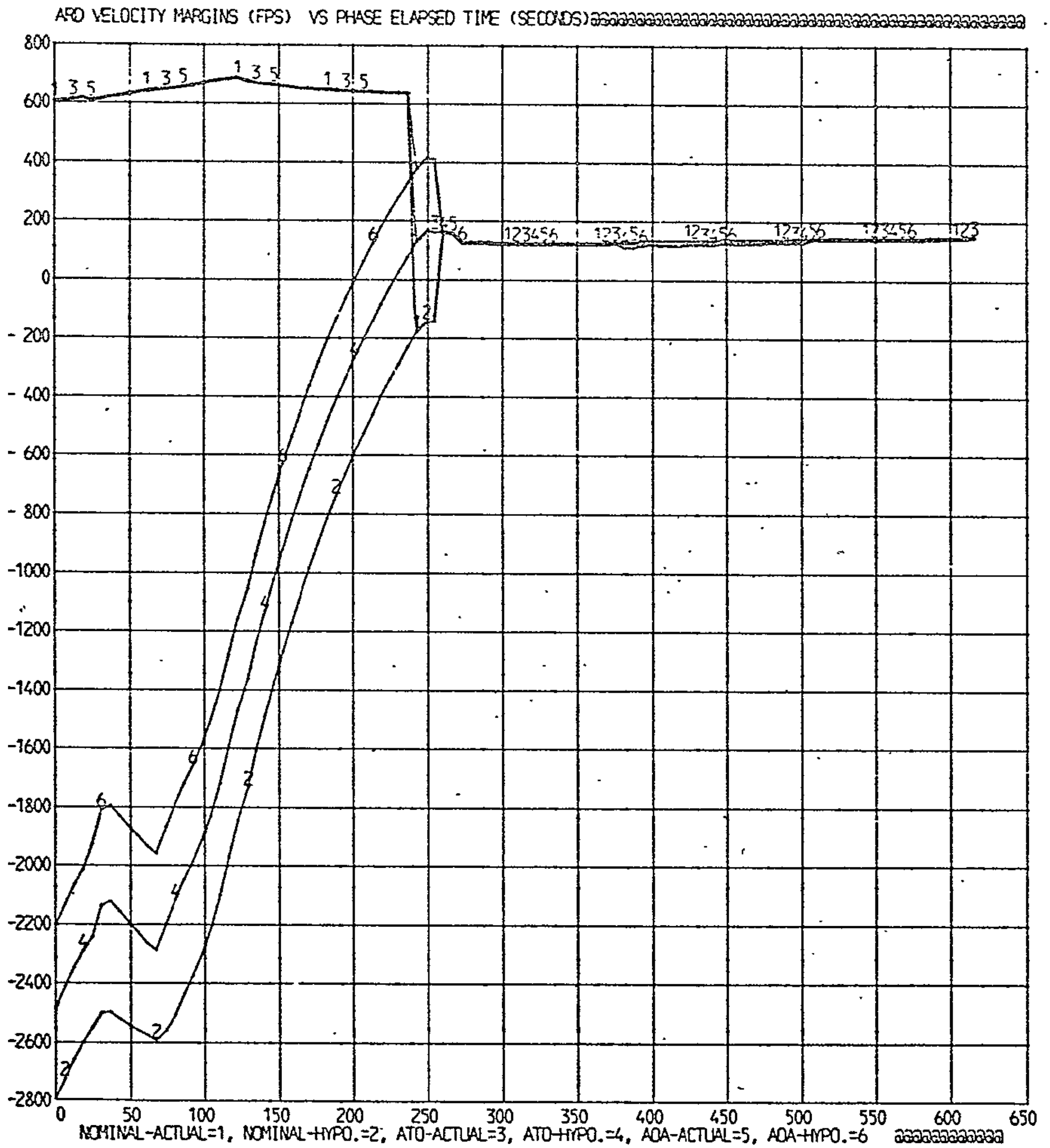


FIGURE 3.1: ATO - Aborted No-Wind OFT-1 - ARD Downrange Margin Histories

ORIGINAL PAGE IS
OF POOR QUALITY

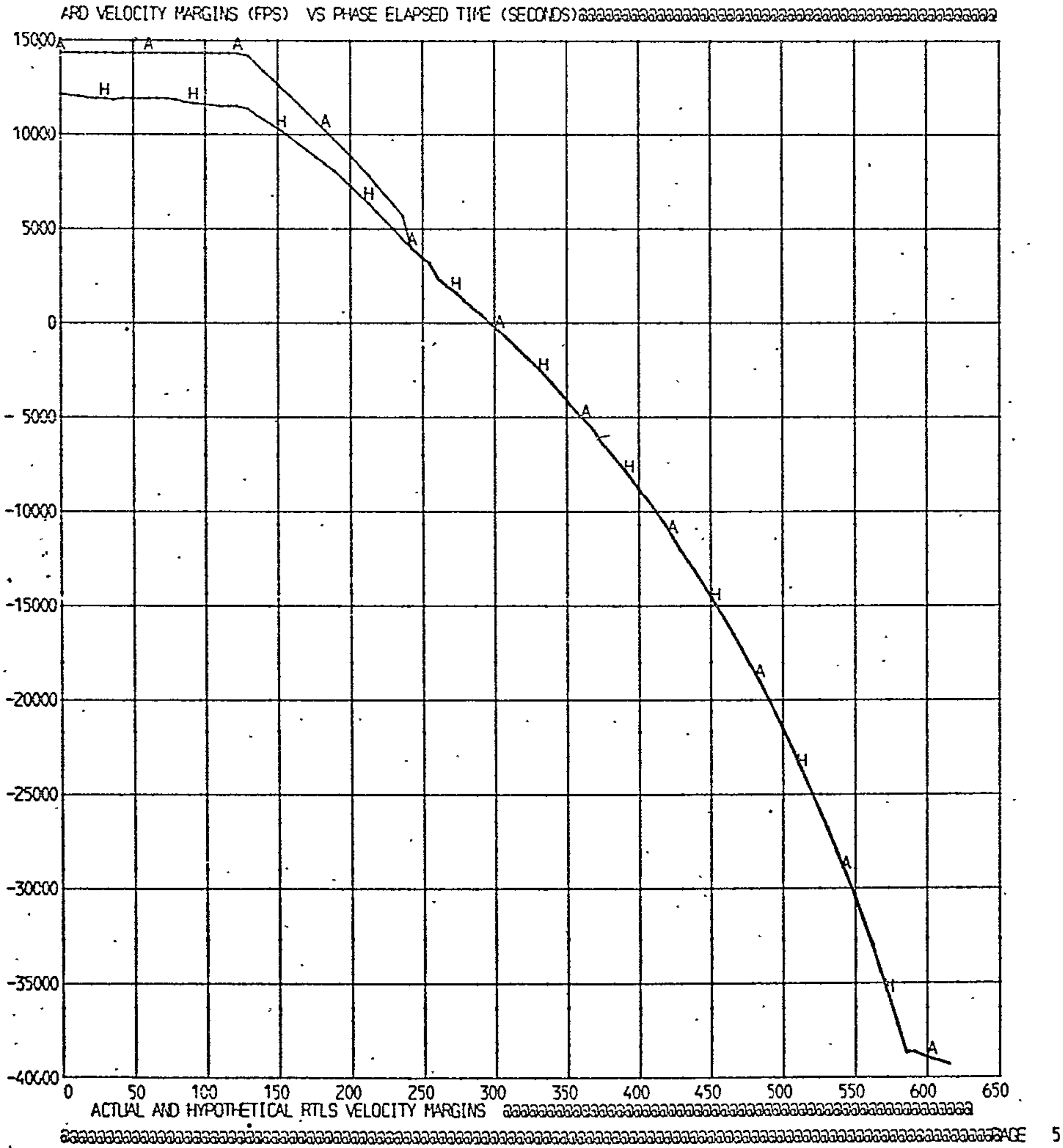


FIGURE 3.2: ATO - Aborted No-Wind OFT-1 - ARD RTLS Margin Histories

```
                 ABORT REGION DETERMINATOR
     PET  242.7       SELECTED SOURCETLM        GMT L/045000.0
                                         I
          ACTUAL MODE                    I     HYPOTHETICAL MODE
 ---------------------------------------------------------------------
          THROTTLES                      I         THROTTLES
 COMMANDED  .0                  ABORT    I
       L        C        R       SEL     I
  TLM     .00     .00     .00        NOM I                    L      C      R
  ARD     .00   1.09   1.09              I    HYPOTHETICAL   .00   1.09   1.09
 ---------------------------------------------------------------------
         VEL MARGINS                     I       VEL MARGINS
 REGION   MPROP    XOMS      SUM         I REGION    MPROP    XOMS     SUM
                                         I
  NOM   -175.66       .00  -175.66       I NOM   -175.76       .00  -175.76
                                         I
  RTLS 4026.76              4026.76      I RTLS 4026.75              4026.75
                                         I
  AOA    384.39       .01   384.40       I AOA    384.39       .01   384.40
                                         I
  ATO    133.43       .00   133.43       I ATO    133.43       .00   133.43
 ---------------------------------------------------------------------
       EVENT   TLM     ARD               I     RTLS EVENT PREDICTION

        IGO     .0   379.1               I     DELQ DISS      .0 TMECO     .0
        MECO   .00  621.83               I   TIME TO TURN    .00 RMECO     .0
        TMEO    .0   242.7               I        PET TURN   .00 VMECO     .0
        VMFO    0.   6922.               I TIME END TURN     .00 GMECO     .0

 PRPLT    OMS     RCS    CURRENT WT      I     DELTHT PITCH        .0
