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Validation and Verification Flight Test for TCAS II Logic Version 6.04A

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EXECUTIVE SUMMARY

This document describes the flight tests performed on the Traffic Alert and Collision Avoidance System (TCAS)-II version 6.04a (v6.04a) logic in September 1993. The v6.04a logic was designed to reduce unnecessary coordinated crossing advisories on TCAS equipped aircraft intending to level off 1000 feet apart from each other. The flight tests were designed to confirm the operation of the v6.04a logic under actual flight conditions, and to determine pilot acceptance of the changes.

The flight test geometries were designed, through computer simulations, to stress the revised areas of the logic. The encounters were modified during the flight tests to accommodate pilot reaction time, greater repeatability, weather conditions, and air traffic control. Four different sets of encounters were used for the tests.

The flight tests were performed with the Technical Center's Boeing 727 (B727), N40, and a second B727, N355PA, leased for these tests. N40 was equipped with a Bendix TCAS II unit, and N355PA was equipped with a Collins TCAS II unit. Twenty-four pilots participated in the flight tests.

The test designs were quite successful, with v6.04a triggered in 120 of the 165 recorded TCAS encounters which generated RAs. Analysis of the collected data showed that the TCAS logic performed well in all encounters. The v6.04a logic reduced the number of crossing encounters by about 50% (compared to previous TCAS logic versions). The participating pilots were pleased with the reduction in crossing advisories, and had no complaints with the revised logic.

Several problems relating to the TCAS equipment were discovered during the tests. A coding error in the Collins TCAS prevented the unit from operating in the correct sensitivity level. A transponder error was responsible for occasional bad altitude reports. The Bendix TCAS erroneously placed the target into a 7.5 minute dormancy due to this error. Questions about the performance of the Bendix interference limiting algorithms were raised.

The appendixes contain plots of all the planned encounter simulations, the encounter geometry set-ups, and plots of all the encounter flight data. Appendix G analyzes several crossing encounters which were expected to generate non-crossing advisories. The TCAS logic operated properly in all of the encounters.

1
INTRODUCTION

1.1 PURPOSE AND SCOPE OF THIS DOCUMENT

This document provides a description of the design, test, and results of the Traffic Alert and Collision Avoidance System (TCAS)-II logic version 6.04a (v6.04a) flight test program. The tests were conducted in September 1993. The document specifically addresses the performance of the new logic in decreasing the number of crossing advisories. Other issues identified or demonstrated by the flight tests are also discussed.

1.2 BACKGROUND

Several requests for changes to the TCAS-II v6.0 logic have been made since its acceptance by RTCA, Incorporated in September 1989. Many of these changes were incorporated into the v6.04 logic change, which has been extensively tested and analyzed by the FAA, The MITRE Corporation, the MIT Lincoln Laboratory, and The Analytical Sciences Corporation (TASC). The v6.04 logic was designed to correct many deficiencies in the TCAS-II logic, and align the TCAS advisories more closely with the existing ATC system. The Technical Center conducted an operational flight test of the v6.04 logic on July 14 and 15, 1992. The observers and pilots participating in those tests generally agreed that v6.04 would relieve conflicts with normal ATC procedures and eliminate many "nuisance" resolution advisories (RAs). (RAs are often called a nuisance when they are not required to maintain adequate separation.)

Prior to the general release of the v6.04 logic change, a few disturbing encounters occurred aboard commercial aircraft using the previous logic versions (v6.0 - v6.02). These encounters involved two TCAS equipped aircraft approaching a common horizontal point at oppositely signed high vertical rates, with both planes intending to level off 1000 feet apart from each other. While this type of encounter can usually be expected not to generate any RAs, or to issue non-crossing RAs, in a few cases crossing RAs were issued. These advisories were contrary to the air traffic control (ATC) clearances and the intentions of both pilots. As such, the pilots were reluctant to follow the RAs. Analysis of these encounters (using ATC radar data) showed no problems with the TCAS performance in these situations, but indicated that similar encounters could result in inadequate separation, even if both pilots followed the RAs properly. The analysis also concluded that the changes and corrections in version 6.04 of the logic would only marginally improve the TCAS performance in these situations.

It was decided that a quick, simple and effective change should be added to the v6.04 logic, if possible, to eliminate these known TCAS shortcomings, instead of

waiting until the next major logic revision is released. (Logic Change 7 is scheduled for release in June, 1996.) The requirement for these changes was to eliminate these unnecessary crossing RAs without negating the benefits of reduced RA rates to be expected with v6.04. The changes were kept as simple as possible to avoid introducing problems in other areas of the logic, and to facilitate testing, verification, and validation of the change. This change has been named v6.04a.

1.3 DESCRIPTION OF THE LOGIC CHANGES

The following changes and corrections to v6.04 were included in the v6.04a logic used during the flight tests.

1.3.1 CHANGES

In v6.04a, the crossing encounter logic has been modified to declare a conflict at the full vertical TAU boundary, instead of waiting for the ZTHR to be violated. This allows the v6.04a logic to detect the conflict earlier than preceding logic versions, and increases the likelihood that a non-crossing RA will be selected.

If a non-crossing RA cannot be selected, issuance of the RA is delayed until 850 feet (ft) in encounters where both aircraft have opposite converging rates. The RA is delayed until 600 ft in encounters where one of the aircraft is level, or where both aircraft have a same sign vertical rate. This delay continues to allow the aircraft to level off. If the altitude separation becomes inadequate for the planes to level off, RAs to continue the vertical rate (or rates) are issued.

1.3.2 CORRECTIONS

An error in the v6.04 logic has been corrected. This error allowed the displayed rate to be reduced. This could occur when TCAS issued a "maintain rate" RA to a plane in a high vertical rate, followed by a corrective RA if the planes tracked rate slipped below the rate to maintain. TCAS would then issue it's strongest corrective RA, which displayed a 2500 feet per minute (fpm) vertical rate. This rate, however, could be well below the modeled rate to maintain, and would reduce separation. The corrected v6.04a logic maintains the display of the proper rate.

1.3.3 REVISIONS TO v6.04a SINCE EXECUTION OF THE FLIGHT TESTS

An additional revision to the logic was being tested at the MITRE Corporation at the time of the flight tests. Simulations of the v6.04a logic indicated that certain geometries would result in an increase in unnecessary non-crossing RAs. This increase was allowed because a test for vertical miss distance (VMD) was not applied in these geometries under v6.04a. This test was re-applied in these

encounter types in the final logic version, which was released by The MITRE Corporation on September 21, 1993.

The final version of the logic, which was not available at the time of the flight tests, is officially referred to as TCAS logic version 6.04a (released September 21, 1993). However, for the purposes of clarity in this paper, the final logic version will be referred to as v6.04a'. V6.04a will refer to the logic version as flight tested, which was released July 20, 1993.

1.4 TEST OBJECTIVES

The objectives of the flight test were to confirm the operation of the v6.04a logic, which has been extensively tested through computer simulation, under actual flight conditions, and to determine the pilot acceptance of these changes.

1.5 DESCRIPTION OF THE EQUIPMENT

1.5.1 TCAS EQUIPMENT

The flight tests were conducted using production TCAS-II units equipped with v6.04a of the TCAS-II logic. Two Technical Center owned Bendix TCAS-II units were modified by Bendix with the new logic. Rockwell lent the Technical Center two TCAS-II units with the v6.04a logic. Rockwell then sent two different units with a software patch at the end of the first week of flight testing (see Rockwell Coding Error below).

Note that to maintain consistency with the Technical Center data and file naming conventions, Allied-Signal Aerospace Company is referred to as Bendix and Rockwell International is referred to as Rockwell throughout this document.

1.5.2 AIRCRAFT AND INSTALLATION

One Bendix unit was installed on the Technical Center Boeing 727 (B727), N40. The unit was installed on the TCAS project rack in the passenger compartment. A Bendix transponder was used with the TCAS. One Rockwell unit was installed aboard a leased B727, N355PA. The v6.04a unit replaced its installed TCAS-II unit in the electronics bay, and a data recorder was installed on a project rack in the passenger compartment. The standard Rockwell transponder was used with the TCAS. The other TCAS units were available as spares, in case of hardware failure.

The N40 cockpit was equipped with an modified weather radar traffic display in the center console, and two traffic alert (TA)/RA instantaneous vertical speed indicators (IVSIs) displays. The N355PA cockpit was equipped with two TA/RA vertical speed indicators (VSI) displays.

1.5.3 OTHER EQUIPMENT

N40 was equipped with the Technical Center's TCAS advanced applications display driver (TAADD). This personal computer (PC) based system receives TCAS information from the data recorder port of the Bendix TCAS unit, and is programmed to display selected parameters in real time. This capability was used to accurately monitor the range to the target aircraft when setting up the encounter geometries. TAADD also receives own-aircraft state data directly from the aircraft, and is capable of high update rate recording.

2
TEST DESCRIPTION

2.1 TEST DESIGN

Preparation for the overall flight test plan was outlined in two documents, "Preparatory Plan For The Flight Test Demonstration Of TCAS-II Logic Version 6.04a", and "Flight Test Demonstration For TCAS-II Logic Version 6.04a Test Plan", both written in early August, 1993. The actual design of the encounters was not started until September 1, 1993, when updates to the Technical Center's Fast Time Encounter Generator (FTEG) program to include the v6.04a logic were completed.

Hundreds of different encounter geometries were performed and examined using the FTEG in order to develop a test set of four encounters for the flight tests. The FTEG program was run on a 486-based personal computer. The results of the FTEG were transferred onto a Perkin Elmer 3220 computer for plotting.

While a variety of encounter types was examined, the clear effect of logic version 6.04a was only seen in encounters with opposing vertical rates. As such, only variations on this encounter type were included in the flight tests.

The week of September 13, 1993, was used for engineering tests on equipment installation and encounter geometries. During this time, the encounter set was modified for pilot reaction time, greater repeatability, weather, and the convenience of air traffic control (ATC). Further changes were made at the request of subject pilots to make the encounters more similar to commercial flight operations. All of these different encounter set variations were flown:

2.1.1 GROUP 1 - ORIGINAL ENCOUNTER SET

The original encounter set was chosen to represent four areas of concern about the new logic. In order to maximize the possible delay in issuing initial RAs while still allowing for large vertical rates over the period of the encounter, all encounters were designed to operate in sensitivity level (SL) 5 (between 5,000 and 10,000 ft altitude). The closing speed of all the encounters was 500 knots (kts). Simulation results of these encounters are included in appendix A.

Encounter one. This encounter was designed to demonstrate an encounter in which two planes with opposing vertical rates plan to pass closely, but with adequate vertical separation. (That is, TCAS is not needed.) Examination of the plots shows that the new logic will issue a positive advisory to maintain the current rate (plots A-2 and A-3), while v6.02 would issue only a preventive advisory (plots A-18 and A-19), and v6.04 would issue no resolution advisory (RA) (plots A-10 and A-11).

The RA issued by v6.04a could be considered a nuisance RA, since adequate separation is maintained without TCAS. Some concern has been expressed about an increase in the RA rate expected with v6.04a over v6.04.

Encounter two. Some concern was expressed at the RTCA SC-147 meetings about the proposal to delay RAs to allow level-offs to be detected. Depending on the encounter, these delays can range up to about nine seconds. This encounter was designed as a "worst case", in which both planes begin a level-off maneuver to 400 ft apart during the delay.

The delay in issuing the RA can be seen on plots A-4 and A-5. (The indicator on the plot with no RA text indicates the start of the delay). However, the v6.04a logic actually issues the advisory earlier than previous logic versions (22 seconds after TA, vs. 26 seconds for v6.04 and 24 seconds for v6.02. See plots A-12, A-13, A-20, and A-21) due to the use of the full TAU boundary. (Note: An initial RA delay can also be observed on all other runs in the Group 1 encounters. See plots A-2 through A-9.)

Encounter three. This encounter is a variation on Encounter two, with the aircraft attempting to level-off 600 ft apart. It demonstrates a geometry in which the RA delay, coupled with a crossing RA, does not provide adequate separation. This is the type of encounter v6.04a attempts to eliminate. Examination of plots A-6 and A-7 shows that the v6.04a logic generates advisories essentially similar to those issued by the previous versions (plots A-14, A-15, A-22 and A-23), but the new RA delay provides less time to execute the crossing maneuver.

While in this particular geometry, v6.04a provides less separation than previous logic versions, slight variations to this geometry produce less separation with the v6.02 and v6.04 logic. Overall, the v6.04a logic is less likely to produce poor separation in this geometry type. Simulation testing of the logic by both the MITRE Corporation and the FAA Technical Center has shown that the v6.04a logic will significantly reduce the occurrence of this type of encounter.

While v6.04a minimizes the number of these encounters, this specific encounter merely demonstrates the inability of the changes in v6.04a to totally eliminate this inadequacy from the logic; as such, this geometry was modified to simulate an ATC blunder in subsequent test sets.

Encounter four. Encounter four was designed to demonstrate a corner post-type encounter, where two aircraft with opposing vertical rates level-off 1000 ft apart. The version 6.04a logic issues preventive advisories in this scenario (plots A-8 and A-9). The previous versions of the logic produce crossing advisories; although the results of each are quite dissimilar (see plots A-16, A-17, A-24, and A-25).

2.1.2 GROUP 2 - CHANGES TO THE ENCOUNTER SET DURING THE ENGINEERING TESTS

The initial encounter set was modified during the engineering tests. These encounters are referred to as Group 2 (see appendix B), and were modified as follows:

Encounter one. No change.

Encounter two. Encounter two was modified so that the aircraft were to level-off at the same altitude. This modification made the encounter simulate an ATC blunder. (See plots B-2, B-3, B-6, B-7, B-10, and B-11)

Encounter three. Encounter three was modified so that the aircraft were to level-off 800 ft apart from each other. This modification made the encounter simulate an overshoot by one or both aircraft. (See plots B-4, B-5, B-8, B-9, B-12, and B-13)

Encounter four. No change.

2.1.3 GROUPS 3 AND 4 - FURTHER CHANGES TO THE ENCOUNTERS

The encounters were designed to be performed in SL 5. In the area we performed these encounters, however, this altitude band was controlled by Atlantic City (below 8000 ft) and Washington Center (above 8000 ft). This led to coordination and communications problems with ATC. Additionally, poor weather was expected to make this altitude band unflyable on some of the test days. As such, the basic encounters were further modified to operate in SL 6 so that the encounters could be flown from 10,000 to 20,000 ft. The encounter closing speed remained 500 kts. These encounters are referred to as Group 3. Plots of these encounters are included in appendix C.

Several of the subject pilots commented that it seemed unrealistic to perform these encounters with such a low closing speed above 10,000 ft. As such, the

encounters were further modified to increase the closing speed to 600 kts. These encounters are referred to as Group 4, and are included in appendix D.

2.2 ENCOUNTER DESCRIPTIONS

Full descriptions of each encounter set-up are included in appendix E. All of the encounters involved similar opposite vertical rate geometries. Some of the encounters involved level-off maneuvers at varying altitude separations.

2.3 FAA AND INDUSTRY PARTICIPATION

The MITRE Corporation was helpful in implementing the logic in the FTEG, and suggesting encounter types for the encounters. Numerous other organizations, including airlines and TCAS manufacturers, were involved in the planning and execution of the test flights.

2.3.1 PILOT SELECTION

One of the objectives of the flight test demonstration was to determine pilot acceptance of the changes brought about by the v6.04a logic. This required the participation of a range of commercial pilots. The Air Line Pilots Association (ALPA) was contacted about scheduling pilots for the tests. In addition, several FAA pilots were asked to participate in the tests. Table 1 lists the pilots and their affiliations.

2.3.2 MANUFACTURER PARTICIPATION

The TCAS manufacturers also participated in the tests. As mentioned above, Bendix upgraded the Technical Center TCAS-II units to v6.04a, and Rockwell loaned version 6.04a TCAS units to the Technical Center for the tests. Dwight Unruh, Aaron Reinholz and Ross Cairns, engineers from Rockwell, were present during some of the testing, and were very helpful in the analysis of the Rockwell unit problems (see below). Ross Beins, of Rockwell, and Sandy Wyatt, of Honeywell, participated as subject pilots.

Table 1. PARTICIPATING PILOTS AND THEIR AFFILIATIONS

PILOT	AFFILIATION	
Al Bazer	FAA Technical Center	test pilot
Keith Biehl	FAA Technical Center	test pilot
Mark Ehrhart	FAA Technical Center	test pilot
John Geyser	FAA Technical Center	test pilot
Kenny Johnson	FAA Technical Center	test pilot
Jess Terry	FAA Technical Center	test pilot
Ross Beins	Rockwell	manufacturer pilot
Sandy Wyatt	Honeywell	manufacturer pilot
Al Mattox	American Airlines	airline pilot
Ken Adams	Delta Airlines	airline pilot
Ed Briggs	Delta Airlines	airline pilot
Gary Donovan	Delta Airlines	airline pilot
Glen Samels	Delta Airlines	airline pilot
Gregory Crum *	Southwest Airlines	airline pilot
Howard Dulmage *	Southwest Airlines	airline pilot
Ken Gile *	Southwest Airlines	airline pilot
Mark Jensen *	Southwest Airlines	airline pilot
Chris Head	USAir	airline pilot
David West	FAA Atlanta ACO	certification pilot
Bob Quirk	FAA Atlantic City FINFO	flight inspection pilot
Ed Strange	FAA Atlantic City FINFO	flight inspection pilot
George Kaseote	FAA Headquarters AIR-110	Aircraft Certification
Rick Weiss	FAA Headquarters AXO-4	Systems Operation
Ralph Rissmiller	FAA Wichita ACO	certification pilot

* These pilots visited the Technical Center for the flight test on 9/20/93. This flight was terminated prior to performing any of the encounters due to the failure of a flap cable on N40. The initial diagnosis of the problem indicated that N40 could not be repaired that day, and the pilots departed.

2.4 TEST CONDUCT

2.4.1 GENERAL

Technical Center TCAS personnel were present to conduct all aspects of the flight tests. During each flight, TCAS personnel were present in the passenger compartment and cockpit of N40, and aboard N355PA.

All of the encounters required participation by TCAS personnel to control the maneuver timing required by the planned geometries. The TAADD, located in the passenger compartment of N40, was used to monitor the range to the target aircraft. When the range approached the maneuver range specified for each encounter, the range was called out over the intercom to the TCAS engineer monitoring the encounter in N40's cockpit. At the appropriate range, the engineer called out to the pilots of both aircraft to execute the maneuver.

2.4.2 FLIGHT BRIEFINGS

Prior to each flight, the TCAS personnel, Technical Center test pilots, and the subject pilots met to discuss the planned encounters. The planned encounter geometries were discussed thoroughly at this time. The briefings included instructions for appropriate response to the advisories. The altitudes for the encounter set were usually specified at this time. Occasionally, however, the altitude band for the encounters was not determined until a clear block of airspace was determined in flight.

2.4.3 ENCOUNTER RULES

All encounters followed these rules:

1. Encounters will be made with nominal lateral offsets of 1/4 nmi (1519 ft) with both captains on the inside of each encounter for best visibility. This offset is included as a safety feature.

2. The pilots flying the left seat will be responsible for the lateral separation on each encounter.

3. The flight crews must maintain radio communications with each other, as well as monitor the IVSI/VSI and altimeter for precision maneuvering.

4. All breakoffs will be to the right, with the higher plane climbing and the lower plane descending.

5. In-flight visibility of 7 nmi is required.

6. Visual contact is required prior to following RA. Landing lights may be used to aid visibility.

7. Loss of visual contact will require breakoffs.

8. All airspeeds listed in the encounter descriptions are true airspeed. These airspeeds should be maintained as best as possible through the vertical maneuvers by adjusting the aircraft thrust.

2.5 DATA COLLECTION

2.5.1 FLIGHT LOGS

On all flights, TCAS personnel were located in positions to monitor and record on flight logs the performance of the TCAS equipment, as well as the progression of the encounters and pilot comments on TCAS performance. The flight logs include information that assists in the flight data analysis, such as the start and stop time

of each run, the run and encounter number, the time and range of target acquisition and TCAS alarms, and the times and ranges of any target anomalies, such as target drops or late acquisition. The flight logs also include time information on the data recording periods, as well as any system anomalies (such as hang-ups or error conditions).

2.5.2 DATA RECORDING

Rockwell TCAS data recorders were installed on both aircraft and were used to collect the data from both the Rockwell and Bendix TCAS units. Additionally, the TAADD was used to collect own aircraft data at a high rate to analyze pilot response to the maneuvers.

2.5.3 POST-FLIGHT DEBRIEFINGS

A post-flight debriefing was held after each flight to compare the actual encounter results with the simulated results using various versions of the TCAS logic. Pilot comments on the expected changes in TCAS performance with the v6.04a logic were noted, as were comments on any other aspect of TCAS not associated with the logic change.

3
TEST RESULTS

3.1 COLLECTED DATA

A total of 12 version 6.04a flights were performed, which included a total of 101 encounters. TCAS units were installed on both aircraft, thus providing 202 TCAS encounters. Table 2 summarizes the flight dates, times, and encounters. Some of these encounters were not set up or executed properly. Others are missing the flight data due to problems with the data recorders. These runs are noted in Table 2.

3.1.1 DATA PLOTS

Data plots of each encounter, if available, are included in appendix F. A detailed description of the format of these plots is included in appendix F, as well.

3.1.2 SIMULATED PILOT RESPONSE

Many of the plots in appendix F include a simulated pilot response to the RAs as generated by the plotting software. This response uses the RAs in the actual data to trigger a .25g acceleration (.33g for increase and reversal RAs) to the minimum acceptable rate for the advisories. The simulation uses a 2.5 second pilot delay for increase and reversal RAs, and a 5 second delay for all other RAs. Each plot includes only the simulated response for that aircraft, while still showing the actual response of the target aircraft.

The Analysis of Data section, below, includes some mention of the altitude separations at closest point of approach (CPA) using the simulated pilot response. In these cases, the simulated response from both aircraft have been used together. Further explanation of this calculation is included in the Pilot Performance During the Encounters section, below.

It should be noted that, had the pilots responded to the RAs as simulated, the subsequent RAs issued by TCAS might have been different. The simulated pilots response is most useful to show those runs where the actual pilot response to the RA was inadequate.

Table 2. SUMMARY OF FLIGHT DATES, TIMES, AND ENCOUNTERS

Teble Notes: Run starting times are approximate. The encounter number indicates the geometry from the encounter set.

A "C" or "N" in the CR column indicates Crossing or Non-crossing advisories.

An "A" in the RC (Rockwell) or BX (Bendix) column indicates that the v6.04a logic was exercised. A "-" indicates that v6.04a was not exercised. Blank indicates there was no RA, or data is unavailable.

9/13/93 afternoon Engineering Test Flight Encounter Set 1

Flight notes: This was the initial engineering test flight. The pilots worked on their technique to set up the encounters and hold the airspeeds. The initial maneuvering distances were altered to accommodate pilot reaction times and aircraft acceleration. Switch setting aboard N40 held Bendix TCAS in SL 4. Rockwell TCAS also held in SL 4 due to software error. George Lyddane (FAA) participated in this flight.

Start Time	CR	RC	BX	Encounter Number
15:42	N	-	-	1
15:47	C	A	A	1 - airspeed held better, maneuver distance modified
15:53	C	A	A	2
15:58	C	A	A	3
16:05	N	-	-	4
16:10	N	A	-	1 - maneuver distance modified
16:16	N	-	-	4 - level-off with 800 ft separation
16:21	N	-	-	4 - same geometry as 16:16

Table 2. SUMMARY OF FLIGHT DATES, TIMES, AND ENCOUNTERS (CON'T)

9/14/93 afternoon Engineering Test Flight Encounter Set 2

Flight notes: Encounters modified from those flown on 9/13/93. Rockwell TCAS held in SL 4, Bendix unit in the correct SL (SL 5). The maneuver distances require more changes since the TCAS units are now operating in the proper SL.

Start Time	CR	RC	BX	Encounter Number
13:37	C	A	A	1
13:43	N	A	A	2
13:49	C	A	A	2 - increase maneuver distance
13:55*				3 - late target acquisition prevents initial maneuver
14:00	N	-	-	3
14:06	N	-	-	4
14:12	N	A	-	1 - poor encounter set-up
14:17	C	A	A	1
14:22*				2 - no maneuver
14:28	C	A	A	2
14:33	C	A	A	2
14:38	N	-	-	3
14:44	C	A	A	4

9/15/93 morning Engineering Test Flight Encounter Set 2

Flight notes: Encounter set flown as modified during 9/14/93 flight.

Start Time	CR	RC	BX	Encounter Number
9:38	C	A	A	1
9:44*				2 - too much lateral separation
9:50	C	A	A	2
9:56*				3 - run aborted due to other traffic
10:02	N	A	A	3
10:08	N	A	A	4

9/16/93 morning Engineering Test Flight Encounter Set 3

Flight notes: Encounters performed in SL 6. Encounters modified for higher altitude. Guest pilots: Rick Weiss (FAA), Ross Beins (Rockwell).

Start Time	CR	RC	BX	Encounter Number
10:15	N	A	A	1
10:21	C	A	A	1
10:27	C	A	A	2
10:33	N	-	-	3
10:39*				3 - run aborted due to other traffic
10:45	N	-	-	3
10:52	N	A	-	4

Table 2. SUMMARY OF FLIGHT DATES, TIMES, AND ENCOUNTERS (CON'T)

9/17/93 afternoon Operational Test Flight Encounter Set 3

Flight notes: Subject pilots: Sandy Wyatt (Honeywell), Glen Samels (Delta Airlines).

Start Time	CR	RC	BX	Encounter Number
10:32*				1 - late acquisition - run aborted
10:38	C	A	A	1
10:44	C	A	A	2
10:50*				3 - Only a TA was issued.
10:56*				4 - Only a TA was issued.
11:02	C	A	A	1
11:14	N	A	A	2
11:19	N	-	-	3
11:25	N	A	A	4

9/20/93 morning Operational Test Flight Encounter Set 3

Flight notes: Rockwell v6.04a TCAS-II with corrected software installed aboard N355PA. Flight aborted due to N40 mechanical failure. Subject pilots: Howard Dulmage, Gregory Crum, Ken Gile, and Mark Jensen (all from Southwest Airlines).

9/20/93 afternoon Operational Test Flight Encounter Set 3

Flight notes: N40 was repaired earlier than expected. Flight conducted with FAA Technical Center pilots.

Start Time	CR	RC	BX	Encounter Number
14:24	C	A	A	1
14:30	C	A	A	2
14:36	C	A	A	3 - run set up poorly
14:42	N	-	A	3 - run aborted due to other traffic - Bendix issues RA on other target as well (see Plot F-181)
14:48	N	A	-	3
14:53	N	A	A	4

Table 2. SUMMARY OF FLIGHT DATES, TIMES, AND ENCOUNTERS (CON'T)

9/21/93 morning Operational Test Flight Encounter Set 3

Flight notes: Subject pilots: Ken Adams and Ed Briggs (Delta Airlines), Al Mattox (American Airlines), David West (FAA)

Start Time	CR	RC	BX	Encounter Number
10:41	C	A	A	1
10:48	C	A	A	2
10:55	C	A	A	3
11:02	N	-	A	4
11:09	C	A	A	1
11:17	C	A	A	2
11:23	N	A	A	3
11:29	N	A	A	4

9/21/93 afternoon Operational Test Flight Encounter Set 3

Flight notes: Subject pilots: Same as morning flight.

Start Time	CR	RC	BX	Encounter Number
14:17	C	A	A	1
14:24	C	A	A	2
14:30	C	A	A	3
14:36	N	A	A	4
14:43	C	A	A	1
14:50	C	A	A	2
14:56	N	A	A	3
15:03*				4 - Bendix TCAS issued a TA only. Rockwell TCAS issued no alerts. (see Plot F-182 for Bendix data)

9/22/93 morning Operational Test Flight Encounter Set 4

Flight notes: The airspeeds for the encounters were modified to 300 kts. Subject pilots: Al Mattox (American Airlines), Chris Head (USAir)

Start Time	CR	RC	BX	Encounter Number
10:31	N	-		1 - incorrect encounter geometry - N355PA didn't maneuver
10:37	N	A	A	1
10:43	C	A	A	2
10:48	N	-	-	3
10:55*				4 - late acquisition of target - run aborted
11:00	N	-	A	4
11:06	C	A	A	1
11:12	C	A	A	2
11:17	N	A	-	3
11:23				4 - incorrect encounter geometry - N355PA didn't maneuver
11:29	N		-	4 - No RA on Rockwell system

Table 2. SUMMARY OF FLIGHT DATES, TIMES, AND ENCOUNTERS (CON'T)

9/22/93 afternoon Operational Test Flight Encounter Set 4

Flight notes: Subject pilot: Chris Head (USAir)

Start Time	CR	RC	BX	Encounter Number
14:02	C	A	A	1
14:08	C	A	A	2
14:14	N	A	-	3
14:20	N	-	-	4

9/23/93 morning Operational Test Flight Encounter Set 4

Flight notes: Subject pilots: Gary Donovan (Delta Airlines), Ralph Rissmiller (FAA), George Kaseote (FAA)

Start Time	CR	RC	BX	Encounter Number
10:14	N	A	A	1
10:20	N	A	A	2
10:26	N	-	A	3
10:31*				4 - Bendix and Rockwell both drop tracks. See Surveillance Problems
10:36*				4 - Bendix does not track target. See Surveillance Problems
10:43	C	-	A	4
10:49				1 - Run aborted due to other aircraft
10:55	C	A	A	1
11:00*				2 - Run aborted due to other aircraft
11:06	C		A	2 - TA only on Rockwell
11:12	N	-	A	3
11:18	N	-		4 - No RA on Bendix

9/23/93 afternoon Operational Test Flight Encounter Set 4

Flight notes: Subject pilots: Same as morning flight. Gary Donovan (Delta Airlines), Ralph Rissmiller (FAA), George Kaseote (FAA)

Start Time	CR	RC	BX	Encounter Number
13:59	C			1 - No RA on either Bendix or Rockwell
14:05	C	A	A	2
14:11	N	-		3 - No RA on Bendix
14:16	N	-	-	4
14:22	C	A	A	1
14:28	C	A	A	2
14:33	C	A	A	3 - Late start of maneuver
14:39	C	A	A	3
14:45	N	-	-	4

* Plots are not available for this encounter, except as noted.

3.2 ANALYSIS OF DATA

3.2.1 SUCCESS OF THE ENCOUNTER GEOMETRIES IN TESTING v6.04a

The encounters were designed to trigger those areas of the logic specific to v6.04a. The encounters worked well in triggering this logic, with 120 of the 165 recorded TCAS encounters generating RAs exercising v6.04a.

3.2.1.1 DIFFICULTY SETTING UP ENCOUNTERS DUE TO AIRCRAFT

The high vertical rate maneuvers which prompted v6.04a are normally the result of the use of the sophisticated flight management systems (FMS) typically used in newer passenger jet aircraft. As such, these encounters were meant to emulate the response of two such aircraft. The two aircraft used for these flight tests, both B727 built in the 1960's, have no such automated capabilities. As such, all vertical rates and level-offs had to be flown by hand. This resulted in several problems:

- Maintaining the vertical rate of the aircraft accurately was difficult. The pilots were further hampered in this effort by the slow response of the IVSI and VSI displays to rate changes. The pilots could not easily maintain the vertical rate required by the encounter geometry while reacting to the TCAS traffic alert (TA) and scanning the sky for visual acquisition of the target aircraft.

- The level-off maneuver was rarely as smooth as would be expected with an FMS, or at the rate desired for the encounters. This is hardly surprising, since there is no G-meter in the cockpit, and the pilots were estimating the level-off required. The difference in the time for these level-offs affects the TCAS ability to recognize the level-off maneuver. Additionally, the level-off altitude was frequently off from the planned altitude, and impromptu adjustments were made to the flight paths.

- The level of activity required to execute these level-off maneuvers distracted the pilots from the encounter and TCAS displays. Responding to the advisories was also made more difficult by the interruption of the current activity (i.e., manually leveling-off from a 3000 fpm climb to 12600'), which was often contrary to the TCAS advisory (i.e., Maintain Climb), instead of just interrupting the FMS.

The results of the flights may have been more similar to actual RAs triggering version 6.04a had FMS equipped aircraft been used for the tests. More pilot comments on the logic performance may have been made if their attention had not been in such demand just to fly the encounter geometry.

3.2.1.2 DIFFICULTY IN SETTING UP THE ENCOUNTERS DUE TO LACK OF ACQUISITION

Several of the encounters could not be set up because the Bendix TCAS unit, from which the range to the target was measured, had not acquired the target aircraft. This problem was exacerbated when the altitude levels and airspeeds of the encounters were increased, since the required start of maneuver distance was also increased. (Note maneuver distance increases from Group 1 to Group 4 on the planned encounters in appendix E.)

3.2.2 PRINTOUTS AND DATA PLOTS

Two methods were used for examining data from the flight tests. Data plots were created for all encounters (assuming data was available) performed during the flight tests. These plots provide a quick review of each encounter. All available plots from the encounters are included in appendix F. The plots are described on pages F-1 through F-4. Various printouts were created to analyze some encounters in more detail. These analyses are included below, but no printouts are reproduced in this report.

3.2.3 SEPARATION AT CPA

The following data analysis includes mention of the separations at CPA. This data has been gathered, or calculated, from the plots in appendix F. Up to four different values are included for the separation at CPA. This section describes the reason for the four values.

The separations at CPA are measured differently by each TCAS unit involved in an encounter, so there are two measured CPA values for each encounter (one from each airplane). The CPA on each plot is calculated as the minimum of the slant range data. This range data has been passed through the TCAS range tracker, and is only available about once per second. The altitude data at this time is then used as the vertical separation at CPA. The altitude data is processed through the TCAS altitude tracker.

The separations at CPA can be affected by time rounding to the nearest second. Measurement errors and tracker lag may affect the time of the altitude data chosen for CPA. Note that due to the high relative vertical speeds (6000 fpm) and high closure rates (500 kts or greater) in these encounters, a slight time difference in the CPA time calculation between the two TCAS systems can make a significant difference in the range and altitude separation at CPA figures. (i.e., A one second difference could be a 100 ft altitude difference and over an 800 ft range difference.)

The simulated response altitude separation figure included on each plot is for that plane only. It still uses the actual measured data for the target aircraft altitude, and doesn't include any difference due to simulated response from the target aircraft. The altitude separation at CPA with simulated pilot response, as included in the text below, is calculated by adding the differences in altitudes from both simulated responses to the measured separation from each TCAS. This provides two different values, one for each airplane.

3.2.4 TCAS LOGIC PERFORMANCE

The main objective of the flight tests was to verify and validate that the v6.04a logic performed as expected, generating acceptable advisories which resulted in adequate separations. The logic performed as expected.

3.2.4.1 ACCEPTABILITY OF THE ENCOUNTER RESULTS (SEPARATION).

A summation of the altitude separation at CPA is included in Table 3. Of the 101 encounters flown during the tests, only four resulted in altitude separations of less than 500 ft. Three of these encounters (see plots F-7 through F-12 in appendix F) occurred on the first day of flight tests with both TCAS units stuck in the incorrect sensitivity level (see Erroneous Sensitivity Levels below).

The only remaining poor altitude separation occurred during Run 2 of the 9/15/93 flight (plots F-45 and F-46 in appendix F). This encounter geometry called for both planes to level-off co-altitude. What altitude separation existed at CPA was the result of following the TCAS advisory. The simulated pilot response shows that the vertical separation in this encounter would be expected to increase with quicker and more accurate pilot response from both pilots. The resulting separation with the simulated pilot response was approximately equal to the SL 5 ALIM of 400 ft. Note that the TCAS recognized the approximately 1 nmi slant range at CPA, which was mainly due to the horizontal offset.

9/15/93 9:51 Run 2	actual response	simulated response (both)
	N40 / N355PA	N40 / N355PA
separation at CPA:	201 ft / 246 ft	373 ft / 418 ft

All the other encounters generated, or allowed, separations of over 500 ft.

TABLE 3. ALTITUDE AND RANGE SEPARATIONS AT CPA (IN FEET)

Note: All altitude and range values are actual recorded TCAS data from the TCAS trackers. Slight differences in the CPA time calculations by the two systems may result in large range at CPA differences due to the high closure rates.

9/13/93

	BENDIX		ROCKWELL	
run time	altitude	range	altitude	range
15:42	1316	2120	1288	1555
15:48	291	1403	290	826
15:54	261	1938	139	1354
15:59	93	1488	80	966
16:05	1962	2157	1969	1409
16:11	1882	2843	1850	2223
16:16	1381	1257	1391	789
16:22	1501	1816	1458	1142

9/14/93

	BENDIX		ROCKWELL	
run time	altitude	range	altitude	range
13:38	830	1999	926	1464
13:44	1037	3141	1010	2624
13:50	548	1245	565	686
14:01	1266	1367	1277	771
14:07	948	2090	946	1488
14:12	1481	2582	1520	1999
14:18	871	3189	975	2624
14:29	880	2339	1098	1755
14:34	789	2643	956	2096
14:39	645	2308	787	1786
14:45	514	4873	567	4441

9/15/93

	BENDIX		ROCKWELL	
run time	altitude	range	altitude	range
09:38	737	1901	813	1282
09:51	201	6300	246	5899
10:03	1302	6604	1294	6228
10:09	2078	3779	2069	3262

9/16/93

	BENDIX		ROCKWELL	
run time	altitude	range	altitude	range
10:16	1527	2521	1455	1962
10:22	1510	2795	1562	2217
10:28	1396	5094	1456	4575
10:39	2251	6890	2284	6562
10:46	2080	3117	2024	2576
10:53	2009	5760	2055	5353

TABLE 3. ALTITUDE AND RANGE SEPARATIONS AT CPA (IN FEET)

9/17/93		BENDIX		ROCKWELL
run time	altitude	range	altitude	range
10:39	1568	1804	1561	1221
10:45	982	1288	1029	704
11:03	1332	7260	1441	6872
11:15	1651	1440	1585	838
11:20	1786	7874	1766	7546
11:26	1523	3736	1446	3189

9/20/93		BENDIX		ROCKWELL
run time	altitude	range	altitude	range
14:25	1628	4897	1719	4459
14:31	1142	2485	1244	1968
14:36	919	1354	1076	765
14:43	995	2296	993	1798
14:48	1464	2952	1415	2418
14:54	1812	4314	1757	3821

9/21/93		BENDIX		ROCKWELL
run time	altitude	range	altitude	range
10:42	1778	5073	1774	4532
10:49	1367	2703	1430	1725
10:56	1085	4028	1209	3542
11:03	1855	3293	1806	2691
11:10	1269	1689	1269	1130
11:17	842	4696	1011	4192
11:24	1861	7844	1824	7510
11:30	1786	3730	1778	3202
14:18	1635	6015	1657	5602
14:24	1011	1737	1176	601
14:31	1208	1598	1272	1014
14:37	1716	3189	1662	2545
14:44	1785	6215	1794	5675
14:50	1678	2400	1646	1859
14:57	1050	4216	1091	3718
15:03	1010	1579	-	-

TABLE 3. ALTITUDE AND RANGE SEPARATIONS AT CPA (IN FEET)

9/22/93

	BENDIX		ROCKWELL	
Run time	altitude	range	altitude	range
10:32	1025	4247	981	3718
10:38	2408	3068	2320	2296
10:44	456	8500	664	8093
10:49	1538	4472	1558	3834
11:01	2223	2460	2148	1142
11:07	1362	3609	1372	3007
11:12	1541	2782	1644	2053
11:18	2634	6744	2683	6288
11:24	2485	25926	2627	1780*
11:30	1739	10487	1746	10165
14:03	1694	2697	1749	1537
14:09	978	5820	969	5371
14:15	2043	5365	2068	4836
14:20	2137	6373	2024	5930

** Note: The slant range appears smaller than the altitude difference due to the altitude and range trackers.*

9/23/93

	BENDIX		ROCKWELL	
run time	altitude	range	altitude	range
10:15	2572	4557	2532	3894
10:21	2205	2041	2159	644
10:27	2103	3979	1971	3384
10:44	1392	2861	1401	2284
10:50	1293	2807	1298	1889
10:56	906	2813	941	2229
11:07	953	874	945	297
11:13	1688	2624	1661	1950
11:19	1498	3886	1474	3262
14:00	2420	3669	2492	3068
14:06	1644	3676	1537	3068
14:12	1439	16077	1350	15749
14:17	1822	3809	1874	3183
14:23	1204	4945	1156	4380
14:29	1250	1889	1220	1196
14:34	1169	6094	1090	5565
14:40	1183	3038	1201	2387
14:46	2281	3092	2264	2527

3.2.4.2 COMPARABILITY OF RESULTS FROM THE DIFFERING ENCOUNTER DESIGNS

As mentioned above, the design of the encounters was changed numerous times during the flight test period. The encounters were flown in different altitude bands and with different airspeeds. The altitude changes affected the SL levels. Significant changes to the encounters were necessary to compensate for the changes to VMD and TAU associated with the different SLs. Further changes were required by the increased airspeeds. While the geometries and TCAS parameters changed significantly from encounter set to encounter set, the encounters continued to test the v6.04a logic. Examination of the simulation results for the different encounter sets shows little change in the RAs issued by the TCAS. (Compare appendices A through D.)

3.2.4.3 COMPARISON OF RESULTS USING PREVIOUS LOGIC VERSIONS

The resulting altitude separations generated by the TCAS RAs was generally quite similar to the previous logic versions in the crossing situations. However, the v6.04a logic provided dramatically increased separation in those encounters for which it generated non-crossing advisories. All of the encounters were expected to generate crossing advisories if using previous logic versions. Eighty-seven encounters were sufficiently well set-up and executed in the test flights to be considered successful runs. V6.04a generated non-crossing advisories or allowed the planned (non-crossing) level-off maneuvers in 44 of these runs.

It was hoped that the Technical Center's PLAYBACK software would allow comparison of each actual encounter as flown using the v6.02 and v6.04 software. However, due to the fact that Playback does not use the same inputs and surveillance processing as the TCAS units, exact comparison is not possible. Encounters played back with the same v6.04a logic may produce results significantly different from those achieved in flight. As such, only simulations of the planned encounter set, which are more easily controlled, have been used for comparison of the performance of the various logic versions.

The simulations of the planned encounters show that the v6.04a logic was expected to generate additional clearance over previous logic versions by allowing non-crossing advisories without degrading performance significantly when issuing crossing advisories.

3.2.4.4 EXPECTED CHANGES TO RESULTS USING LOGIC v6.04a'

The logic version installed in the TCAS units at the time of the tests was version 6.04a, which was released on July 20, 1993. During the testing period, The MITRE Corporation announced further, slight changes to the planned logic version which improved TCAS performance. These changes were not completed at the time of the flight tests. However, all four groups of planned encounters were re-simulated using the final (September 21, 1993) logic version, with absolutely no

changes to the results. These final changes to the logic had no effect on the types of encounter geometries performed in this flight test.

3.2.5 TCAS UNIT PERFORMANCE

The TCAS hardware operated reliably during the flight tests. There were no TCAS unit failures. However, several peculiarities were noted during the flight test period.

3.2.5.1 ERRONEOUS SENSITIVITY LEVELS

Numerous peculiarities were noted during the engineering test flights conducted the first week of the flight tests. These peculiarities were traced to incorrect sensitivity levels.

3.2.5.1.1 TEST RACK SWITCH SETTINGS

The TCAS equipment on N40 was installed on a test rack in the passenger compartment. This rack installation includes several test switches, some of which can be used to test the system on the ground by "fooling" TCAS into thinking it is in the air. These switches have the net effect of setting the TCAS into SL 4. Just prior to landing after the 9/13/93 engineering flight, when RAs should be inhibited, a CLIMB RA was issued on a taxing aircraft. N40 was at approximately 200 ft when the RA was issued. A quick check of the test rack after the flight revealed that the on ground test switches were still in the "test" position. The switches were all reset to their proper TCAS configuration, and no further problems were observed with sensitivity levels aboard N40.

Under normal circumstances, this error would not have degraded the TCAS performance significantly, as the TCAS units adjust to the higher of the sensitivity levels during a coordinated encounter. On this particular flight, however, both TCAS units were in the wrong (lower) sensitivity level (see below). The TA and RA times for all encounters were significantly reduced, and the encounter geometries did not work out as simulated due to these reduced advisory times. The encounter results for this day, 9/13/93, can be seen on plots F-1 through F-20 in appendix F.

3.2.5.1.2 ROCKWELL CODING ERROR

While examining the results of the early engineering flights and redesigning the encounters for a higher altitude band, it was discovered that the Rockwell TCAS unit was not operating in the proper sensitivity level. It was, in fact, progressing only to SL 4. The Technical Center verified this error with Rockwell, which examined their code and found the error that evening. SL 4 is the maximum sensitivity level used when the radar altimeter data is declared "good". Due to the error, the unit failed to declare the analog radar altimeter data as "bad" above

2500', and thus didn't allow the sensitivity level to increase. Rockwell corrected the code and supplied a corrected TCAS unit to the Technical Center for the remainder of the testing. Due to shipping time, however, the corrected TCAS unit was not available for flight testing until September 20. All flights prior to September 20 were flown using the unit operating at SL 4 or less.

As stated above, this coding error, coupled with the wrong switch setting on the Bendix test rack, significantly affected the TCAS performance on the 9/13/93 flight. For the flights conducted on 9/14/93 and 9/15/93, this error was not expected to affect the test data, since the TCAS aboard N40 was operating in the correct sensitivity level (SL 5). The Rockwell TCAS did increase its SL (to SL 5) to match N40's TCAS SL.

The 9/16/93 and 9/17/93 flights were conducted between 10,000 and 20,000 ft, which should place TCAS into SL 6. While the TCAS logic is designed to match the sensitivity levels, it would not normally be expected to increase the SL by more than one level. During these flights, the Rockwell SL was off by two levels. Analysis of the flight data showed that the Rockwell system did properly increase the SL (to SL 6) to match TCAS equipped targets, while still operating in the incorrect level (SL 4) on non-TCAS equipped targets.

3.2.5.2 SURVEILLANCE PROBLEMS

Several surveillance problems were noted during the test flights. These problems ranged from 'pop-up' TAs and RAs to a complete failure to display the target aircraft. These problems are discussed in more depth in the Other Issues Raised During the Flight Tests, below.

3.2.5.2.1 POP-UP TAS AND RAS

Numerous occurrences of late acquisition, short pop-up TAs, and pop-up RAs were observed. Most of these occurrences were noted on the Rockwell TCAS system.

3.2.5.2.2 FAILURE TO TRACK

On 9/23/93, the Bendix TCAS unit aboard N40 dropped N355PA early on in one encounter, and failed completely to track it during the following encounter. N355PA also reported that it didn't acquired N40. Examination of the flight data revealed that the Rockwell unit had, in fact, tracked N40. It was merely outside of the displayed altitude band. The Bendix unit, however, had put itself into dormancy mode. These problems are discussed in Surveillance problems, below.

3.2.6 PILOT PERFORMANCE DURING THE ENCOUNTERS

Except for the initial engineering test flight, the pilots generally followed the RAs during the encounters. There were no comments made to indicate that the maneuvers were difficult to achieve, and examination of the data plots in appendix F shows that the pilot reactions were usually more robust than the simulated response.

The pilots did ignore advisories on several encounters during the first engineering flight. The TCAS units were not operating at the proper sensitivity level (see above) during this flight, and, subsequently, the encounters didn't turn out as planned. It should be noted that it is virtually impossible for these high vertical rate crossing encounters to actually occur in sensitivity level four, which is between 2350' above ground level (AGL) and 5000' mean sea level (MSL). These would be very unusual flight operations for this altitude, and the encounters actually require more of an altitude band than is contained in SL 4. These encounters occurred on 9/13/93 at approximately 15:54 and 15:59 (see plots F-9 through F-12 in appendix F). In both of these encounters, the TCAS issued crossing advisories, which were ignored by N40. Examination of the plots of these runs, and the simulated pilot response, shows that the separations at CPA were as such:

9/13/93 15:54	actual response N40 / N355PA	simulated response (both) N40 / N355PA
separation at CPA	261 ft / 139 ft	386 ft / 264 ft

9/13/93 15:59	actual response N40 / N355PA	simulated response (both) N40 / N355PA
separation at CPA	93 ft / 80 ft	225 ft / 52 ft

Once again, it is important to note that both TCAS were operating improperly due to an improper switch setting on the test rack of N40, and a coding error in the Rockwell system.

Note that the simulated separation at CPA is significantly greater than the actual pilot response, which ignored the advisory, in three of the four calculations for these two runs.

3.2.7 PILOT ACCEPTANCE OF THE LOGIC CHANGES

During the flight de-briefings and the flight tests, the pilots expressed surprise at the number of crossing advisories still issued with the v6.04a logic. They had expected that v6.04a would eliminate crossing RAs rather than further biasing against them. While disappointed that not all of the crossing advisories were eliminated, they felt that any drop in the number of such RAs was an improvement. As such, they were pleased with the changes to the logic. The pilots did not express concern with the results of following any of the advisories.

3.2.7.1 CROSSING RAS ISSUED AFTER PERCEIVED LEVEL-OFF

On several runs the pilots complained that the TCAS issued the crossing advisories after perceiving that both they and the target had leveled-off. These runs were analyzed in detail, and the TCAS logic was found to operate as designed. The analysis of these encounters is included in appendix G.

3.3 OTHER ISSUES RAISED DURING THE FLIGHT TESTS

Although the main scope of the flight test program was to test and demonstrate the version 6.04a logic change, some known problems were examined, and some additional TCAS problems were surfaced during the testing and analysis. Table 4 contains a list of system anomalies noted during the flight tests. Note that the TCAS logic worked as designed in all encounters.

3.3.1 INTERFERENCE LIMITING

Some of the problems noted as surveillance anomalies during the flight test were actually caused by the invocation of the TCAS interference limiting algorithms. These problems were especially apparent in the Rockwell TCAS. Interference limiting was not expected to be needed in the area where the flight tests were conducted, and as such, it's use was surprising. (The flight tests were conducted near Atlantic City, New Jersey, or over the Delaware Bay area between New Jersey and Delaware.) Examination of the data showed that there were frequently 20 TCAS targets in the area of the flights tests. As such, the MOPS interference limiting algorithms appear to have been operating properly in the Rockwell system. The Bendix system does not use the MOPS algorithms for interference limiting, and did not exhibit similar symptoms.

These observations bring to mind several questions: Since the Bendix system didn't appear to limit its interrogations, is the Bendix system meeting the interference limiting intent of the MOPS? Are the interference limiting algorithms having more of an impact on TCAS performance than previously thought? The FAA and its contractor organizations continue to study interference limiting and its effects on both the ATC system and TCAS.

3.3.2 SURVEILLANCE PROBLEMS

Surveillance problems were discovered with both the Bendix and Rockwell v6.04a TCAS units during the flight test period. A list of system anomalies, including plot numbers if available, is included in Table 4. Some of these anomalies are related to interference limiting, some to incorrect system inputs, and others are due to surveillance problems.

Table 4. SYSTEM ANOMALIES NOTED FROM THE ENCOUNTER PLOTS

The time indicates the starting TA or RA time of the encounter. The Plot number indicates the page in appendix F of the plotted data.

NO TAs:
(RAs were issued in these encounters with no TA precursor.)

9/15/93	Bendix	10:09:27	Plot F-49
9/16/93	Rockwell	10:33:53	Plot F-58

POP-UP TAs:
(All of the following encounters show no track prior to the TA. *The TA is short* indicates that the length of the TA was obviously less than expected.)

9/16/93	Rockwell	10:45:50	Plot F-60	(The TA is short)
9/17/93	Rockwell	10:38:17	Plot F-64	(The TA is short)
9/21/93	Rockwell	14:50:11	Plot F-114	(The TA is short)
	Rockwell	14:56:46	Plot F-116	
9/22/93	Rockwell	14:20:01	Plot F-144	(The TA is short)
9/23/93	Rockwell	10:14:17	Plot F-146	(The TA is short)
	Rockwell	10:26:11	Plot F-150	(The TA is short)
	Rockwell	10:43:24	Plot F-152	
	Rockwell	14:05:39	Plot F-166	(Very short TA)
	Rockwell	14:16:14	Plot F-170	
	Rockwell	14:39:56	Plot F-178	(RA follows TA by 1 second)

SHORT non-pop-up TAs:
(The length of the TAs in these encounters was obviously less than expected, even though the system was tracking the aircraft prior to the TA.)

9/13/93	Rockwell	16:05:15	Plot F-14
	Rockwell	16:10:31	Plot F-16
9/14/93	Rockwell	13:43:44	Plot F-24
9/22/93	Rockwell	10:37:39	Plot F-120
9/23/93	Rockwell	10:49:56	Plot F-154

Table 4. SYSTEM ANOMALIES NOTED FROM THE ENCOUNTER PLOTS (CON'T)

RAs POSTED AT or near CPA:
(Most of the following RAs were posted at or within 2 seconds of CPA. These type of RAs are generally regarded as nuisances by the pilots. Most of these RAs were weakening RAs. The INITIAL RAs of the 9/20 14:42 run (both systems) were too late to achieve any additional separation.)

9/13/93	Bendix	15:48:24	Plot F-7	RA alters 2 sec prior to CPA
	Rockwell	15:47:49	Plot F-8	RA alters 1 sec prior to CPA
9/14/93	Bendix	13:50:05	Plot F-25	RA weakens 2 sec prior to CPA.
	Rockwell	14:06:47	Plot F-30	RA weakens 1 sec prior to CPA.
	Rockwell	14:33:31	Plot F-38	RAs posted at CPA and 1 sec prior to CPA.
	Bendix	14:45:19	Plot F-41	RA weakens 1 sec prior to CPA.
	Rockwell	14:44:46	Plot F-42	RA weakens 1 sec prior to CPA.
9/15/93	Rockwell	9:50:32	Plot F-46	RA changes from crossing descend to descend 1 sec prior to CPA.
	Bendix	9:51:22	Plot F-45	RA changes from crossing climb to climb 1 sec prior to CPA.
9/17/93	Bendix	10:39:17	Plot F-63	RA weakens 2 sec prior to CPA
	Bendix	11:20:37	Plot F-71	Weakening RAs posted at CPA and 1 sec prior to CPA.
9/20/93	Bendix	14:36:55	Plot F-79	RA weakens 1 sec prior to CPA.
	Rockwell	14:42:35	Plot F-82	Initial RA too late for pilot to respond. Issued 4 sec before CPA.
	Bendix	14:43:05	Plot F-81	Initial RA too late for pilot to respond. Issued 6 sec before CPA.
9/21/93	Bendix	14:24:54	Plot F-105	RA weakens at CPA.
	Rockwell	14:24:06	Plot F-106	Maintain RA issued 1 sec prior to CPA.
9/22/93	Bendix	14:09:36	Plot F-139	RA altered 1 sec prior to CPA.
	Rockwell	14:14:22	Plot F-142	RA weakens 1 sec prior to CPA.
9/23/93	Rockwell	14:11:04	Plot F-168	RA weakens at CPA.
	Rockwell	14:28:11	Plot F-174	RA strengthened 1 sec prior to CPA.
	Rockwell	14:33:45	Plot F-176	RA weakens 2 sec prior to CPA.

Table 4. SYSTEM ANOMALIES NOTED FROM THE ENCOUNTER PLOTS

RAs WHICH DIDN'T ACHIEVE GOOD SEPARATION:			
(The following encounters did not achieve good separations when following the RAs. Simulated pilot response resulted in poor separations as well. These encounters occurred when both TCAS systems were in the incorrect sensitivity level due to an incorrectly set test switch.)			
9/13/93	Rockwell	15:47:49	Plot F-8
	Bendix	15:48:24	Plot F-7
	Rockwell	15:53:40	Plot F-10
	Bendix	15:54:15	Plot F-9
	Rockwell	15:58:59	Plot F-12
	Bendix	15:59:34	Plot F-11
		Pilot response to this encounter was poor. Proper pilot response would alter the encounter significantly, but still result in poor separation.	
(Simulated pilot response suggests that poor vertical separation would have been achieved on the following encounter had the pilots not over-responded to the RA.)			
9/14/93	Bendix	14:45:19	Plot F-41
	Rockwell	14:44:46	Plot F-42
(Simulated pilot response would not drastically improve the poor vertical separation in this encounter.)			
9/15/93	Bendix	9:51:22	Plot F-45
	Rockwell	9:50:32	Plot F-46

3.3.2.1 ROCKWELL TCAS

The Rockwell TCAS exhibited a propensity to issue "pop-up" TAs on the target aircraft. These TAs were commonly posted in the 4 to 6 nmi range. Some pop-up RAs were also observed on the Rockwell system. Pop-up advisories occur when a target, which was not previously displayed on the screen, is displayed immediately as either a TA or an RA. At least two different problems with the surveillance system are responsible for these problems; Mode S monitoring mode and a lack of replies.

3.3.2.1.1 MODE S MONITORING MODE

The Rockwell system has a mode called Mode S monitoring, which apparently functions as follows: A track may be placed into monitoring mode when:

- **the running sum reaches -20. The running sum is similar to a reply counter, and a negative number such as this indicates that no reply has been received recently.**
- **a more threatening aircraft appears. This may occur if the TCAS is already at its maximum number of tracks capability.**

- interference limiting is invoked. The TCAS has detected enough other TCAS units in the area to require limiting the TCAS interrogations.

Apparently, once an aircraft is placed in this mode, it is not reinterrogated until a DF0 message from the aircraft is overheard while listening for other squitters. These DF0 messages are replies to other TCAS units, and would normally be considered fruit. This process essentially provides a random re-interrogation time, with the lack of interrogations leading to unreliable tracking and pop-up TAs. It also appears that, while an aircraft is in the monitoring mode, a variation on the MOPS running sum technique is utilized.

Analysis of two runs from the 9/23/93 morning flight, during which there was no apparent tracking by either system, revealed that the Rockwell system had, in fact, tracked N40. N40 did not appear on the display because its relative altitude was outside of the display's altitude window. The flight data contained several different track segments on N40. These segments were unexpectedly dropped without coasting, and were dropped when placed into the Mode S monitoring mode. However, the relationship of the Mode S monitoring mode to these track drops is unknown.

3.3.2.1.2 LACK OF REPLIES

Analysis of the 9/23/93 afternoon flight data showed that, even when the Rockwell system did start to interrogate the target aircraft, not enough replies were received to establish the track. The interrogations with the AQ bit set always received replies. However, subsequent interrogations, without the AQ bit set, often received no replies. In these same periods of no such replies, both squitters and TCAS broadcast messages from the target aircraft were heard. The mechanism of this reply failure is unknown, and may be related to the transponder in the target aircraft. Investigation into this problem is continuing.

3.3.2.2 BENDIX TCAS

The Bendix system failed to track the target aircraft on two runs on the morning of 9/23/93. This failure was originally thought to be an equipment failure aboard the target plane, as other aircraft were being tracked by the Bendix system at the same time. The Rockwell TCAS aboard N355PA also did not display N40, and the TCAS unit and transponder aboard N355PA were reset. While this provided no immediate improvement, both TCAS units did operate as expected later in the flight.

Examination of the Bendix data revealed that the Bendix system had tracked N355PA, but had put the plane into an erroneously long dormancy. At 10:31:51 the target aircraft, range 17.8 nmi, was placed in dormancy for 6 seconds. This corresponds with the range, a 1200 knot closure, and a time to endanger of 48 seconds. Seven seconds later, at 10:31:58 and range 16.7 nmi, a two second dormancy was calculated. Three seconds later, at 10:32:01 and range 16.2 nmi, a dormancy time of under a second should have been calculated. However, a dormancy time of 7.5 minutes was calculated. The reply at this time reported an

altitude of 93,800 ft, although the actual altitude was 14,375 ft. It appears that two bits in the mode S altitude message were flipped; bit 28 (indicating binary or gilham altitude) and bit 25 (one of the altitude code bits). The 7.5 minute dormancy apparently came from an altitude dormancy calculation as follows:

(93,800 ft - 3000 ft) / 12,000 ft/min = 7.5 minutes

where: 93,800 ft is the reported altitude
3,000 ft is the interference altitude limit
12,000 ft/min is the maximum possible vertical closure

It appears that the Bendix system calculates an altitude dormancy time once the target range is within 16 nmi. There does not appear to be any confidence check on the reported altitude used for this calculation. A second interrogation for bearing update in the same cycle received a reply with the correct altitude of 14,375 ft. This altitude report was ignored.

While this bit flip error was apparently caused by an rarely observed problem in the target's Rockwell transponder, it certainly raises questions about the Bendix system's surveillance: When is this altitude dormancy invoked? Should there be some type of reasonableness check on the reported altitude? Should a reasonable maximum be placed on dormancy times? Bendix has indicated that this type of dormancy problem can only occur during track initialization, and they will include a reasonableness check in their next significant software update (change 7).

3.3.3 BAD ALTITUDE REPORTS

Bad altitude reports from the target plane similar to that which caused the dormancy problem were received at other times during the flight tests. In reviewing 90 minutes of flight data over several days, 6 replies had bad altitude reports. No other TCAS replies contained bad reports.

The Technical Center reviewed some of its data base for similar bad altitude reports in Atlanta and Chicago, and found over 200 such cases. No altitude dormancy problems were associated with any of these cases. All of the bad altitudes traced by the Technical Center were broadcast from Rockwell transponder equipped aircraft. Collins has since found the problem, designed a fix for it, and issued a service bulletin to repair the affected transponders.

3.3.4 DISPLAY PROBLEMS

Previous work at the Technical Center has shown that the lag in the VSIs and IVSIs makes performing TCAS advisories accurately difficult, if not impossible. In these flight tests, N40 was equipped with an IVSI TCAS display; while N355PA was equipped with a VSI. Pilots in both planes quickly discovered that the IVSI and VSI were not accurate enough to set up the encounter geometries, which called for quick 3000 fpm climbs or descents, and smooth level-offs to specific

altitudes. The pilots instead noted the pitch angle required to achieve the desired rates and aimed for that pitch.

Observers aboard both N40 and N355PA noted that the pilots were rarely able to "put the needle in the green" or keep it just "outside of the red" during the TCAS advisories. This difficulty was obviously the result of the time lag between the pilots actions and the indication on the display. This lag generally caused the pilots to overshoot the target rate considerably, both on the corrective and weakening advisories. This problem can readily be observed on many of the plots, which show large differences between the simulated and actual pilot responses. Note that these differences are mainly the result of a difference in the rate of climb or descent, not reaction time.

4
CONCLUSIONS

4.1 SUMMARY OF RESULTS.

4.1.1 ACCOMPLISHMENT OF THE FLIGHT TEST PLAN OBJECTIVES

The objectives of the flight test plan were to confirm the operation of the version 6.04a logic under actual flight conditions, and to determine the pilot acceptance of these changes. These objectives were successfully accomplished through the design and execution of encounters which stressed the revised areas of the logic, and by performing these encounters with both Federal Aviation Administration (FAA) test pilots and aircraft industry pilots.

4.1.2 ENCOUNTER DESIGN

The encounters were designed using computer simulation to trigger those areas of the logic revised in v6.04a. The four encounters chosen (and their refined replacements) were designed to test various aspects of, and concerns about, the logic. Further, the encounters were designed for ease of set-up, to minimize airspace requirements, and for repeatability. The encounters were modified numerous times over the course of the flight testing, altering them for available airspace, pilot preferences, and weather conditions. This constant modification, coupled with the inexactness of actually flying the airplanes, made for a much wider range of actually flown encounters than initially planned. The encounters all performed well, with a good measure of the encounters triggering the v6.04a logic.

The encounters were designed to simulate those encounters common with use of flight management systems at airport corner-posts. Neither of the test aircraft was equipped with a flight management system (FMS). While the encounters did a good job of triggering the v6.04a logic, the pilots were so busy setting up the encounter geometry, which normally would have been done by the FMS, that they had little opportunity to watch the encounter. Test airplanes equipped with modern FMS would have provided a more realistic setting for the encounters, more accuracy in flying the encounters, and improved pilot observation of the TCAS performance.

4.1.3 TECHNICAL PERFORMANCE OF THE LOGIC

The v6.04a logic performed as expected in the flight tests. Previous logic versions would be expected to issue crossing advisories in all of the encounters (as designed). V6.04a issued or allowed level-off maneuvers in over 50% of the well executed encounters.

The results of the flight tests compared favorably with the logic simulations. The only dissimilarities between the planned encounters and the actual flights occurred on the first day of the engineering flight tests, when both TCAS units were operating in the incorrect sensitivity level. These errors were traced to the installation of one TCAS unit and a coding error in the other TCAS unit. Once these problems were corrected, no further unexpected differences in the logic performance were noted. No anomalies in the TCAS v6.04a logic performance were noted.

Four of the 101 encounters flown during the test resulted in altitude separations of less than 500 ft. Three of these were the result of the TCAS units being in the incorrect sensitivity level (see above). The only remaining poor separation apparently resulted from poor pilot response to the TCAS RAs. Pilot response simulation indicates that approximately 400 ft of separation, which was the desired ALIM figure, would have been achieved had the pilots followed the RAs properly.

Pilots questioned the crossing climb maneuvers on several encounters in which they perceived that both planes had leveled-off. Analysis of these encounters shows that the data indicated both planes still had significant tracked vertical rates at the time the advisories were issued, and the TCAS logic acted properly on these inputs. Differences in the pilot observations and TCAS data can be explained through pilot perception of near-level flight as level, and lag determining level-off in the TCAS altitude tracker.

4.1.4 PILOT ACCEPTANCE OF THE MANEUVERS

The pilots had no complaints about the revised logic, other than that it still allows altitude crossings. They expressed no complaints with any of the non-crossing advisories, and agreed that any reduction in the number of crossing advisories was worthwhile.

4.1.5 EFFECTS ON RESULTS DUE TO FURTHER CHANGES IN THE LOGIC

The final revision to v6.04a was not released until the flight tests were in progress. However, comparison of the simulation results using the tested logic version and the final logic version shows no differences in performance or results for the planned encounters.

4.2 SUMMARY OF OTHER ISSUES

4.2.1 TCAS UNIT PERFORMANCE PROBLEMS

Several peculiarities were noted in the flight test and traced back to the TCAS units. Erroneous sensitivity levels were noted in the Rockwell system, which was traced to a coding error. Rockwell supplied the Technical Center with corrected boxes by the end of the first week.

Numerous problems with TCAS surveillance, such as pop-up TAs, pop-up RAs, and failure to track, were observed during the flight test. Some of these problems were related to interference limiting. Although the tests were conducted in an area which would not be expected to invoke interference limiting, the number of TCAS equipped targets frequently exceeded twenty. The Rockwell TCAS markedly limited its surveillance, while no limiting was noted with the Bendix system. Further examination of the Bendix interference limiting algorithms is recommended.

4.2.2 TRANSPONDER REPLY PROBLEMS

Some of the surveillance problems seem to be the result of problems with the transponder replies. Investigation of these transponder problems is ongoing at the FAA Technical Center. These problems can be compounded by the failure of TCAS to check the replies for reasonableness, such as the Bendix system using a 93,800 ft altitude reply from a plane at 14,375 ft, and then using this bad reply to make the track dormant for 7.5 minutes. The TCAS surveillance algorithms should be improved to eliminate absurd replies. Collins is currently correcting an error in some of their transponders, and Bendix plans to add a reasonableness check to their Change 7 logic.

4.2.3 DISPLAY PROBLEMS

During this and previous flight tests at the Technical Center, it has become obvious that following the TCAS advisories accurately is nearly impossible due to the lag in the vertical speed indicators (VSIs), and instantaneous vertical speed

indicators (IVSIs). Pilots were unable to "put the needle in the green" or keep it just "outside the red" due to the slow feedback of actual vertical rate. As such, the pilots were prone to overreacting to all RAs. This problem can lead to much larger altitude deviations than necessary.

All flight tests were conducted using VSIs and IVSIs, as the Technical Center presently has no pitch guidance type advisory system available. The effect on pilot accuracy of using a pitch guidance system is unknown.

APPENDIX A

Simulation Results for Group 1 Encounters

Four different groups of encounters were used for the v6.04a logic flight tests. This appendix includes the simulation results for the original encounter set, Group 1, which was used only on the 9/13/93 engineering test flight. The plots can be compared to see the simulated results of three TCAS logic versions; v6.04a, v6.04, and v6.02.

An explanation of the plots is included on pages F-1 through F-4 (appendix F). Note that since these are simulation results, some of the information fields, such as FLIGHT DATE, may have superfluous entries.

There are two plots for each encounter, one from the viewpoint of each TCAS. These plots correspond to the encounter run numbers as follows:

logic version	6.04a	6.04	6.02
Run 1	Plots A-2 and A-3	A-10 and A-11	A-18 and A-19
Run 2	Plots A-4 and A-5	A-12 and A-13	A-20 and A-21
Run 3	Plots A-6 and A-7	A-14 and A-15	A-22 and A-23
Run 4	Plots A-8 and A-9	A-16 and A-17	A-24 and A-25

Encounter ID 1 Filename m TSTPLN4.T

ENCOUNTER ID: 1

TARGET ID: 2

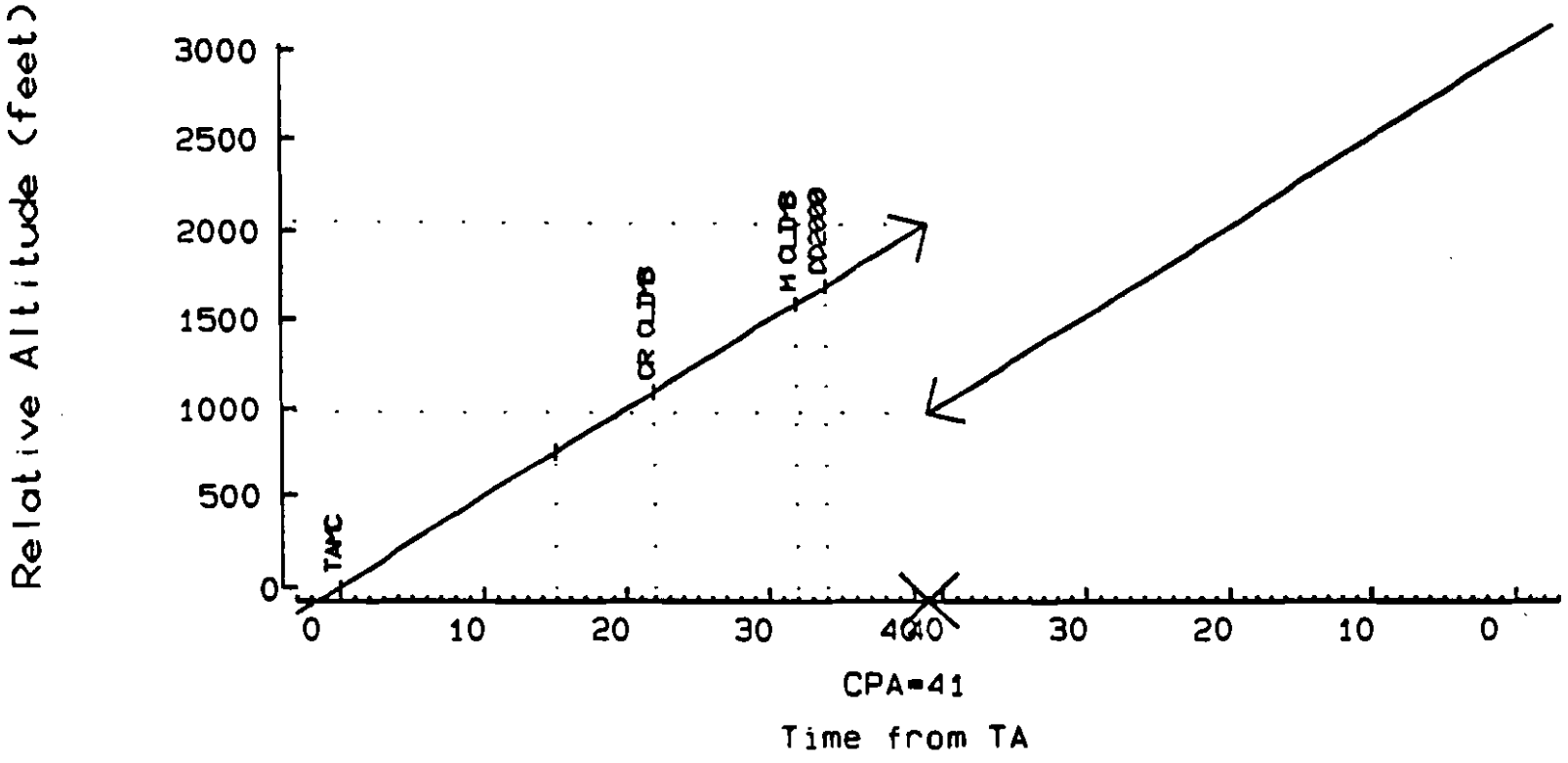
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -217

RANGE at CPA: 1288 ft



TA TIME: 00:00:10 CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P Alt. Difference at CPA: 1075 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-2

Plane 1

Run 1

Logic v6.04a

Group 1

>

Encounter ID 2 Filename m TSTPLN4.T

ENCOUNTER ID: 2

TARGET ID: 1

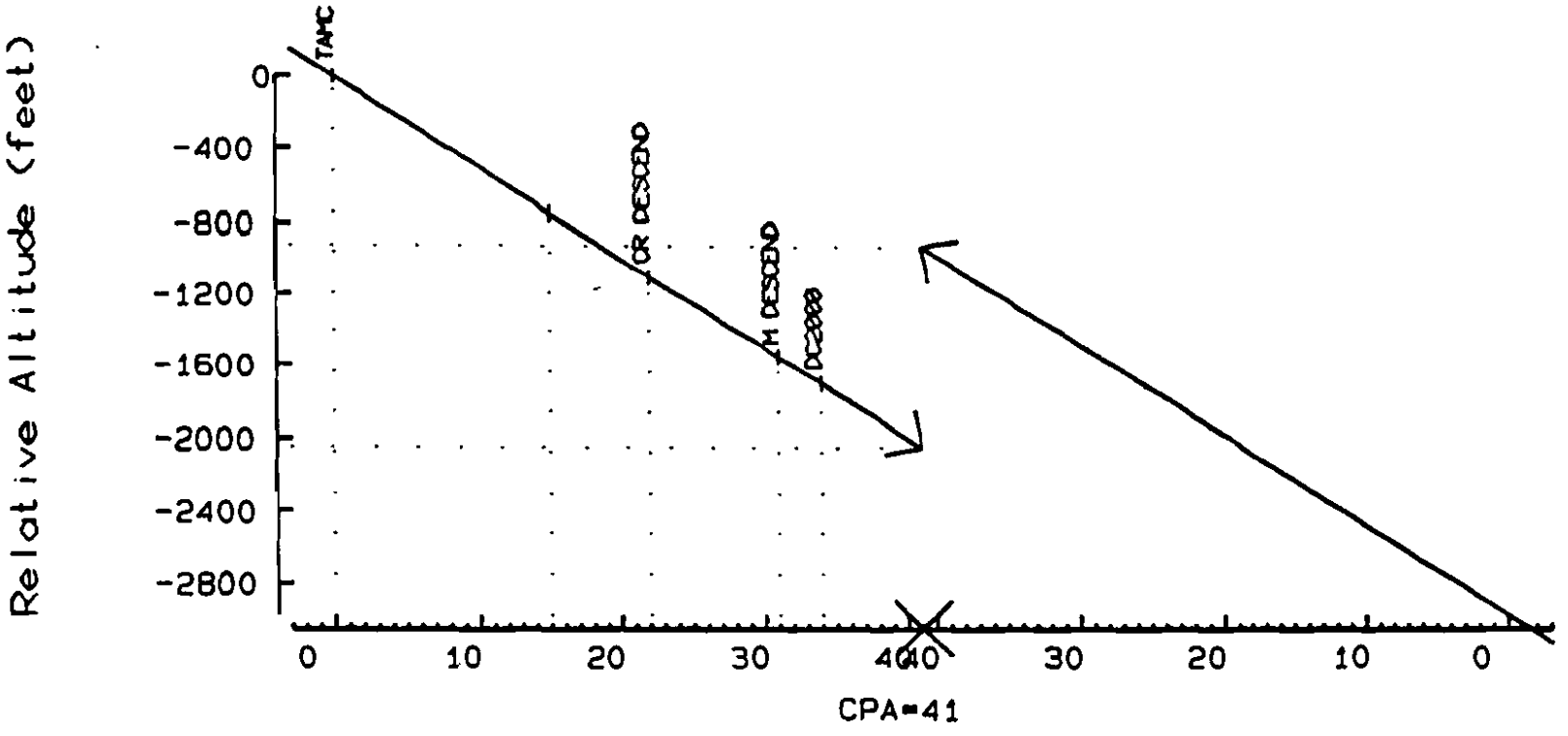
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -217

RANGE at CPA: 1288 ft



TA TIME: 00:00:10

CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 1125 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-3

Plane 2

Run 1

Logic v6.04a

Group 1

>

Encounter ID 3 Filename m TSTPLN4.T

ENCOUNTER ID: 3

TARGET ID: 2

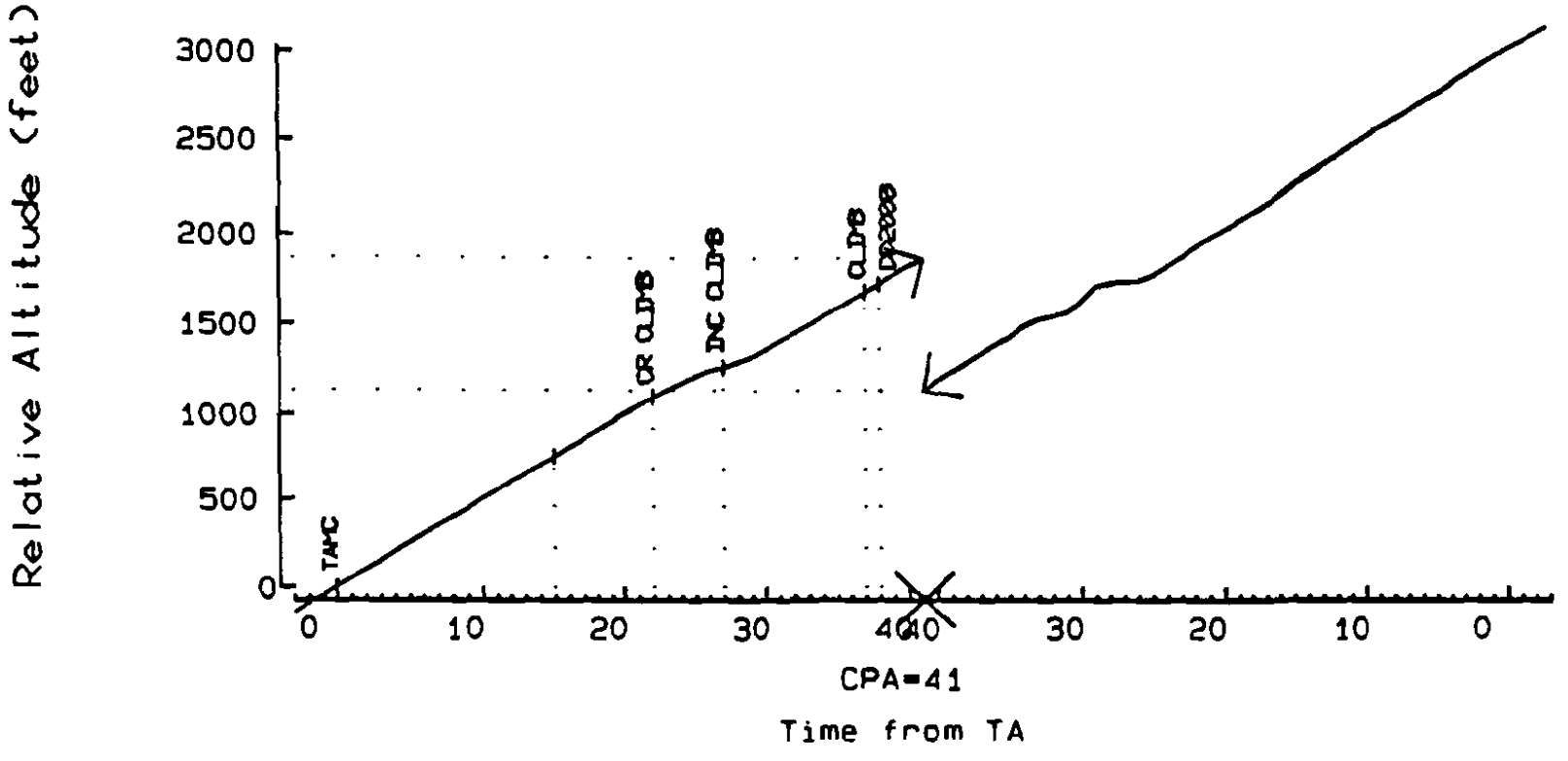
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -234

RANGE at CPA: 1111 ft



TA TIME: 00:00:10

CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 737 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

Group 1 Logic v6.04a Run 2 Plane 1 A-4

Encounter ID 4 Filename m TSTPLN4.T

ENCOUNTER ID: 4

TARGET ID: 1

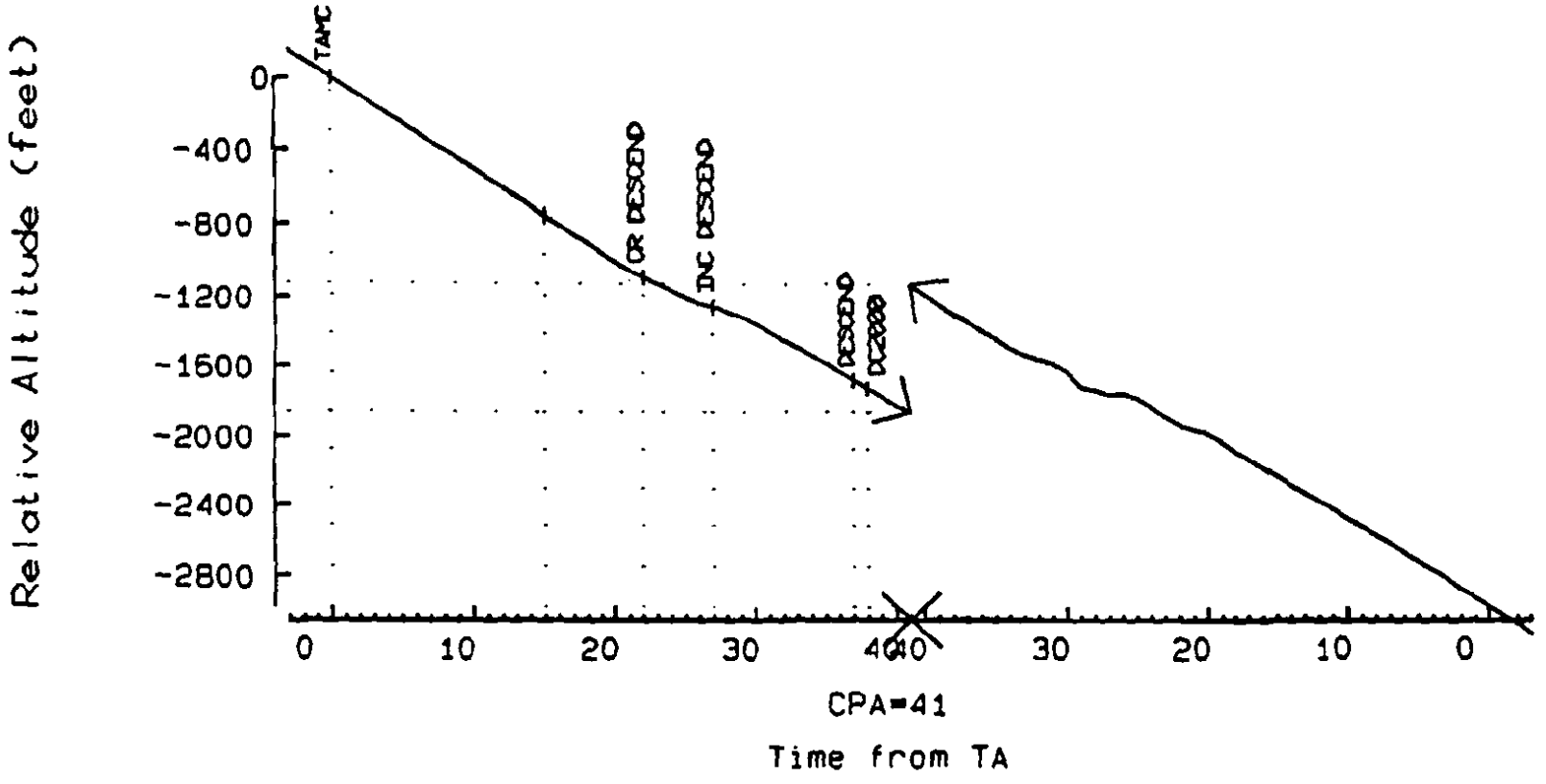
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -234

RANGE at CPA: 1111 ft



TA TIME: 00:00:10

CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 737 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-5

Plane 2

Run 2

Logic v6.04a

Group 1

>

Encounter ID 5 Filename m TSTPLN4.T

ENCOUNTER ID: 5

TARGET ID: 2

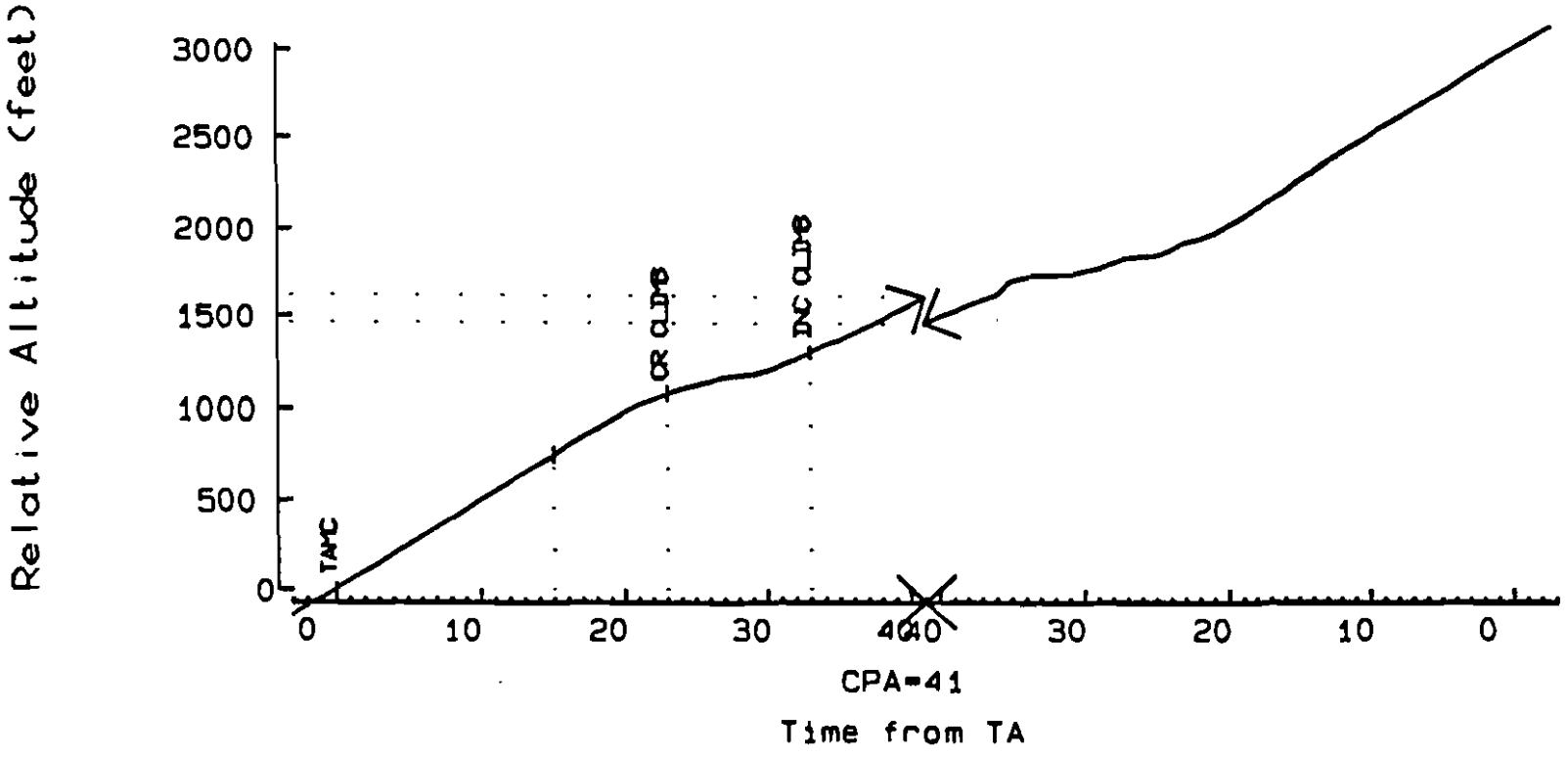
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -252

RANGE at CPA: 984 ft



TA TIME: 00:00:10 CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P Alt. Difference at CPA: 148 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-6

Plane 1

Run 3

Logic v6.04a

Group 1

>

Encounter ID 6 Filename m TSTPLN4.T

ENCOUNTER ID: 6

TARGET ID: 1

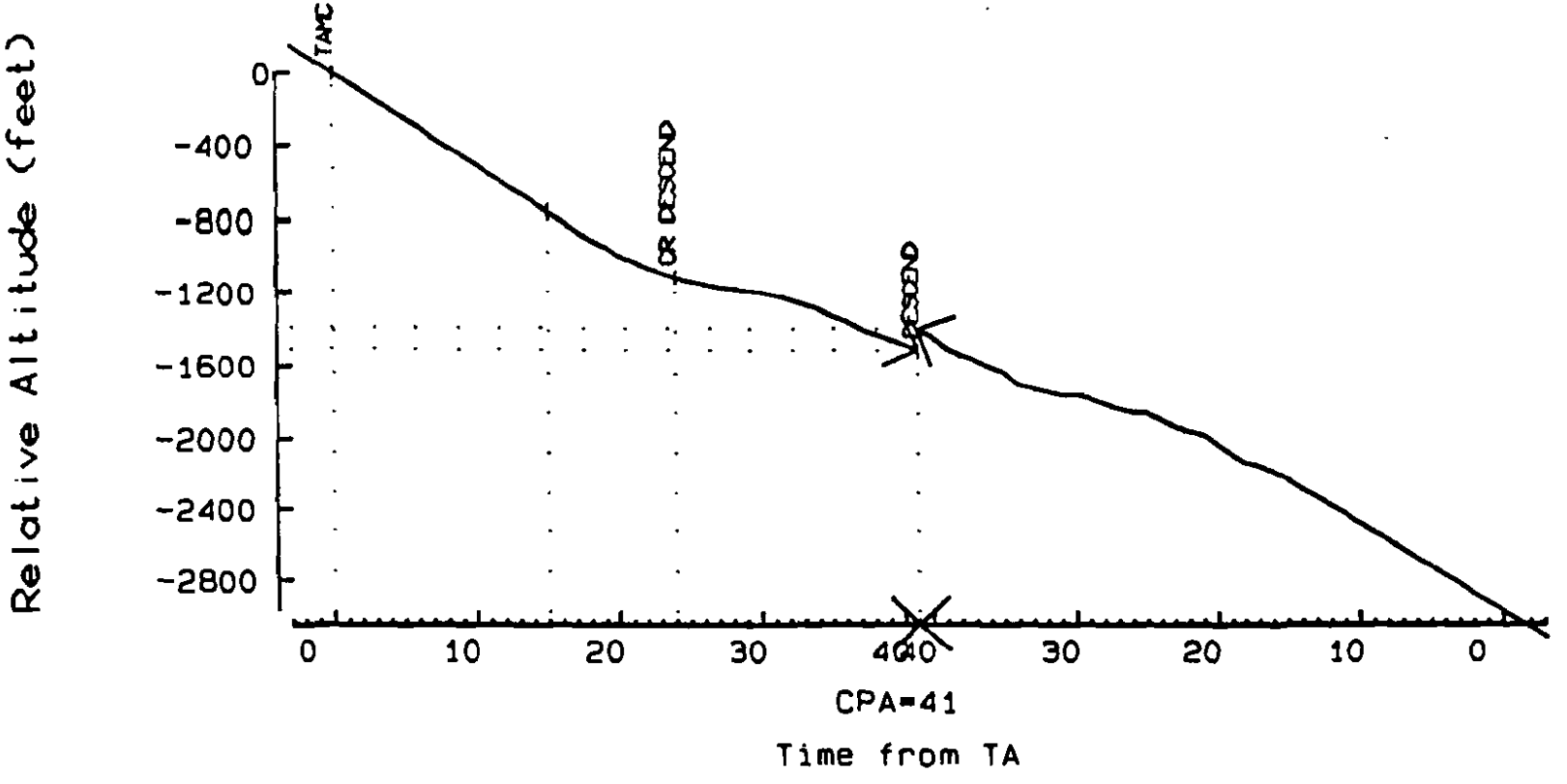
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -252

RANGE at CPA: 984 ft



TA TIME: 00:00:10

CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 117 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-7

Plane 2

Run 3

Logic v6.04a

Group 1

>

Encounter ID 7 Filename m TSTPLN4.T

ENCOUNTER ID: 7

TARGET ID: 2

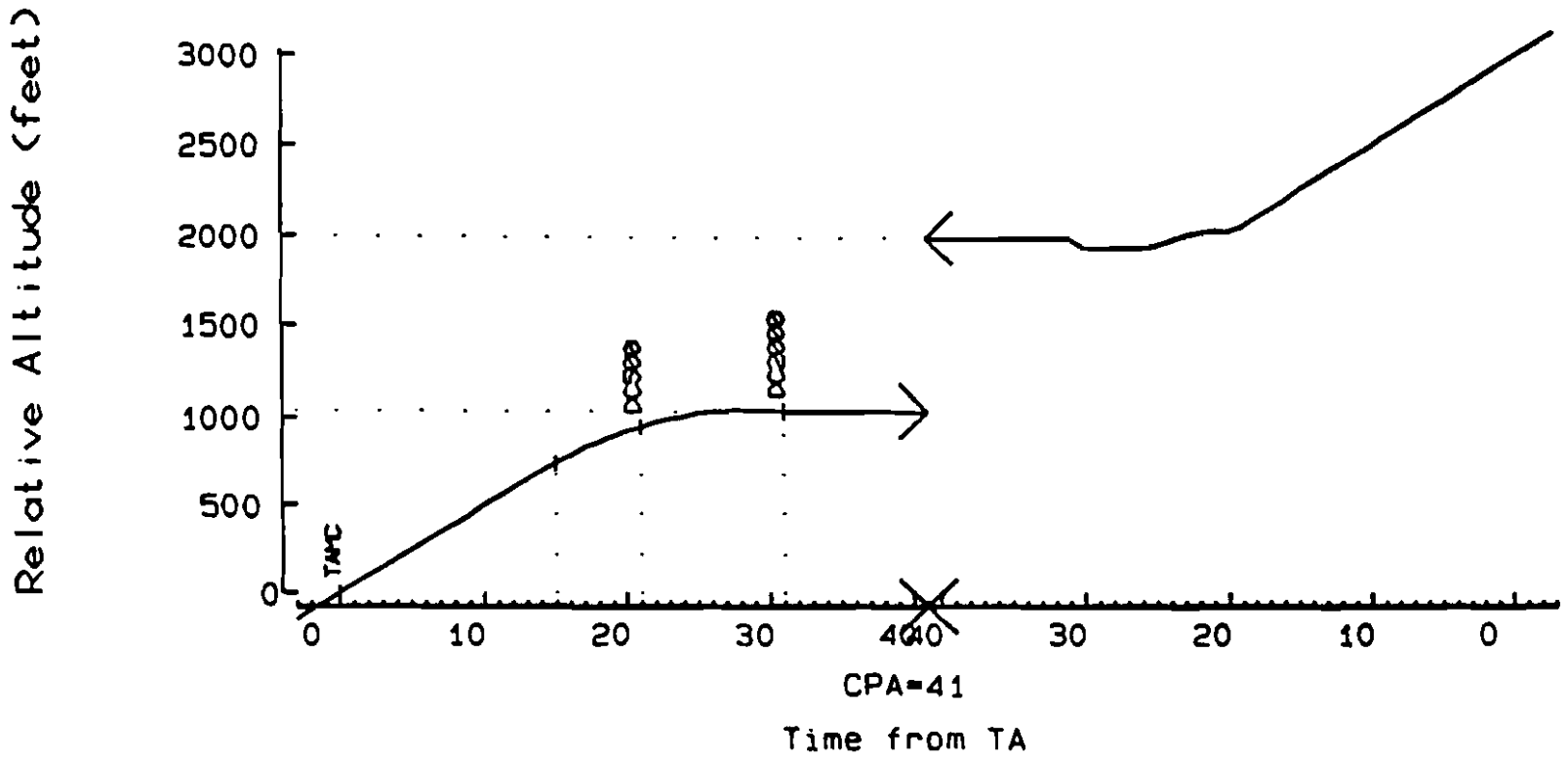
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -235

RANGE at CPA: 1245 ft



TA TIME: 00:00:10 CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P Alt. Difference at CPA: 961 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-8

Plane 1

Run 4

Logic v6.04a

Group 1

>

Encounter ID 8 Filename m TSTPLN4.T

ENCOUNTER ID: 8

TARGET ID: 1

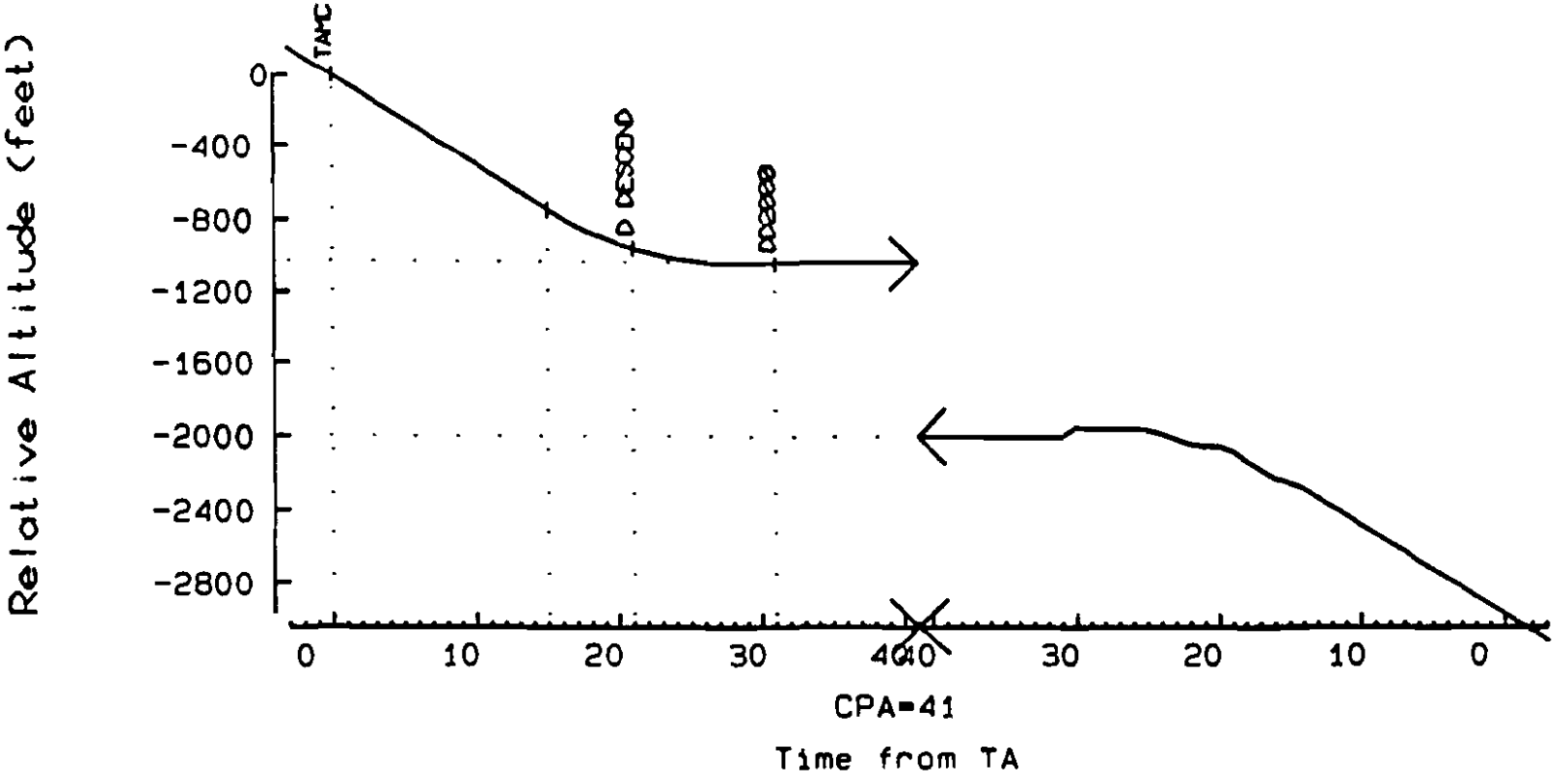
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -235