 LBS   17584.   3797.    VEH1347580.I          MECO-IS       .6
 DELV    157.  [illegible]  ETP 845781.I       PITCHDOWN Z         .0
```

FIGURE 3.3: ATO - Aborted OFT 1 ARD Digital Displays

ABORT REGION DETERMINATOR

```
PET  261.0        SELECTED SOURCETLM        GMT L/045000.0
                                   I
          ACTUAL MODE              I        HYPOTHETICAL MODE
-------------------------------------------------------------------
            THROTTLES              I           THROTTLES
COMMANDED  .C              ABORT   I
      L      C     R        SEL    I
  TLM   .00   .0    .00       ATO  I                        L      C      R
  ARD   .00  1.09   1.09       -   I    HYPOTHETICAL       .00   1.09   1.09
-------------------------------------------------------------------
        VEL MARGINS                I        VEL MARGINS
REGION   MPROP    XOMS       SUM   I REGION   MPROP     XOMS      SUM
                                   I
 NOM   [redacted] [redacted] [redacted] I NOM  [redacted] [redacted] [redacted]
                                   I
 RTLS  [redacted]          [redacted]  I RTLS [redacted]          [redacted]
                                   I
 AOA   [redacted] [redacted] [redacted] I AOA  [redacted] [redacted] [redacted]
                                   I
 ATO   163.23      .00     163.29  I ATO   163.29      .00    163.29
-------------------------------------------------------------------
     EVENT   TLM      ARD          I     RTLS EVENT PREDICTION
     TGO      .0    357.6          I     DELC DIST       .0 TMECO      .0
     MECO    .00   616.81          I   TIME TO TURN     .00 RMECO      .0
     TMEO     .0    242.7          I        PET TURN    .00 VMECO      .0
     VMEO     0.    6922.          I  TIME END TURN     .00 GMECO      .0

PRPLT    OMS     RCS   CURRENT WT  I    DELTHT PITCH       .0
LBS    17584.   3797.   VEH1099364.I    MECO-IS         .0
DELV     142.  [redacted]   ETP 804559.I    PITCHDOWN Z        .0
```

FIGURE 3.3 CONTINUED

ORIGINAL PAGE IS
OF POOR QUALITY

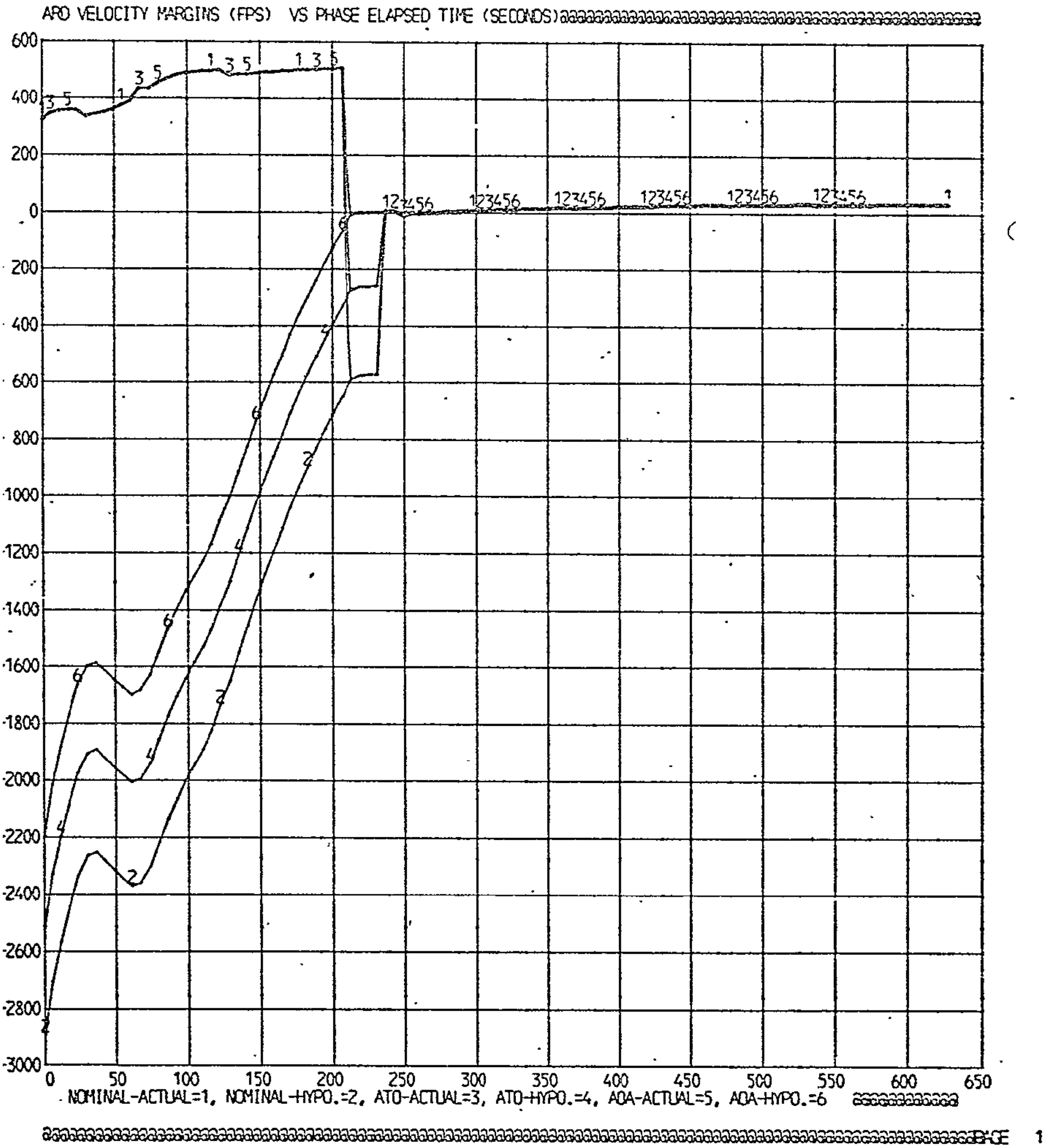


FIGURE 4.1: AOA-Aborted Mean-Wind OFT-1 - ARD
Downrange Margin Histories

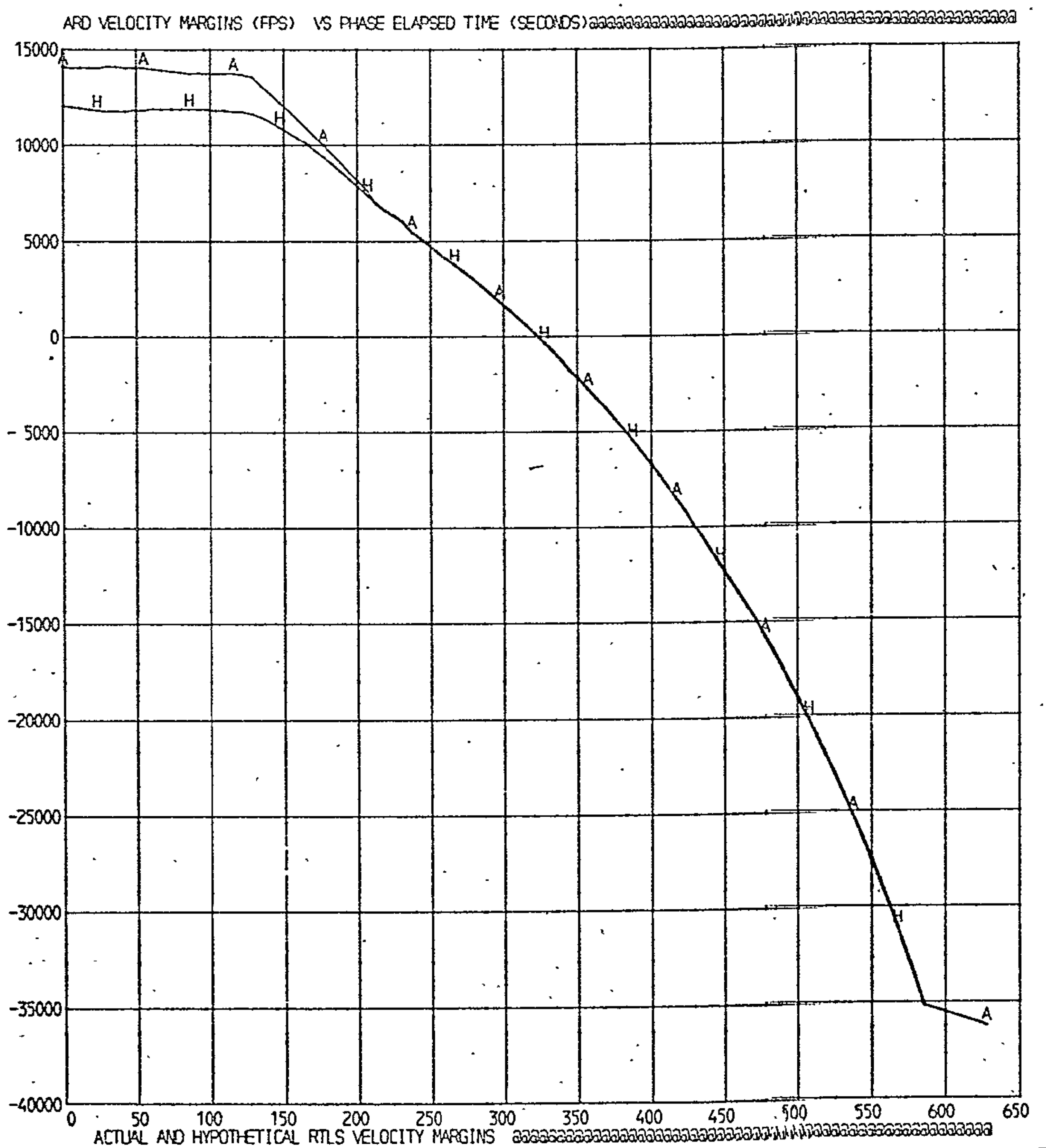


FIGURE 4.2: AOA-Aborted Mean-Wind OFT-1 - ARD RTLS Margin Histories

```
                    ABORT REGION DETERMINATOR

     PET  213.0      SELECTED SOURCETLM      GMT L/045000.0
                                        I
            ACTUAL MODE                 I      HYPOTHETICAL MODE
----------------------------------------------------------------------
             THROTTLES                  I           THROTTLES
COMMANDED  .0                 ABORT     I
          L      C      R      SEL      I
                                                         L      C      R
  TLM    .00    .00    .00      NOM     I
  ARD    .00   1.09   1.09              I    HYPOTHETICAL     .00   1.09   1.09
----------------------------------------------------------------------
           VEL MARGINS                  I          VEL MARGINS
REGION   MPROP     XOMS       SUM       I REGION    MPROP      XOMS       SUM
                                        I
 NOM   -585.05      .00  -585.05        I NOM     -585.56       .00  -585.56
                                        I
 RTLS  7012.69            7012.69       I RTLS    7012.68             7012.68
                                        I
 AOA     -7.32      .00     -7.32       I AOA       -7.32       .00     -7.32
                                        I
 ATO   -269.62      .00   -269.62       I ATO     -269.62       .00   -269.62
----------------------------------------------------------------------
       EVENT   TLM      ARD             I     RTLS EVENT PREDICTION

        ICO      .0    424.3            I      DELO DISS      .0  TMECO      .0
       MECO     .00   637.29            I   TIME TO TURN     .00  RMECO      .0
       TMEO      .0    213.0            I       PET TURN     .00  VMECO      .0
       VMEO      0.    5737.            I TIME END TURN      .00  GMECO      .0

PRPLT    OMS     RCS   CURRENT WT       I     DELTHT PITCH         .0