RANGE at CPA: 1245 ft



TA TIME: 00:00:10

CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 968 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-9

Plane 2

Run 4

Logic v6.04a

Group 1

>

Encounter ID 9 Filename m TSTPLN4.T

ENCOUNTER ID: 9

TARGET ID: 2

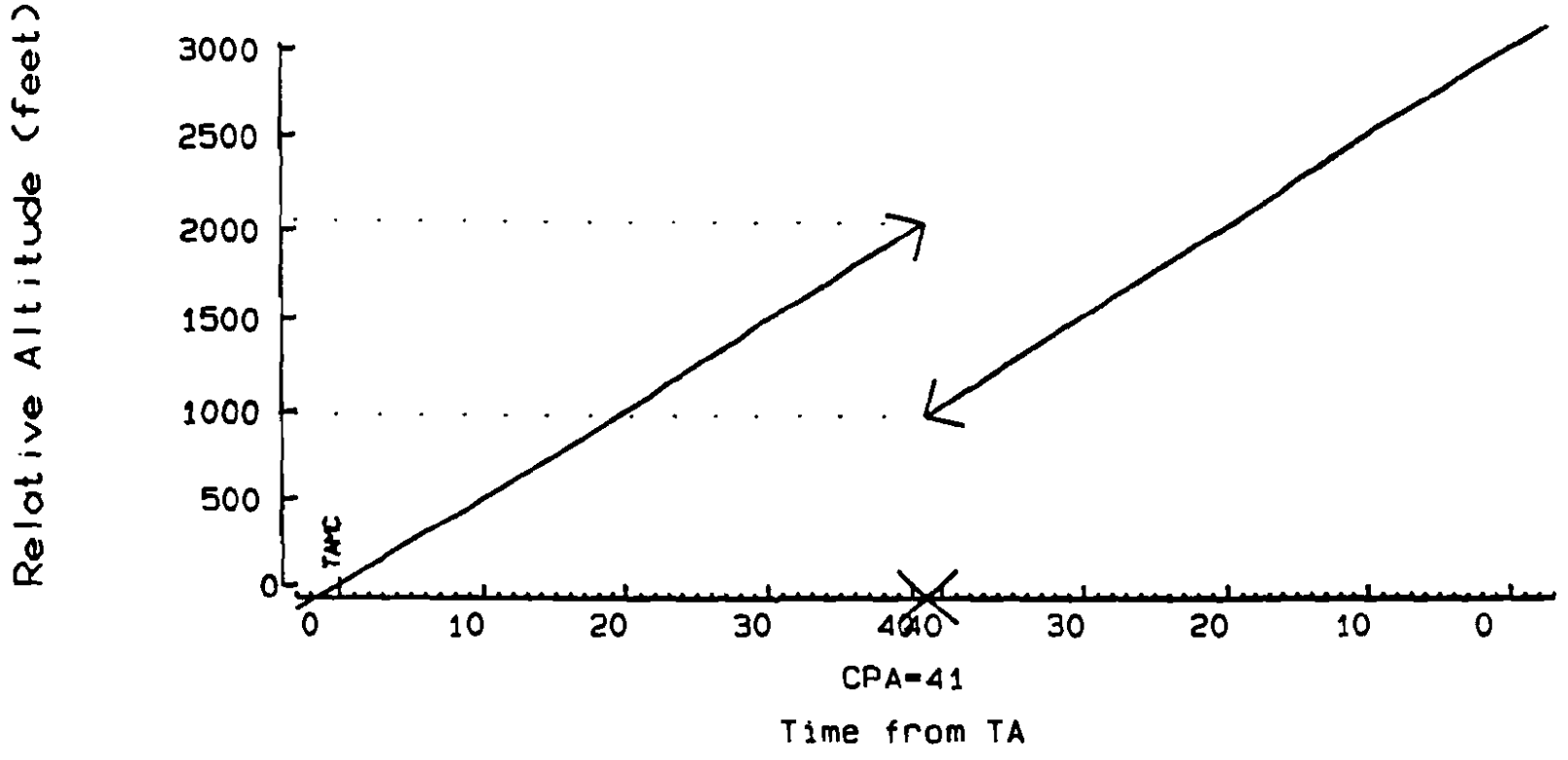
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -217

RANGE at CPA: 1288 ft



TA TIME: 00:00:10 CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P Alt. Difference at CPA: 1075 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-10 Plane 1 Run 1 Logic v6.04 Group 1

Encounter ID 10 Filename m TSTPLN4.T

ENCOUNTER ID: 10

TARGET ID: 1

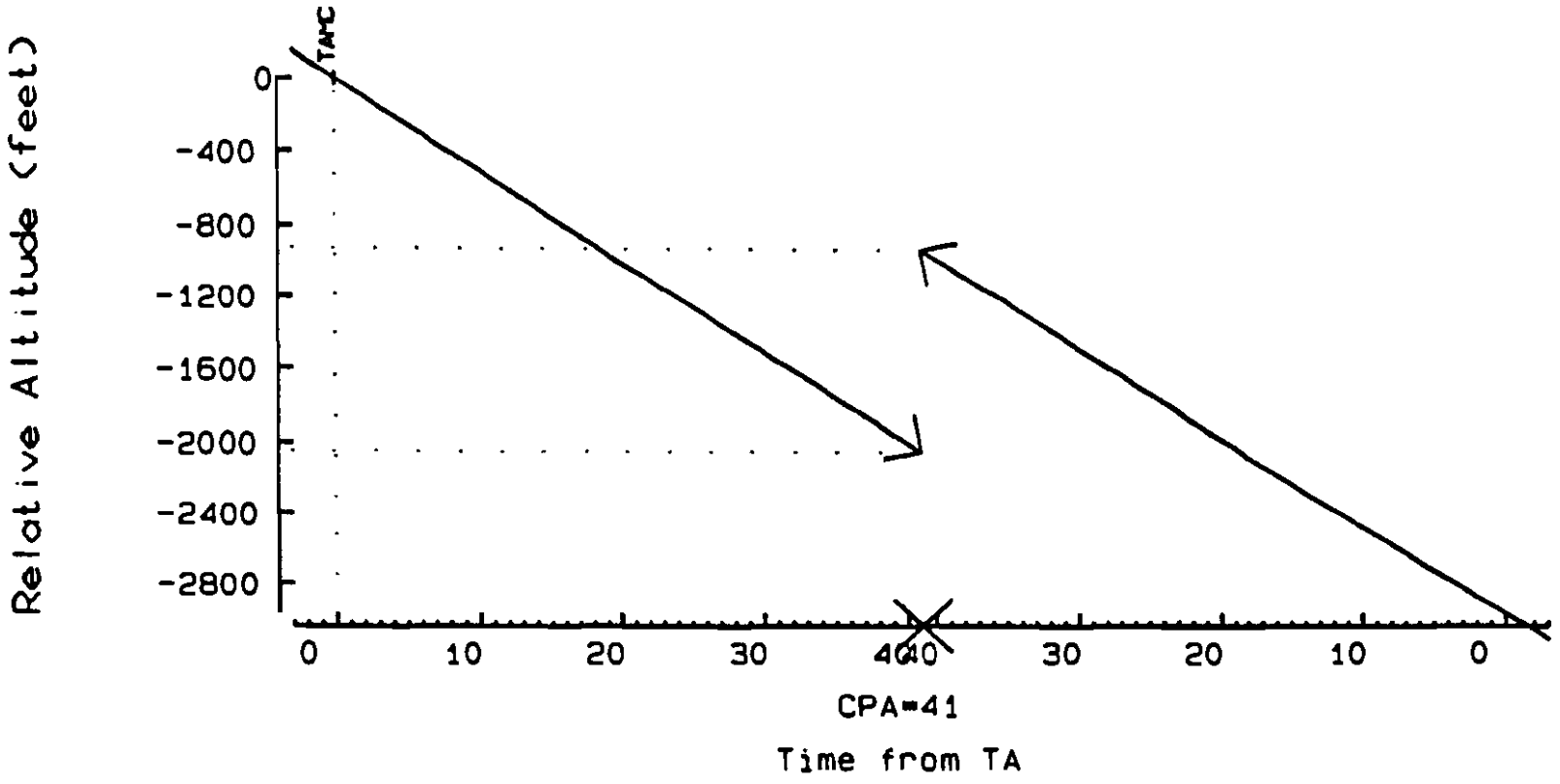
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -217

RANGE at CPA: 1288 ft



TA TIME: 00:00:10

CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 1125 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-11

Plane 2

Run 1

Logic v6.04

Group 1

>

Encounter ID 11 Filename m TSTPLN4.T

ENCOUNTER ID: 11

TARGET ID: 2

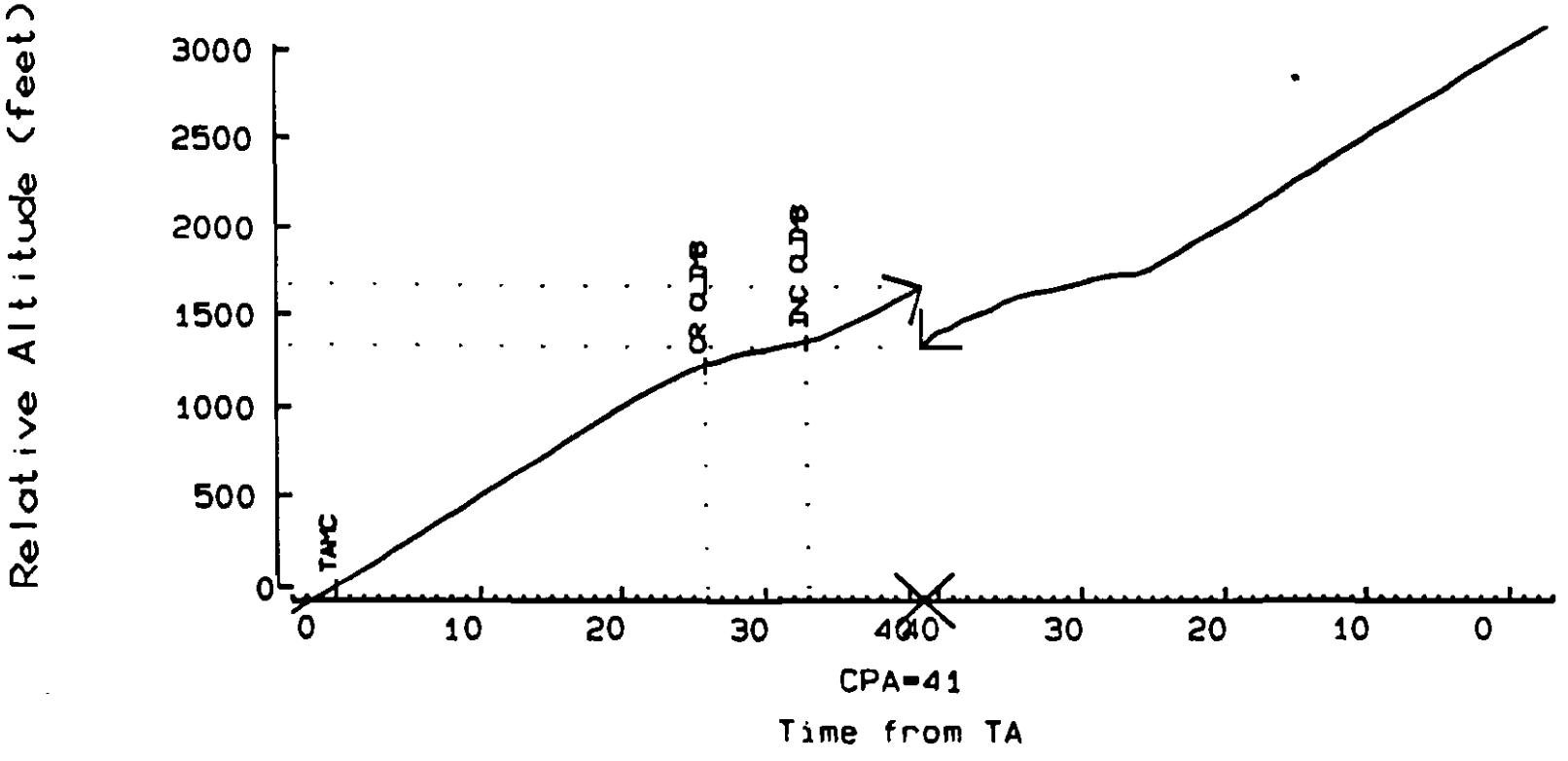
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -248

RANGE at CPA: 1002 ft



TA TIME: 00:00:10 CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P Alt. Difference at CPA: 333 ft

PROCESSED ON: 02/17/94 by ACO-320 FAA Technical Center

A-12

Plane 1

Run 2

Logic v6.04

Group 1

>

Encounter ID 12 Filename m TSTPLN4.T

ENCOUNTER ID: 12

TARGET ID: 1

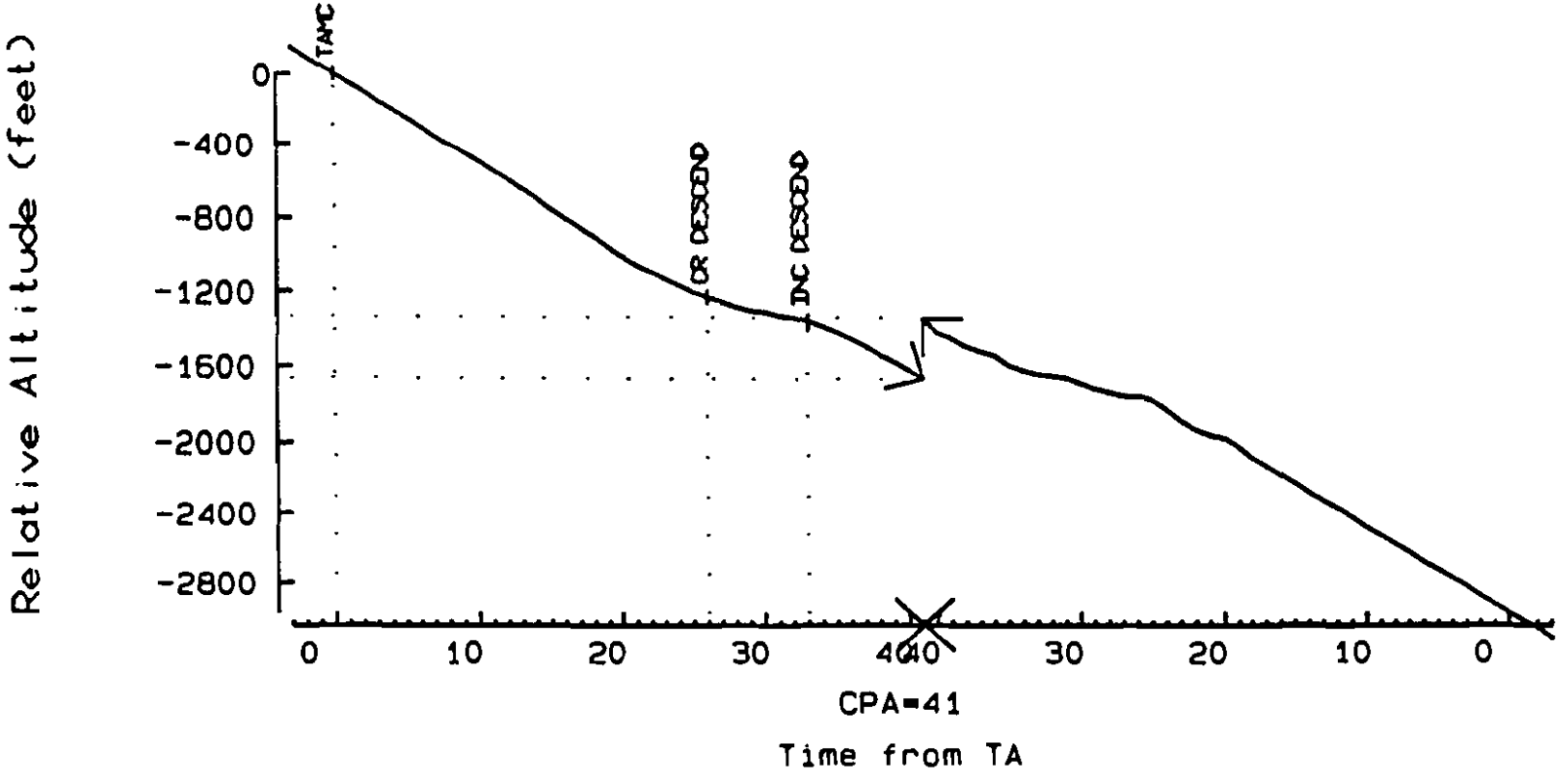
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -248

RANGE at CPA: 1002 ft



TA TIME: 00:00:10

CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 333 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-13

Plane 2

Run 2

Logic v6.04

Group 1

>

Encounter ID 13 Filename m TSTPLN4.T

ENCOUNTER ID: 13

TARGET ID: 2

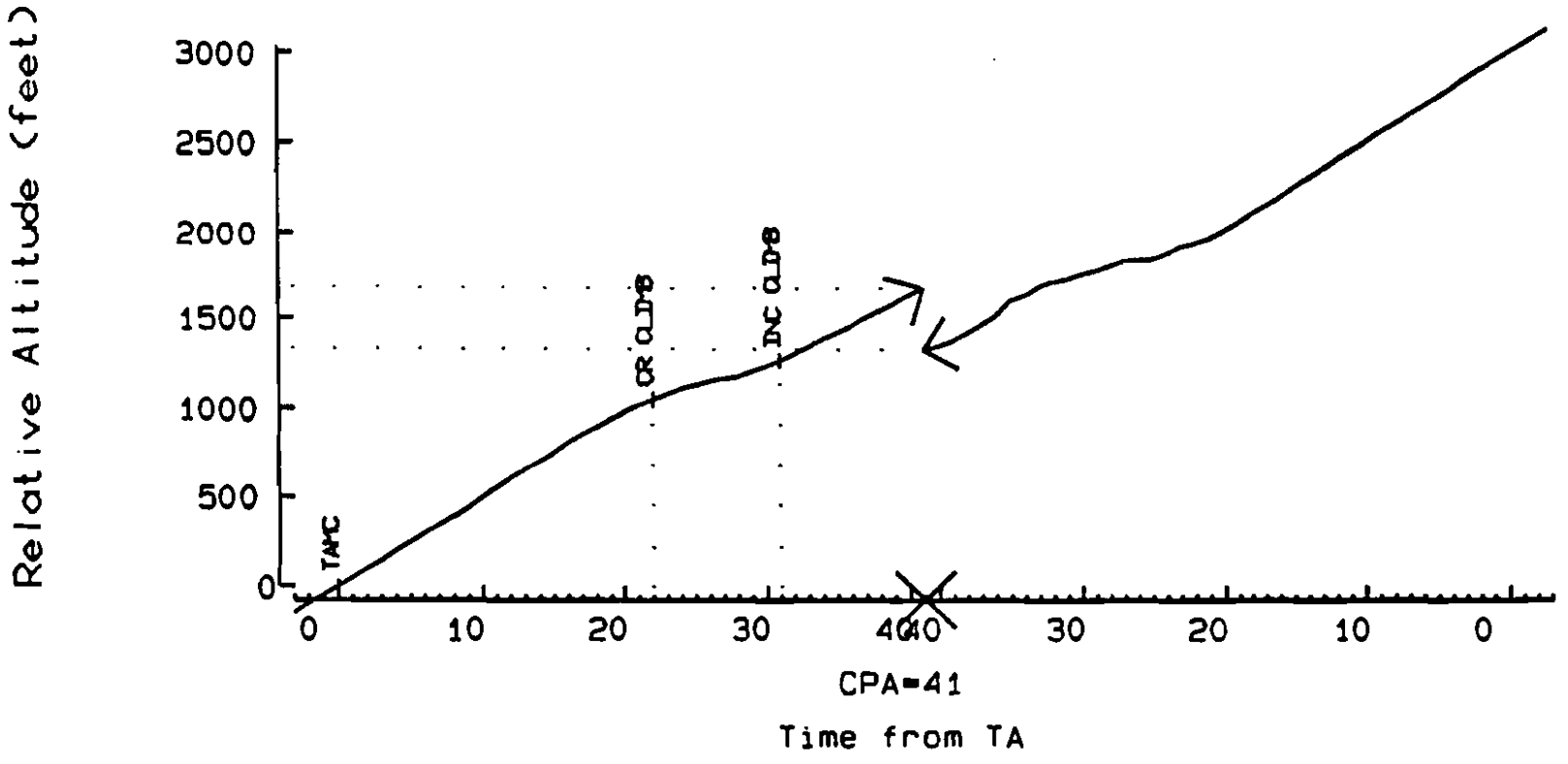
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -247

RANGE at CPA: 1008 ft



TA TIME: 00:00:10 CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P Alt. Difference at CPA: 347 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-14

Plane 1

Run 3

Logic v6.04

Group 1

>

Encounter ID 14 Filename m TSTPLN4.T

ENCOUNTER ID: 14

TARGET ID: 1

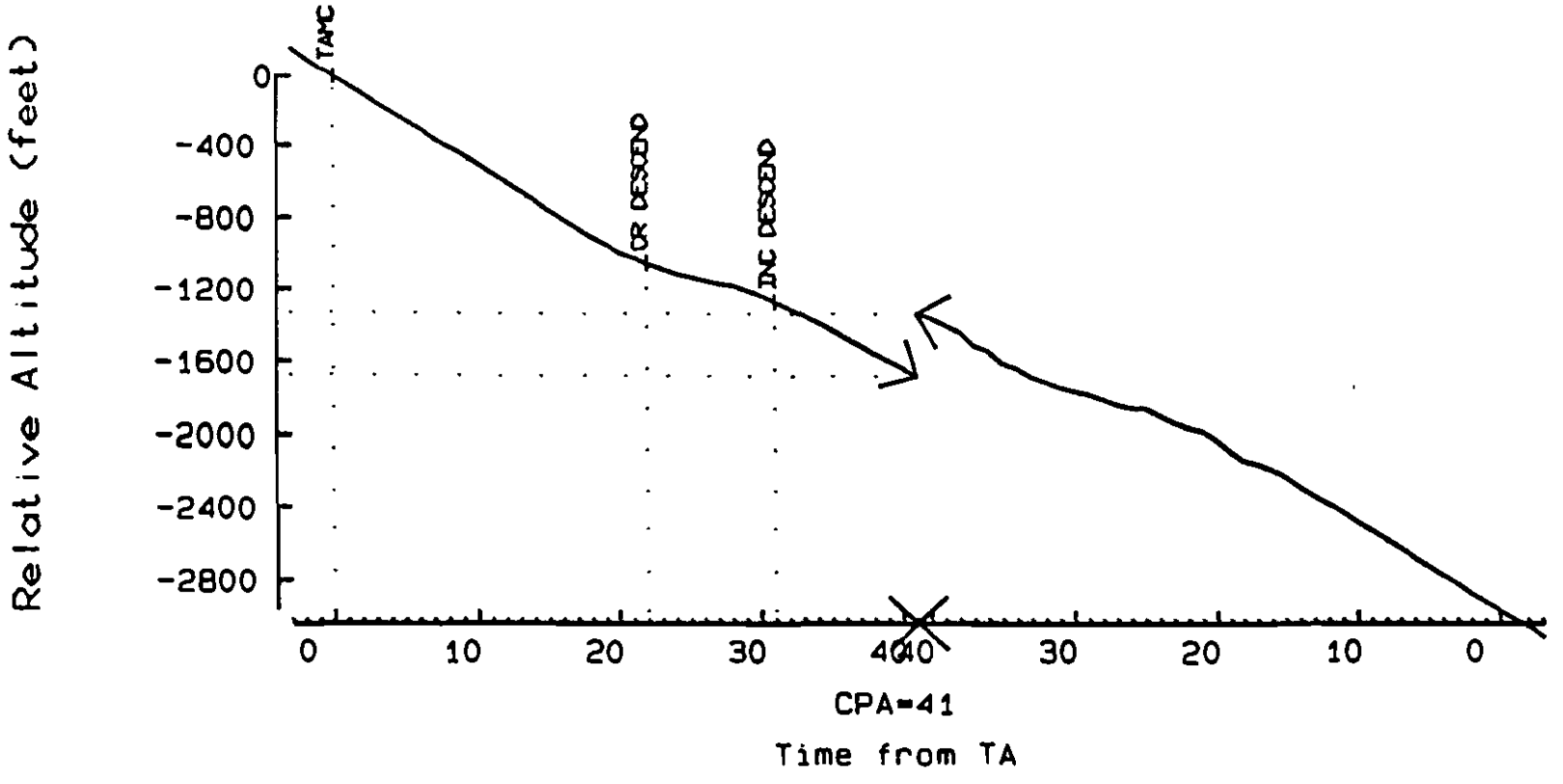
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -247

RANGE at CPA: 1008 ft



TA TIME: 00:00:10

CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 345 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

>

A-15

Plane 2

Run 3

Logic v6.04

Group 1

Encounter ID 15 Filename m TSTPLN4.T

ENCOUNTER ID: 15

TARGET IO: 2

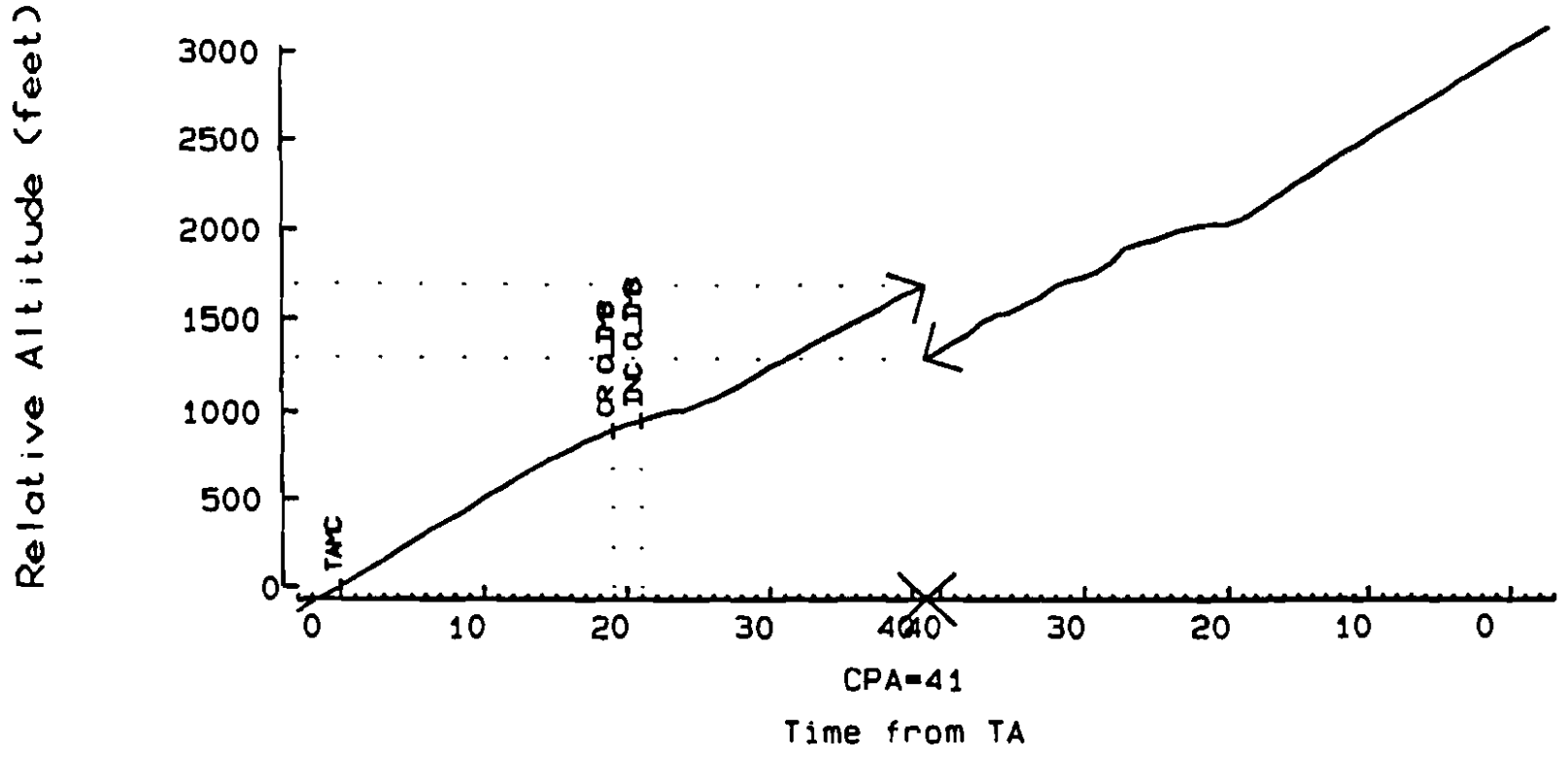
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -246

RANGE at CPA: 1014 ft



TA TIME: 00: 00: 10 CPA TIME: 00: 00: 51

FLIGHT DATE: RP/1./9P Alt. Difference at CPA: 412 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

>

A-16

Plane 1

Run 4

Logic v6.04

Group 1

Encounter ID 16 Filename m TSTPLN4.T

ENCOUNTER ID: 16

TARGET ID: 1

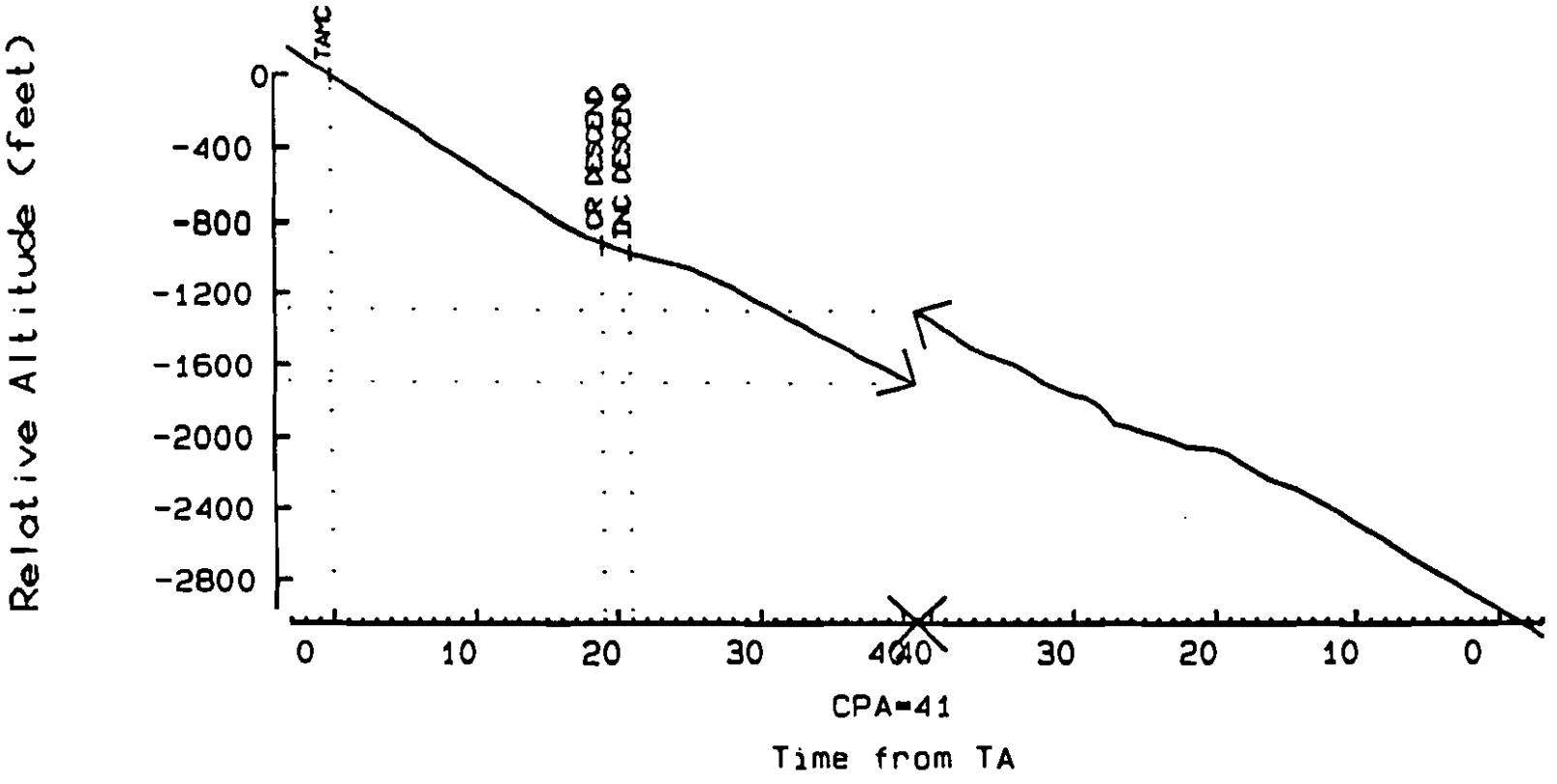
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -246

RANGE at CPA: 1014 ft



TA TIME: 00: 00: 10

CPA TIME: 00: 00: 51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 412 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-17

Plane 2

Run 4

Logic v6.04

Group 1

>

Encounter ID 17 Filename m TSTPLN4.T

ENCOUNTER ID: 17

TARGET ID: 2

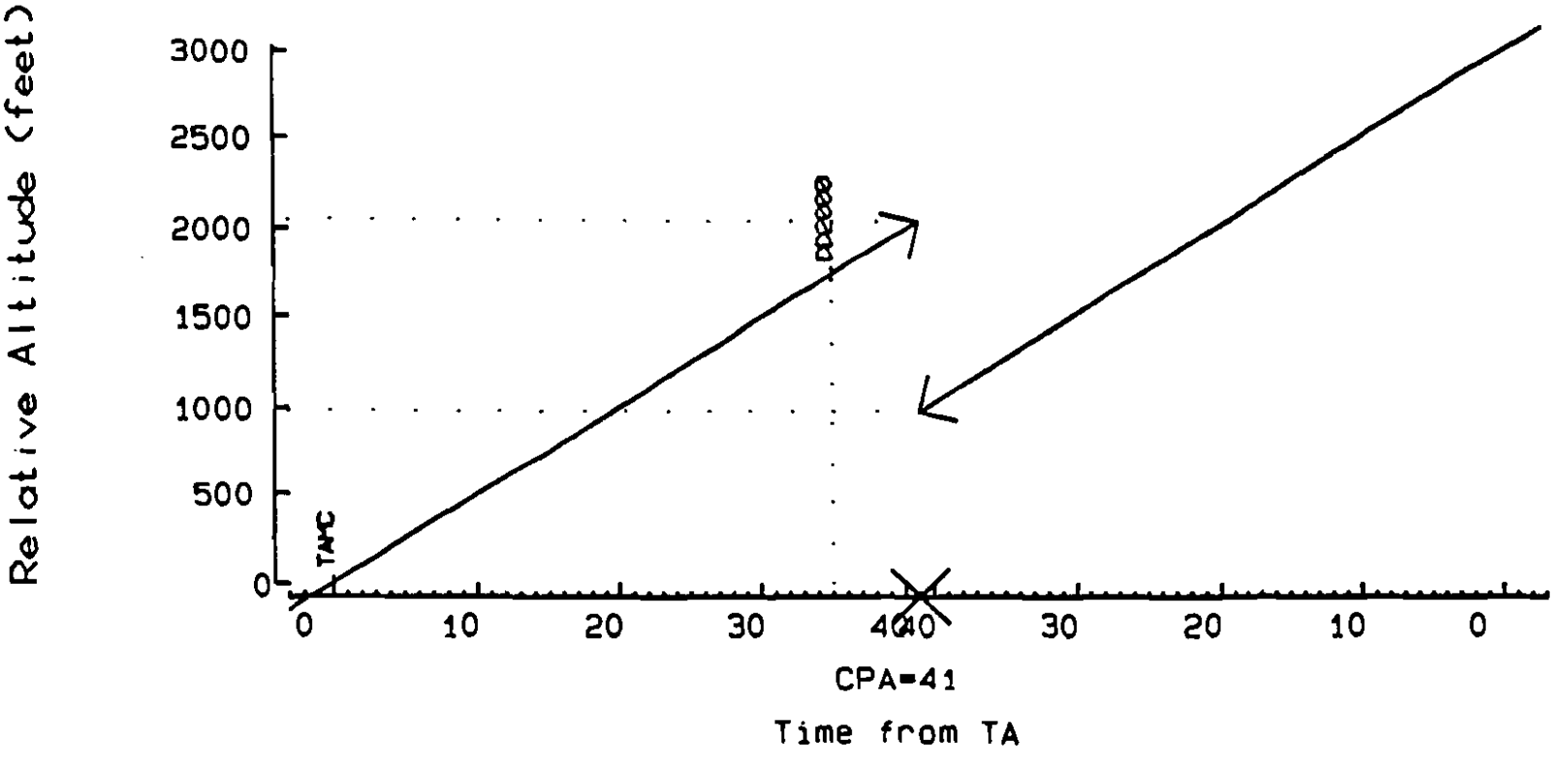
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -217

RANGE at CPA: 1288 ft



TA TIME: 00:00:10

CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 1075 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-18

Plane 1

Run 1

Logic v6.02

Group 1

>

Encounter ID 18 Filename m TSTPLN4.T

ENCOUNTER ID: 18

TARGET ID: 1

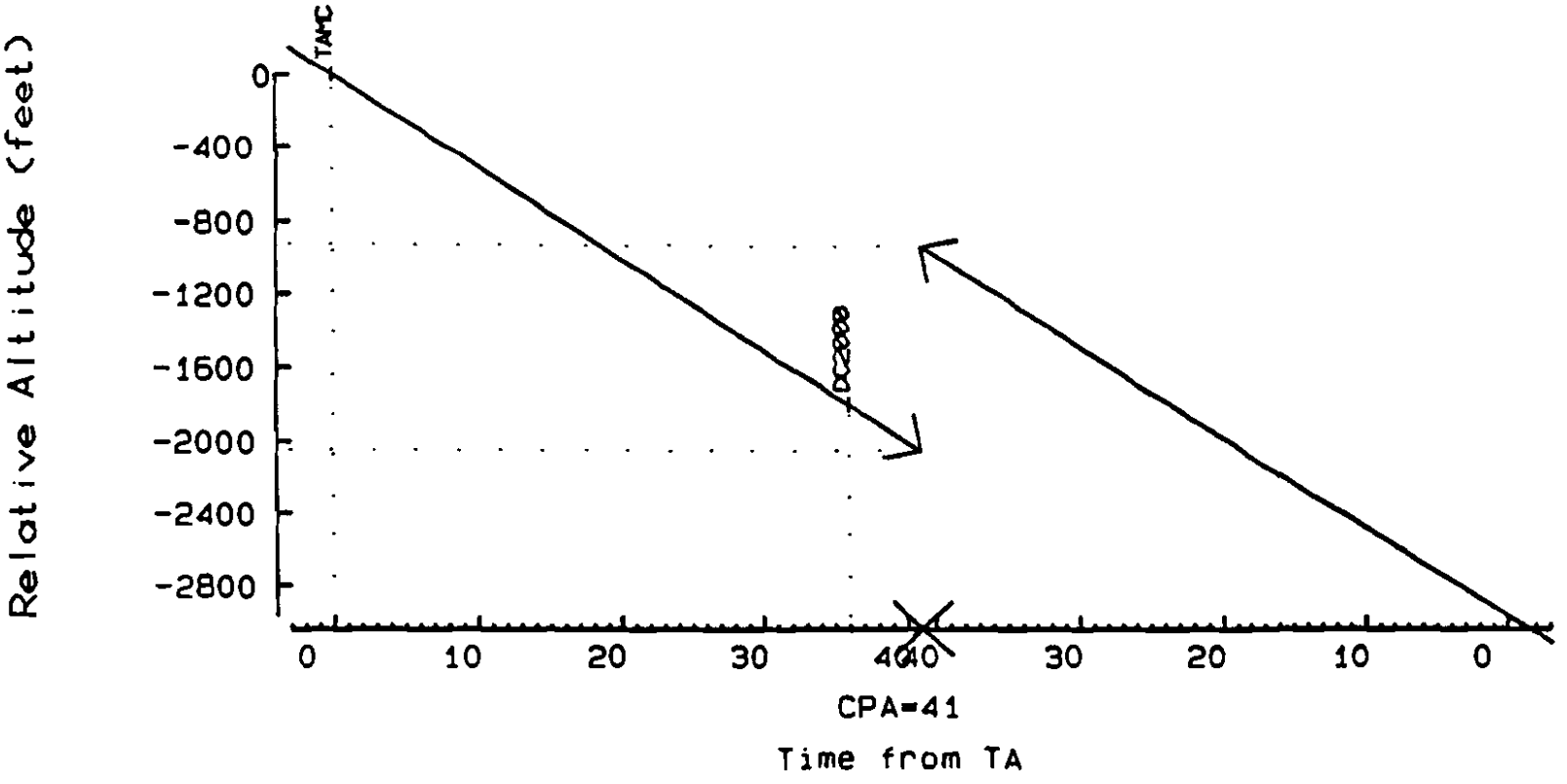
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -217

RANGE at CPA: 1288 ft



TA TIME: 00:00:10

CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 1125 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-19

Plane 2

Run 1

Logic v6.02

Group 1

>

Encounter ID 19 Filename m TSTPLN4.T

ENCOUNTER ID: 19

TARGET ID: 2

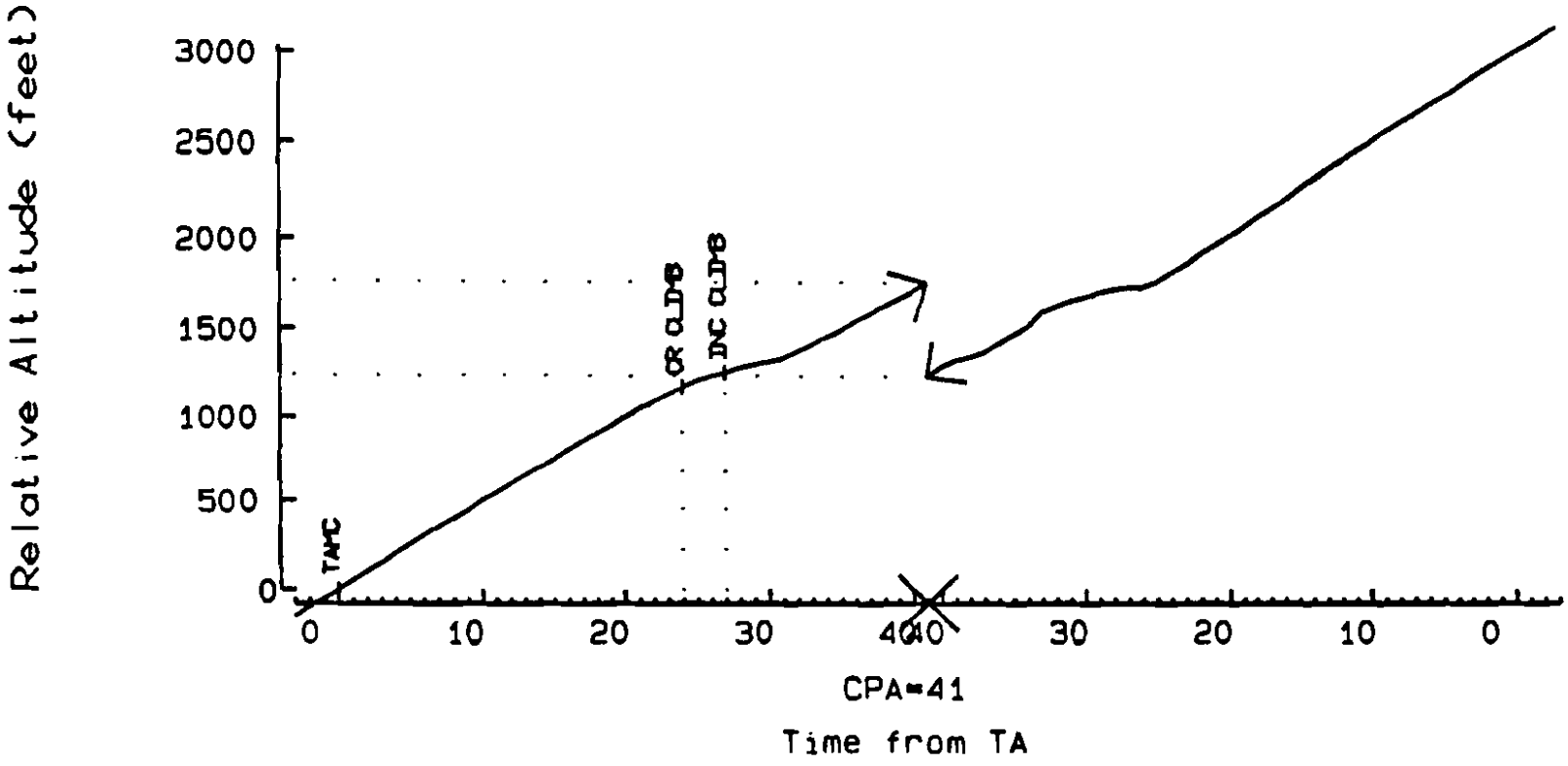
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -242

RANGE at CPA: 1045 ft



TA TIME: 00:00:10

CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 533 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-20

Plane 1

Run 2

Logic v6.02

Group 1

>

Encounter ID 20 Filename m TSTPLN4.T

ENCOUNTER ID: 20

TARGET ID: 1

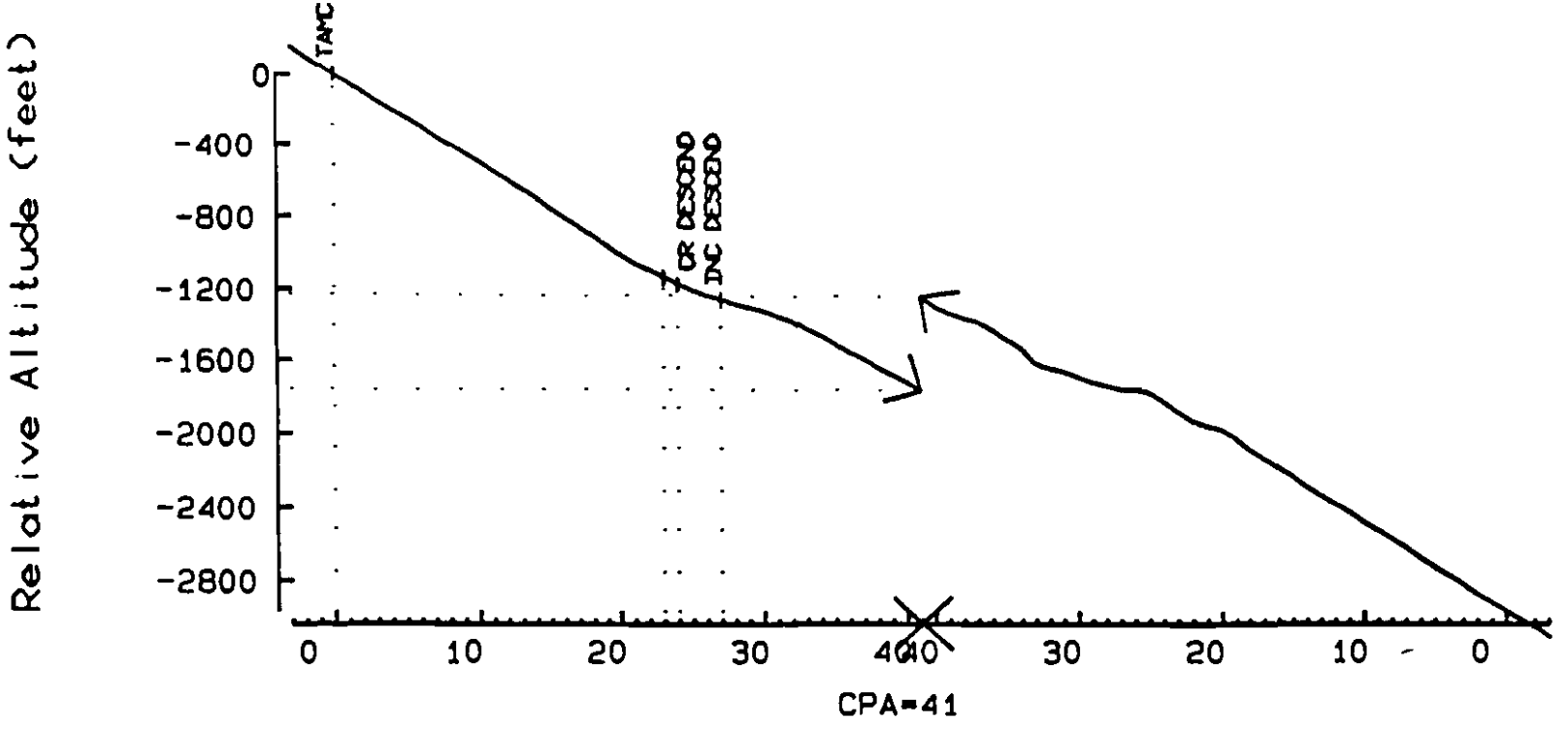
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -242

RANGE at CPA: 1045 ft



TA TIME: 00:00:10

CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 533 ft

PROCESSED ON: 02/17/94 by ACO-320 FAA Technical Center

A-21

Plane 2

Run 2

Logic v6.02

Group 1

>

Encounter ID 21 Filename m TSTPLN4.T

ENCOUNTER ID: 21

TARGET ID: 2

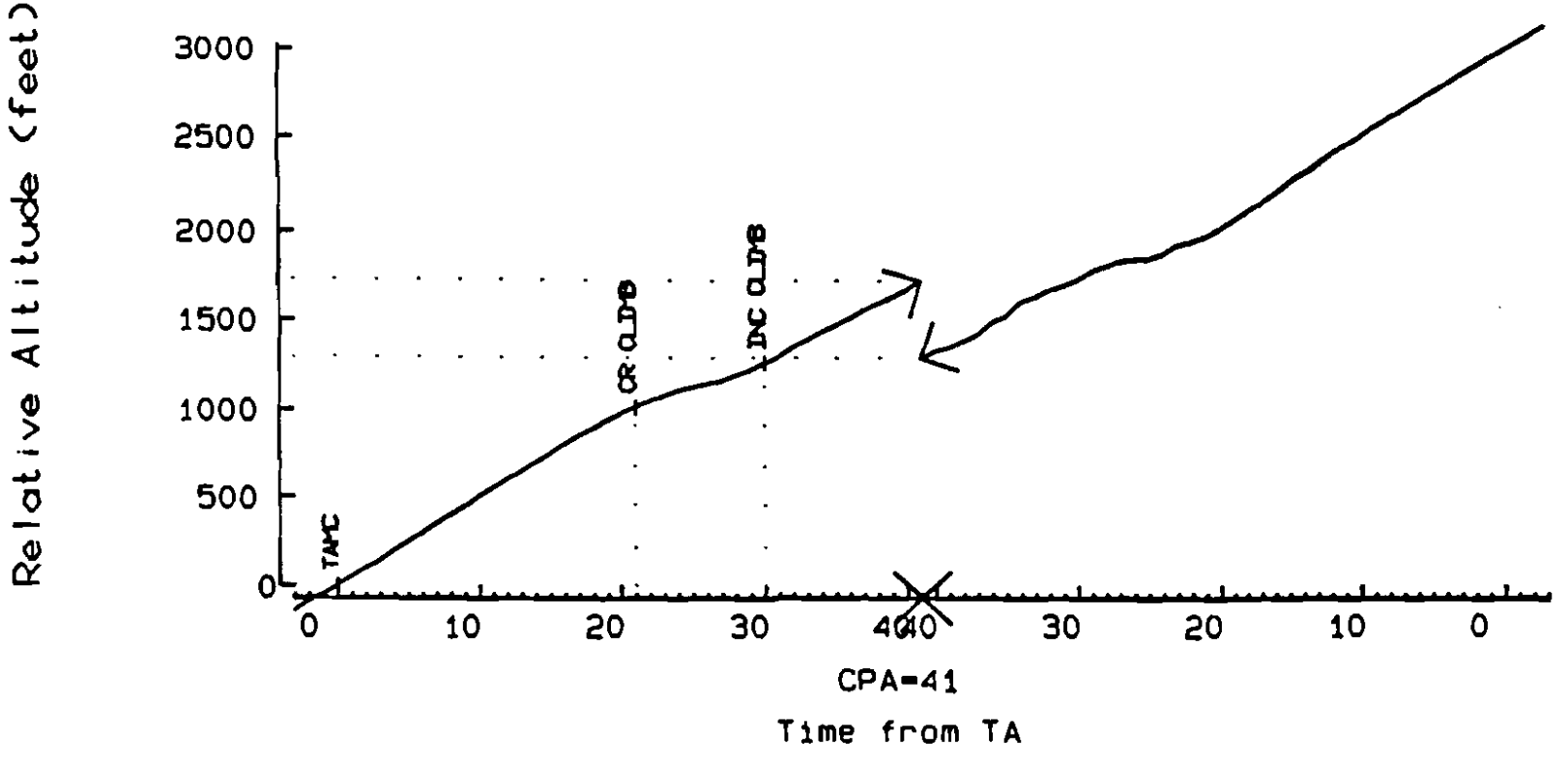
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -244

RANGE at CPA: 1026 ft



TA TIME: 00:00:10

CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 432 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

>

A-22

Plane 1

Run 3

Logic v6.02

Group 1

Encounter ID 22 Filename m TSTPLN4.T

ENCOUNTER ID: 22

TARGET ID: 1

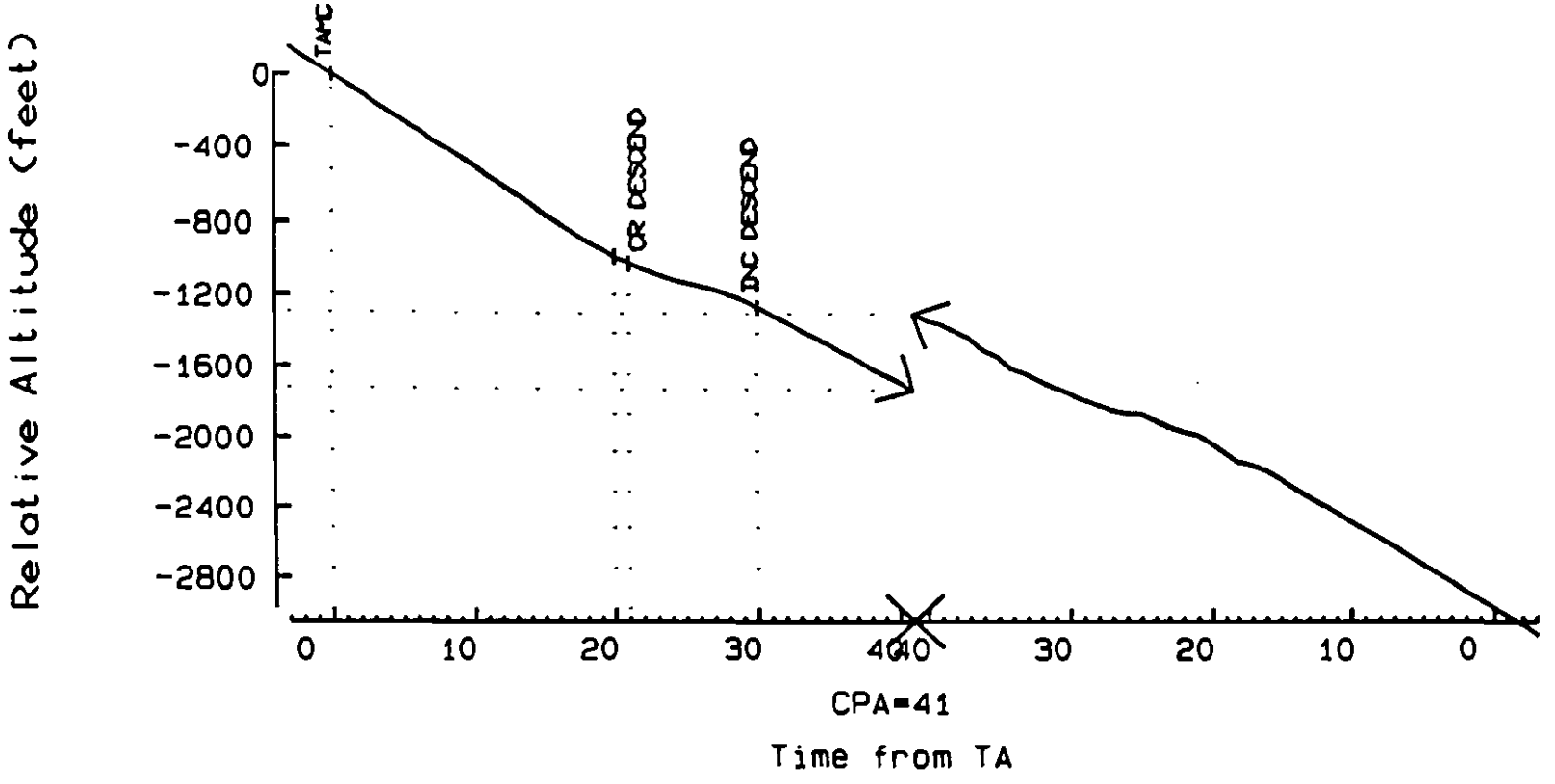
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -244

RANGE at CPA: 1026 ft



TA TIME: 00:00:10

CPA TIME: 00:00:51

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 431 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

A-23

Plane 2

Run 3

Logic v6.02

Group 1

Encounter ID 23 Filename m TSTPLN4.T

ENCOUNTER ID: 23

TARGET ID: 2

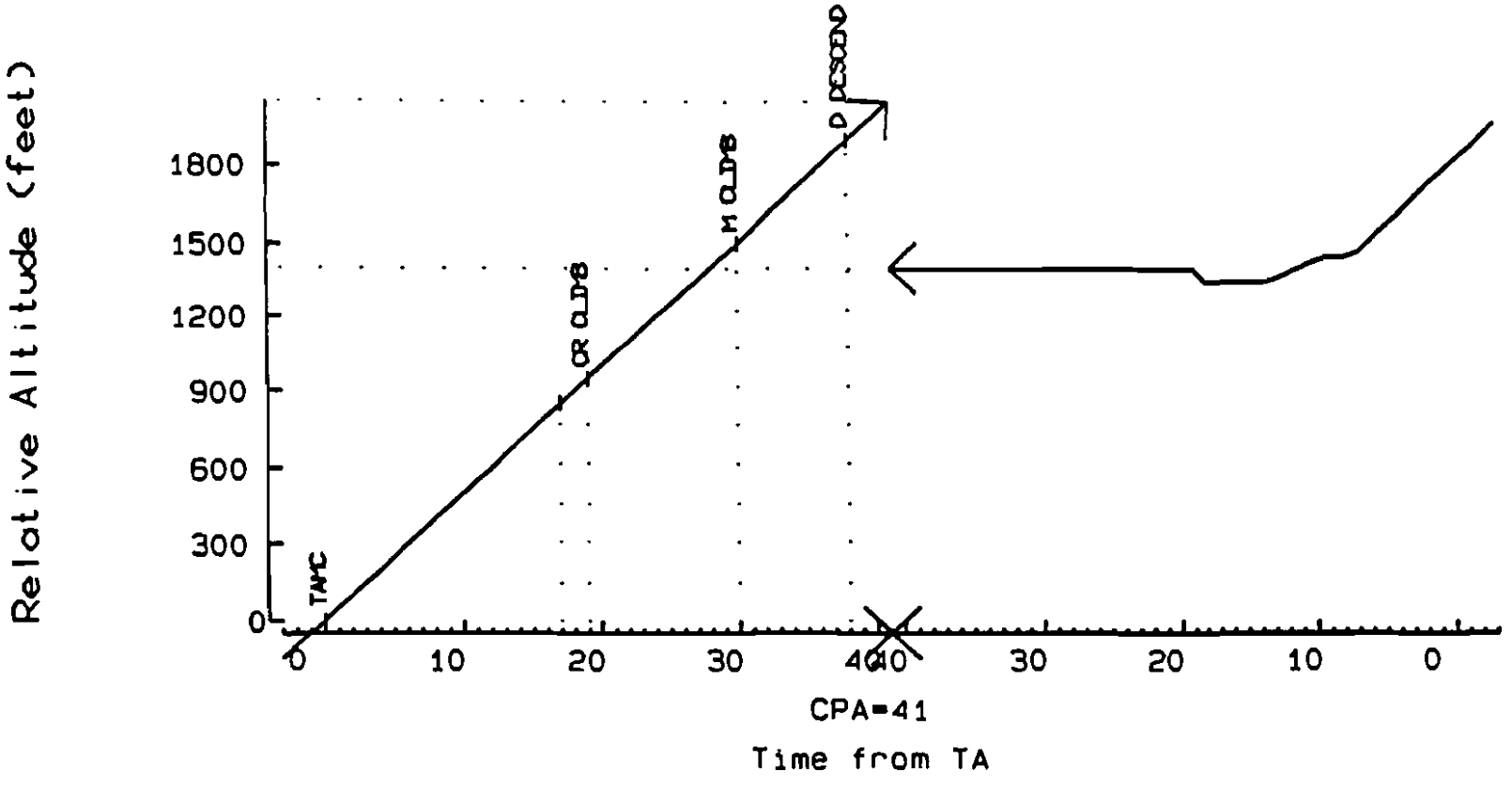
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -403

at CPA: -201

RANGE at CPA: 1221 ft



TA TIME: 00: 00: 22 CPA TIME: 00: 01: 03

FLIGHT DATE: RP/1./9P Alt. Difference at CPA: 650 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

>

A-24

Plane 1

Run 4

Logic v6.02

Group 1

Encounter ID 24 Filename m TSTPLN4.T

ENCOUNTER ID: 24

TARGET ID: 1

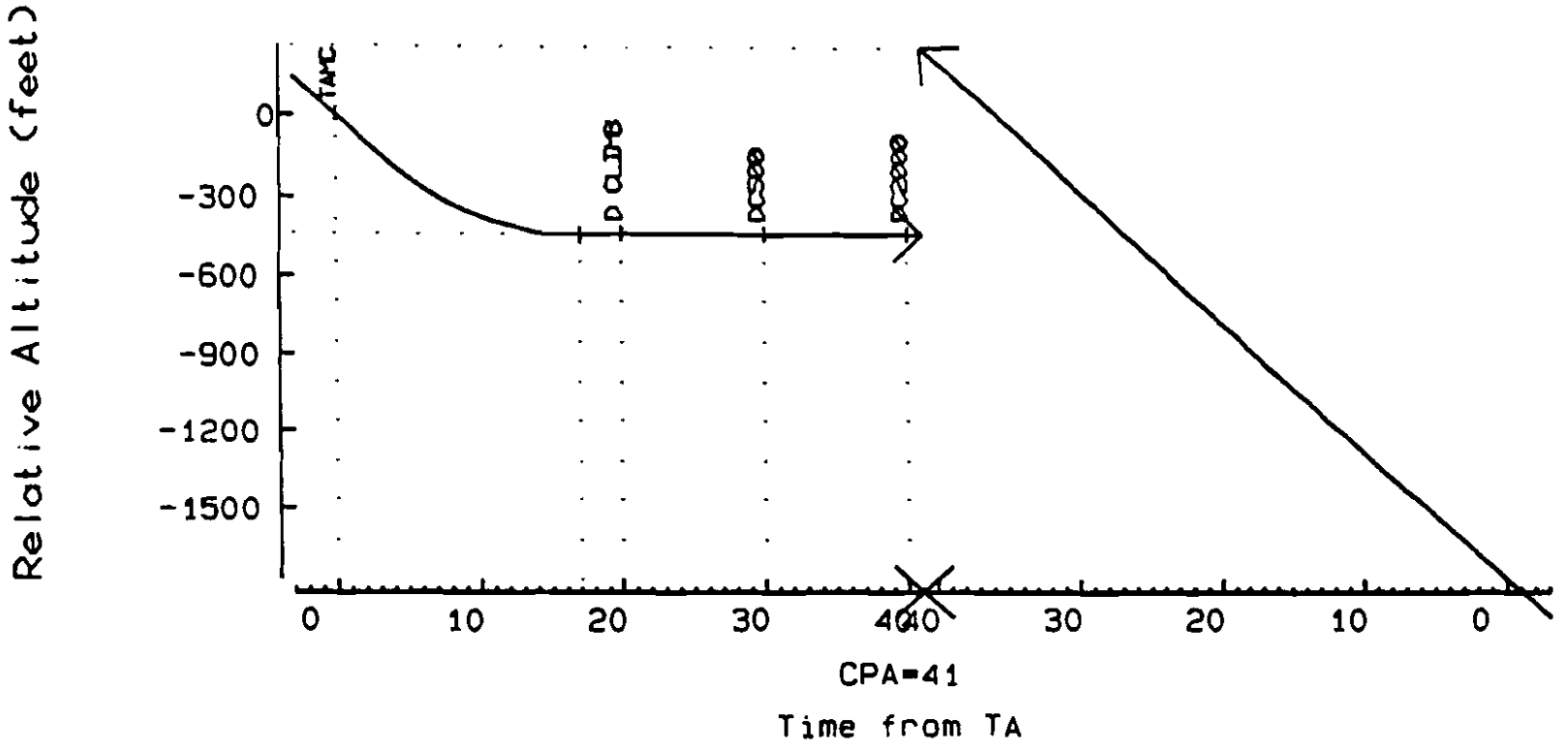
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -403

at CPA: -201

RANGE at CPA: 1221 ft



TA TIME: 00:00:22

CPA TIME: 00:01:03

FLIGHT DATE: RP/1./9P

Alt. Difference at CPA: 714 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

>

A-25

Plane 2

Run 4

Logic v6.02.

Group 1

APPENDIX B

Simulation Results for Group 2 Encounters

Four different groups of encounters were used for the v6.04a logic flight tests. This appendix includes the simulation results for the modified encounter set, Group 2, which was used on the 9/14/93 and 9/15/93 test flights. The plots can be compared to see the simulated results of three TCAS logic versions; v6.04a, v6.04, and v6.02.

An explanation of the plots is included on pages F-1 through F-4 (appendix F). Note that since these are simulation results, some of the information fields, such as FLIGHT DATE, may have superfluous entries.

There are two plots for each encounter, one from the viewpoint of each TCAS. These plots correspond to the encounter run numbers as follows:

logic version	6.04a	6.04	6.02
Run 1	*same as Group 1. Please see appendix A for these plots.*		
Run 2	Plots B-2 and B-3	B-6 and B-7	B-10 and B-11
Run 3	Plots B-4 and B-5	B-8 and B-9	B-12 and B-13
Run 4	*same as Group 1. Please see appendix A for these plots.*		

Encounter ID 3 Filename m TSTPLN6.T

ENCOUNTER ID: 3

TARGET ID: 2

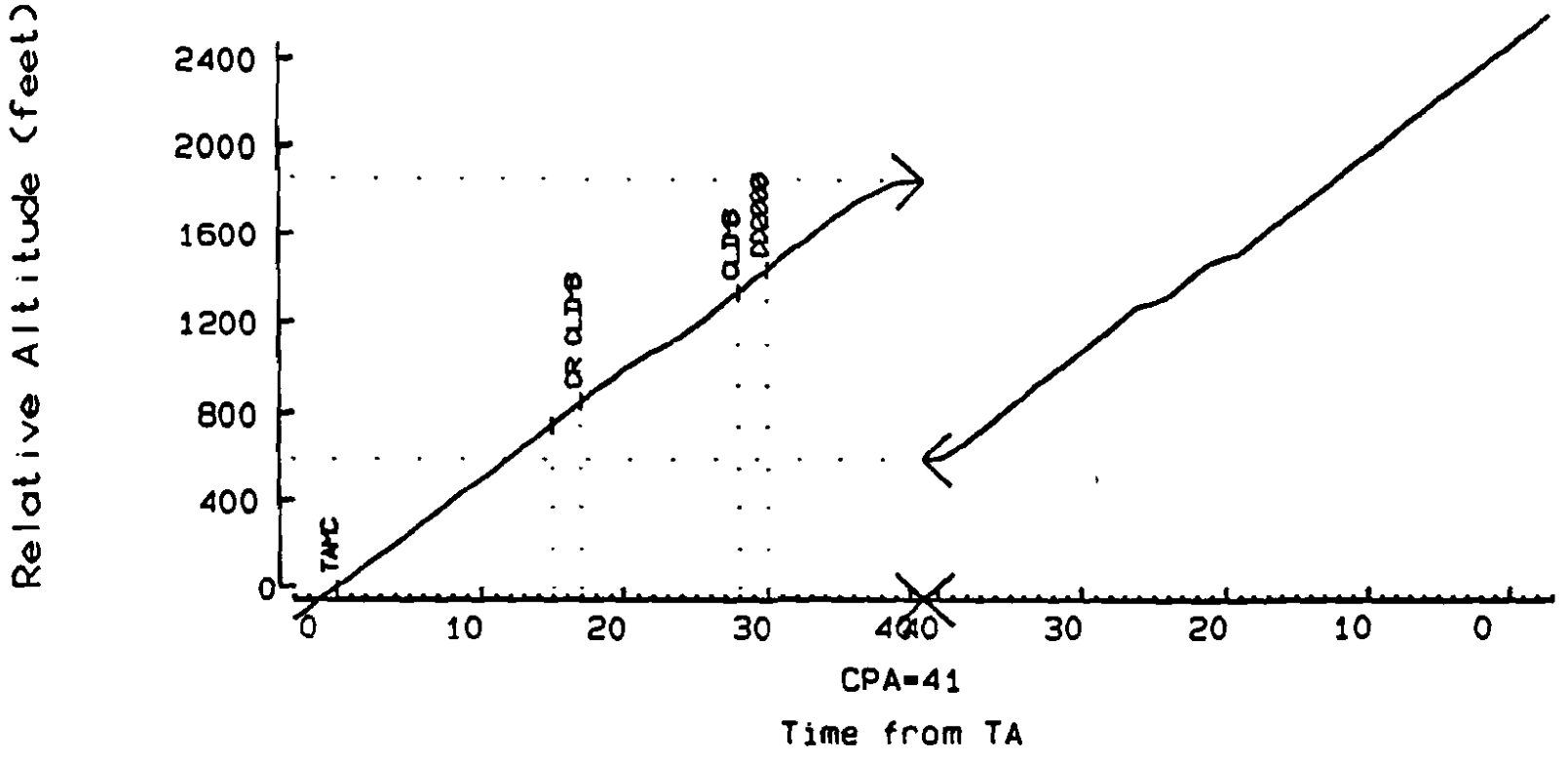
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -217

RANGE at CPA: 1403 ft



TA TIME: 00:00:22 CPA TIME: 00:01:03

FLIGHT DATE: RP/2./9P Alt. Difference at CPA: 1269 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

B-2

Plane 1

Run 2

Logic v6.04a

Group 2

Encounter IO 4 Filename m TSTPLN6.T

ENCOUNTER ID: 4

TARGET ID: 1

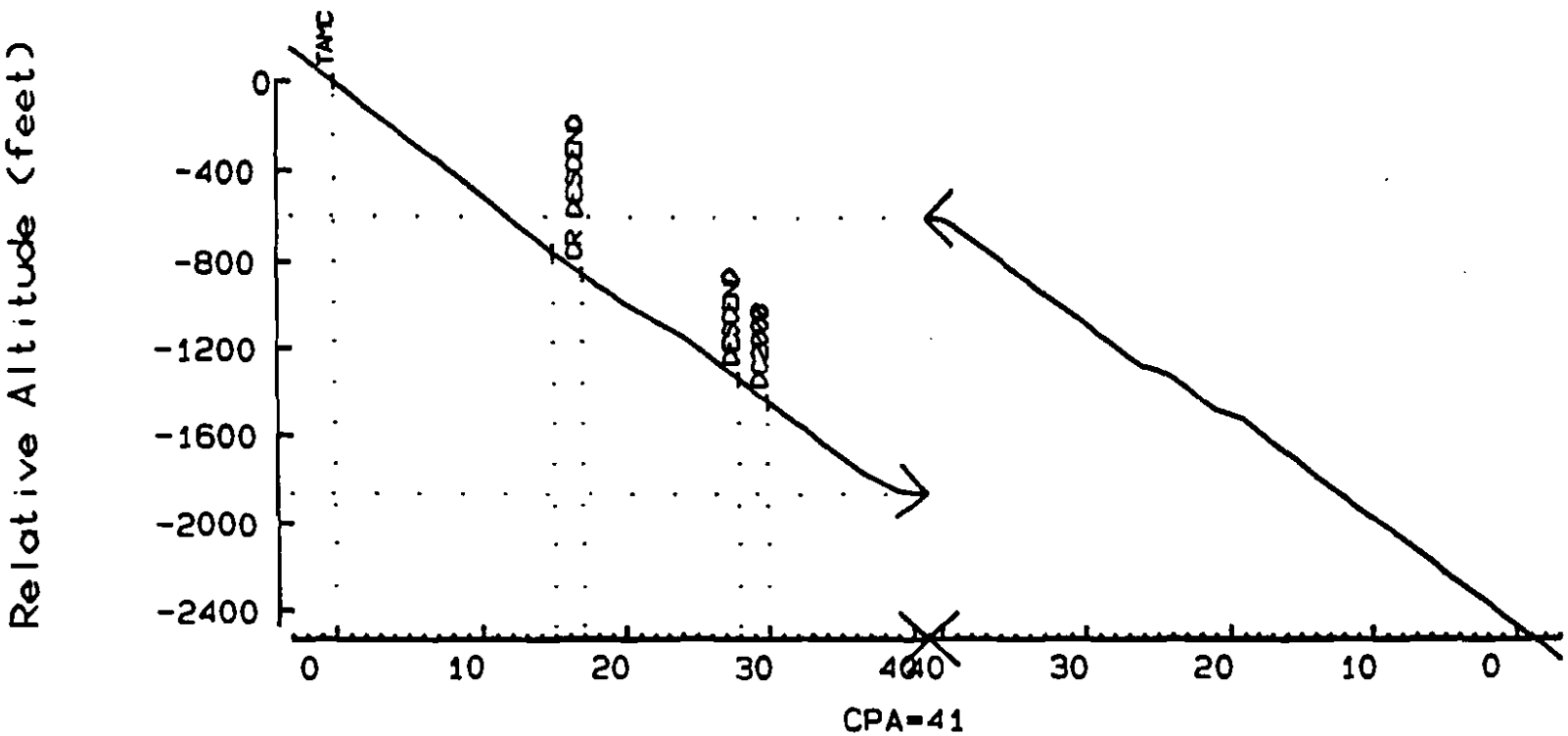
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -217

RANGE at CPA: 1403 ft



TA TIME: 00: 00: 22

CPA TIME: 00: 01: 03

FLIGHT DATE: RP/2./9P

Alt. Difference at CPA: 1269 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

B-3

Plane 2

Run 2

Logic v6.04a

Group 2

>

Encounter ID 5 Filename m TSTPLN6.T

ENCOUNTER ID: 5

TARGET ID: 2

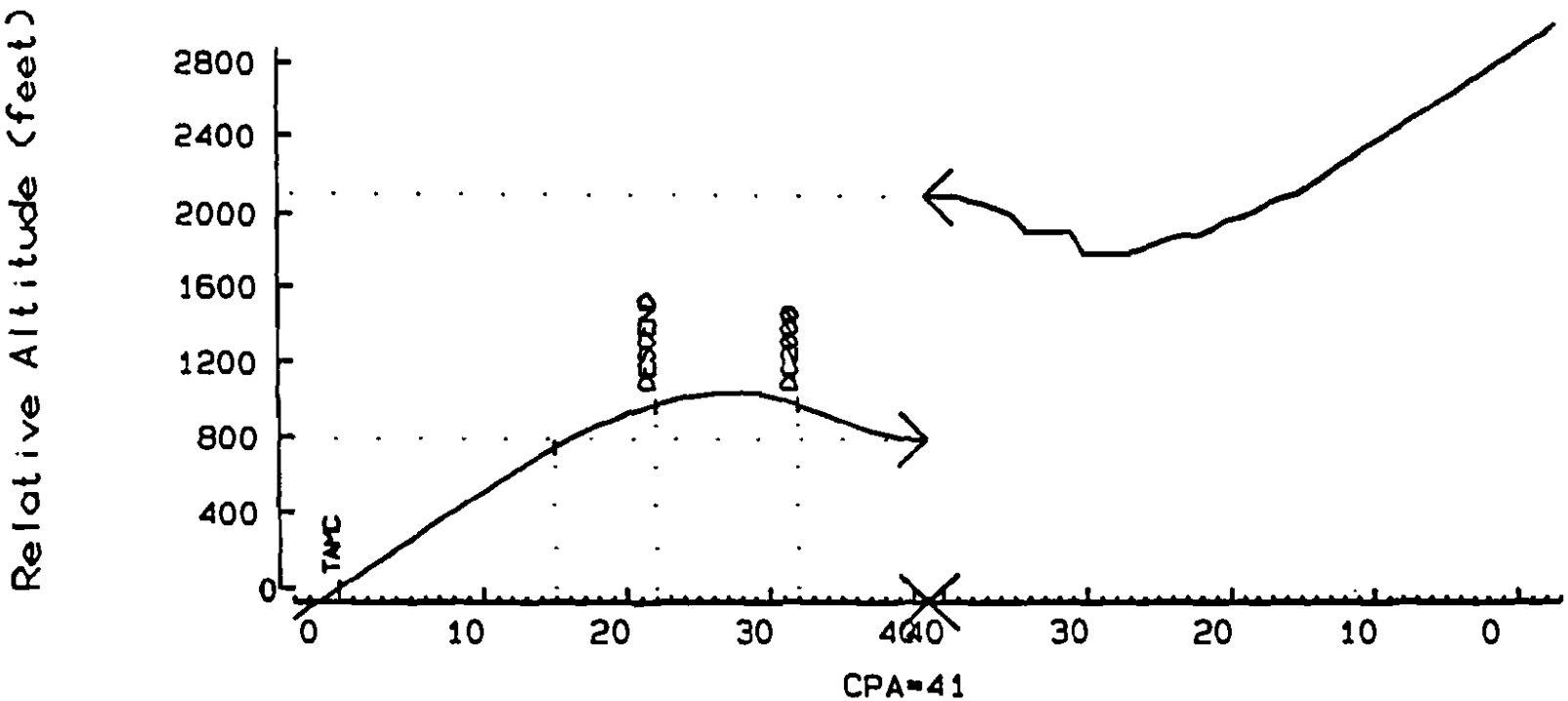
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -503

at CPA: -218

RANGE at CPA: 1458 ft



TA TIME: 00:00:22

CPA TIME: 00:01:03

FLIGHT DATE: AP/2./9P

Alt. Difference at CPA: 1303 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

B-4

Plane 1

Run 3

Logic v6.04a

Group 2

>

Encounter ID 6 Filename m TSTPLN6.T

ENCOUNTER ID: 6

TARGET ID: 1

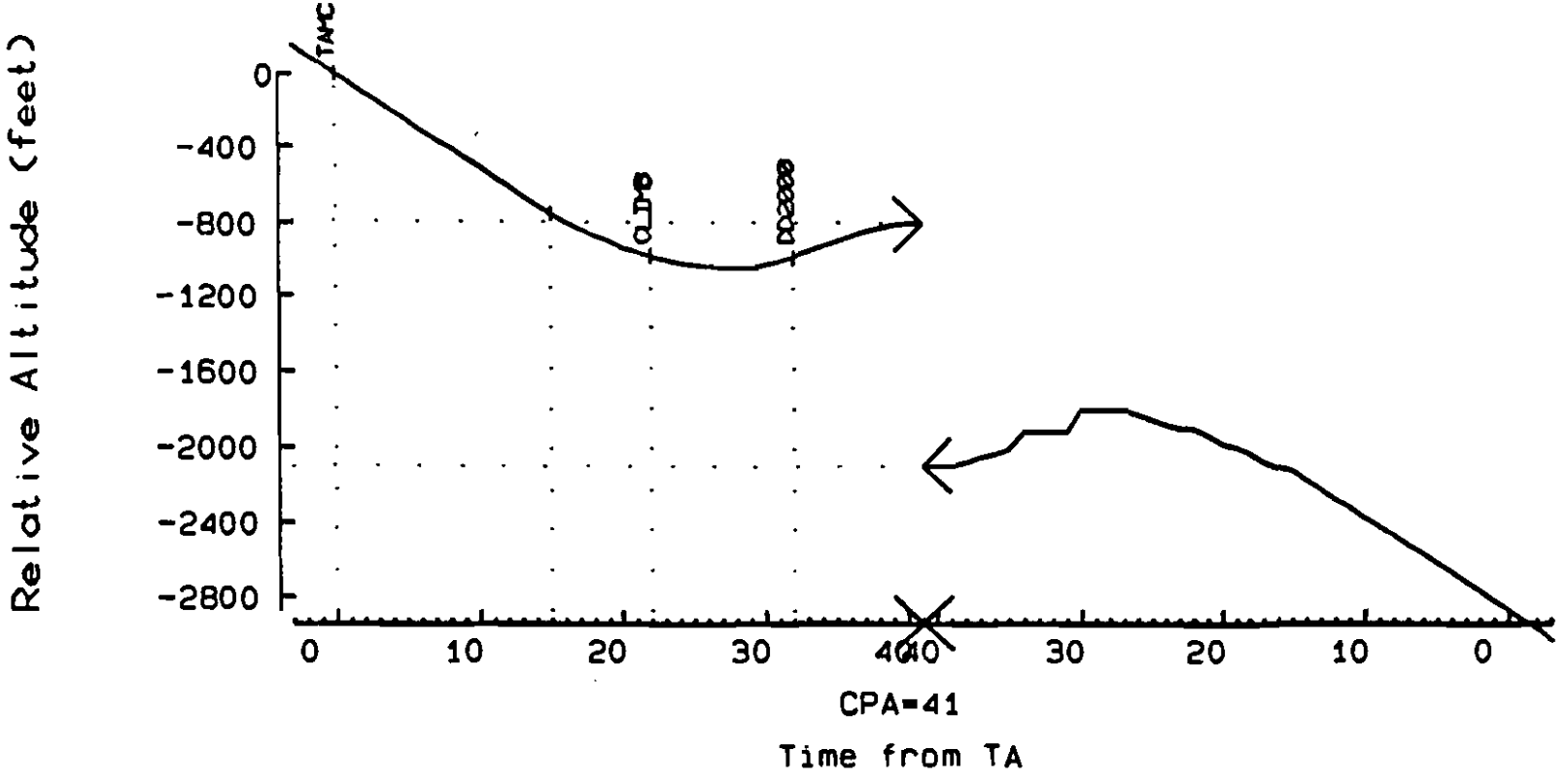
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -503

at CPA: -218

RANGE at CPA: 1458 ft



TA TIME: 00:00:22 CPA TIME: 00:01:03

FLIGHT DATE: RP/2./9P Alt. Difference at CPA: 1303 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

B-5

Plane 2

Run 3

Logic v6.04a

Group 2

>

Encounter ID 11 Filename m TSTPLN6.T

ENCOUNTER ID: 11

TARGET ID: 2

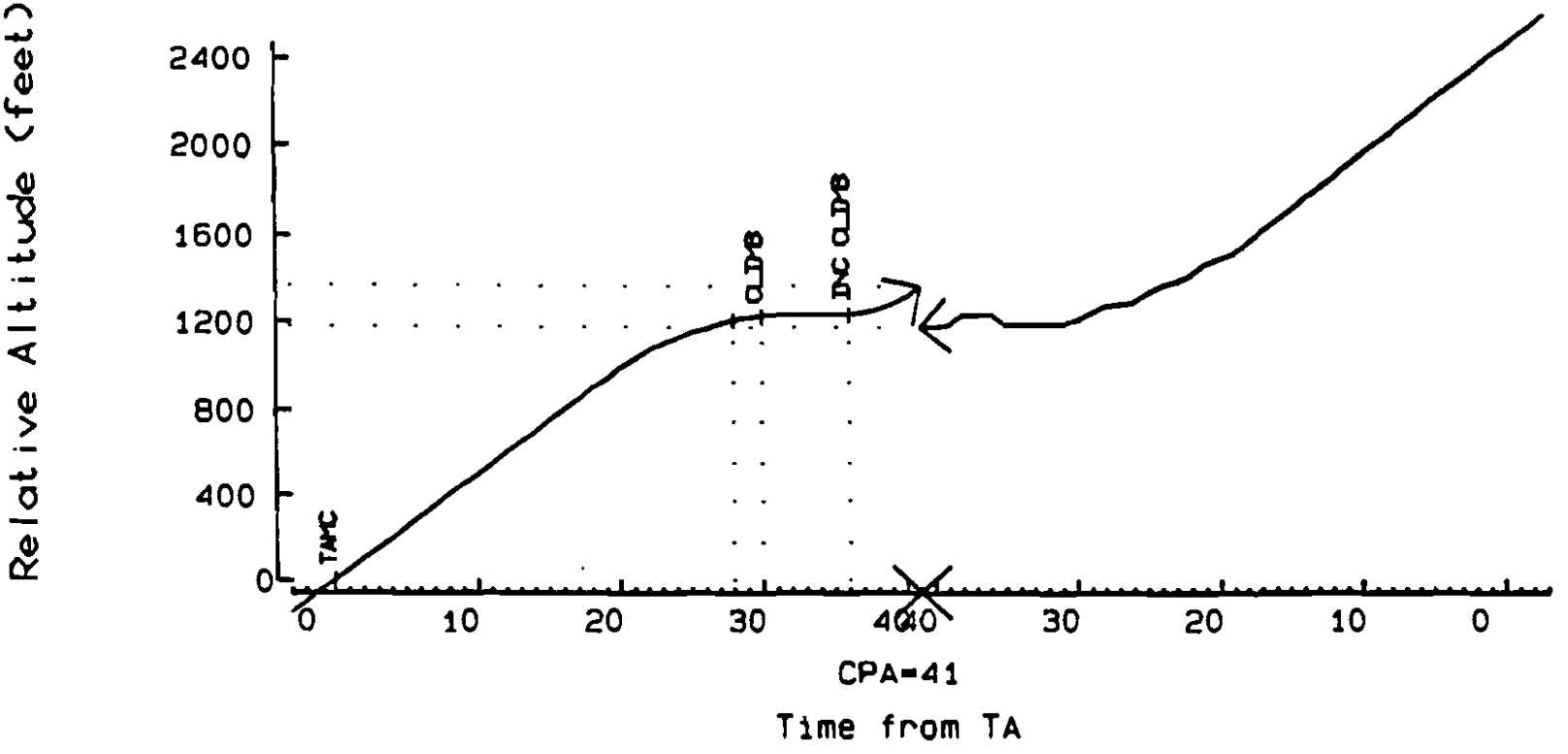
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -249

RANGE at CPA: 996 ft



TA TIME: 00:00:22

CPA TIME: 00:01:03

FLIGHT DATE: RP/2./9P

Alt. Difference at CPA: 190 ft

PROCESSED ON: 02/17/94 by ACO-320 FAA Technical Center

8-6

Plane 1

Run 2

Logic v6.04

Group 2

>

Encounter ID 12 Filename m TSTPLN6.T

ENCOUNTER ID: 12

TARGET ID: 1

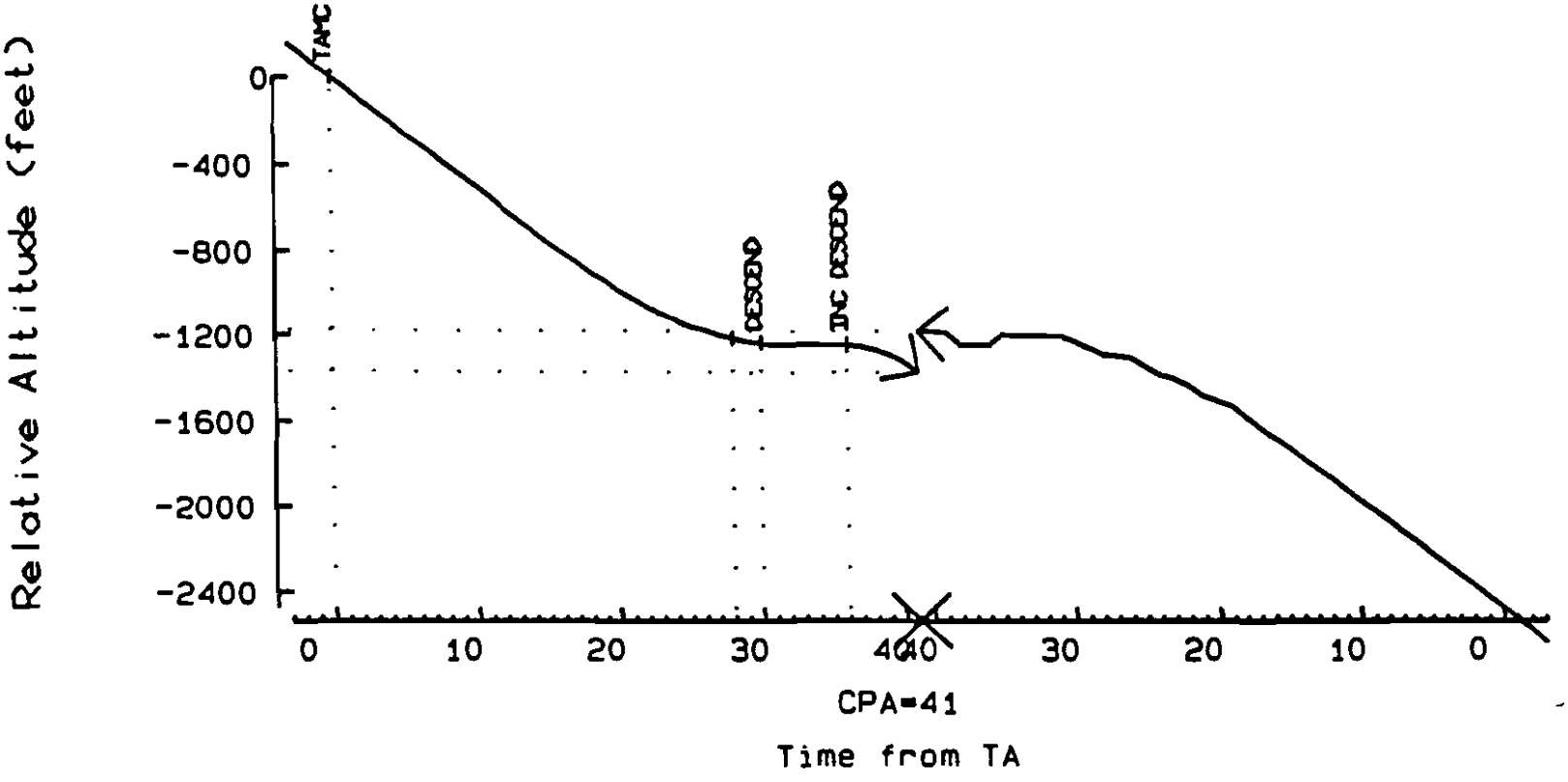
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -249

RANGE at CPA: 996 ft



TA TIME: 00:00:22

CPA TIME: 00:01:03

FLIGHT DATE: RP/2./9P

Alt. Difference at CPA: 190 ft

PROCESSED ON: 02/17/94 by ACO-320 FAA Technical Center

B-7

Plane 2

Run 2

Logic v6.04

Group 2

>

Encounter ID 13 Filename m TSTPLN6.T

ENCOUNTER ID: 13

TARGET ID: 2

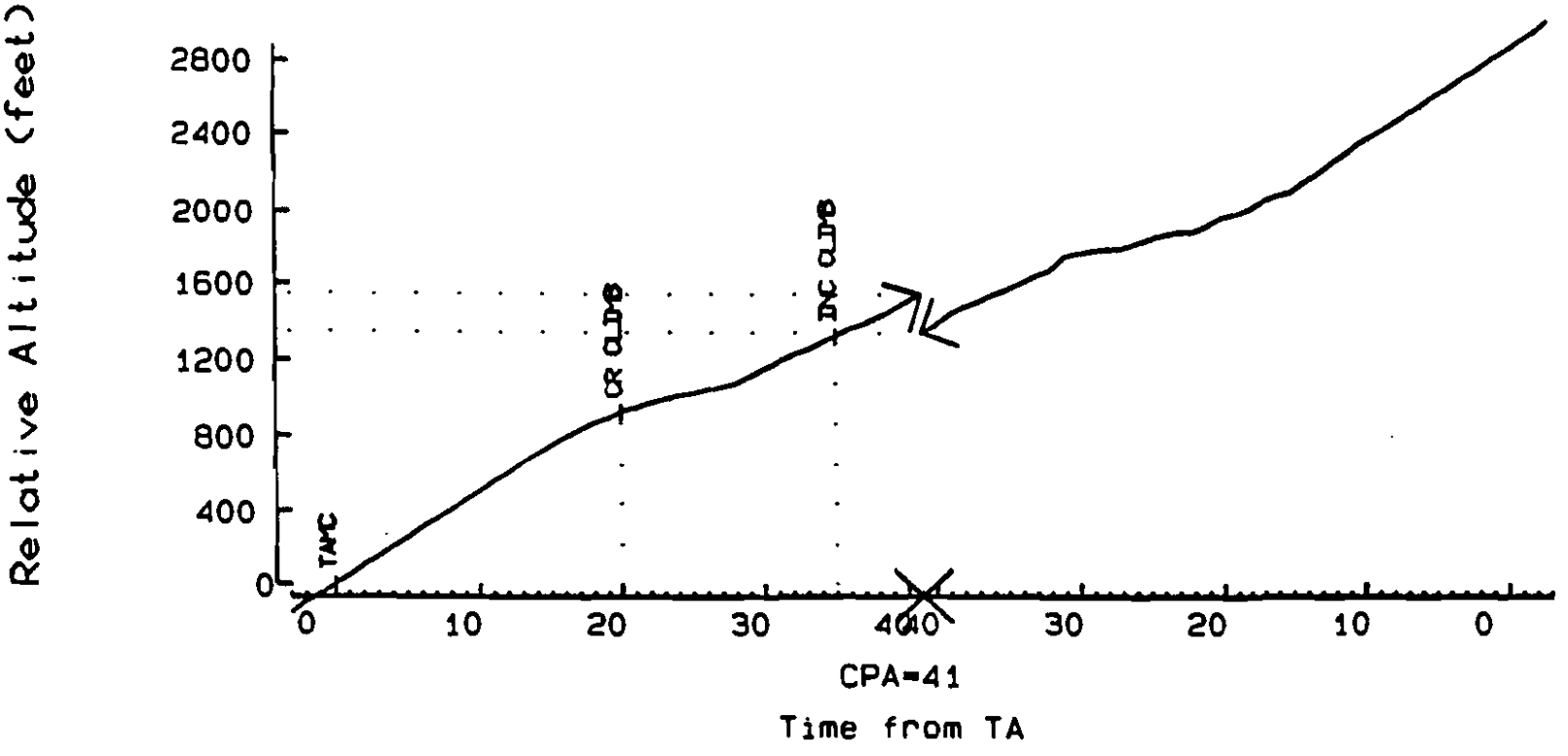
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -503

at CPA: -250

RANGE at CPA: 990 ft



TA TIME: 00:00:22 CPA TIME: 00:01:03

FLIGHT DATE: RP/2./9P Alt. Difference at CPA: 209 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

B-8

Plane 1

Run 3

Logic v6.04

Group 2

>

Encounter ID 14 Filename m TSTPLN6.T

ENCOUNTER ID: 14

TARGET ID: 1

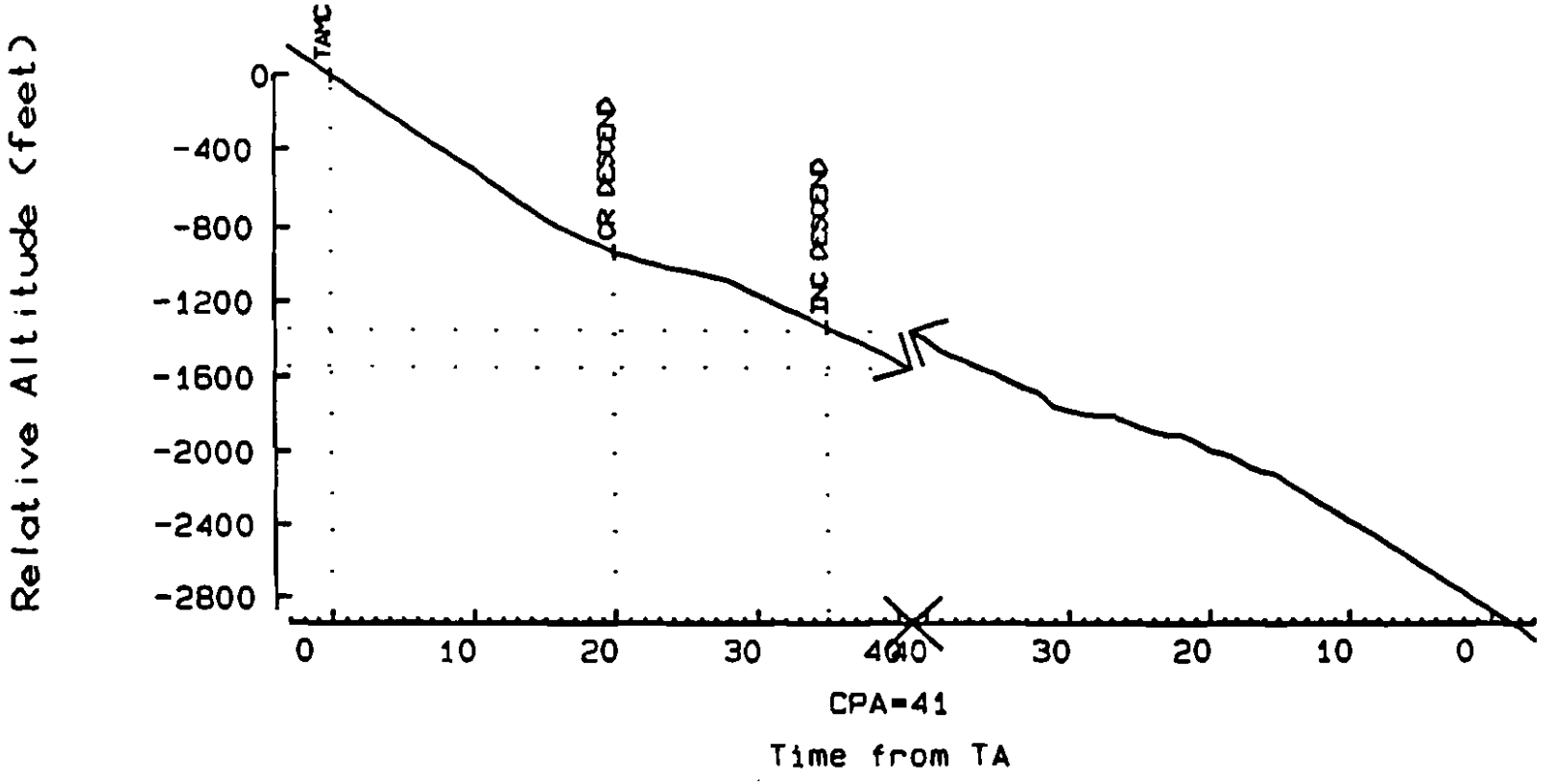
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -503

at CPA: -250

RANGE at CPA: 990 ft



TA TIME: 00:00:22 CPA TIME: 00:01:03

FLIGHT DATE: RP/2./9P Alt. Difference at CPA: 209 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