LBS   17584.   3797.   VEH1232677.      I     MECO-IS           .0
DELV    145.  [illegible]  ETP 937872.  I     PITCHDOWN Z          .0
```

FIGURE 4.3: AOA-Aborted OFT-1 ARD Digital Displays

```
ABORT REGION DETERMINATOR

PET  237.0        SELECTED SOURCE TLM         GMT L/045000.0
                                          I
        ACTUAL MODE                       I      HYPOTHETICAL MODE
--------------------------------------------------------------------
         THROTTLES                        I        THROTTLES
COMMANDED  .C                ABORT        I
        L     C      R        SEL         I
TLM    .00   .00    .00             AOA   I                          L      C      R
ARD    .00   1.09   1.09                  I   HYPOTHETICAL          .00   1.09   1.09
--------------------------------------------------------------------
          VEL MARGINS                     I       VEL MARGINS
REGION   MPROP      XOMS        SUM       I REGION   MPROP      XOMS        SUM
                                          I
NOM   [illegible] [illegible] [illegible] I NOM   [illegible] [illegible] [illegible]
                                          I
RTLS  [illegible]             [illegible] I RTLS  [illegible]             [illegible]
                                          I
AOA      3.96       .00         3.96      I AOA      3.96       .00         3.96
                                          I
ATO   [illegible] [illegible] [illegible] I ATO   [illegible] [illegible] [illegible]
--------------------------------------------------------------------
   EVENT    TLM      ARD                  I     RTLS EVENT PREDICTION

   IGO       .0    305.1                  I        DELQ DISS       .0 TMECO    .0
   MECO     .00    632.13                 I   TIME TO TURN        .00 RMECO    .0
   TMFO      .0    213.0                  I       PET TURN        .00 VMECO    .0
   VMEO      0.    5737.                  I  TIME END TURN        .00 GMECO    .0

PRPLT    OMS      RCS       CURRENT WT    I    DELTHT PITCH      .0
LBS   17594.     3797.     VEH1178661.    I    MECO-IS        .0
DELV    151.   [illegible] ETP 683656.    I    PITCHDOWN Z       .0
```