B-9 Plane 2 Run 3 Logic v6.04 Group 2

>

Encounter ID 19 Filename m TSTPLN6.T

ENCOUNTER ID: 19

TARGET ID: 2

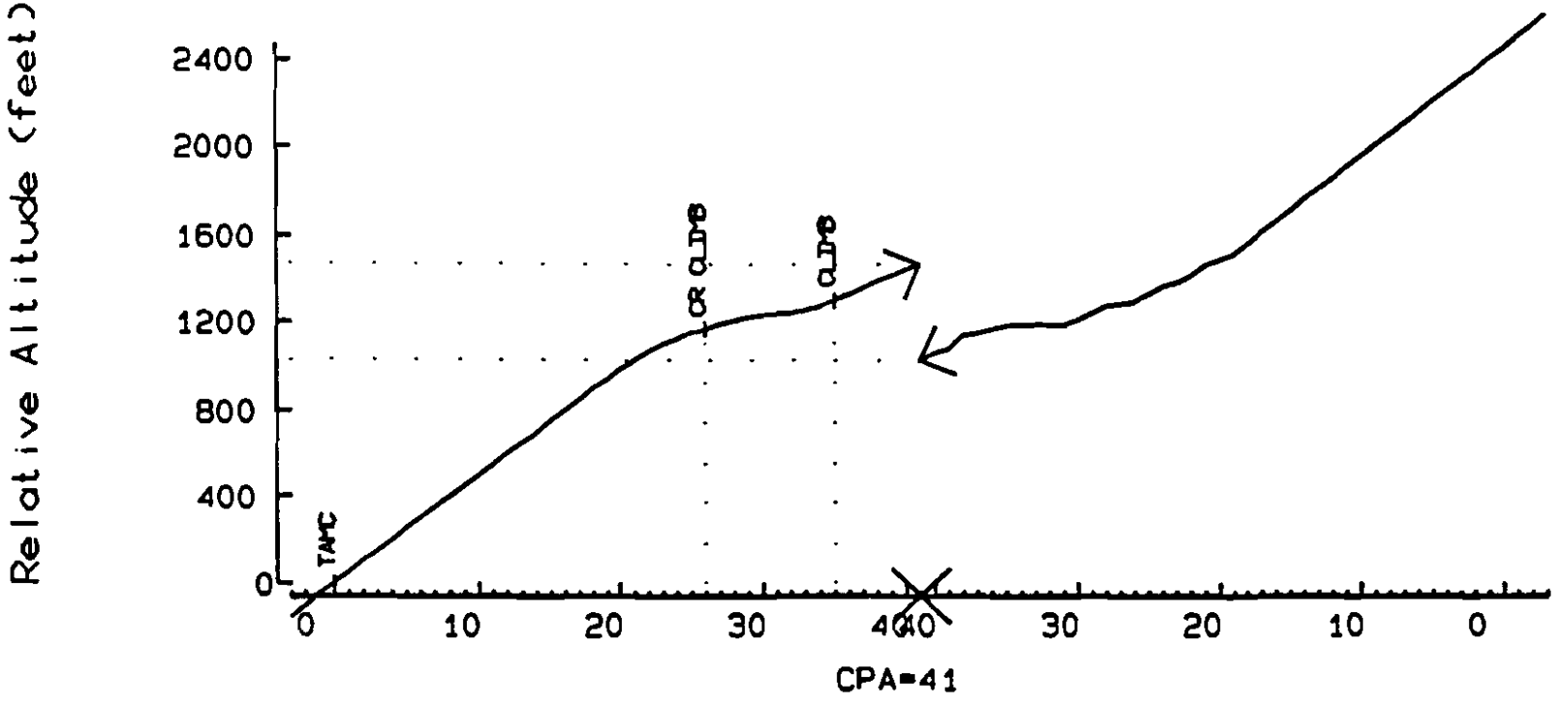
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -245

RANGE at CPA: 1039 ft



TA TIME: 00:00:22

CPA TIME: 00:01:03

FLIGHT DATE: RP/2./9P

Alt. Difference at CPA: 442 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

B-10

Plane 1

Run 2

Logic v6.02

Group 2

>

Encounter ID 20 Filename m TSTPLN6.T

ENCOUNTER ID: 20

TARGET ID: 1

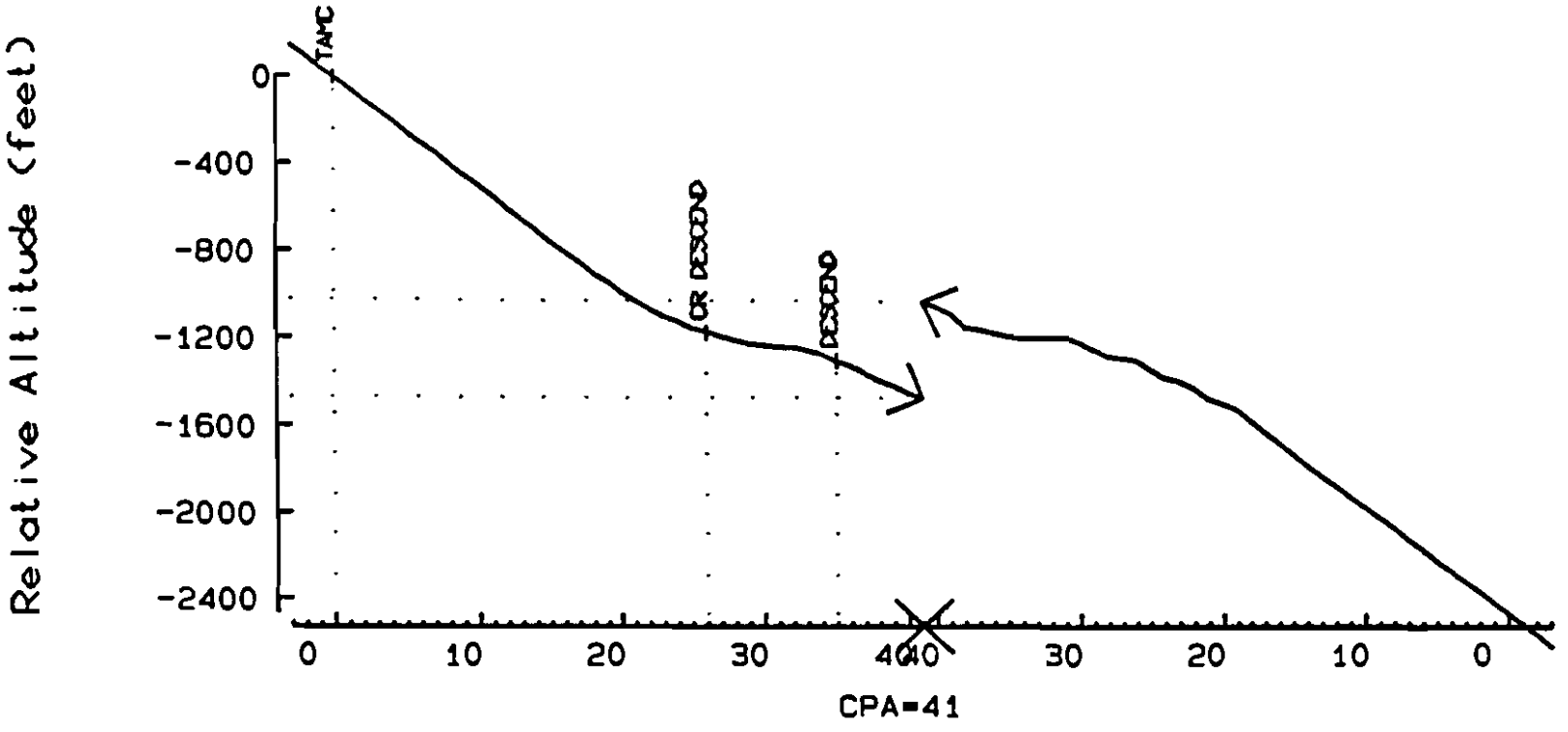
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -245

RANGE at CPA: 1039 ft



TA TIME: 00:00:22 CPA TIME: 00:01:03

FLIGHT DATE: RP/2./9P Alt. Difference at CPA: 443 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

B-11

Plane 2

Run 2

Logic v6.02

Group 2

>

Encounter ID 21 Filename m TSTPLN6.T

ENCOUNTER ID: 21

TARGET ID: 2

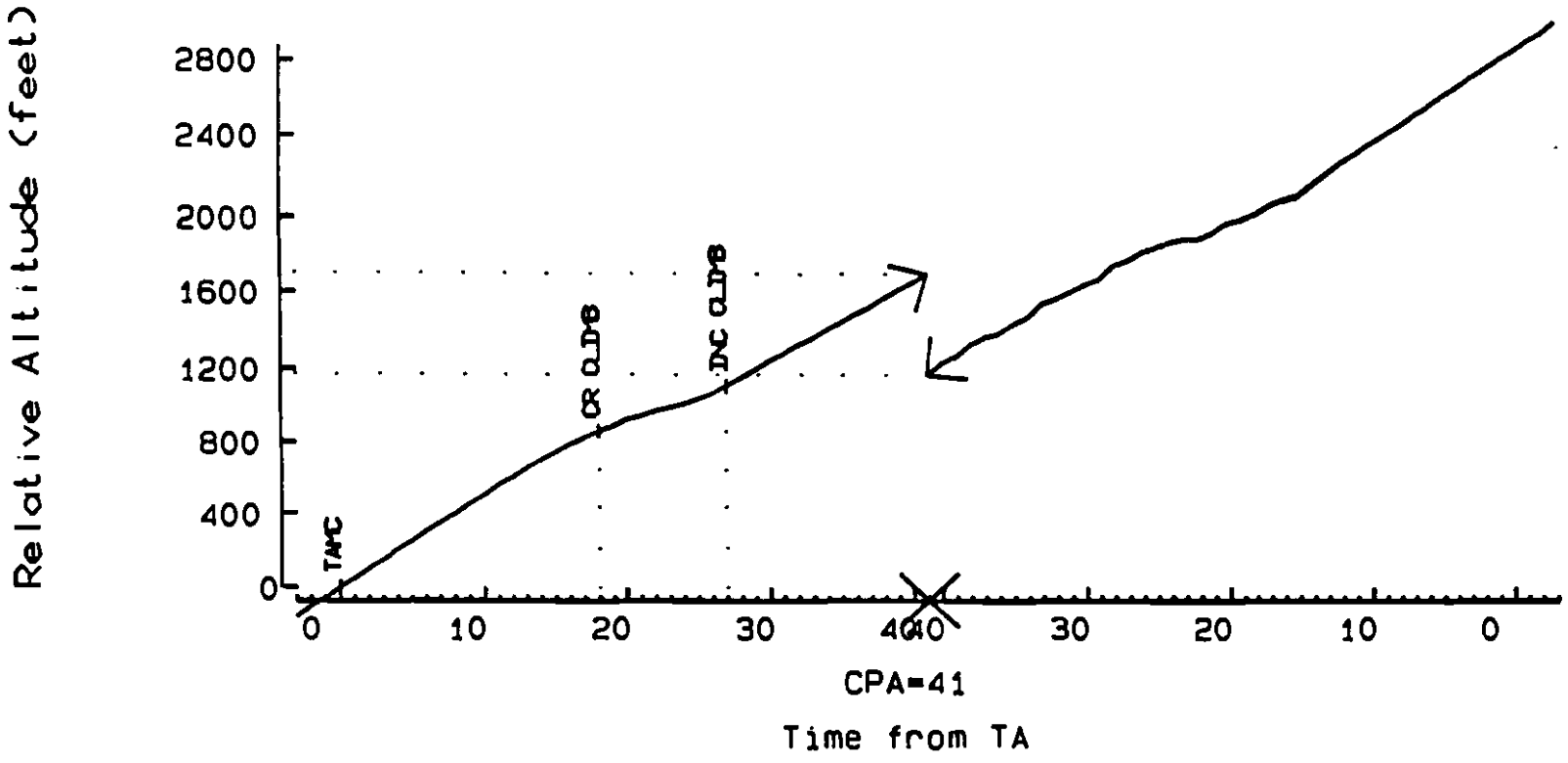
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -503

at CPA: -243

RANGE at CPA: 1045 ft



TA TIME: 00:00:22

CPA TIME: 00:01:03

FLIGHT DATE: RP/2./9P

Alt. Difference at CPA: 526 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

>

B-12

Plane 1

Run 3

Logic v6.02

Group 2

Encounter ID 22 Filename m TSTPLN6.T

ENCOUNTER ID: 22

TARGET ID: 1

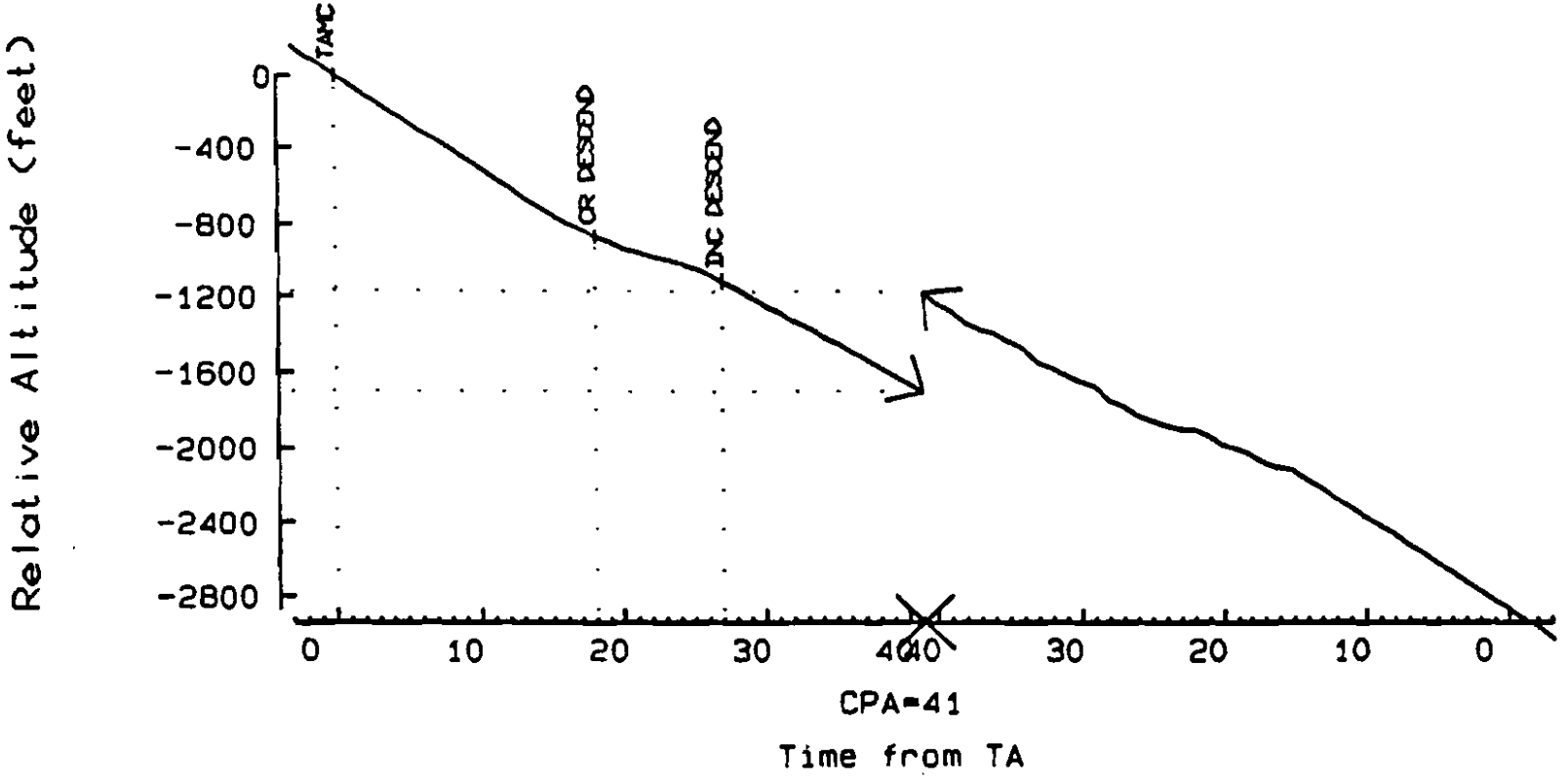
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -503

at CPA: -243

RANGE at CPA: 1045 ft



TA TIME: 00:00:22

CPA TIME: 00:01:03

FLIGHT DATE: RP/2./9P

Alt. Difference at CPA: 526 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

8-13

Plane 2

Run 3

Logic v6.02

Group 2

>

APPENDIX C

Simulation Results for Group 3 Encounters

Four different groups of encounters were used for the v6.04a logic flight tests. This appendix includes the simulation results for the higher altitude encounter set, Group 3, which was used on the 9/16/93 through 9/21/93 test flights. The plots can be compared to see the simulated results of three TCAS logic versions; v6.04a, v6.04, and v6.02.

An explanation of the plots is included on pages F-1 through F-4 (appendix F). Note that since these are simulation results, some of the information fields, such as FLIGHT DATE, may have superfluous entries.

There are two plots for each encounter, one from the viewpoint of each TCAS. These plots correspond to the encounter run numbers as follows:

logic version	6.04a	6.04	6.02
Run 1	Plots C-2 and C-3	C-10 and C-11	C-18 and C-19
Run 2	Plots C-4 and C-5	C-12 and C-13	C-20 and C-21
Run 3	Plots C-6 and C-7	C-14 and C-15	C-22 and C-23
Run 4	Plots C-8 and C-9	C-16 and C-17	C-24 and C-25

Encounter ID 1 Filename m TSTPLN81.T

ENCOUNTER ID: 1

TARGET ID: 2

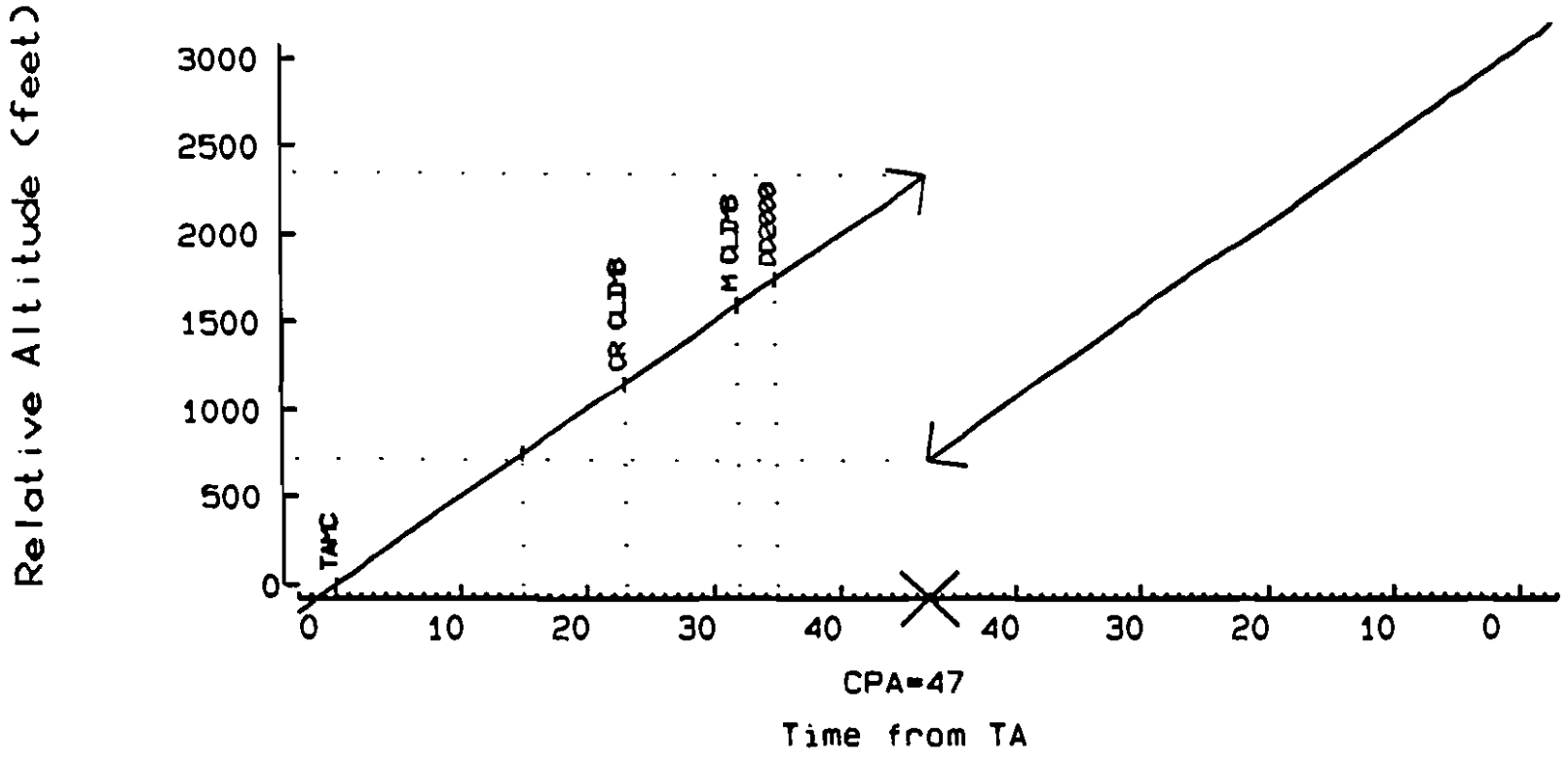
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -191

RANGE at CPA: 1622 ft



TA TIME: 00:00:16 CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P Alt. Difference at CPA: 1631 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-2

Plane 1

Run 1

Logic v6.04a

Group 3

>

Encounter ID 2 Filename m TSTPLN81.T

ENCOUNTER ID: 2

TARGET ID: 1

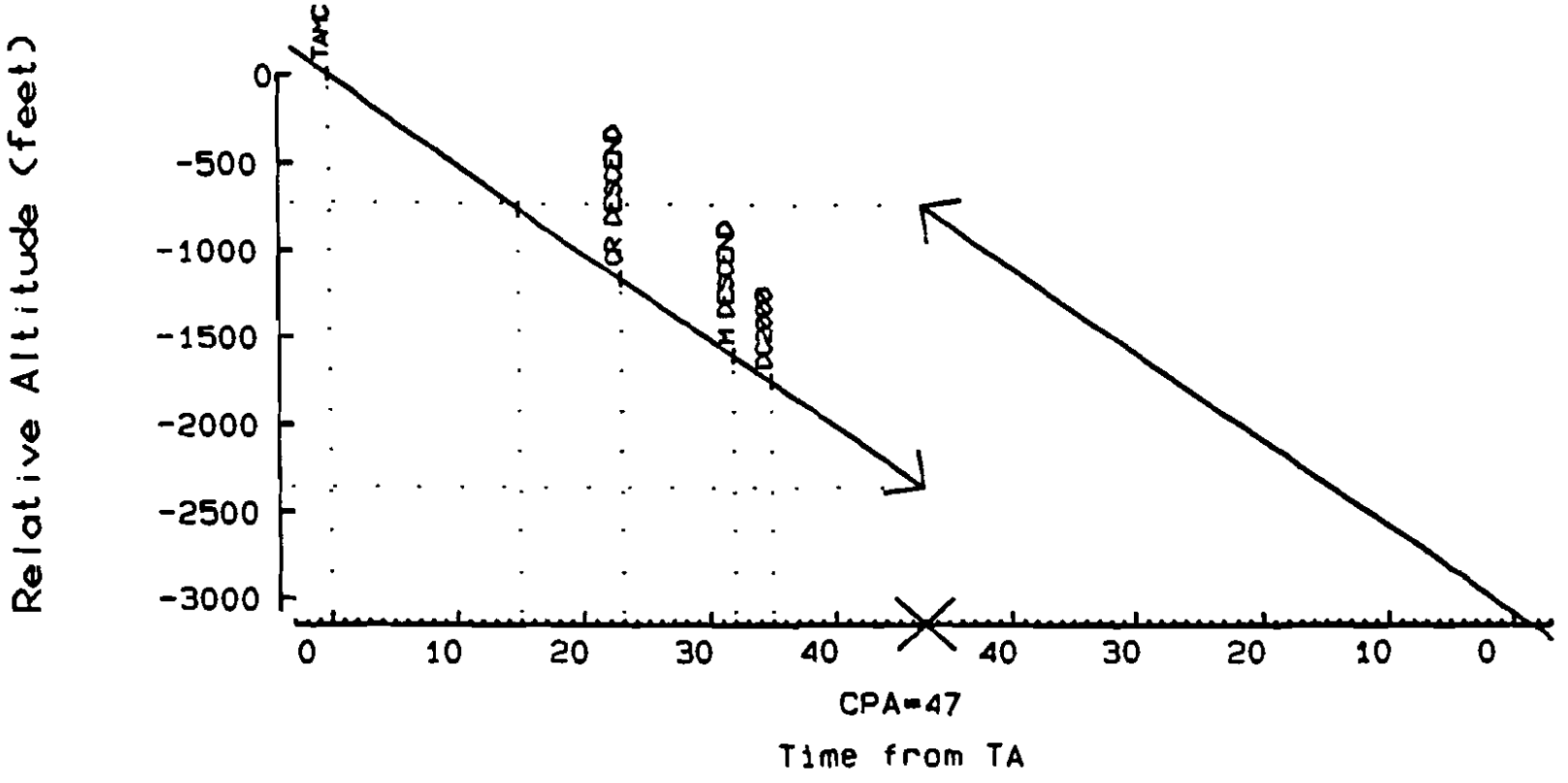
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -191

RANGE at CPA: 1622 ft



TA TIME: 00:00:16

CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P

Alt. Difference at CPA: 1631 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-3

Plane 2

Run 1

Logic v6.04a

Group 3

>

Encounter ID 3 Filename m TSTPLN81.T

ENCOUNTER ID: 3

TARGET ID: 2

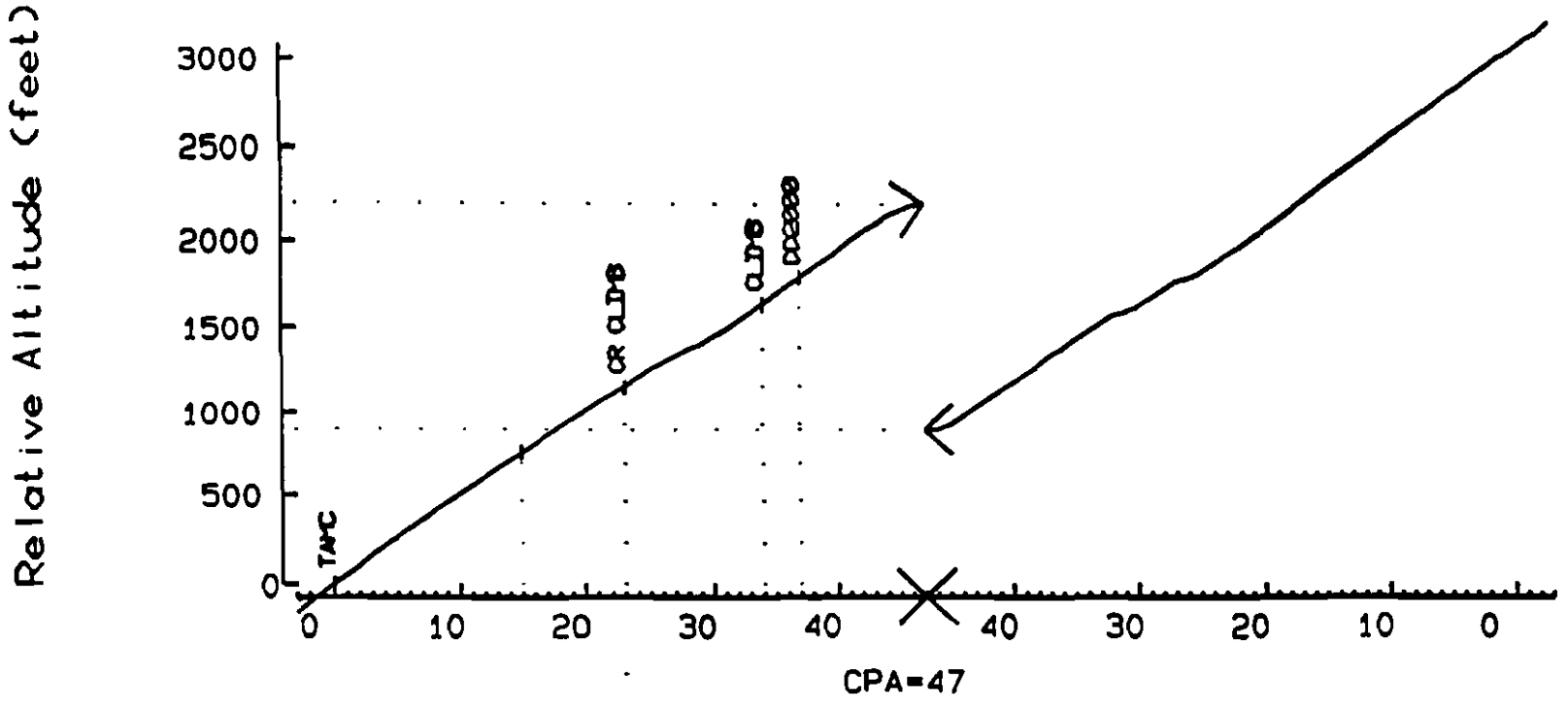
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -211

RANGE at CPA: 1452 ft



TA TIME: 00:00:16

CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P

Alt. Difference at CPA: 1312 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-4

Plane 1

Run 2

Logic v6.04a

Group 3

>

Encounter ID 4 Filename m TSTPLN81.T

ENCOUNTER ID: 4

TARGET ID: 1

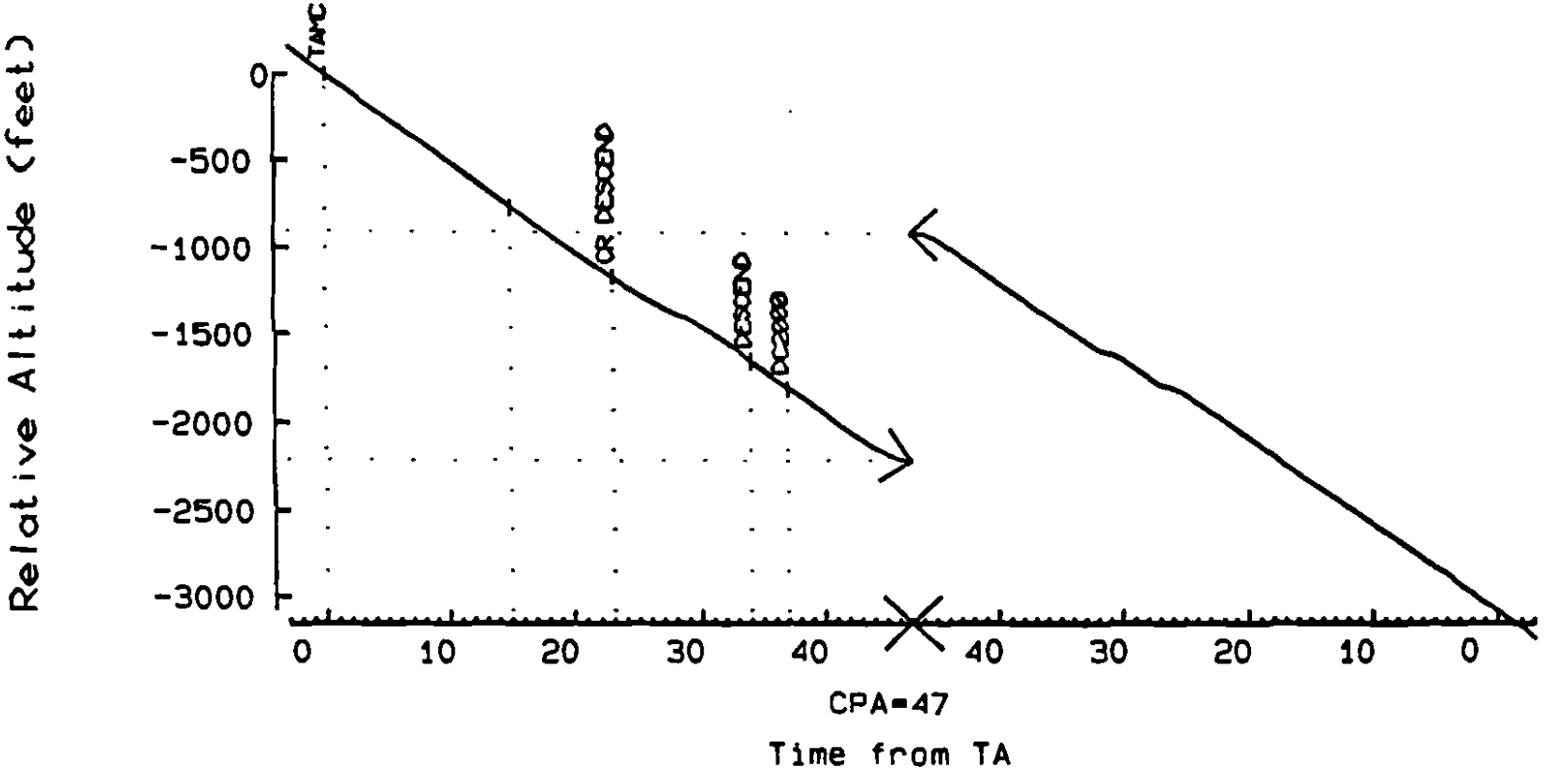
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -211

RANGE at CPA: 1452 ft



TA TIME: 00:00:16 CPA TIME: 00:01:03

FLIGHT DATE: AP/3./9P Alt. Difference at CPA: 1312 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-5

Plane 2

Run 2

Logic v6.04a

Group 3

>

Encounter ID 5 Filename m TSTPLN81.T

ENCOUNTER ID: 5

TARGET ID: 2

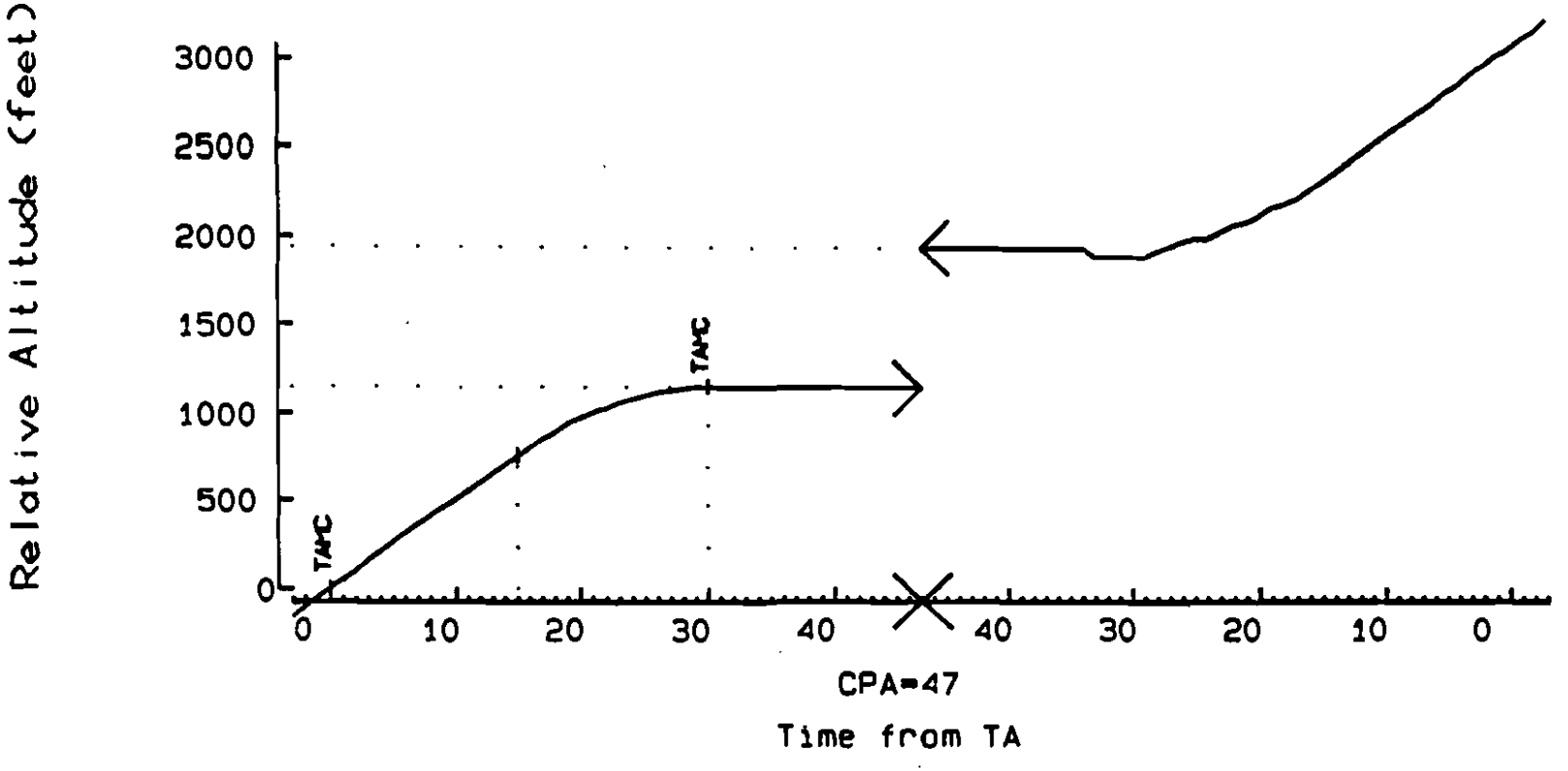
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -239

RANGE at CPA: 1184 ft



TA TIME: 00:00:16

CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P

Alt. Difference at CPA: 806 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-6

Plane 1

Run 3

Logic v6.04a

Group 3

>

Encounter ID 6 Filename m TSTPLN81.T

ENCOUNTER ID: 6

TARGET ID: 1

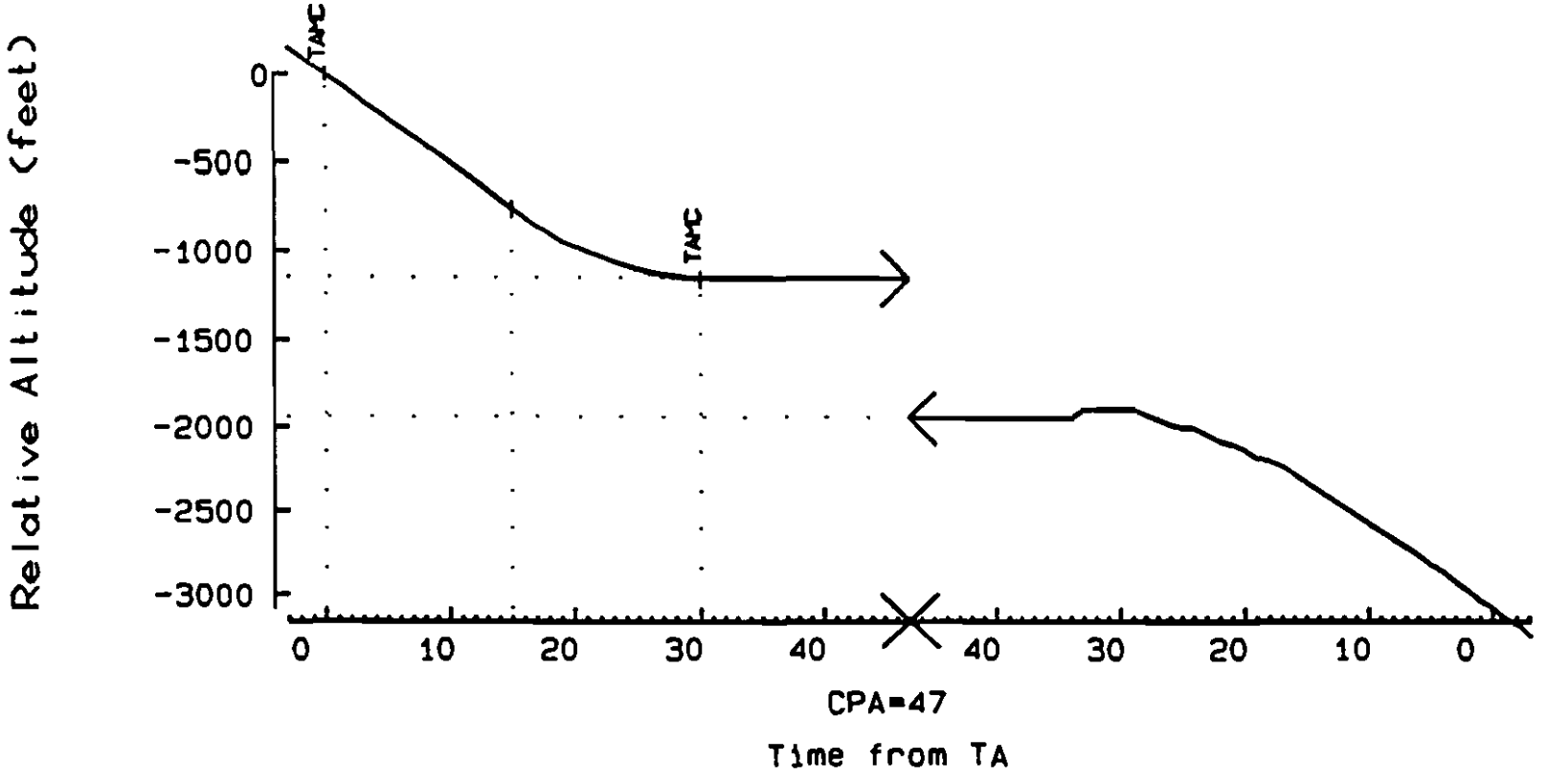
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -239

RANGE at CPA: 1184 ft



TA TIME: 00:00:16

CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P

Alt. Difference at CPA: 806 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-7

Plane 2

Run 3

Logic v6.04a

Group 3

>

Encounter ID 7 Filename m TSTPLN81.T

ENCOUNTER ID: 7

TARGET ID: 2

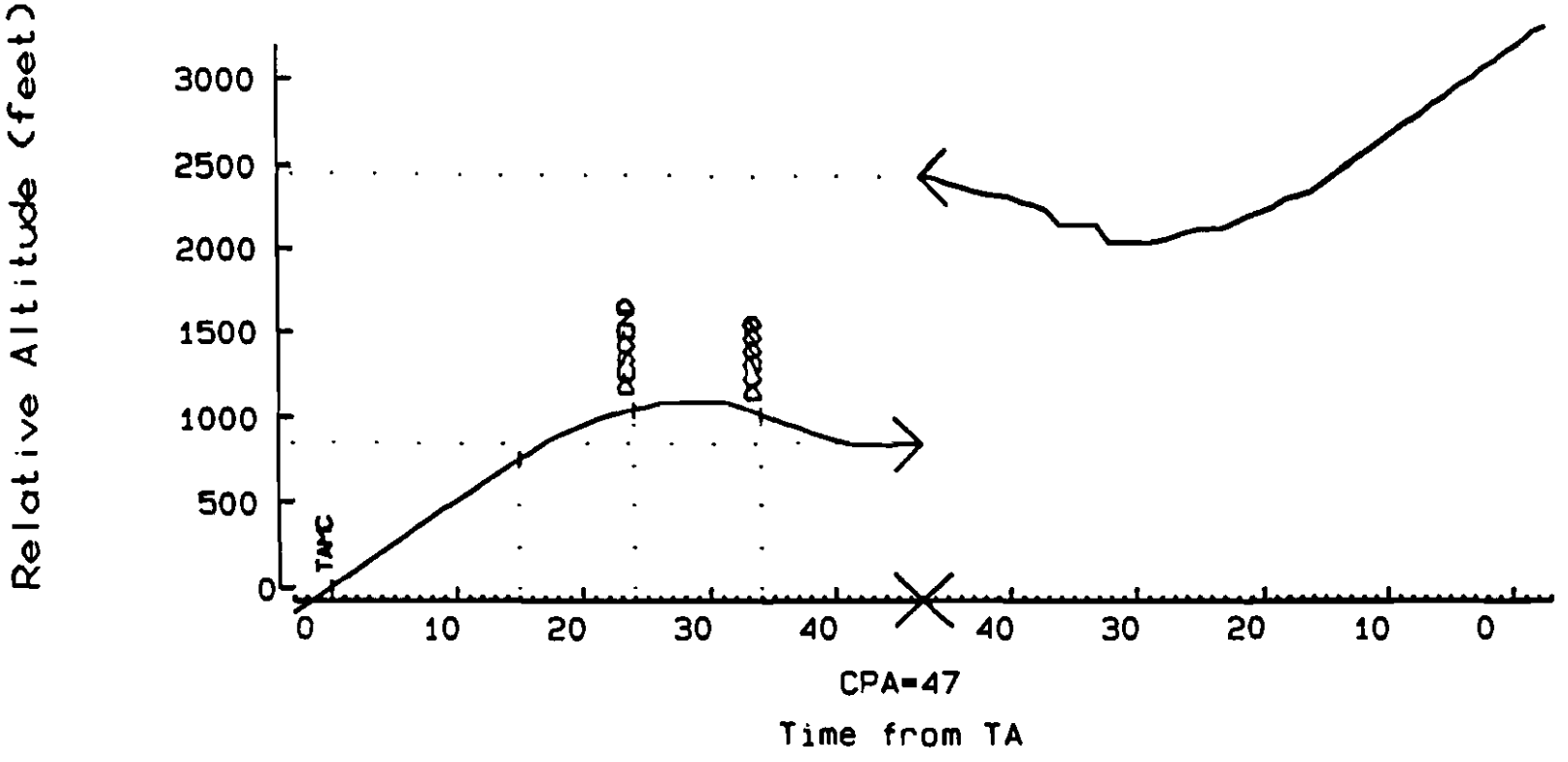
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -214

RANGE at CPA: 1610 ft



TA TIME: 00:00:16 CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P Alt. Difference at CPA: 1602 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-8

Plane 1 Run 4 Logic v6.04a Group 3

>

Encounter ID 8 Filename m TSTPLN81.T

ENCOUNTER ID: 8

TARGET ID: 1

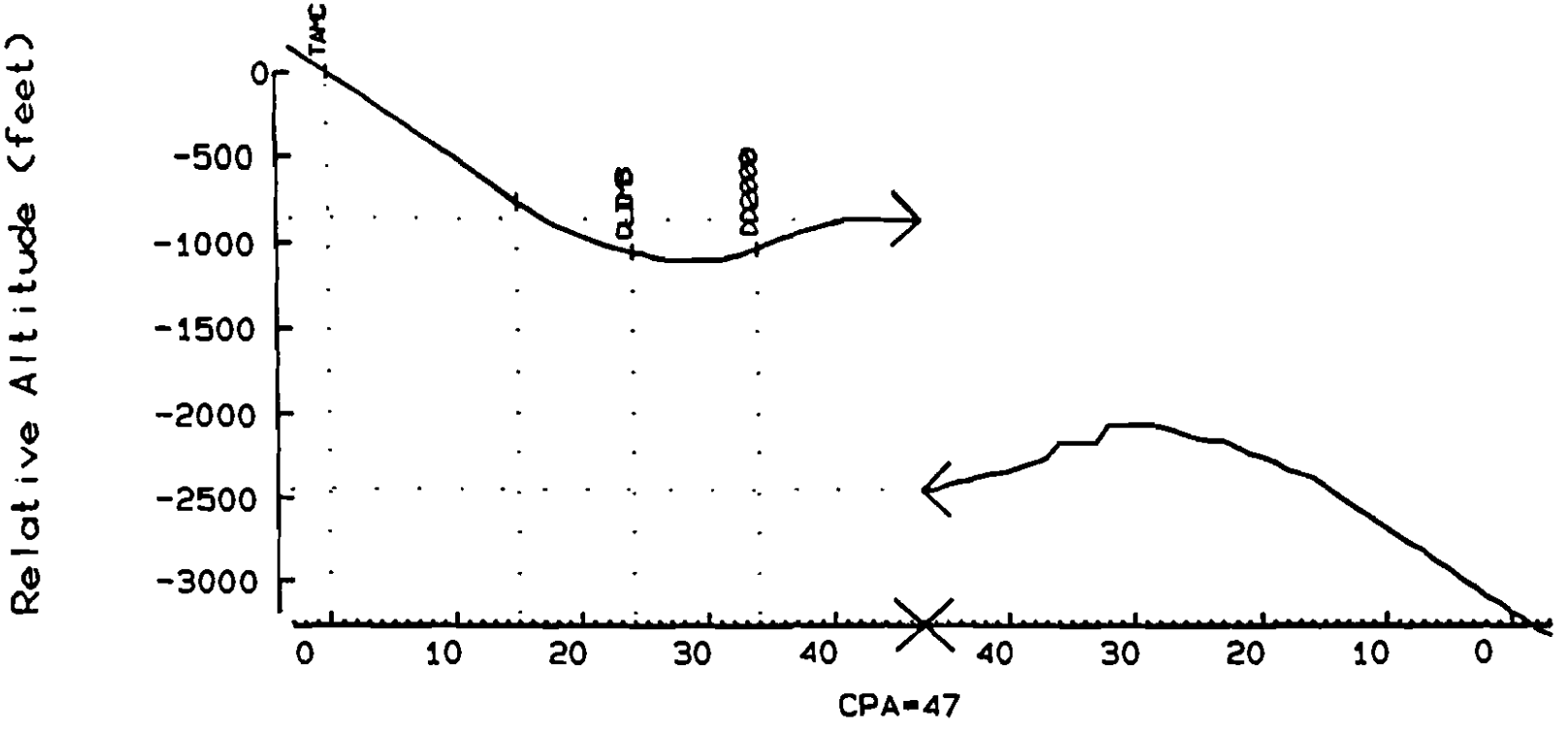
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -214

RANGE at CPA: 1610 ft



TA TIME: 00:00:16 CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P Alt. Difference at CPA: 1602 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-9

Plane 2

Run 4

Logic v6.04a

Group 3

Encounter ID 9 Filename m TSTPLN81.T

ENCOUNTER ID: 9

TARGET ID: 2

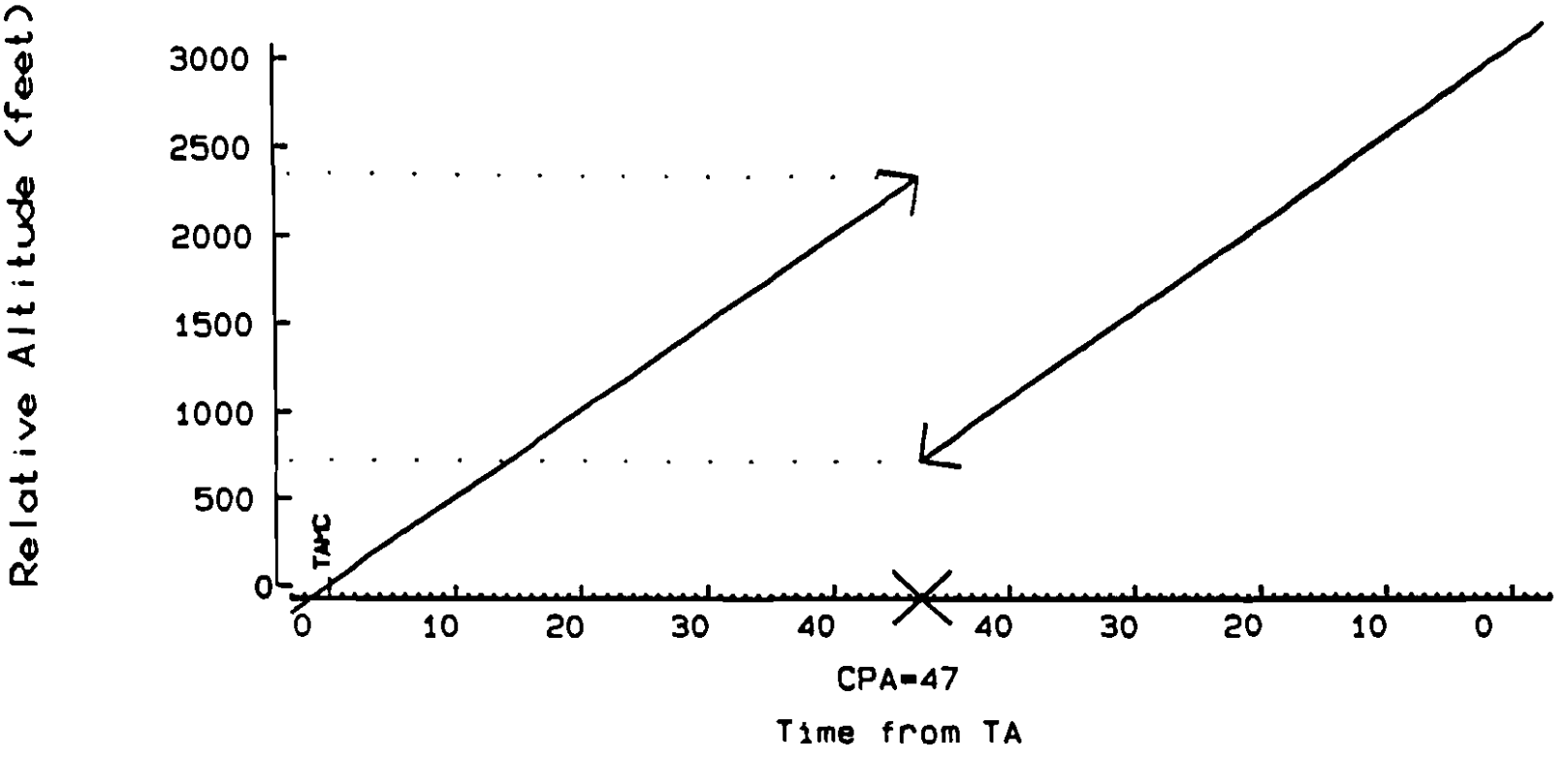
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -191

RANGE at CPA: 1622 ft



TA TIME: 00:00:16 CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P Alt. Difference at CPA: 1631 ft

PROCESSED ON: 02/17/94 by ACO-320 FAA Technical Center

C-10

Plane 1

Run 1

Logic v6.04

Group 3

>

Encounter ID 10 Filename m TSTPLN81.T

ENCOUNTER ID: 10

TARGET ID: 1

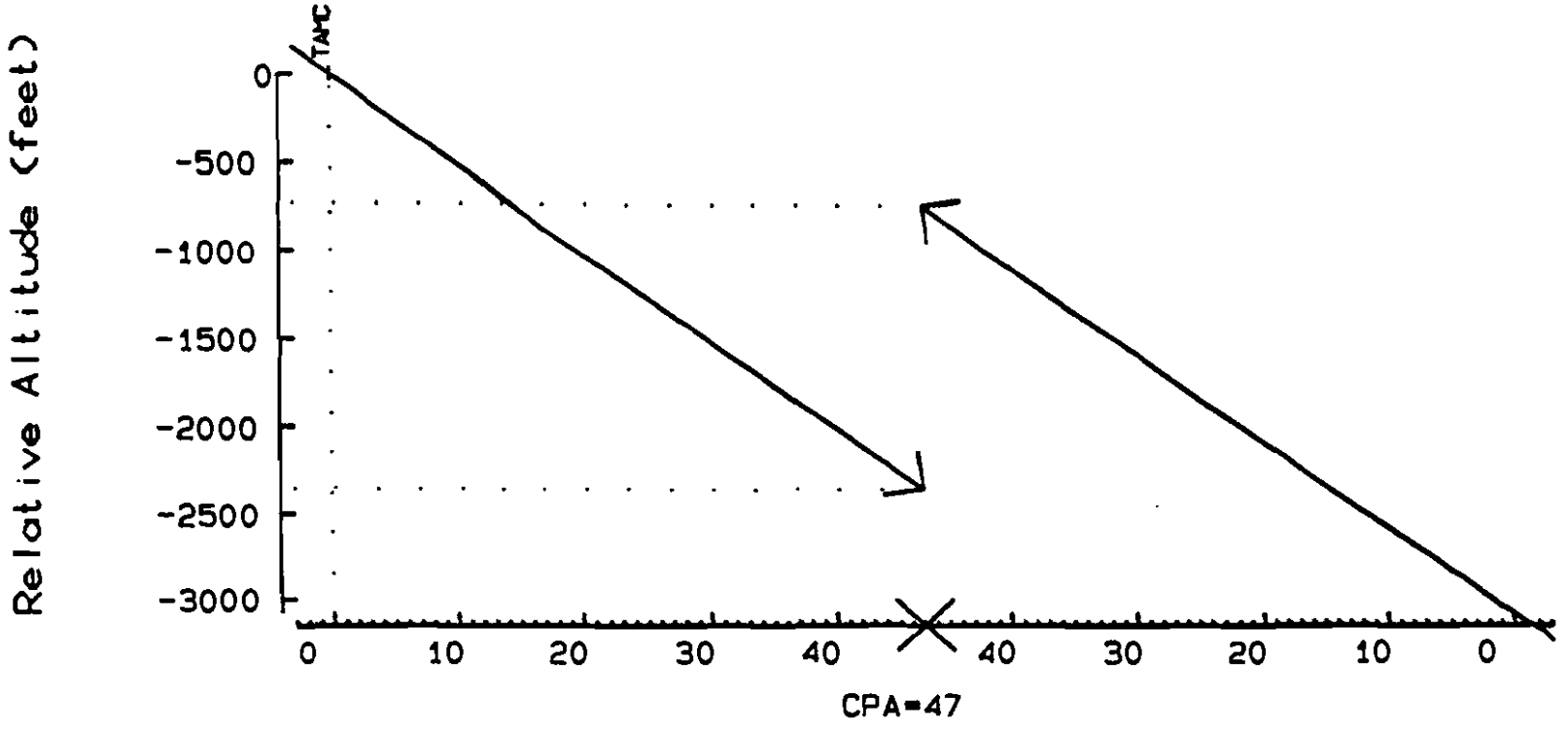
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -191

RANGE at CPA: 1622 ft



TA TIME: 00:00:16

CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P

Alt. Difference at CPA: 1631 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-11

Plane 2

Run 1

Logic v6.04

Group 3

Encounter ID 11 Filename m TSTPLN81.T

ENCOUNTER ID: 11

TARGET ID: 2

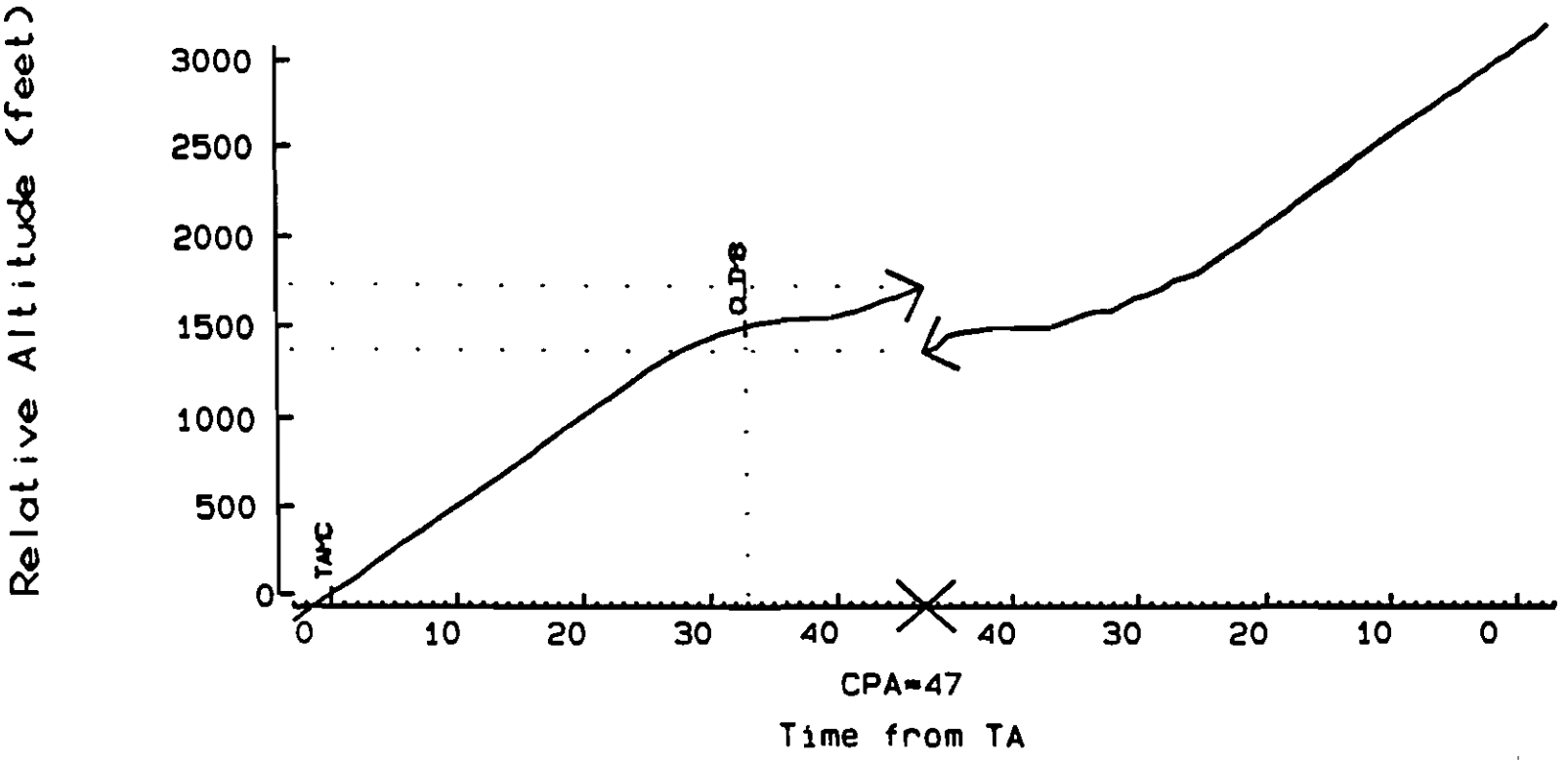
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -247

RANGE at CPA: 1020 ft



TA TIME: 00:00:16 CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P Alt. Difference at CPA: 372 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-12

Plane 1

Run 2

Logic v6.04

Group 3

>

Encounter ID 12 Filename m TSTPLN81.T

ENCOUNTER ID: 12

TARGET ID: 1

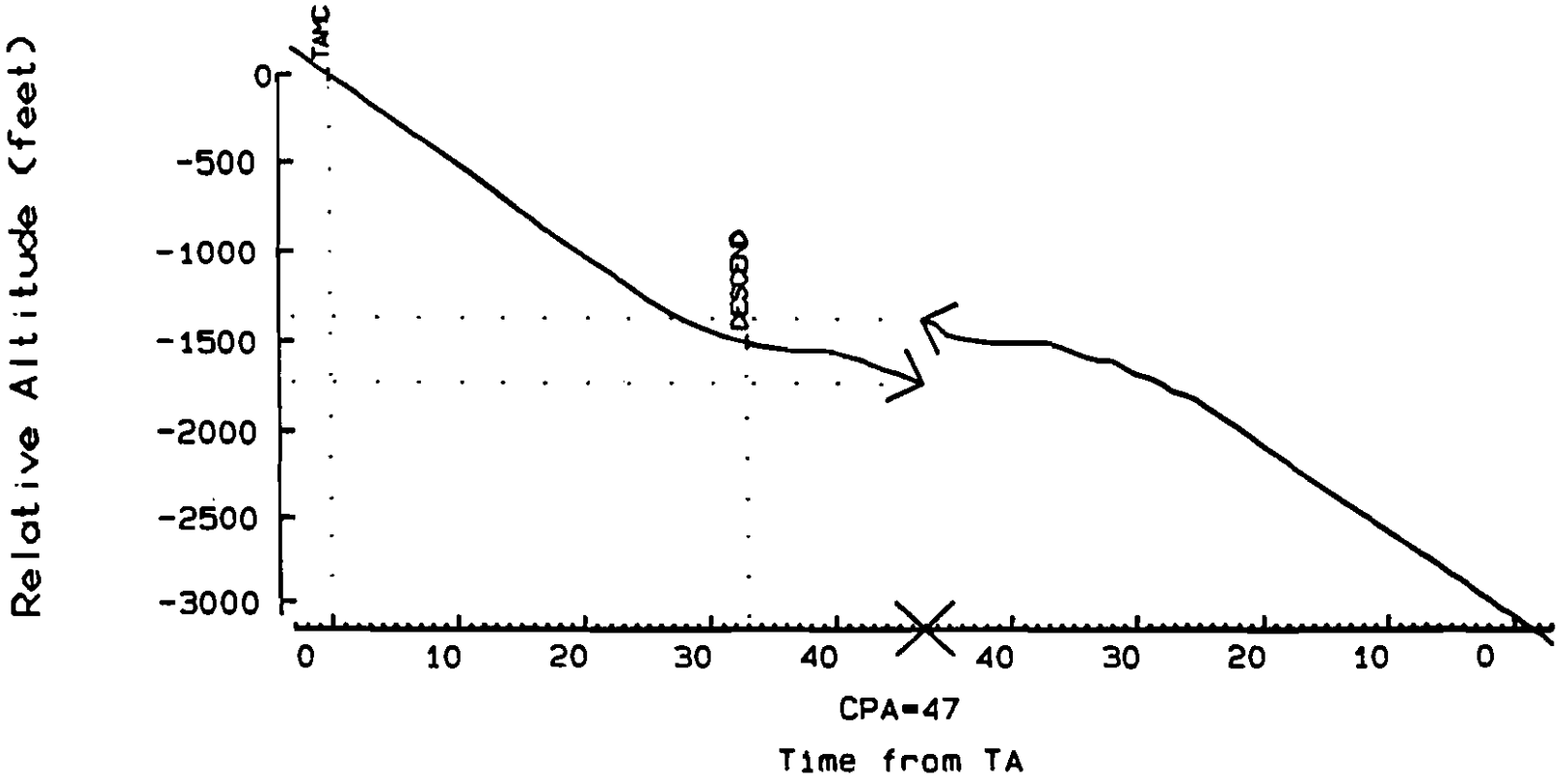
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -247

RANGE at CPA: 1020 ft



TA TIME: 00:00:16

CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P

Alt. Difference at CPA: 373 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-13

Plane 2

Run 2

Logic v6.04

Group 3

>

Encounter ID 13 Filename m TSTPLN81.T

ENCOUNTER ID: 13

TARGET ID: 2

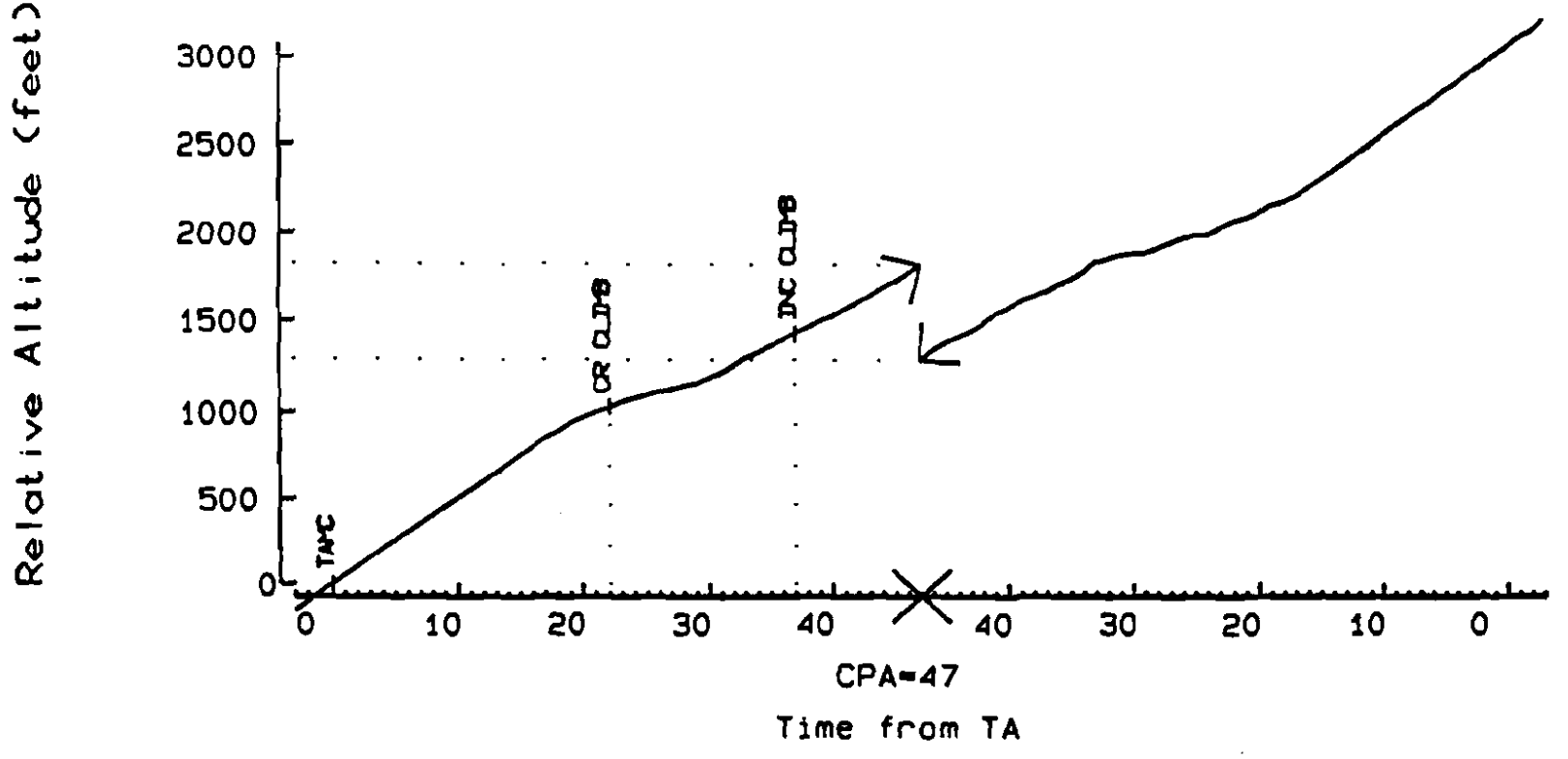
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -241

RANGE at CPA: 1057 ft



TA TIME: 00:00:16

CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P

Alt. Difference at CPA: 542 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-14

Plane 1

Run 3

Logic v6.04

Group 3

>

Encounter ID 14 Filename m TSTPLN81.T

ENCOUNTER ID: 14

TARGET ID: 1

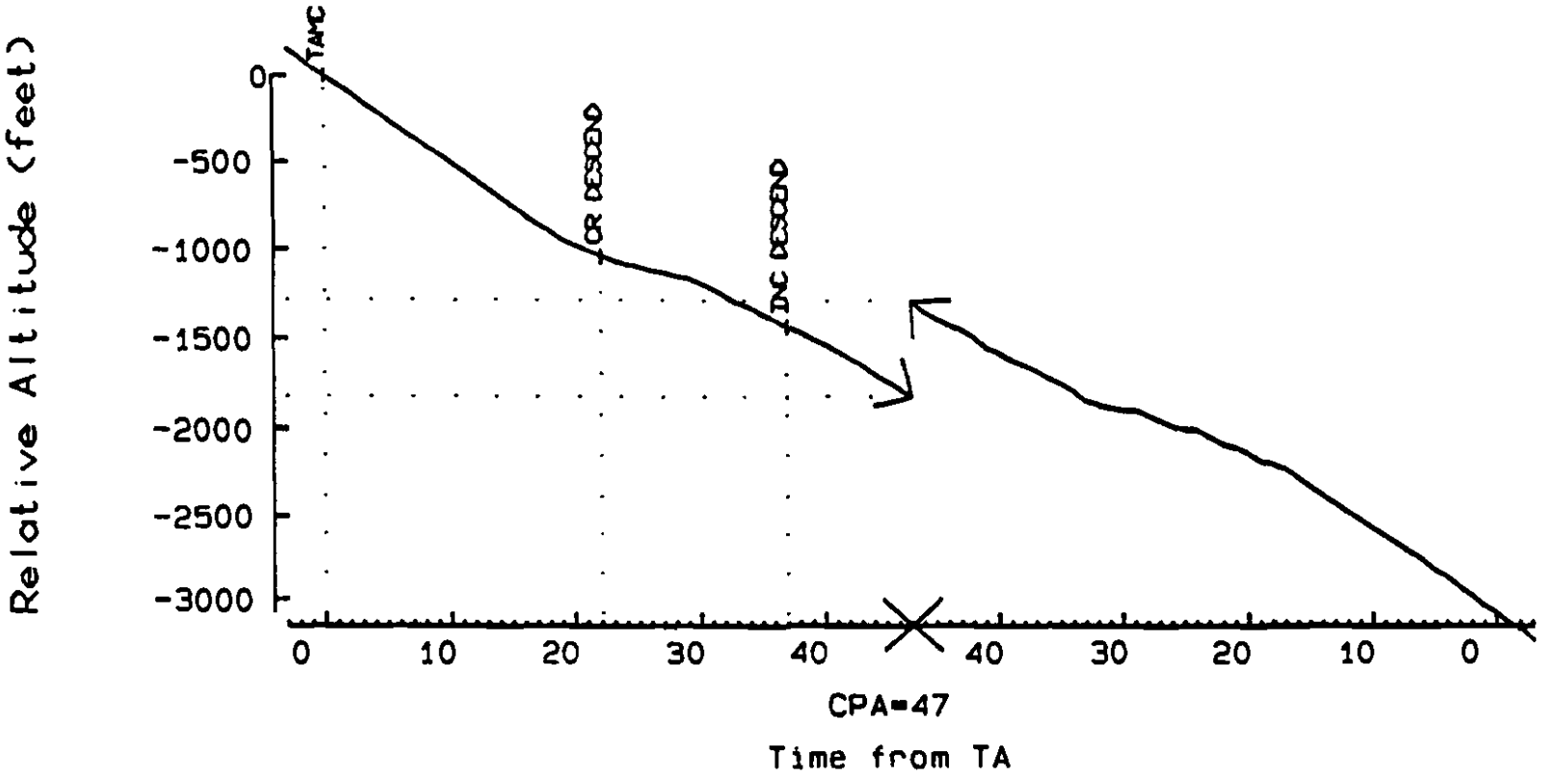
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -241

RANGE at CPA: 1057 ft



TA TIME: 00:00:16

CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P

Alt. Difference at CPA: 542 ft

PROCESSED ON: 02/17/94 by ACO-320 FAA Technical Center

C-15

Plane 2

Run 3

Logic v6.04

Group 3

>

Encounter ID 15 Filename m TSTPLN81.T

ENCOUNTER ID: 15

TARGET ID: 2

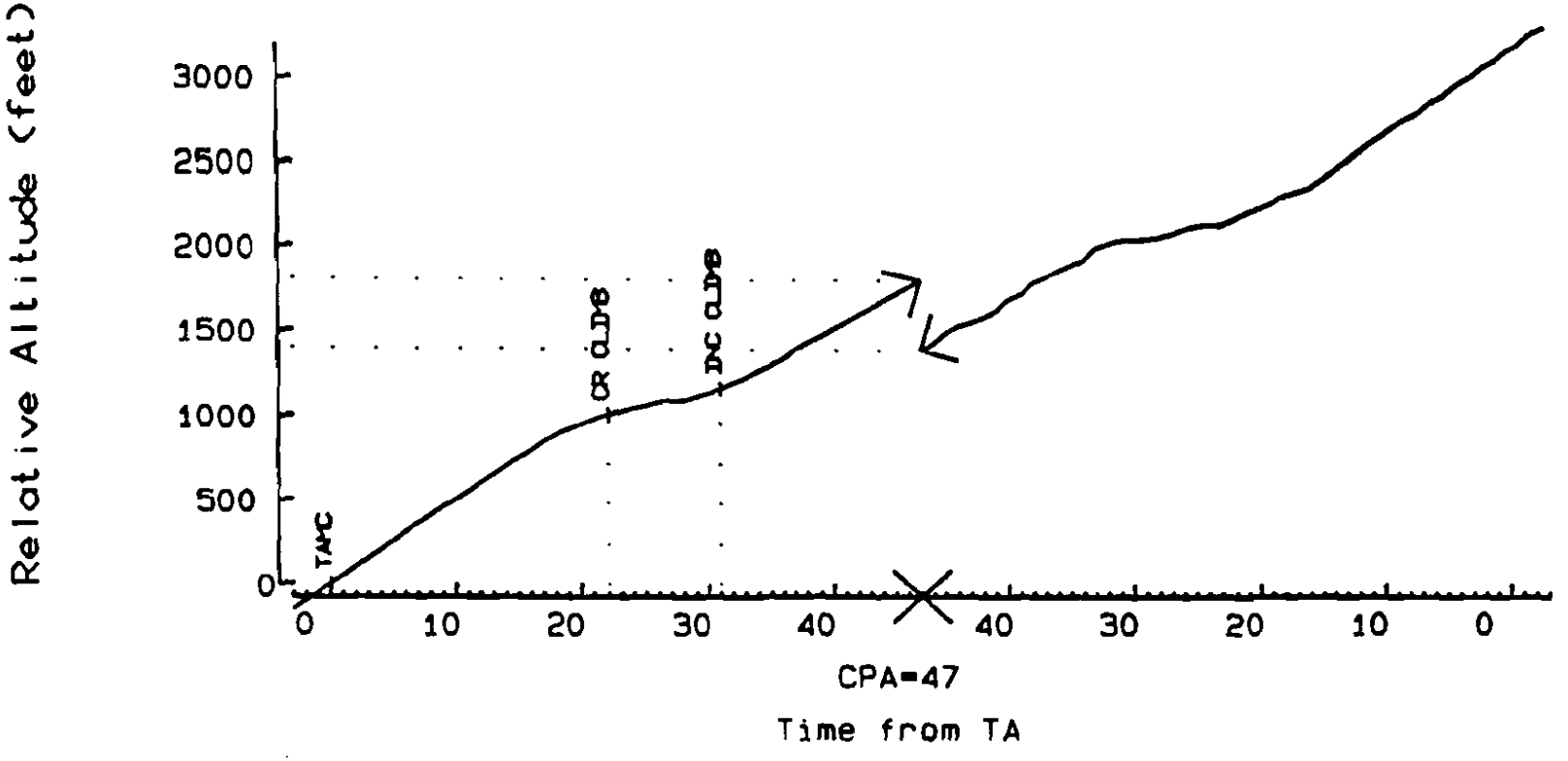
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -246

RANGE at CPA: 1020 ft



TA TIME: 00:00:16 CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P Alt. Difference at CPA: 419 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-16

Plane 1

Run 4

Logic v6.04

Group 3

>

Encounter IO 16 Filename m TSTPLN81.T

ENCOUNTER ID: 16

TARGET ID: 1

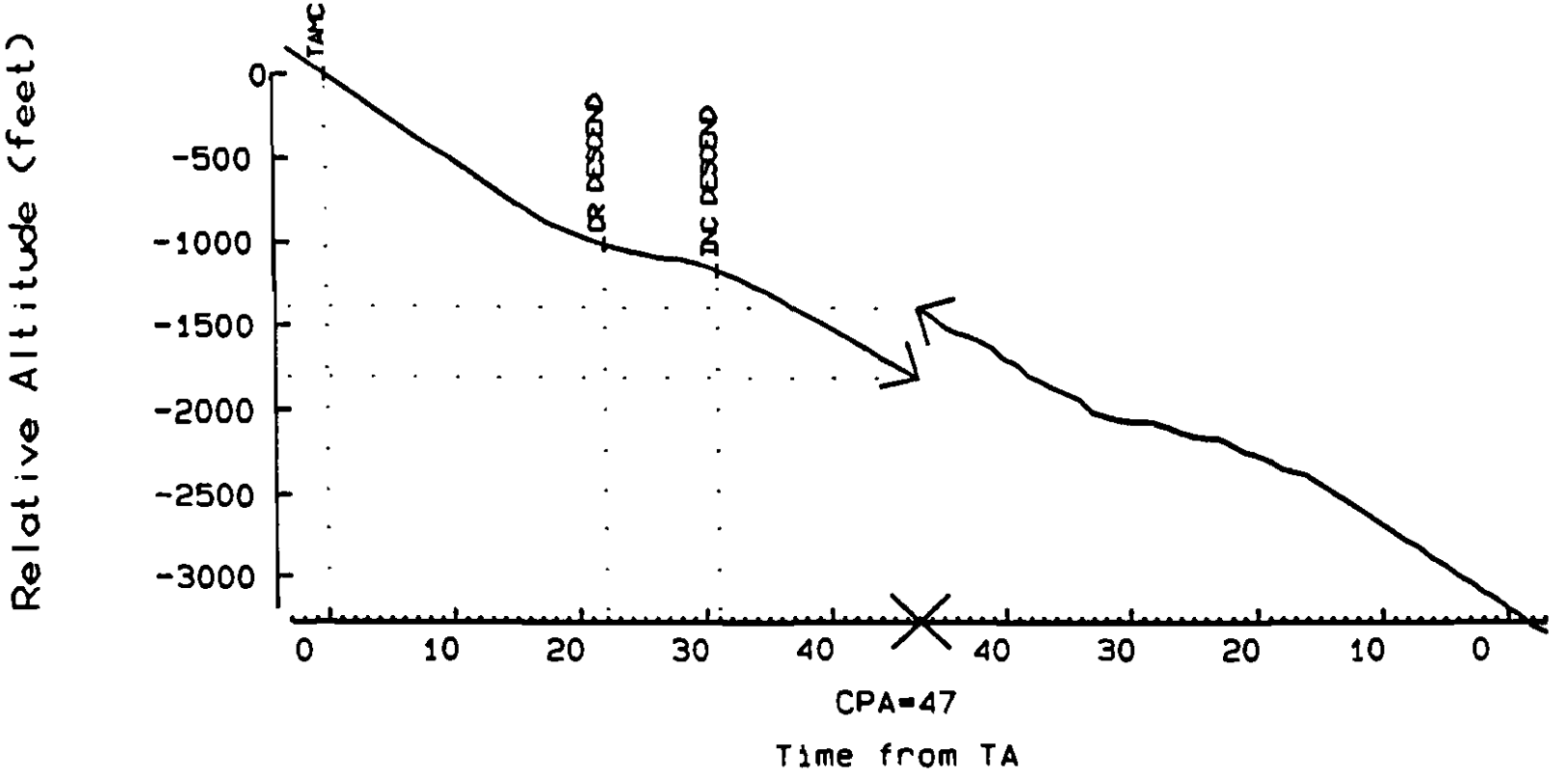
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -246

RANGE at CPA: 1020 ft



TA TIME: 00: 00: 16 CPA TIME: 00: 01: 03

FLIGHT DATE: RP/3./9P Alt. Difference at CPA: 420 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-17 Plane 2 Run 4 Logic v6.04 Group 3

>

Encounter ID 17 Filename m TSTPLN81.T

ENCOUNTER ID: 17

TARGET ID: 2

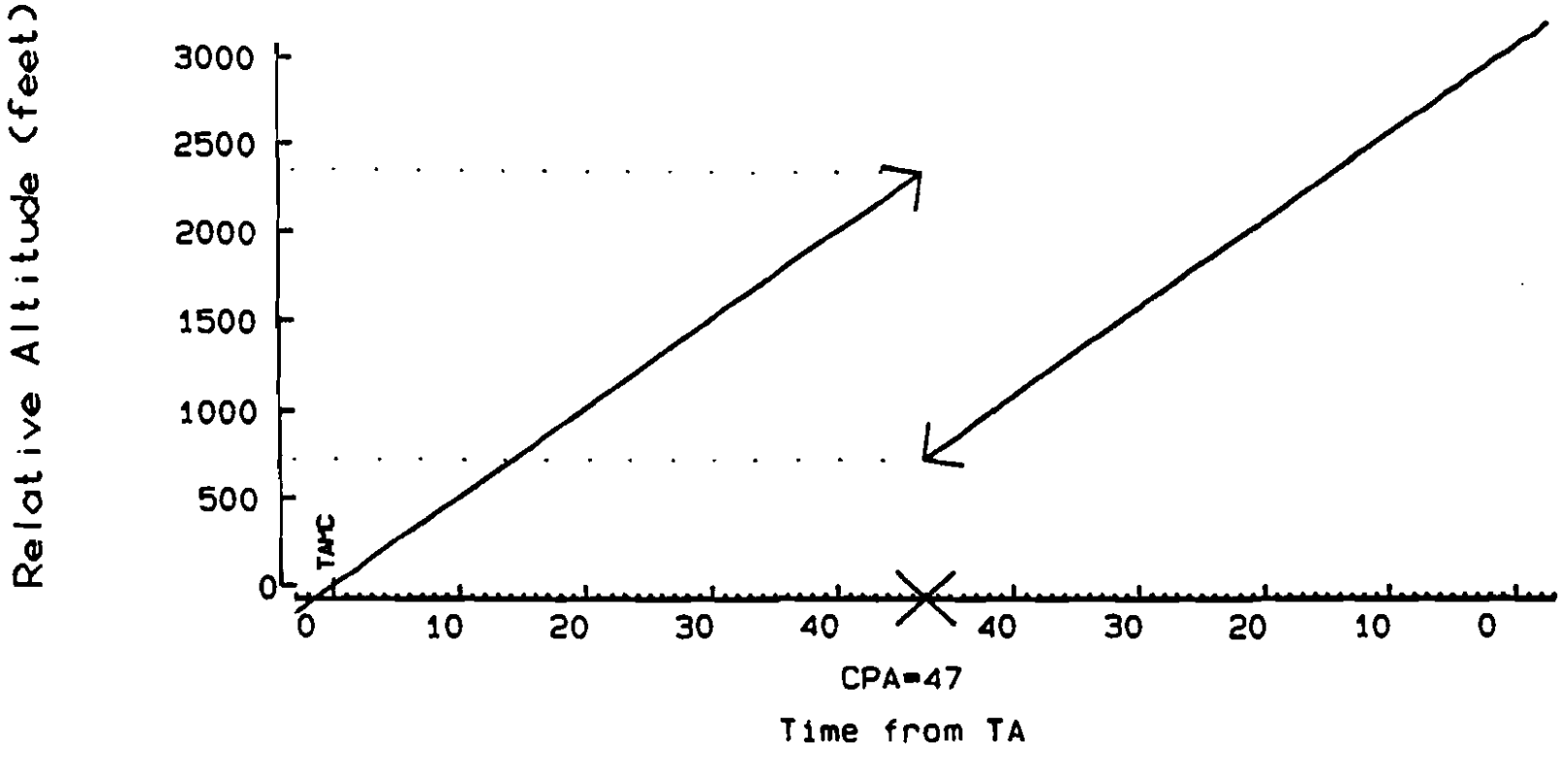
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -191

RANGE at CPA: 1622 ft



TA TIME: 00: 00: 16 CPA TIME: 00: 01: 03

FLIGHT DATE: RP/3./9P Alt. Difference at CPA: 1631 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-18

Plane 1

Run 1

Logic v6.02

Group 3

>

Encounter ID 18 Filename m TSTPLN81.T

ENCOUNTER ID: 18

TARGET ID: 1

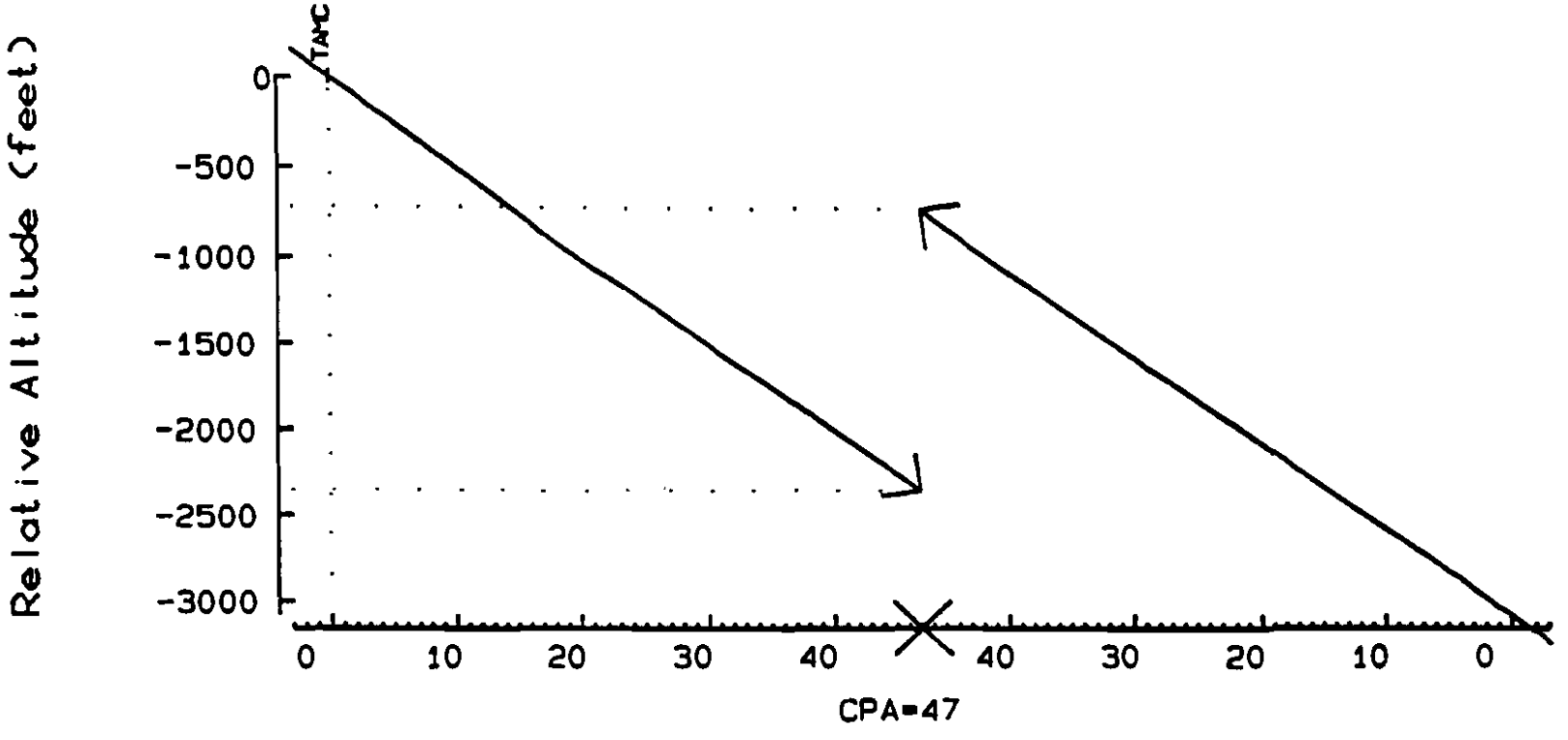
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -191

RANGE at CPA: 1622 ft



TA TIME: 00:00:16 CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P Alt. Difference at CPA: 1631 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-19

Plane 2

Run 1

Logic v6.02

Group 3

>

Encounter ID 19 Filename m TSTPLN81.T

ENCOUNTER ID: 19

TARGET ID: 2

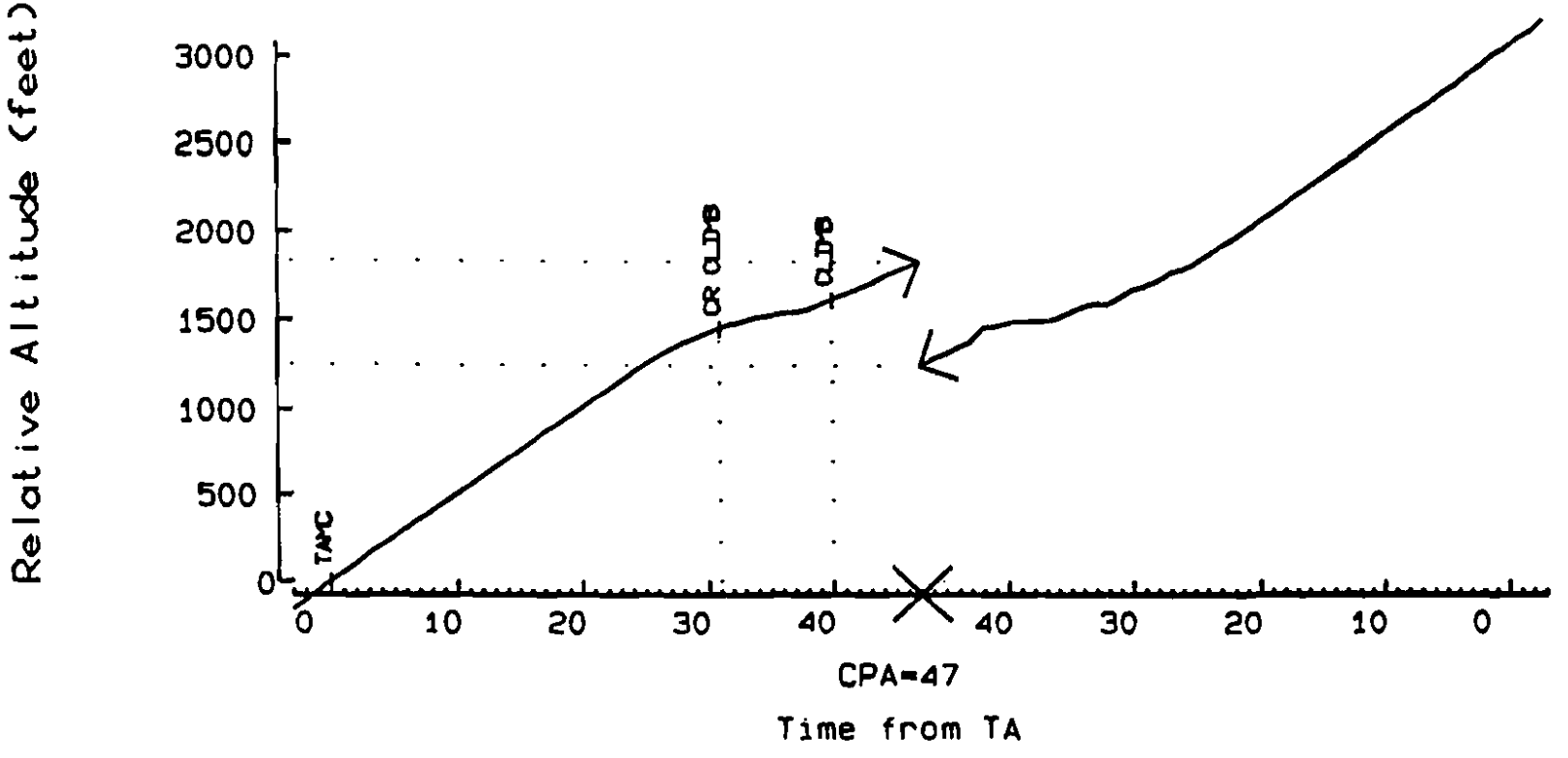
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -241

RANGE at CPA: 1069 ft



TA TIME: 00:00:16 CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P Alt. Difference at CPA: 587 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-20

Plane 1

Run 2

Logic v6.02

Group 3

>

Encounter ID 20 Filename m TSTPLN81.T

ENCOUNTER ID: 20

TARGET ID: 1

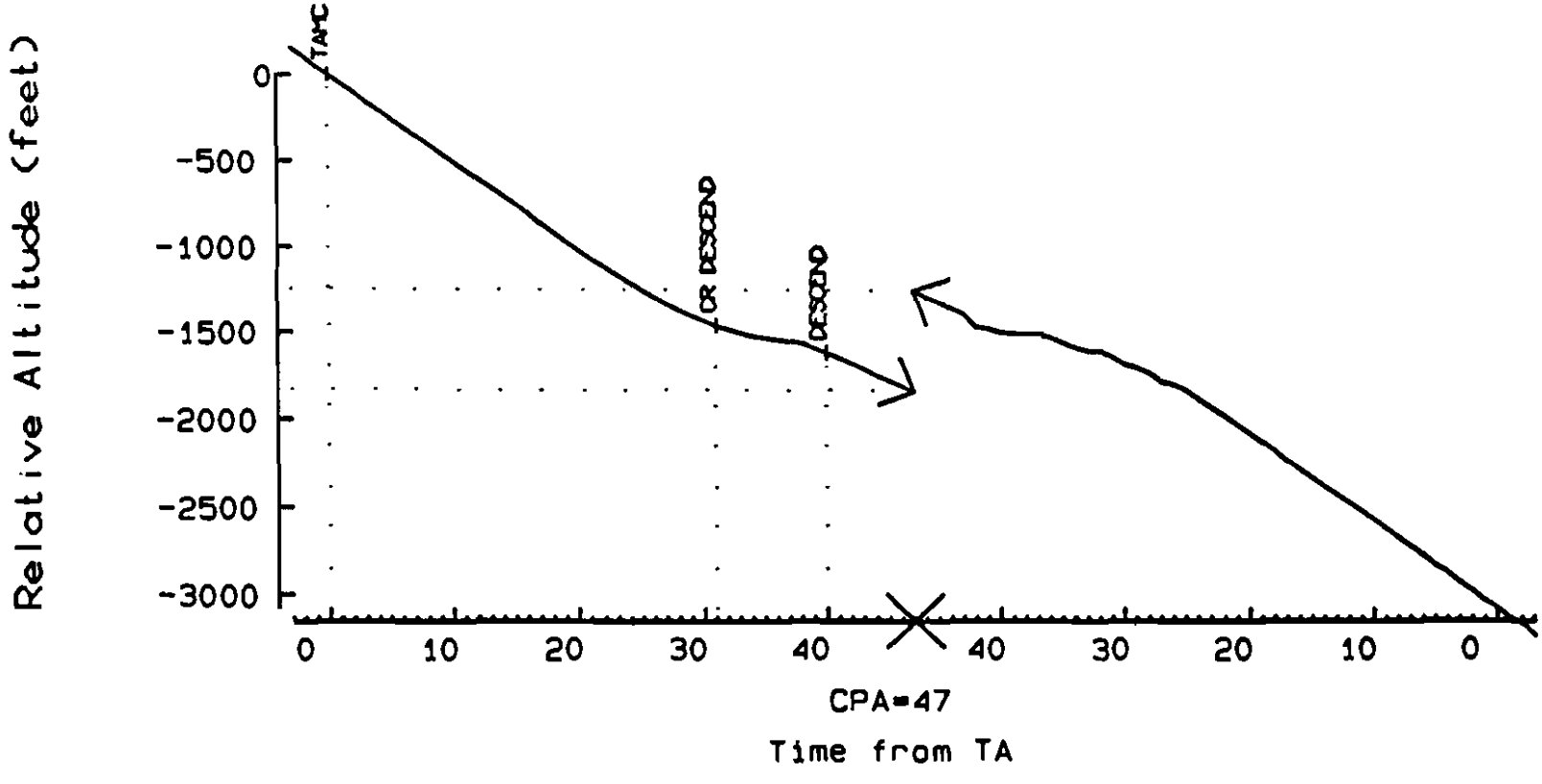
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -241

RANGE at CPA: 1069 ft



TA TIME: 00:00:16

CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P

Alt. Difference at CPA: 587 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-21

Plane 2

Run 2

Logic v6.02

Group 3

>

Encounter ID 21 Filename m TSTPLN81.T

ENCOUNTER ID: 21

TARGET ID: 2

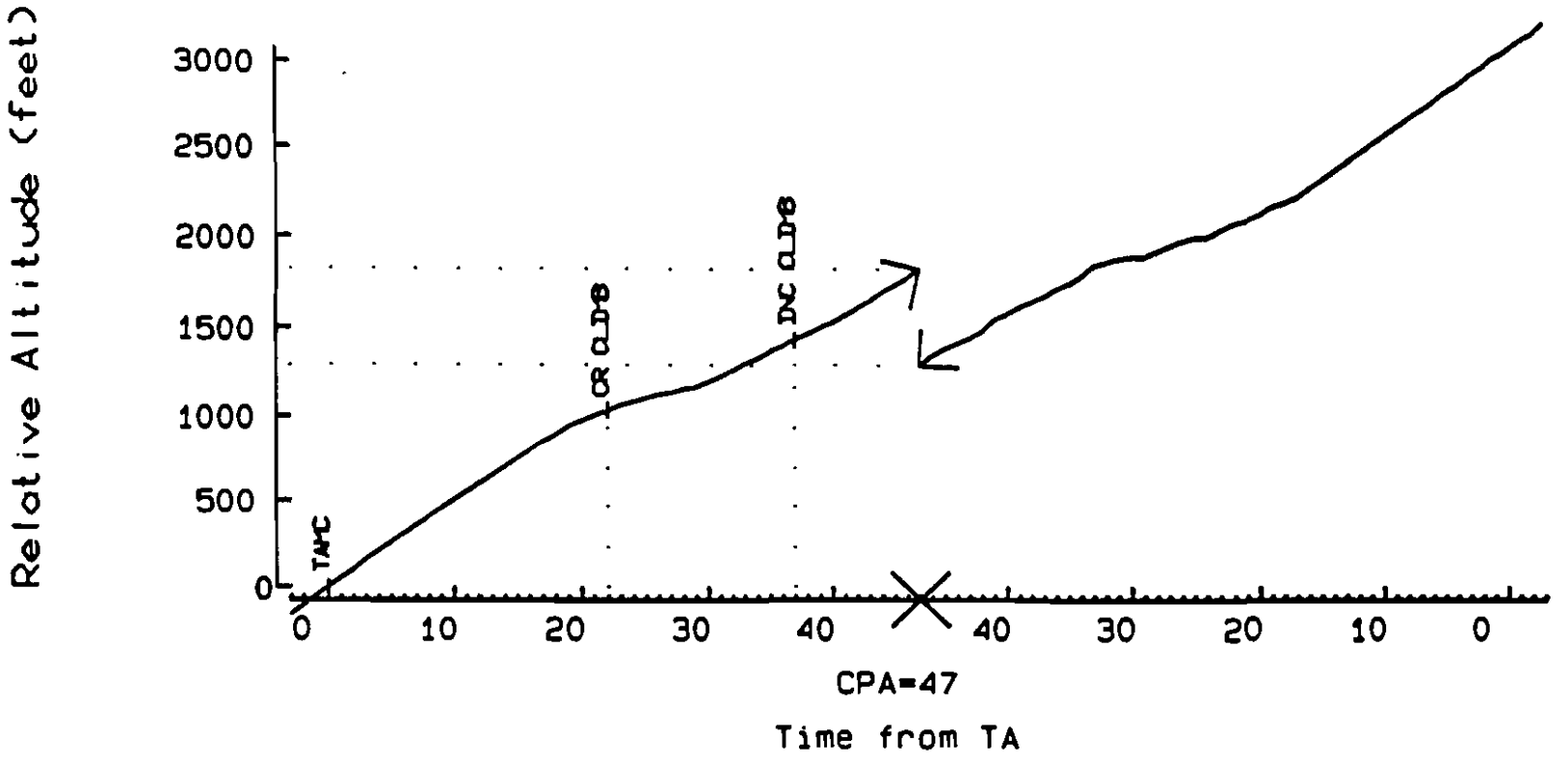
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -241

RANGE at CPA: 1057 ft



TA TIME: 00:00:16

CPA TIME: 00:01:03

FLIGHT DATE: AP/3./9P

Alt. Difference at CPA: 542 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-22

Plane 1

Run 3

Logic v6.02

Group 3

>

Encounter ID 22 Filename m TSTPLN81.T

ENCOUNTER ID: 22

TARGET ID: 1

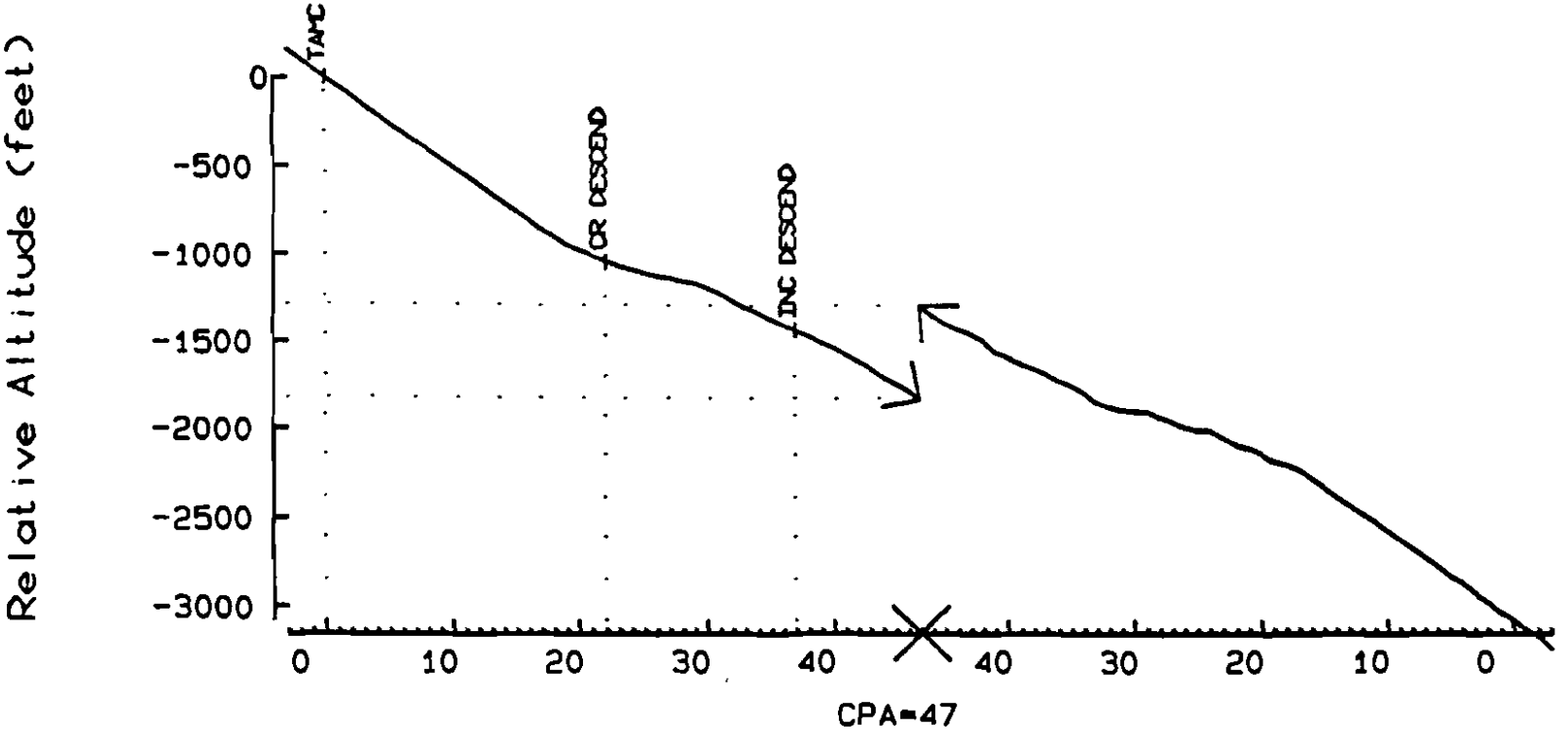
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -241

RANGE at CPA: 1057 ft



TA TIME: 00:00:16 CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P Alt. Difference at CPA: 542 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-23

Plane 2

Run 3

Logic v6.02

Group 3

Encounter ID 23 Filename m TSTPLN81.T

ENCOUNTER ID: 23

TARGET ID: 2

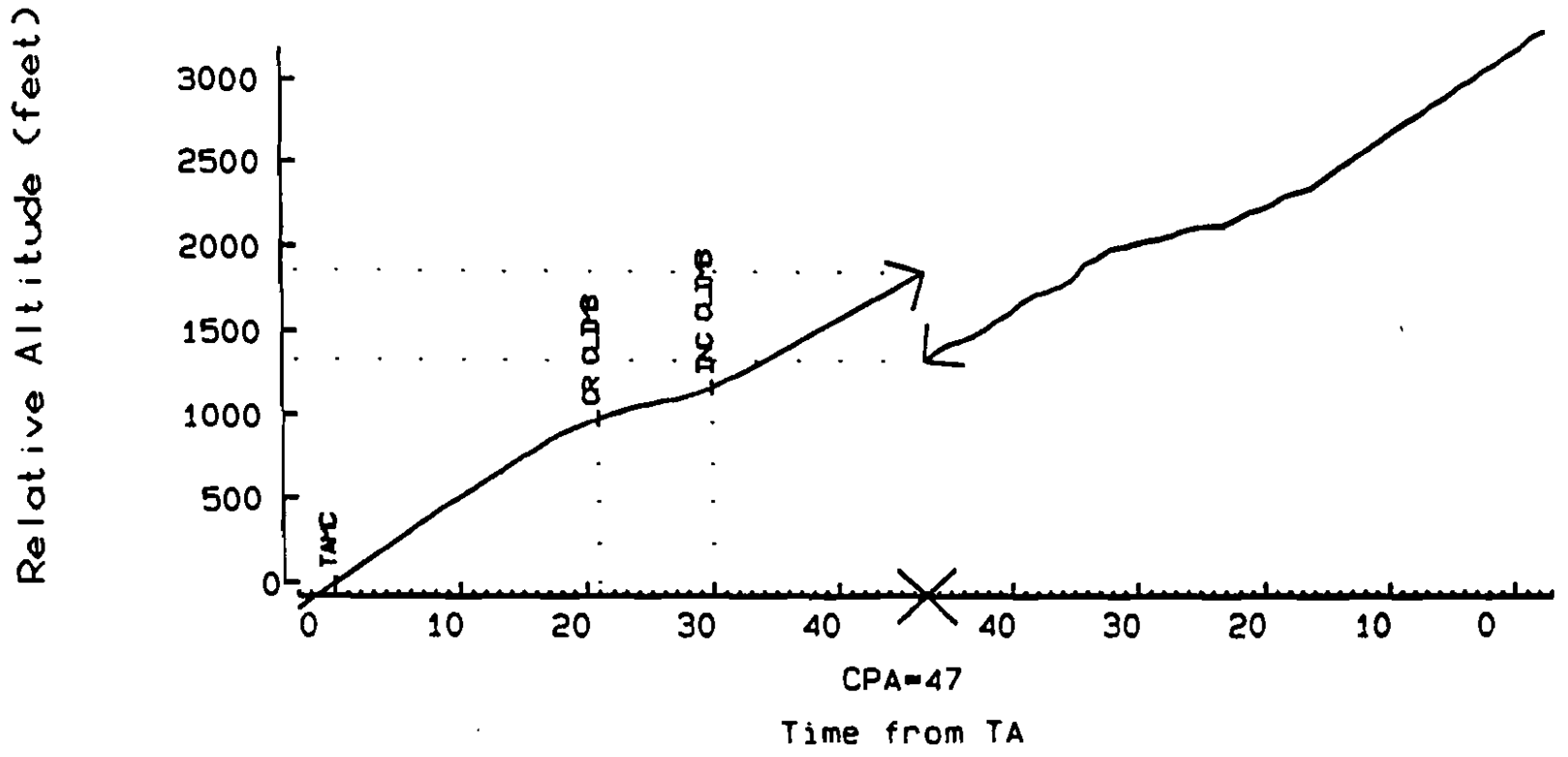
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -502

at CPA: -242

RANGE at CPA: 1051 ft



TA TIME: 00:00:16

CPA TIME: 00:01:03

FLIGHT DATE: AP/3./9P

Alt. Difference at CPA: 534 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-24

Plane 1

Run 4

Logic v6.02

Group 3

>

Encounter ID 24 Filename m TSTPLN81.T

ENCOUNTER ID: 24

TARGET ID: 1

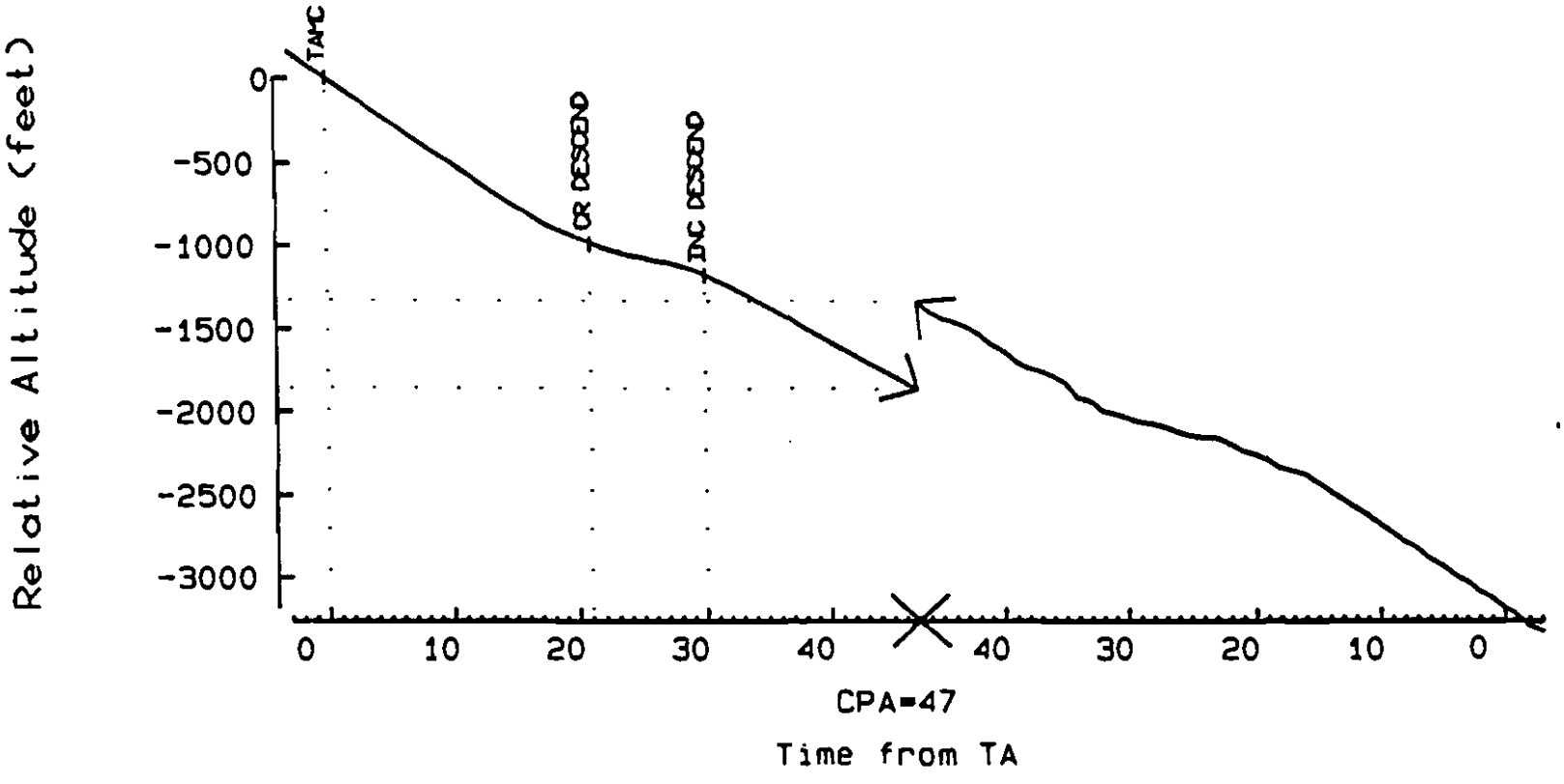
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -502

at CPA: -242

RANGE at CPA: 1051 ft



TA TIME: 00:00:16

CPA TIME: 00:01:03

FLIGHT DATE: RP/3./9P

Alt. Difference at CPA: 534 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

C-25

Plane 2

Run 4

Logic v6.02

Group 3

>

APPENDIX D

Simulation Results for Group 4 Encounters

Four different groups of encounters were used for the v6.04a logic flight tests. This appendix includes the simulation results for the higher altitude and airspeed encounter set, Group 4, which was used on the 9/22/93 and 9/23/93 test flights. The plots can be compared to see the simulated results of three TCAS logic versions; v6.04a, v6.04, and v6.02.

An explanation of the plots is included on pages F-1 through F-4 (appendix F). Note that since these are simulation results, some of the information fields, such as FLIGHT DATE, may have superfluous entries.

There are two plots for each encounter, one from the viewpoint of each TCAS. These plots correspond to the encounter run numbers as follows:

logic version	6.04a	6.04	6.02
Run 1	Plots D-2 and D-3	D-10 and D-11	D-18 and D-19
Run 2	Plots D-4 and D-5	D-12 and D-13	D-20 and D-21
Run 3	Plots D-6 and D-7	D-14 and D-15	D-22 and D-23
Run 4	Plots D-8 and D-9	D-16 and D-17	D-24 and D-25

Encounter ID 1 Filename m TSTPLN9.T

ENCOUNTER ID: 1

TARGET ID: 2

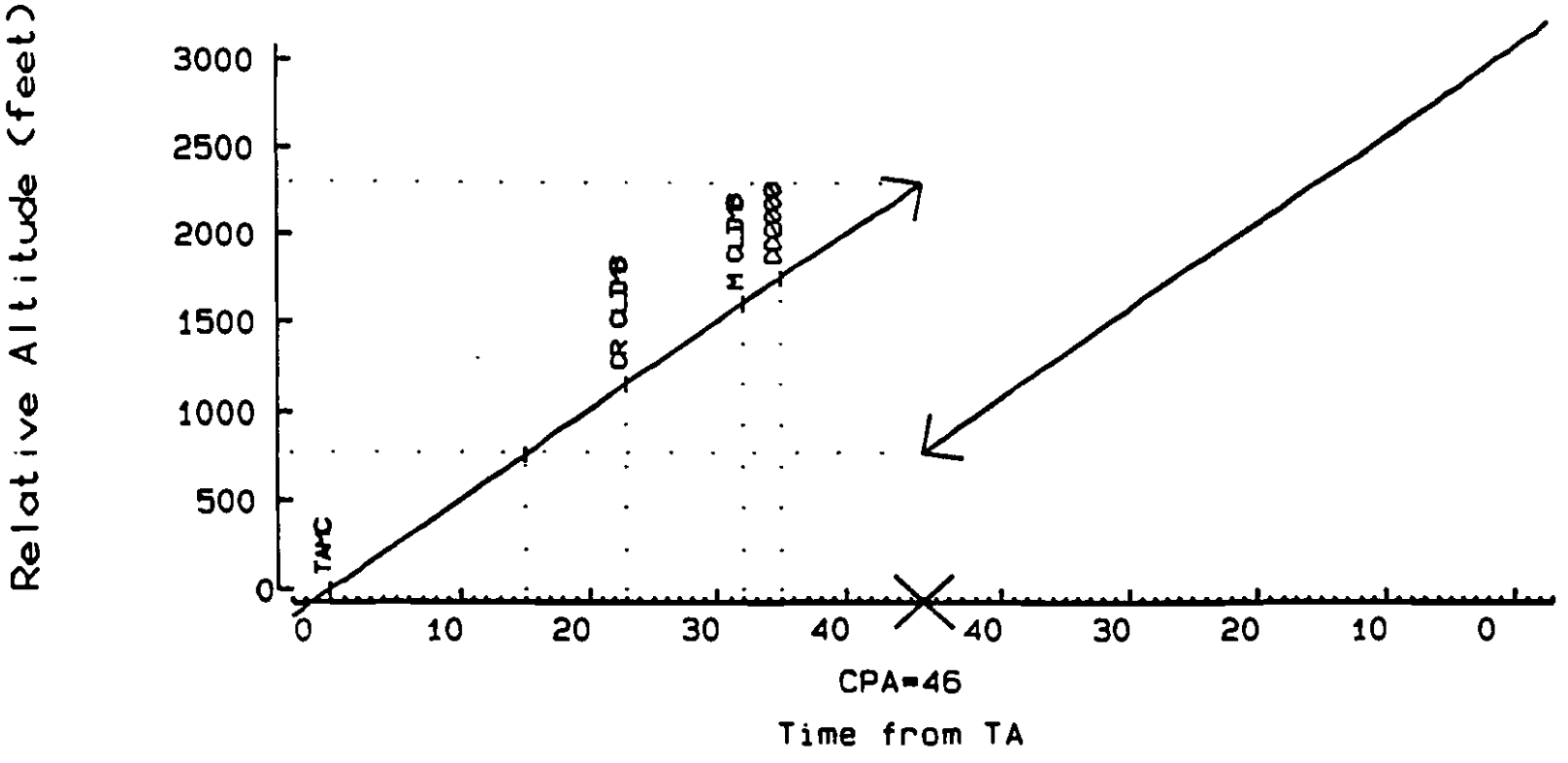
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -602

at CPA: -317

RANGE at CPA: 1433 ft



TA TIME: 00:00:15 CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P Alt. Difference at CPA: 1531 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

D-2

Plane 1

Run 1

Logic v6.04a

Group 4

>

Encounter ID 2 Filename m TSTPLN9.T

ENCOUNTER ID: 2

TARGET ID: 1

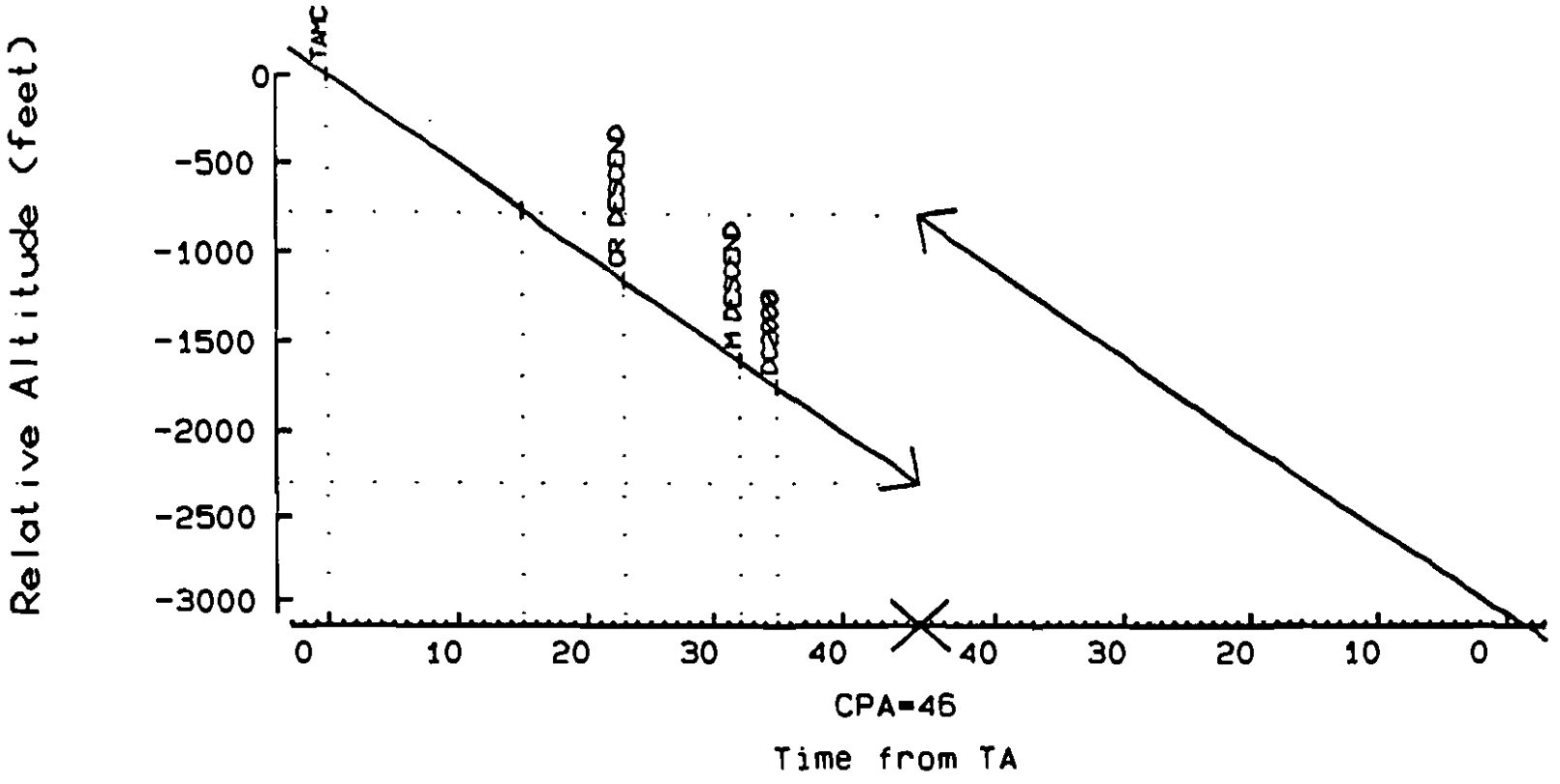
INTRUDER EQUIPAGE: TCAS II

OWN IO: 2

RANGE RATE at TA: -602

at CPA: -317

RANGE at CPA: 1433 ft



TA TIME: 00:00:15 CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P Alt. Difference at CPA: 1531 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

>

D-3

Plane 2

Run 1

Logic v6.04a

Group 4

Encounter ID 3 Filename m TSTPLN9.T

ENCOUNTER ID: 3

TARGET ID: 2

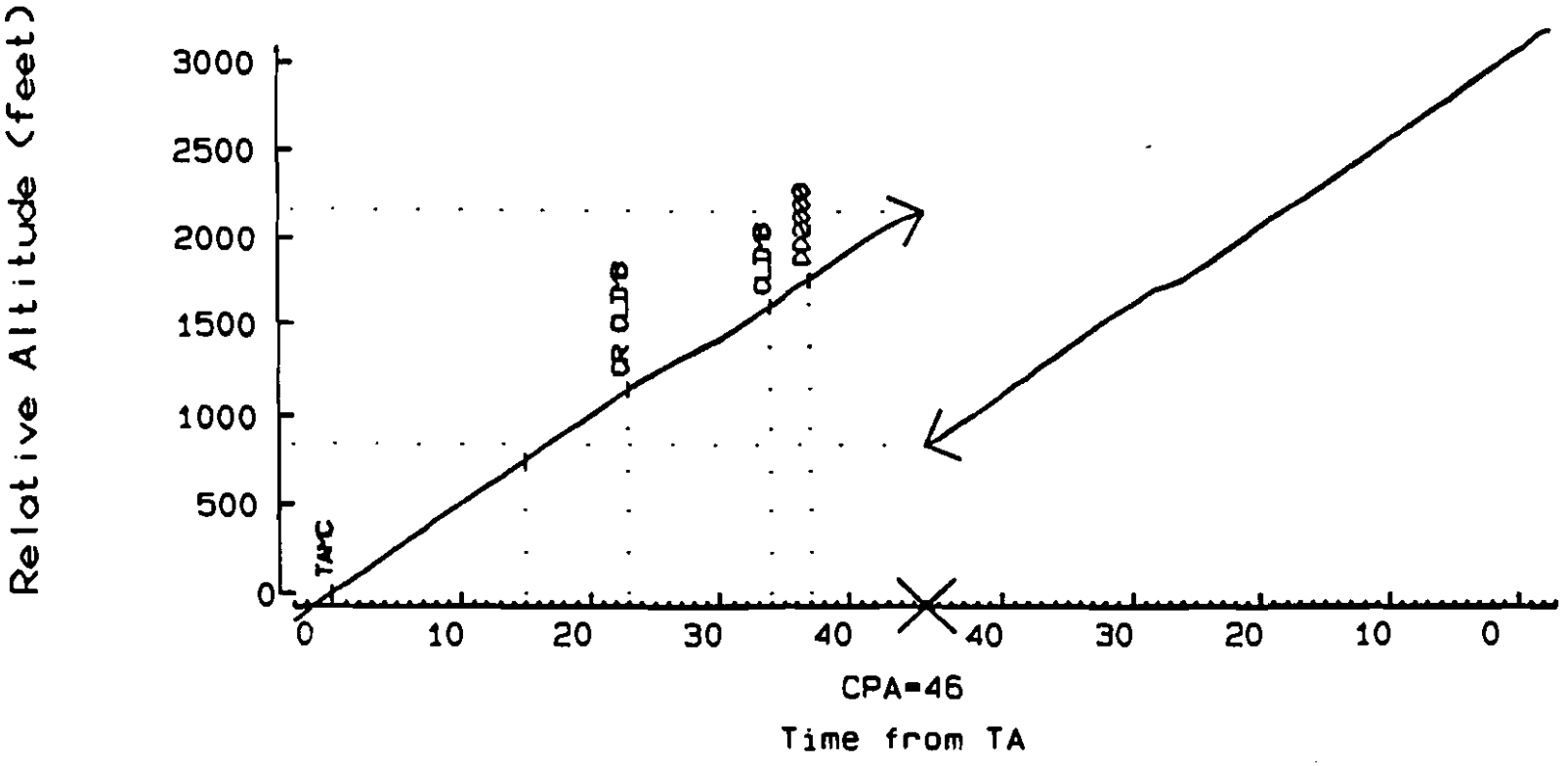
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -602

at CPA: -334

RANGE at CPA: 1300 ft



TA TIME: 00:00:15 CPA TIME: 00:01:01

FLIGHT DATE: AP/4./9P Alt. Difference at CPA: 1316 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

D-4

Plane 1

Run 2

Logic v6.04a

Group 4

>

Encounter ID 4 Filename m TSTPLN9.T

ENCOUNTER ID: 4

TARGET ID: 1

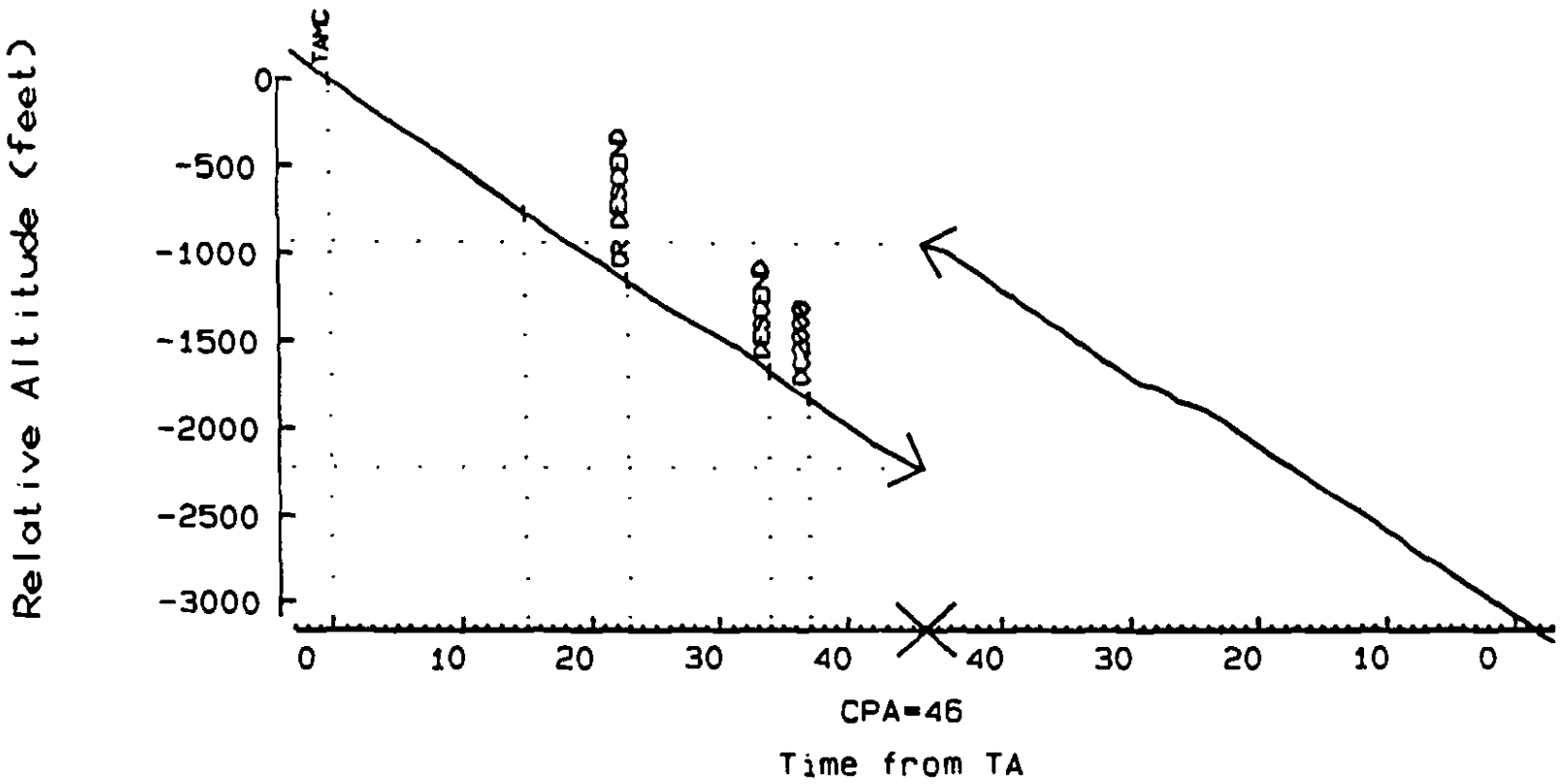
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -602

at CPA: -334

RANGE at CPA: 1300 ft



TA TIME: 00:00:15

CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P

Alt. Difference at CPA: 1289 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

D-5

Plane 2

Run 2

Logic v6.04a

Group 4

Encounter ID 5 Filename m TSTPLN9.T

ENCOUNTER ID: 5

TARGET ID: 2

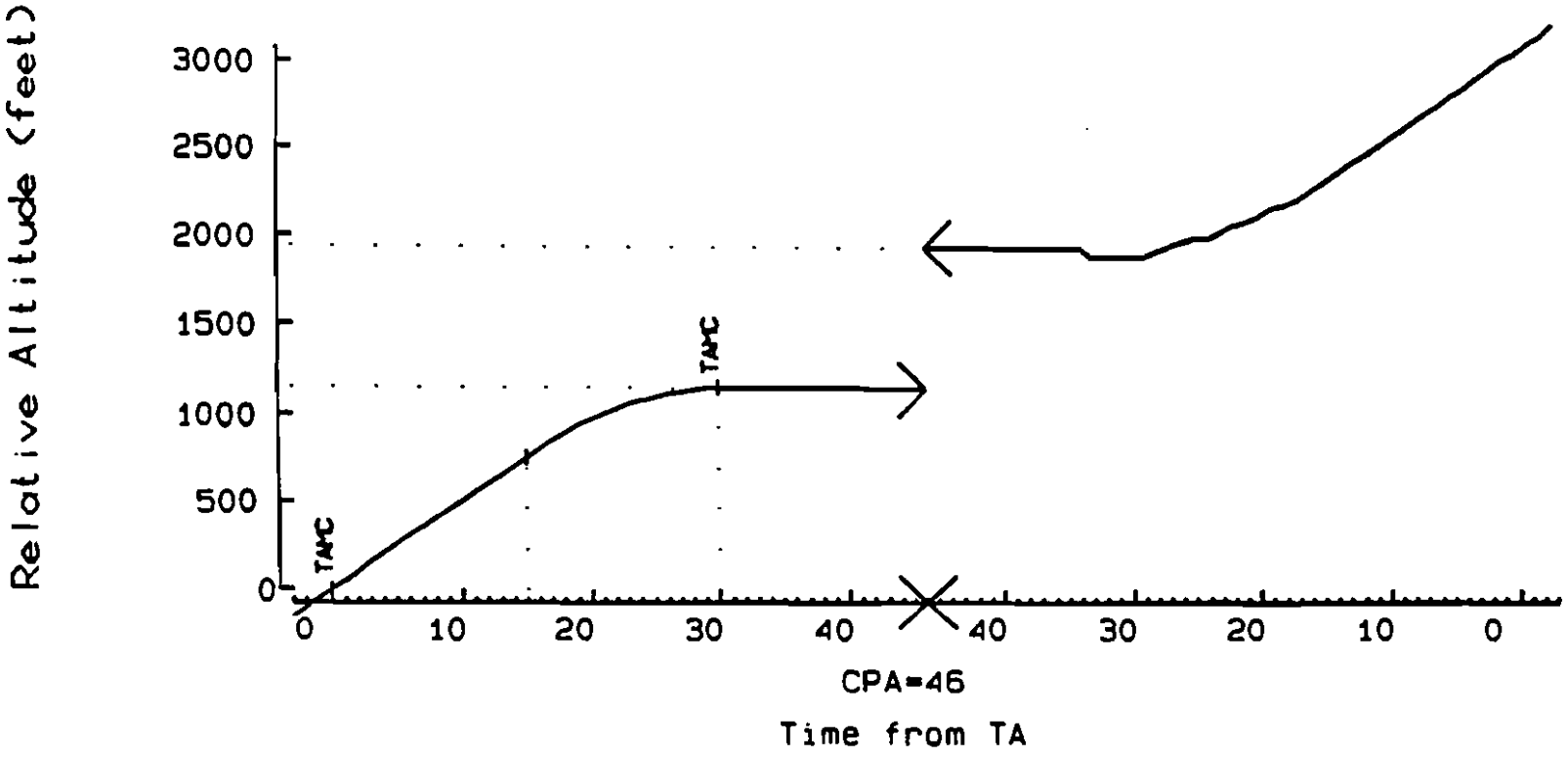
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -602

at CPA: -362

RANGE at CPA: 1081 ft



TA TIME: 00:00:15 CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P Alt. Difference at CPA: 806 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

D-6

Plane 1

Run 3

Logic v6.04a

Group 4

>

Encounter IO 6 Filename m TSTPLN9.T

ENCOUNTER ID: 6

TARGET ID: 1

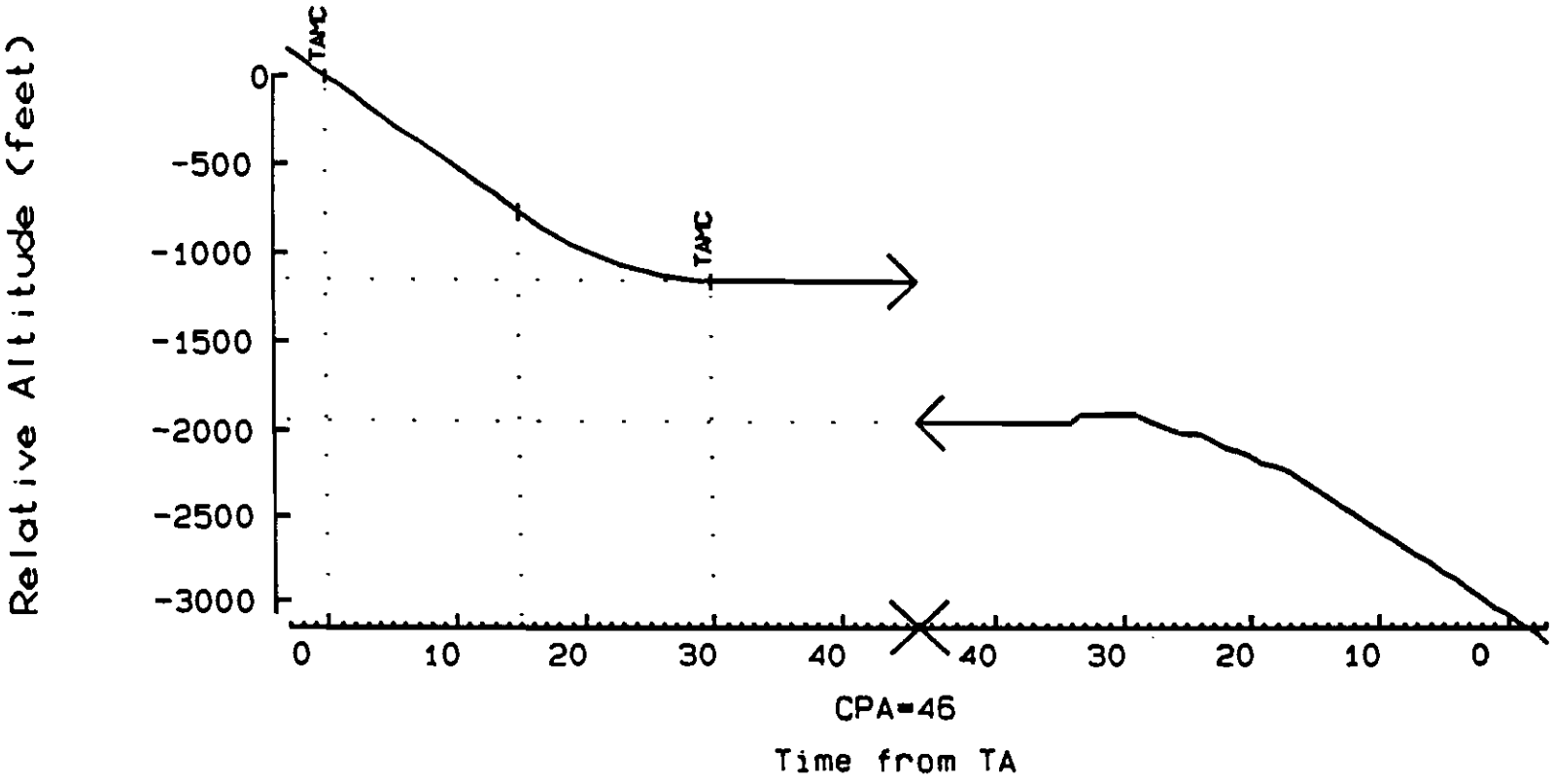
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -602

at CPA: -362

RANGE at CPA: 1081 ft



TA TIME: 00:00:15 CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P Alt. Difference at CPA: 806 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

Group 4 Logic v6.04a Run 3 Plane 2 D-7

>

Encounter ID 7 Filename m TSTPLN9.T

ENCOUNTER ID: 7

TARGET ID: 2

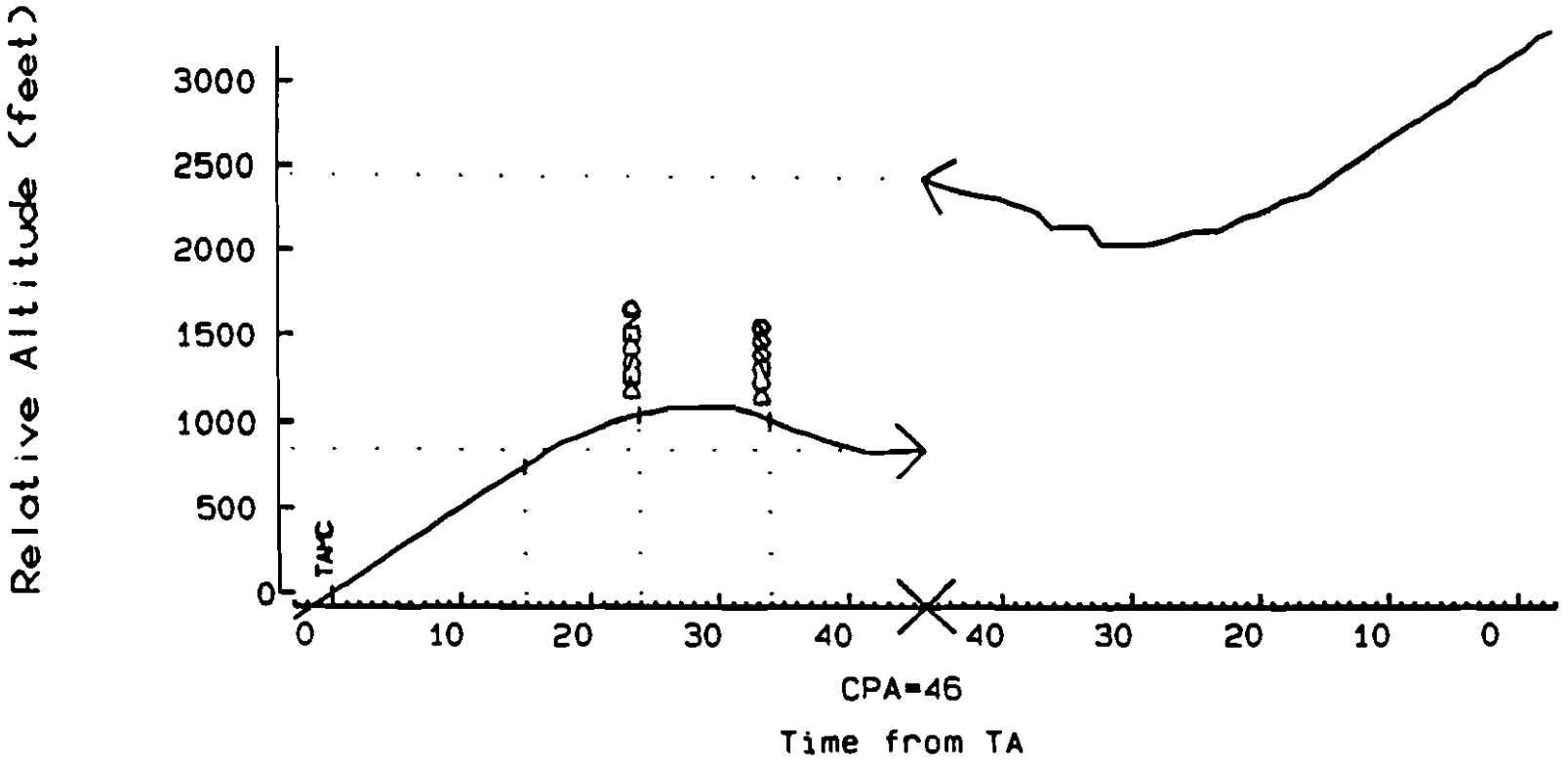
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -602

at CPA: -331

RANGE at CPA: 1488 ft



TA TIME: 00:00:15 CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P Alt. Difference at CPA: 1603 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

D-8

Plane 1

Run 4

Logic v6.04a

Group 4

>

Encounter ID 8 Filename m TSTPLN9.T

ENCOUNTER ID: 8

TARGET ID: 1

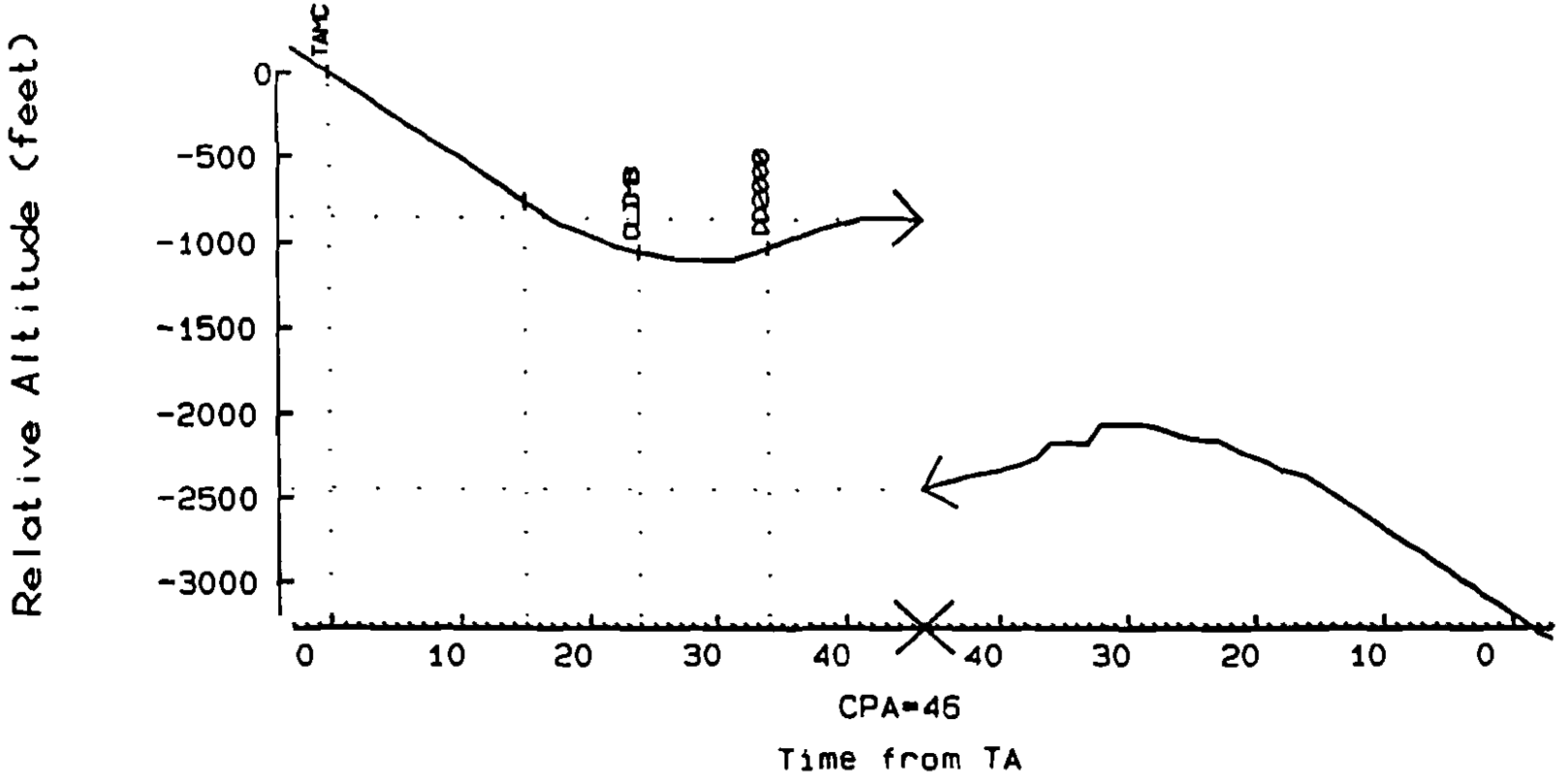
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -602

at CPA: -331

RANGE at CPA: 1488 ft



TA TIME: 00:00:15 CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P Alt. Difference at CPA: 1603 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

Group 4 Logic v6.04a Run 4 Plane 2 D-9

>

Encounter ID 9 Filename m TSTPLN9.T

ENCOUNTER ID: 9

TARGET ID: 2

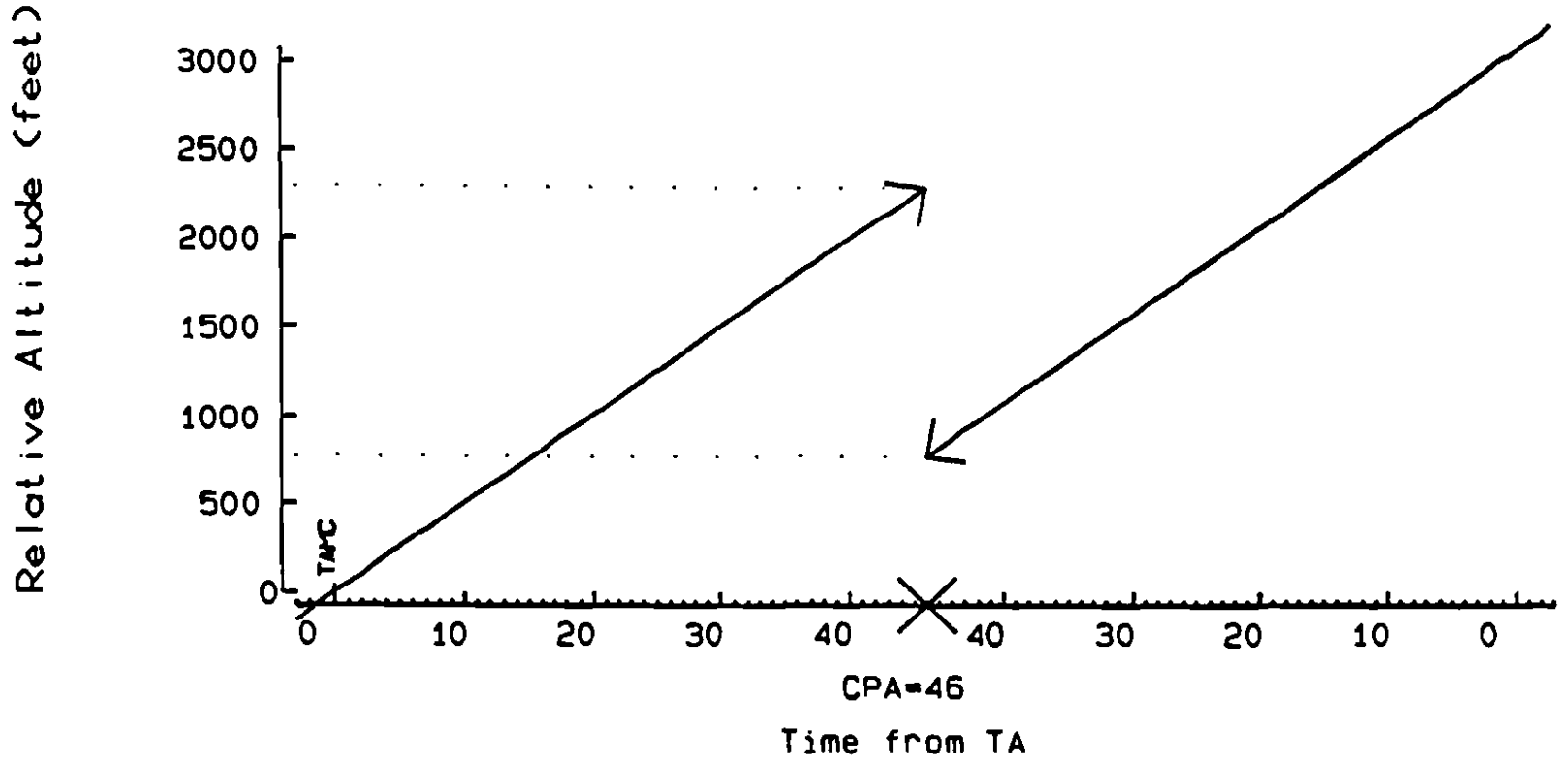
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -602

at CPA: -317

RANGE at CPA: 1433 ft



TA TIME: 00:00:15 CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P Alt. Difference at CPA: 1531 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

D-10

Plane 1

Run 1

Logic v6.04

Group 4

>

Encounter ID 10 Filename m TSTPLN9.T

ENCOUNTER ID: 10

TARGET ID: 1

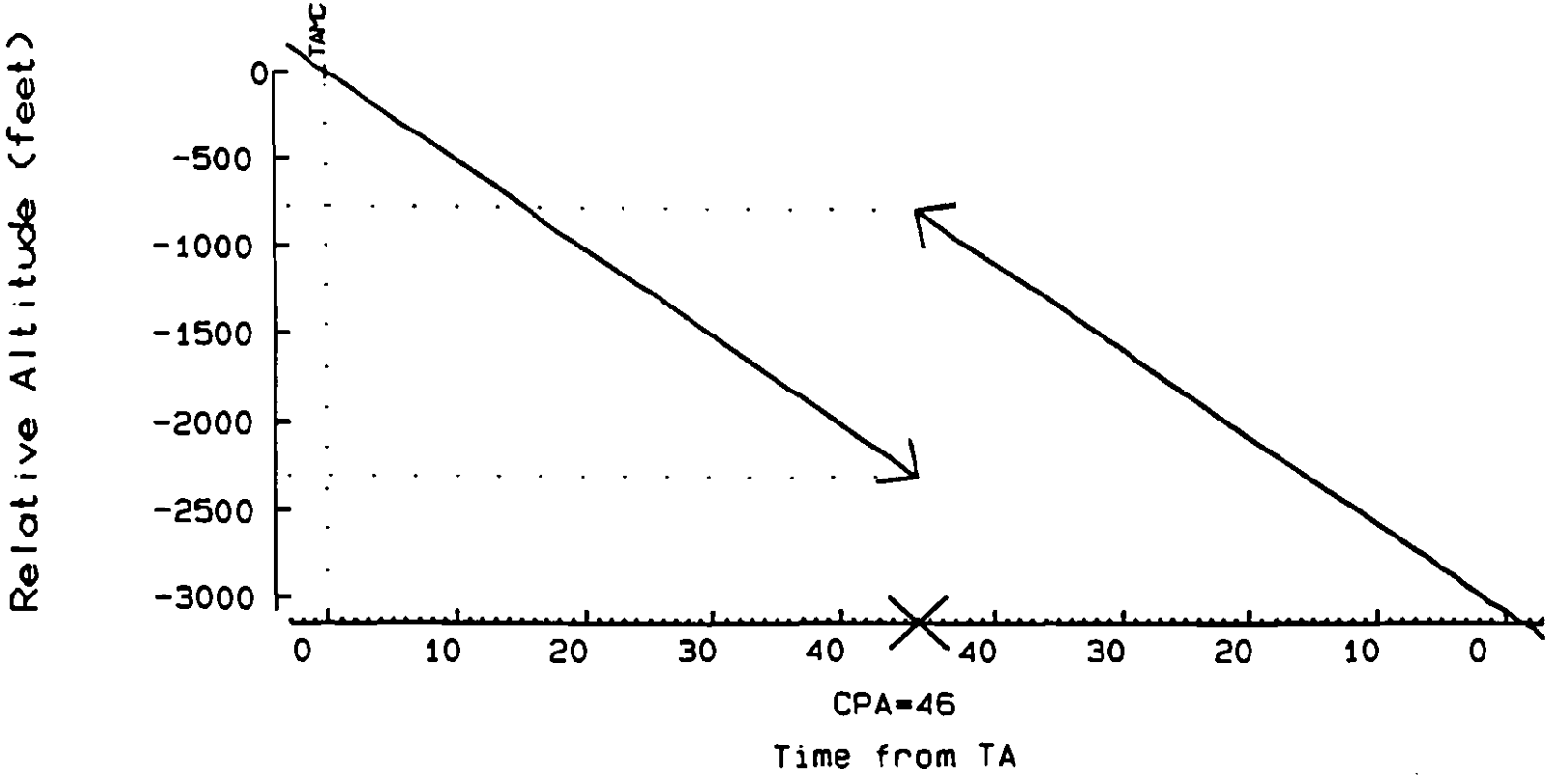
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -602

at CPA: -317

RANGE at CPA: 1433 ft



TA TIME: 00:00:15 CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P Alt. Difference at CPA: 1531 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

D-11 Plane 2 Run 1 Logic v6.04 Group 4

>

Encounter ID 11 Filename m TSTPLN9.T

ENCOUNTER ID: 11

TARGET ID: 2

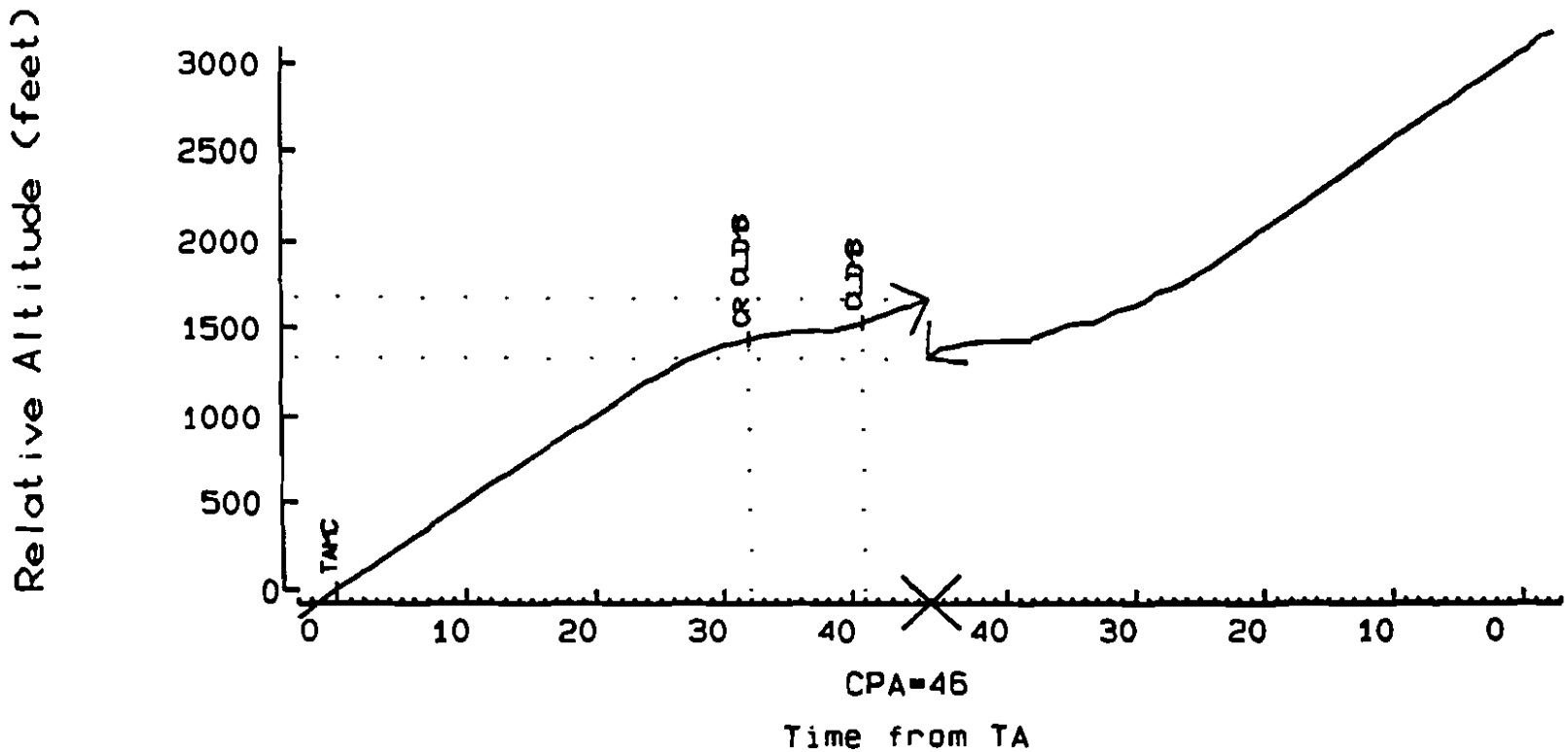
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -602

at CPA: -373

RANGE at CPA: 917 ft



TA TIME: 00:00:15

CPA TIME: 00:01:01

FLIGHT DATE: AP/4./9P

Alt. Difference at CPA: 347 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

D-12

Plane 1

Run 2

Logic v6.04

Group 4

>

Encounter ID 12 Filename m TSTPLN9.T

ENCOUNTER ID: 12

TARGET ID: 1

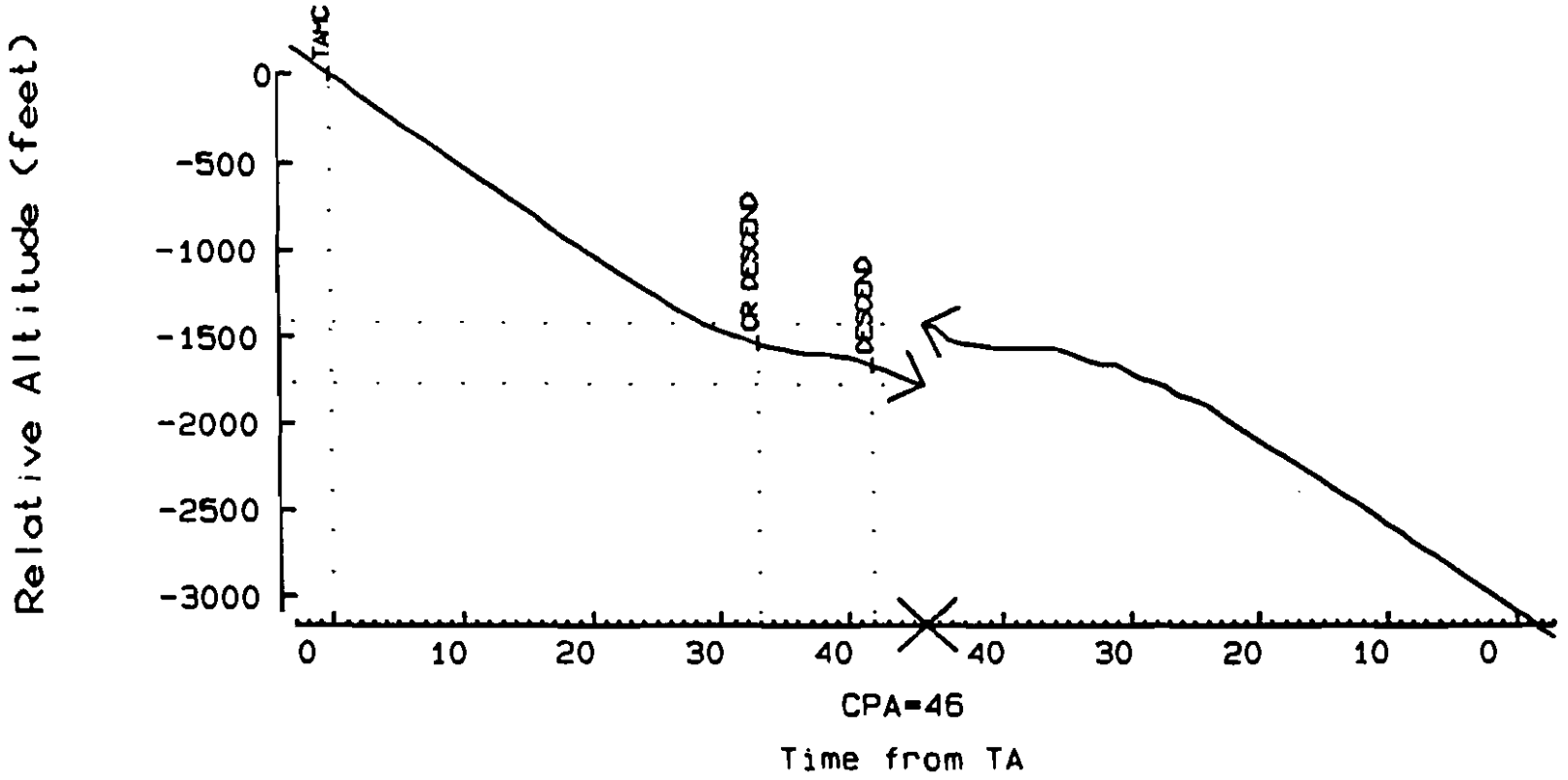
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -602

at CPA: -373

RANGE at CPA: 917 ft



TA TIME: 00:00:15

CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P

Alt. Difference at CPA: 363 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

>

D-13

Plane 2

Run 2

Logic v6.04

Group 4

Encounter ID 13 Filename m TSTPLN9.T

ENCOUNTER ID: 13

TARGET ID: 2

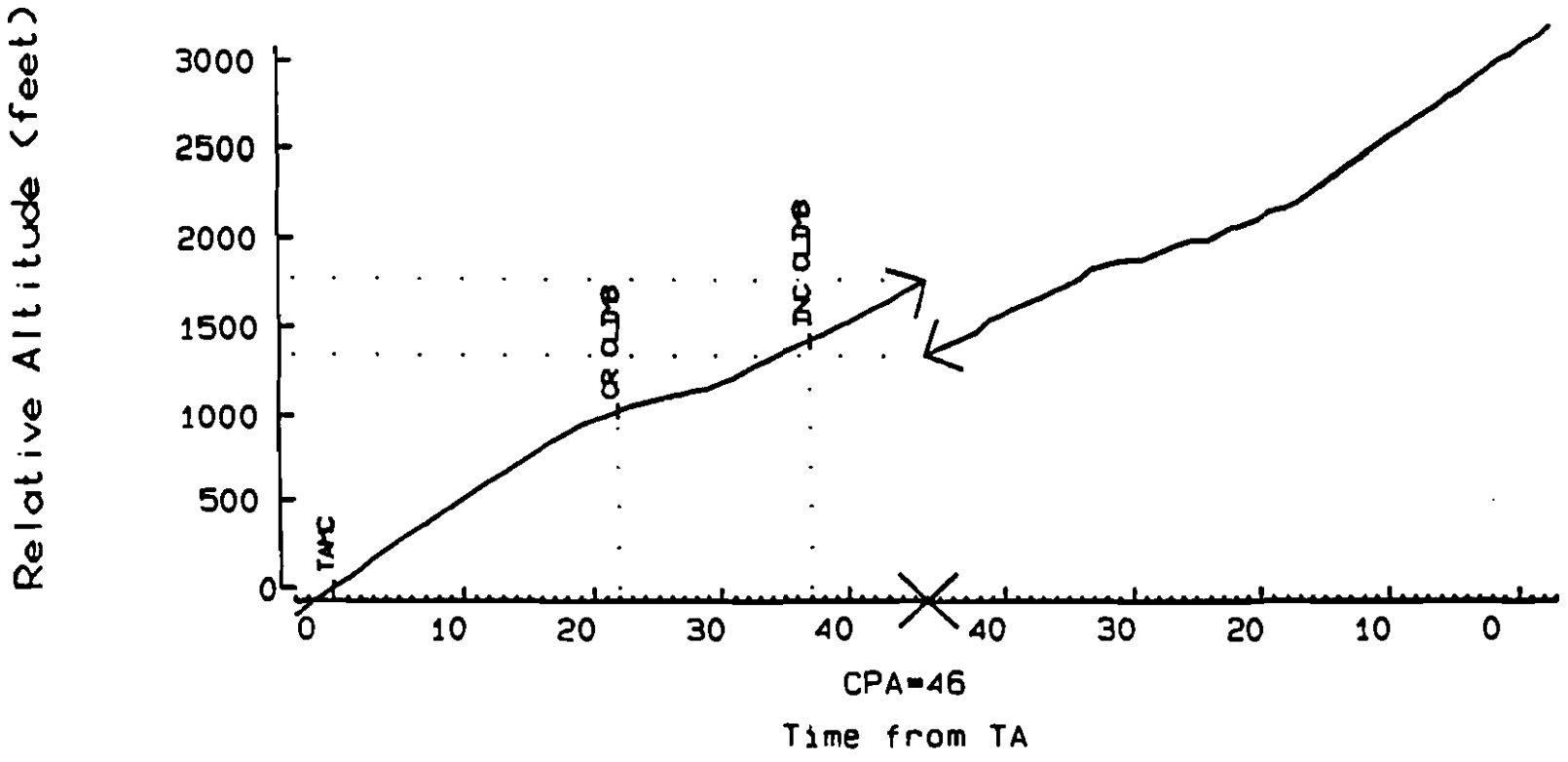
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -602

at CPA: -370

RANGE at CPA: 935 ft



TA TIME: 00:00:15

CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P

Alt. Difference at CPA: 435 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

D-14

Plane 1

Run 3

Logic v6.04

Group 4

>

Encounter ID 14 Filename m TSTPLN9.T

ENCOUNTER ID: 14

TARGET ID: 1

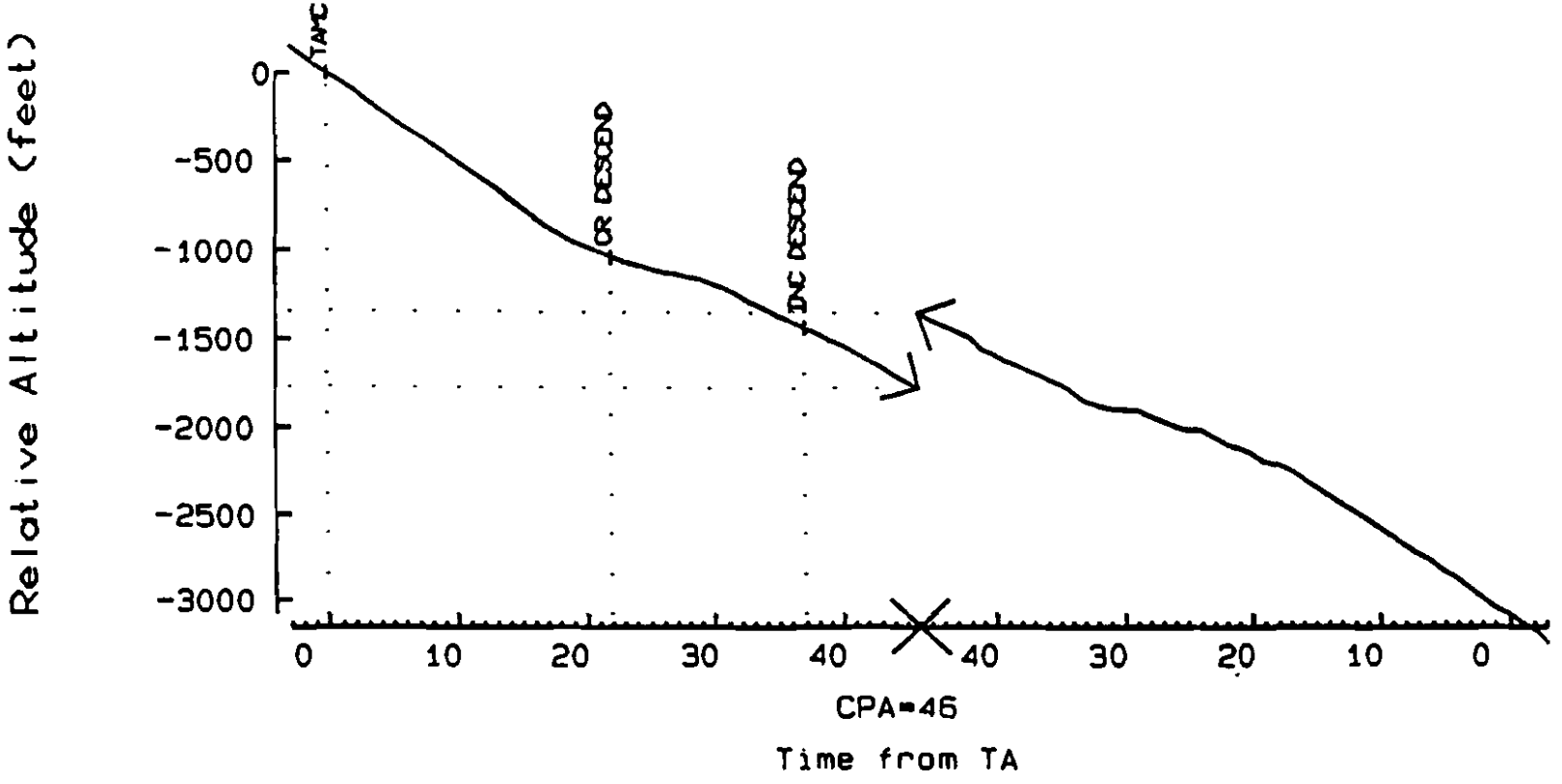
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -602

at CPA: -370

RANGE at CPA: 935 ft



TA TIME: 00:00:15 CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P Alt. Difference at CPA: 435 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

>

D-15 Plane 2 Run 3 Logic v6.04 Group 4

Encounter ID 15 Filename m TSTPLN9.T

ENCOUNTER ID: 15

TARGET ID: 2

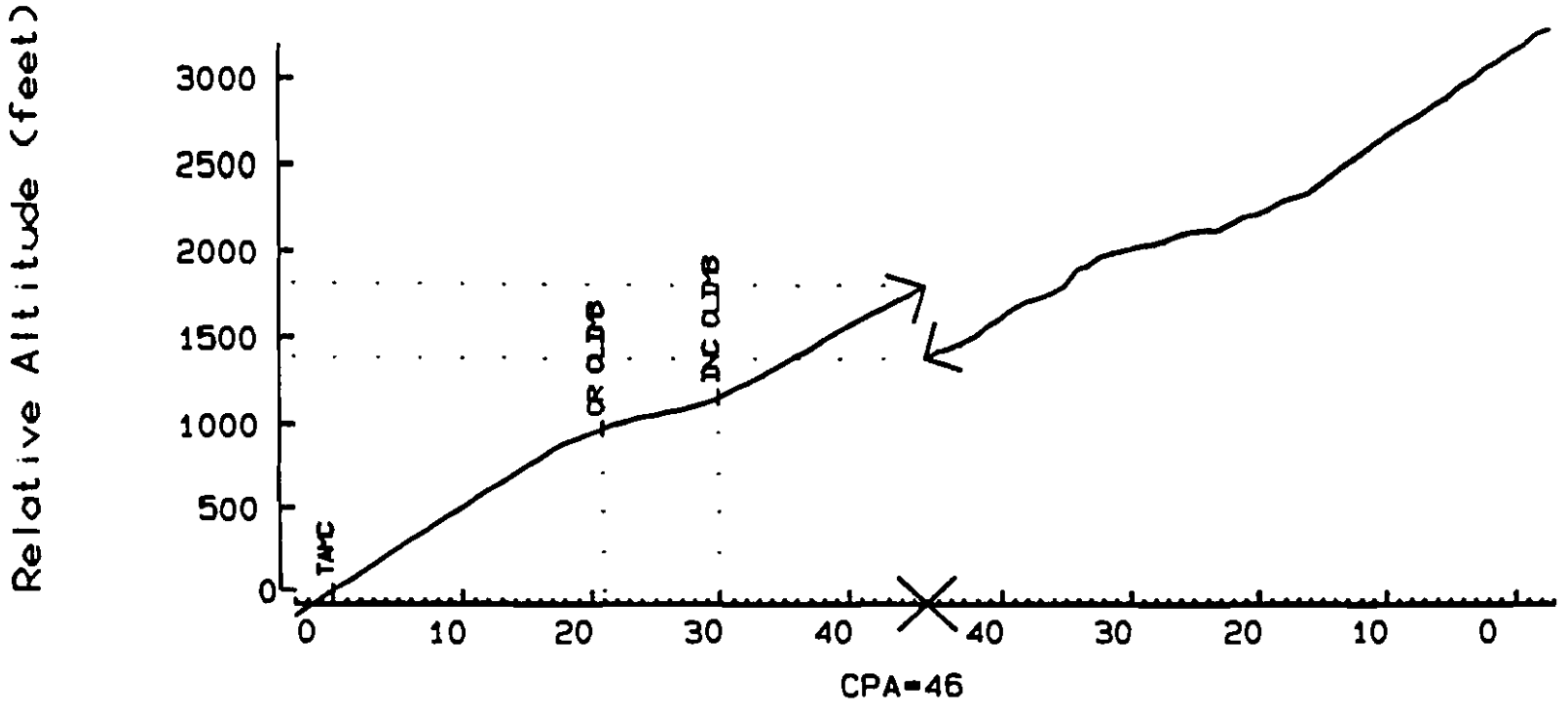
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -602

at CPA: -370

RANGE at CPA: 929 ft



TA TIME: 00: 00: 15 CPA TIME: 00: 01: 01

FLIGHT DATE: RP/4./9P Alt. Difference at CPA: 434 ft

PROCESSED ON: 02/17/94 by ACO-320 FAA Technical Center

>

D-16

Plane 1

Run 4

Logic v6.04

Group 4

Encounter ID 16 Filename m TSTPLN9.T

ENCOUNTER ID: 16

TARGET ID: 1

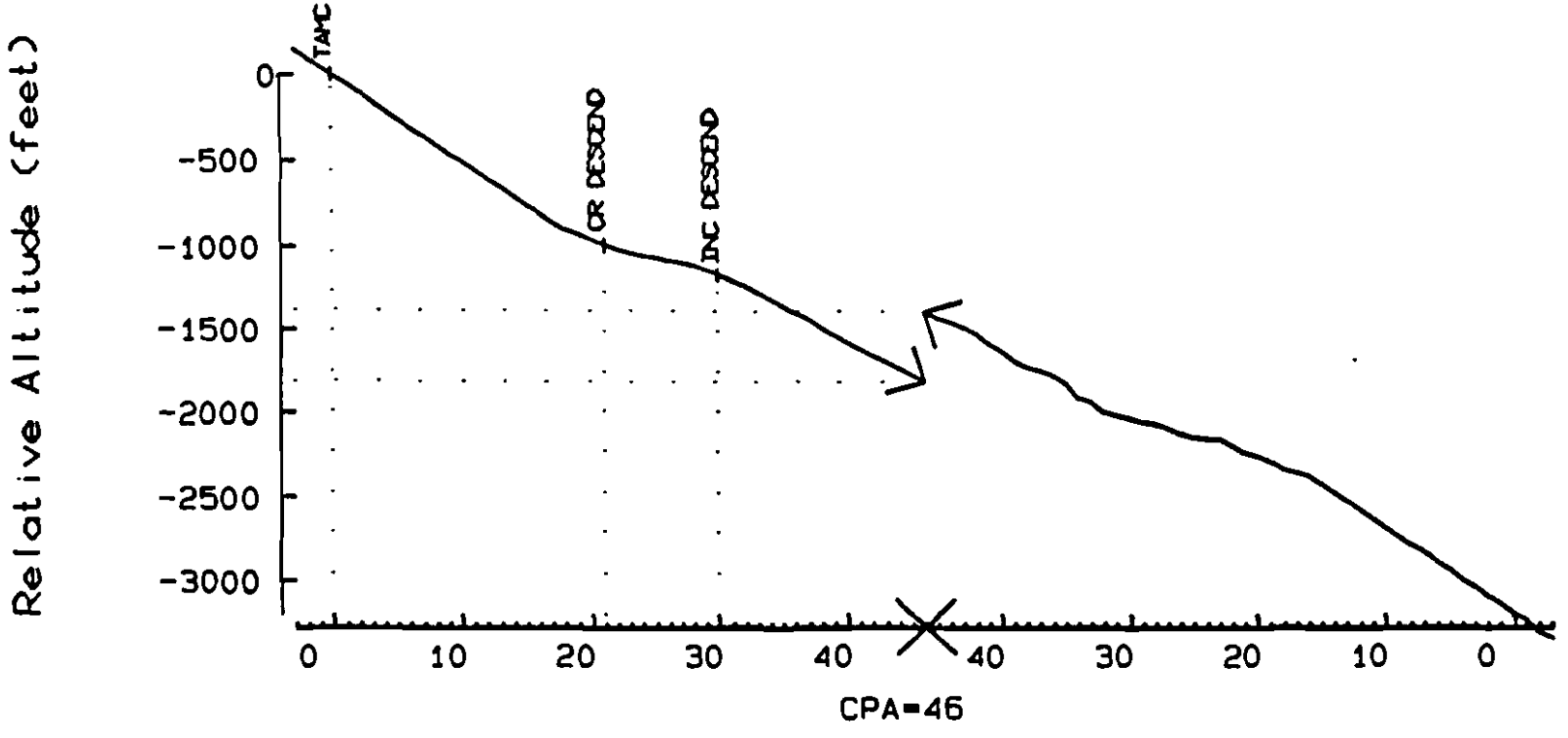
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -602

at CPA: -370

RANGE at CPA: 929 ft



TA TIME: 00:00:15

CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P

Alt. Difference at CPA: 435 ft

PROCESSED ON: 02/17/94 by ACO-320 FAA Technical Center

D-17

Plane 2

Run 4

Logic v6.04

Group 4

Encounter ID 17 Filename m TSTPLN9.T

ENCOUNTER ID: 17

TARGET ID: 2

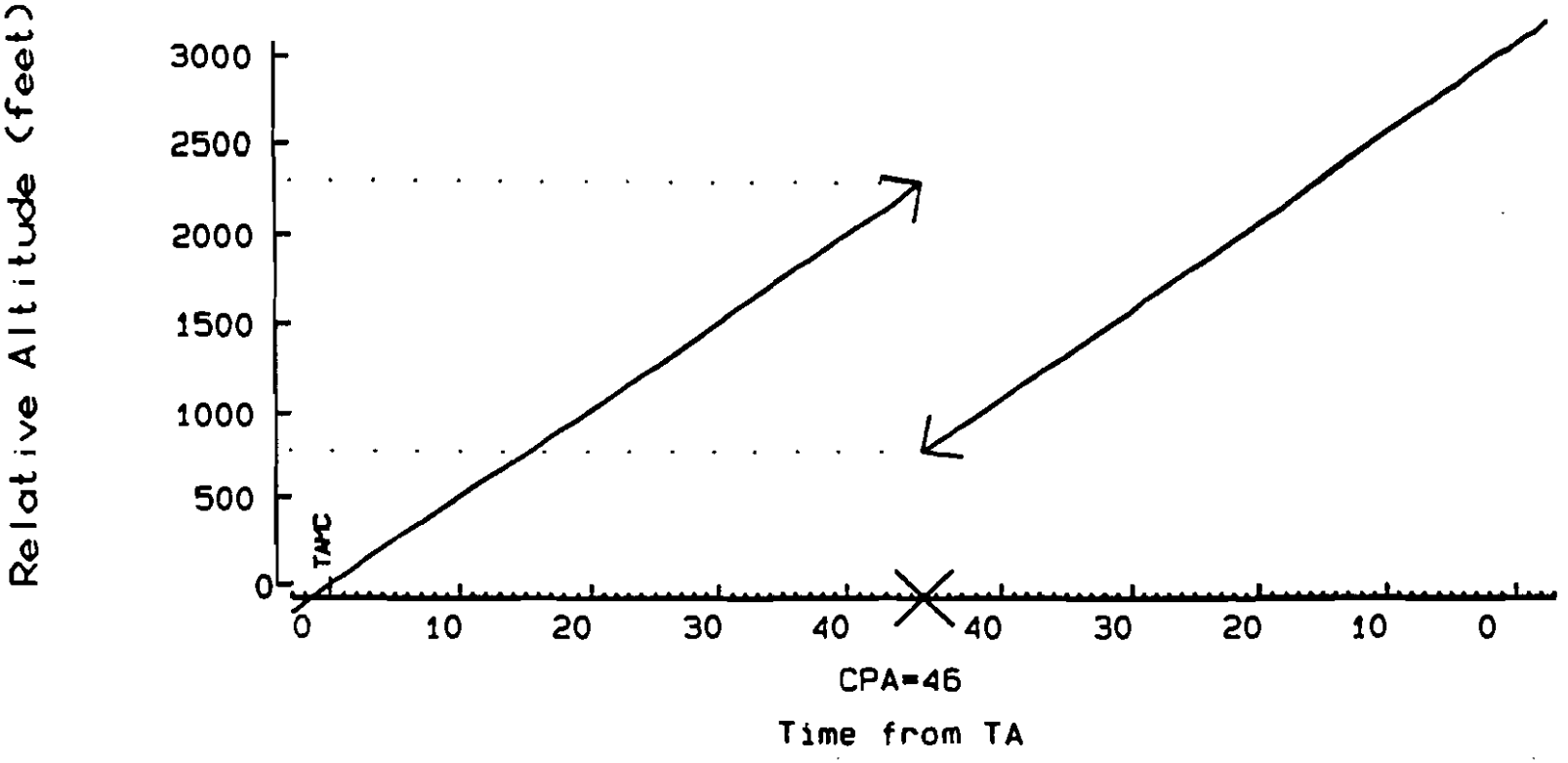
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -602

at CPA: -317

RANGE at CPA: 1433 ft



TA TIME: 00:00:15 CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P Alt. Difference at CPA: 1531 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

D-18

Plane 1

Run 1

Logic v6.02

Group 4

>

Encounter ID 18 Filename m TSTPLN9.T

ENCOUNTER ID: 18

TARGET ID: 1

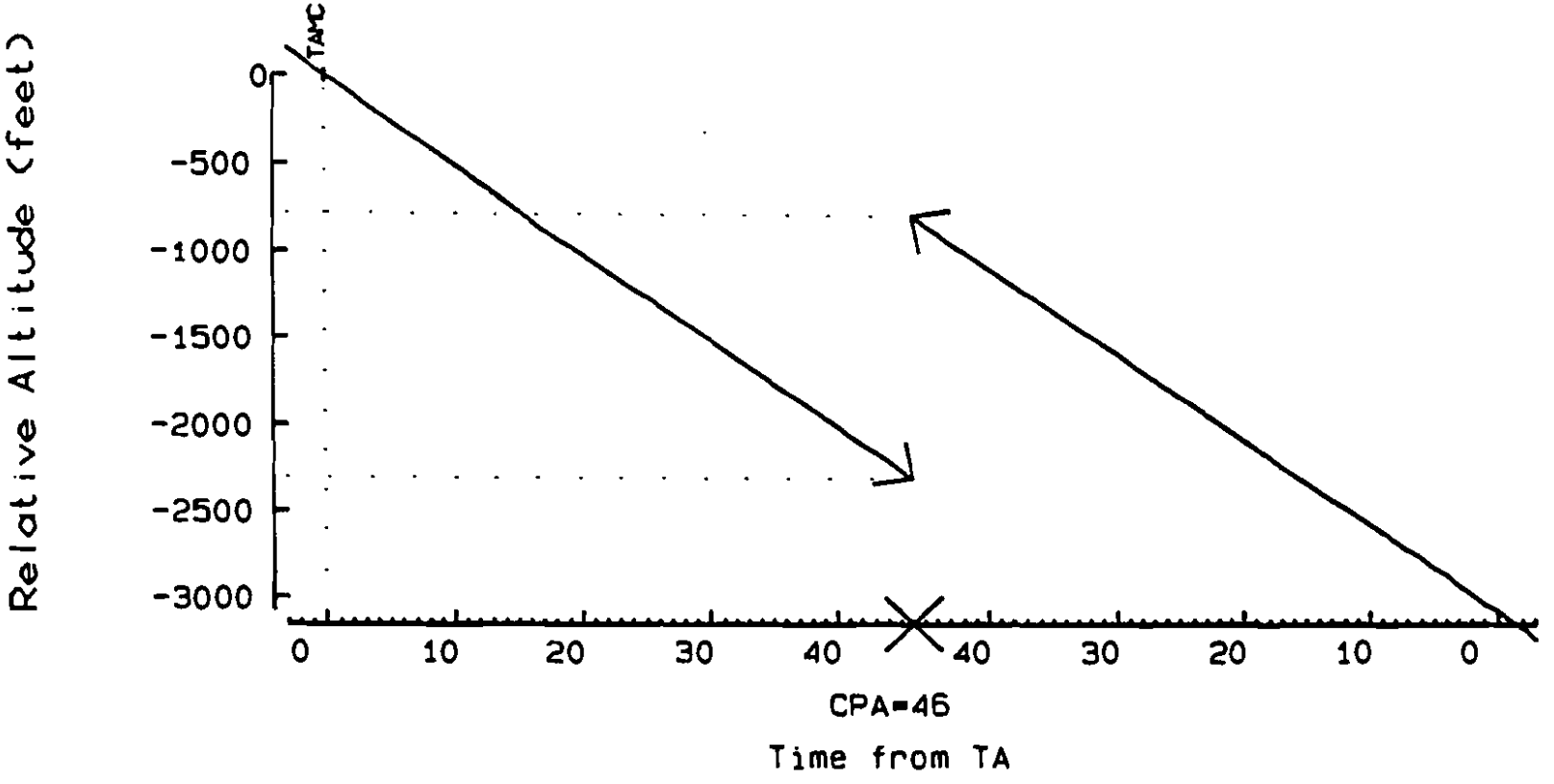
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -602

at CPA: -317

RANGE at CPA: 1433 ft



TA TIME: 00:00:15

CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P

Alt. Difference at CPA: 1531 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

>

D-19

Plane 2

Run 1

Logic v6.02

Group 4

Encounter ID 19 Filename m TSTPLN9.T

ENCOUNTER ID: 19

TARGET ID: 2

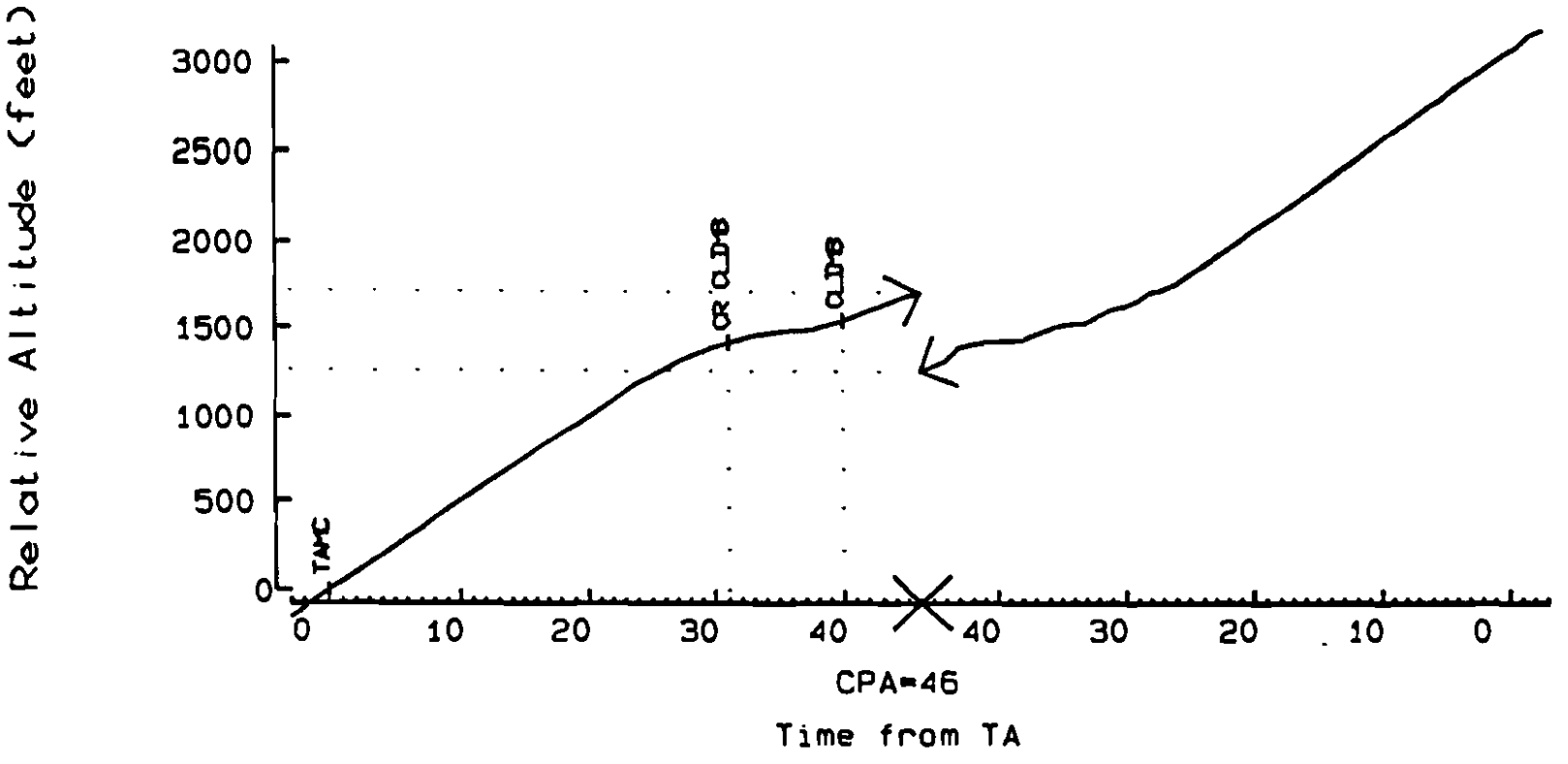
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -602

at CPA: -370

RANGE at CPA: 935 ft



TA TIME: 00:00:15

CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P

Alt. Difference at CPA: 463 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

D-20

Plane 1

Run 2

Logic v6.02

Group 4

>

Encounter ID 20 Filename m TSTPLN9.T

ENCOUNTER ID: 20

TARGET ID: 1

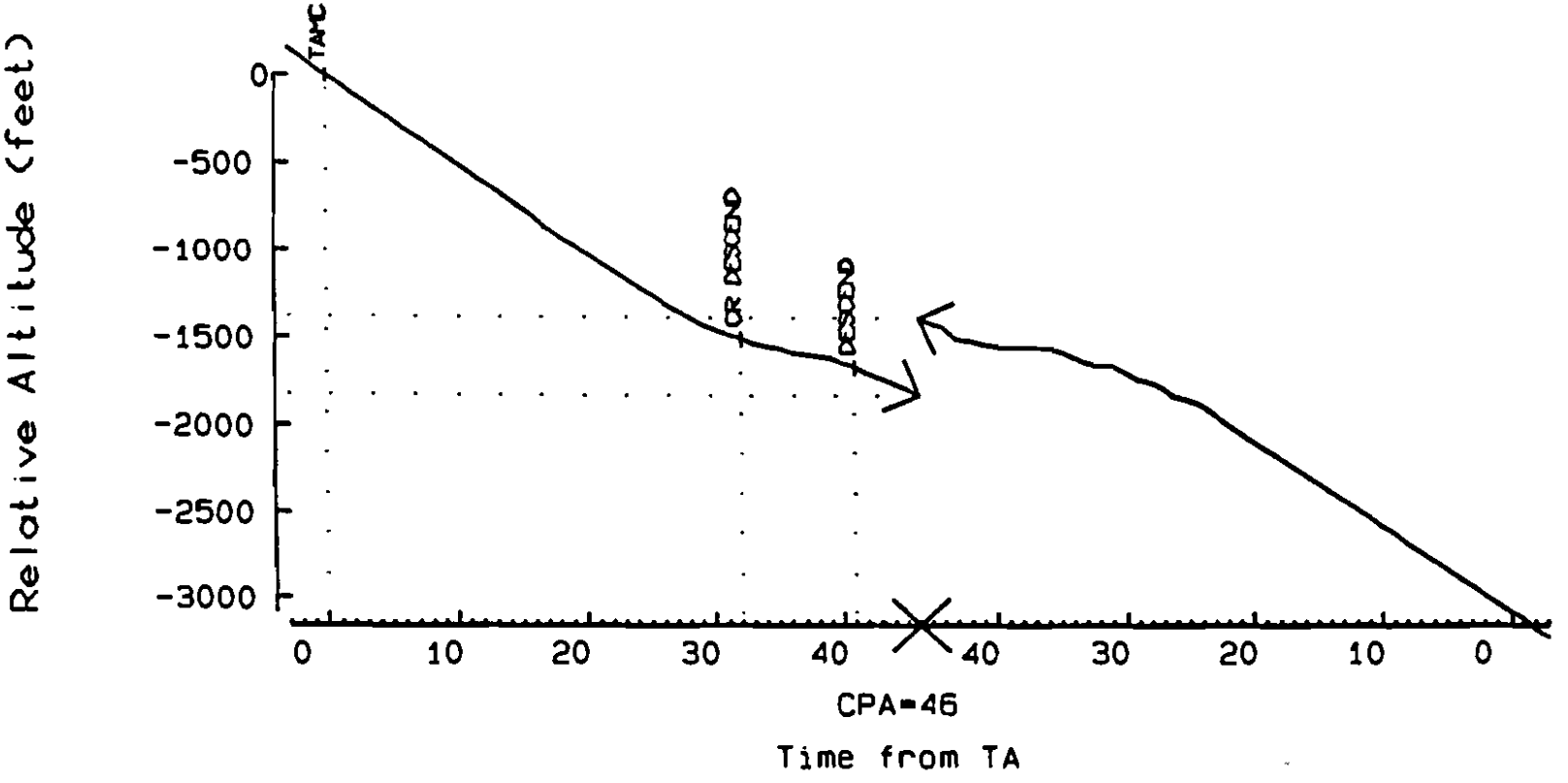
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -602

at CPA: -370

RANGE at CPA: 935 ft



TA TIME: 00:00:15 CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P Alt. Difference at CPA: 439 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