FIGURE 4.3 CONTINUED

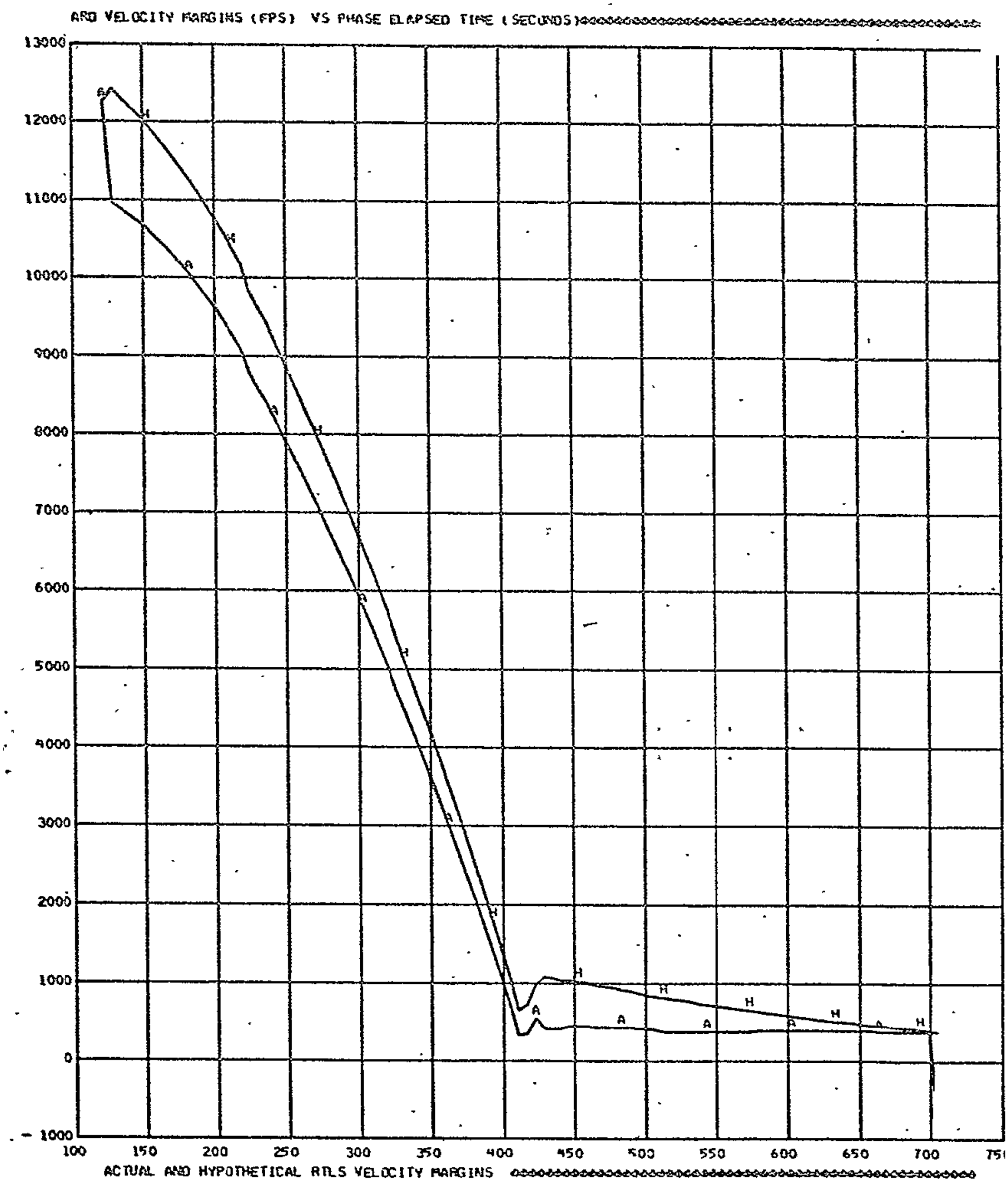


FIGURE 5.1: RTLS-Aborted Mean-Wind OFT-1 - ARD
RTLS Margin Histories

```
                    ABORT REGION DETERMINATOR
       PET  122.7      SELECTED SOURCETLM      GMT L7045000.0
                                    I
            ACTUAL MODE             I      HYPOTHETICAL MODE
------------------------------------------------------------------
               THROTTLES            I        THROTTLES
COMMANDED  .0               ABORT   I
          L     C     R      SEL    I
 TLM     .00   .00   .00       NOM  I                      L     C     R
 ARD     .00  1.09  1.09            I     HYPOTHETICAL   .00  1.09  1.09
------------------------------------------------------------------
          VEL MARGINS               I        VEL MARGINS
REGION   MPROP    XOMS     SUM      I REGION    MPROP    XOMS     SUM
                                    I
 NOM -2664.92      .00      .00     I NOM -2664.92       .00      .00
                                    I
 RTLS12204.70          12204.70     I RTLS12204.70           12204.70
                                    I
 AOA -1956.91      .00      .00     I AOA -1956.91       .00      .00
                                    I
 ATO -2277.22      .00      .00     I ATO -2277.22       .00      .00
------------------------------------------------------------------
      EVENT   TLM     ARD           I      RTLS EVENT PREDICTION

       TGO     .0     58.0          I      DELO DISS      .0 TMECO    .0
       MECO   .00  180.68           I   TIME TO TURN     .00 RMECO    .0
       TMEO    .0      .0           I       PET TURN     .00 VMECO    .0
       VMEO    0.      0.           I TIME END TURN      .00 GMECO    .0

PRPLT    OMS    RCS   CURRENT WT  I     DELTHT PITCH      .0
LBS   17584.  3797.   VEH1574710.I     MECO-IS        .0
DELV    113.  [illegible]  ETP1279905.I     PITCHDOWN Z        .0
```