Group 4 Logic v6.02 Run 2 Plane 2 D-21

>

Encounter ID 21 Filename m TSTPLN9.T

ENCOUNTER ID: 21

TARGET ID: 2

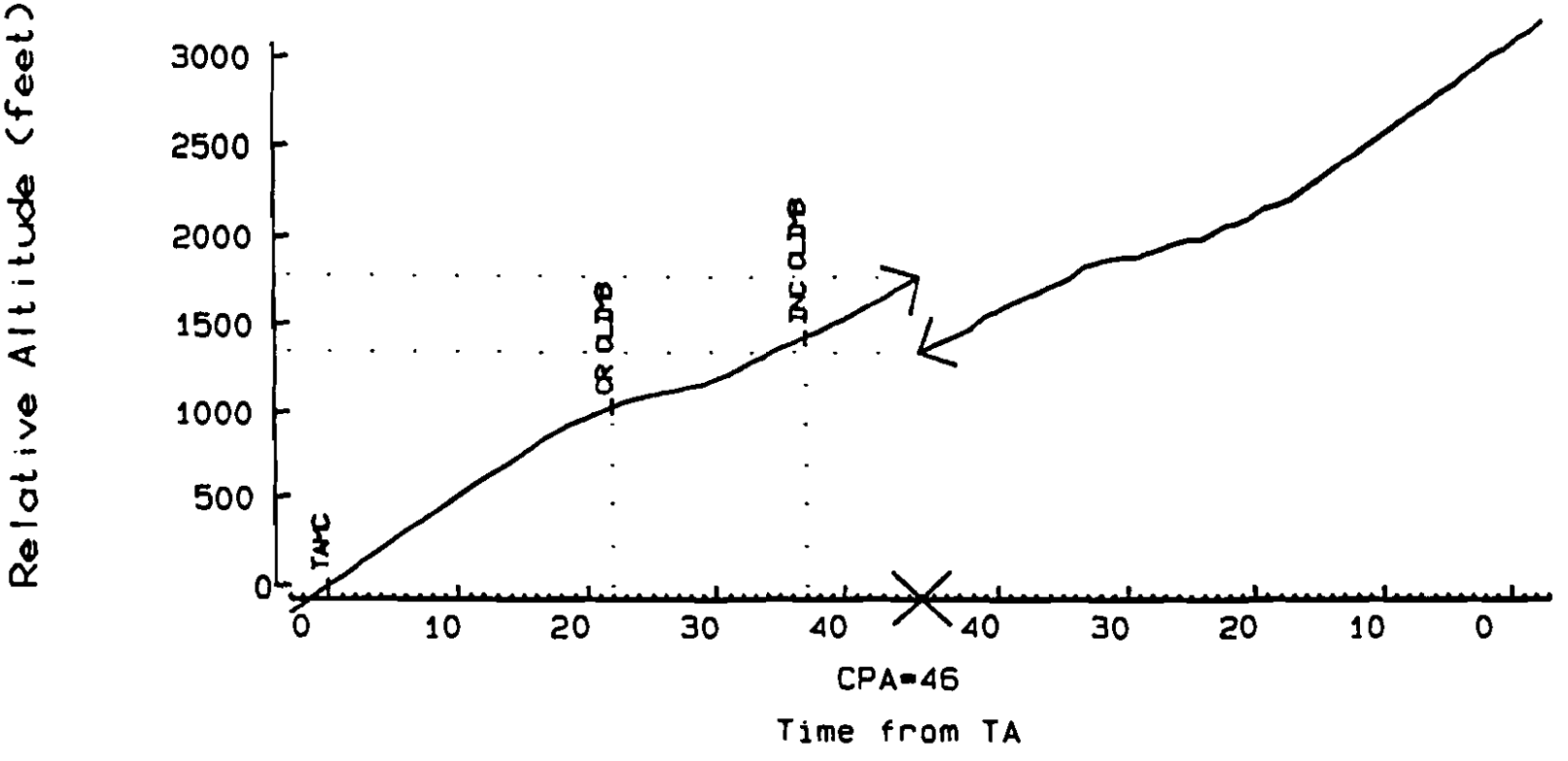
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -602

at CPA: -370

RANGE at CPA: 935 ft



TA TIME: 00:00:15

CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P

Alt. Difference at CPA: 435 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

D-22

Plane 1

Run 3

Logic v6.02

Group 4

>

Encounter ID 22 Filename m TSTPLN9.T

ENCOUNTER ID: 22

TARGET ID: 1

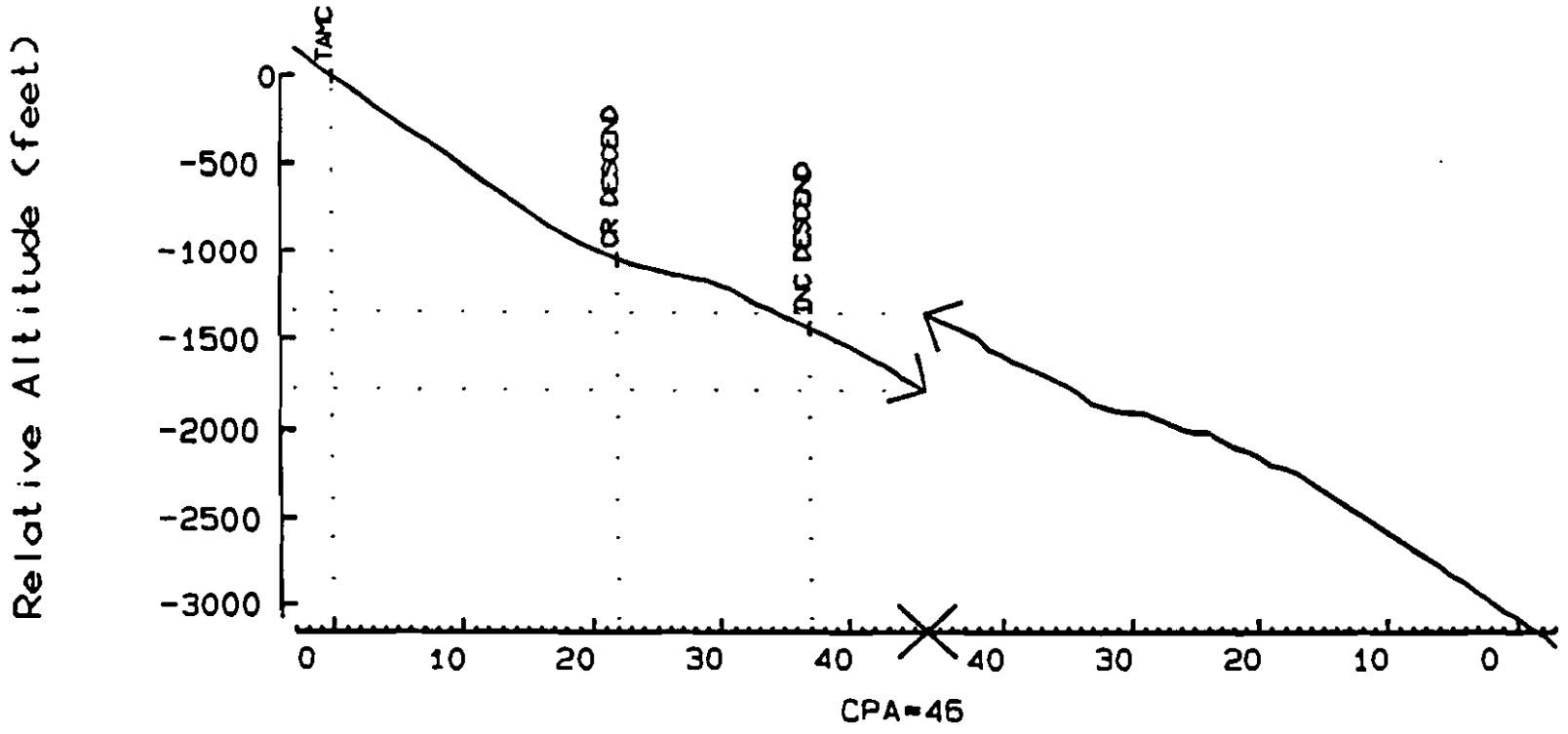
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -602

at CPA: -370

RANGE at CPA: 935 ft



TA TIME: 00:00:15 CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P Alt. Difference at CPA: 435 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

>

D-23

Plane 2

Run 3

Logic v6.02

Group 4

Encounter ID 23 Filename m TSTPLN9.T

ENCOUNTER ID: 23

TARGET ID: 2

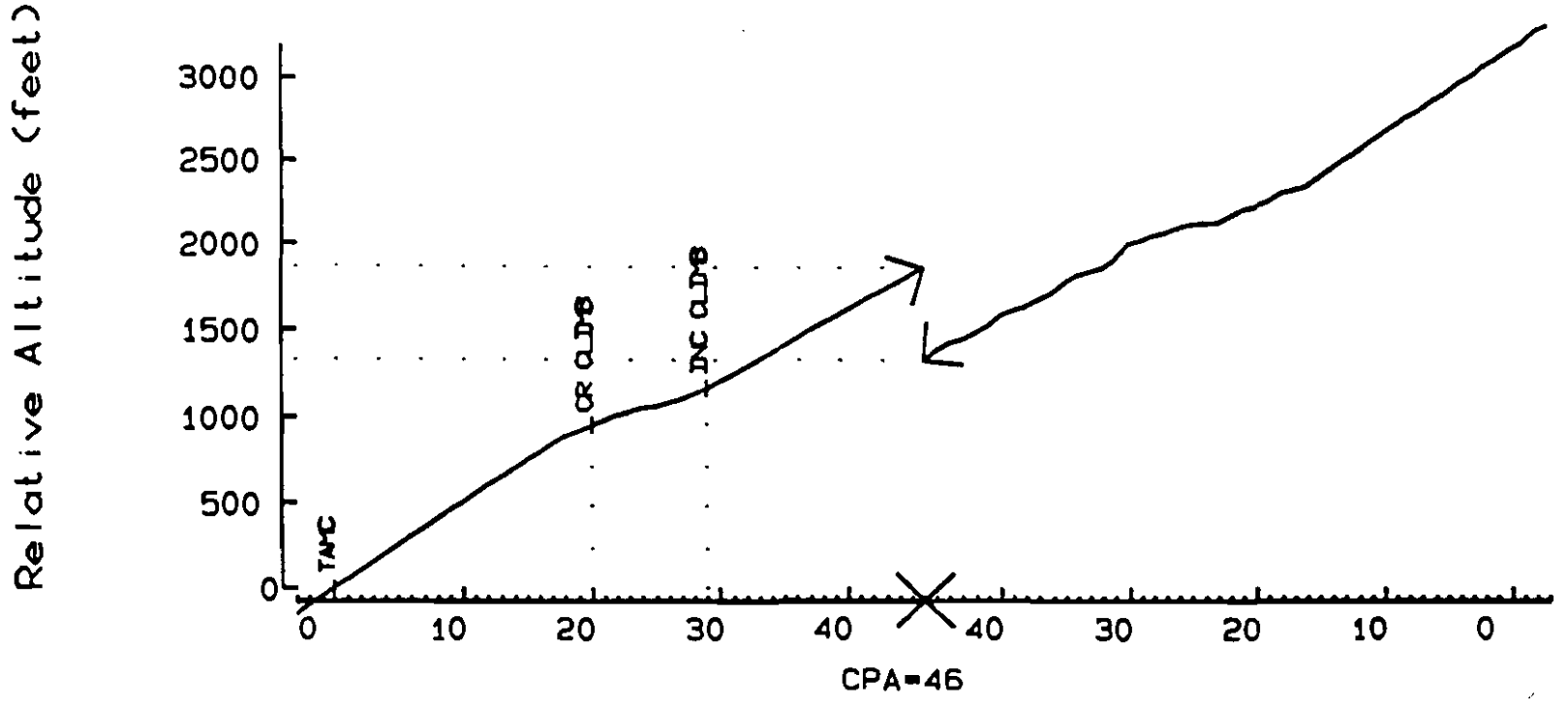
INTRUDER EQUIPAGE: TCAS II

OWN ID: 1

RANGE RATE at TA: -602

at CPA: -367

RANGE at CPA: 953 ft



TA TIME: 00:00:15

CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P

Alt. Difference at CPA: 545 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

>

D-24

Plane 1

Run 4

Logic v6.02

Group 4

Encounter ID 24 Filename m TSTPLN9.T

ENCOUNTER ID: 24

TARGET ID: 1

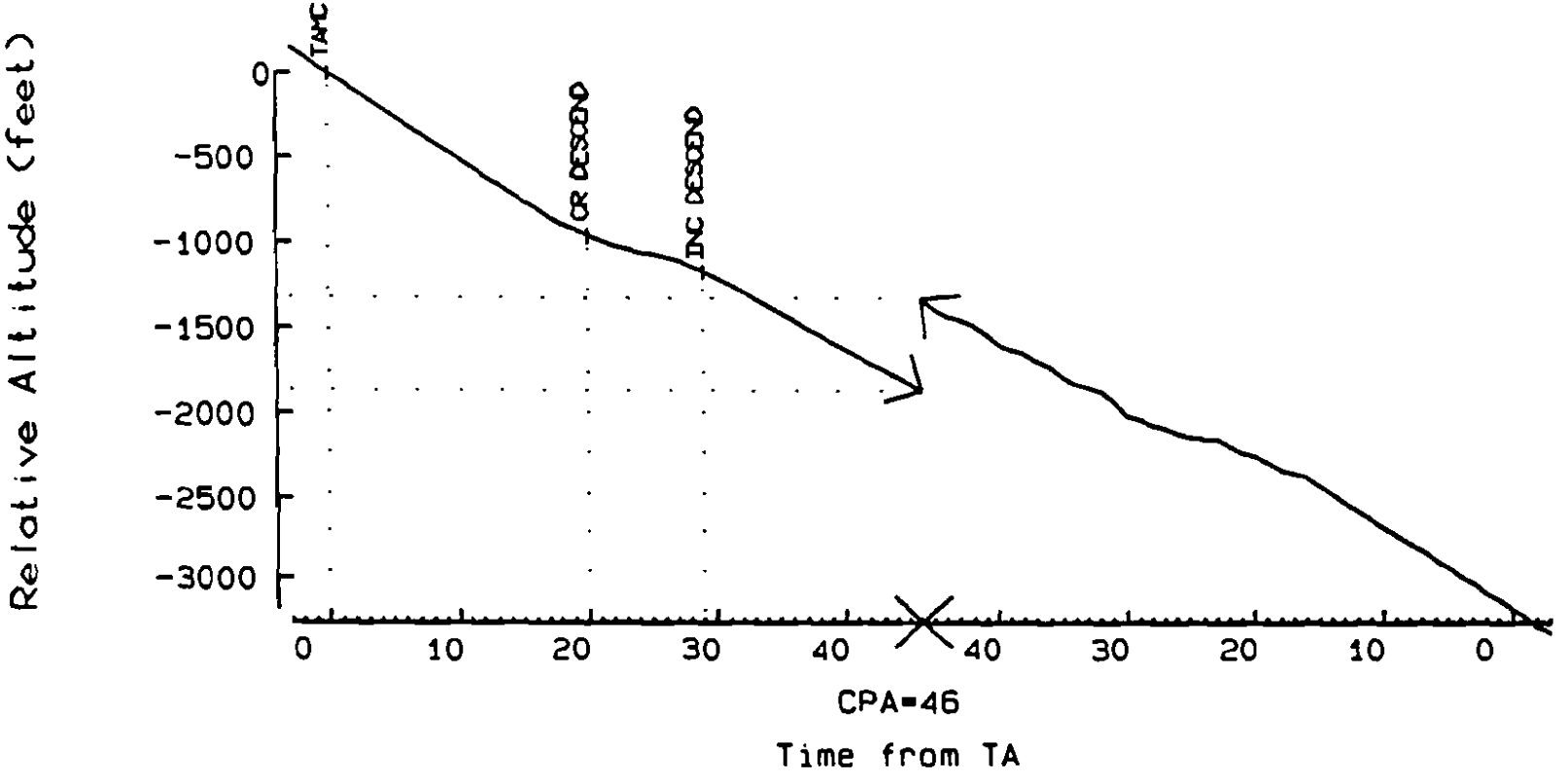
INTRUDER EQUIPAGE: TCAS II

OWN ID: 2

RANGE RATE at TA: -602

at CPA: -367

RANGE at CPA: 953 ft



TA TIME: 00:00:15

CPA TIME: 00:01:01

FLIGHT DATE: RP/4./9P

Alt. Difference at CPA: 545 ft

PROCESSED ON: 02/17/94 by ACD-320 FAA Technical Center

>

D-25

Plane 2

Run 4

Logic v6.02

Group 4

APPENDIX E

Encounter Descriptions

There were four groups of encounters flown, as described in the Test Design section, above. The plots in this appendix are visual representations of the planned encounters used in the flight test. The following additional flight information was included with the encounters:

Encounter starting separation is 12 nautical miles (nmi).

Encounter closing speed is 500 knots (kts) (Groups 1-3) or 600 kts (Group 4).

The encounters are altitude critical. All altitudes must be between 5,000 and 10,000 ft (Groups 1 and 2) or 10,000 and 20,000 ft (Groups 3 and 4). Suggested altitudes are included on the encounter drawings. These may be altered within the permissible altitude range depending on weather conditions and available airspace.

All encounters must include a 1/4 mile horizontal safety offset.

The initial climb (or descend) maneuver (to 3000 fpm) should be accomplished quickly (at about .2 g). Both planes should start their maneuvers simultaneously.

Any planned subsequent maneuvers NOT ASSOCIATED WITH TCAS ADVISORIES should be gentle maneuvers (.1g) as indicated on the encounter drawings. If the geometry is set up correctly, those maneuvers should also be simultaneous.

Respond to all TCAS resolution advisories during the encounters. TCAS advisories are expected to occur during the level-off maneuvers described by the encounter drawings.

Continue following TCAS advisories such that you follow the encounter drawing (which is drawn as without TCAS intervention). That is, if you were leveling off at 12,500 ft before the advisories, try to return to 12,500 ft as the advisories allow.

Responses to TCAS advisories should be as follows:

	Initial RA	Subsequent RAs
Pilot Delay	5 seconds	2.5 seconds

	Initial RA	Subsequent RAs
Acceleration	.25 g	.35g
Vertical Rate	1500 fpm*	2500 fpm*

* or as displayed. MAINTAIN RATE advisories may use a higher rate.

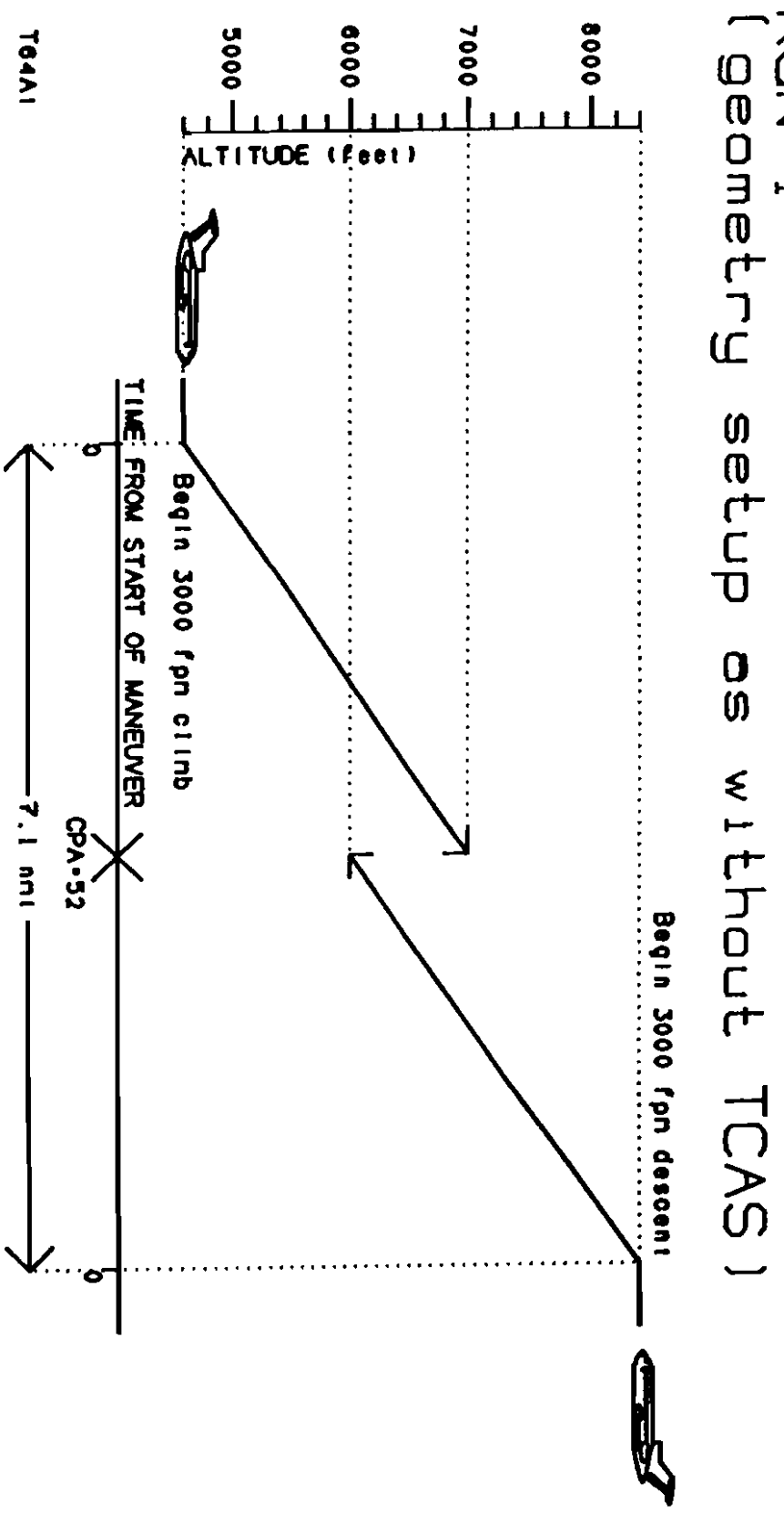
The groups of encounters used the following drawings:

GROUP 1: **Run 1 - Drawing E-3**
Run 2 - Drawing E-4
Run 3 - Drawing E-5
Run 4 - Drawing E-6

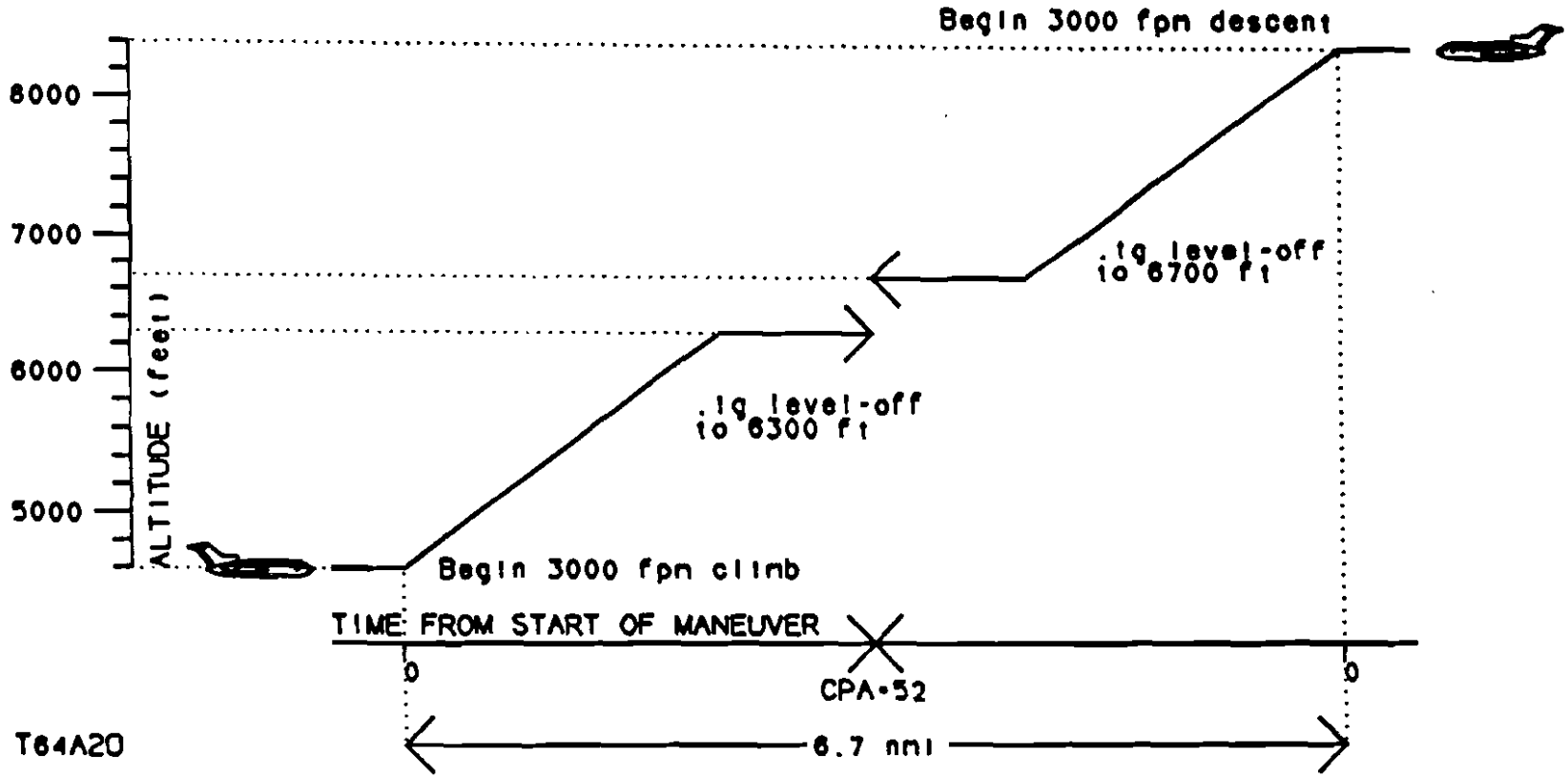
GROUP 2: **Run 1 - Drawing E-3**
Run 2 - Drawing E-7
Run 3 - Drawing E-8
Run 4 - Drawing E-6

GROUPS 3 and 4: **These groups share encounter drawings. Group 3 uses a 500 kt closing speed, while Group 4 uses a 600 kt closing speed. The appropriate maneuver starting distances for each run are included near the bottom of each drawing.**

Run 1 - Drawing E-9
Run 2 - Drawing E-10
Run 3 - Drawing E-11
Run 4 - Drawing E-12

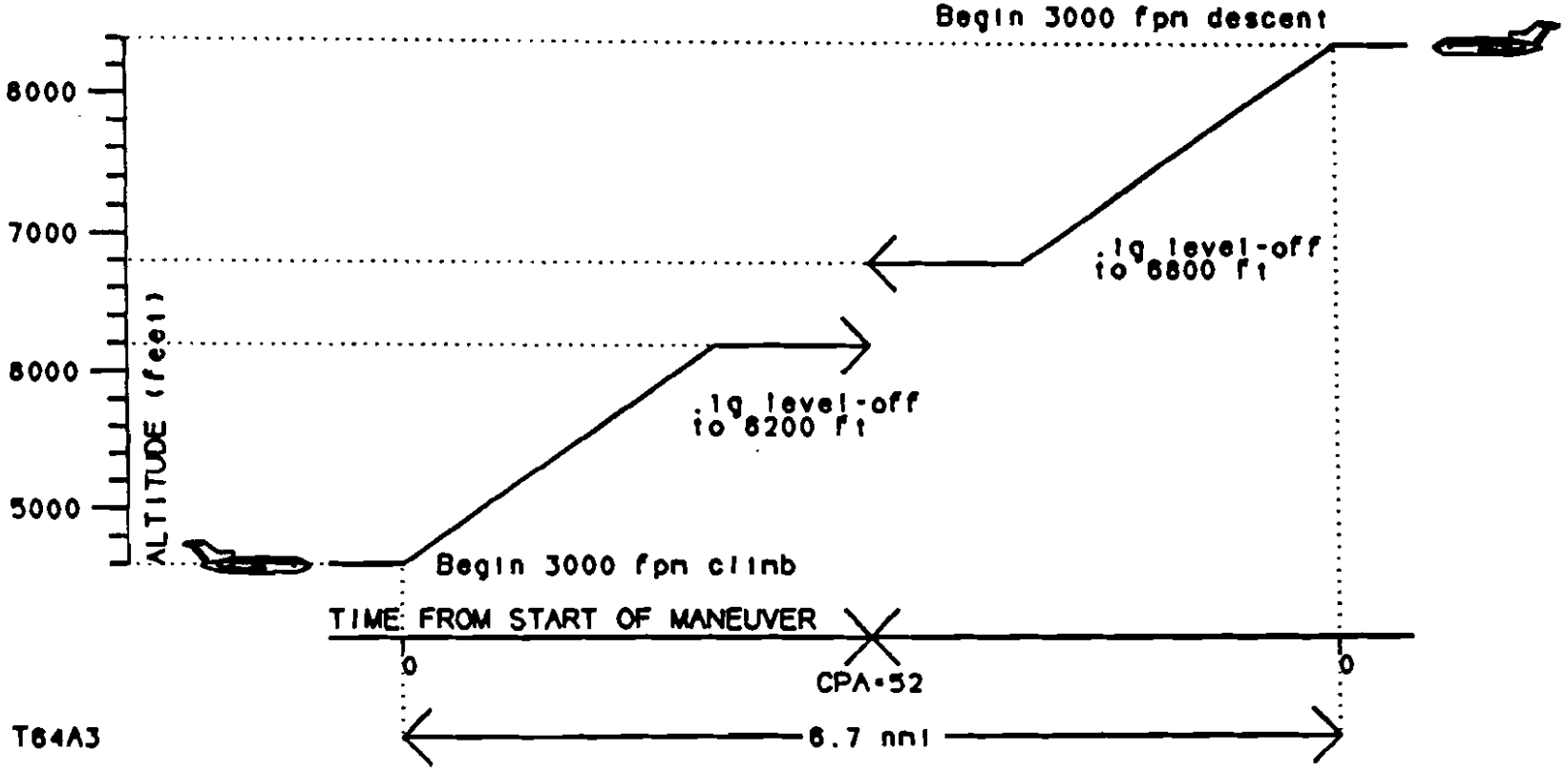

RUN 1
(geometry setup as without TCAS)
5000
6000
7000
8000
ALTITUDE (feet)
T64A1
TIME FROM START OF MANEUVER
0
Begin 3000 fpm climb
CPA-52
7.1 nmi
0
Begin 3000 fpm descent

RUN 2
(geometry setup as without TCAS)

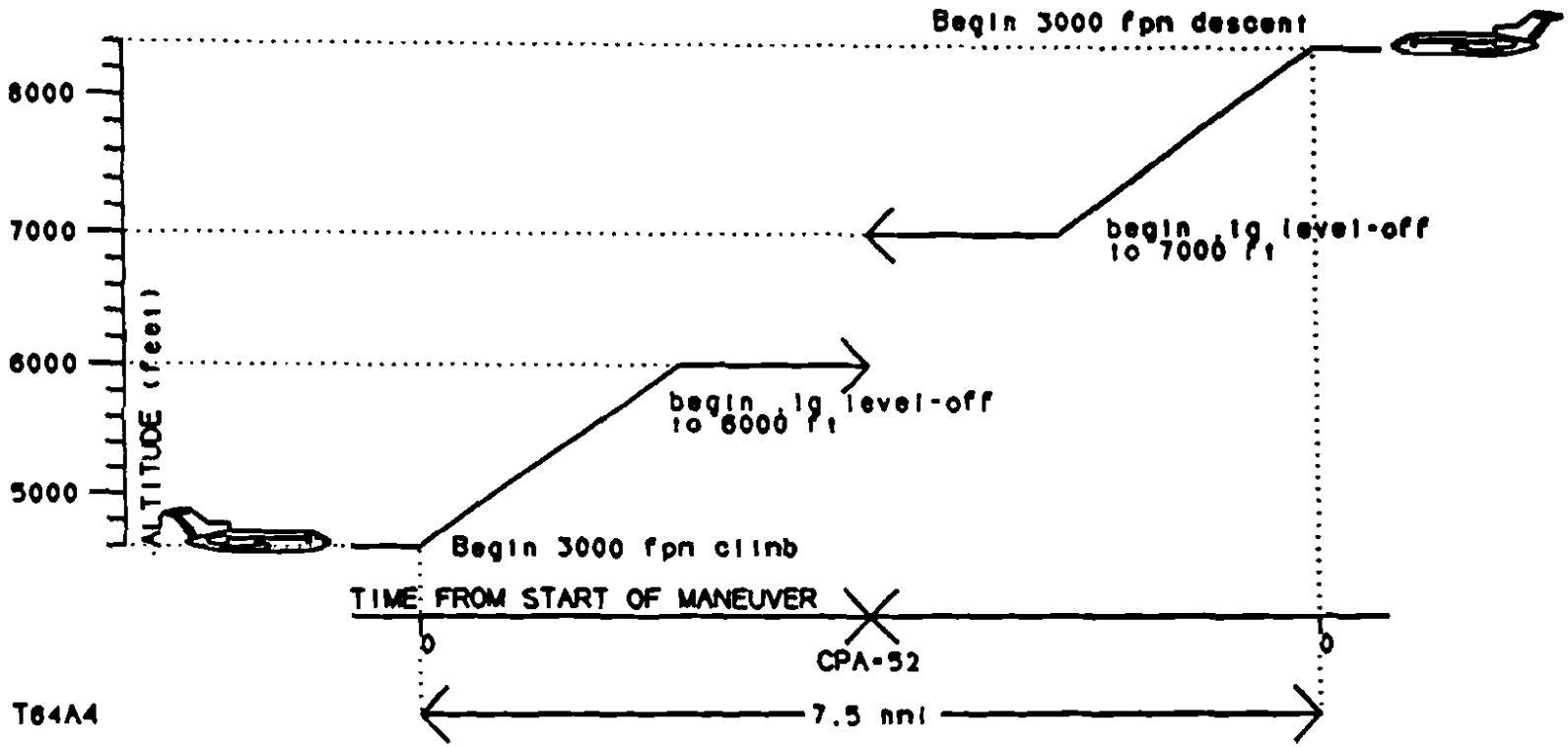


T64A20

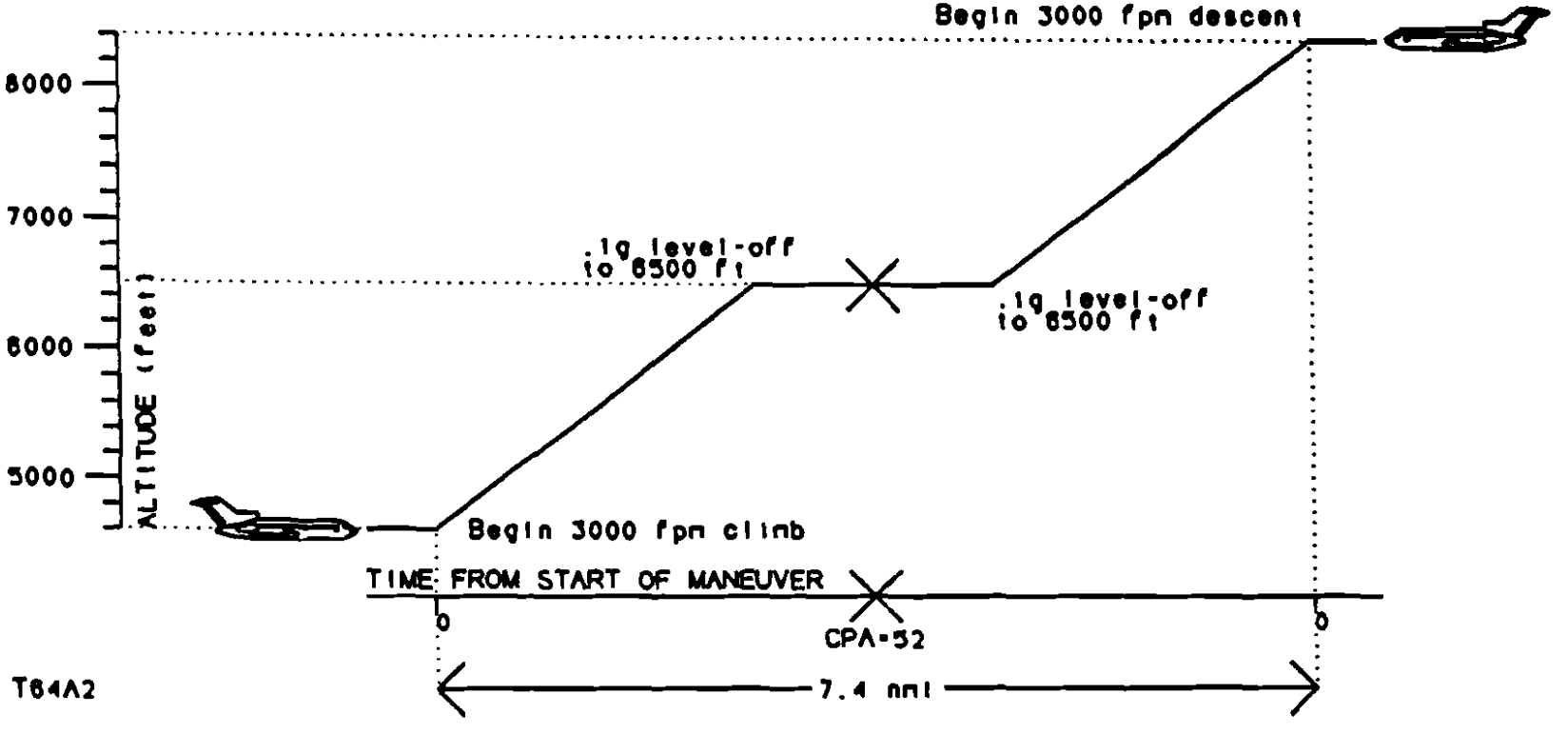
RUN 3
(geometry setup as without TCAS)



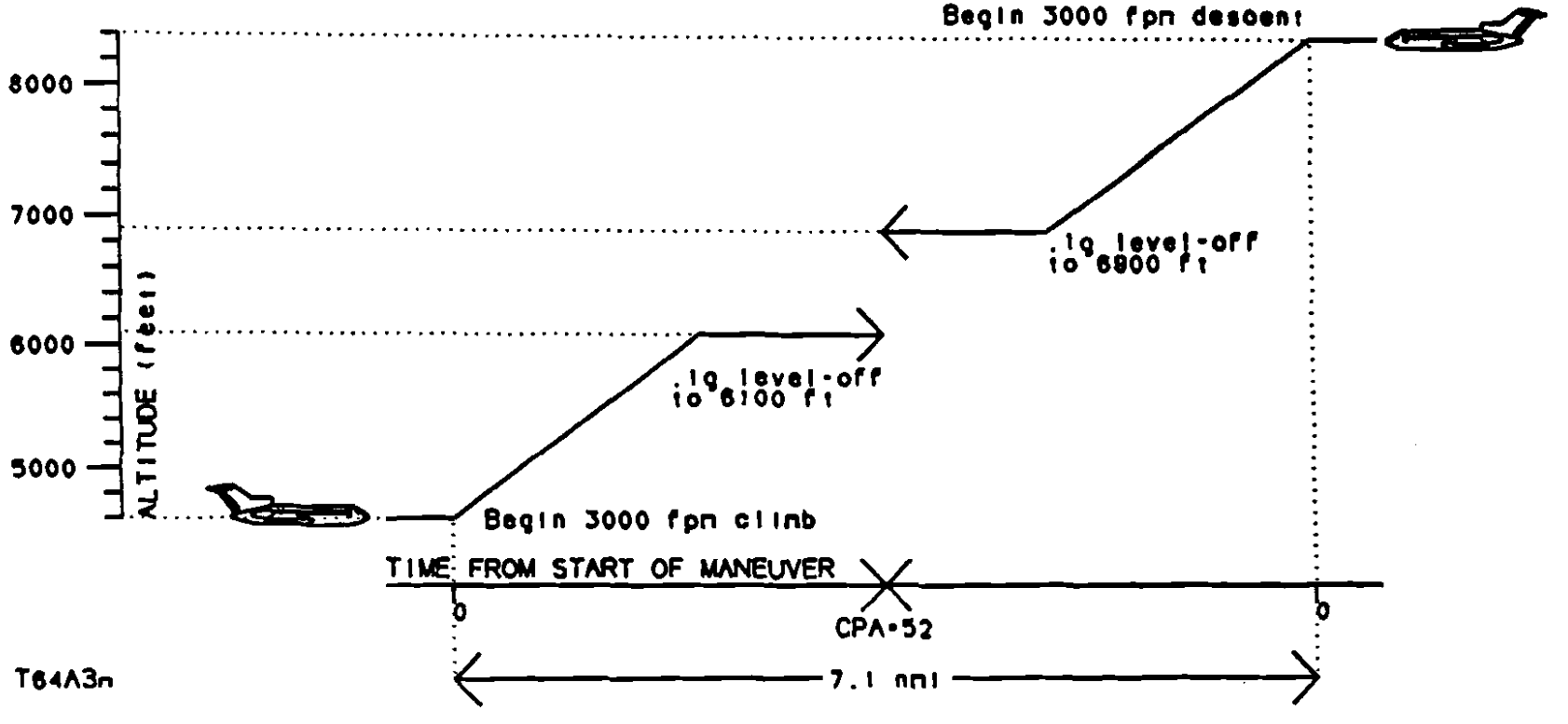
RUN 4
(geometry setup as without TCAS)



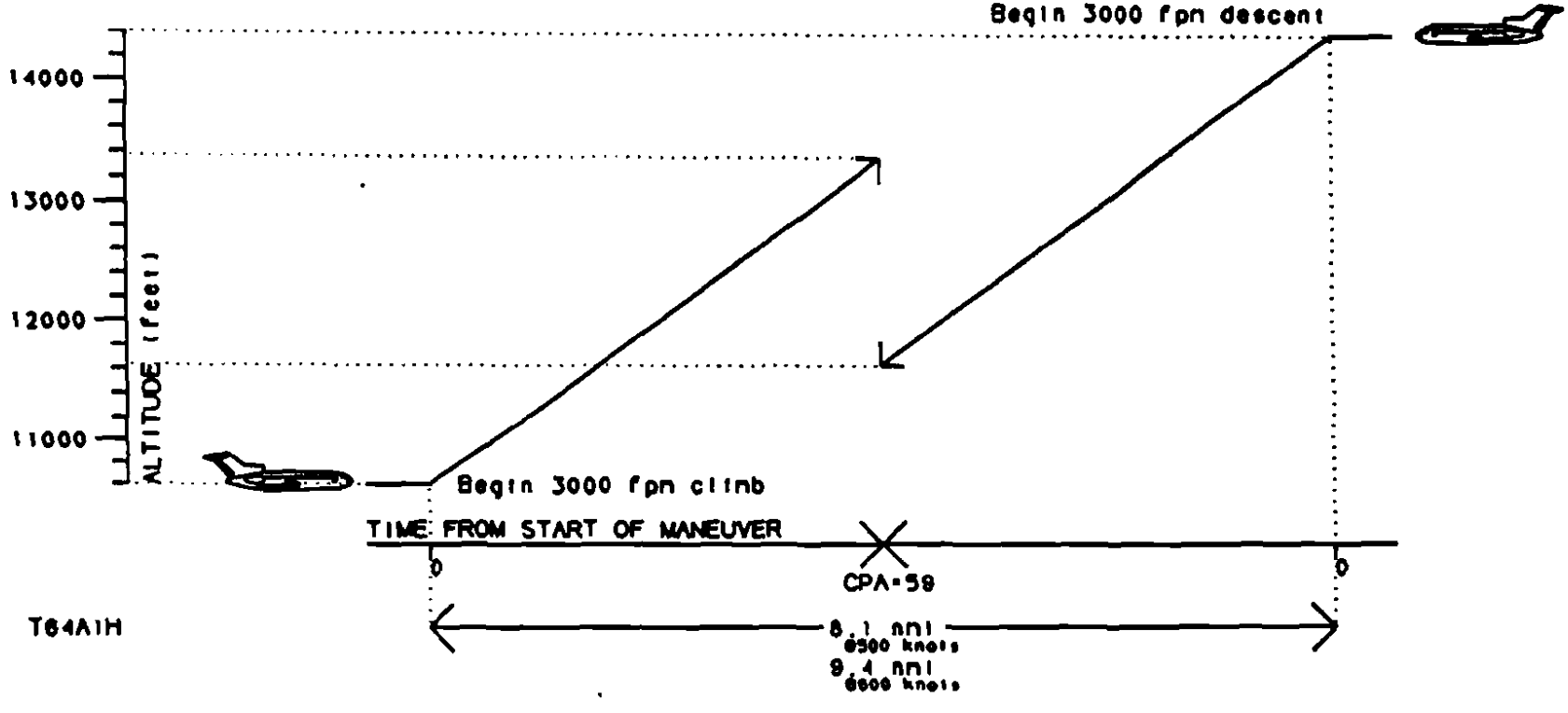
RUN 2
(geometry setup as without TCAS)



RUN 3
(geometry setup as without TCAS)



RUN 1
(geometry setup as without TCAS)



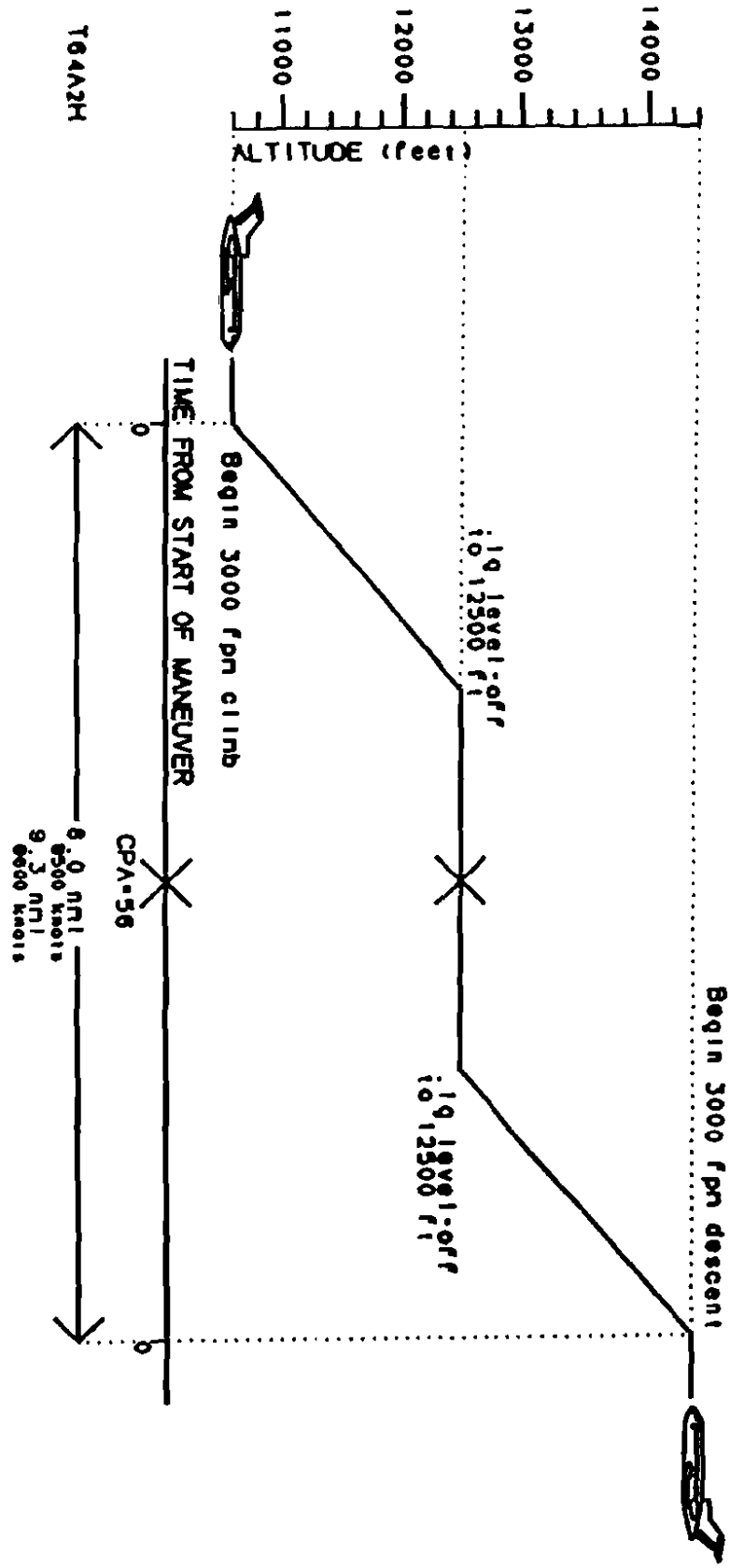
T64A1H

Run 1

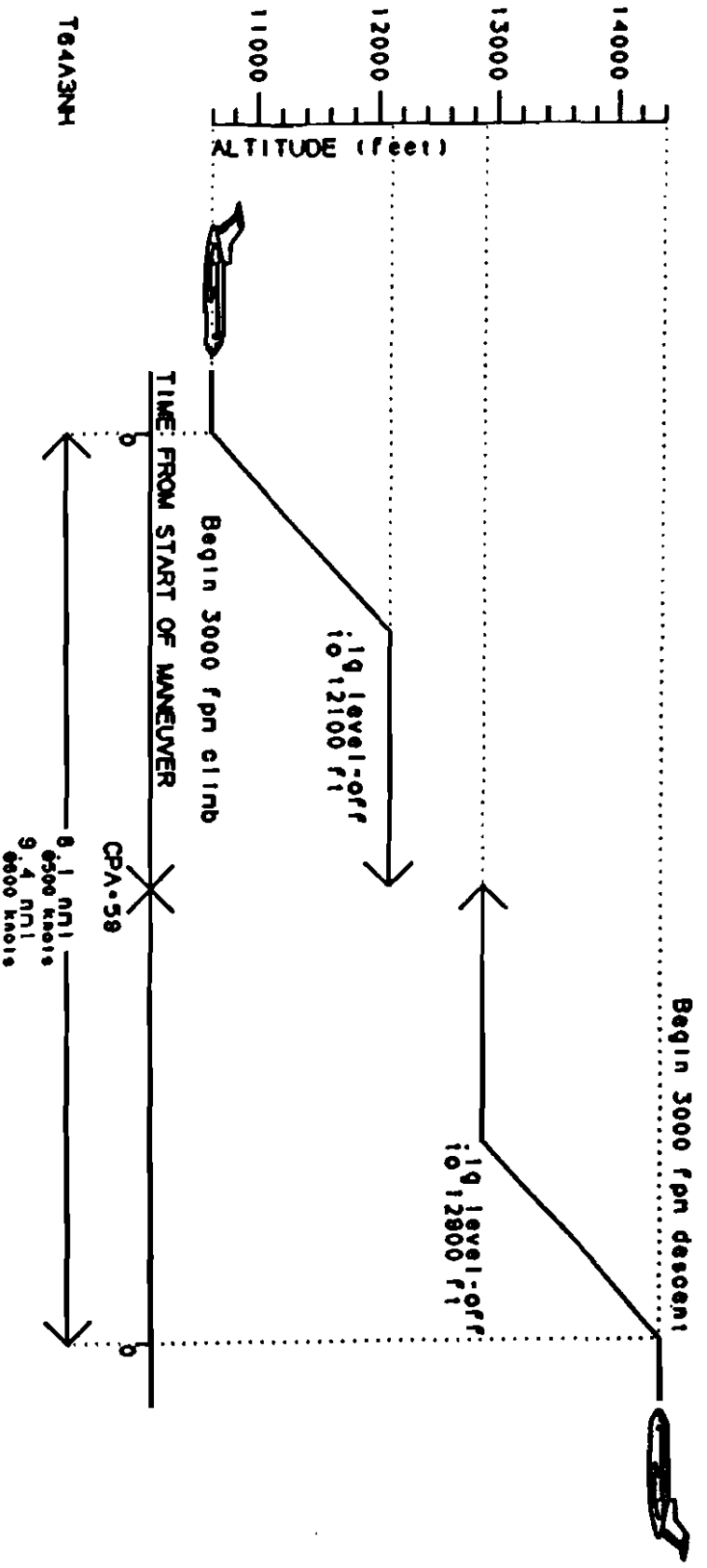
Group 4 / 600 kts

Group 3 / 500 kts

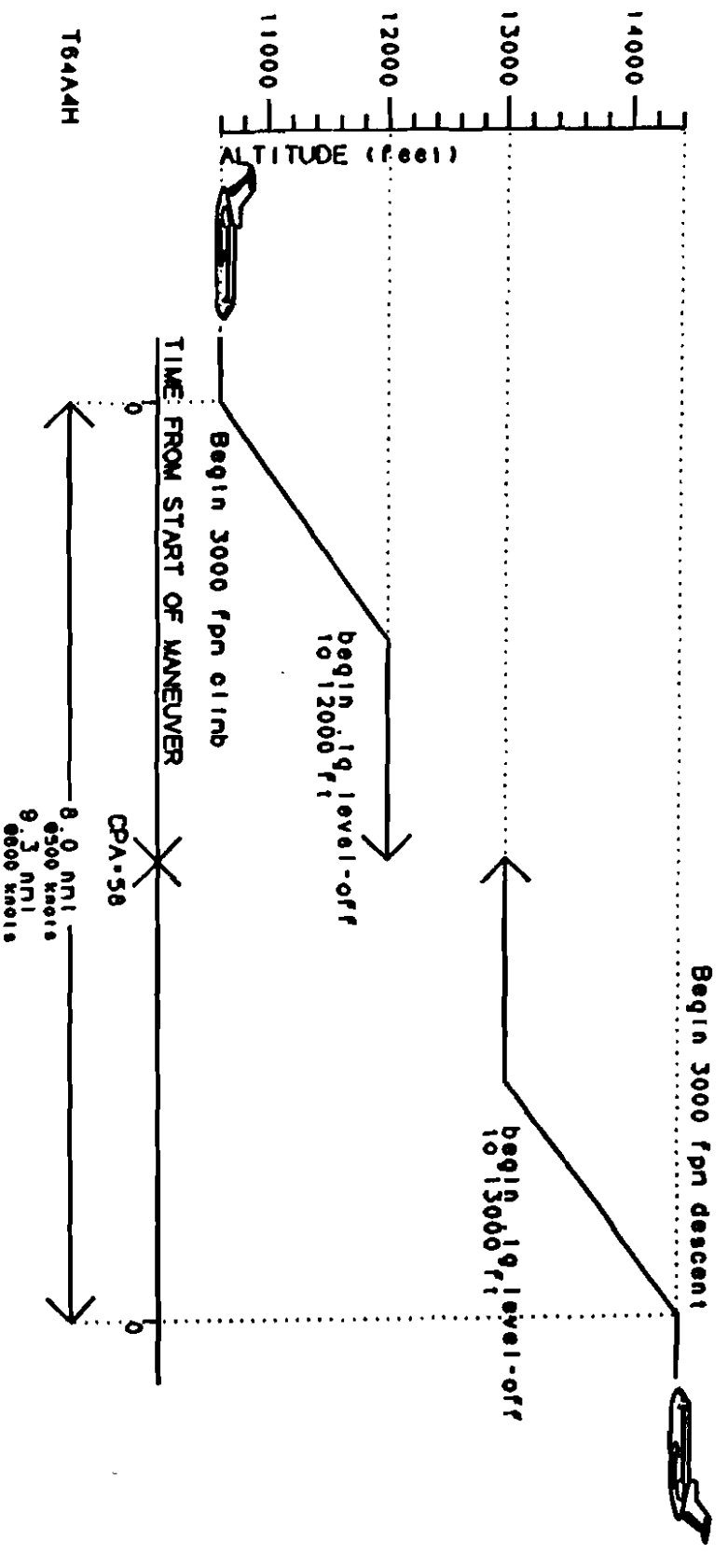
RUN 2
(geometry setup as without TCAS)



RUN 3
(geometry setup as without TCAS)



RUN 4
(geometry setup as without TCAS)



APPENDIX F

Plot Description and Flight Test Encounter Data Plots

PLOT DESCRIPTION

The v6.04a plots produced by the PLOTSIM program may need some explanation for clarity. Please refer to the sample plot on page F-4 for placement of the fields.

- TITLE: **The title line is generated by the program TRD_PLOT. It indicates the name of the input data file used for the data plot. Bendix or Rockwell data files can be identified by the first letter of the filename.**

- ENCOUNTER ID: **This identifies the track being plotted from the file.**

- TARGET ID: **This field should include the intruder's mode-S ID, if so equipped.**

- INTRUDER EQUIPAGE: **This field should indicate the equipage of the target aircraft.**

  Note: The above fields may not be present, or may have obviously erroneous information due to peculiarities in the processing software. These fields have no effect on the accuracy of the plotted data.

- OWN ID: **This field contains the mode-S ID of own-plane's transponder.**
  10791495 N-40
  10746022 N-355PA

- RANGE RATE at TA: **The tracked closing speed (in knots) of the encounter at the time of the first TA or RA. (At time 0 on the X-axis)**

- at CPA: **The tracked range rate at CPA (closest point of approach).**

- RANGE at CPA: **The tracked slant range at CPA (in feet).**

- Alt. Difference with Simulated Pilot Response: **This field (if present) indicates the vertical separation at CPA using the simulated pilot response to the RAs instead of the actual pilot response.**

- Alt. Difference at CPA: **This field indicates the tracked vertical separation at CPA.**

- TA TIME: **Actual time of data indicated as 0 on the x-axis.**

- CPA TIME: **Actual time of data indicated as CPA= on the x-axis (the center of the x-axis, where the two arrowheads form an X).**

- RELATIVE ALTITUDE (the y-axis): **All data on the plot is shown relative to the altitude of own-aircraft when the first TA was issued. That is, it is an absolute altitude scale with the altitude of own-aircraft at TA TIME subtracted from all data.**

Example: Own aircraft is flying at 10,300' at TA TIME. 10,300' is set to be the base altitude, and all data is plotted relative to this base altitude. (That is, 10,300' is subtracted from all altitude data on the plot.)

- Time from TA (the x-axis): All times on the plots are shown relative to the TA TIME. TA TIME is set to the first alarm. On most plots, this is a traffic alert. However, on some plots, no TA was issued, and the first alarm is a resolution advisory. The middle of the axis indicates the CPA of the encounter. Data is normally plotted from 3 seconds prior to TA TIME until CPA TIME.

PLOTTED DATA

TWO PLOTS IN ONE

The plots are actually two plots which share the same y-axis (altitude). On the left side of the plot, time progresses from left to right, stopping at CPA in the center of the plot. This side of the plots shows own-aircraft's altitude, and the time and altitude at which TAs and RAs were issued.

On the right side of the plot, time progresses from right to left, stopping at CPA in the center of the plot. This side of the plots shows the tracked altitude of the target aircraft.

On head-on type encounters, which all of the v6.04a tests were, these opposing time scales APPROXIMATE the range separation of the aircraft. At TA TIME, they are far away, and at CPA TIME, they are only separated vertically. Note that these plots do not actually indicate range, and that significant horizontal range separation may exist at CPA (see the RANGE at CPA field for tracked separation).

POTENTIAL RA and RA DELAY

Some plots indicate the point at which an RA might have first been issued (a potential RA). This is indicated by a time mark on the tracked own altitude plot, but with no accompanying RA description. (Note that RAs are indicated by this time mark with a description of the RA issued, such as CR DESCEND). The time period between this potential RA and the actual time of RA issue is the RA delay time. Several features in the logic can cause an RA delay.

SIMULATED PILOT RESPONSE (SPR)

The dashed line on some plots shows the simulated pilot response. This SPR approximates the own-aircraft response to the TCAS advisories had the pilot responded exactly as is expected.

The SPR has several limitations. The SPR attempts to return to the original altitude rate (at the time of the first RA) when subsequent advisories allow. In the 6.04a encounters, most advisories are issued while leveling-off. The SPR attempts to return to the vertical rate instead of the level-off altitude. The SPR also responds to those RAs posted for the actual flight path. Different RAs may have been issued if the SPR had been flown. (The plotting program does not have the capability to simulate TCAS logic operation.)

It should also be noted that the Alt. Difference with Simulated Pilot Response field applies ONLY to the SPR of own-aircraft. If you wish to compare the SPR results from both planes, you must examine the own-aircraft plots of BOTH planes.

APPARENT ERRORS

The CPA TIME is sometimes off by 1 sec. This is due to rounding of the time data.

The altitude difference may be larger than the range at CPA. This is due to the trackers.

DATA PLOTS

Most of this appendix (pages F-5 through F-182) consists of plots made from the TCAS flight data recorders during the flight tests. There was recorded data from both aircraft for most of the encounters; as such, there are two plots for most of the encounters.

Plots F-5 through F-180 are arranged in groups of two, so that the views from each TCAS system can be compared. Overall, the encounters are arranged in time (and date) order, while each encounter set is arranged with the Bendix plot (from N-40) on the odd-numbered pages and the Collins plot (from N355-PA) on the even-numbered pages.

Plot F-181 is a data plot showing an unplanned encounter with some local traffic during one of the encounters. The target was not TCAS equipped.

Plot F-182 shows only the Bendix system data for that encounter. There is no accompanying Collins data, since the Collins system did not issue any alerts in this encounter.

10/13/93 ENC ID 427 from R930913A.TRD for OWN ****** vs TCAS II INT ← TITLE

ENCOUNTER ID: 427

TARGET ID: 10791495 ← N-40's ID

INTRUDER EQUIPAGE: TCAS II

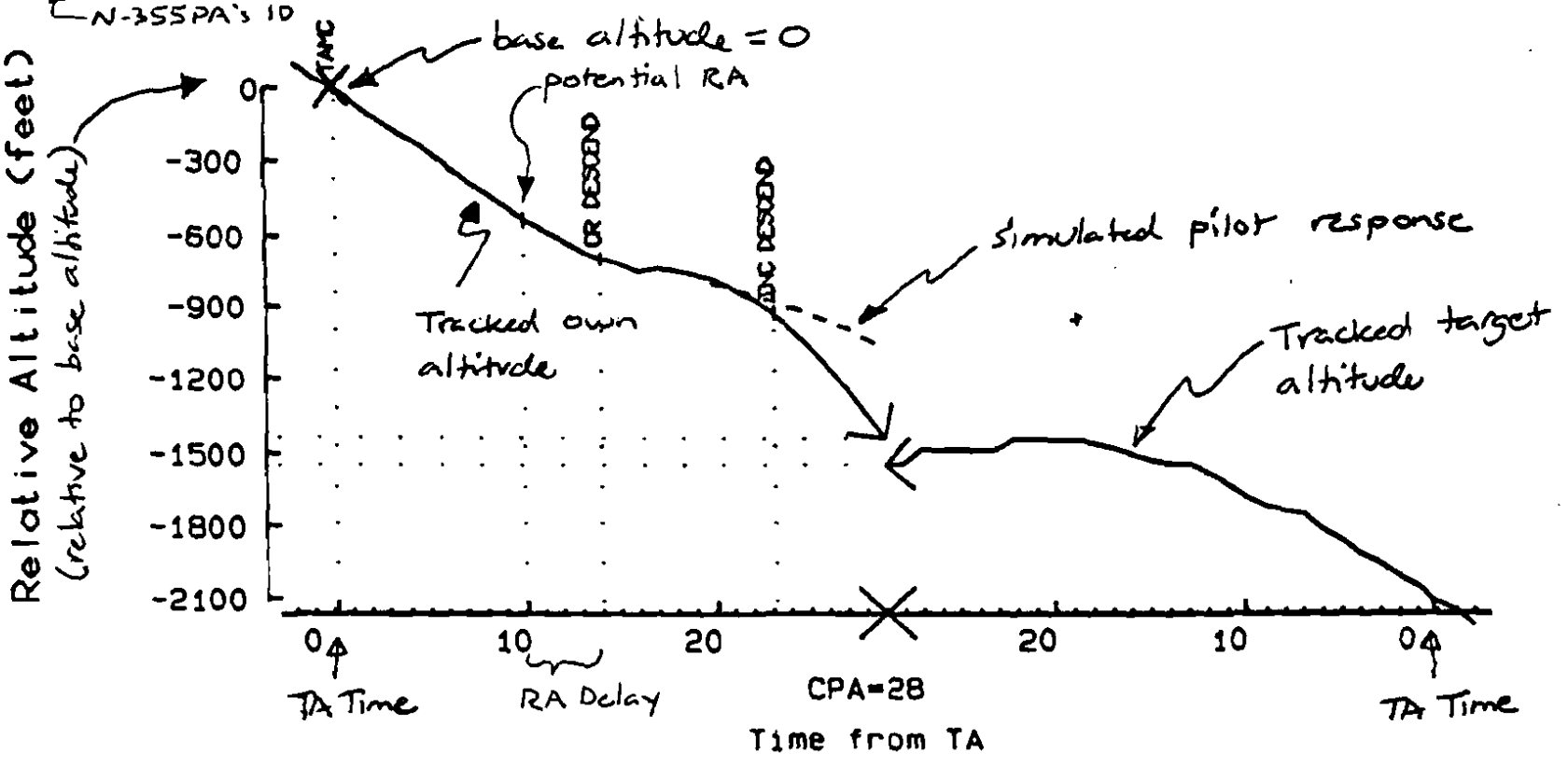
OWN ID: 10746022 ← N-355PA's ID

RANGE RATE at TA: -484

at CPA: -405

RANGE at CPA: 1075 ft

Alt. Difference with Simulated Pilot Response: 481 ft



TA TIME: 15: 58: 59

CPA TIME: 15: 59: 28

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 109 ft

PROCESSED ON: 10/21/93 by ACD-320 FAA Technical Center

F-4

Sample plot - Description of fields

Encounter ID 606 Filename 8930913A.TRD

ENCOUNTER ID: 606

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

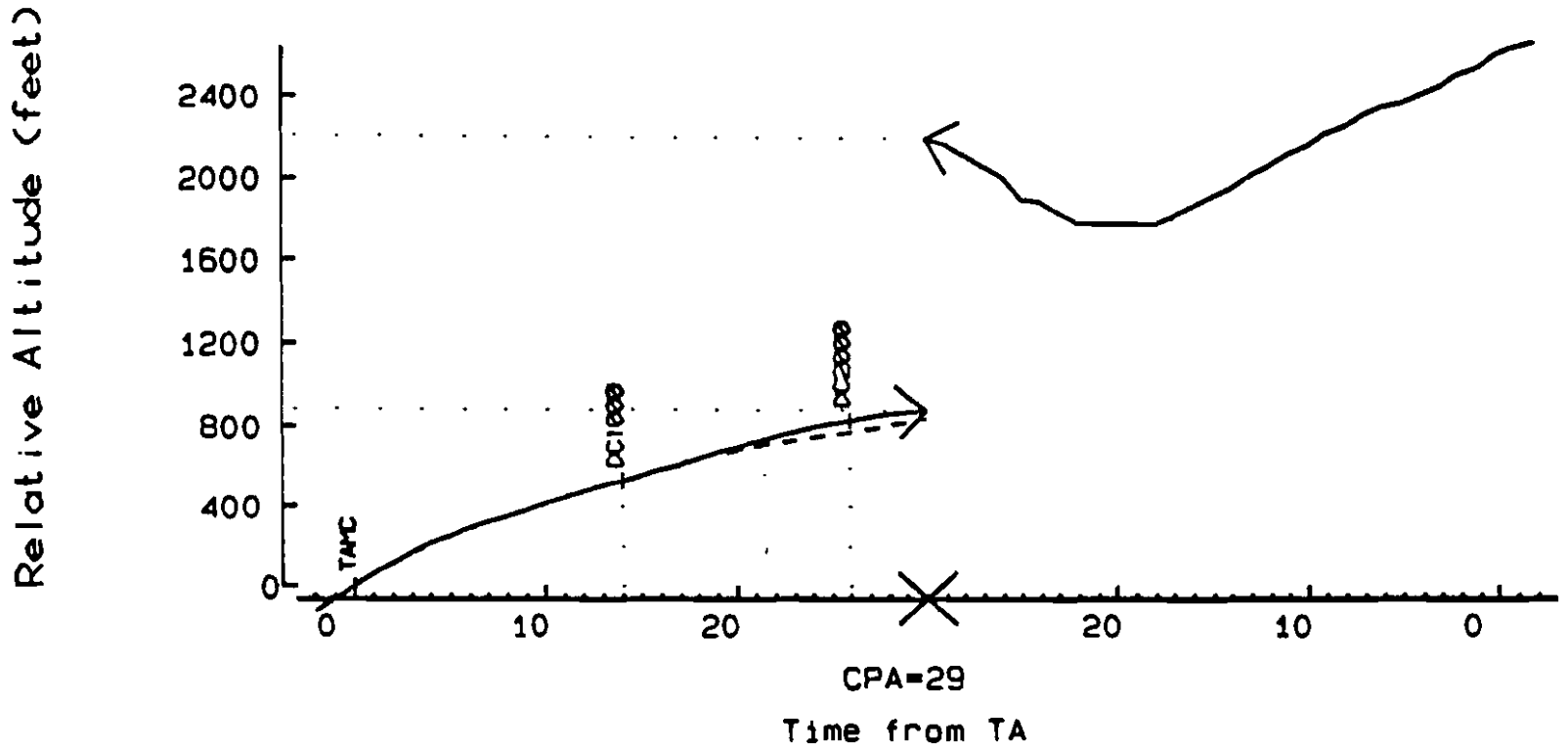
RANGE RATE at TA: -484

at CPA: -22

RANGE at CPA: 2120 ft

Alt. Difference with Simulated Pilot Response: 1361 ft

F-5



TA TIME: 15: 42: 57

CPA TIME: 15: 43: 27

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 1316 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

Encounter ID 210 Filename R930913A.TRD

ENCOUNTER ID: 210

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

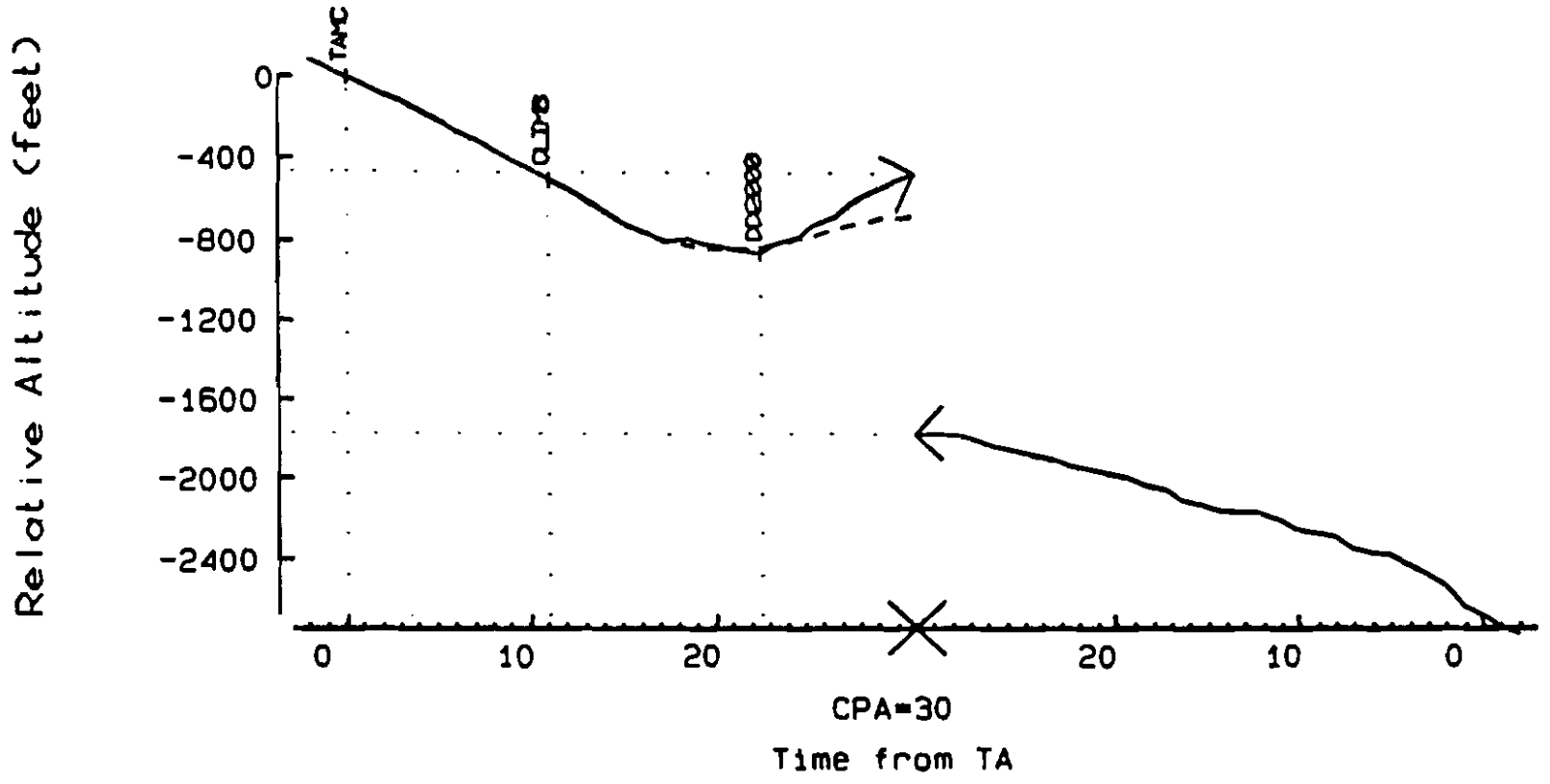
OWN ID: 10746022

RANGE RATE at TA: -486

at CPA: -198

RANGE at CPA: 1555 ft

Alt. Difference with Simulated Pilot Response: 1090 ft



TA TIME: 15: 42: 19

CPA TIME: 15: 42: 50

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 1288 ft

PROCESSED ON: 12/15/93 by ACD-320 FAA Technical Center

F-6

>

Encounter ID 883 Filename B930913A.TRO

ENCOUNTER ID: 883

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

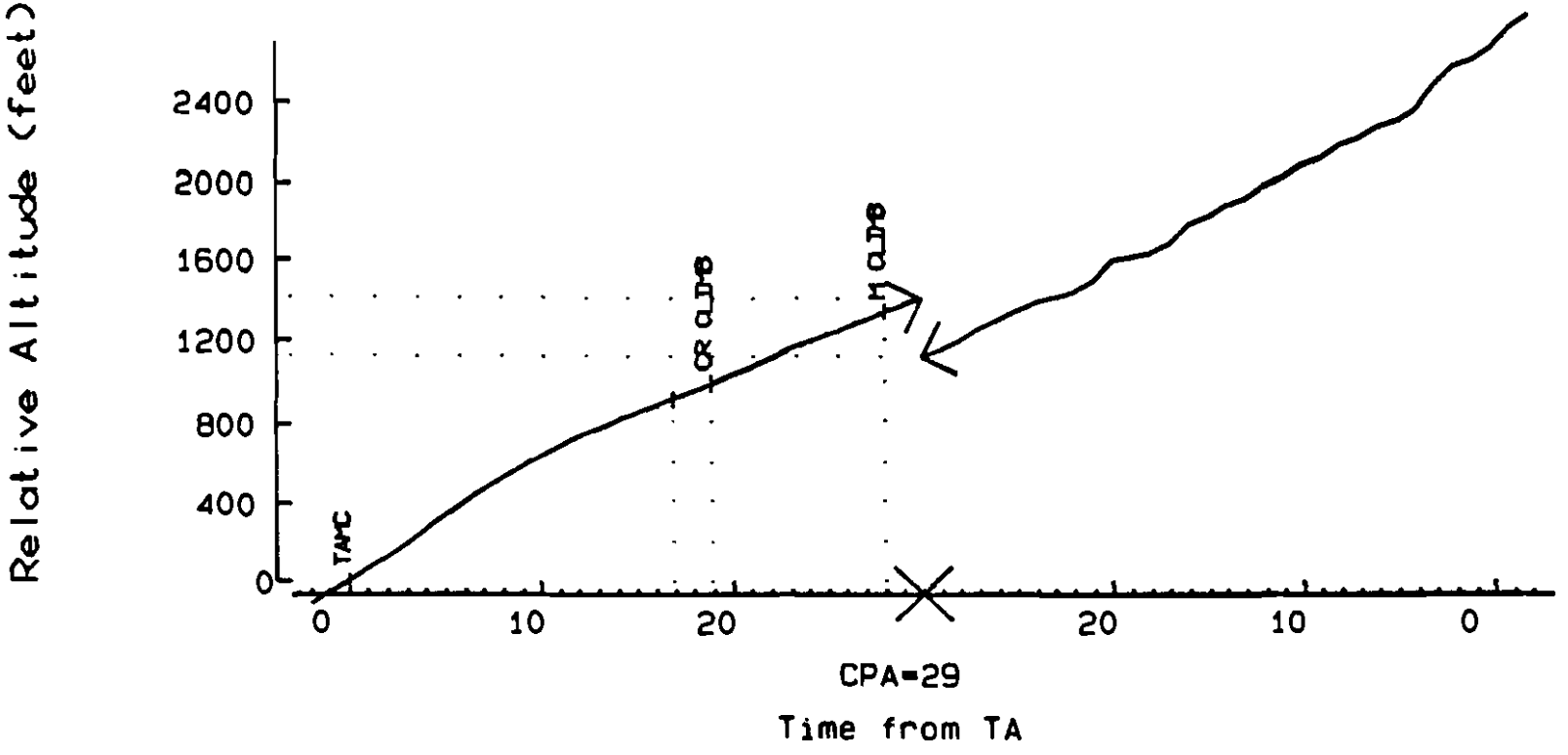
OWN ID: 10791495

RANGE RATE at TA: -504

at CPA: -95

RANGE at CPA: 1403 ft

Alt. Difference with Simulated Pilot Response: 302 ft



TA TIME: 15: 48: 24

CPA TIME: 15: 48: 54

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 291 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

F-7

>

Encounter ID 301 Filename R930913A.TRD

ENCOUNTER ID: 301

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

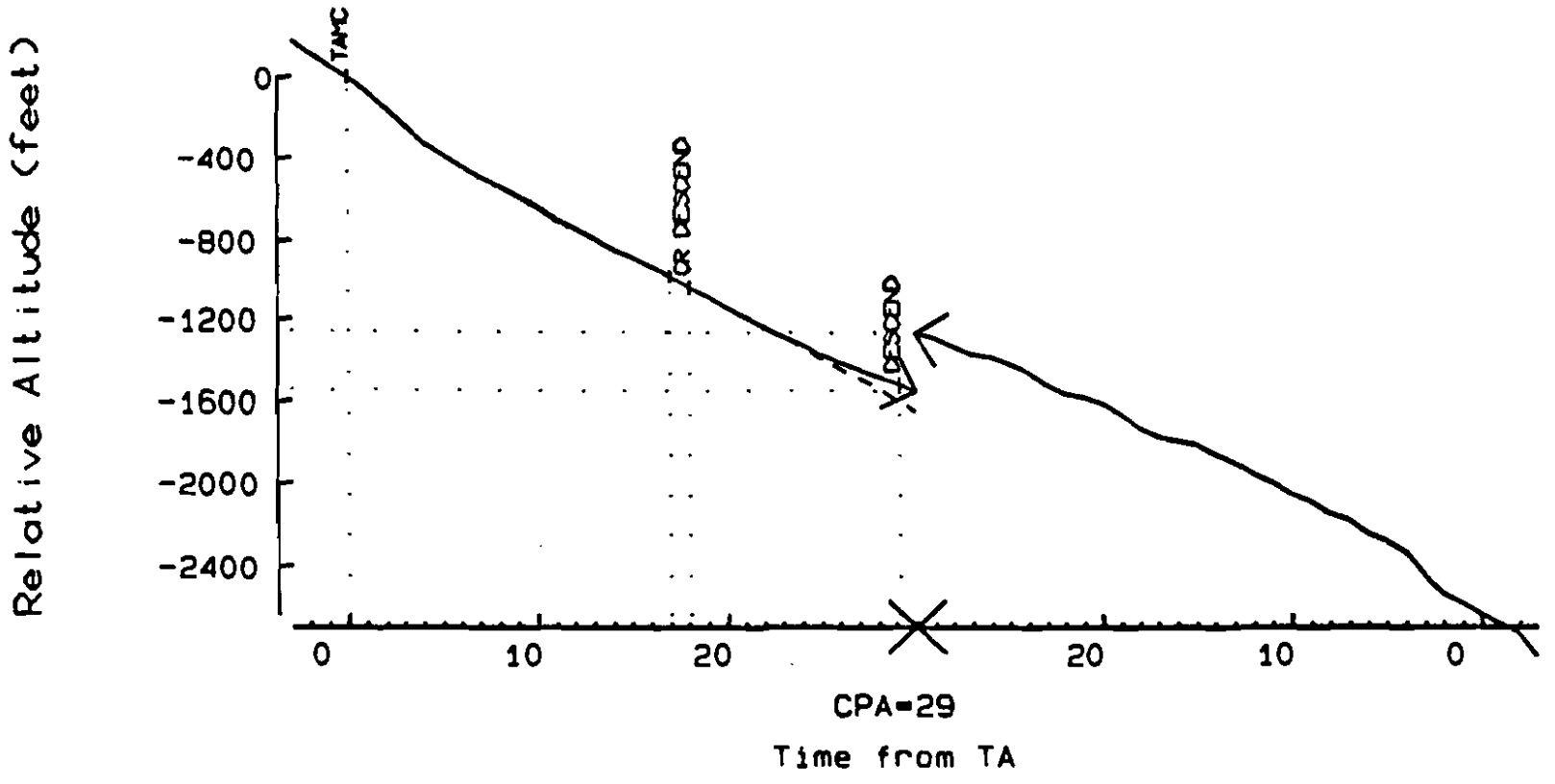
OWN ID: 10746022

RANGE RATE at TA: -496

at CPA: -308

RANGE at CPA: 826 ft

Alt. Difference with Simulated Pilot Response: 381 ft



TA TIME: 15: 47: 49

CPA TIME: 15: 48: 19

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 290 ft

PROCESSED ON: 12/15/93 by ACD-320 FAA Technical Center

>

Encounter ID 1087 Filename 8930913A.TRD

ENCOUNTER ID: 1087

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

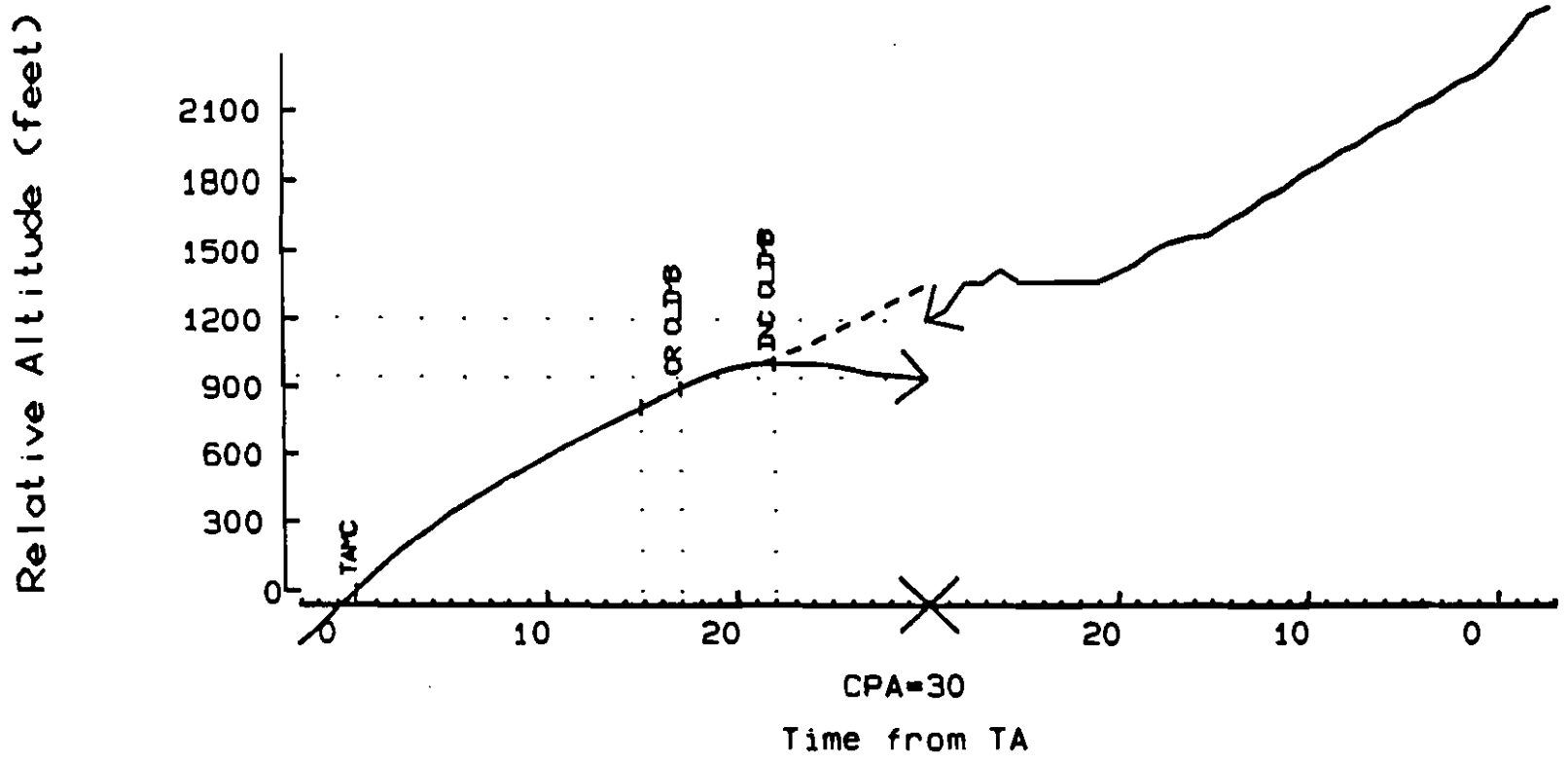
OWN ID: 10791495

RANGE RATE at TA: -524

at CPA: -117

RANGE at CPA: 1938 ft

Alt. Difference with Simulated Pilot Response: 160 ft



TA TIME: 15:54:15

CPA TIME: 15:54:45

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 261 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

Encounter ID 374 Filename R930913A.TRO

ENCOUNTER ID: 374

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

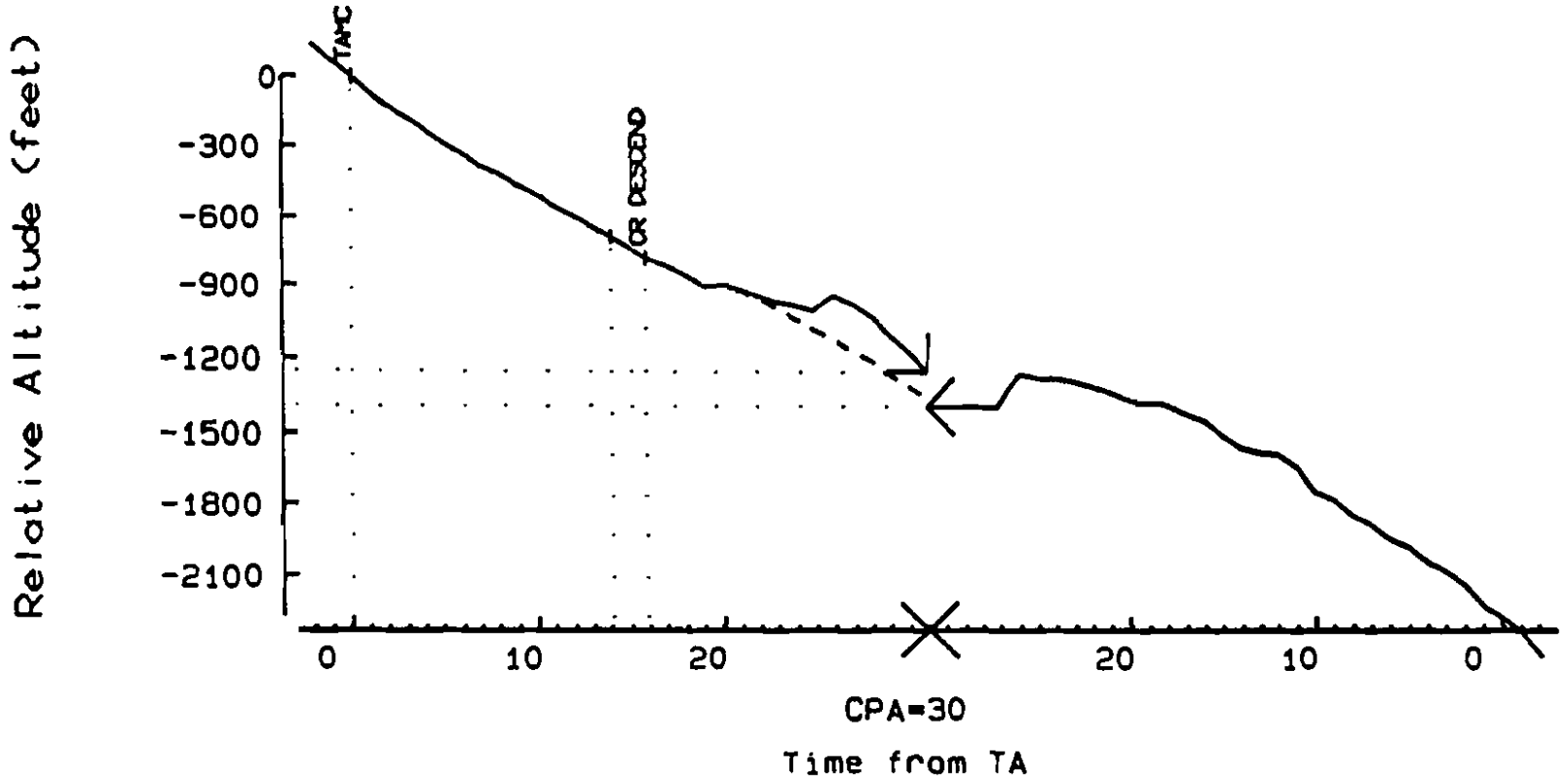
OWN ID: 10746022

RANGE RATE at TA: -521

at CPA: -207

RANGE at CPA: 1354 ft

Alt. Difference with Simulated Pilot Response: 35 ft



TA TIME: 15:53:40

CPA TIME: 15:54:11

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 139 ft

PROCESSED ON: 12/15/93 by ACD-320 FAA Technical Center

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>

Encounter ID 1321 Filename B930913A.TRD

ENCOUNTER ID: 1321

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

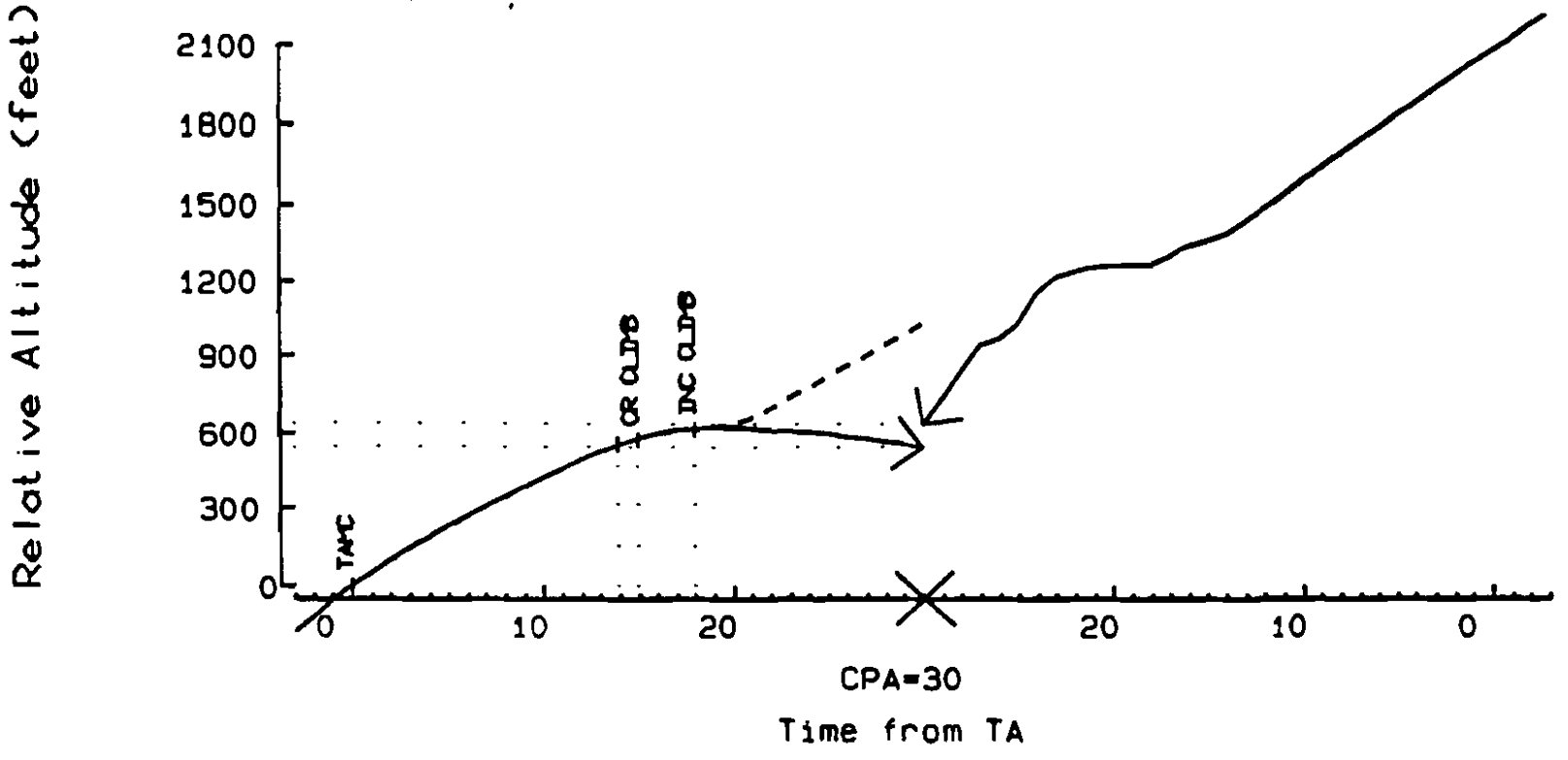
OWN ID: 10791495

RANGE RATE at TA: -489

at CPA: -43

RANGE at CPA: 1488 ft

Alt. Difference with Simulated Pilot Response: 394 ft



TA TIME: 15: 59: 34

CPA TIME: 16: 00: 04

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 93 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

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>

Encounter ID 427 Filename R930913A.TRD

ENCOUNTER ID: 427

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

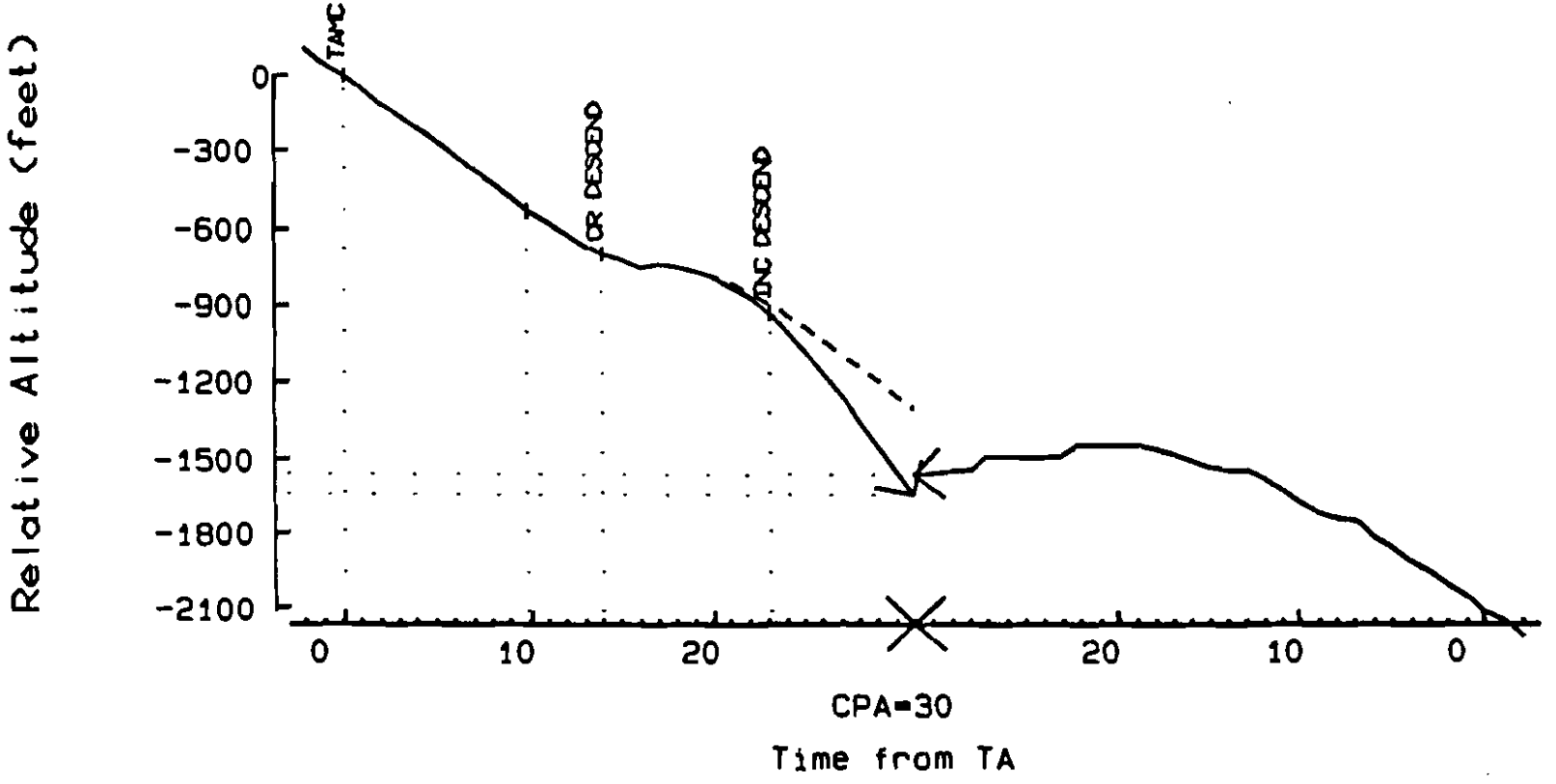
OWN ID: 10746022

RANGE RATE at TA: -484

at CPA: -161

RANGE at CPA: 966 ft

Alt. Difference with Simulated Pilot Response: 262 ft



TA TIME: 15: 58: 59

CPA TIME: 15: 59: 30

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 80 ft

PROCESSED ON: 12/15/93 by ACD-320 FAA Technical Center

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>

Encounter ID 1619 Filename B930913A.TRO

ENCOUNTER ID: 1619

TARGET IO: 10746022

INTRUDER EQUIPAGE: TCAS II

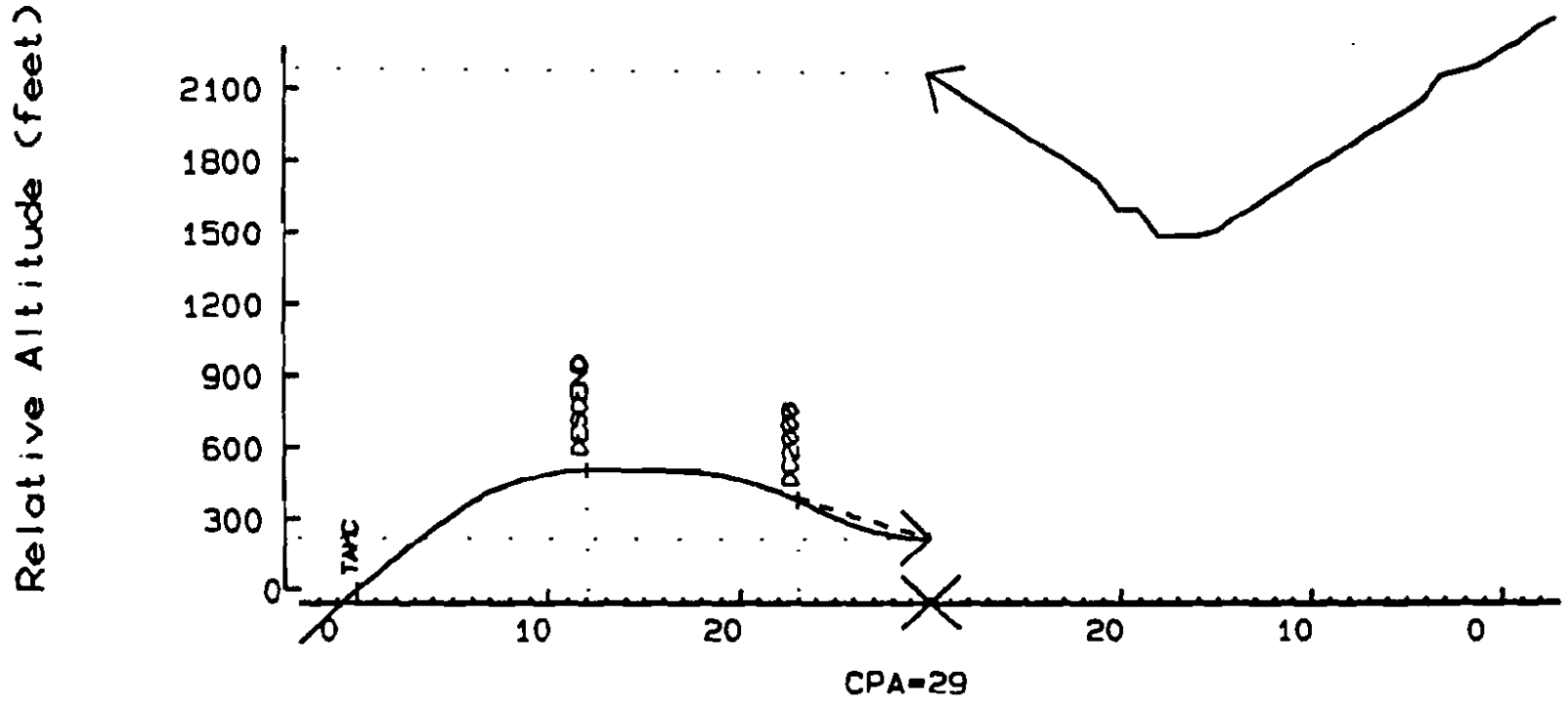
OWN ID: 10791495

RANGE RATE at TA: -513

at CPA: -192

RANGE at CPA: 2157 ft

Alt. Difference with Simulated Pilot Response: 1945 ft



TA TIME: 16: 05: 47

CPA TIME: 16: 06: 17

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 1962 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

F-13

>

Encounter ID 546 Filename R930913A.TRD

ENCOUNTER ID: 546

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

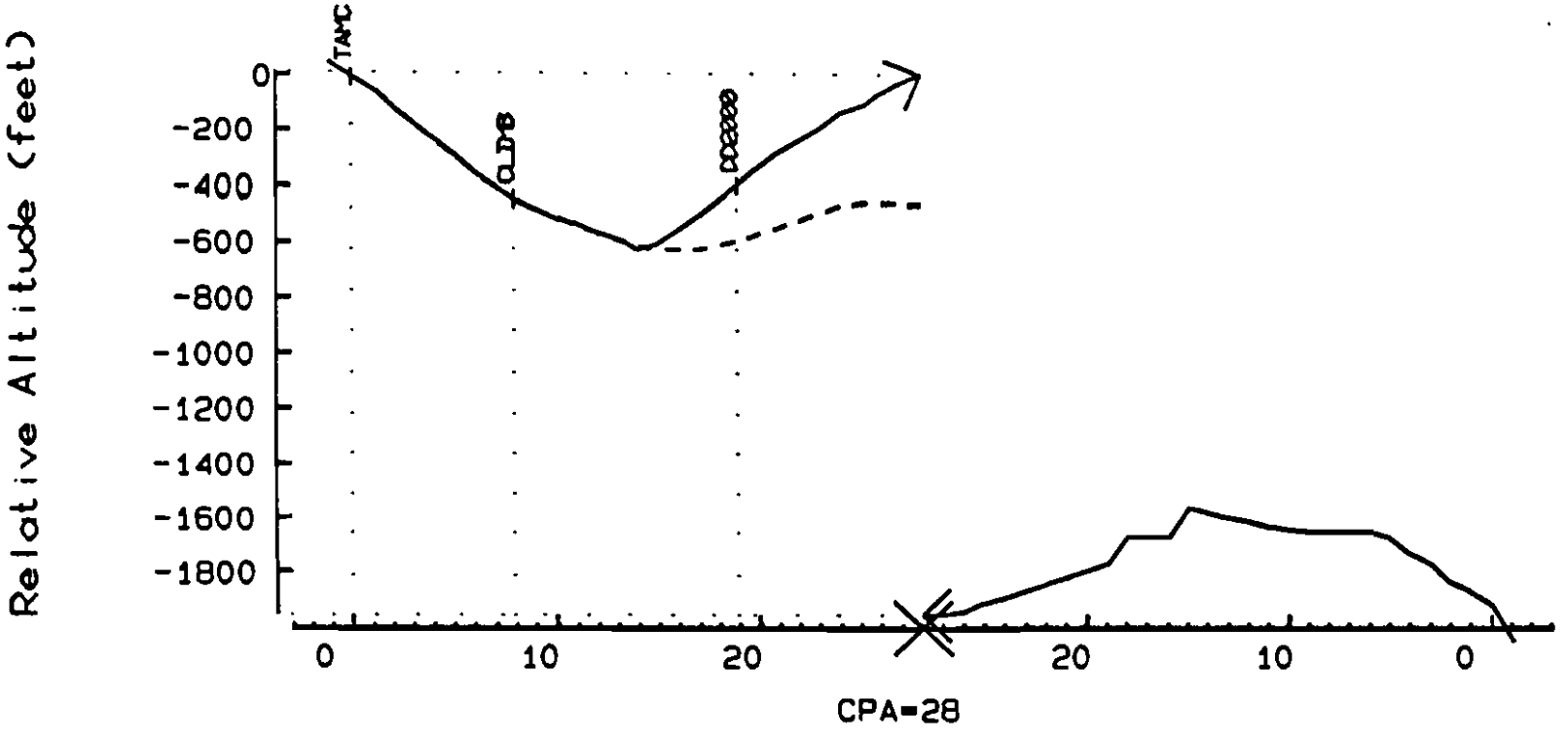
OWN ID: 10746022

RANGE RATE at TA: -503

at CPA: -253

RANGE at CPA: 1409 ft

Alt. Difference with Simulated Pilot Response: 1492 ft



TA TIME: 16: 05: 15

CPA TIME: 16: 05: 43

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 1969 ft

PROCESSED ON: 12/15/93 by ACD-320 FAA Technical Center

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>

Encounter ID 1869 Filename B930913A.TRD

ENCOUNTER ID: 1869

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

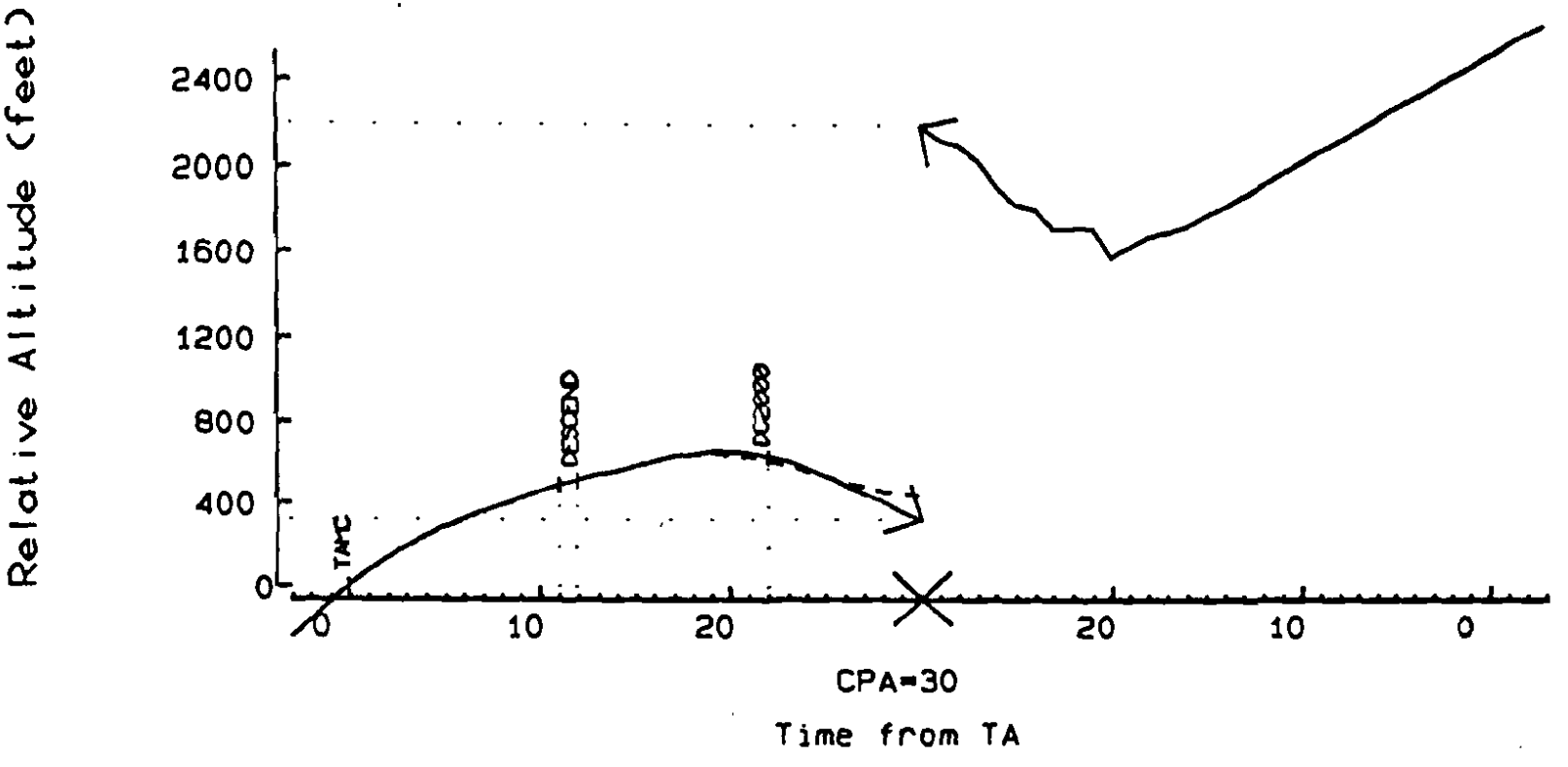
OWN ID: 10791495

RANGE RATE at TA: -484

at CPA: -32

RANGE at CPA: 2843 ft

Alt. Difference with Simulated Pilot Response: 1754 ft



TA TIME: 16: 11: 00

CPA TIME: 16: 11: 30

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 1882 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

>

Encounter ID 639 Filename R930913A.TRD

ENCOUNTER ID: 639

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

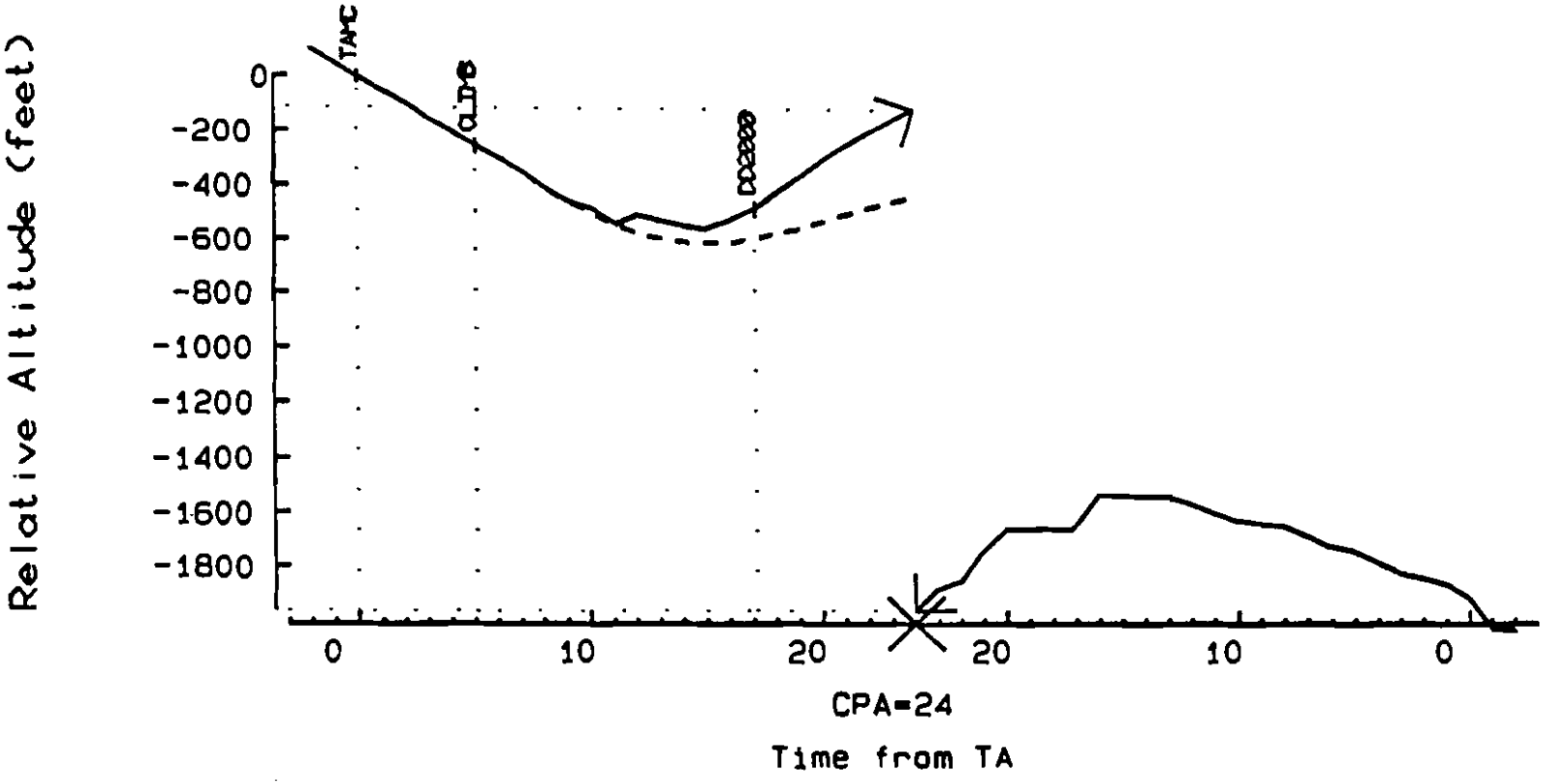
OWN ID: 10746022

RANGE RATE at TA: -447

at CPA: -227

RANGE at CPA: 2223 ft

Alt. Difference with Simulated Pilot Response: 1520 ft



TA TIME: 16: 10: 31

CPA TIME: 16: 10: 55

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 1850 ft

PROCESSED ON: 12/15/93 by ACD-320 FAA Technical Center

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>

Encounter ID 2112 Filename B930913A.TRD

ENCOUNTER ID: 2112

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

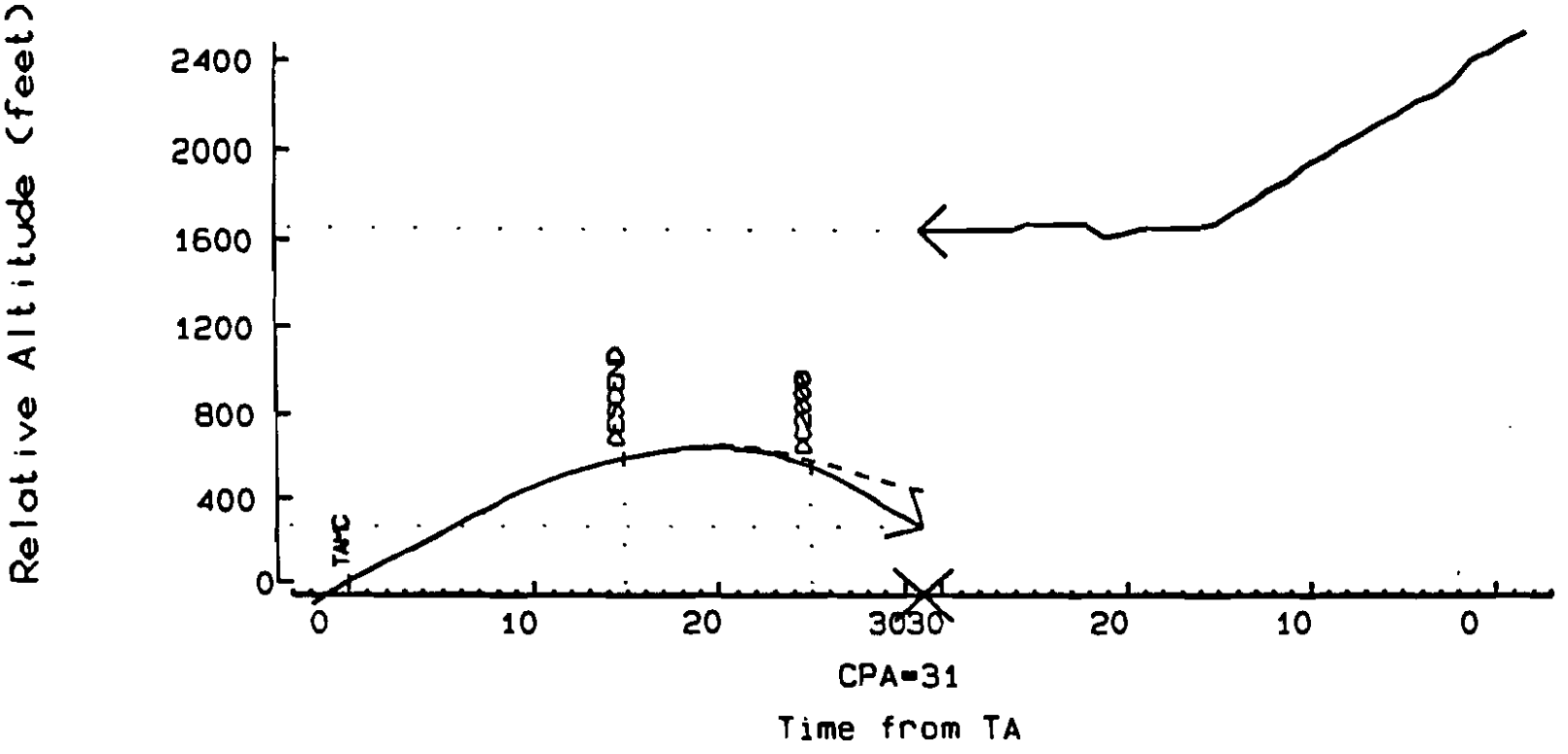
OWN ID: 10791495

RANGE RATE at TA: -518

at CPA: -142

RANGE at CPA: 1257 ft

Alt. Difference with Simulated Pilot Response: 1212 ft



TA TIME: 16: 16: 38

CPA TIME: 16: 17: 09

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 1381 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

>

Encounter ID 735 Filename R930913A.TRD

ENCOUNTER ID: 735

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

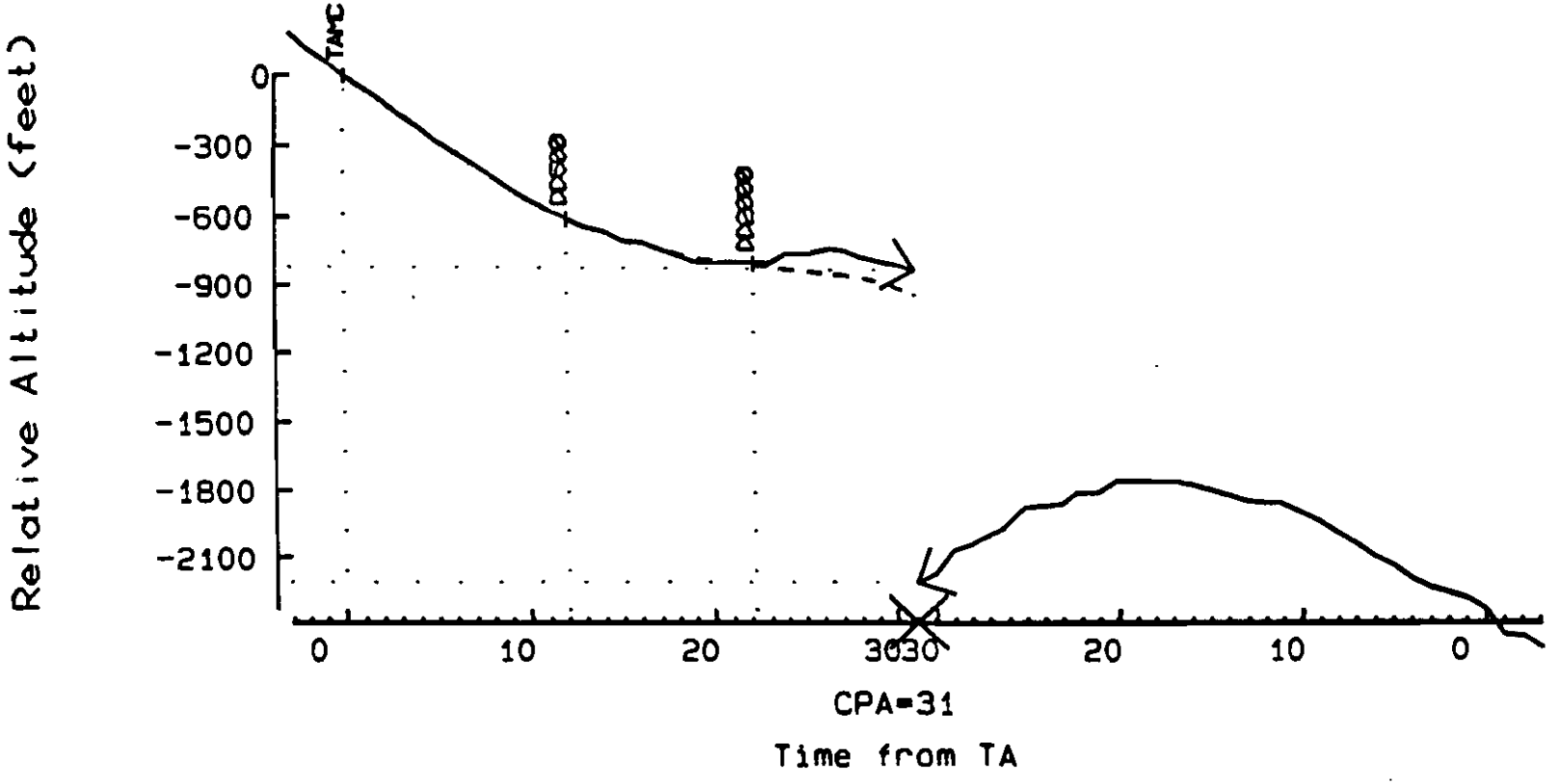
OWN ID: 10746022

RANGE RATE at TA: -524

at CPA: -226

RANGE at CPA: 789 ft

Alt. Difference with Simulated Pilot Response: 1274 ft



TA TIME: 16: 16: 04

CPA TIME: 16: 16: 35

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 1391 ft

PROCESSED ON: 12/15/93 by ACD-320 FAA Technical Center

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>

Encounter ID 2297 Filename B930913A.TRD

ENCOUNTER ID: 2297

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

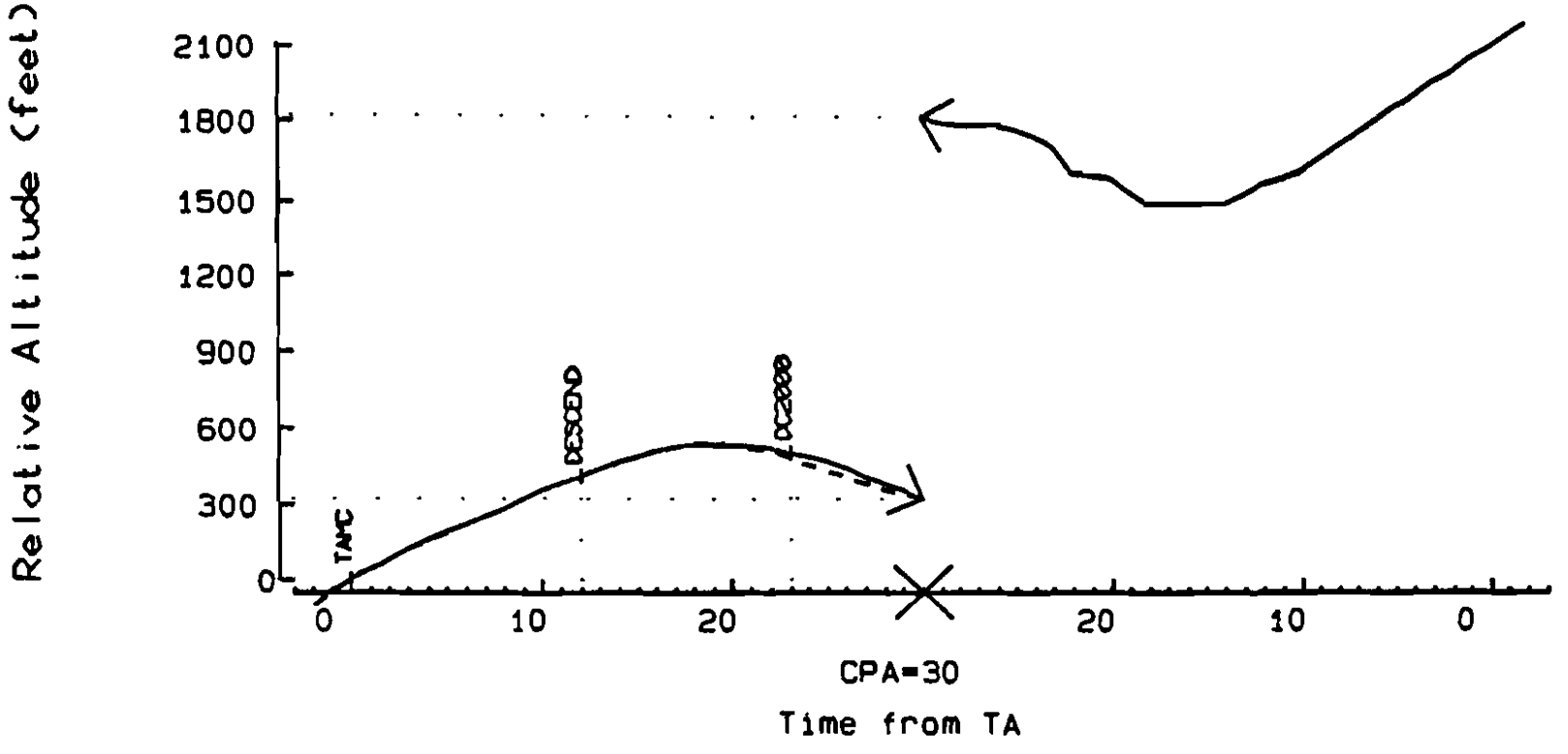
OWN ID: 10791495

RANGE RATE at TA: -489

at CPA: -35

RANGE at CPA: 1816 ft

Alt. Difference with Simulated Pilot Response: 1499 ft



TA TIME: 16: 22: 09

CPA TIME: 16: 22: 39

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 1501 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

Encounter ID 782 Filename R930913A.TRD

ENCOUNTER ID: 782

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

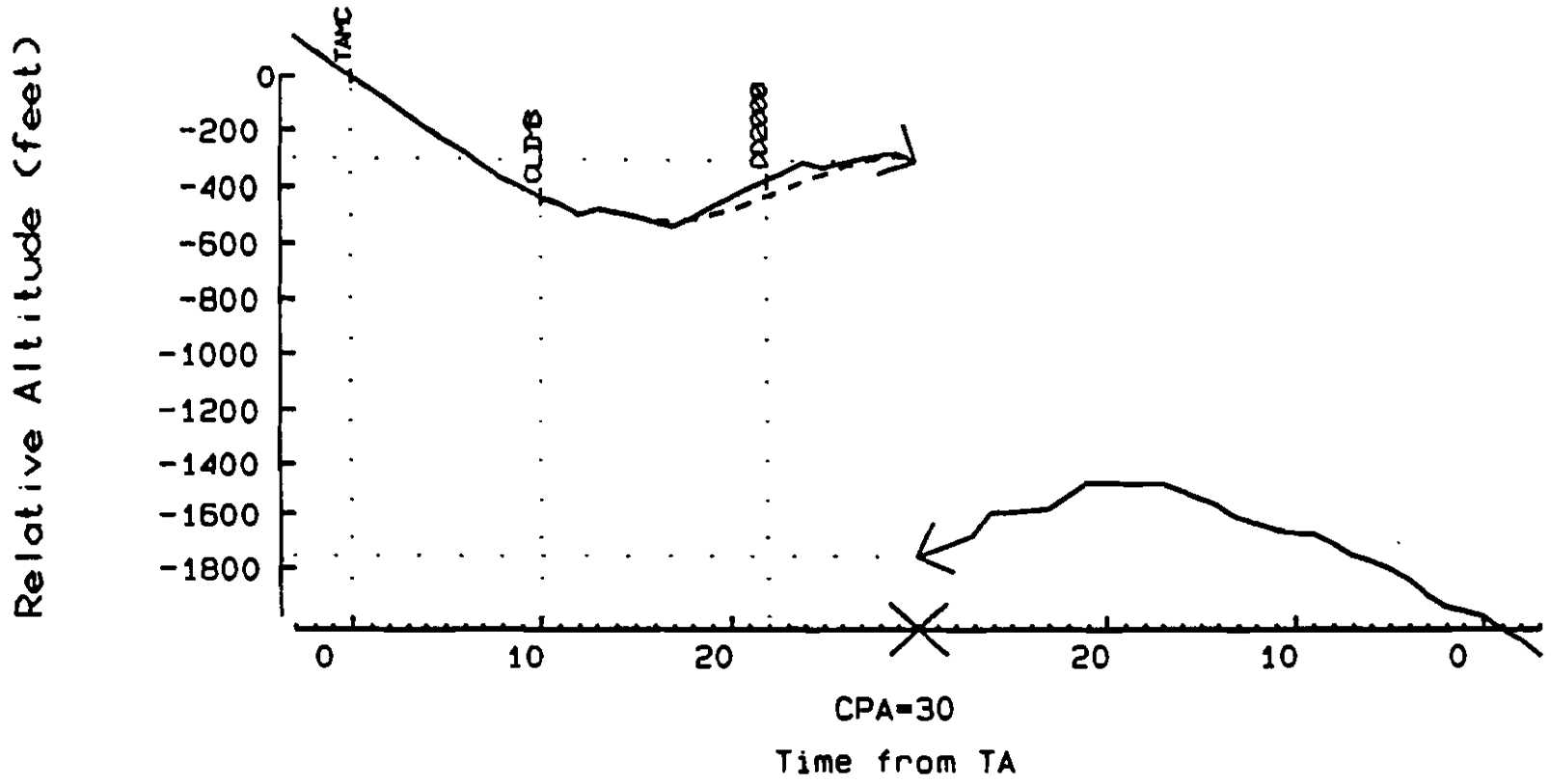
OWN ID: 10746022

RANGE RATE at TA: -480

at CPA: -247

RANGE at CPA: 1142 ft

Alt. Difference with Simulated Pilot Response: 1472 ft



TA TIME: 16: 21: 35

CPA TIME: 16: 22: 05

FLIGHT DATE: 09/13/93

Alt. Difference at CPA: 1458 ft

PROCESSED ON: 12/15/93 by ACD-320 FAA Technical Center

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>

Encounter ID 566 Filename B930914A.TR1

ENCOUNTER ID: 566

TARGET ID: 10746022

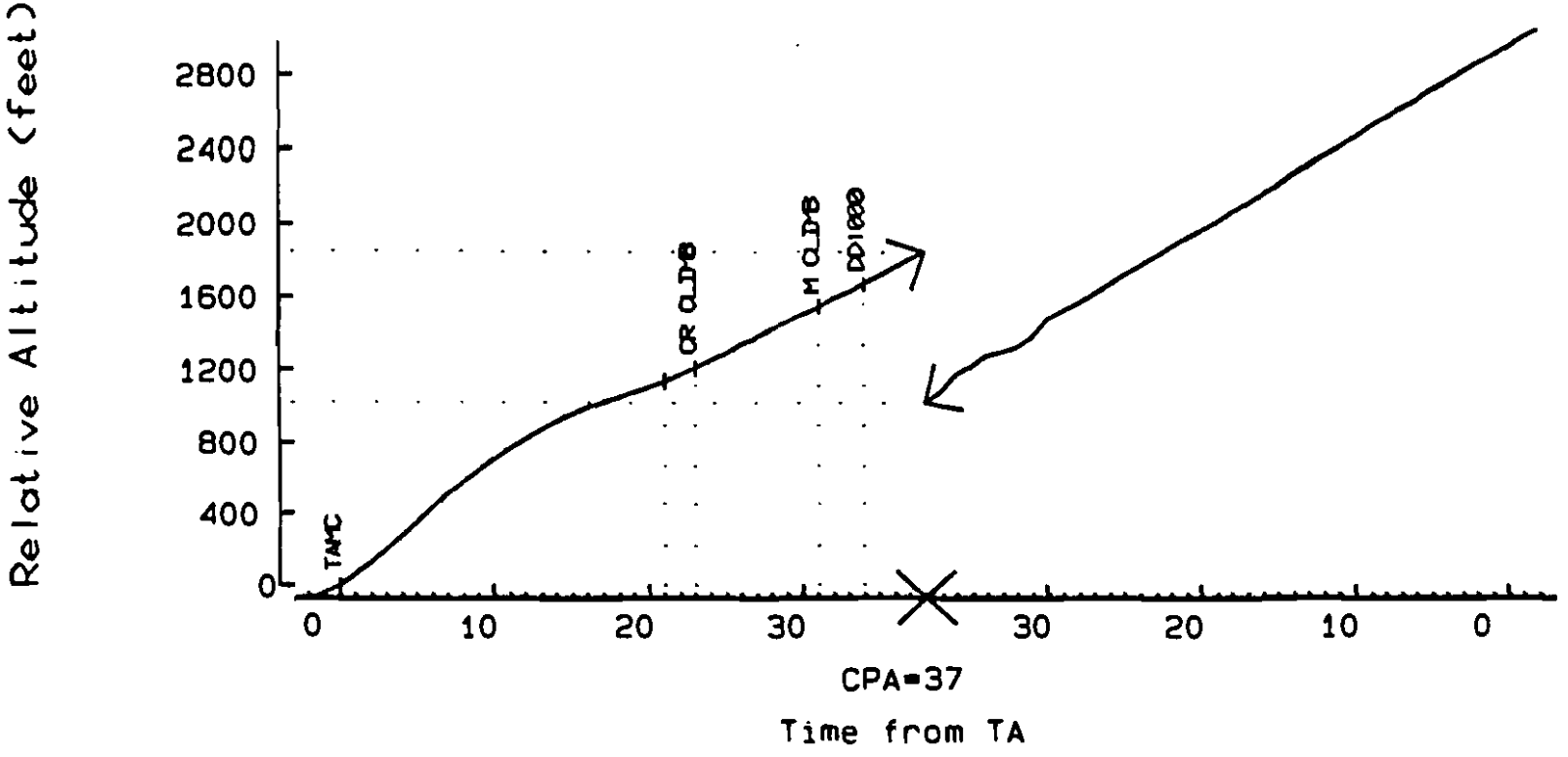
INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

RANGE RATE at TA: -496

at CPA: -81

RANGE at CPA: 1999 ft



TA TIME: 13:38:02 CPA TIME: 13:38:40

FLIGHT DATE: 09/14/93 Alt. Difference at CPA: 830 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

Encounter ID 225 Filename R930914A.TR1

ENCOUNTER ID: 225

TARGET ID: 10791495

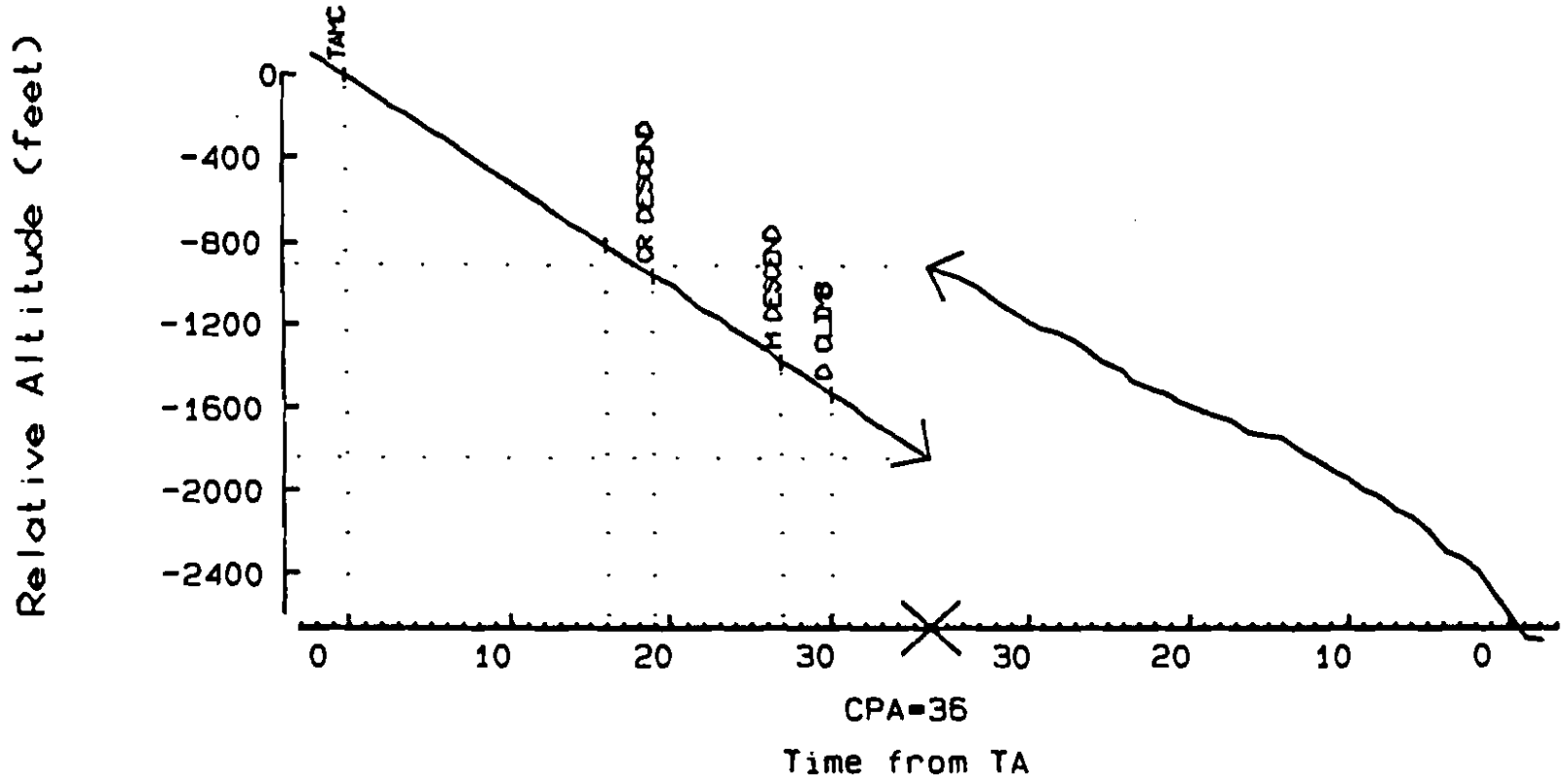
INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

RANGE RATE at TA: -484

at CPA: -178

RANGE at CPA: 1464 ft



TA TIME: 13:37:20 CPA TIME: 13:37:56

FLIGHT DATE: 09/14/93 Alt. Difference at CPA: 926 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

>

Encounter ID 730 Filename 8930914A.TR1

ENCOUNTER ID: 730

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

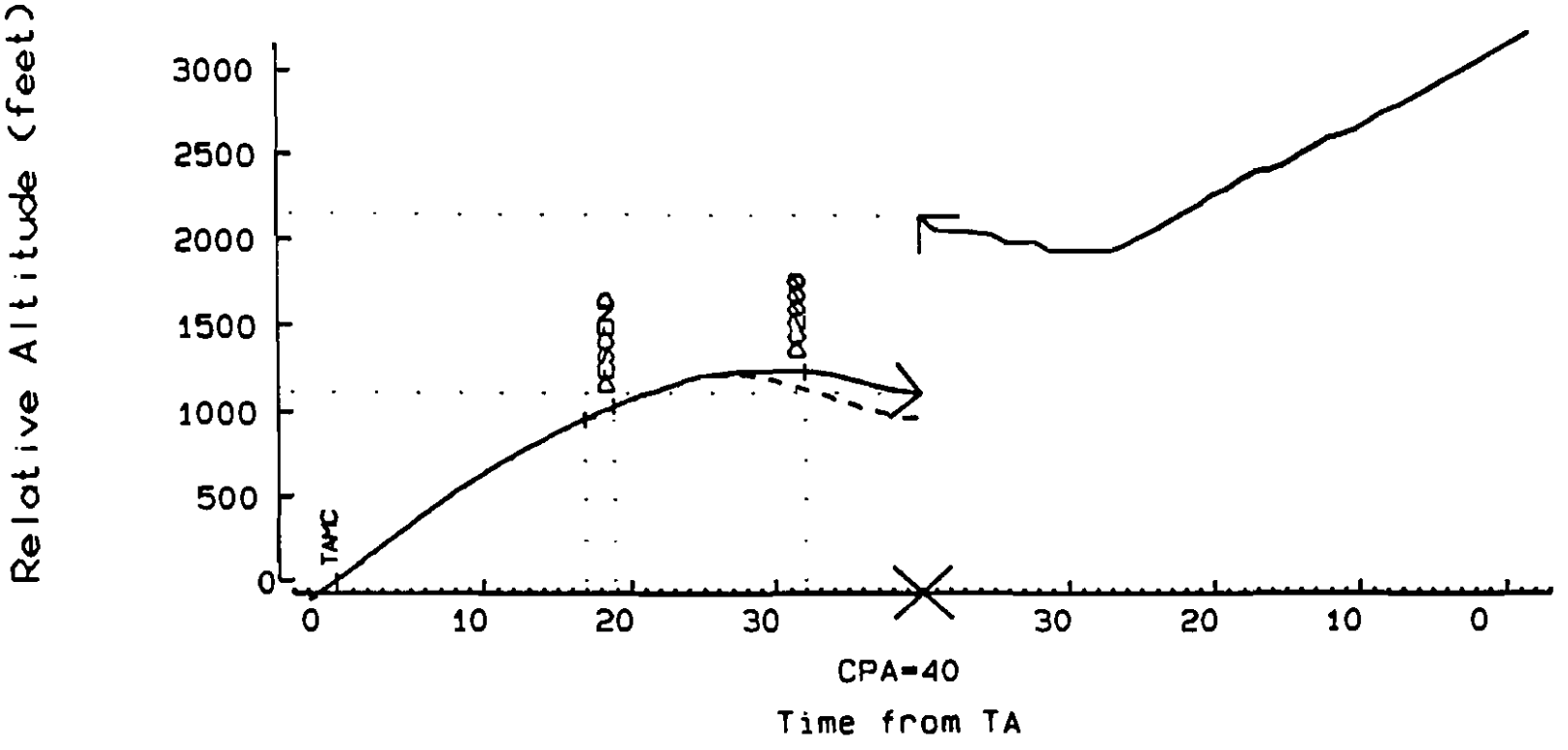
OWN ID: 10791495

RANGE RATE at TA: -503

at CPA: -151

RANGE at CPA: 3141 ft

Alt. Difference with Simulated Pilot Response: 1180 ft



TA TIME: 13: 44: 17

CPA TIME: 13: 44: 57

FLIGHT DATE: 09/14/93

Alt. Difference at CPA: 1037 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

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>

Encounter ID 346 Filename R930914A.TR1

ENCOUNTER ID: 346

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

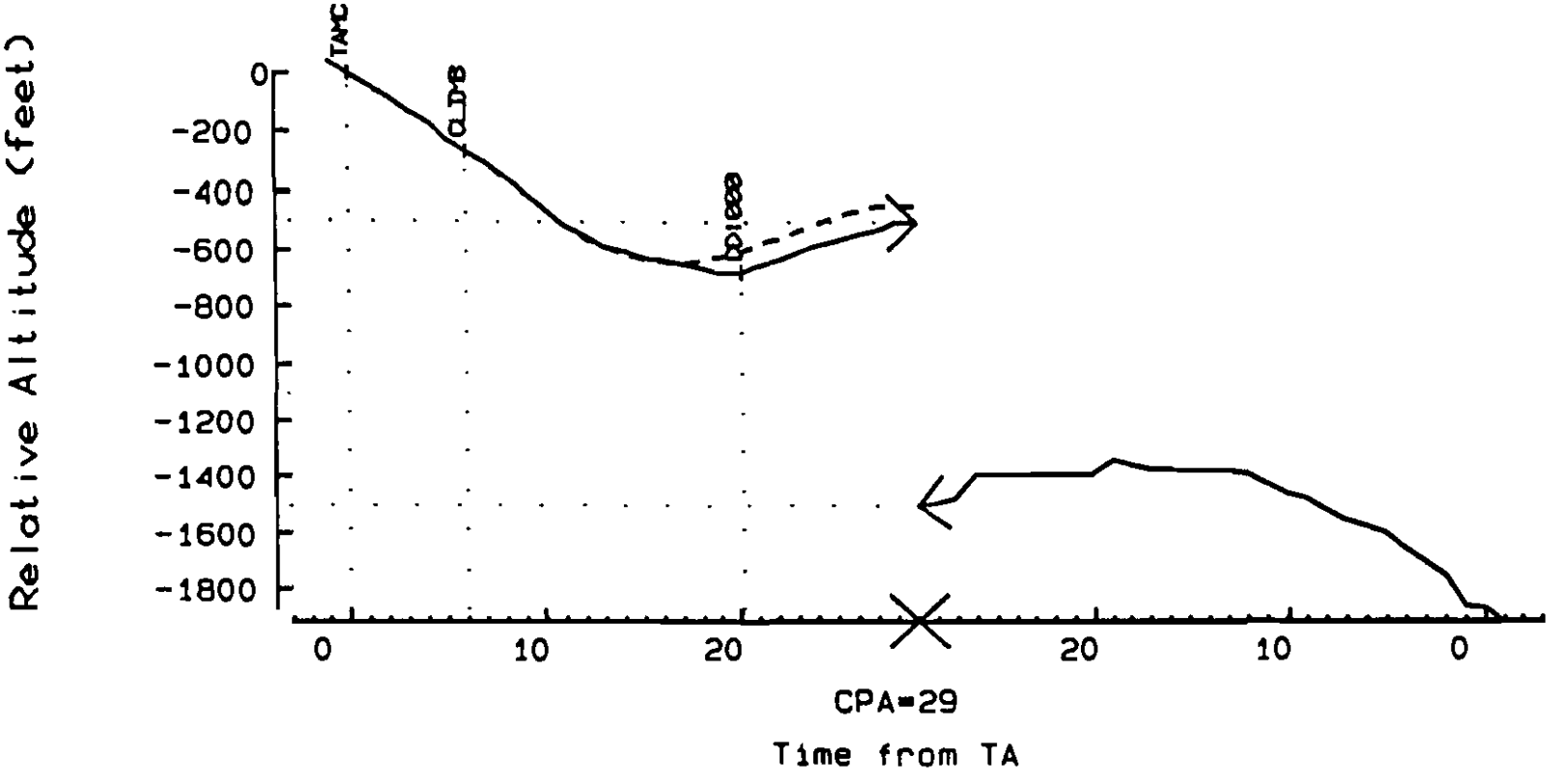
OWN ID: 10746022

RANGE RATE at TA: -473

at CPA: -205

RANGE at CPA: 2624 ft

Alt. Difference with Simulated Pilot Response: 1061 ft



TA TIME: 13: 43: 44

CPA TIME: 13: 44: 13

FLIGHT DATE: 09/14/93

Alt. Difference at CPA: 1010 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

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>

Encounter ID 1080 Filename 8930914A.TR1

ENCOUNTER ID: 1080

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

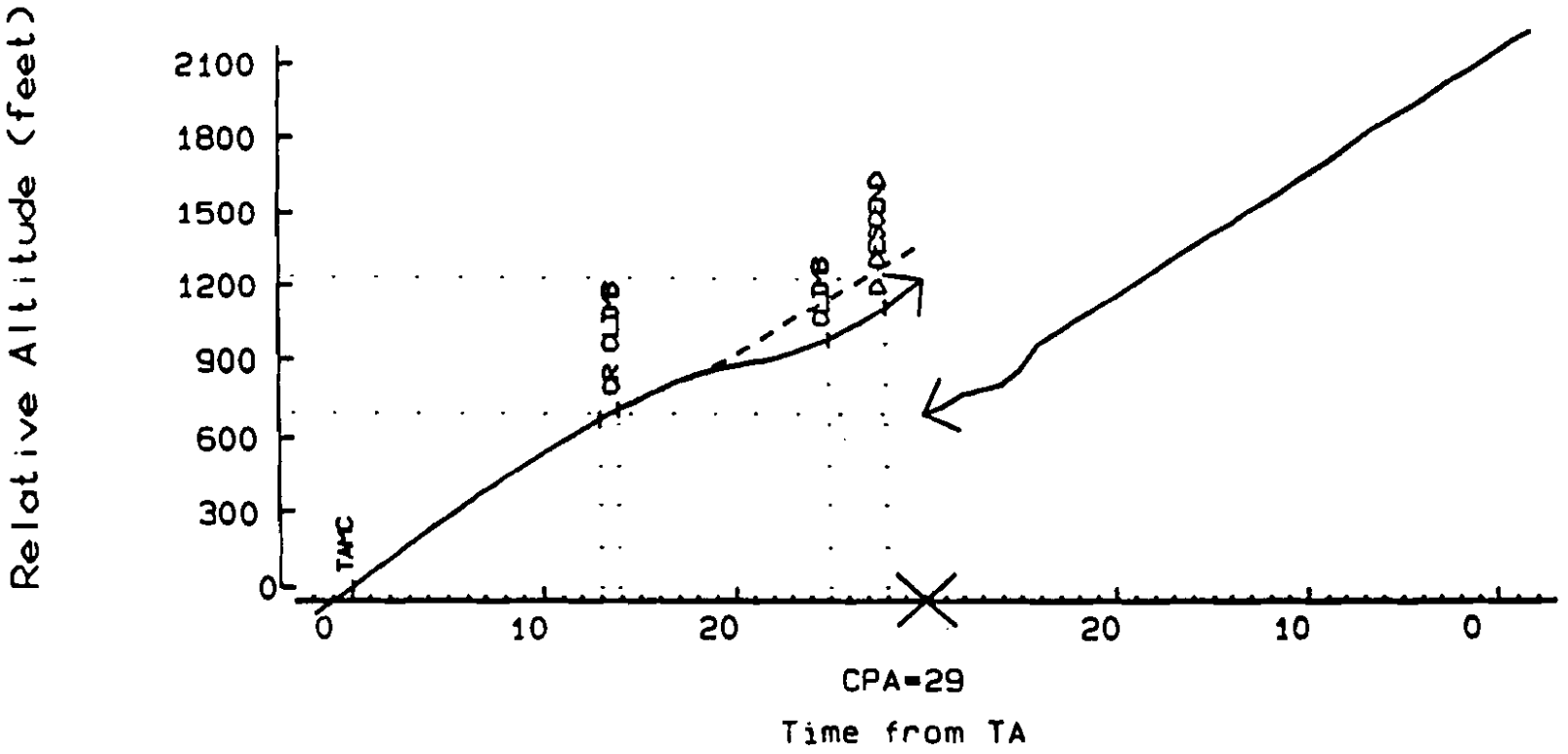
OWN ID: 10791495

RANGE RATE at TA: -497

at CPA: -286

RANGE at CPA: 1245 ft

Alt. Difference with Simulated Pilot Response: 690 ft



TA TIME: 13:50:05

CPA TIME: 13:50:35

FLIGHT DATE: 09/14/93

Alt. Difference at CPA: 548 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

Encounter ID 382 Filename R930914A.TR1

ENCOUNTER ID: 382

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

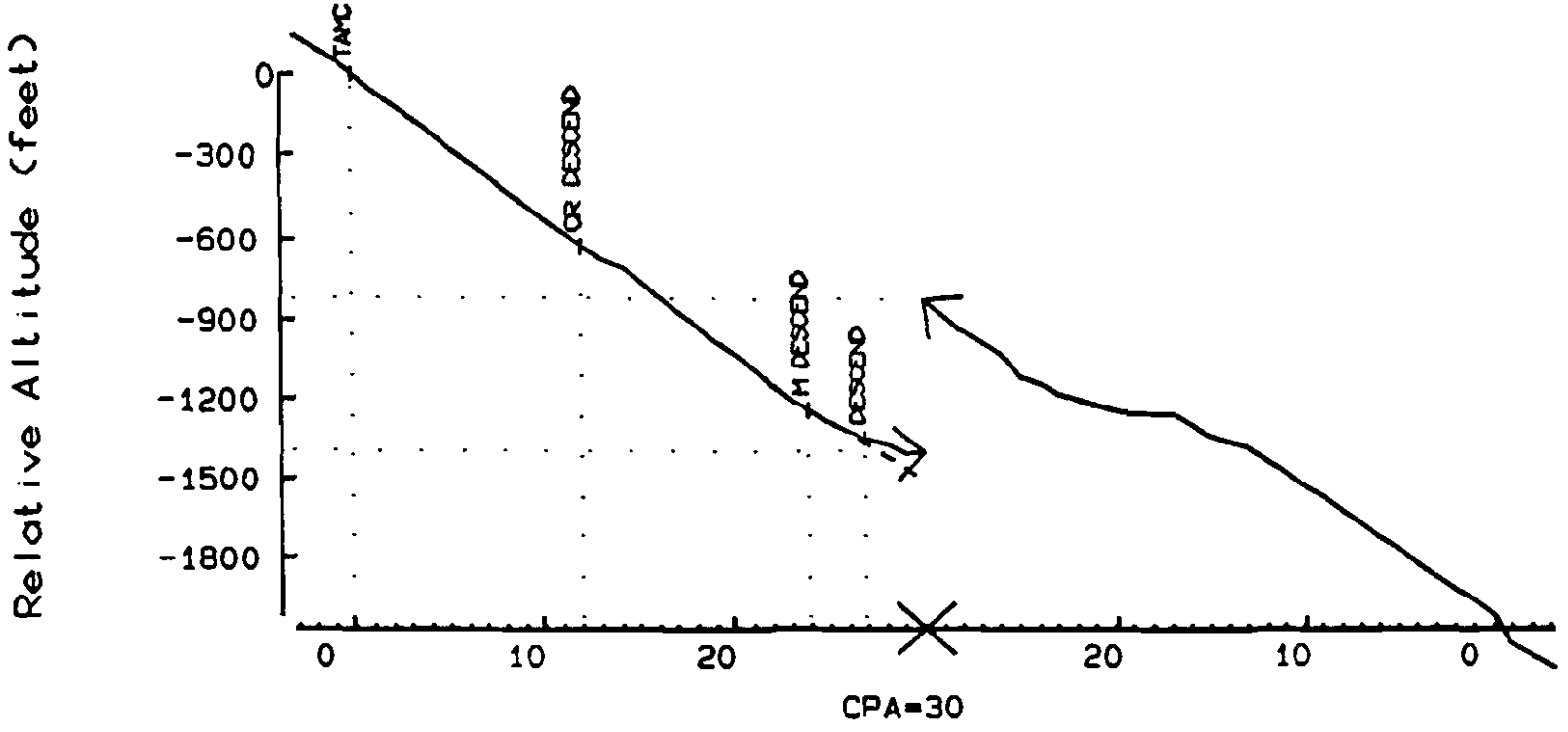
OWN ID: 10746022

RANGE RATE at TA: -482

at CPA: -315

RANGE at CPA: 686 ft

Alt. Difference with Simulated Pilot Response: 681 ft



TA TIME: 13: 49: 21

CPA TIME: 13: 49: 51

FLIGHT DATE: 09/14/93

Alt. Difference at CPA: 565 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

>

Encounter ID 1481 Filename 8930914A.TR1

ENCOUNTER ID: 1481

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

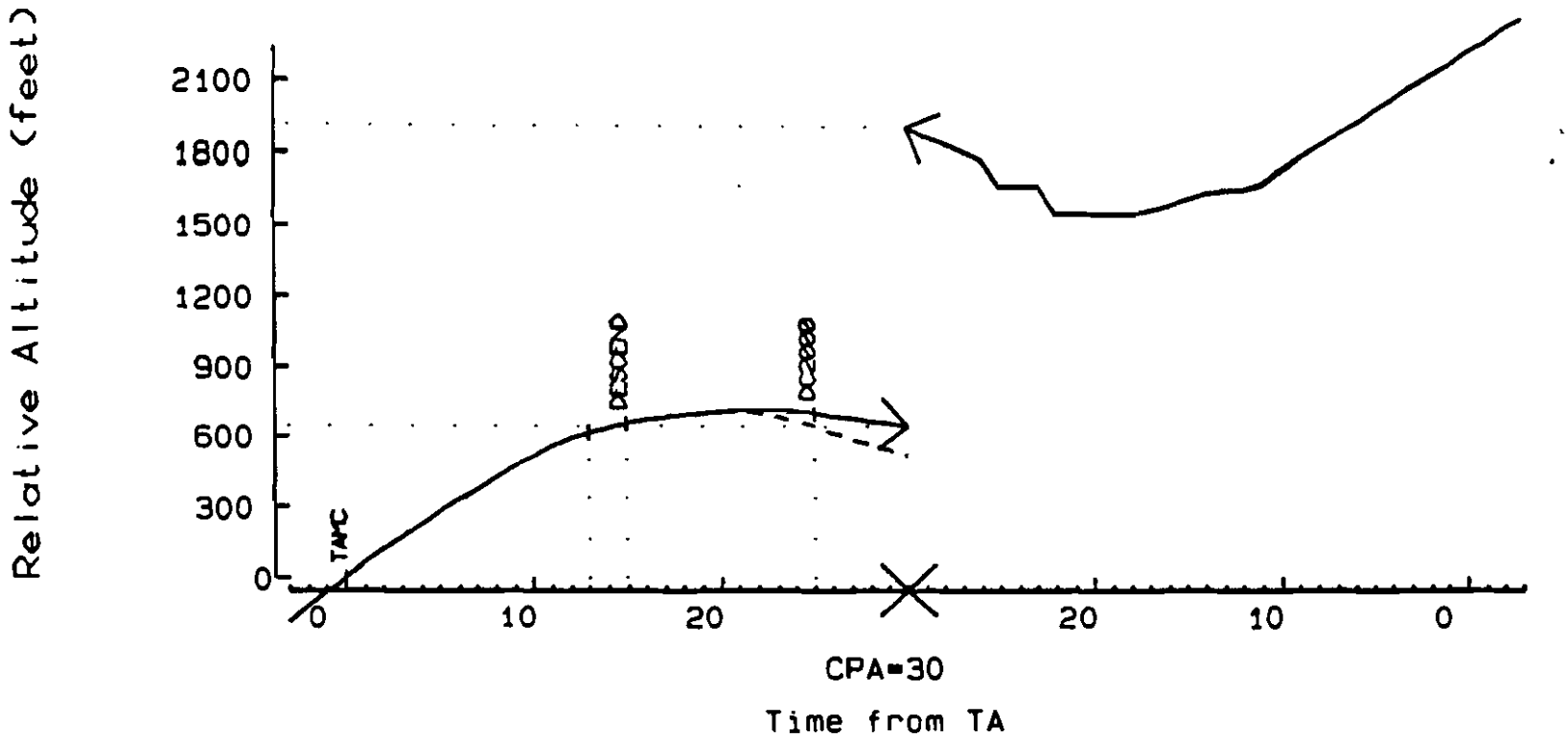
OWN ID: 10791495

RANGE RATE at TA: -508

at CPA: -277

RANGE at CPA: 1367 ft

Alt. Difference with Simulated Pilot Response: 1396 ft



TA TIME: 14:01:40

CPA TIME: 14:02:10

FLIGHT DATE: 09/14/93

Alt. Difference at CPA: 1266 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

Encounter ID 533 Filename R930914A.TR1

ENCOUNTER ID: 533

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

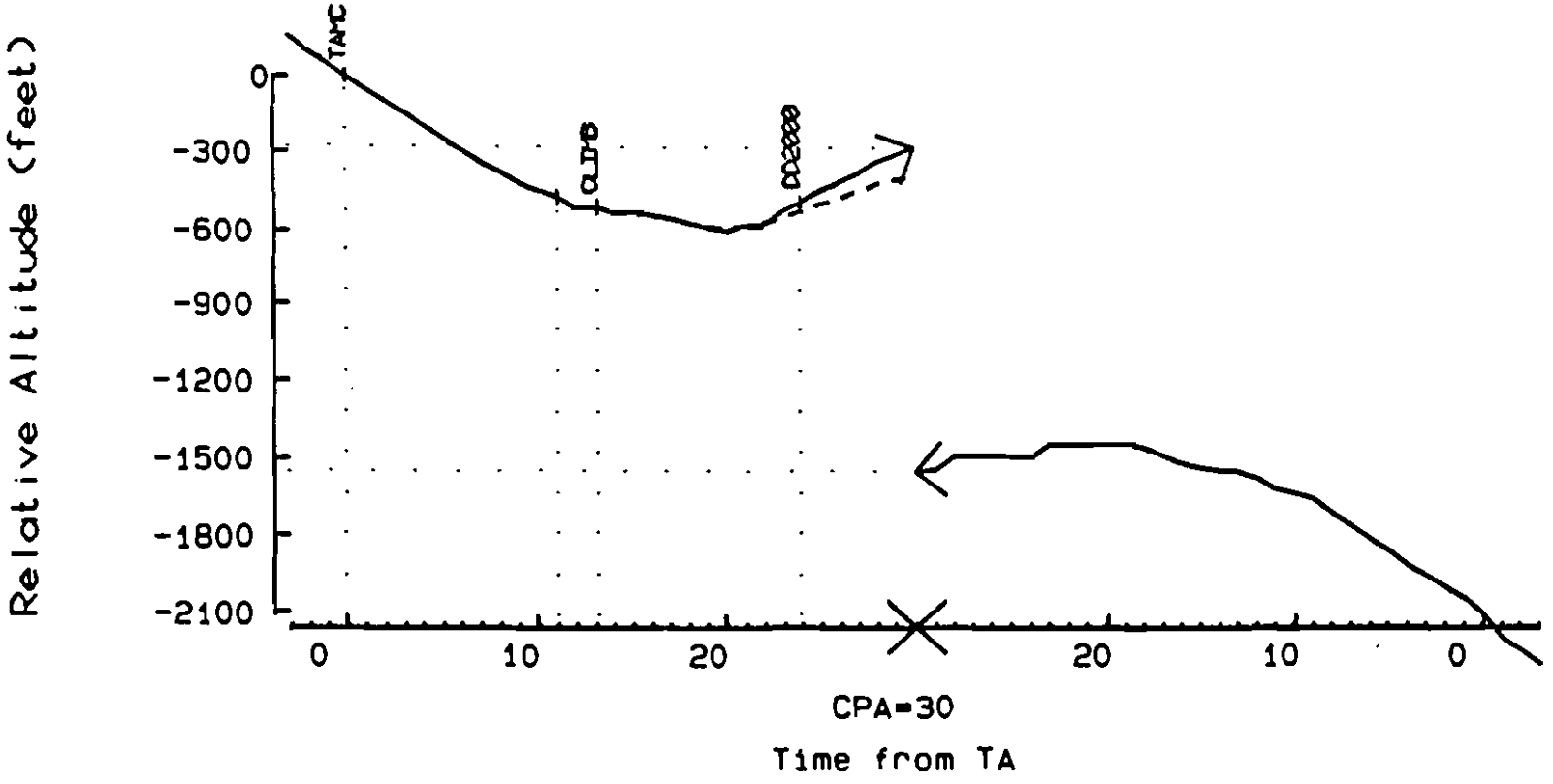
OWN ID: 10746022

RANGE RATE at TA: -502

at CPA: -344

RANGE at CPA: 771 ft

Alt. Difference with Simulated Pilot Response: 1159 ft



TA TIME: 14:00:56

CPA TIME: 14:01:26

FLIGHT DATE: 09/14/93

Alt. Difference at CPA: 1277 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

>

>Encounter ID 4 Filename B930914A.TR2

ENCOUNTER ID: 4

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

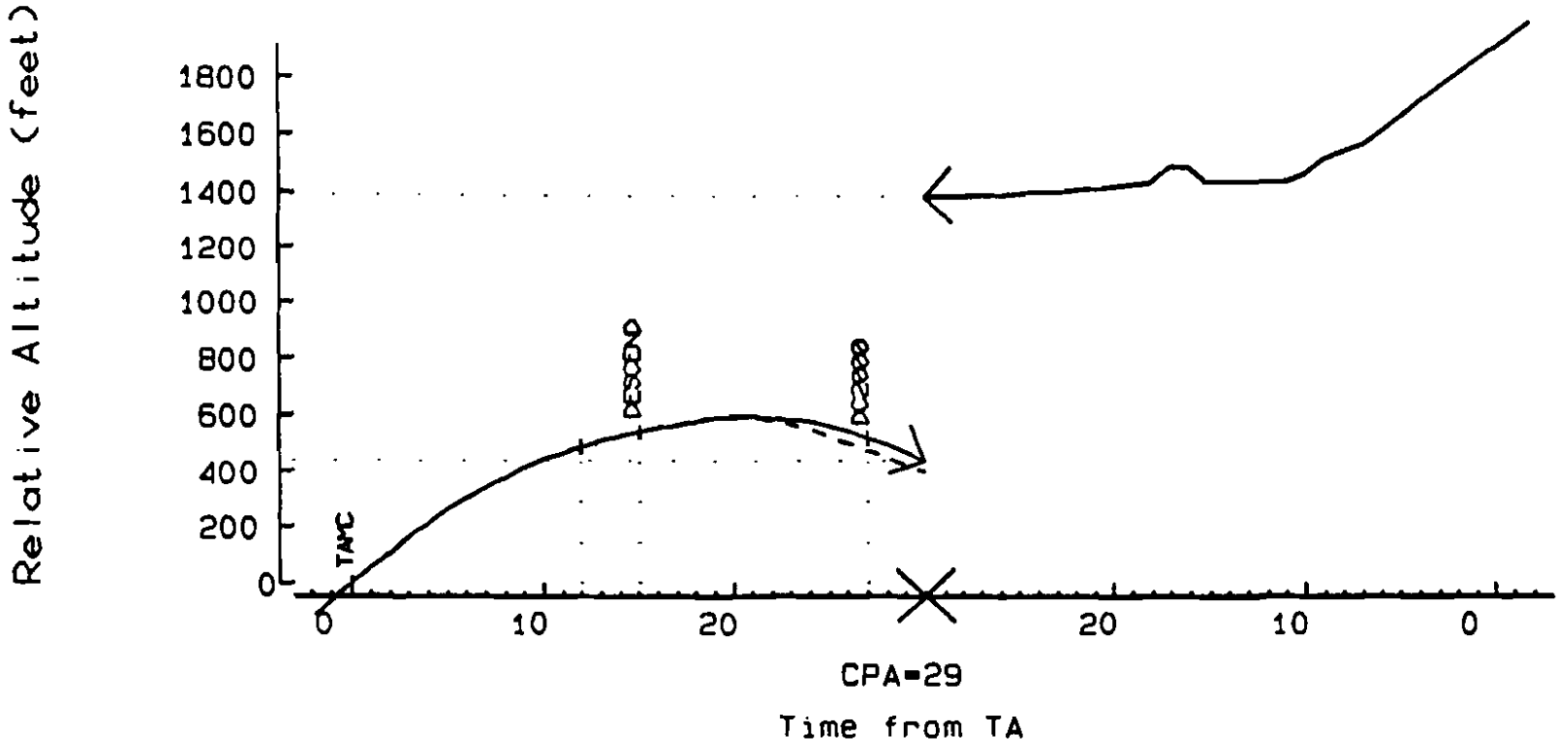
OWN ID: 10791495

RANGE RATE at TA: -491

at CPA: -151

RANGE at CPA: 2090 ft

Alt. Difference with Simulated Pilot Response: 988 ft



TA TIME: 14:07:31

CPA TIME: 14:08:01

FLIGHT DATE: 09/14/93

Alt. Difference at CPA: 948 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

Encounter ID 533 Filename R930914A.TR1

ENCOUNTER ID: 533

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

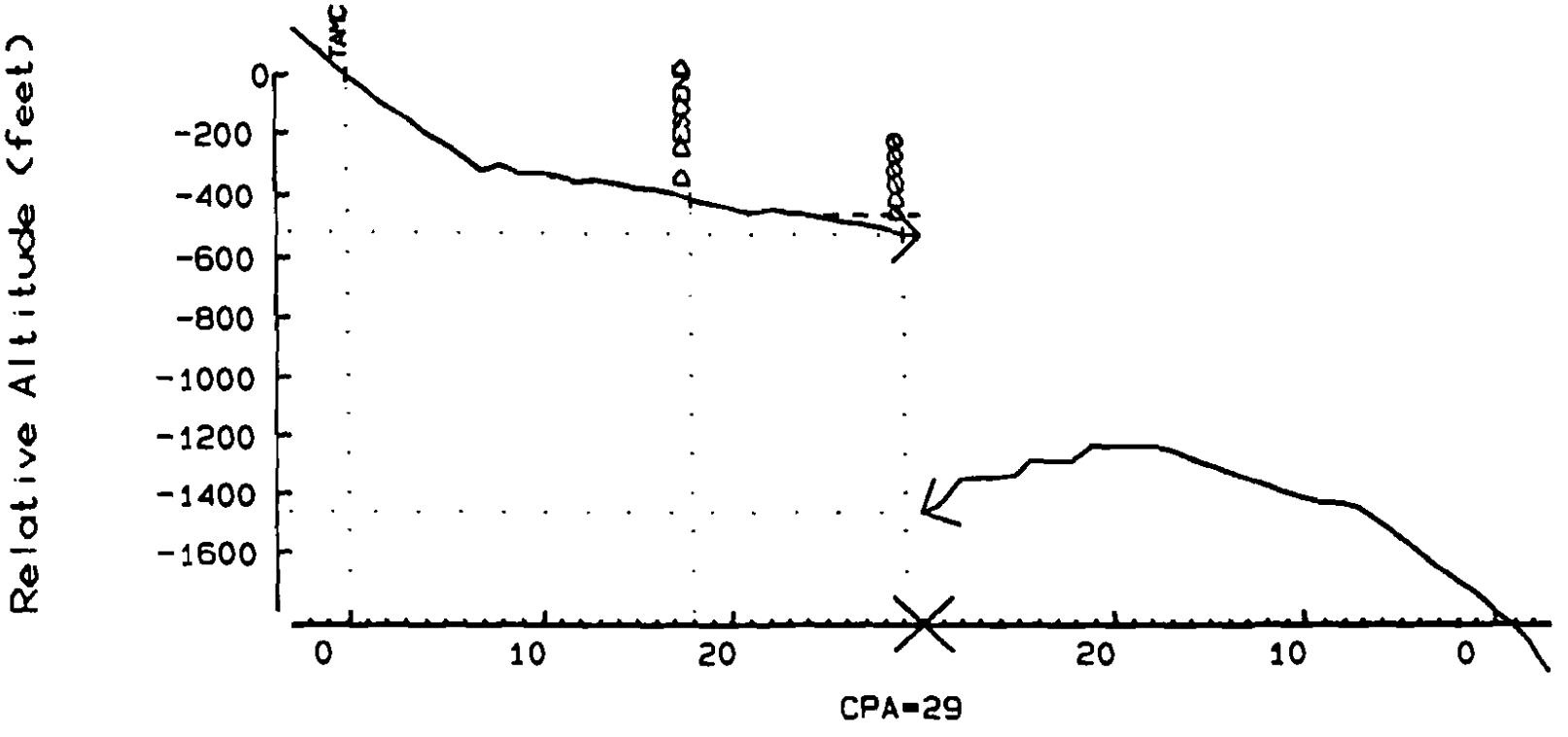
OWN ID: 10746022

RANGE RATE at TA: -497

at CPA: -278

RANGE at CPA: 1488 ft

Alt. Difference with Simulated Pilot Response: 1011 ft



TA TIME: 14:06:47

CPA TIME: 14:07:17

FLIGHT DATE: 09/14/93

Alt. Difference at CPA: 946 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

Encounter ID 179 Filename B930914A.TR2

ENCOUNTER ID: 179

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

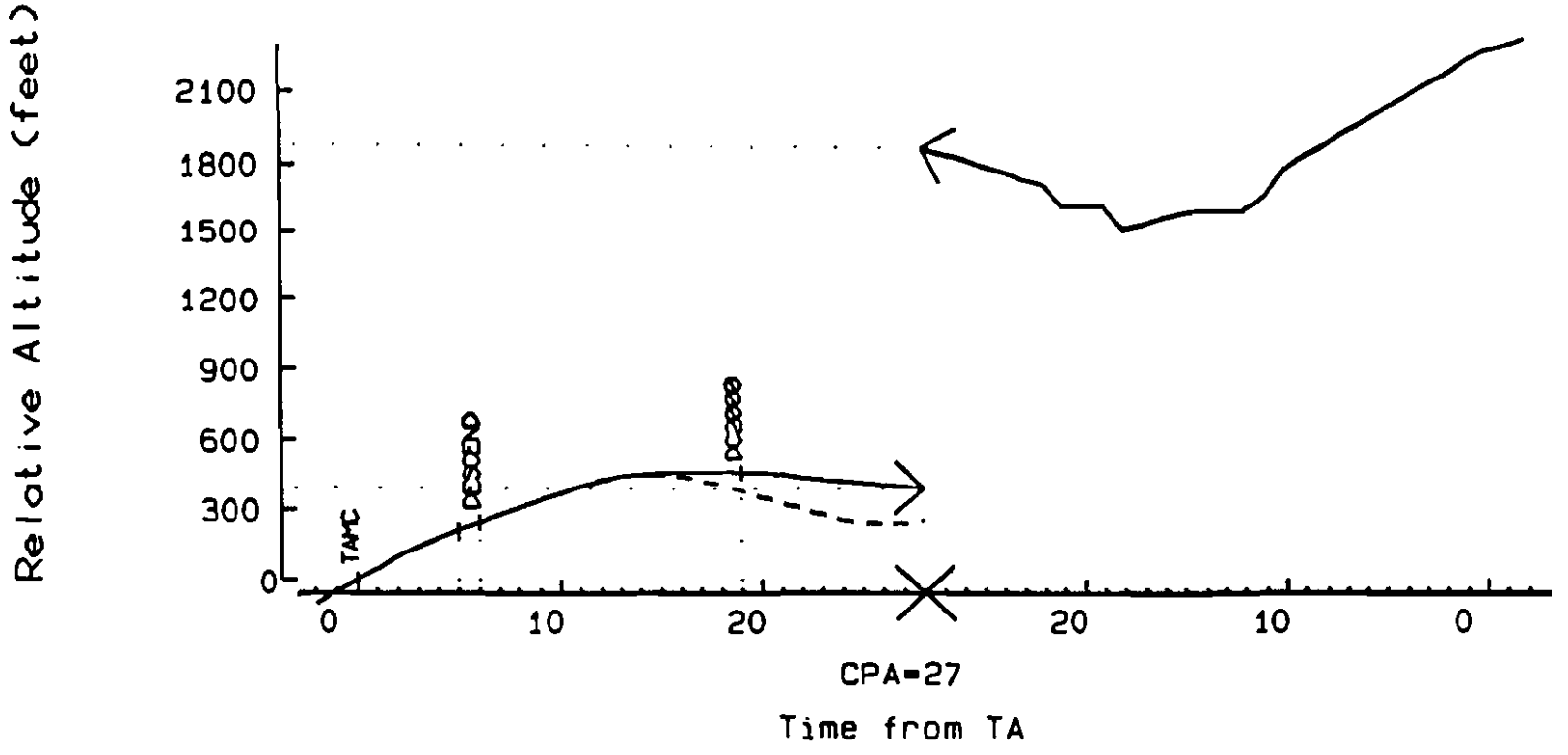
OWN ID: 10791495

RANGE RATE at TA: -502

at CPA: -194

RANGE at CPA: 2582 ft

Alt. Difference with Simulated Pilot Response: 1618 ft



TA TIME: 14: 12: 50

CPA TIME: 14: 13: 18

FLIGHT DATE: 09/14/93

Alt. Difference at CPA: 1481 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

Encounter ID 6 Filename R930914A.TR2

ENCOUNTER ID: 6

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

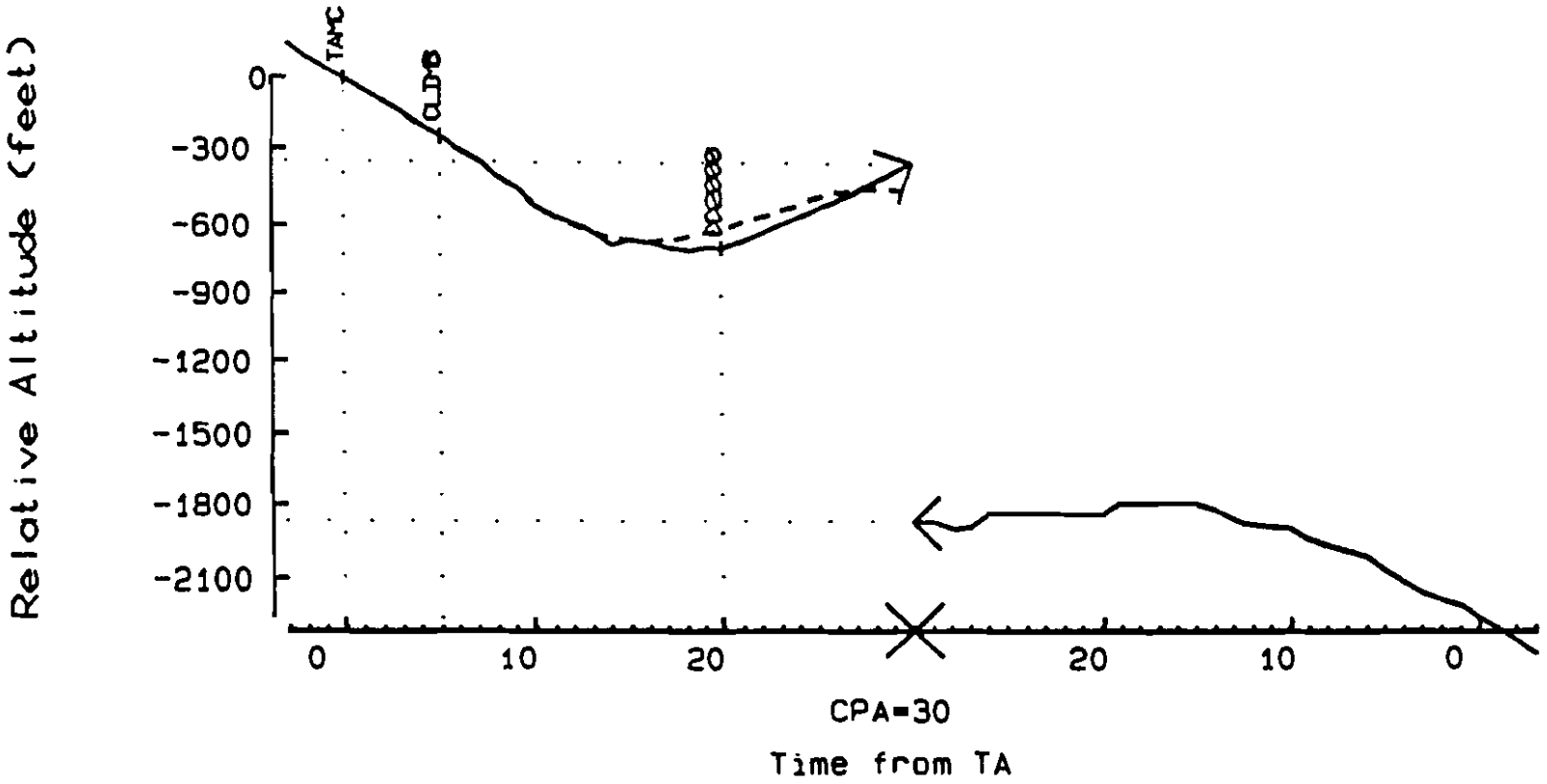
OWN ID: 10746022

RANGE RATE at TA: -498

at CPA: -188

RANGE at CPA: 1999 ft

Alt. Difference with Simulated Pilot Response: 1407 ft



TA TIME: 14: 12: 11

CPA TIME: 14: 12: 41

FLIGHT DATE: 09/14/93

Alt. Difference at CPA: 1520 ft

PROCESSED ON: 12/10/93 by ACO-320 FAA Technical Center

>

Encounter ID 463 Filename 8930914A.TR2

ENCOUNTER ID: 463

TARGET ID: 10746022

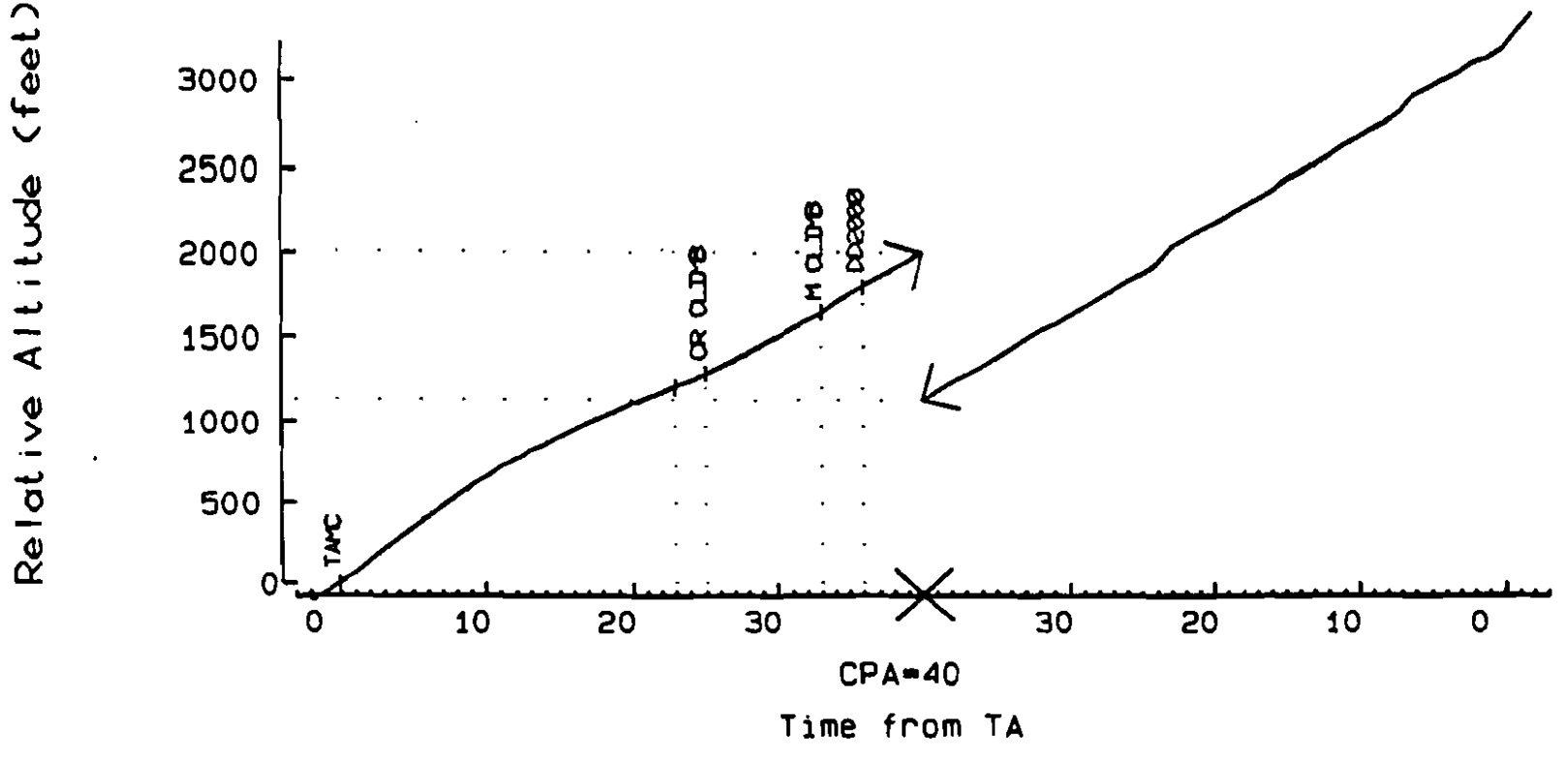
INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

RANGE RATE at TA: -493

at CPA: -67

RANGE at CPA: 3189 ft



TA TIME: 14:18:31 CPA TIME: 14:19:11

FLIGHT DATE: 09/14/93 Alt. Difference at CPA: 871 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

Encounter IO 52 Filename R930914A.TR2

ENCOUNTER ID: 52

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

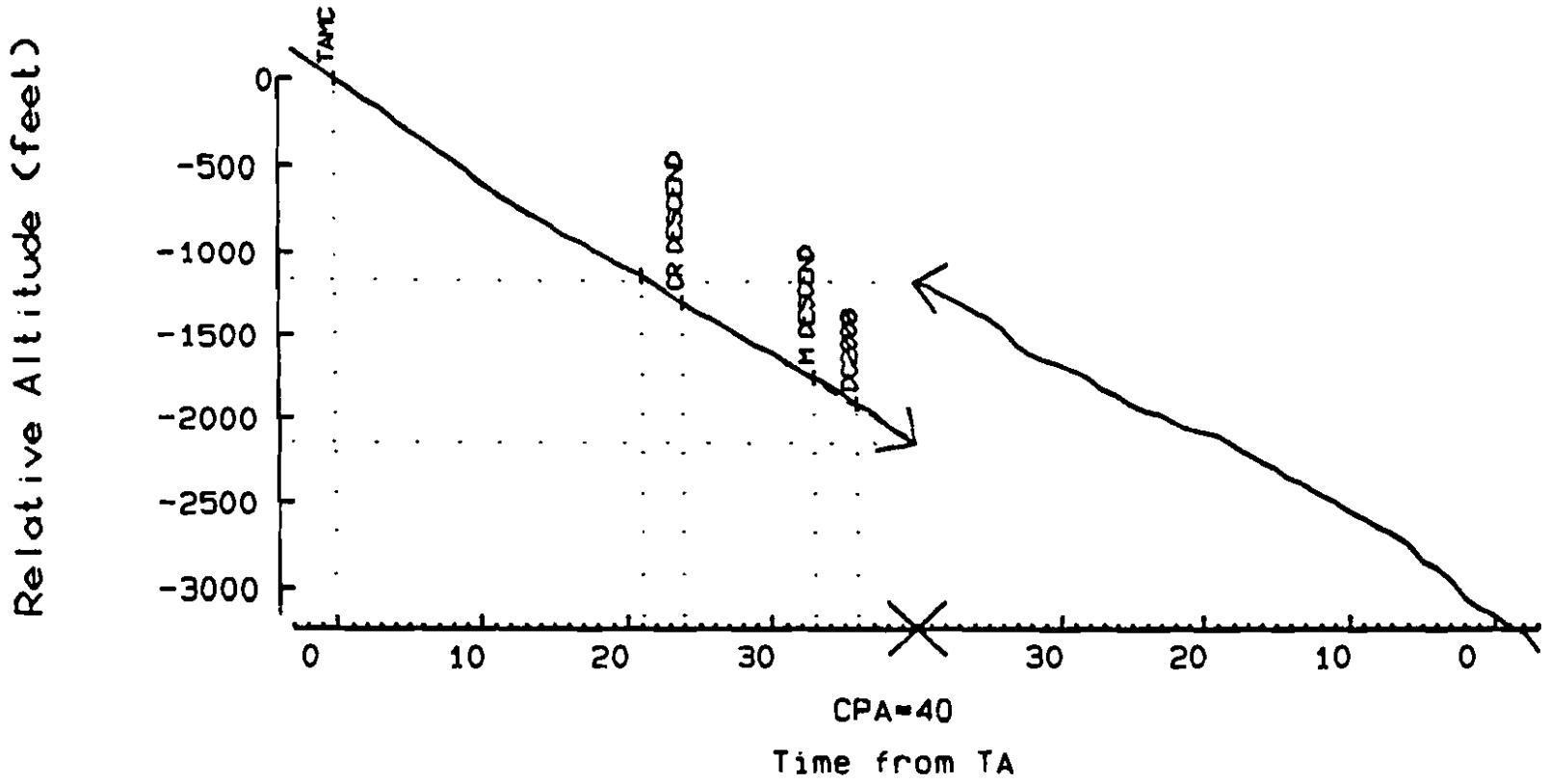
OWN ID: 10746022

RANGE RATE at TA: -485

at CPA: -177

RANGE at CPA: 2624 ft

Alt. Difference with Simulated Pilot Response: 964 ft



TA TIME: 14: 17: 53

CPA TIME: 14: 18: 33

FLIGHT DATE: 09/14/93

Alt. Difference at CPA: 975 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

>

Encounter IO 762 Filename B930914A.TR2

ENCOUNTER ID: 762

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

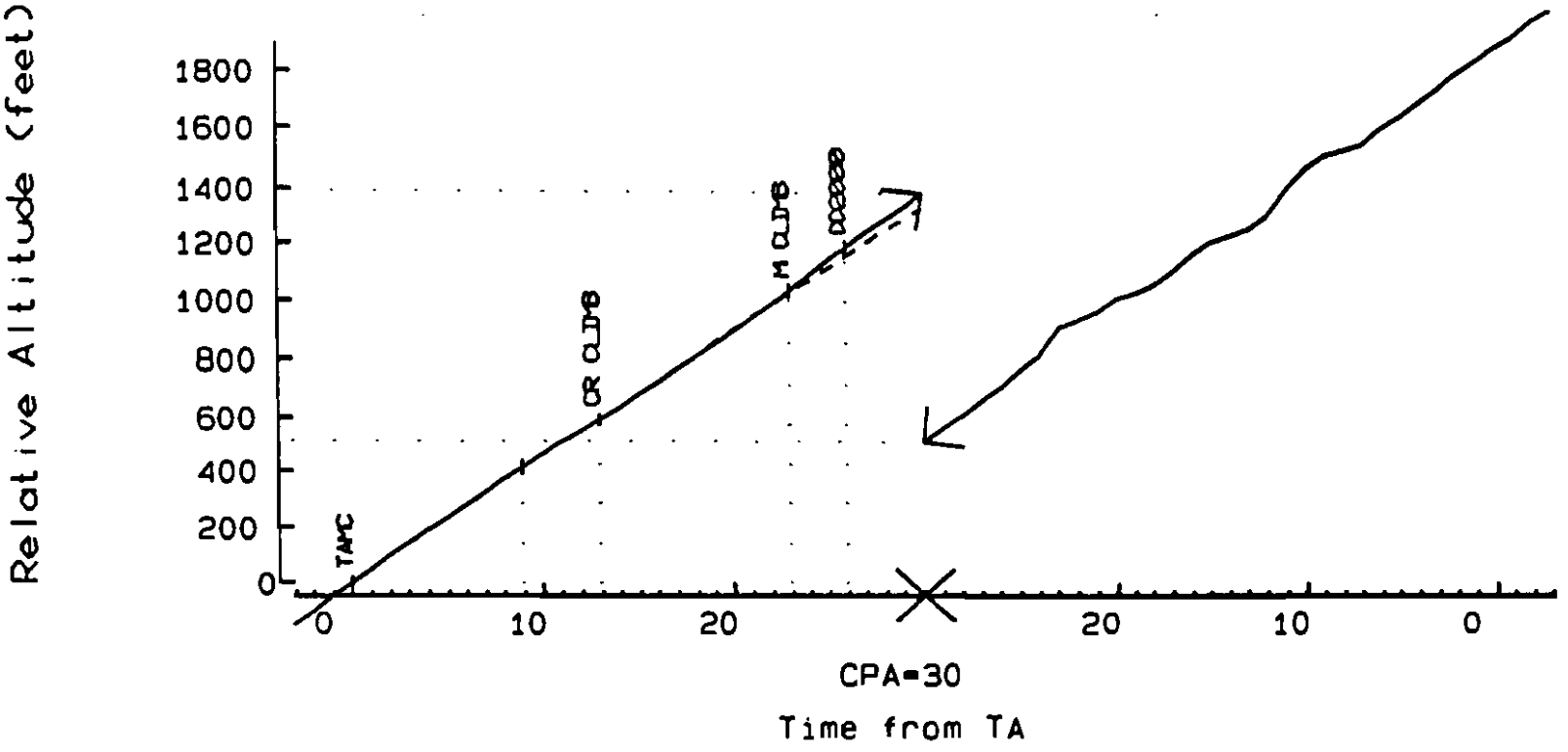
OWN ID: 10791495

RANGE RATE at TA: -502

at CPA: -136

RANGE at CPA: 2339 ft

Alt. Difference with Simulated Pilot Response: 828 ft



TA TIME: 14: 29: 13

CPA TIME: 14: 29: 43

FLIGHT DATE: 09/14/93

Alt. Difference at CPA: 880 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

Encounter ID 204 Filename R930914A.TR2

ENCOUNTER ID: 204

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

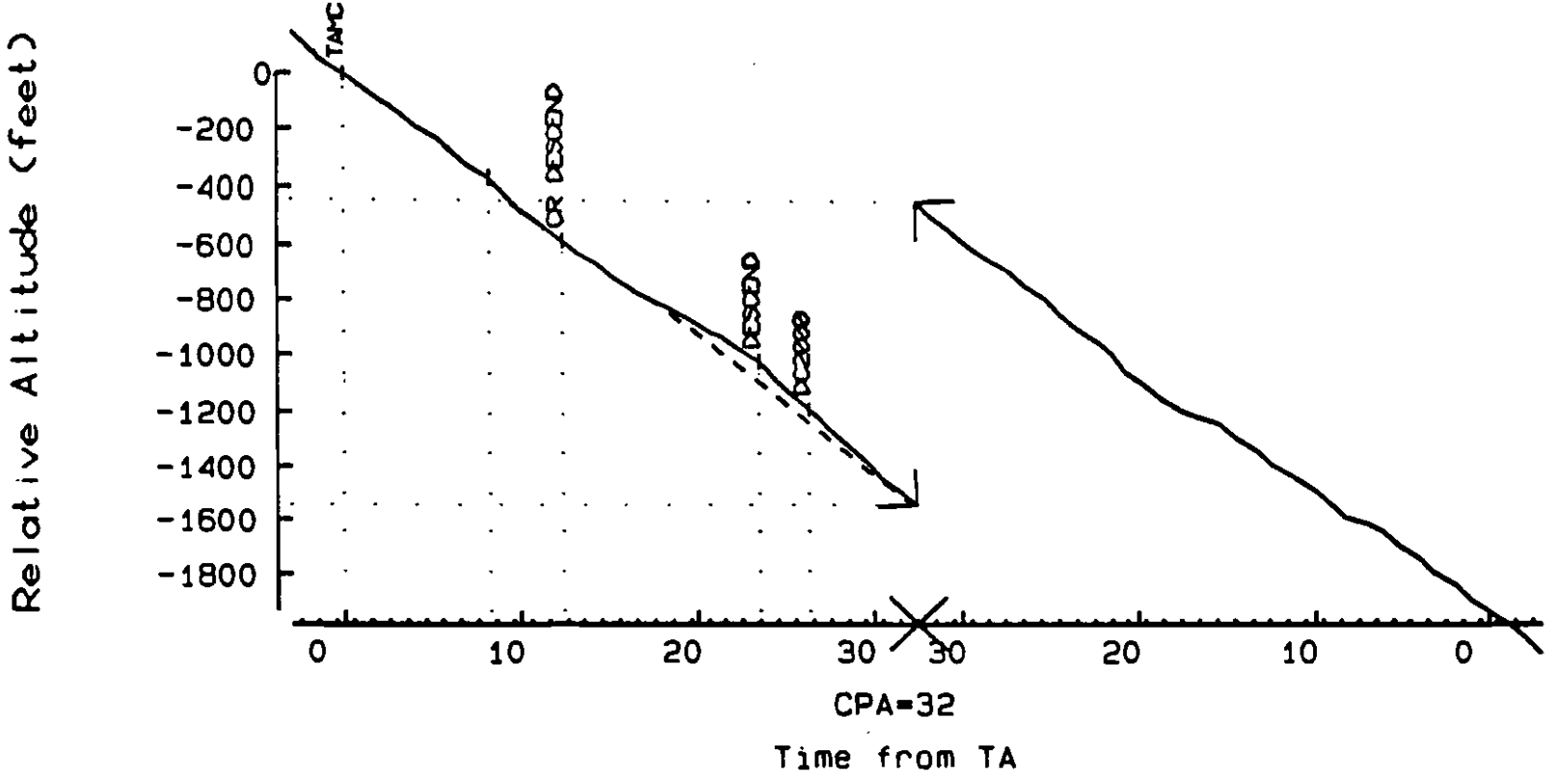
OWN ID: 10746022

RANGE RATE at TA: -511

at CPA: -185

RANGE at CPA: 1755 ft

Alt. Difference with Simulated Pilot Response: 1112 ft



TA TIME: 14: 28: 34

CPA TIME: 14: 29: 06

FLIGHT DATE: 09/14/93

Alt. Difference at CPA: 1098 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