FIGURE 5.2: RTLS-Aborted OFT-1 ARD Digital Displays

ABORT REGION DETERMINATOR

PET 423.0 SELECTED SOURCETLM GMT L/045000.0

ACTUAL MODE					I	HYPOTHETICAL MODE			
	THROTTLES				I	THROTTLES			
COMMANDED	.0			ABORT	I				
	L	C	R	SEL	I				
TLM	.00	.00	.00	RTLS	I		L	C	R
ARD	.00	1.09	1.09		I	HYPOTHETICAL	.00	1.09	1.09

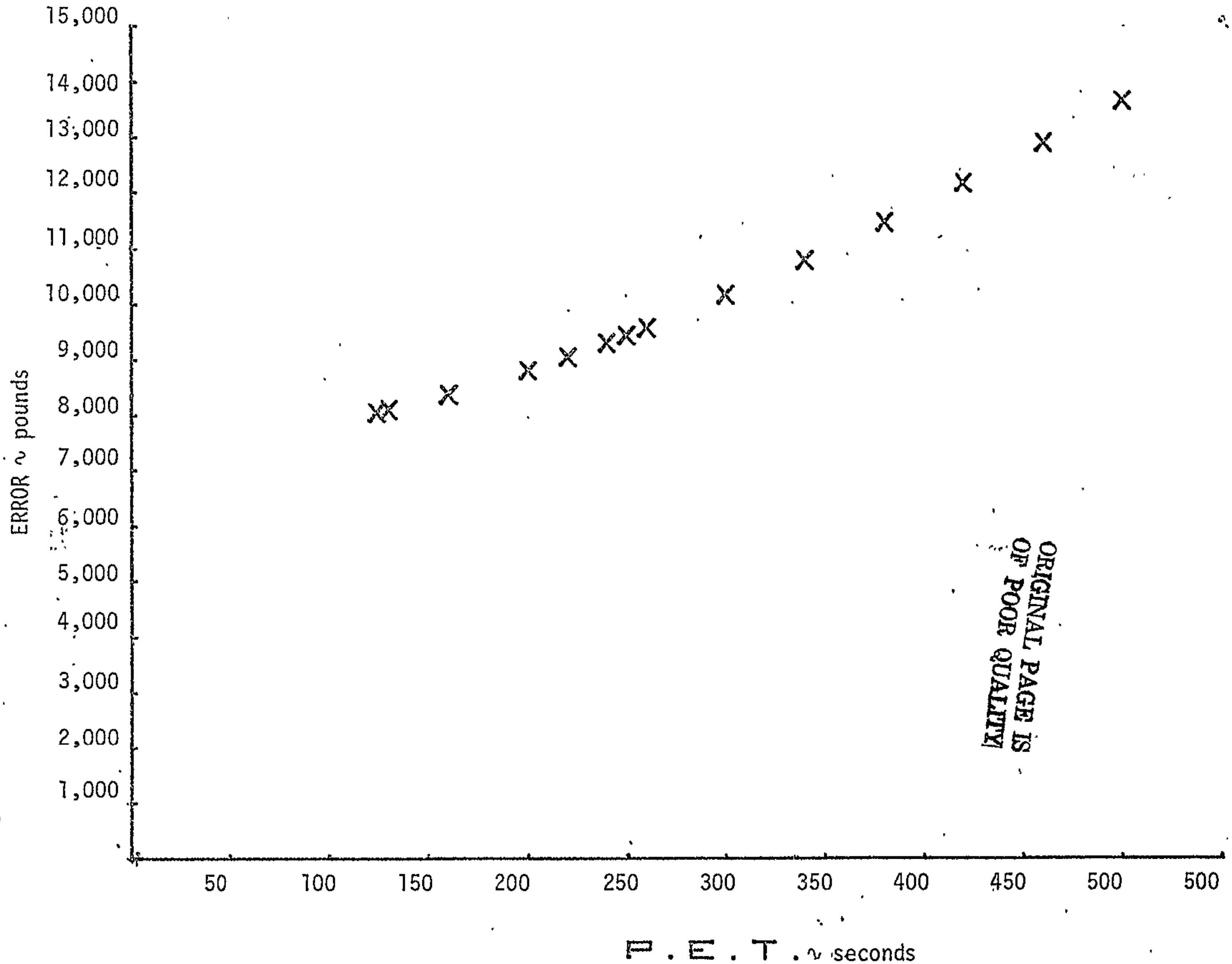
	VEL MARGINS			I		VEL MARGINS		
REGION	MPROP	XOMS	SUM	I	REGION	MPROP	XOMS	SUM
NOM	[redacted]	[redacted]	[redacted]	I	NOM	[redacted]	[redacted]	[redacted]
RTLS	3.5.17		385.17	I	RTLS	831.74		831.74
AOA	[redacted]	[redacted]	[redacted]	I	AOA	[redacted]	[redacted]	[redacted]
ATO	[redacted]	[redacted]	[redacted]	I	ATO	[redacted]	[redacted]	[redacted]

EVENT	TLM	ARD	I	RTLS EVENT PREDICTION			
TGO	.0	*****	I	DELO DISS	.0	TMECO	.0
MECO	.00	******	I	TIME TO TURN	.00	RMECO	.0
TMEO	.0	.0	I	PET TURN	.00	VMECO	.0
VMEO	0.	0.	I	TIME END TURN	.00	GMECO	.0

PRPLT	OMS	RCS	CURRENT WT	I		
LBS	6320.	1053.	VEH 884753.	I	DELTHT PITCH	.0
DELV	72.	[redacted]	ETP 604006.	I	MECO-IS	.0
					PITCHDOWN Z	.0

FIGURE 5.3 CONTINUED

FIGURE 6.1: Worst-Case Special MPS Processor Errors



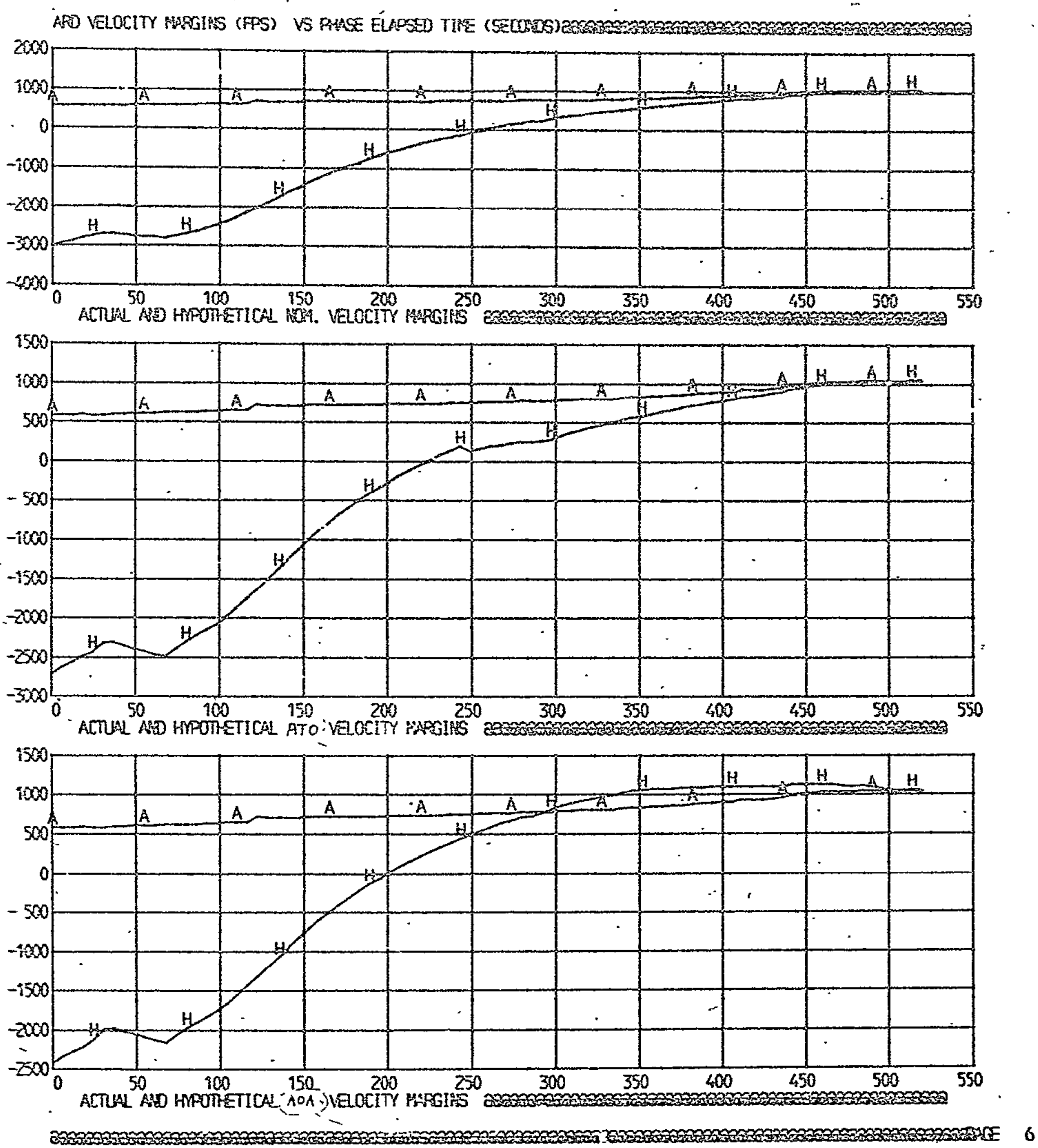


FIGURE 6.2: No-Wind OFT-1 ARD Downrange Margin Histories for Worst-Case Special MPS Processor Weight Errors