>

Encounter ID 910 Filename 8930914A.TR2

ENCOUNTER ID: 910

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

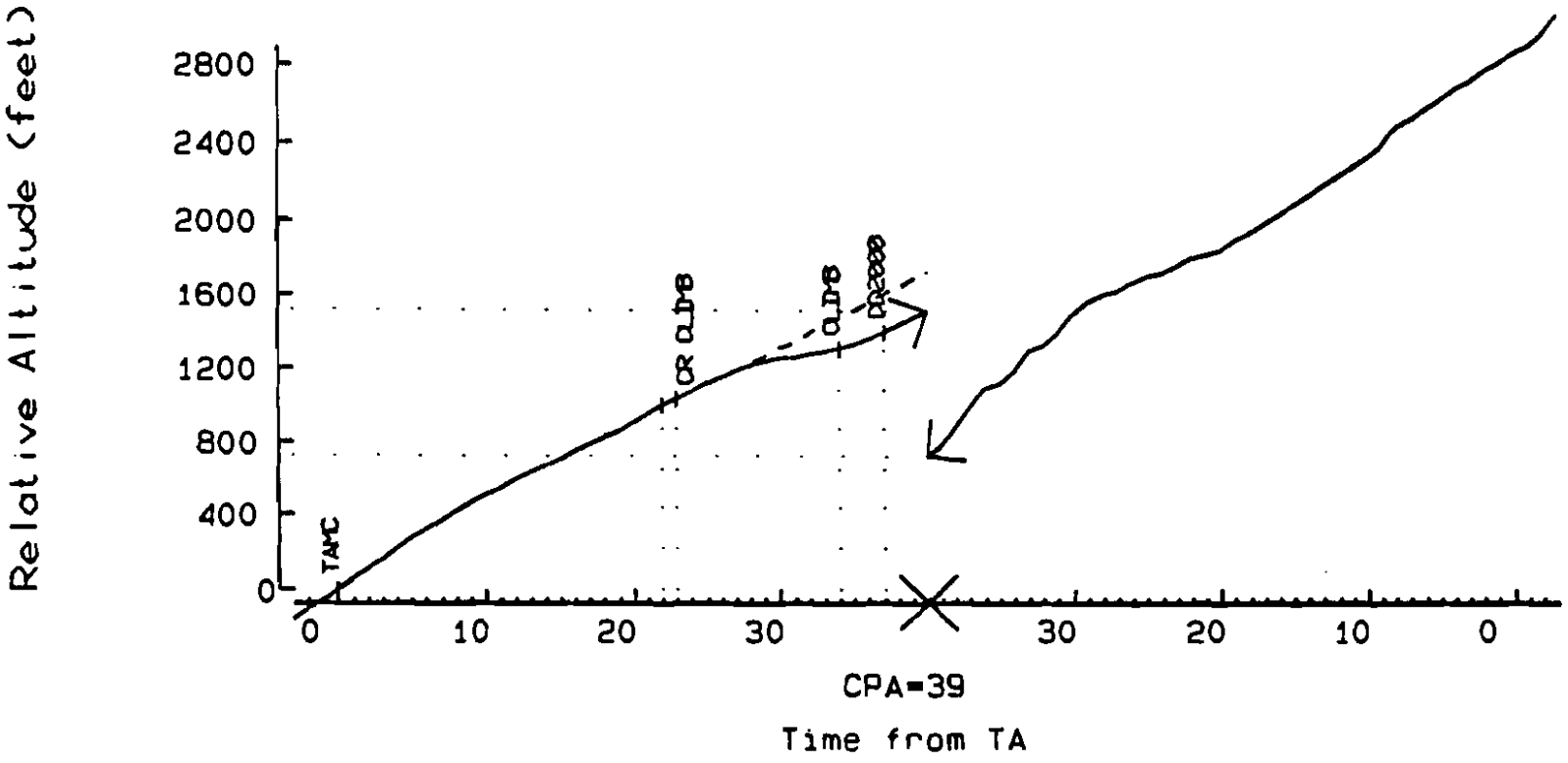
OWN ID: 10791495

RANGE RATE at TA: -497

at CPA: -142

RANGE at CPA: 2643 ft

Alt. Difference with Simulated Pilot Response: 1001 ft



TA TIME: 14:34:10

CPA TIME: 14:34:50

FLIGHT DATE: 09/14/93

Alt. Difference at CPA: 789 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

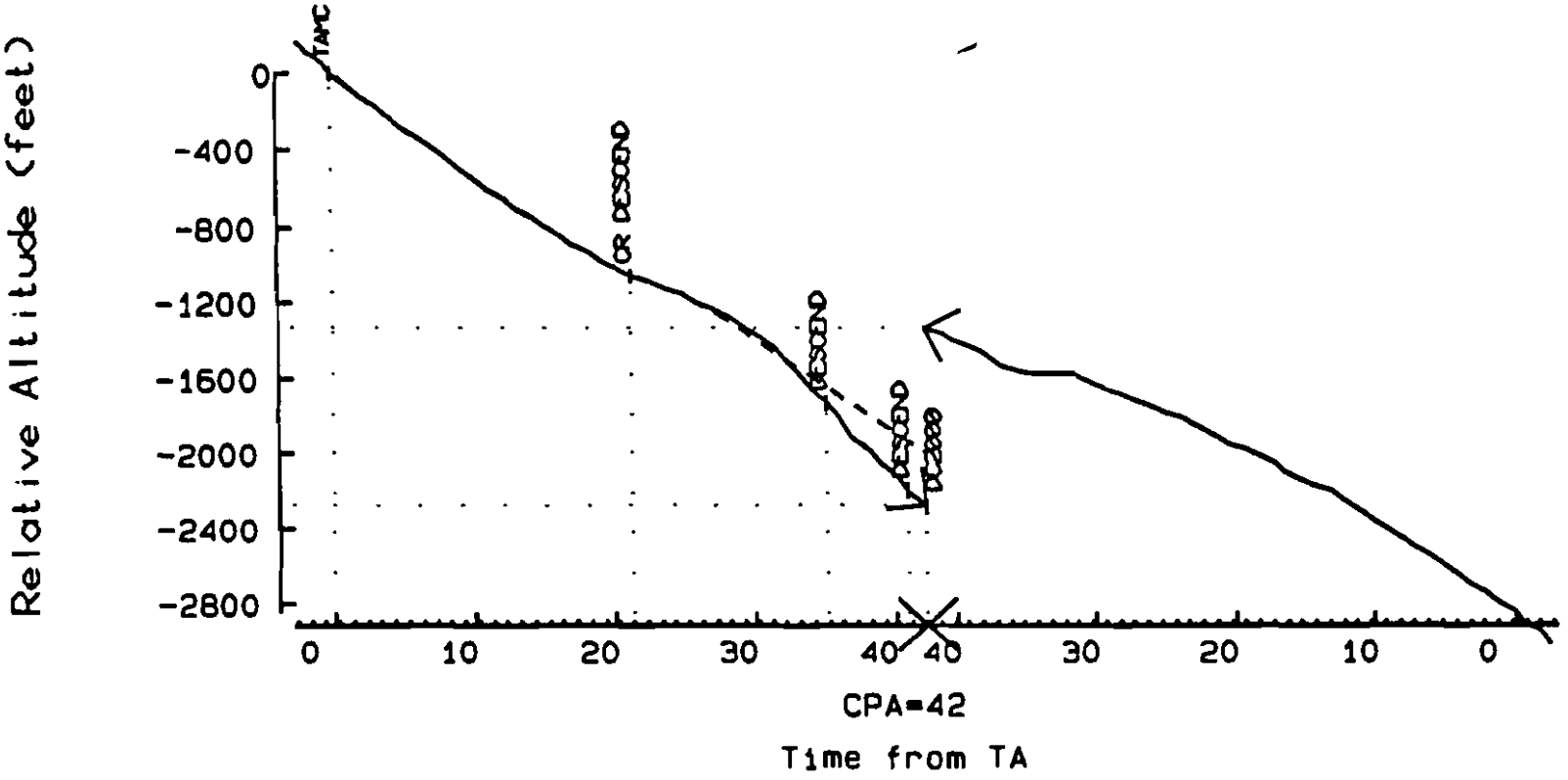
Encounter ID 204 Filename R930914A.TR2

ENCOUNTER ID: 204 RANGE RATE at TA: -484

TARGET ID: 10791495 at CPA: -169

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2096 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 668 ft



TA TIME: 14: 33: 31 CPA TIME: 14: 34: 13

FLIGHT DATE: 09/14/93 Alt. Difference at CPA: 956 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

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>

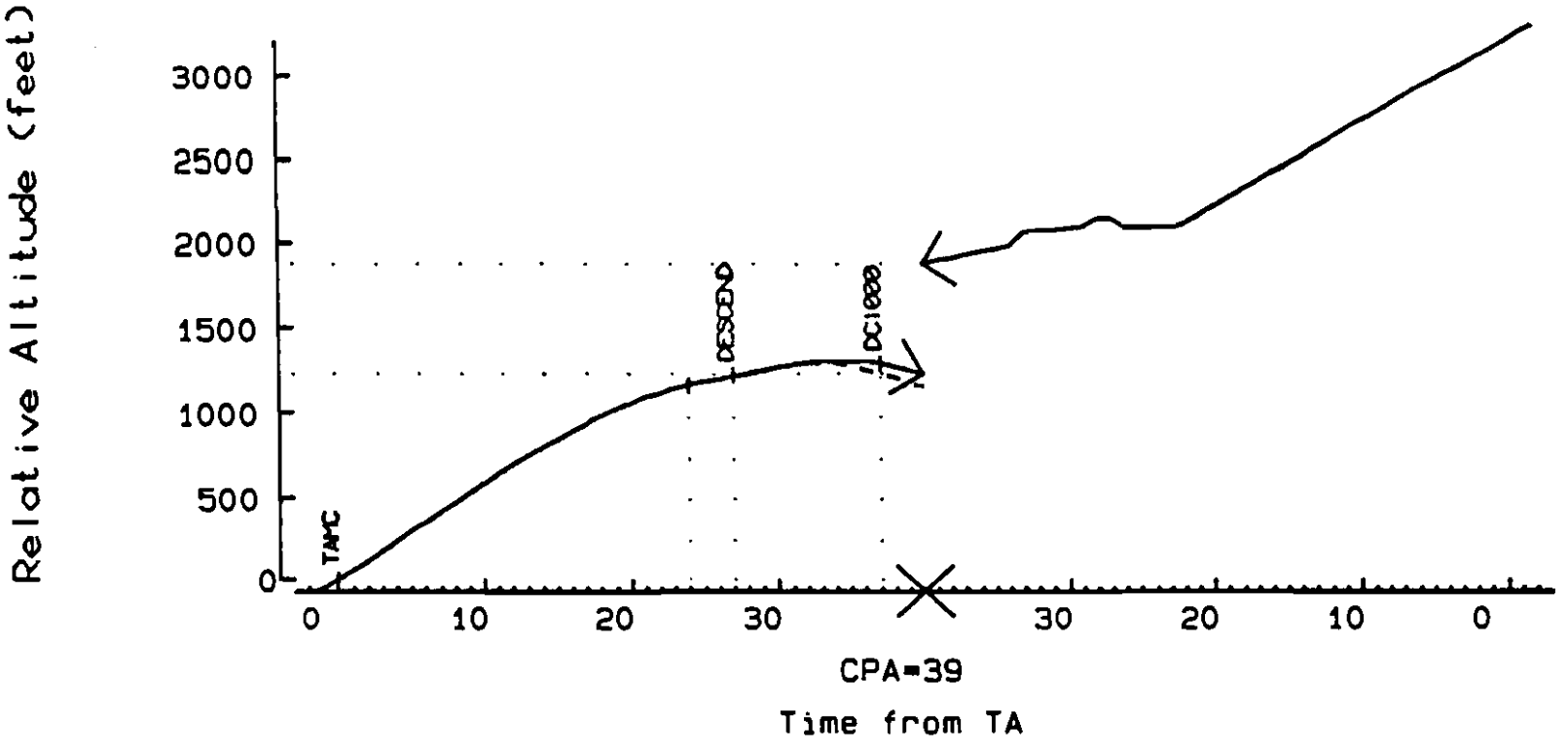
Encounter ID 994 Filename B930914A.TR2

ENCOUNTER ID: 994 RANGE RATE at TA: -504

TARGET ID: 10746022 at CPA: -151

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2308 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 720 ft



TA TIME: 14: 39: 26 CPA TIME: 14: 40: 06

FLIGHT DATE: 09/14/93 Alt. Difference at CPA: 645 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

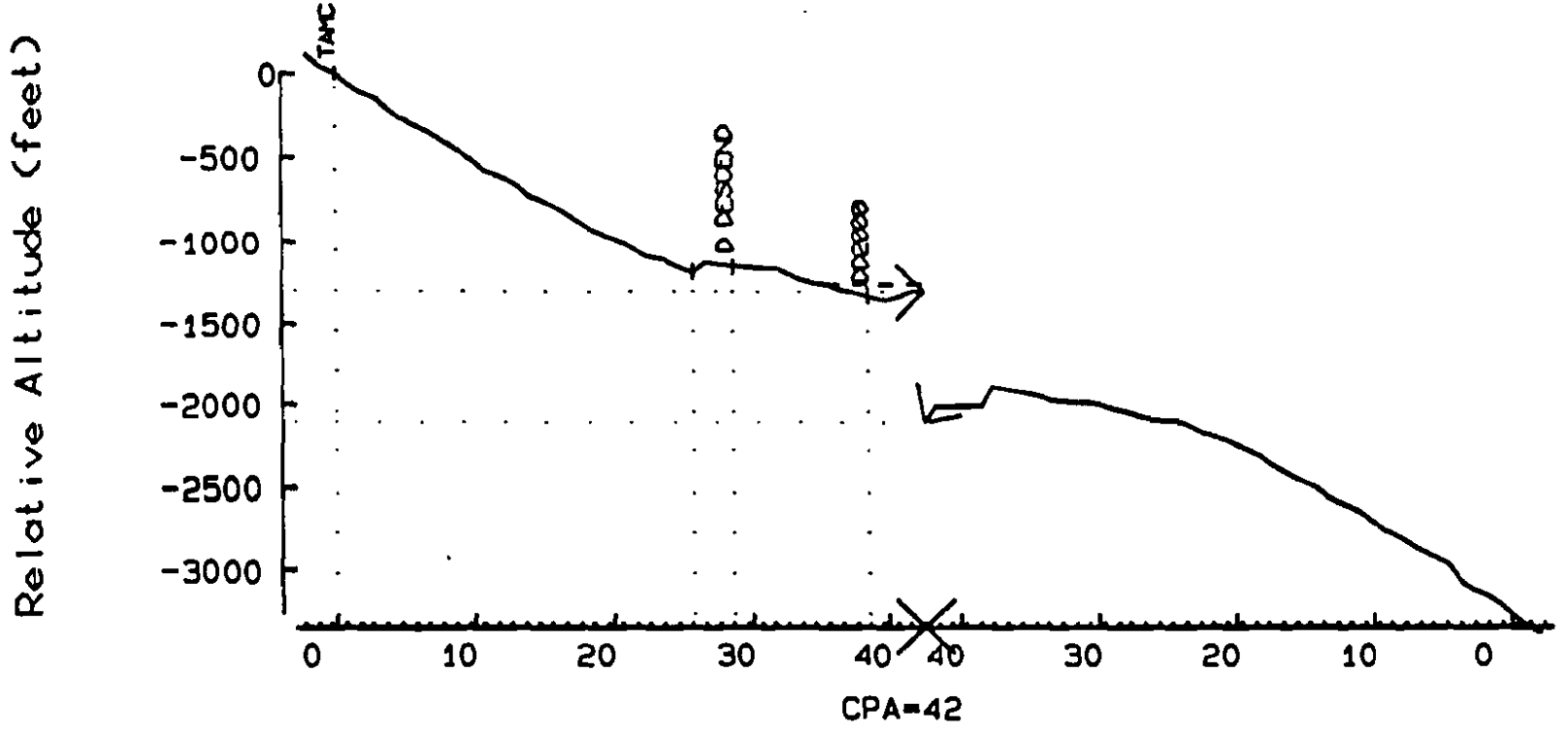
Encounter ID 318 Filename R930914A.TR2

ENCOUNTER ID: 318 RANGE RATE at TA: -509

TARGET ID: 10791495 at CPA: -197

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 1786 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 827 ft



TA TIME: 14: 38: 46 CPA TIME: 14: 39: 29

FLIGHT DATE: 09/14/93 Alt. Difference at CPA: 787 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

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>

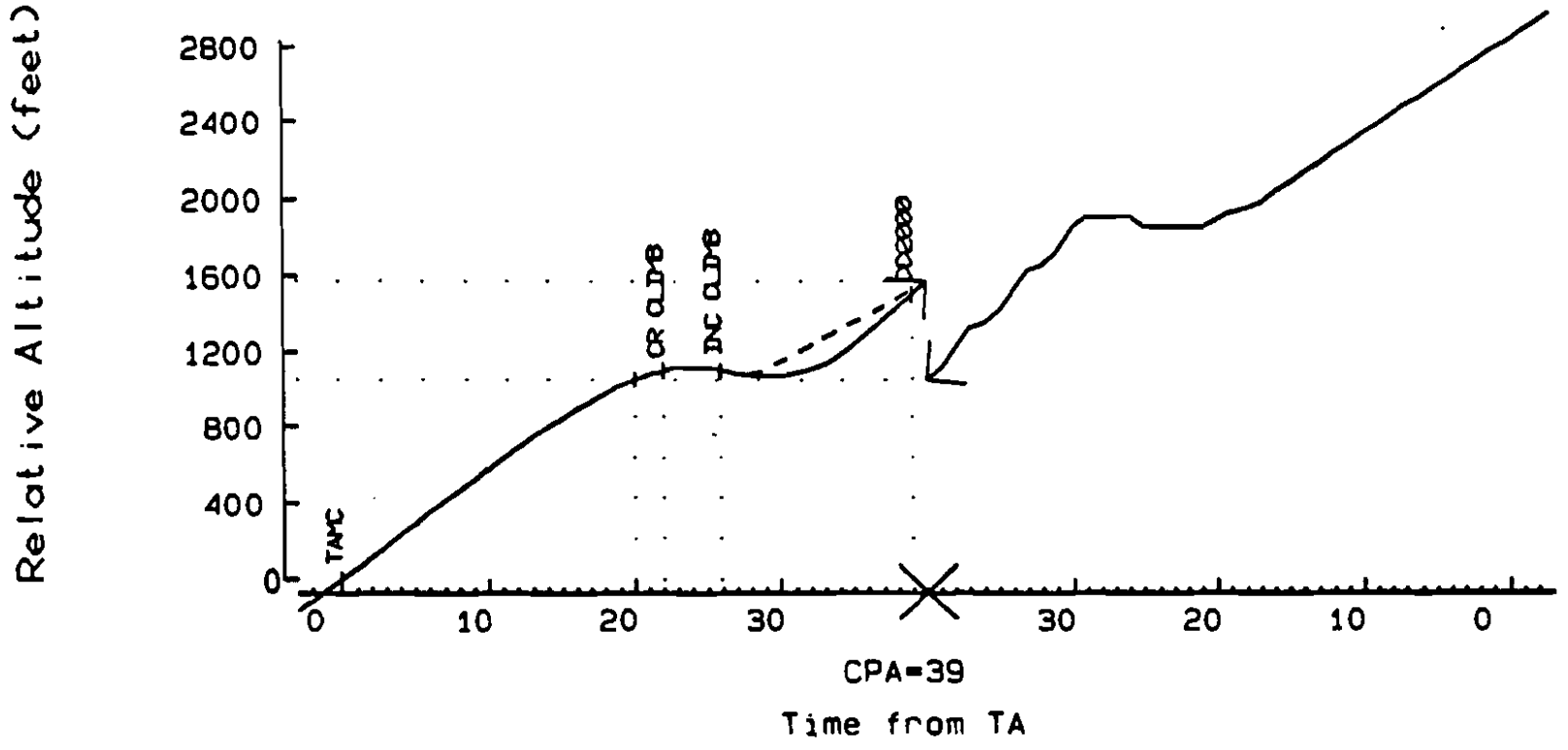
Encounter ID 1246 Filename 8930914A.TR2

ENCOUNTER ID: 1246 RANGE RATE at TA: -485

TARGET ID: 10746022 at CPA: -52

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 4873 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 507 ft



TA TIME: 14:45:19 CPA TIME: 14:45:59

FLIGHT DATE: 09/14/93 Alt. Difference at CPA: 514 ft

PROCESSED ON: 12/08/93 by ACO-320 FAA Technical Center

>

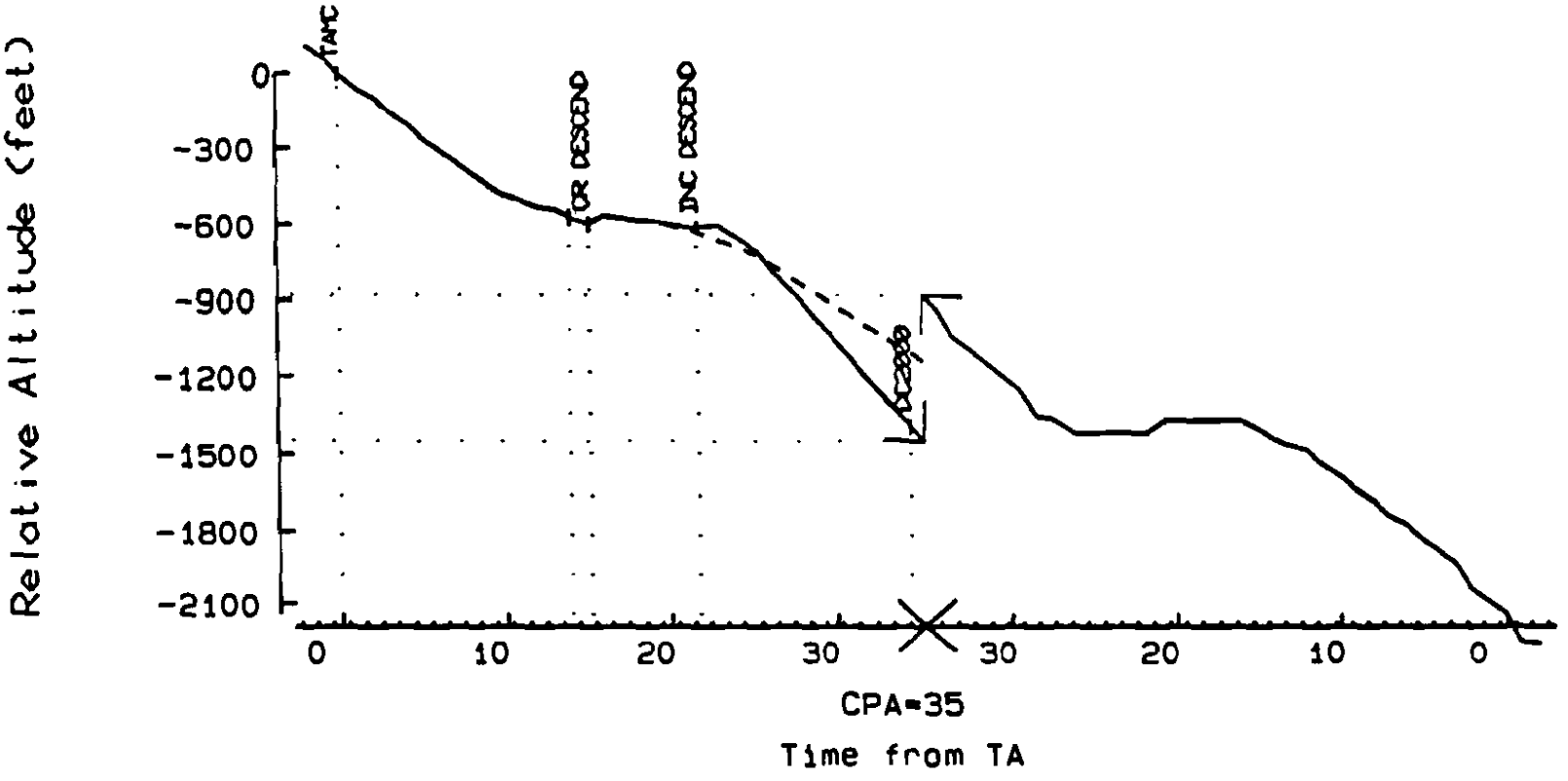
Encounter ID 368 Filename R930914A.TR2

ENCOUNTER ID: 368 RANGE RATE at TA: -484

TARGET ID: 10791495 at CPA: -167

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 4441 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 260 ft



TA TIME: 14: 44: 46 CPA TIME: 14: 45: 21

FLIGHT DATE: 09/14/93 Alt. Difference at CPA: 567 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

Encounter ID 348 Filename 8930915A.TRD

ENCOUNTER ID: 348

TARGET ID: 10746022

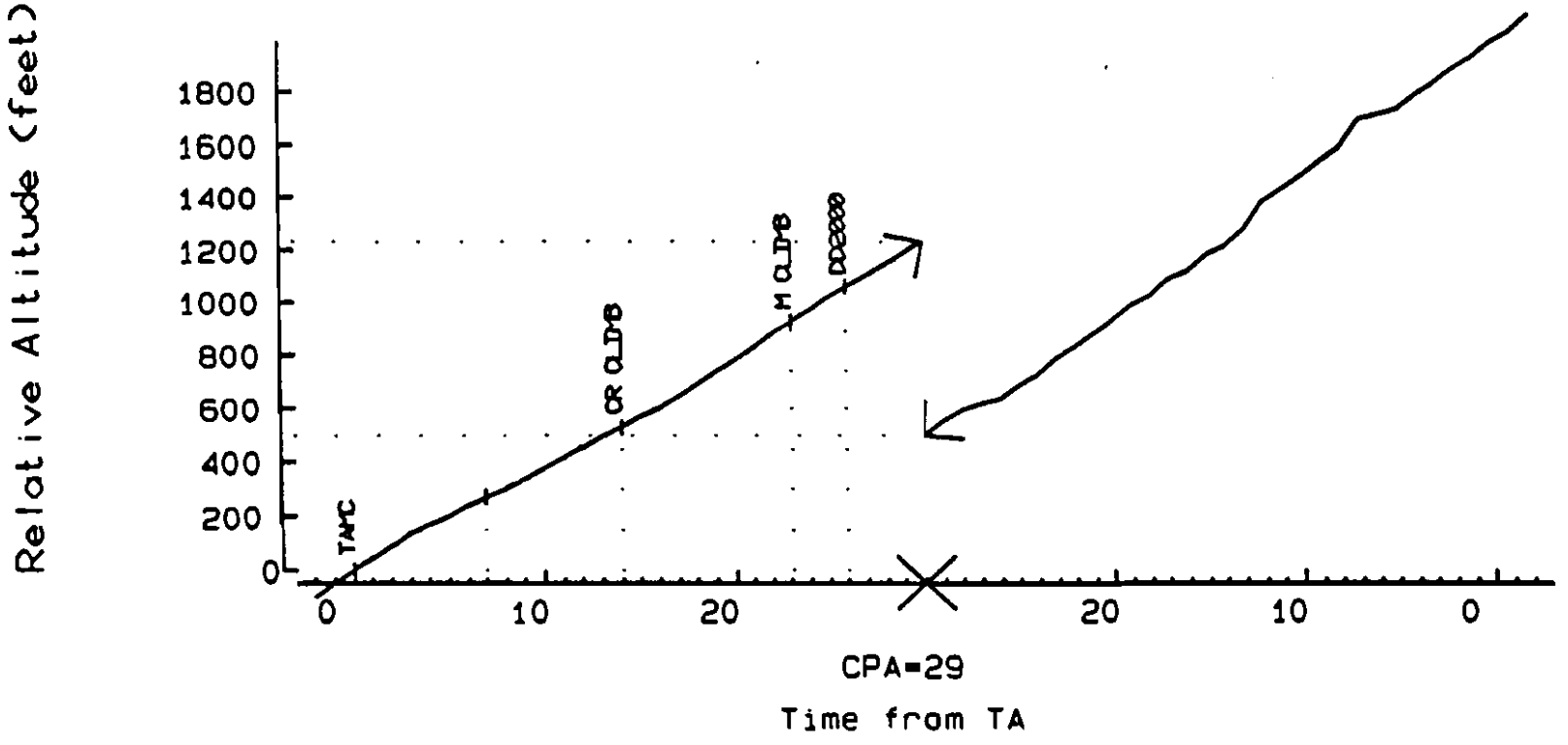
INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

RANGE RATE at TA: -485

at CPA: -54

RANGE at CPA: 1901 ft



TA TIME: 09: 38: 55

CPA TIME: 09: 39: 25

FLIGHT DATE: 09/15/93

Alt. Difference at CPA: 737 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

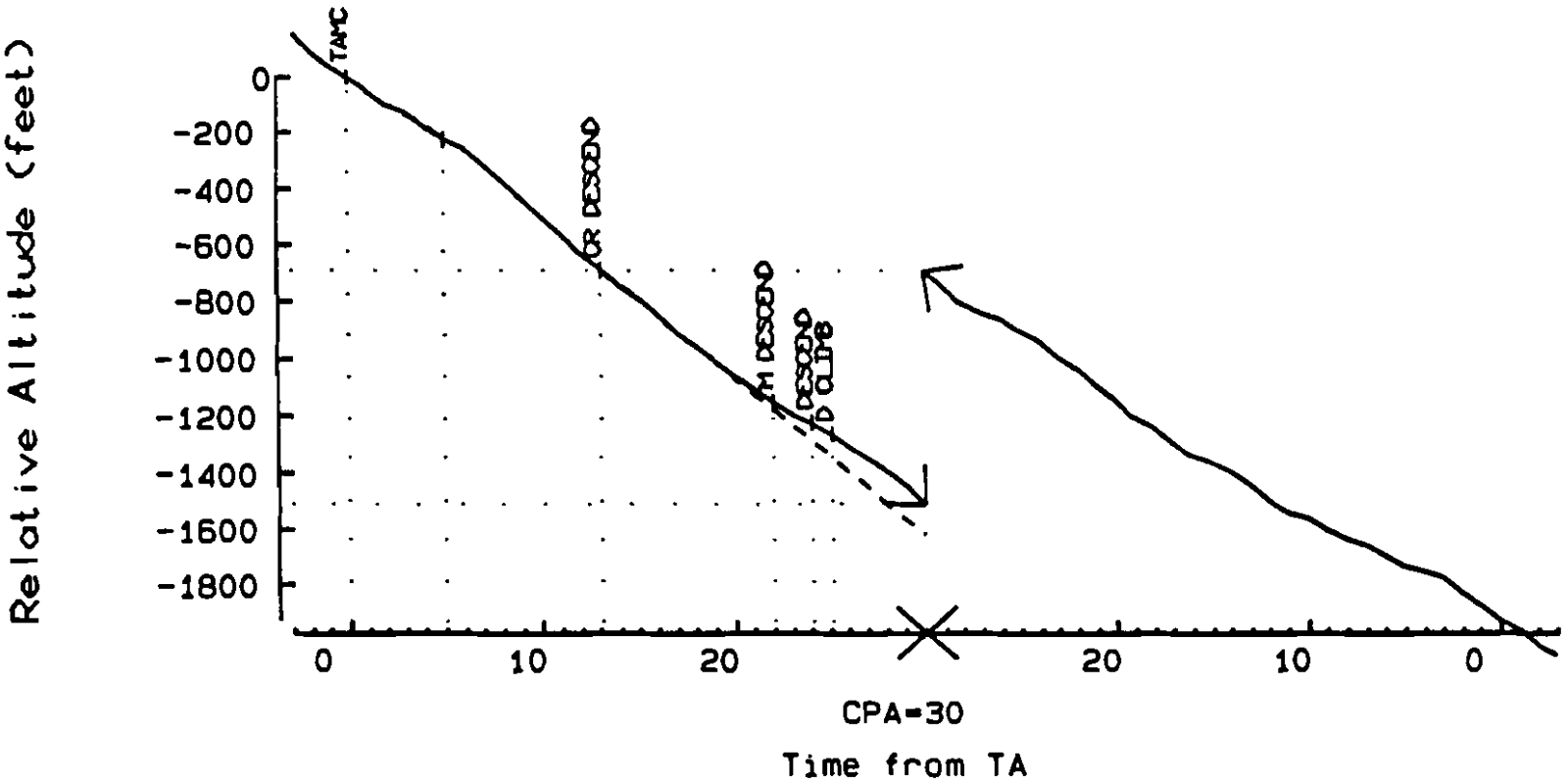
Encounter ID 135 Filename R930915A.TRD

ENCOUNTER ID: 135 RANGE RATE at TA: -470

TARGET ID: 10791495 at CPA: -254

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 1282 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 920 ft



TA TIME: 09:38:05 CPA TIME: 09:38:35

FLIGHT DATE: 09/15/93 Alt. Difference at CPA: 813 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

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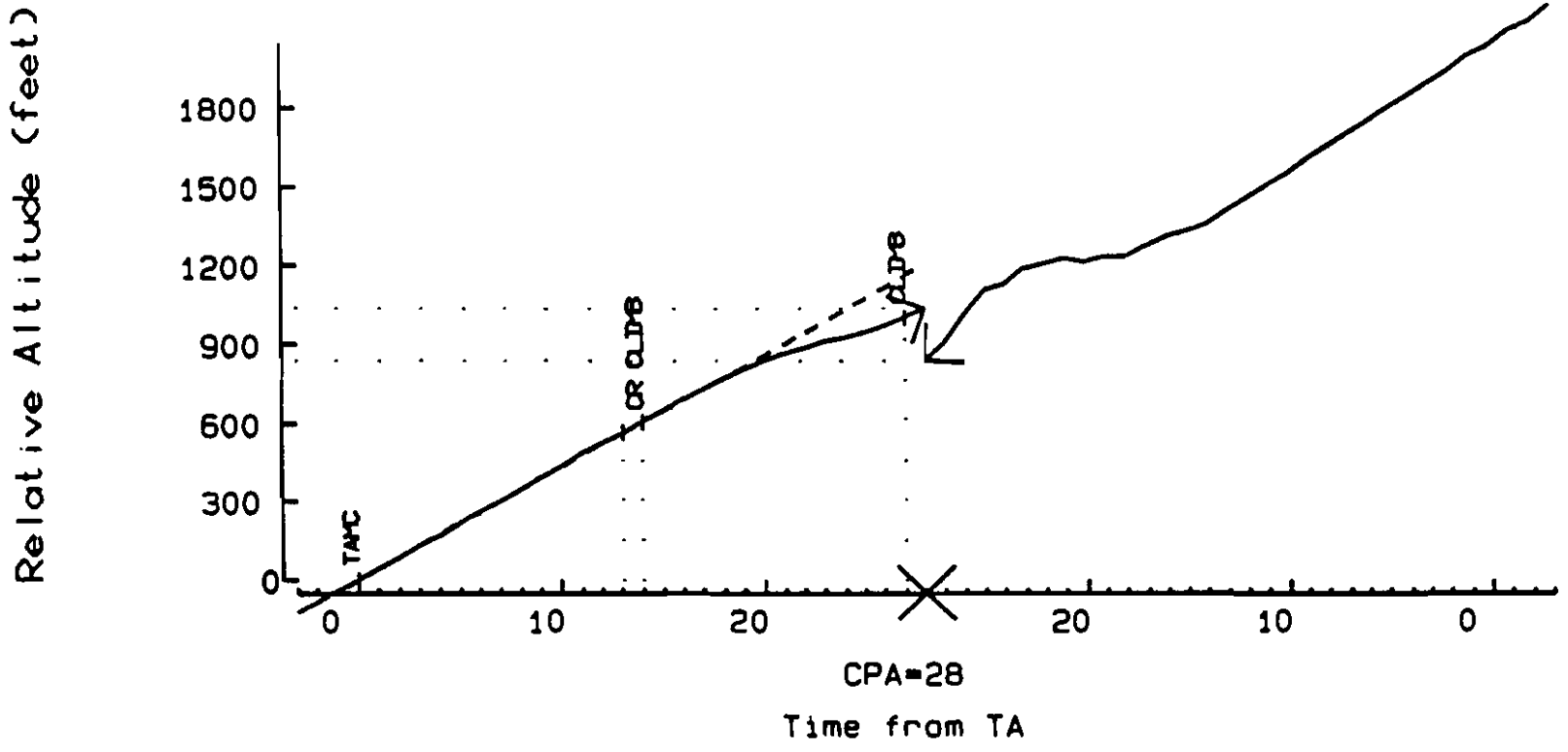
Encounter ID 905 Filename B930915A.TRO

ENCOUNTER ID: 905 RANGE RATE at TA: -484

TARGET ID: 10746022 at CPA: -105

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 6300 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 363 ft



TA TIME: 09:51:22 CPA TIME: 09:51:50

FLIGHT DATE: 09/15/93 Alt. Difference at CPA: 201 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

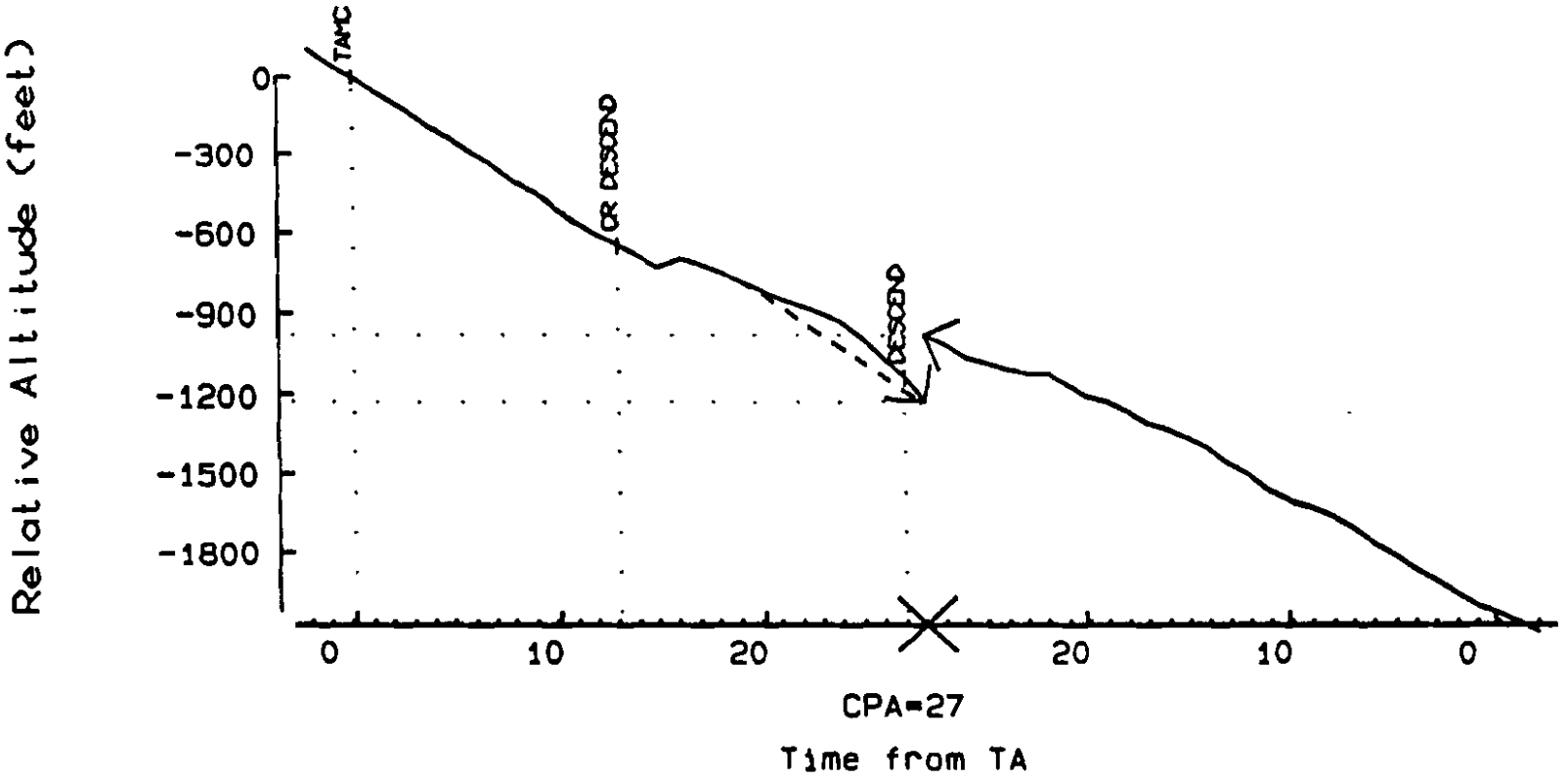
Encounter ID 227 Filename R930915A.TRD

ENCOUNTER ID: 227 RANGE RATE at TA: -483

TARGET ID: 10791495 at CPA: -146

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 5899 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 256 ft



TA TIME: 09:50:32 CPA TIME: 09:51:00

FLIGHT DATE: 09/15/93 Alt. Difference at CPA: 246 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

>

Encounter ID 1448 Filename 8930915A.TRD

ENCOUNTER ID: 1448

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

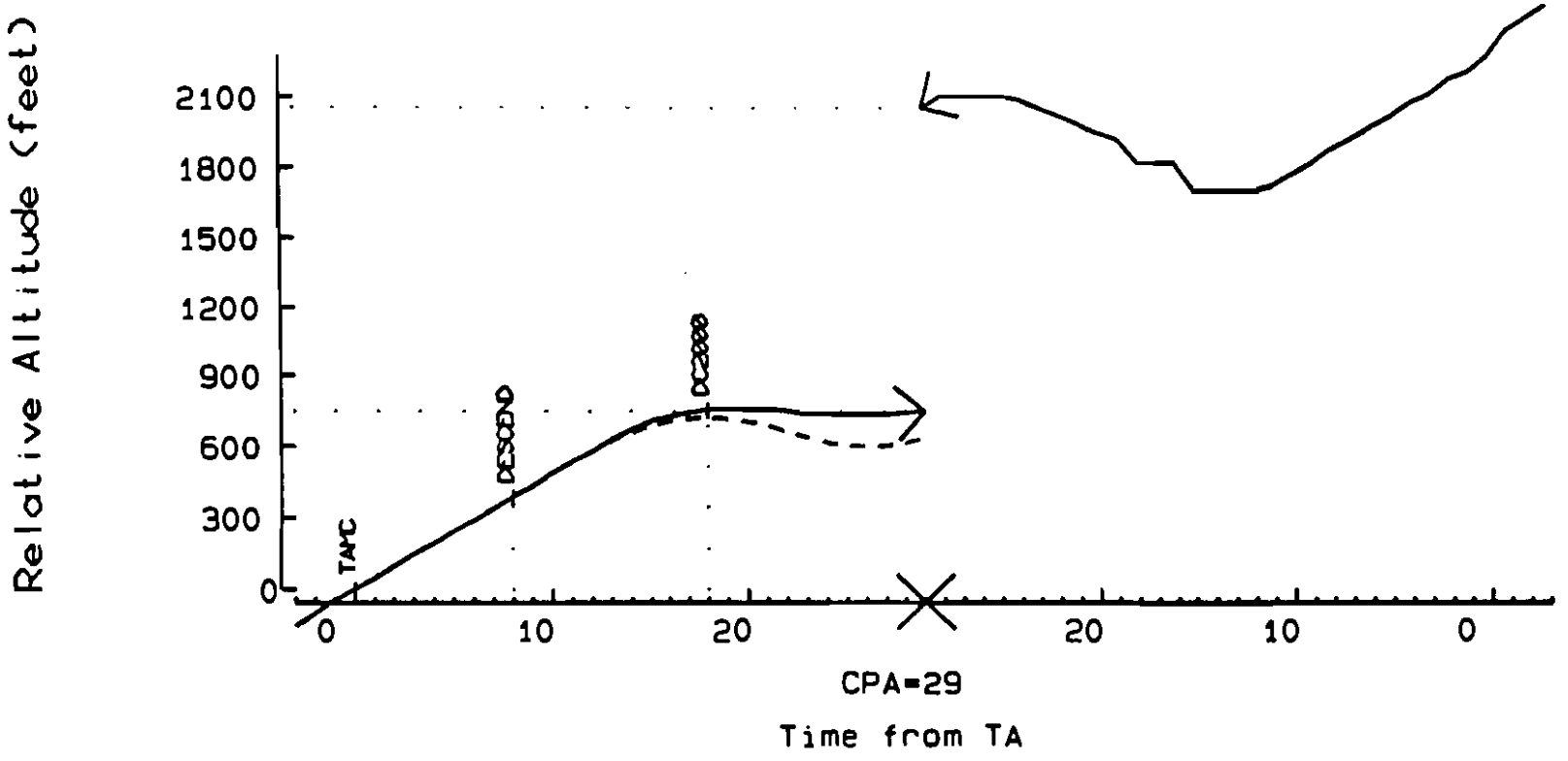
OWN ID: 10791495

RANGE RATE at TA: -496

at CPA: -104

RANGE at CPA: 6604 ft

Alt. Difference with Simulated Pilot Response: 1426 ft



TA TIME: 10: 03: 20

CPA TIME: 10: 03: 49

FLIGHT DATE: 09/15/93

Alt. Difference at CPA: 1302 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

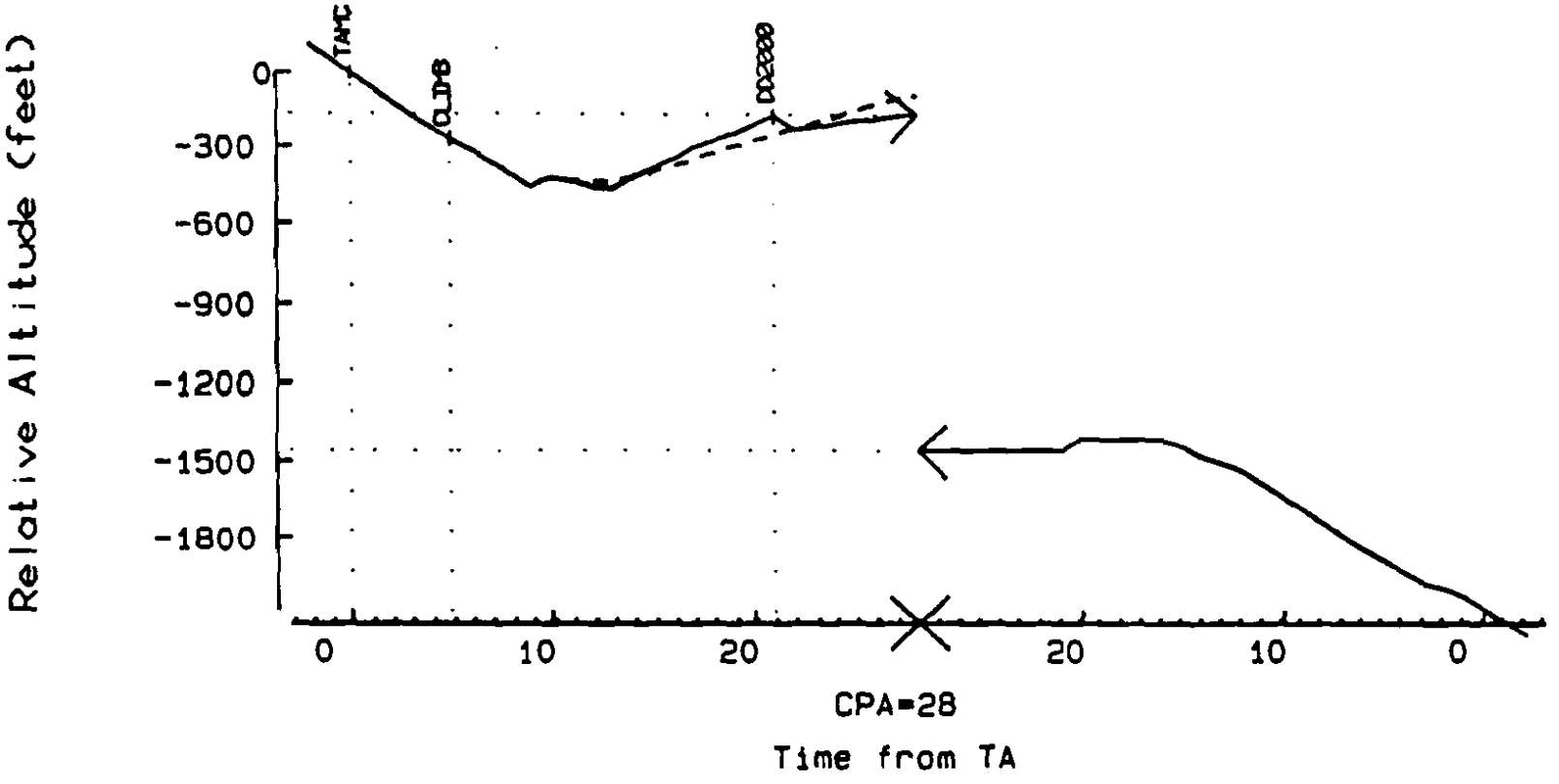
Encounter ID 333 Filename R930915A.TRD

ENCOUNTER ID: 333 RANGE RATE at TA: -488

TARGET ID: 10791495 at CPA: -118

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 6228 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1366 ft



TA TIME: 10: 02: 34 CPA TIME: 10: 03: 02

FLIGHT DATE: 09/15/93 Alt. Difference at CPA: 1294 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

>

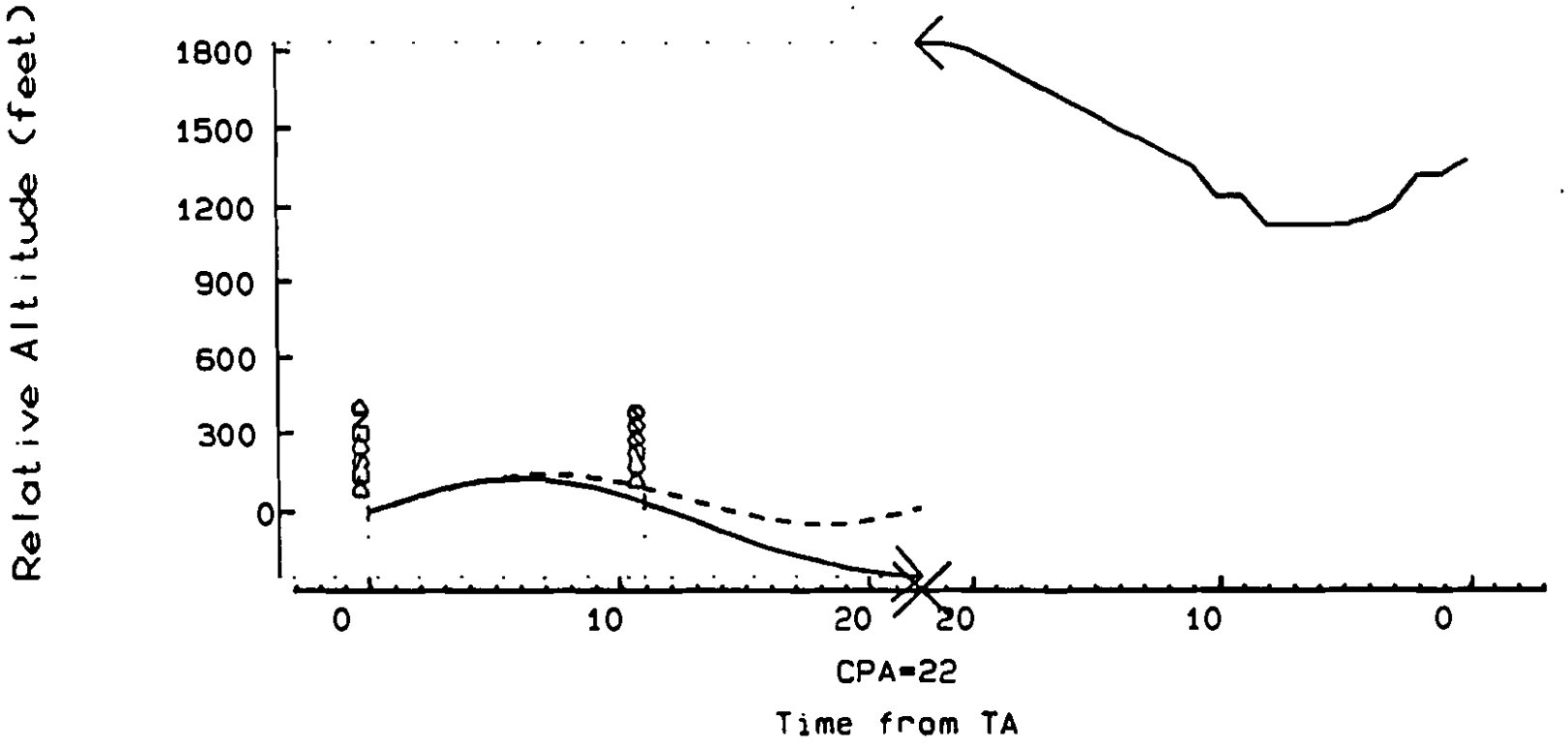
>Encounter ID 1830 Filename 8930915A.TRD

ENCOUNTER ID: 1830 RANGE RATE at TA: -482

TARGET ID: 10746022 at CPA: -51

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 3779 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1819 ft



TA TIME: 10:09:27 CPA TIME: 10:09:49

FLIGHT DATE: 09/15/93 Alt. Difference at CPA: 2078 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

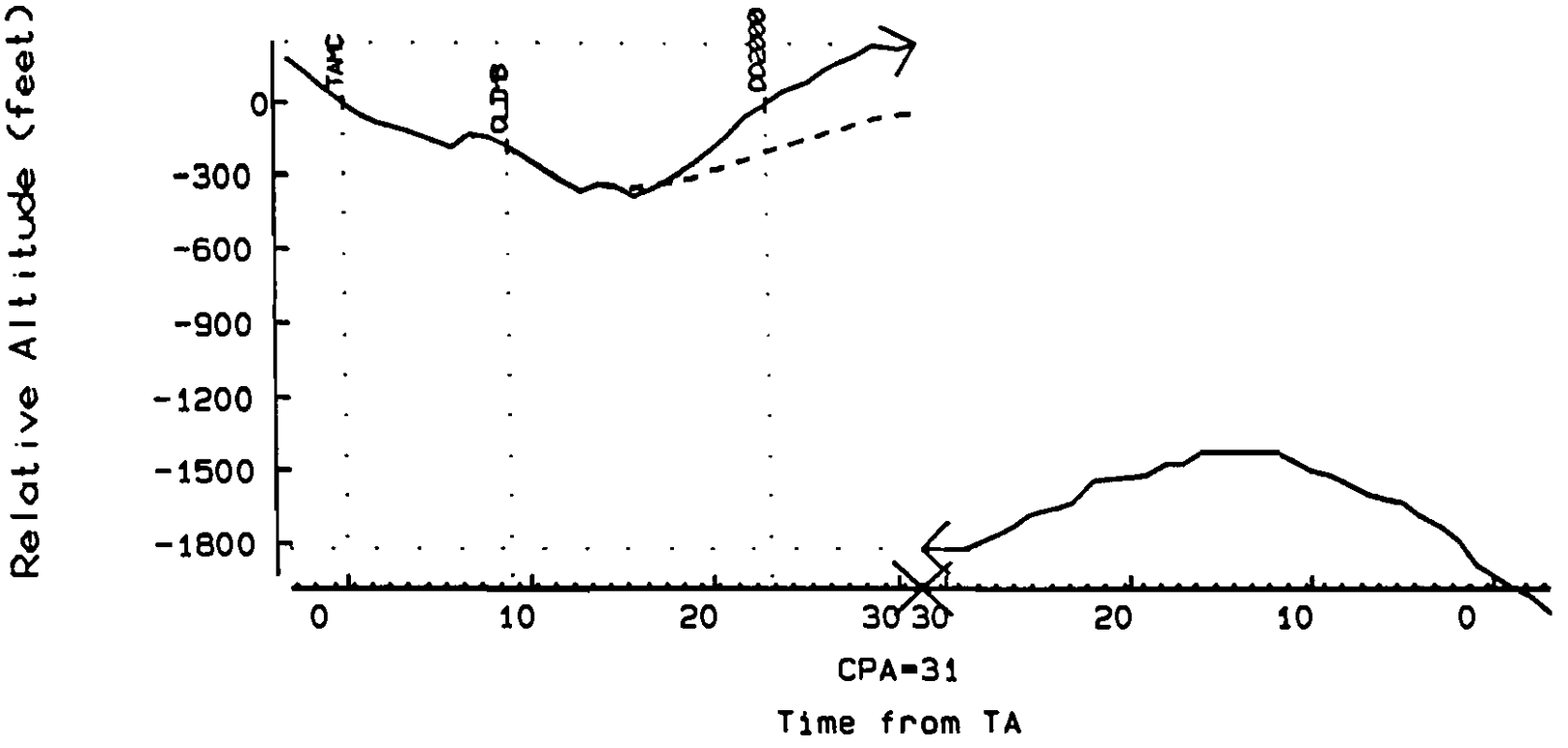
Encounter ID 333 Filename R930915A.TRD

ENCOUNTER ID: 333 RANGE RATE at TA: -503

TARGET ID: 10791495 at CPA: -152

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 3262 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1775 ft



TA TIME: 10: 08: 31 CPA TIME: 10: 09: 02

FLIGHT DATE: 09/15/93 Alt. Difference at CPA: 2069 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

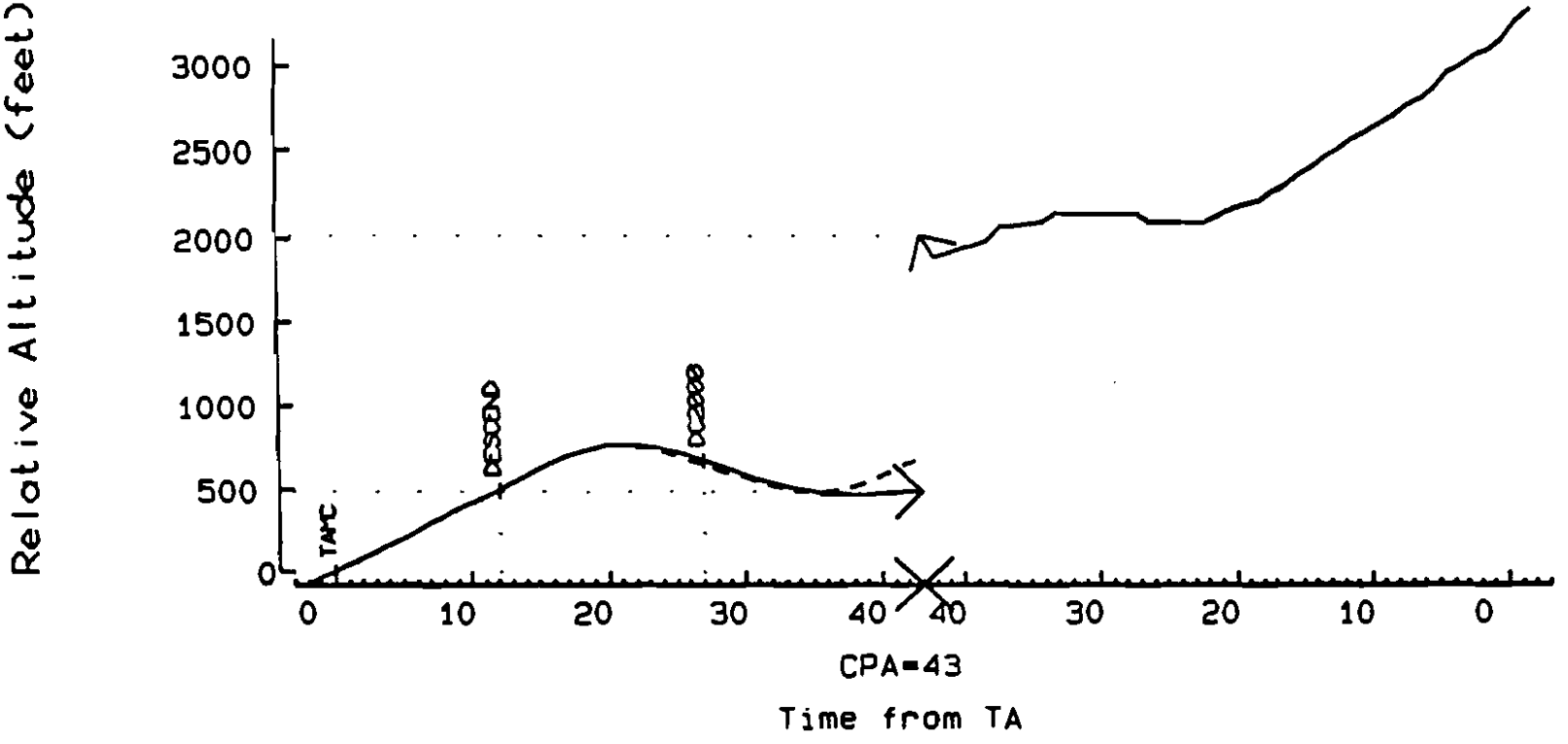
Encounter ID 680 Filename B930916A.TRD

ENCOUNTER ID: 680 RANGE RATE at TA: -509

TARGET ID: 10746022 at CPA: -111

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2521 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1324 ft



TA TIME: 10: 16: 48 CPA TIME: 10: 17: 31

FLIGHT DATE: 09/16/93 Alt. Difference at CPA: 1527 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

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>

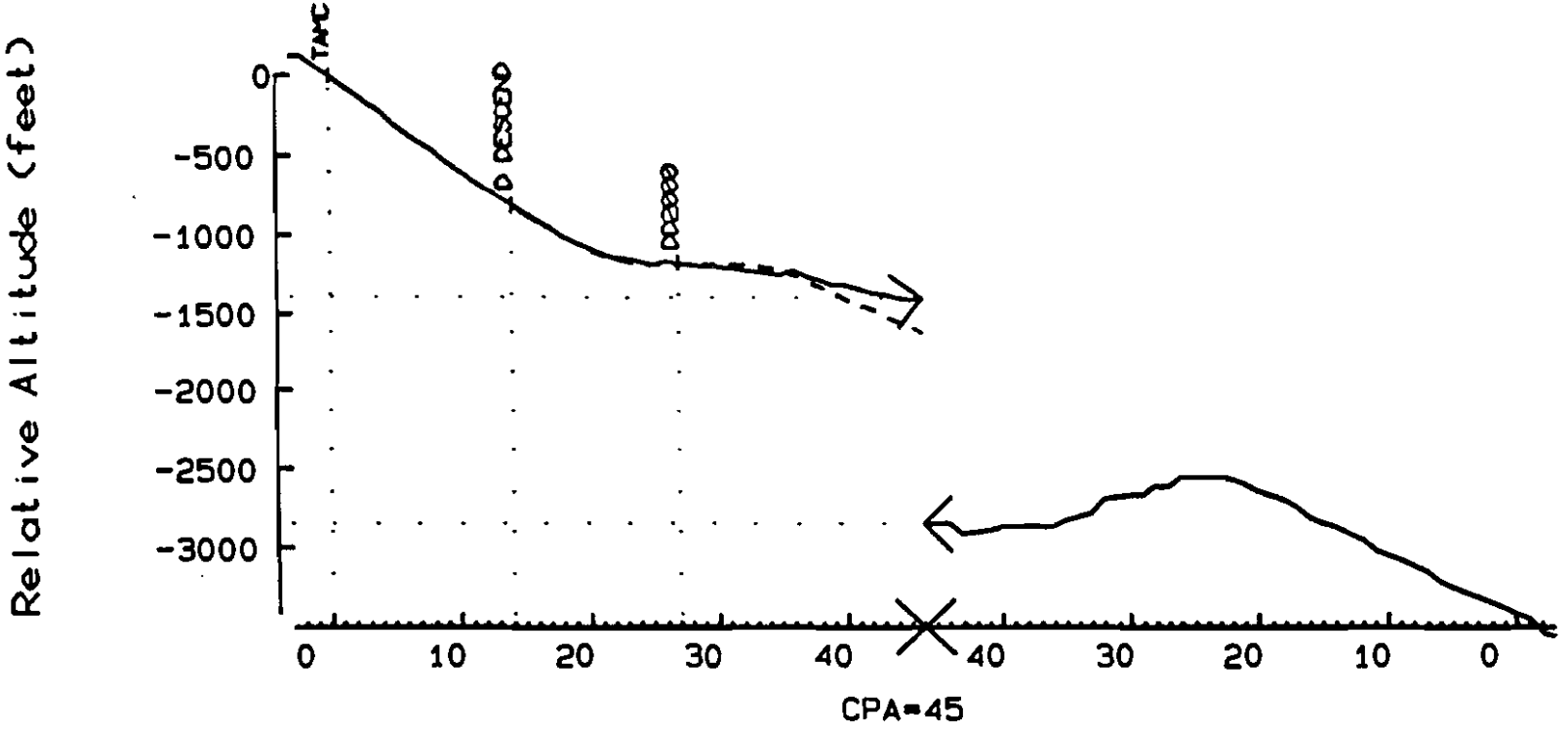
Encounter ID 109 Filename R930916A.TRD

ENCOUNTER ID: 109 RANGE RATE at TA: -508

TARGET ID: 10791495 at CPA: -276

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 1962 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1228 ft



TA TIME: 10: 15: 44 CPA TIME: 10: 16: 30

FLIGHT DATE: 09/16/93 Alt. Difference at CPA: 1455 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

>

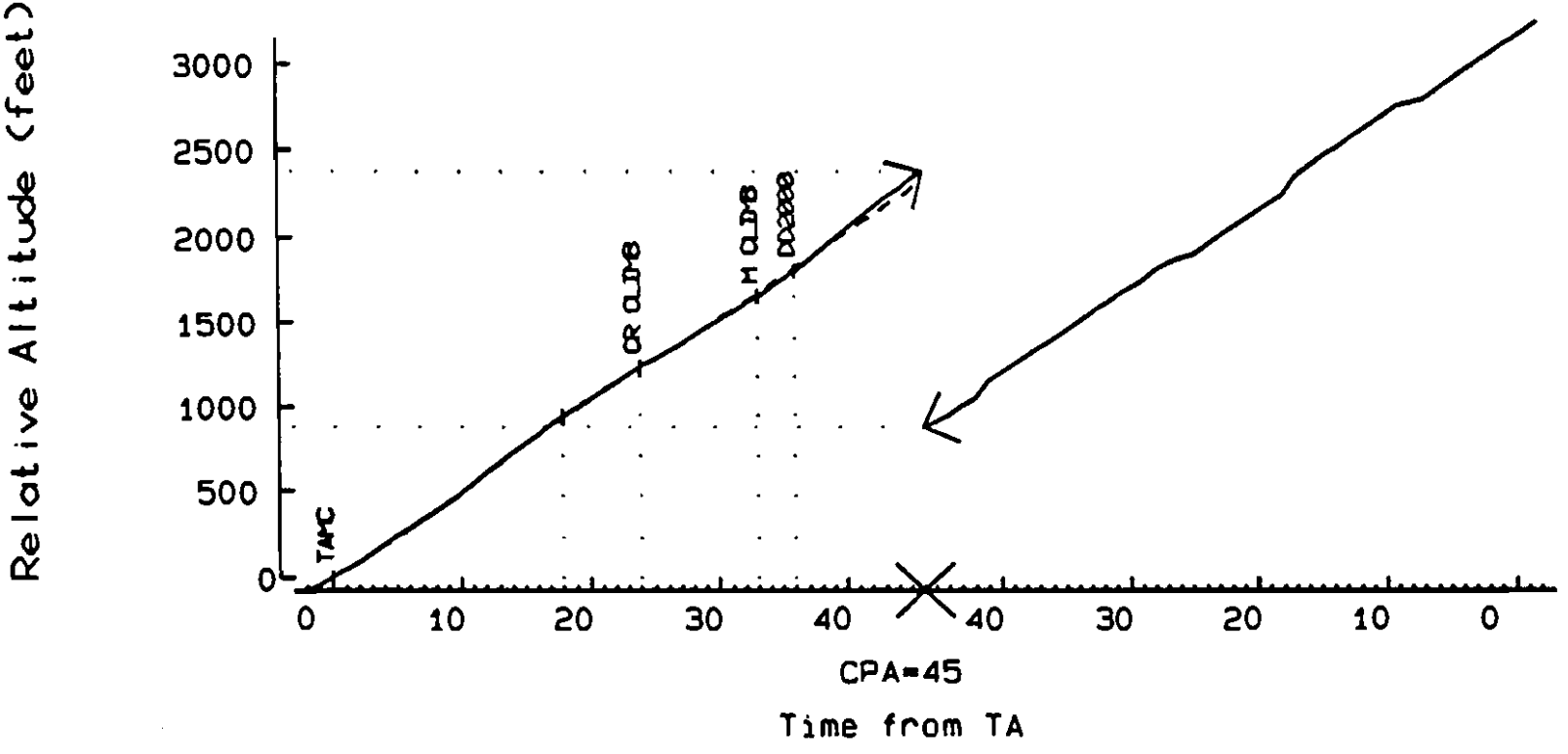
Encounter ID 750 Filename B930916A.TRD

ENCOUNTER ID: 750 RANGE RATE at TA: -504

TARGET ID: 10746022 at CPA: -109

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2795 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1455 ft



TA TIME: 10: 22: 36 CPA TIME: 10: 23: 22

FLIGHT DATE: 09/16/93 Alt. Difference at CPA: 1510 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

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>

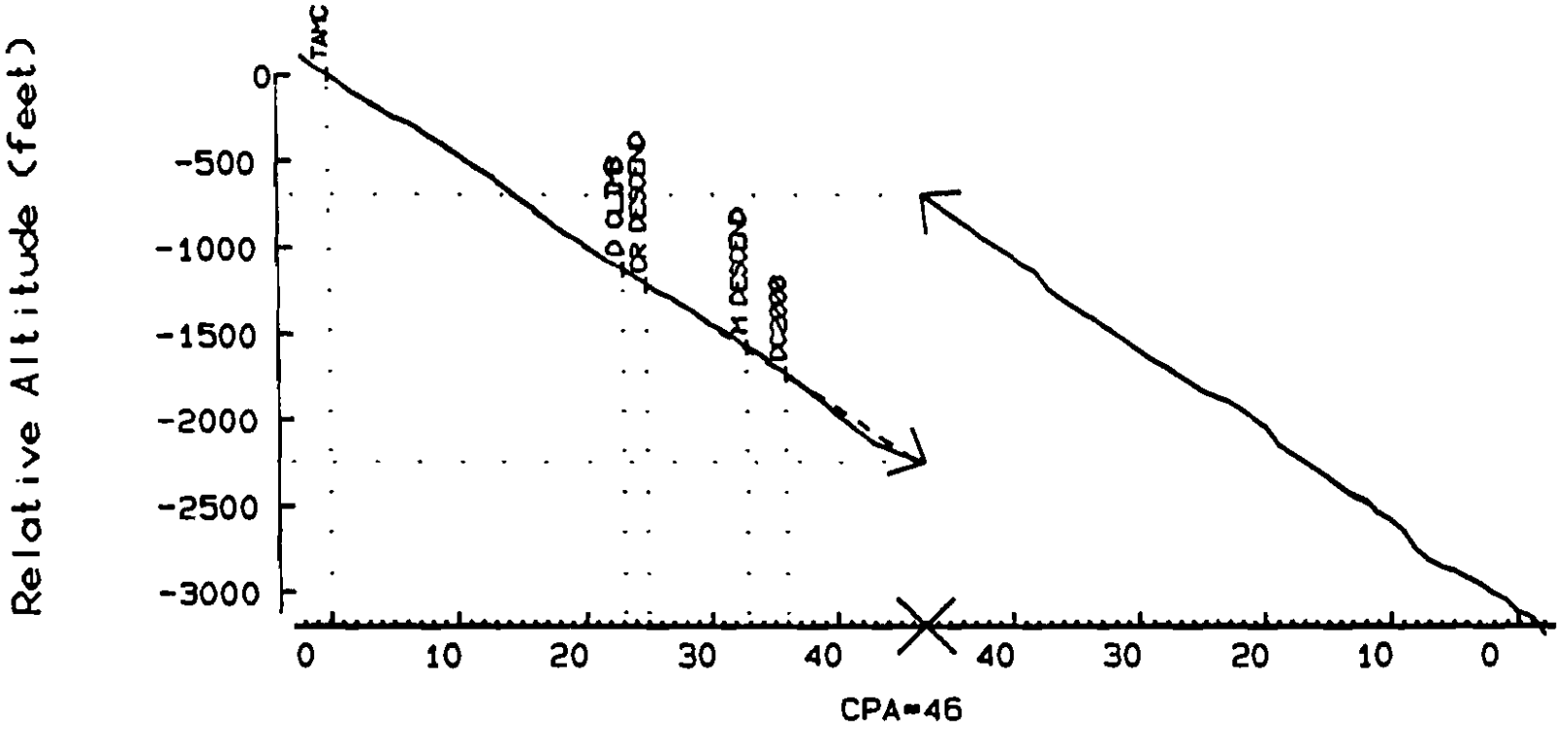
Encounter ID 132 Filename R930916A.TRD

ENCOUNTER ID: 132 RANGE RATE at TA: -498

TARGET ID: 10791495 at CPA: -180

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2217 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1586 ft



TA TIME: 10:21:35 CPA TIME: 10:22:22

FLIGHT DATE: 09/16/93 Alt. Difference at CPA: 1562 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

>

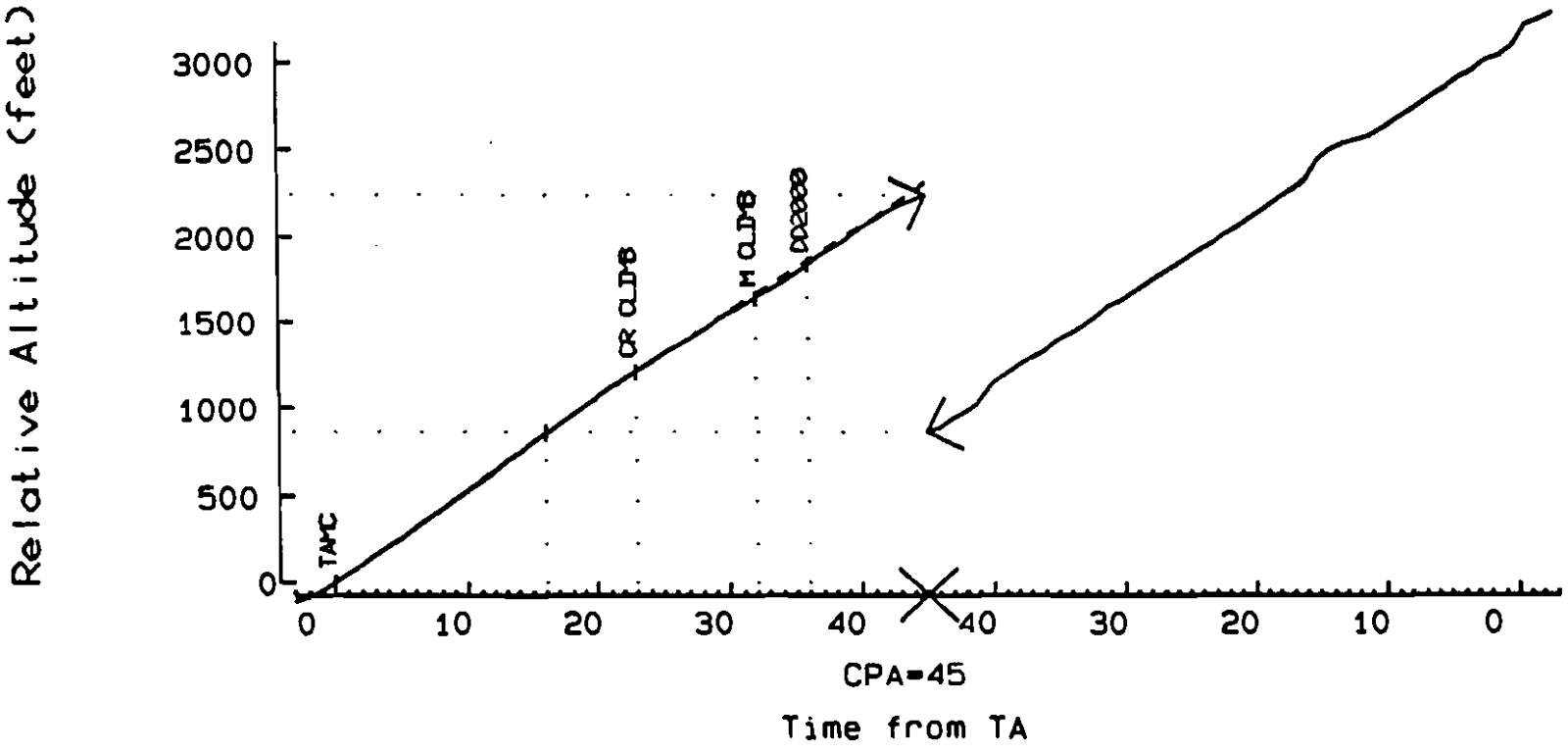
Encounter ID 951 Filename 8930916A.TRD

ENCOUNTER ID: 951 RANGE RATE at TA: -506

TARGET ID: 10746022 at CPA: -97

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 5049 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1458 ft



TA TIME: 10: 28: 46 CPA TIME: 10: 29: 31

FLIGHT DATE: 09/16/93 Alt. Difference at CPA: 1396 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

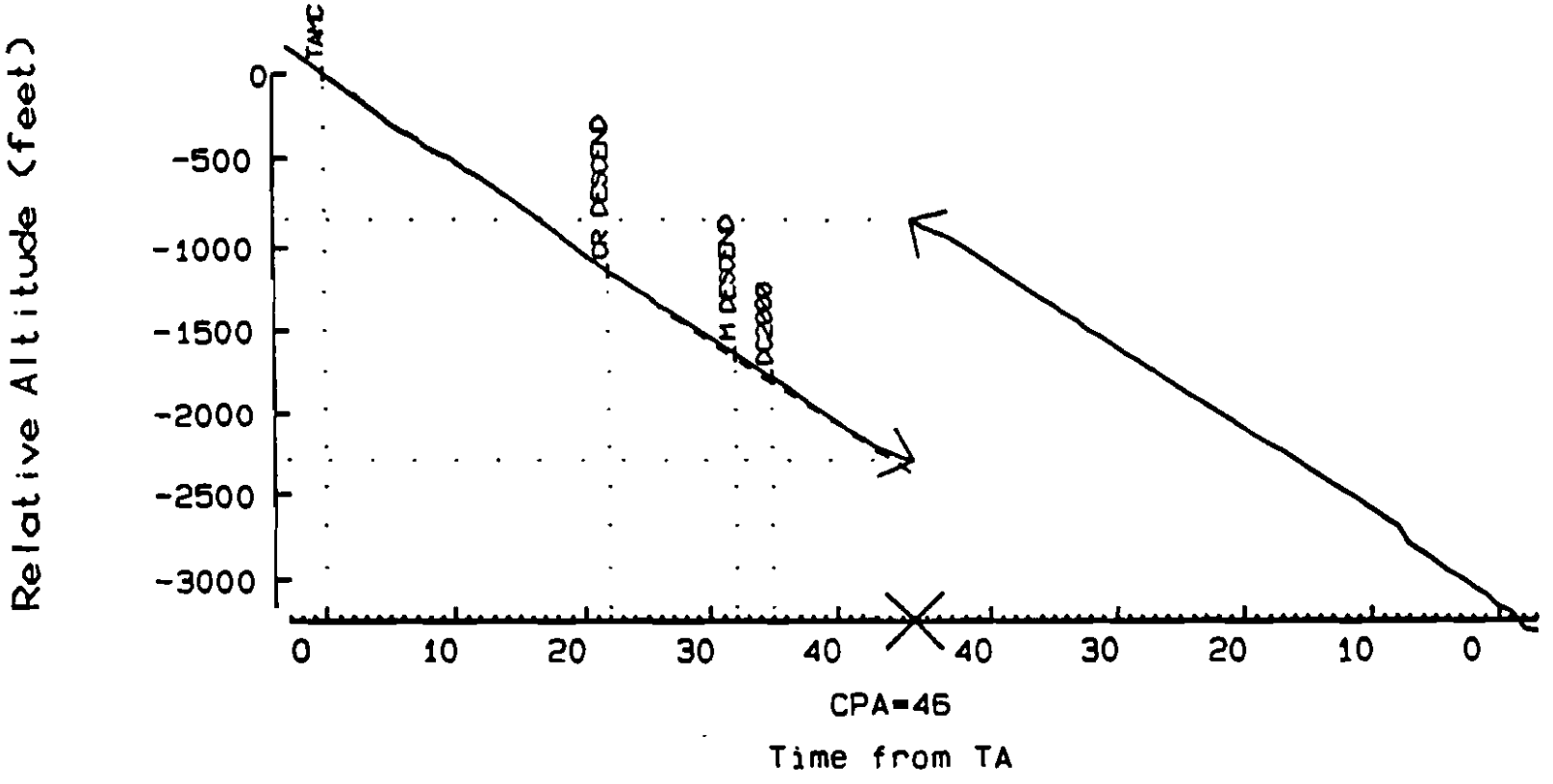
Encounter ID 160 Filename R930916A.TRO

ENCOUNTER ID: 160 RANGE RATE at TA: -499

TARGET ID: 10791495 at CPA: -134

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 4575 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1534 ft



TA TIME: 10: 27: 45 CPA TIME: 10: 28: 31

FLIGHT DATE: 09/16/93 Alt. Difference at CPA: 1456 ft

PROCESSED ON: 12/10/93 by ACO-320 FAA Technical Center

>

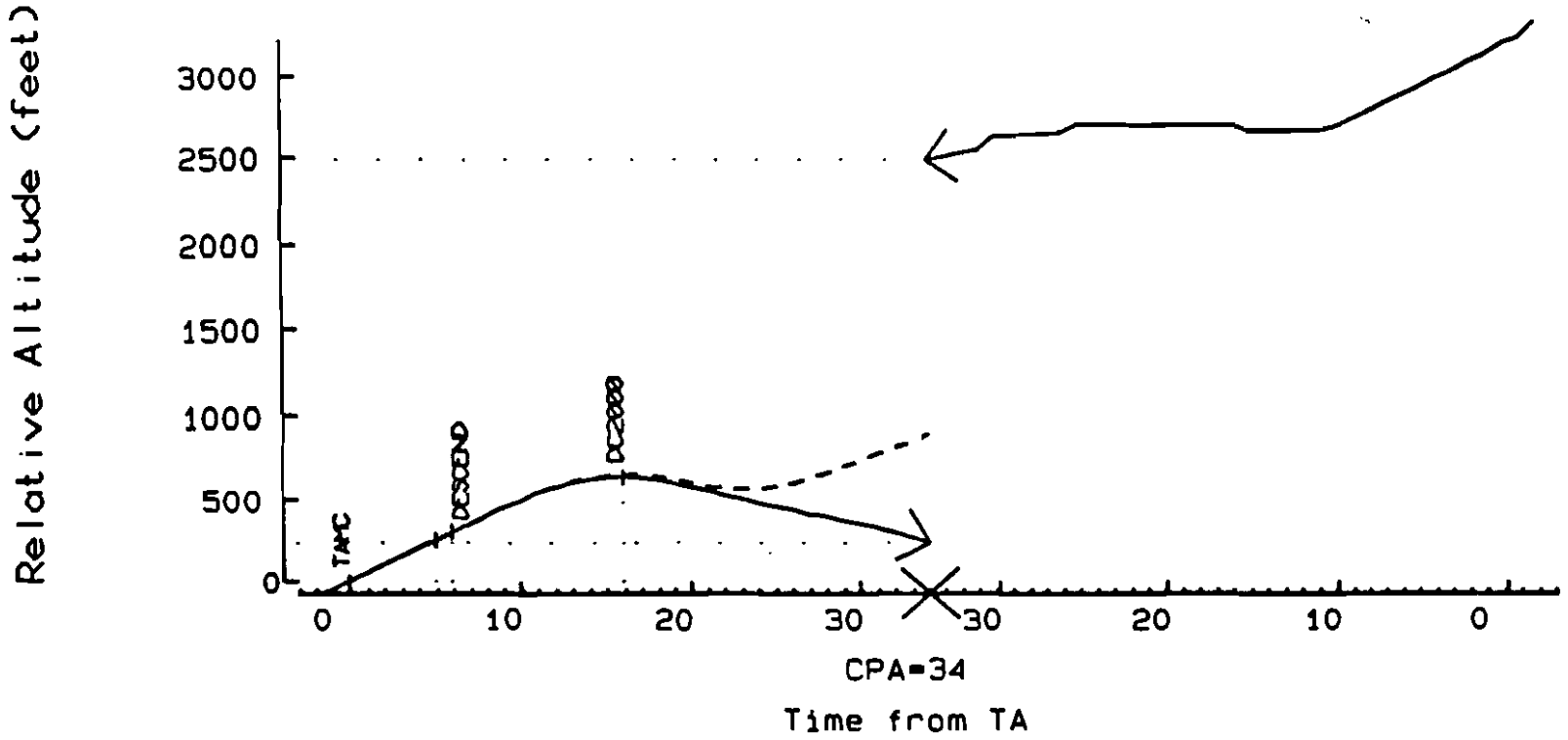
Encounter ID 1036 Filename B930916A.TRD

ENCOUNTER ID: 1036 RANGE RATE at TA: -471

TARGET ID: 10746022 at CPA: -86

INTRUDER EQUIPAGE: TCAS TA RANGE at CPA: 6890 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1597 ft



TA TIME: 10: 34: 49 CPA TIME: 10: 35: 23

FLIGHT DATE: 09/16/93 Alt. Difference at CPA: 2251 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

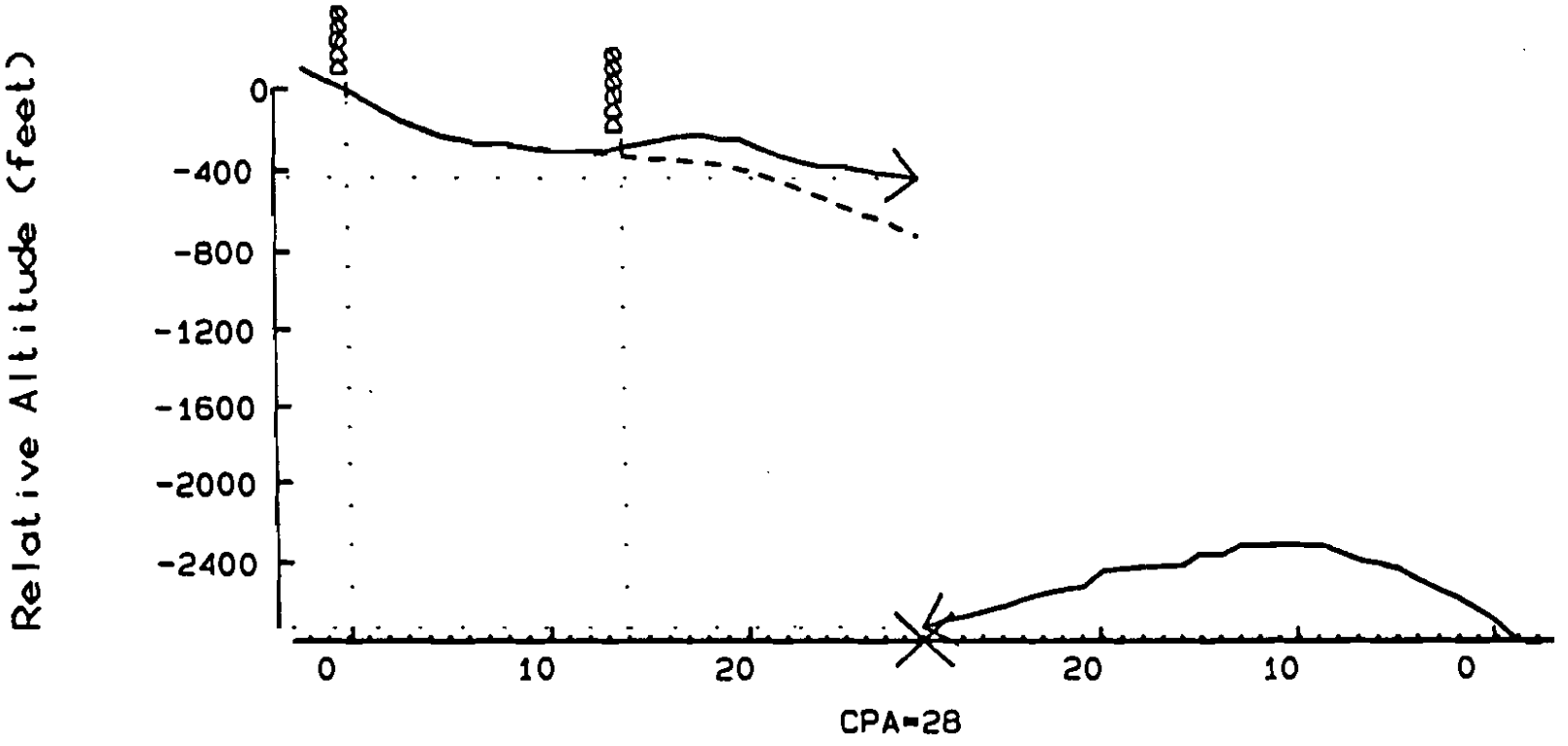
Encounter ID 201 Filename R930916A.TRD

ENCOUNTER ID: 201 RANGE RATE at TA: -470

TARGET ID: 10791495 at CPA: -125

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 6562 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 2001 ft



TA TIME: 10:33:53 CPA TIME: 10:34:22

FLIGHT DATE: 09/16/93 Alt. Difference at CPA: 2284 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

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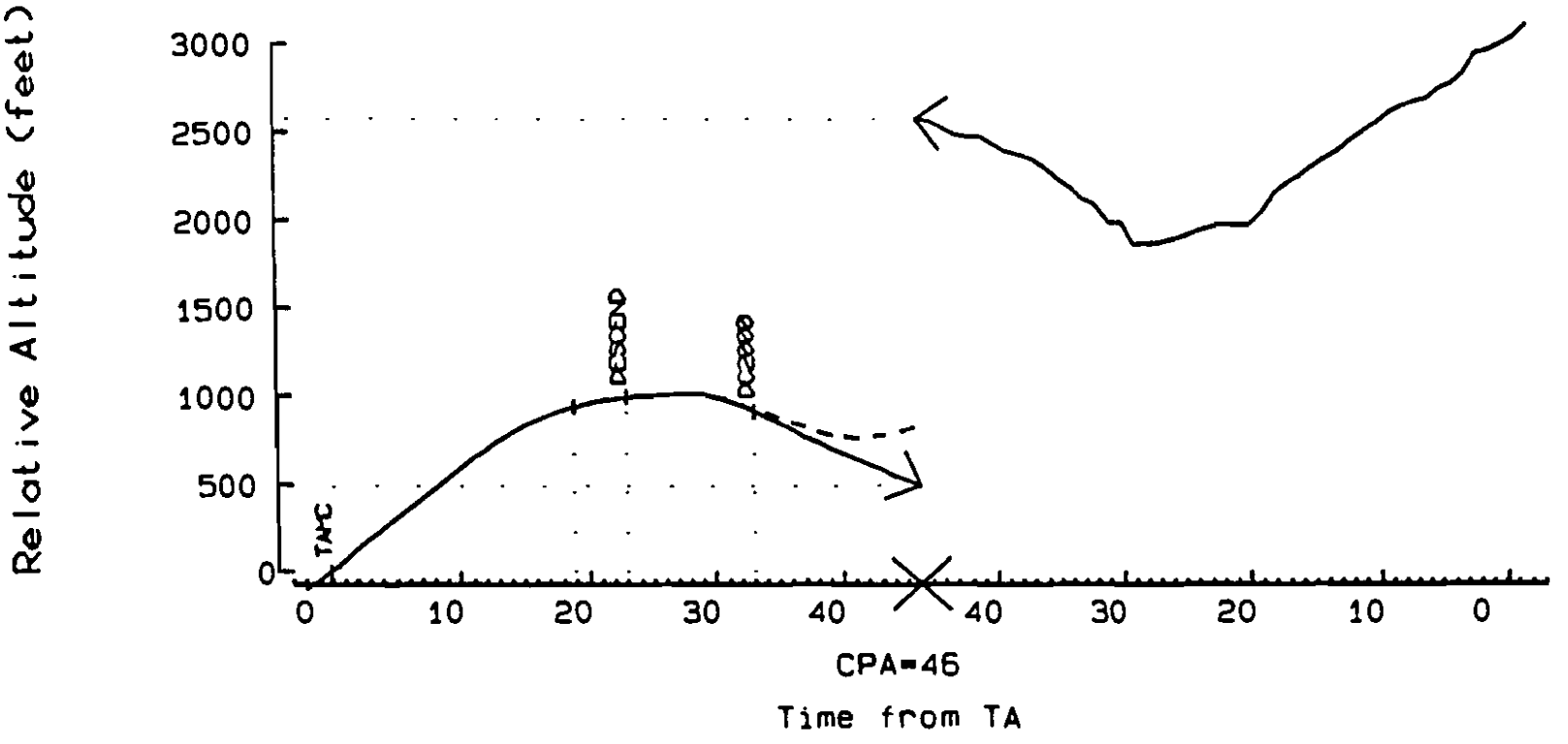
Encounter ID 1407 Filename 8930916A.TRD

ENCOUNTER ID: 1407 RANGE RATE at TA: -493

TARGET ID: 10746022 at CPA: -114

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 3117 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1747 ft



TA TIME: 10: 46: 43 CPA TIME: 10: 47: 29

FLIGHT DATE: 09/16/93 Alt. Difference at CPA: 2080 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

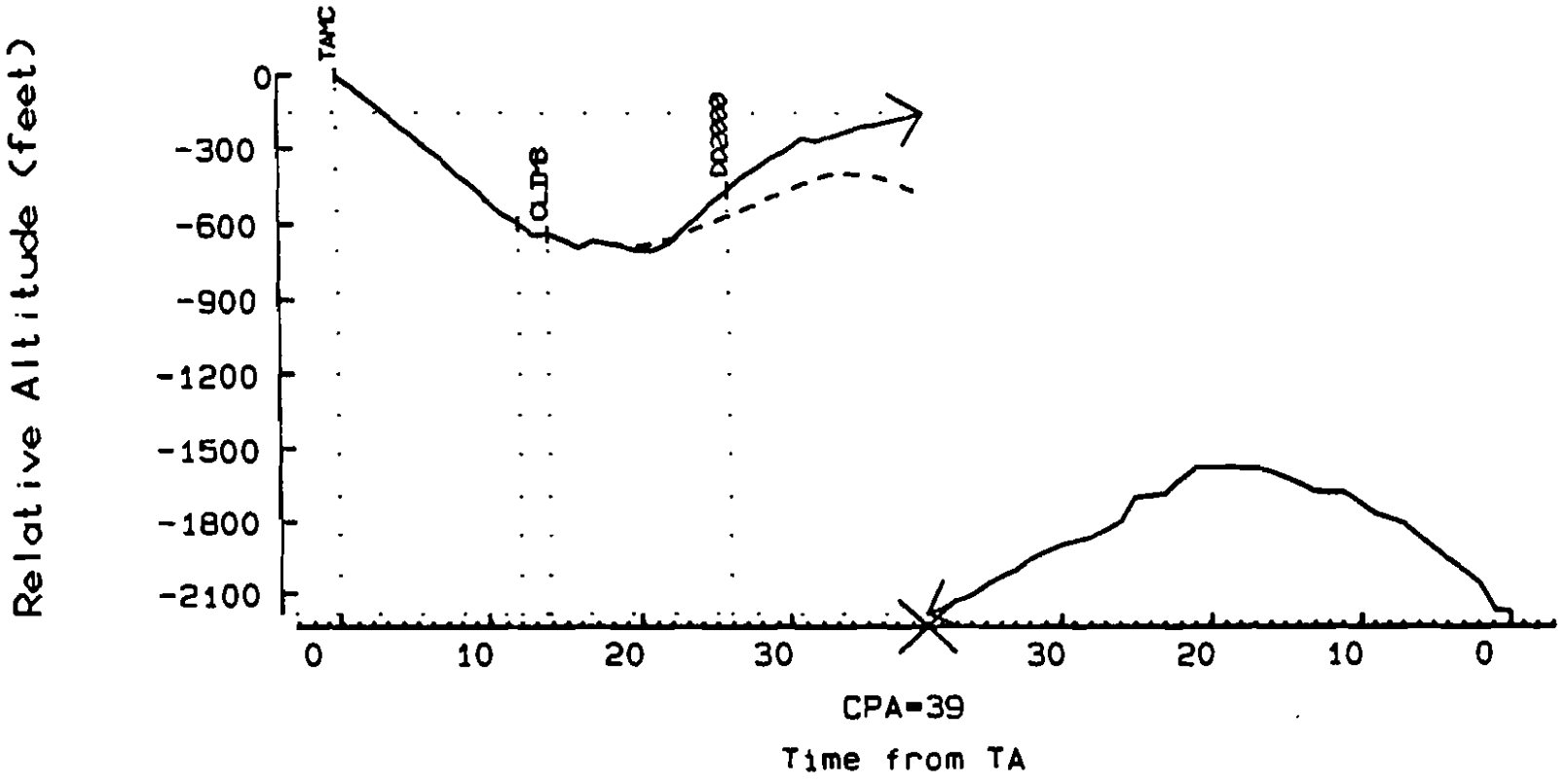
Encounter ID 242 Filename R930916A.TRD

ENCOUNTER ID: 242 RANGE RATE at TA: -436

TARGET ID: 10791495 at CPA: -196

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2576 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1694 ft



TA TIME: 10: 45: 50 CPA TIME: 10: 46: 29

FLIGHT DATE: 09/16/93 Alt. Difference at CPA: 2024 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