6.5

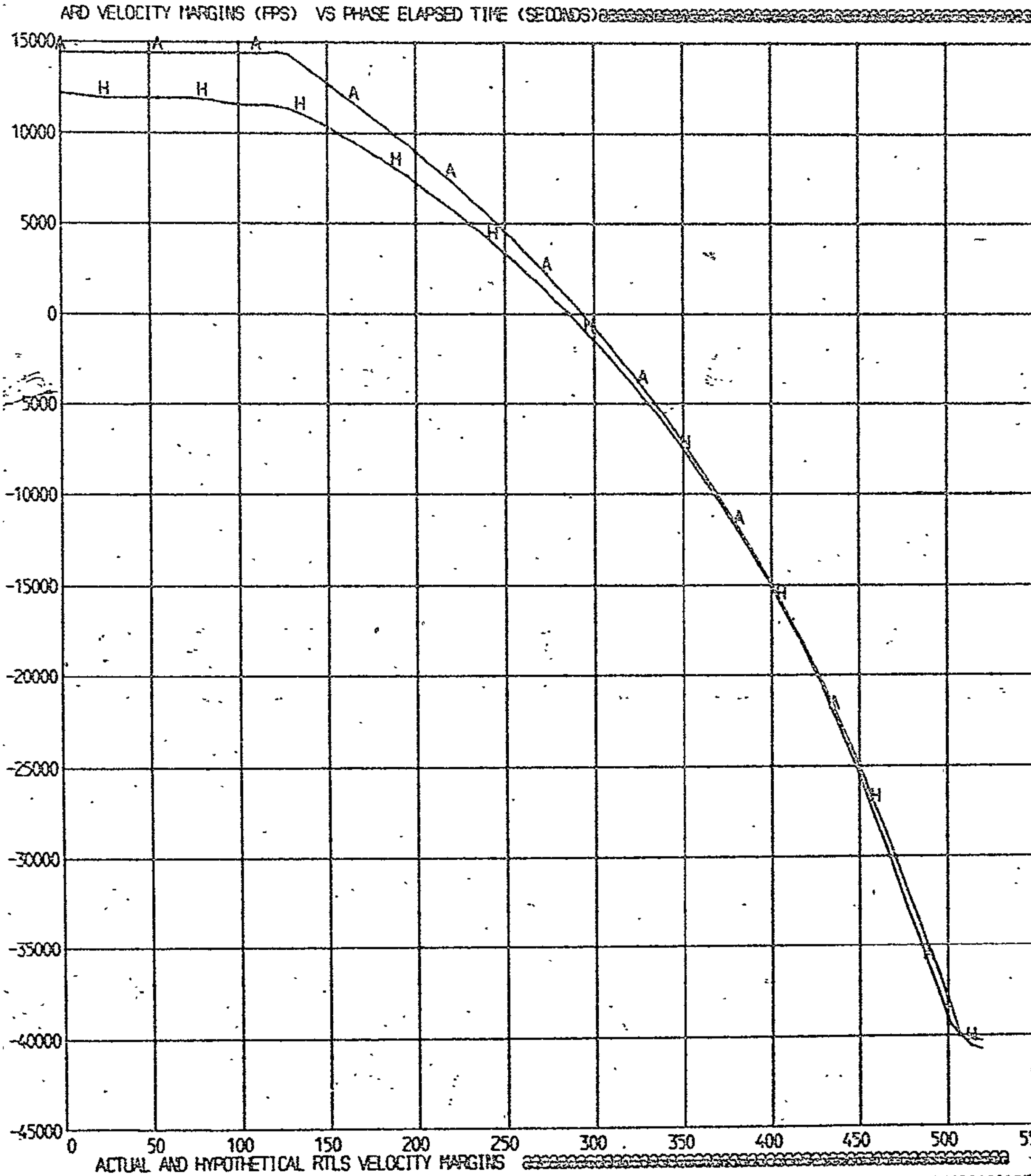


FIGURE 6.3: No-Wind OFT-1 ARD RTLS Margin History For Worst-Case Special MPS Processor Weight Errors

ORIGINAL PAGE IS OF POOR QUALITY

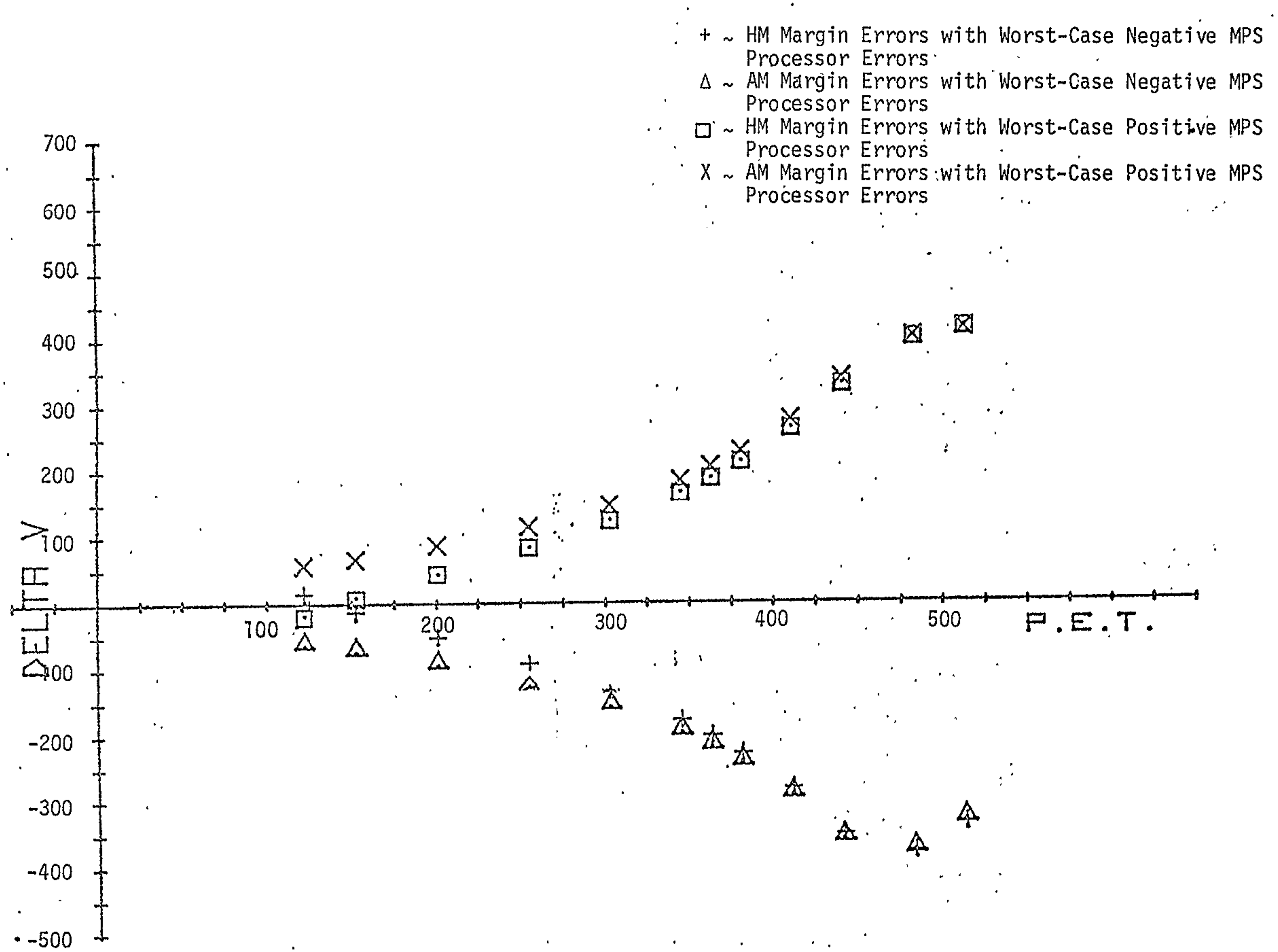


FIGURE (6.4): ARD Sensitivity To Worst-Case Special MPS Processor Errors

FIGURE 6.5: Worst-Case Special MPS Processor Errors Using Sensed Acceleration Algorithm