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>

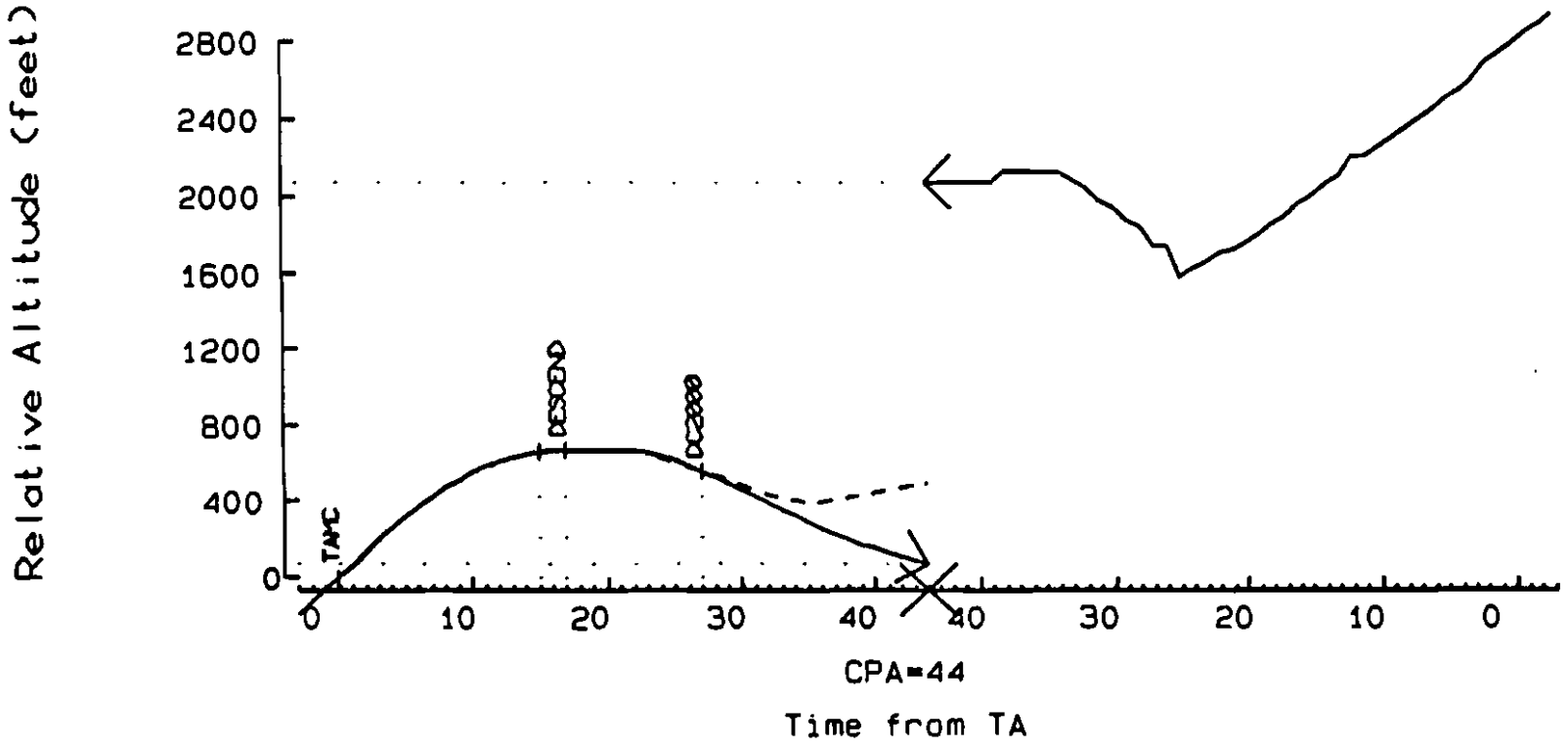
Encounter ID 1612 Filename 8930916A.TRO

ENCOUNTER ID: 1612 RANGE RATE at TA: -489

TARGET ID: 10746022 at CPA: -53

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 5760 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1579 ft



TA TIME: 10:53:32 CPA TIME: 10:54:16

FLIGHT DATE: 09/16/93 Alt. Difference at CPA: 2009 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

Encounter ID 275 Filename R930916A.TRD

ENCOUNTER ID: 275

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

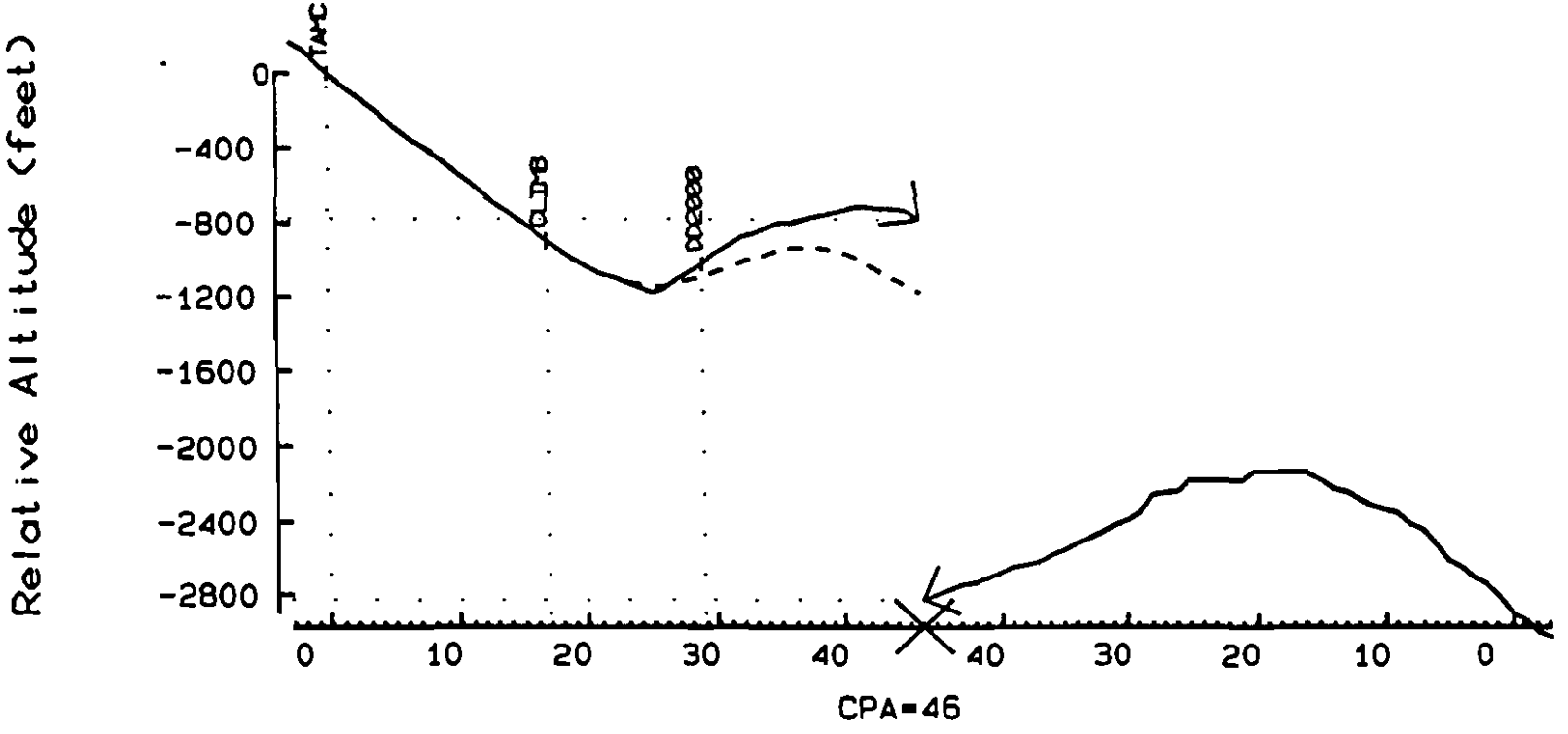
OWN ID: 10746022

RANGE RATE at TA: -493

at CPA: -107

RANGE at CPA: 5353 ft

Alt. Difference with Simulated Pilot Response: 1651 ft



TA TIME: 10:52:38

CPA TIME: 10:53:24

FLIGHT DATE: 09/16/93

Alt. Difference at CPA: 2055 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

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Encounter ID 344 Filename 8930917A.TRD

ENCOUNTER ID: 344

TARGET ID: 10746022

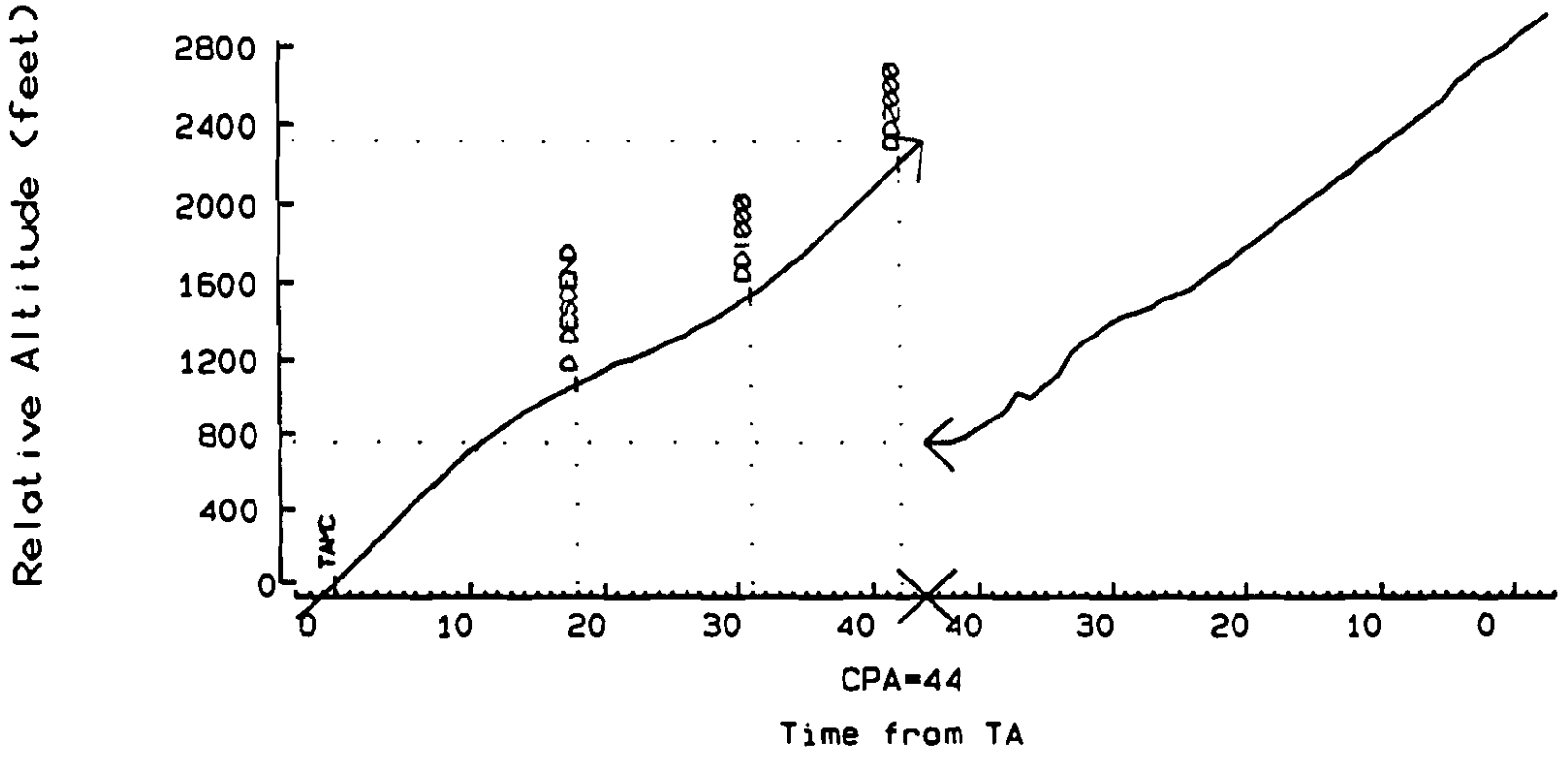
INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

RANGE RATE at TA: -482

at CPA: -73

RANGE at CPA: 1804 ft



TA TIME: 10: 39: 17

CPA TIME: 10: 40: 01

FLIGHT DATE: 09/17/93

Alt. Difference at CPA: 1568 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

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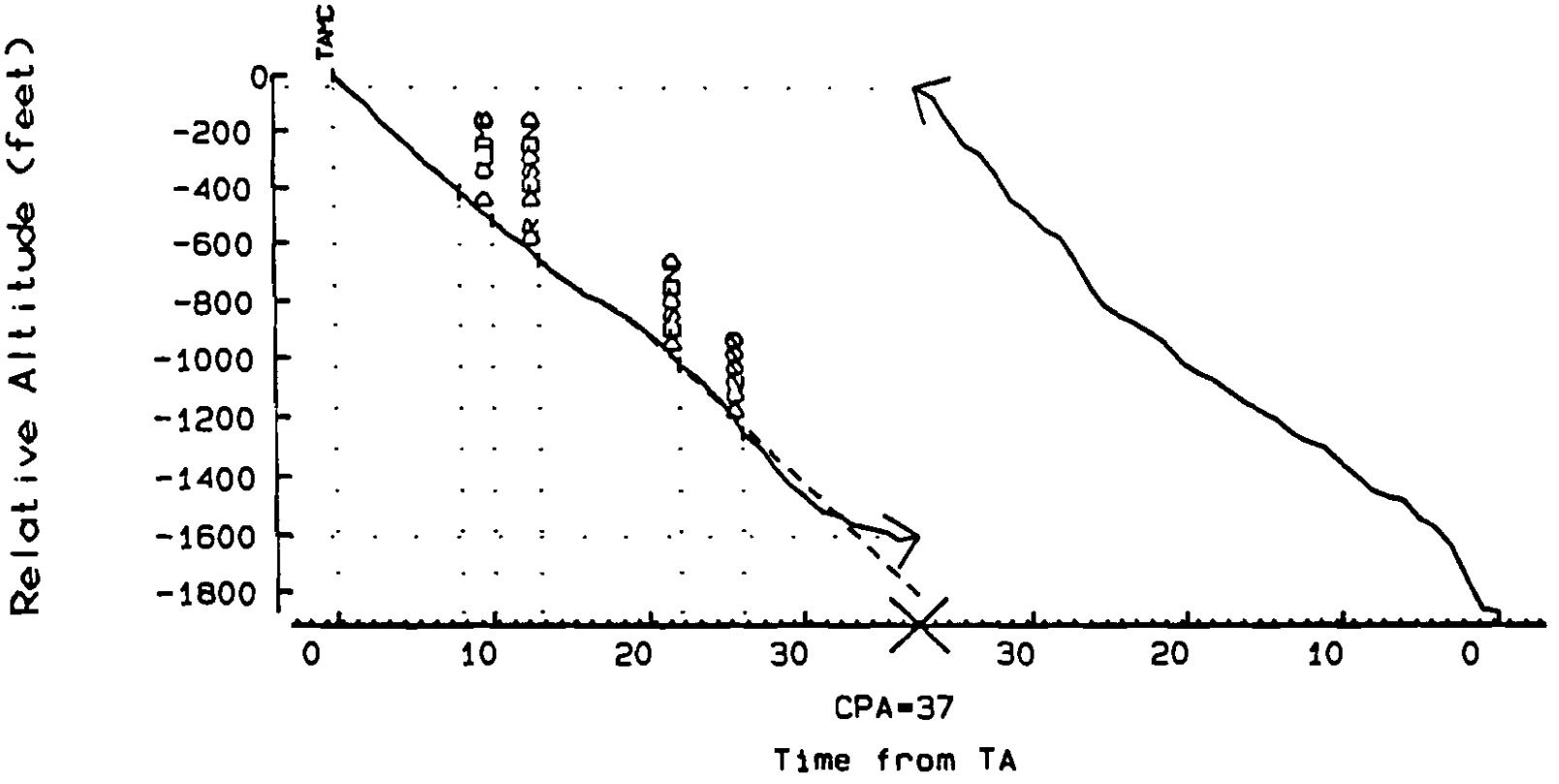
Encounter ID 109 Filename R930917A.TRD

ENCOUNTER ID: 109 RANGE RATE at TA: -474

TARGET ID: 10791495 at CPA: -266

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 1221 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1766 ft



TA TIME: 10: 38: 17 CPA TIME: 10: 38: 55

FLIGHT DATE: 09/17/93 Alt. Difference at CPA: 1561 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

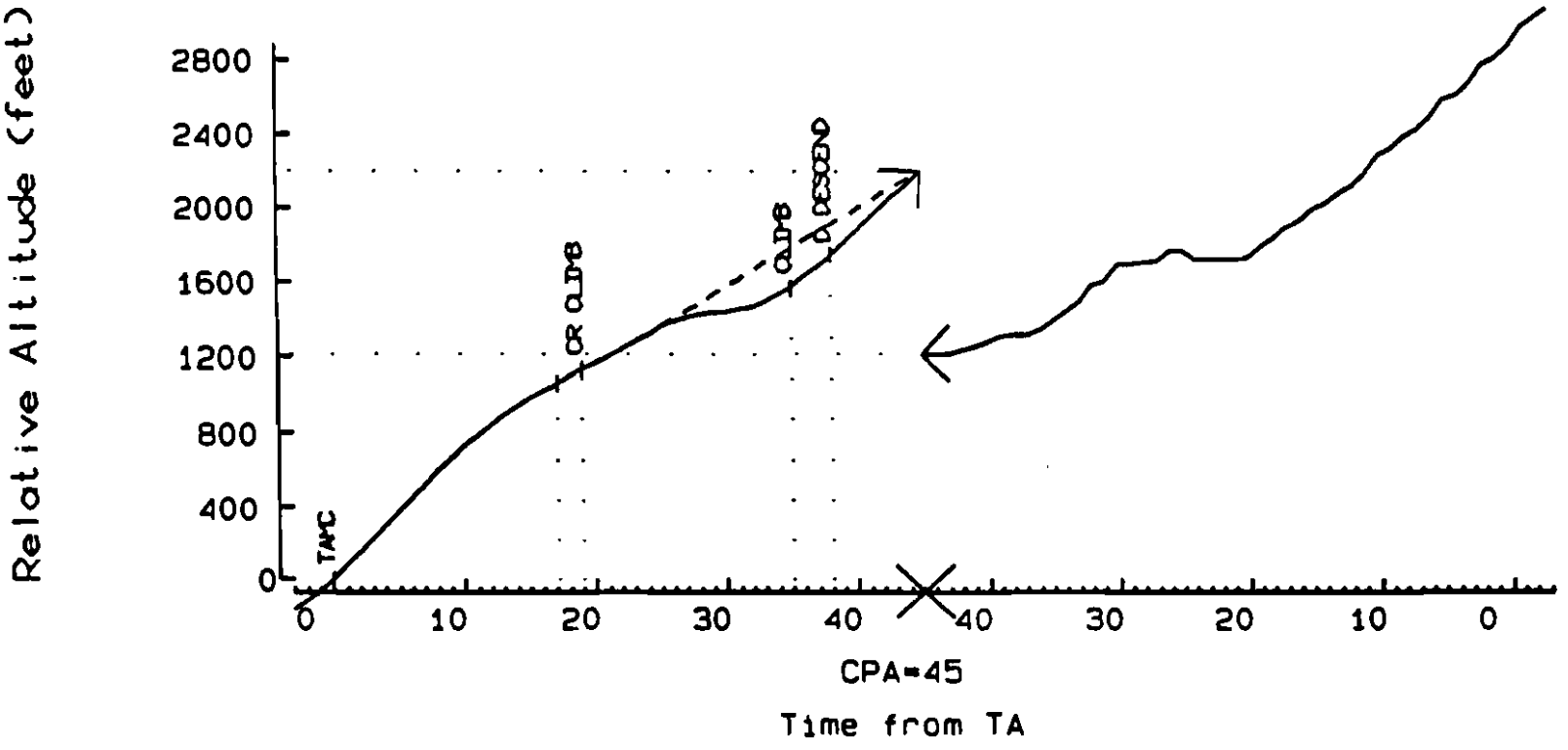
Encounter ID 460 Filename B930917A.TRD

ENCOUNTER ID: 460 RANGE RATE at TA: -522

TARGET ID: 10746022 at CPA: -142

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 1288 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 987 ft



TA TIME: 10: 45: 20 CPA TIME: 10: 46: 05

FLIGHT DATE: 09/17/93 Alt. Difference at CPA: 982 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

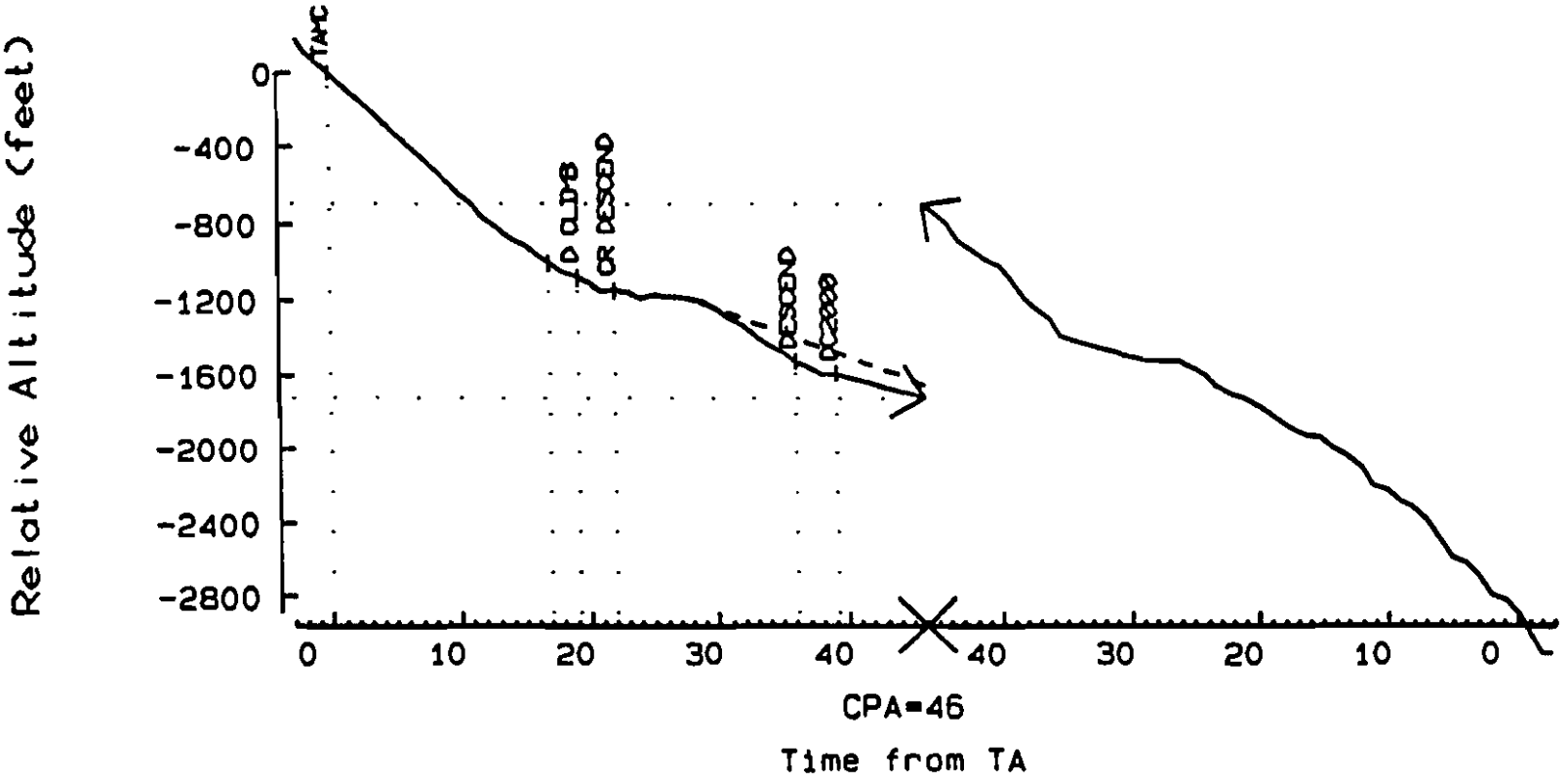
Encounter ID 120 Filename R930917A.TRO

ENCOUNTER ID: 120 RANGE RATE at TA: -519

TARGET ID: 10791495 at CPA: -369

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 704 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 969 ft



TA TIME: 10: 44: 13 CPA TIME: 10: 44: 59

FLIGHT DATE: 09/17/93 Alt. Difference at CPA: 1029 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

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Encounter ID 18 Filename B9309178.TRD

ENCOUNTER ID: 18

TARGET ID: 10746022

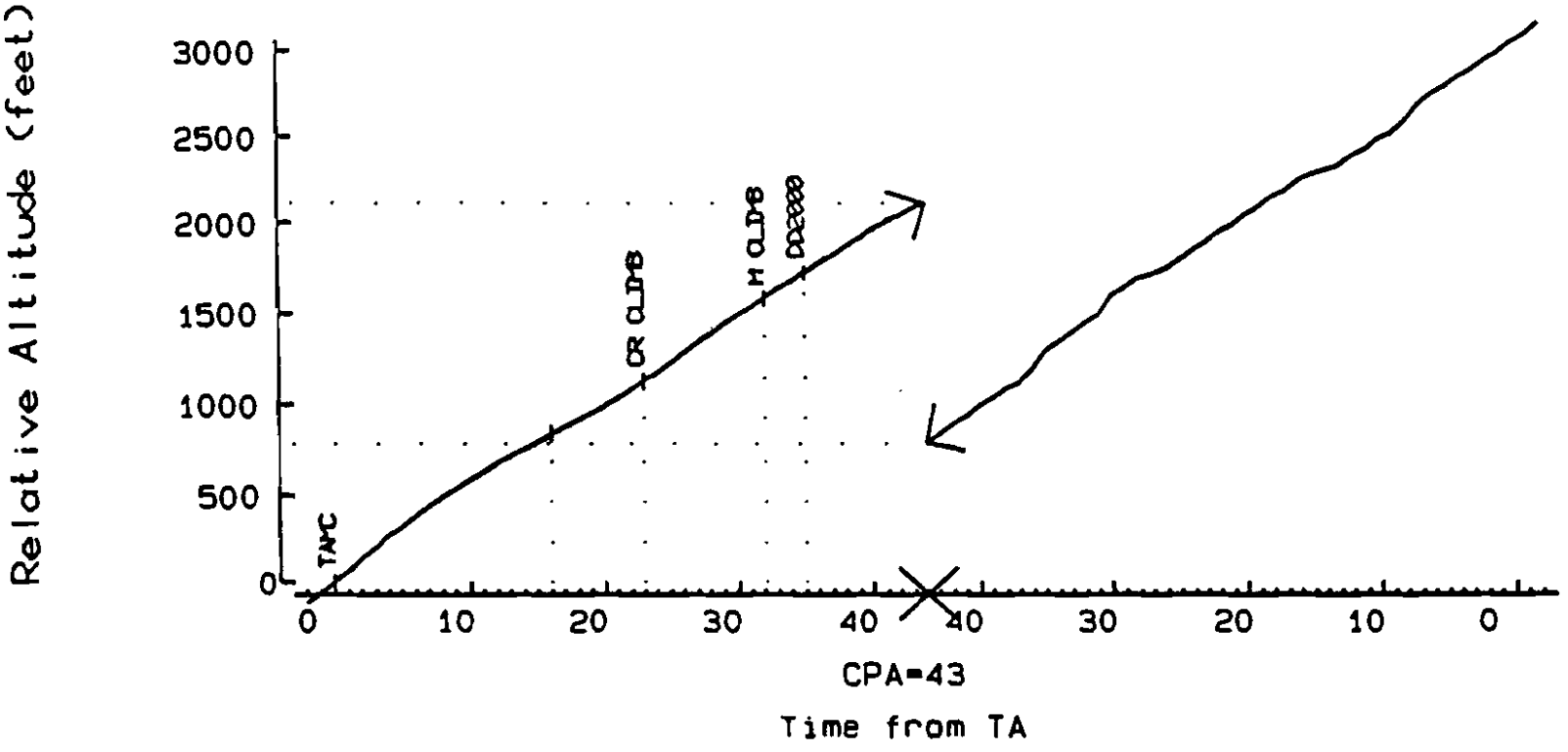
INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

RANGE RATE at TA: -522

at CPA: -106

RANGE at CPA: 7260 ft



TA TIME: 11:03:56

CPA TIME: 11:04:40

FLIGHT DATE: 09/17/93

Alt. Difference at CPA: 1332 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

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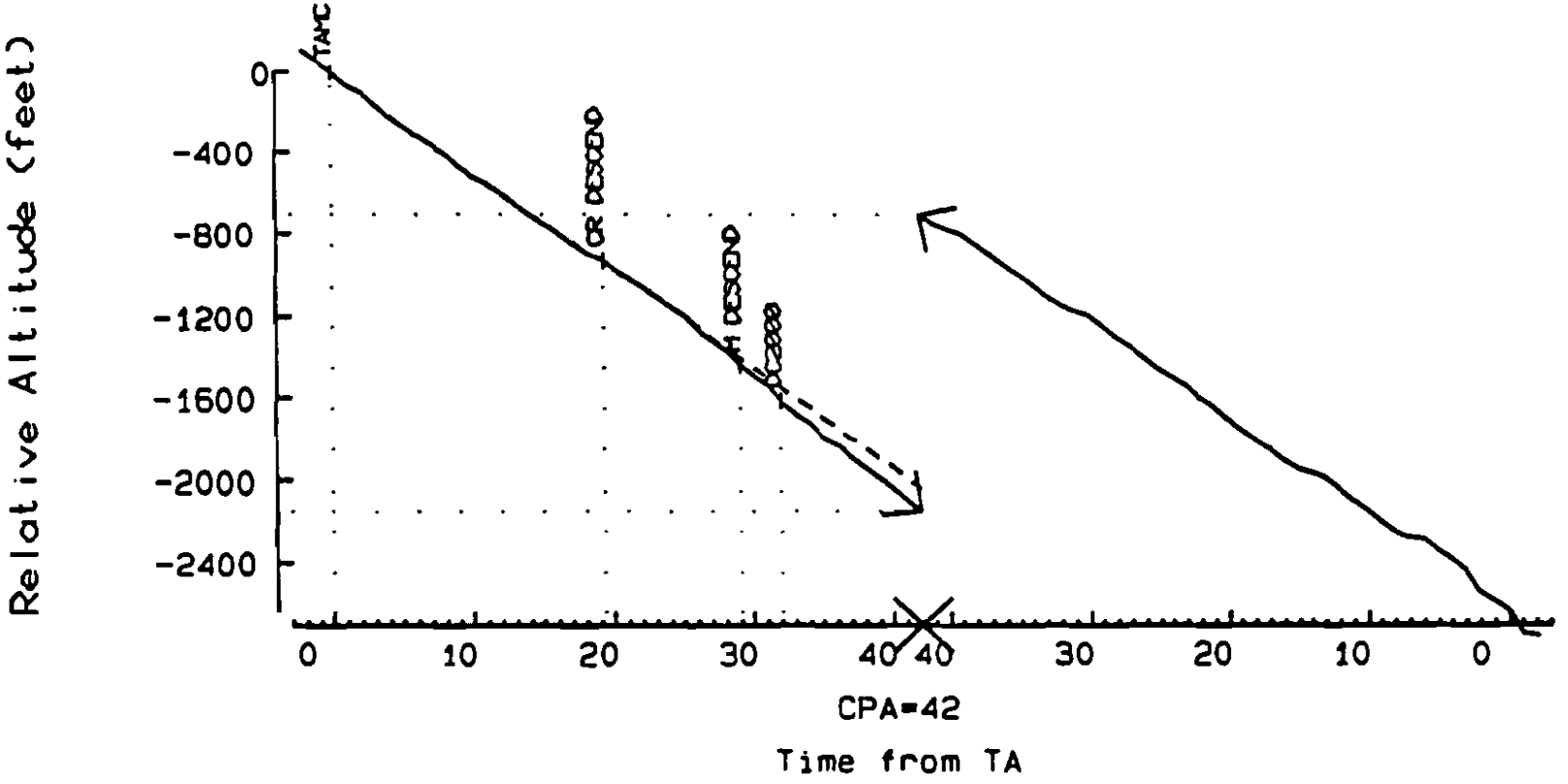
Encounter ID 164 Filename R930917A.TRD

ENCOUNTER ID: 164 RANGE RATE at TA: -514

TARGET ID: 10791495 at CPA: -89

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 6872 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1336 ft



TA TIME: 11:02:53 CPA TIME: 11:03:35

FLIGHT DATE: 09/17/93 Alt. Difference at CPA: 1441 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

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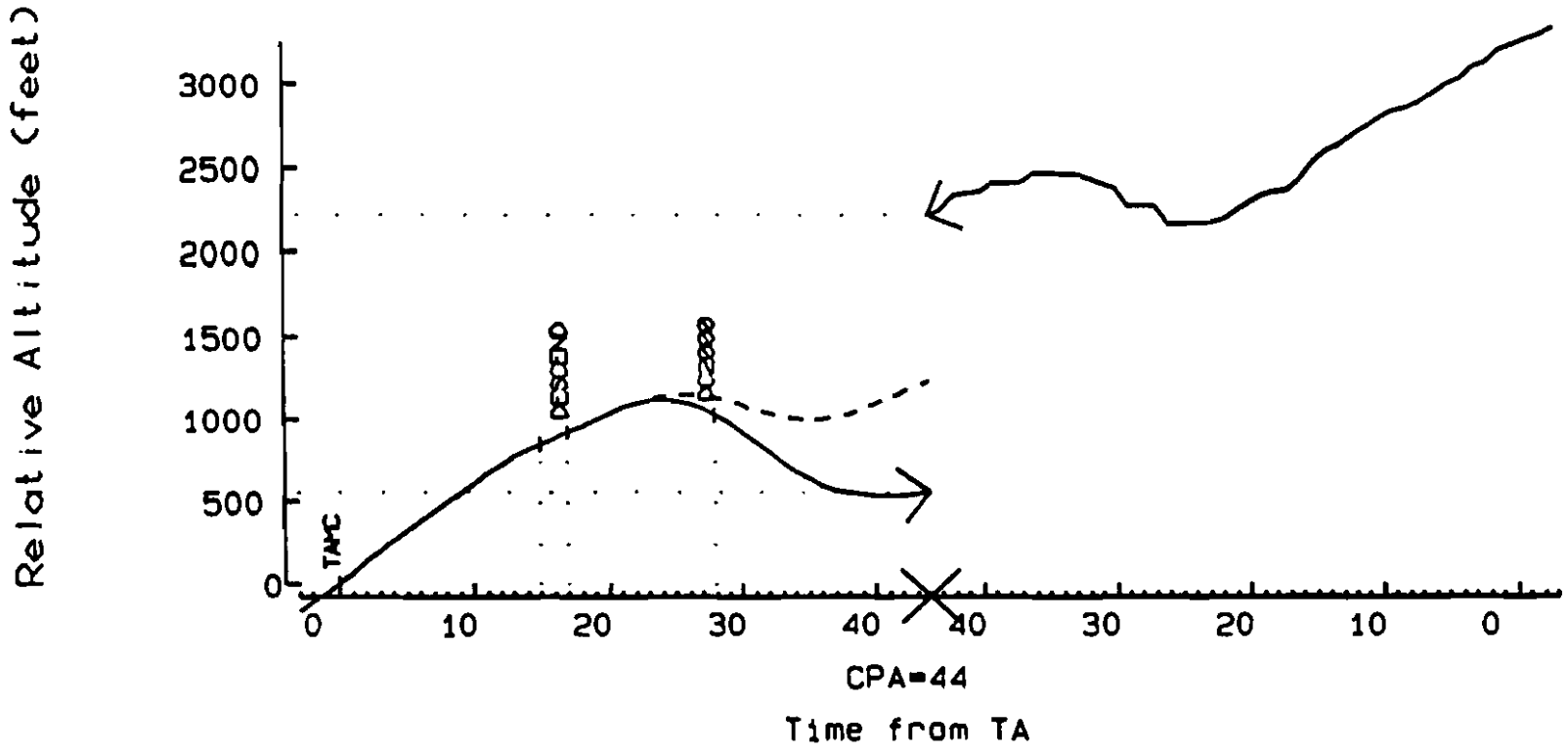
Encounter ID 270 Filename B930917B.TRD

ENCOUNTER ID: 270 RANGE RATE at TA: -531

TARGET ID: 10746022 at CPA: -281

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 1440 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 974 ft



TA TIME: 11:15:05 CPA TIME: 11:15:49

FLIGHT DATE: 09/17/93 Alt. Difference at CPA: 1659 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

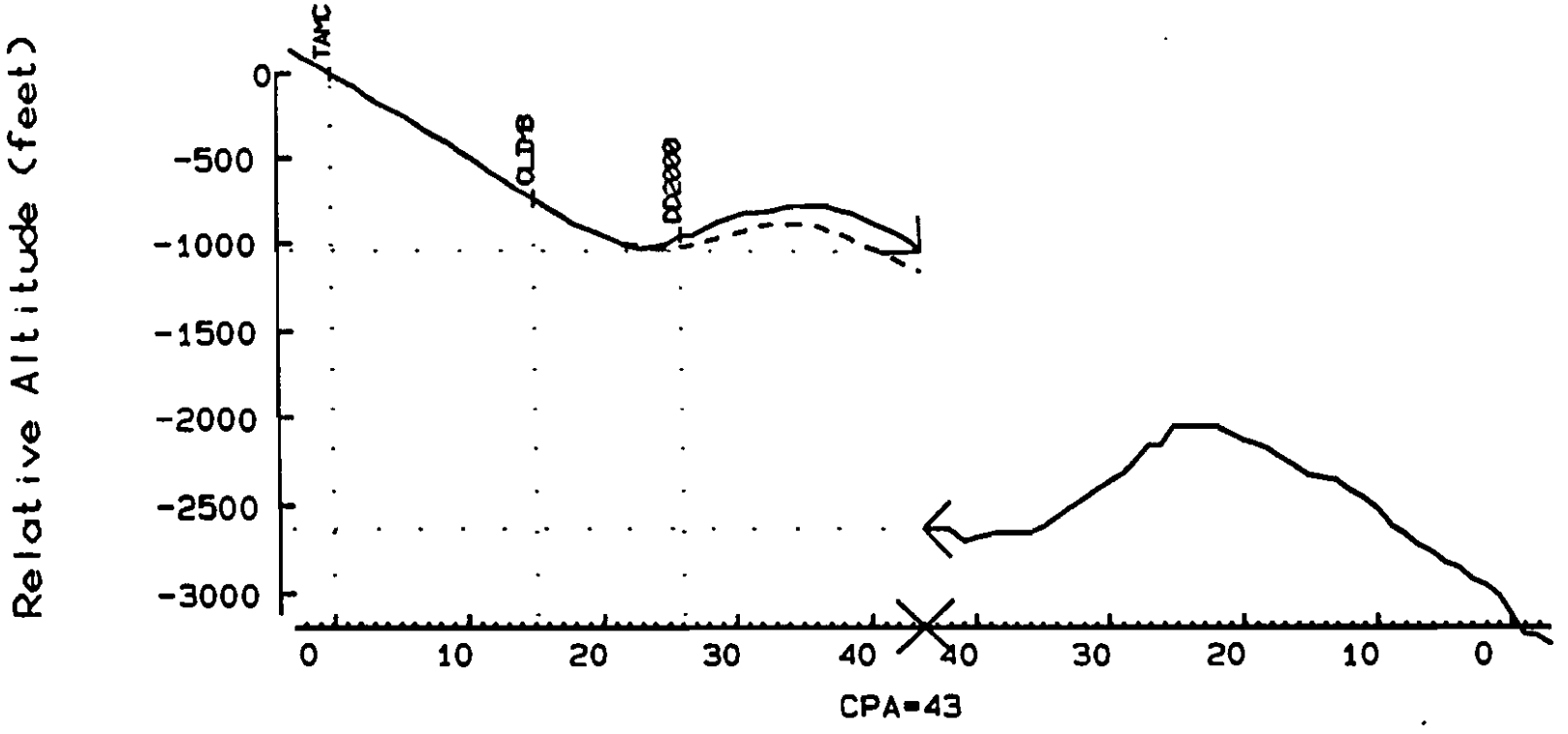
Encounter ID 264 Filename R930917A.TRD

ENCOUNTER ID: 264 RANGE RATE at TA: -532

TARGET ID: 10791495 at CPA: -322

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 838 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1469 ft



TA TIME: 11:14:00 CPA TIME: 11:14:44

FLIGHT DATE: 09/17/93 Alt. Difference at CPA: 1585 ft

PROCESSED ON: 12/10/93 by ACO-320 FAA Technical Center

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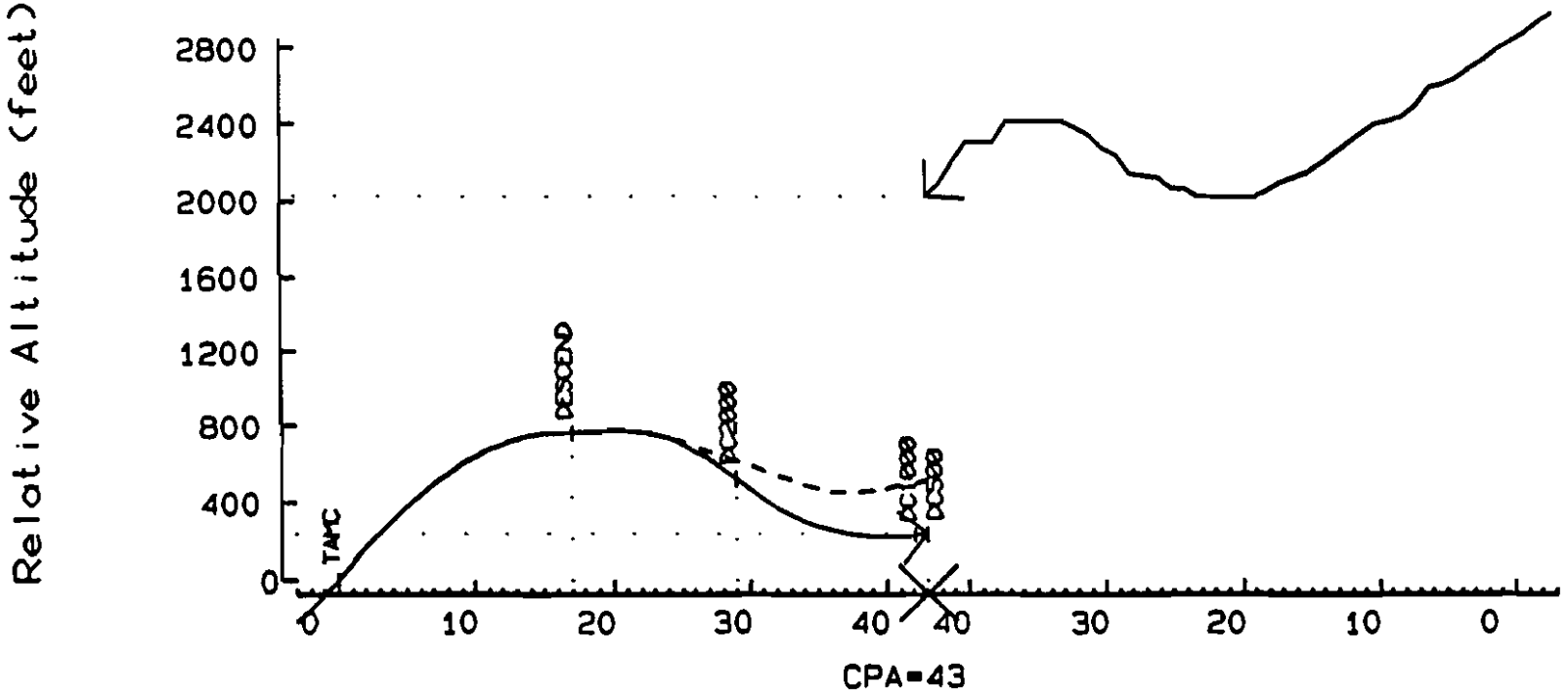
Encounter ID 352 Filename 89309178.TRD

ENCOUNTER ID: 352 RANGE RATE at TA: -503

TARGET ID: 10746022 at CPA: -107

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 7874 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1502 ft



TA TIME: 11:20:37 CPA TIME: 11:21:20

FLIGHT DATE: 09/17/93 Alt. Difference at CPA: 1786 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

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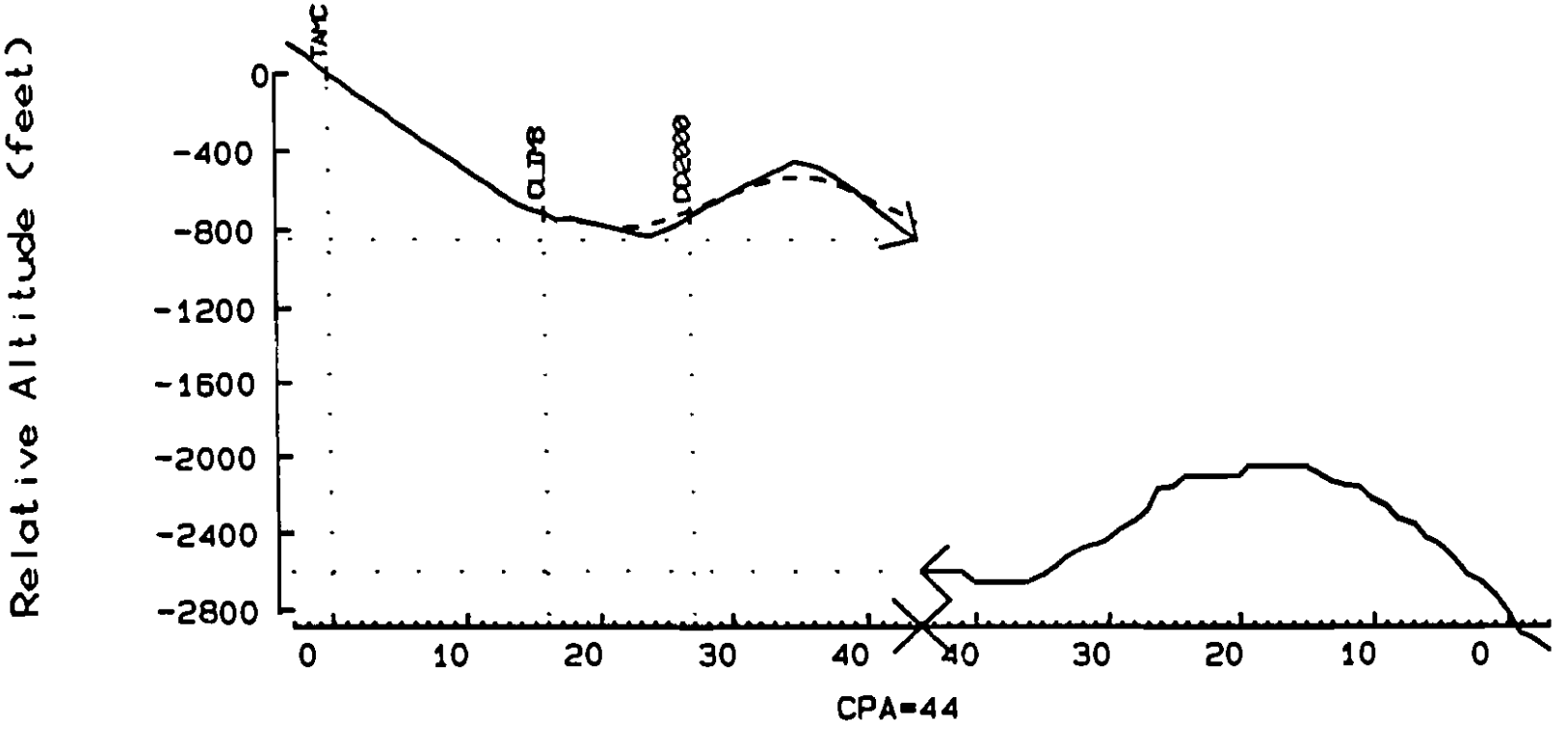
Encounter ID 264 Filename R930917A.TRD

ENCOUNTER ID: 264 RANGE RATE at TA: -515

TARGET ID: 10791495 at CPA: -96

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 7546 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1851 ft



TA TIME: 11:19:31 CPA TIME: 11:20:15

FLIGHT DATE: 09/17/93 Alt. Difference at CPA: 1766 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

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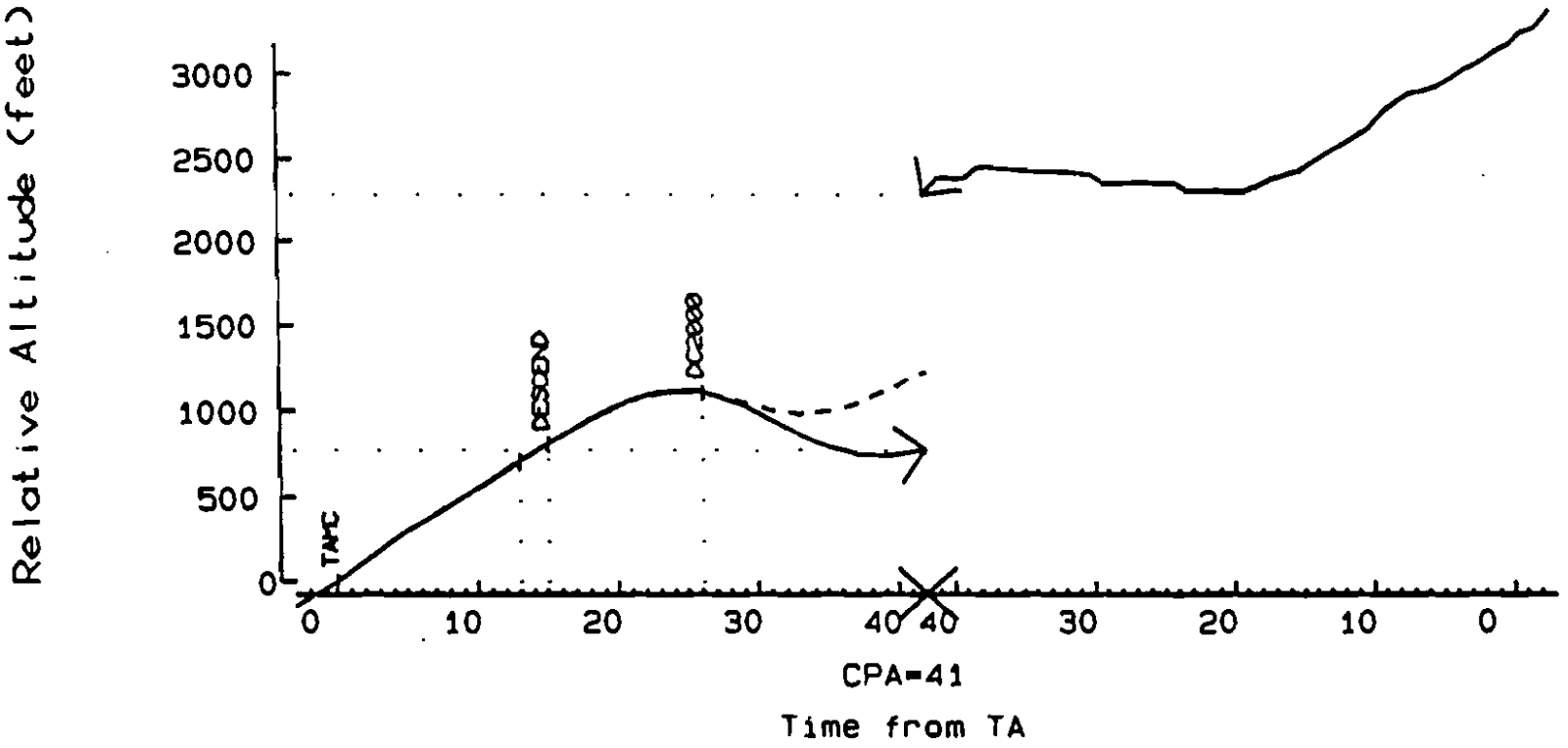
Encounter ID 418 Filename 89309178.TRD

ENCOUNTER ID: 418 RANGE RATE at TA: -543

TARGET ID: 10746022 at CPA: -124

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 3736 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1059 ft



TA TIME: 11:26:25 CPA TIME: 11:27:07

FLIGHT DATE: 09/17/93 Alt. Difference at CPA: 1523 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

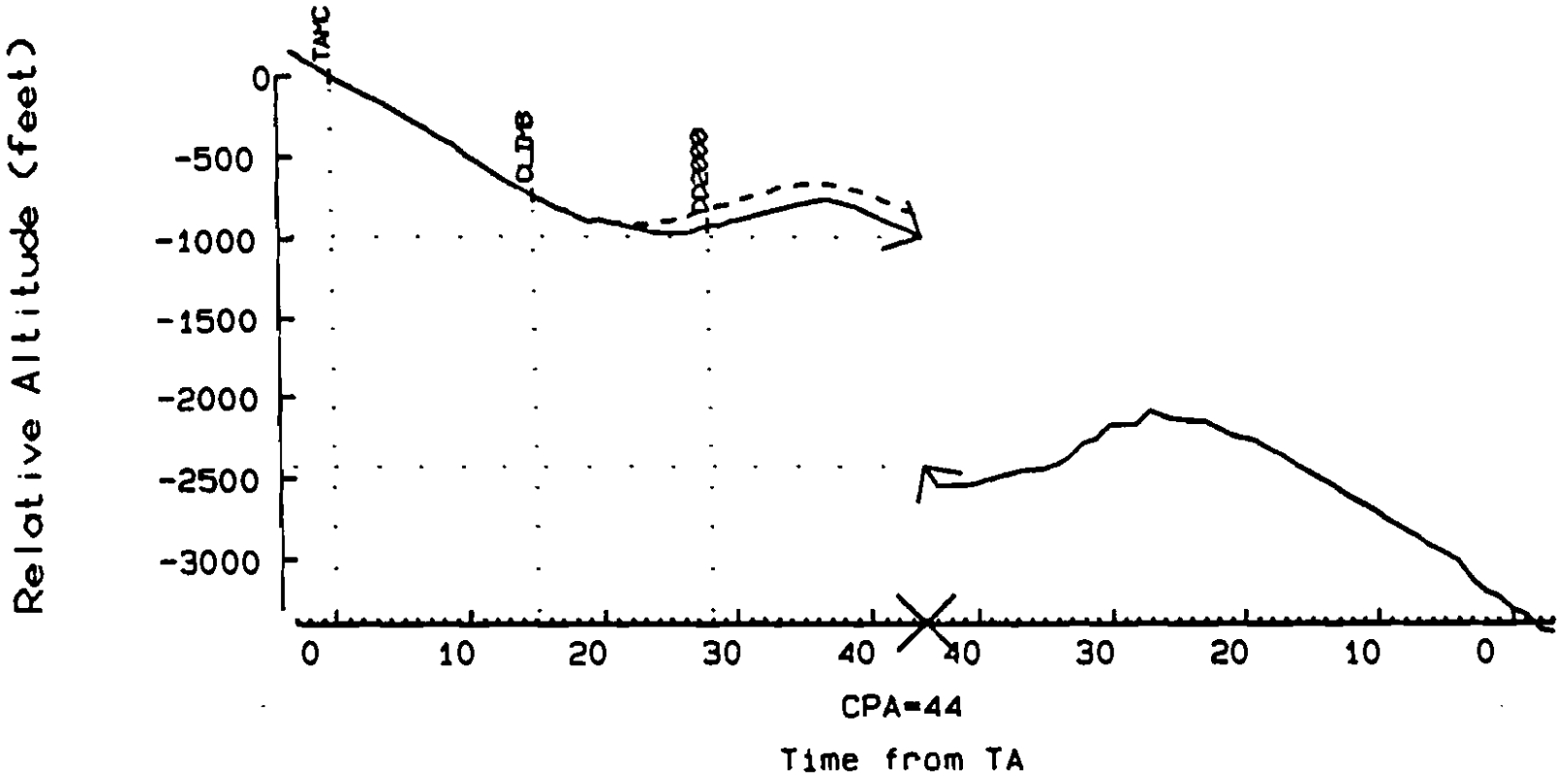
Encounter ID 290 Filename R930917A.TRD

ENCOUNTER ID: 290 RANGE RATE at TA: -539

TARGET ID: 10791495 at CPA: -213

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 3189 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1568 ft



TA TIME: 11:25:18 CPA TIME: 11:26:02

FLIGHT DATE: 09/17/93 Alt. Difference at CPA: 1446 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

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Encounter ID 625 Filename B930920A.TRO

ENCOUNTER ID: 625

TARGET ID: 10746022

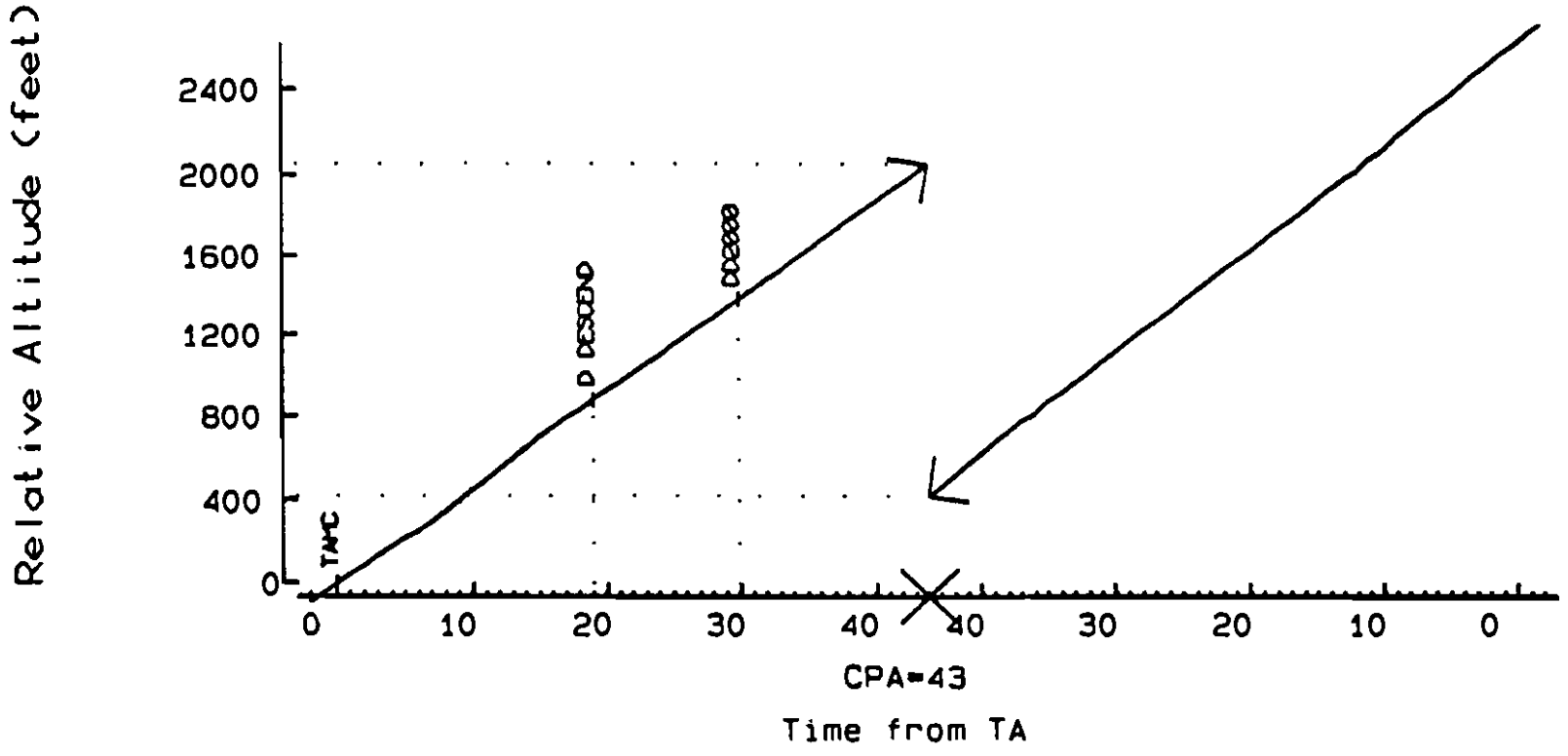
INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

RANGE RATE at TA: -469

at CPA: -86

RANGE at CPA: 4897 ft



TA TIME: 14: 25: 26

CPA TIME: 14: 26: 10

FLIGHT DATE: 09/20/93

Alt. Difference at CPA: 1628 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

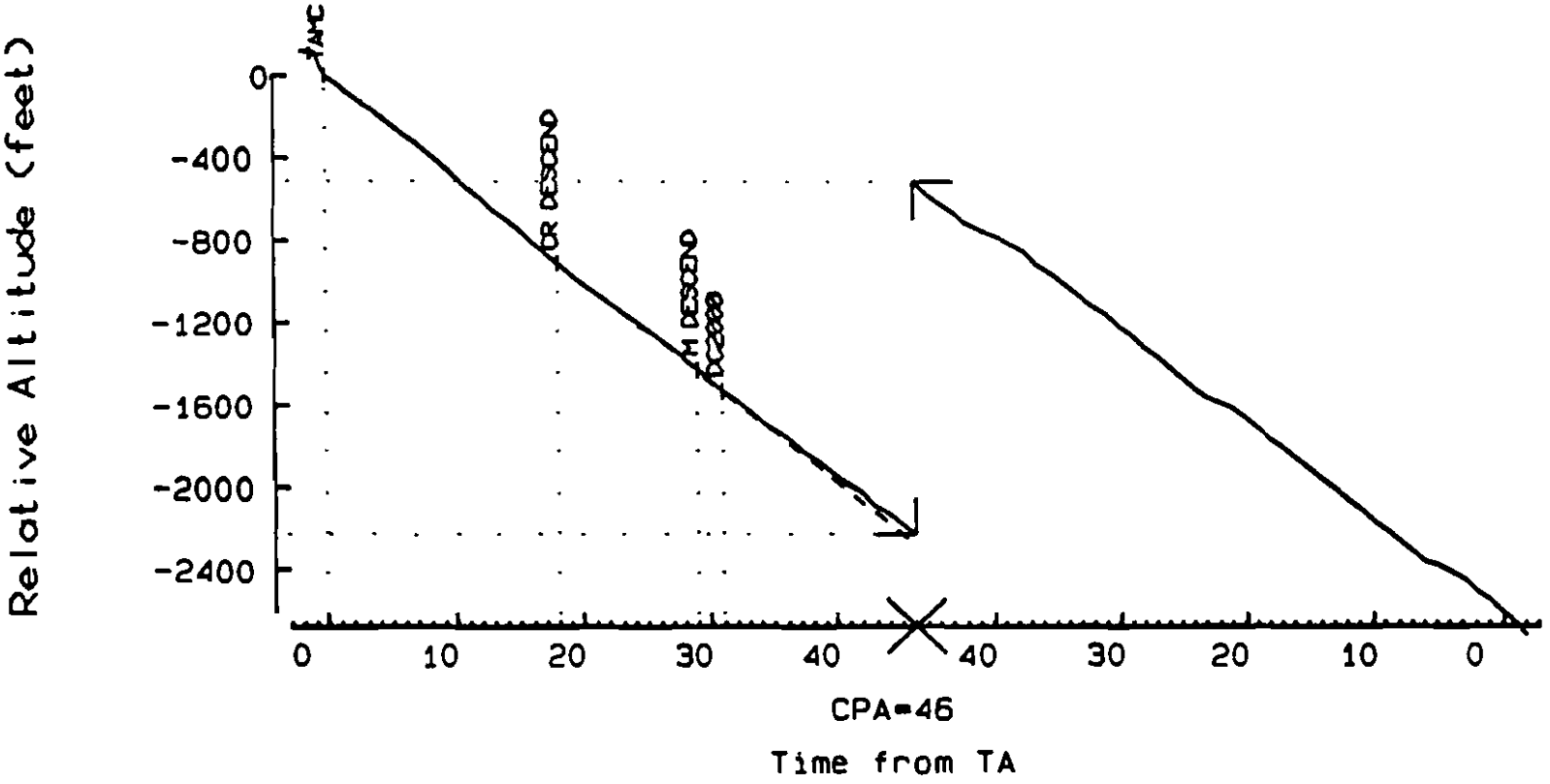
Encounter ID 280 Filename R930920A.TRD

ENCOUNTER ID: 280 RANGE RATE at TA: -468

TARGET ID: 10791495 at CPA: -127

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 4459 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1762 ft



TA TIME: 14: 24: 44 CPA TIME: 14: 25: 30

FLIGHT DATE: 09/20/93 Alt. Difference at CPA: 1719 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

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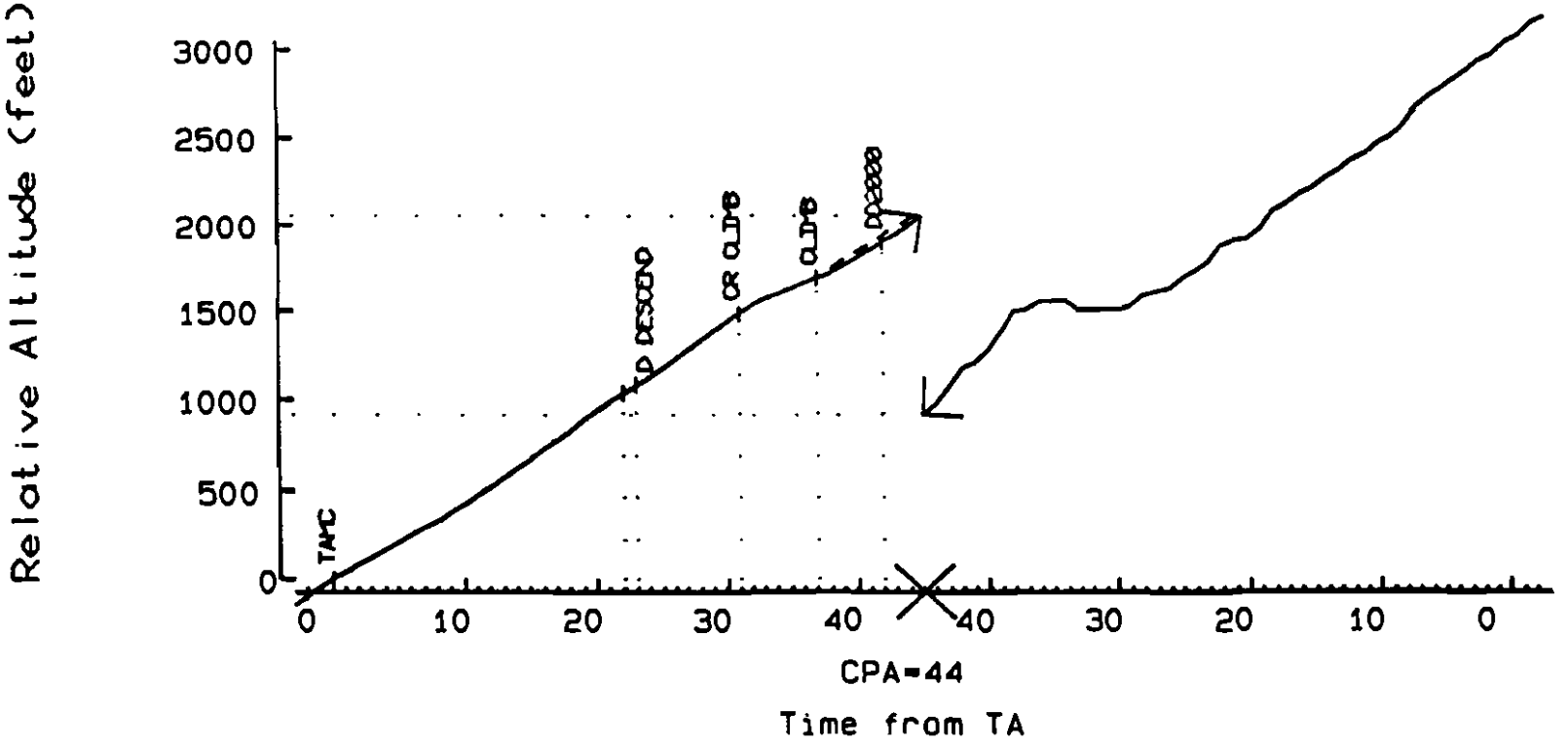
Encounter ID 837 Filename B930920A.TRD

ENCOUNTER ID: 837 RANGE RATE at TA: -490

TARGET ID: 10746022 at CPA: -59

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2485 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1178 ft



TA TIME: 14:31:14 CPA TIME: 14:31:59

FLIGHT DATE: 09/20/93 Alt. Difference at CPA: 1142 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

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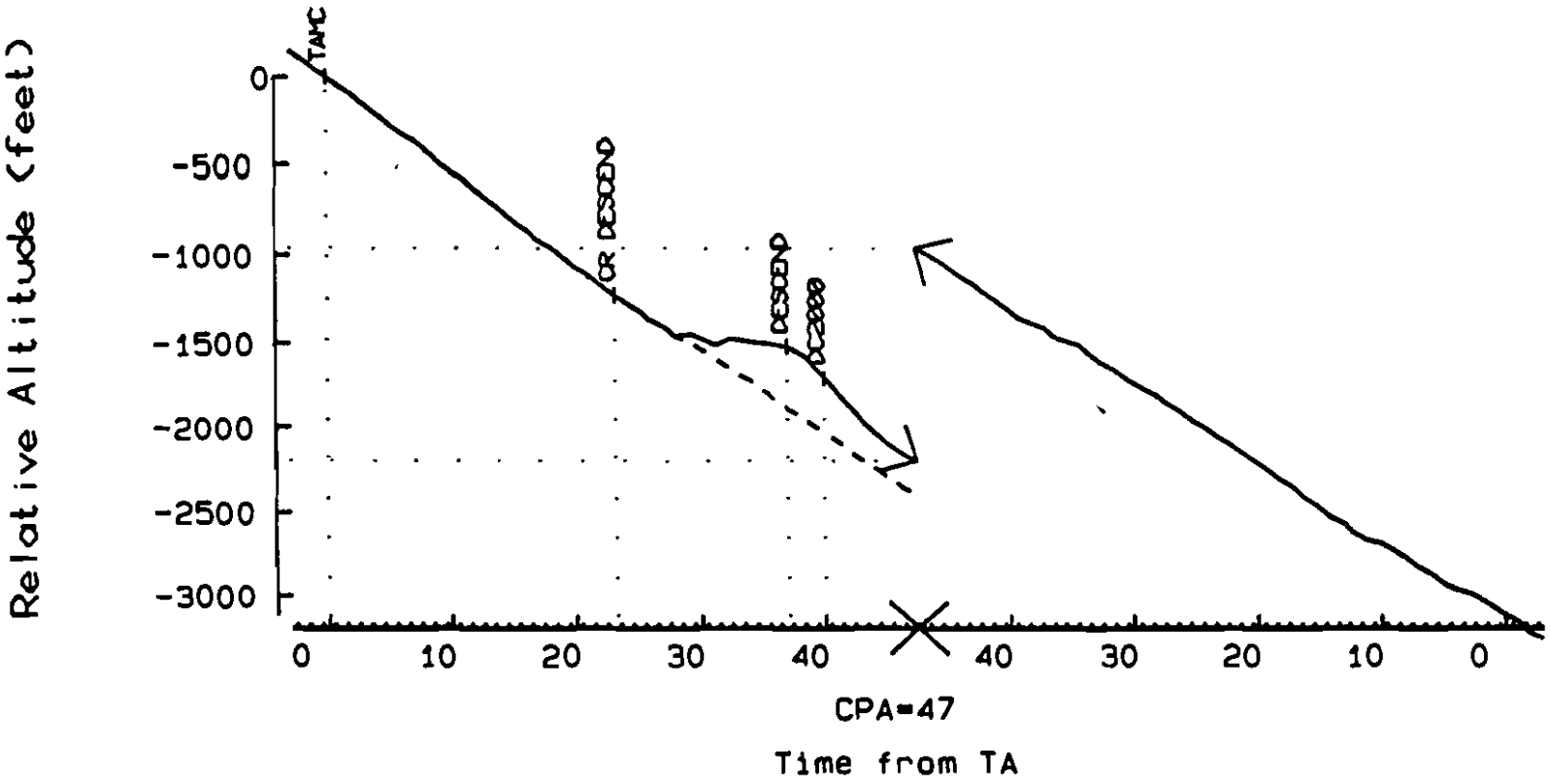
Encounter ID 472 Filename R930920A.TRO

ENCOUNTER ID: 472 RANGE RATE at TA: -490

TARGET ID: 10791495 at CPA: -165

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 1968 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1456 ft



TA TIME: 14:30:31 CPA TIME: 14:31:18

FLIGHT DATE: 09/20/93 Alt. Difference at CPA: 1244 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

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>

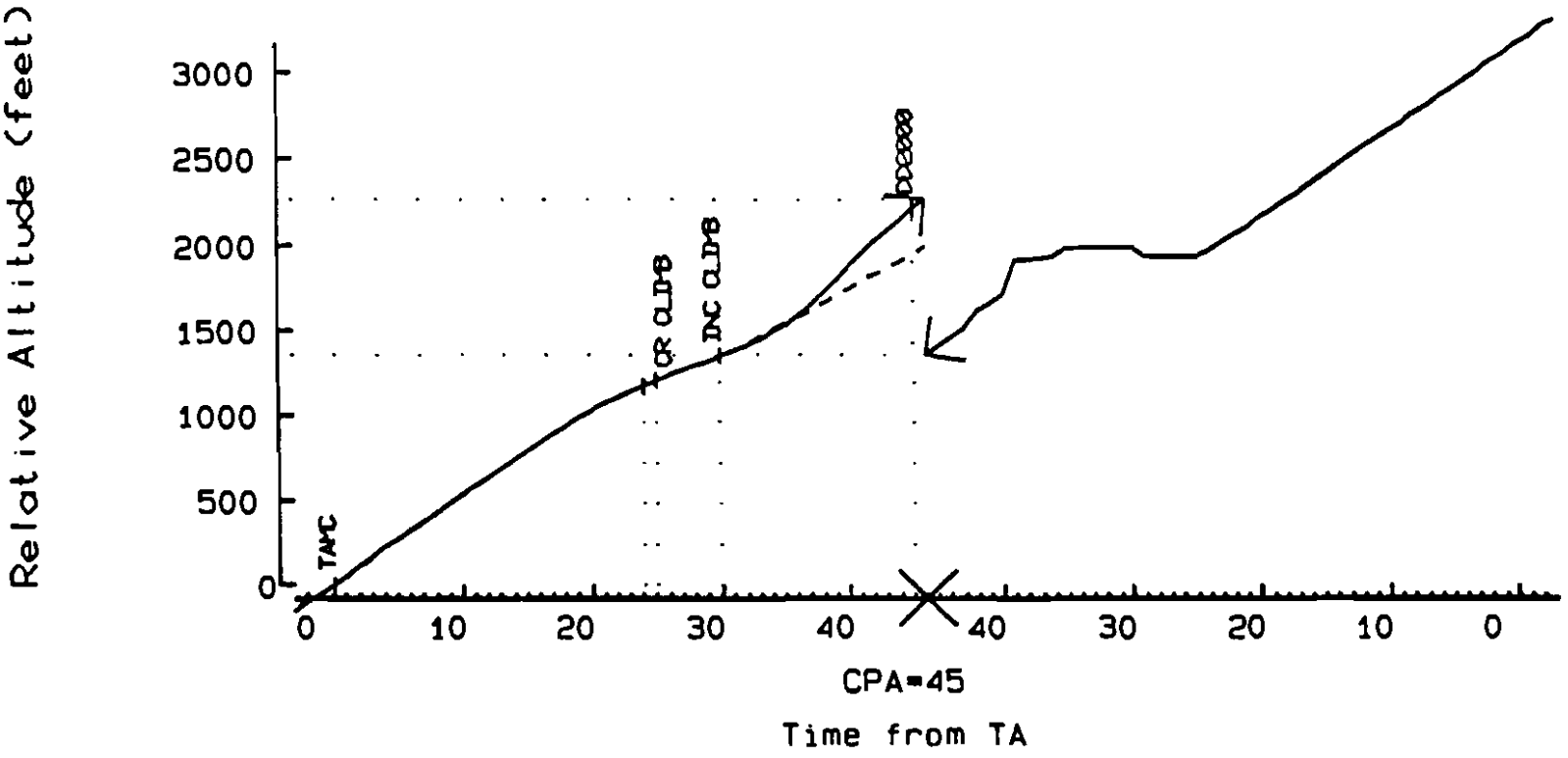
Encounter ID 1099 Filename 8930920A.TRD

ENCOUNTER ID: 1099 RANGE RATE at TA: -490

TARGET ID: 10746022 at CPA: -281

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 1354 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 634 ft



TA TIME: 14:36:55 CPA TIME: 14:37:41

FLIGHT DATE: 09/20/93 Alt. Difference at CPA: 919 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

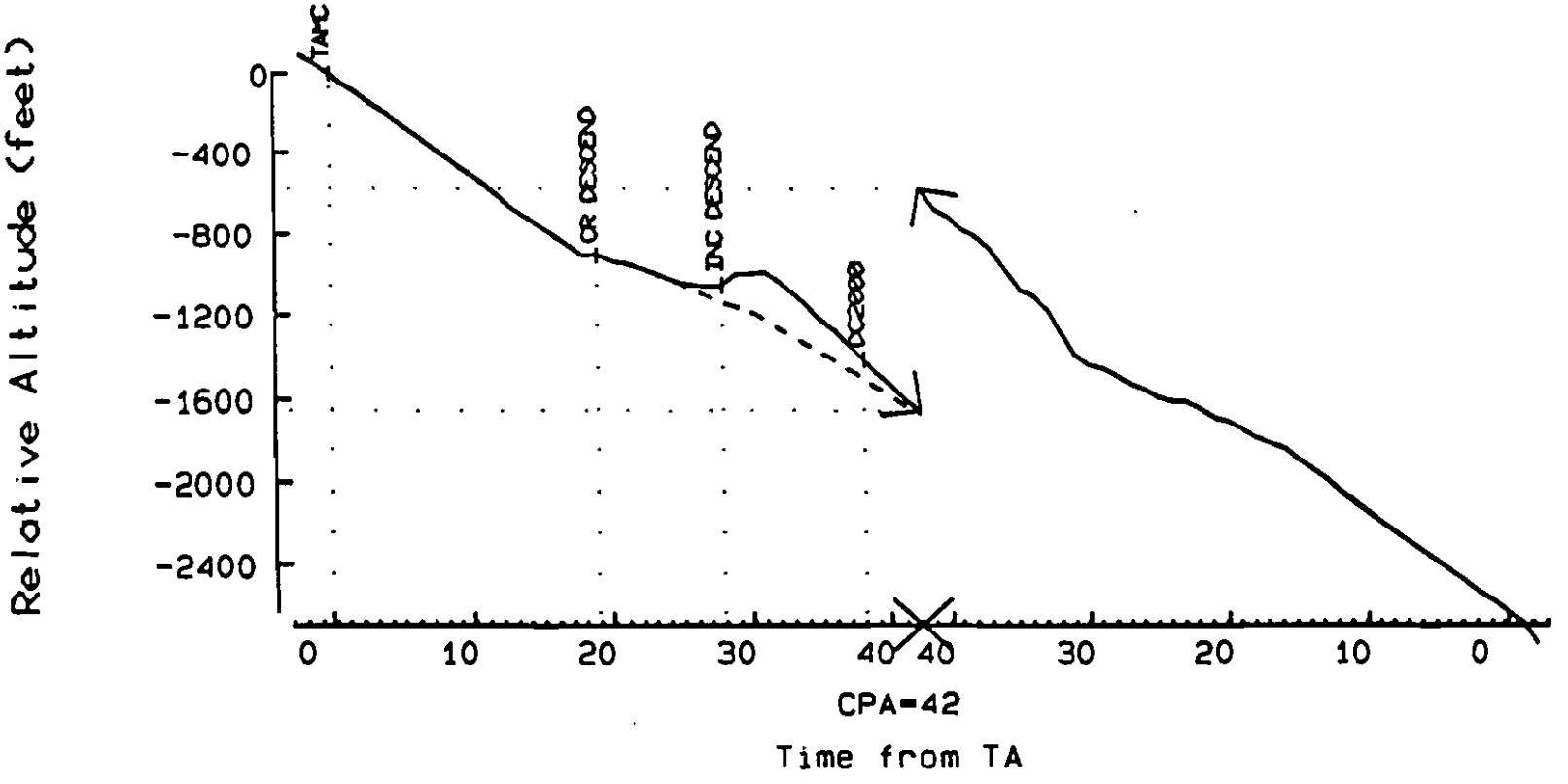
Encounter ID 576 Filename R930920A.TRD

ENCOUNTER ID: 576 RANGE RATE at TA: -511

TARGET ID: 10791495 at CPA: -345

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 765 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1095 ft



TA TIME: 14:36:18 CPA TIME: 14:37:00

FLIGHT DATE: 09/20/93 Alt. Difference at CPA: 1076 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

>

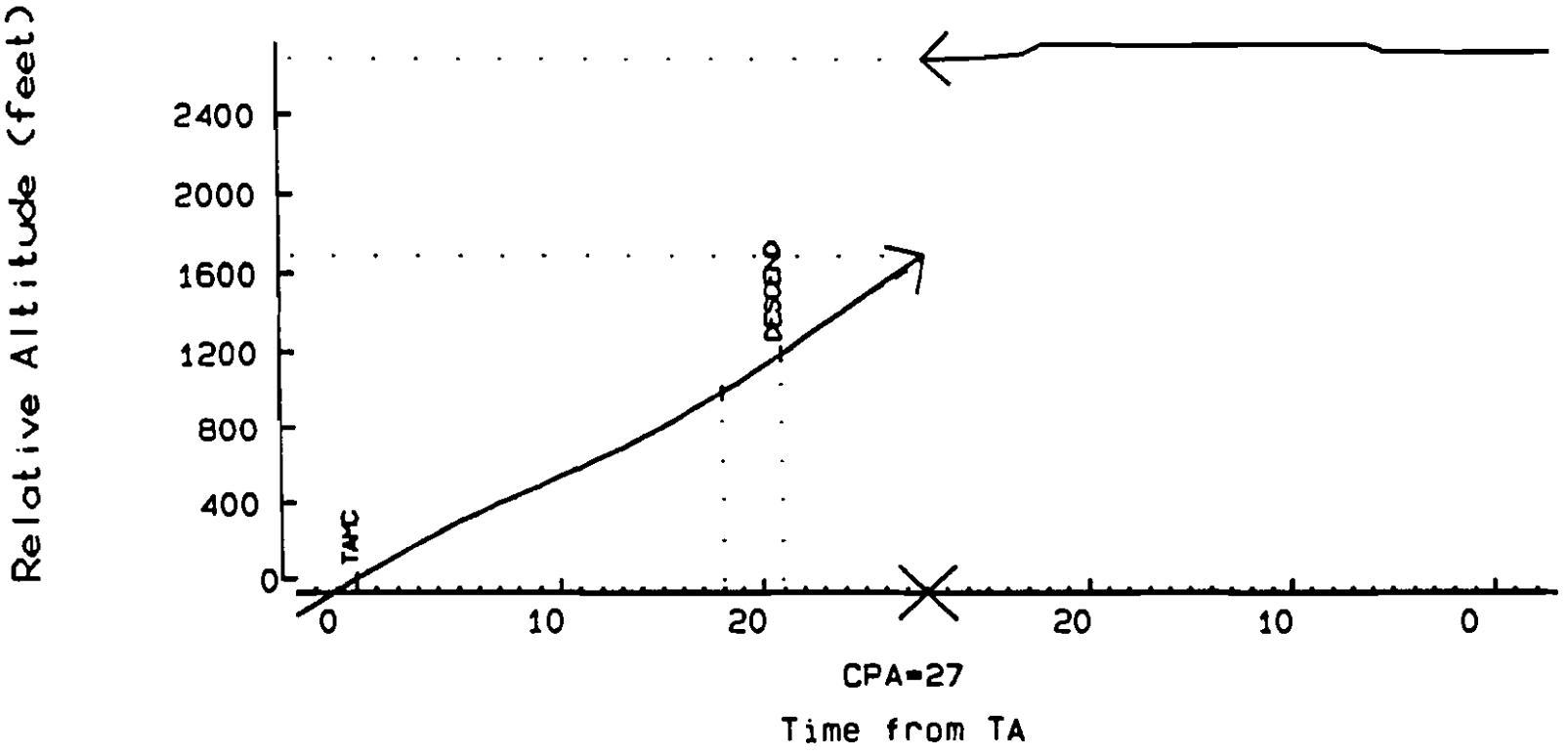
Encounter ID 24 Filename 89309208.TRD

ENCOUNTER ID: 24 RANGE RATE at TA: -459

TARGET ID: 10746022 at CPA: -39

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2296 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1026 ft



TA TIME: 14: 43: 05 CPA TIME: 14: 43: 33

FLIGHT DATE: 09/20/93 Alt. Difference at CPA: 995 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

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Encounter ID 688 Filename R930920A.TRD

ENCOUNTER ID: 688

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

RANGE RATE at TA: -445

at CPA: -171

RANGE at CPA: 1798 ft

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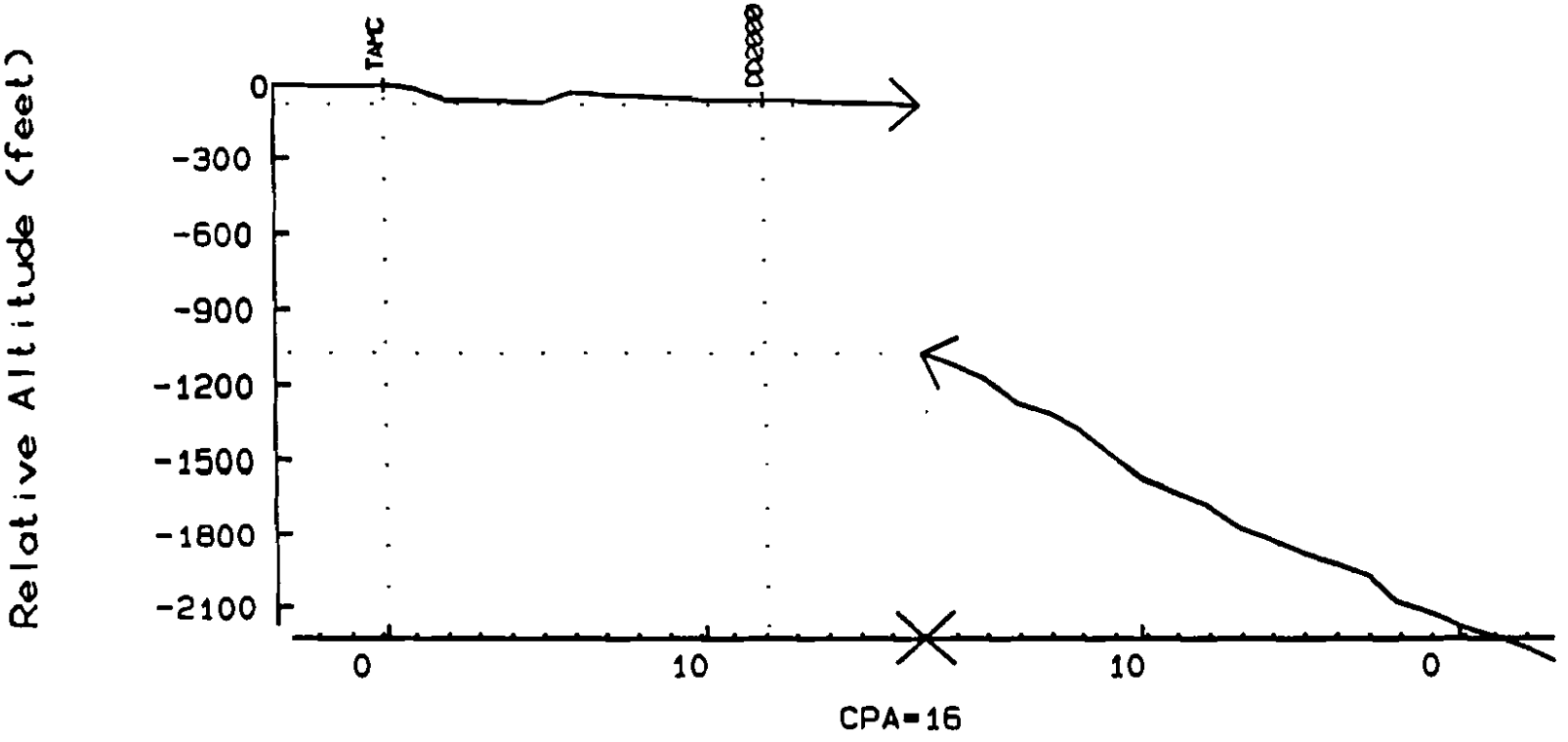


TA TIME: 14: 42: 35

CPA TIME: 14: 42: 52

FLIGHT DATE: 09/20/93

Alt. Difference at CPA: 993 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

>

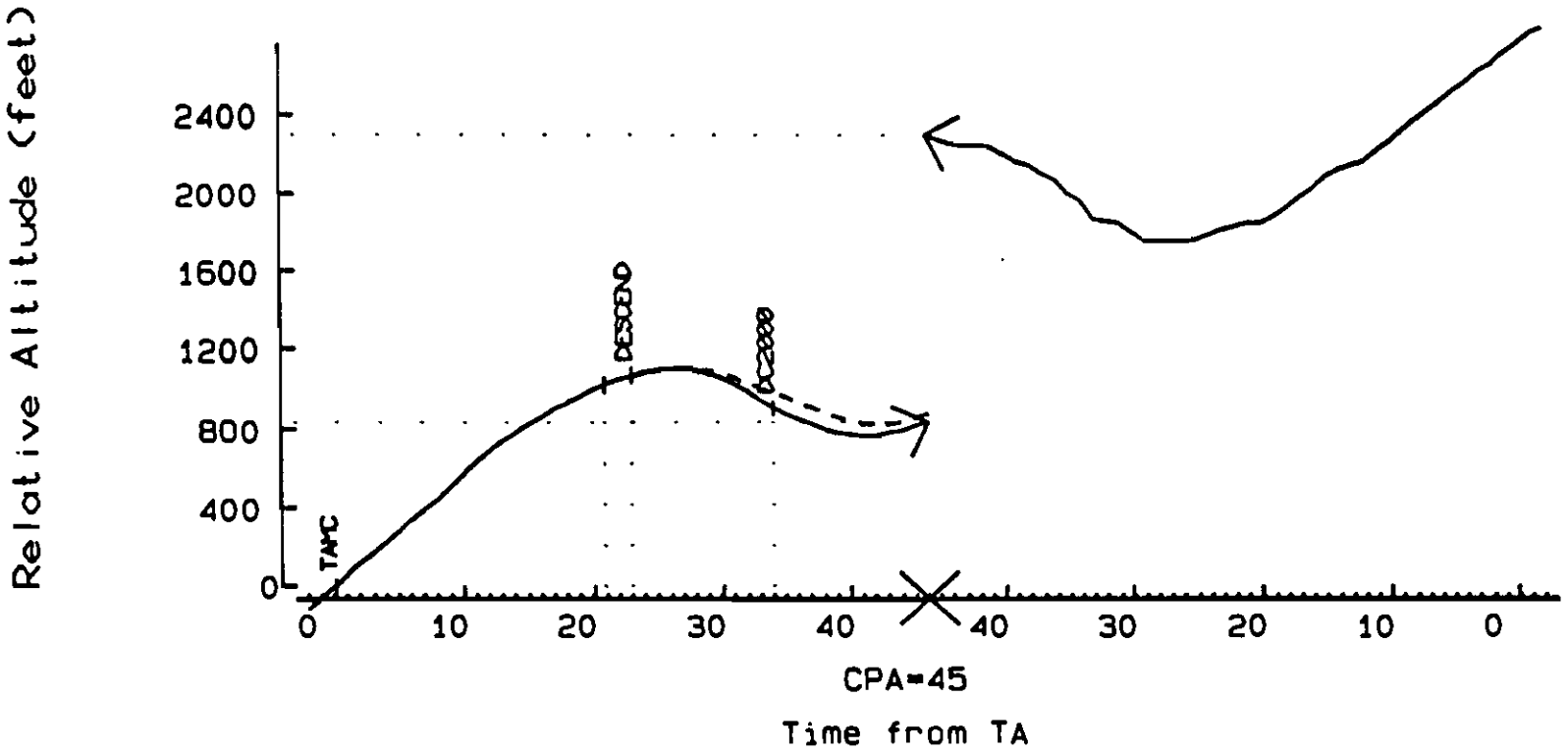
Encounter ID 297 Filename B9309208.TRD

ENCOUNTER ID: 297 RANGE RATE at TA: -495

TARGET ID: 10746022 at CPA: -76

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2952 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1421 ft



TA TIME: 14: 48: 42 CPA TIME: 14: 49: 28

FLIGHT DATE: 09/20/93 Alt. Difference at CPA: 1464 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

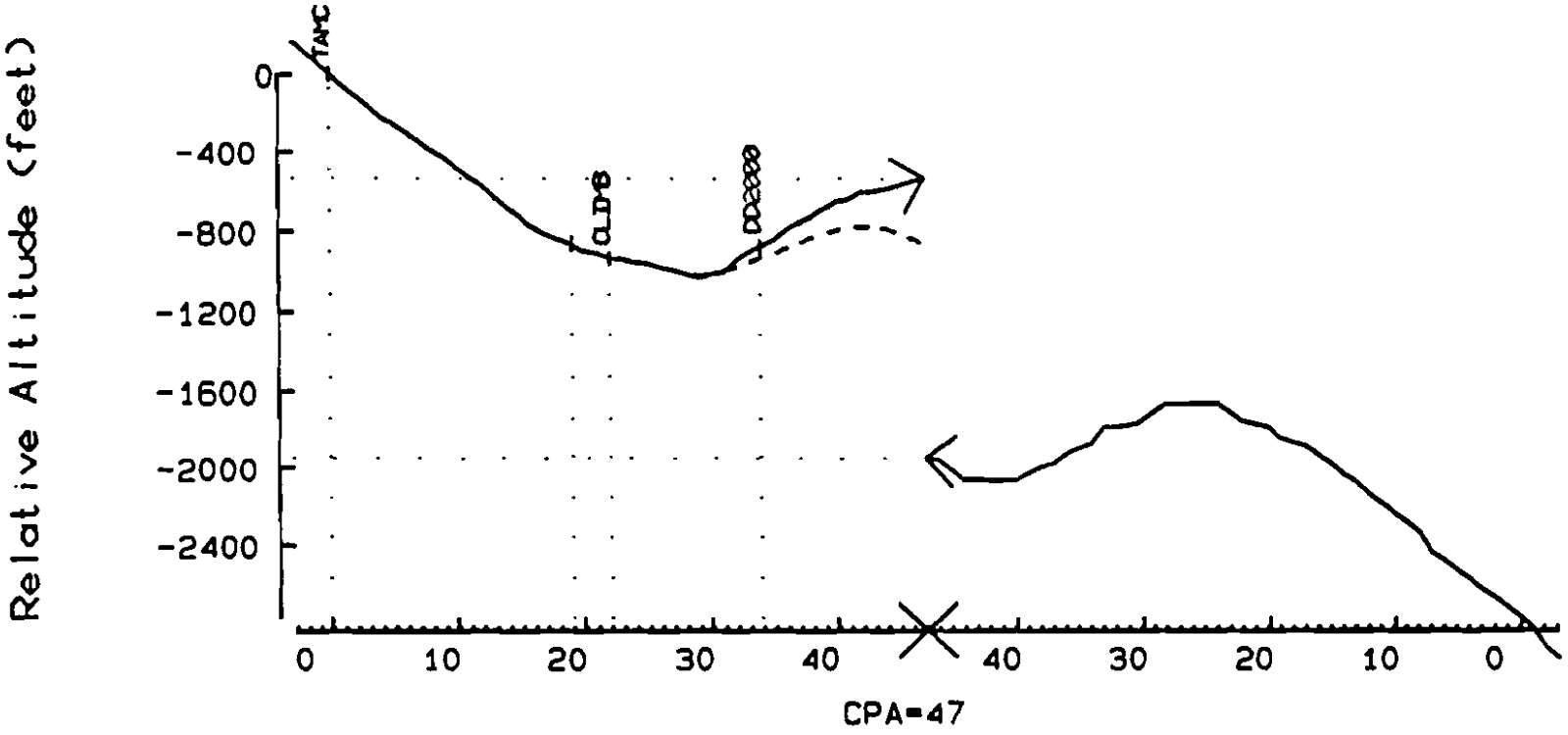
Encounter ID 725 Filename R930920A.TRD

ENCOUNTER ID: 725 RANGE RATE at TA: -494

TARGET ID: 10791495 at CPA: -198

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2418 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1086 ft



TA TIME: 14: 48: 00 CPA TIME: 14: 48: 47

FLIGHT DATE: 09/20/93 Alt. Difference at CPA: 1415 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

F-84

>

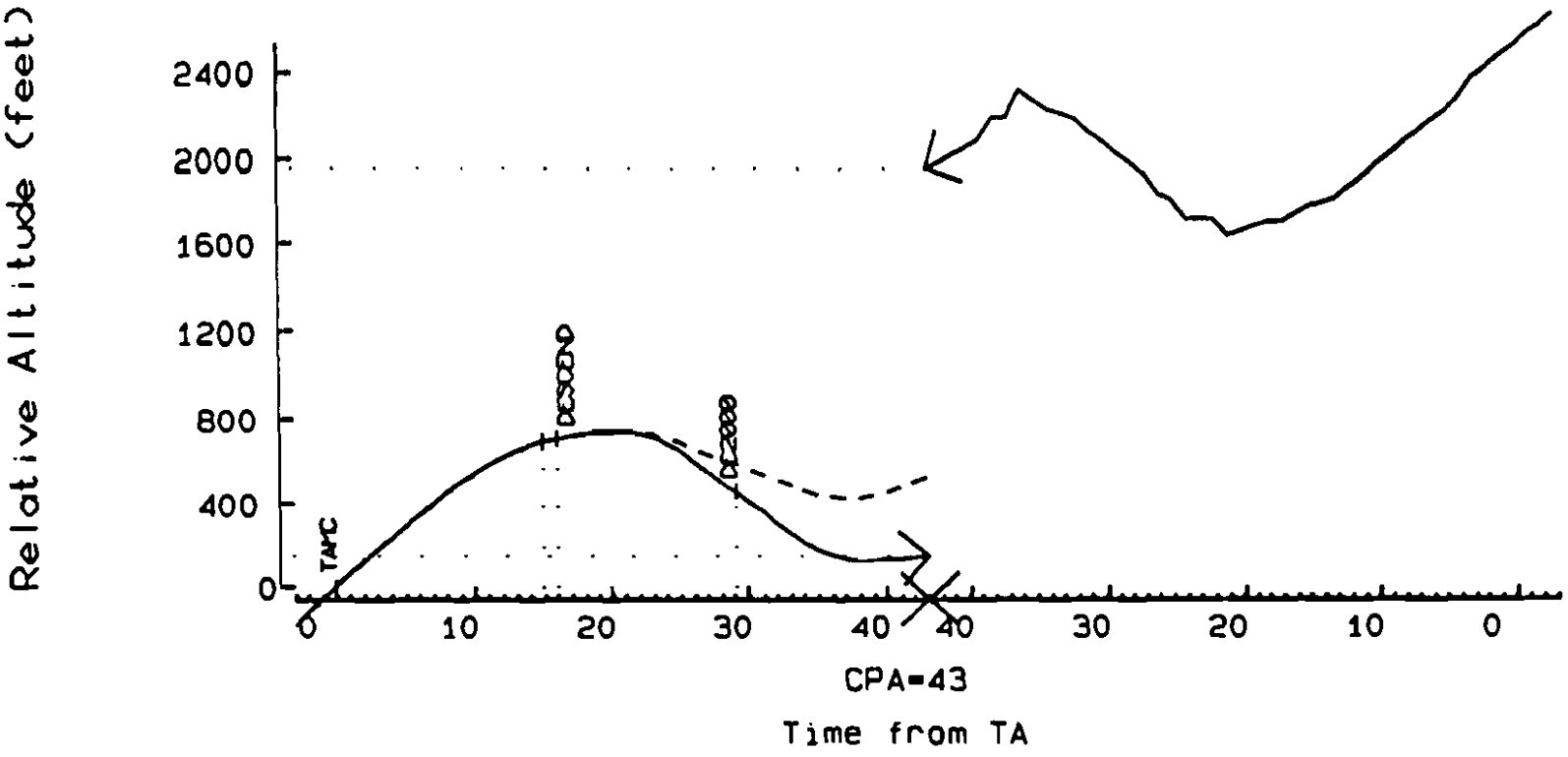
Encounter ID 519 Filename B9309208.TRD

ENCOUNTER ID: 519 RANGE RATE at TA: -481

TARGET ID: 10746022 at CPA: -118

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 4314 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1428 ft



TA TIME: 14:54:21 CPA TIME: 14:55:04

FLIGHT DATE: 09/20/93 Alt. Difference at CPA: 1812 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

Encounter ID 814 Filename A930920A.TRD

ENCOUNTER ID: 814

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

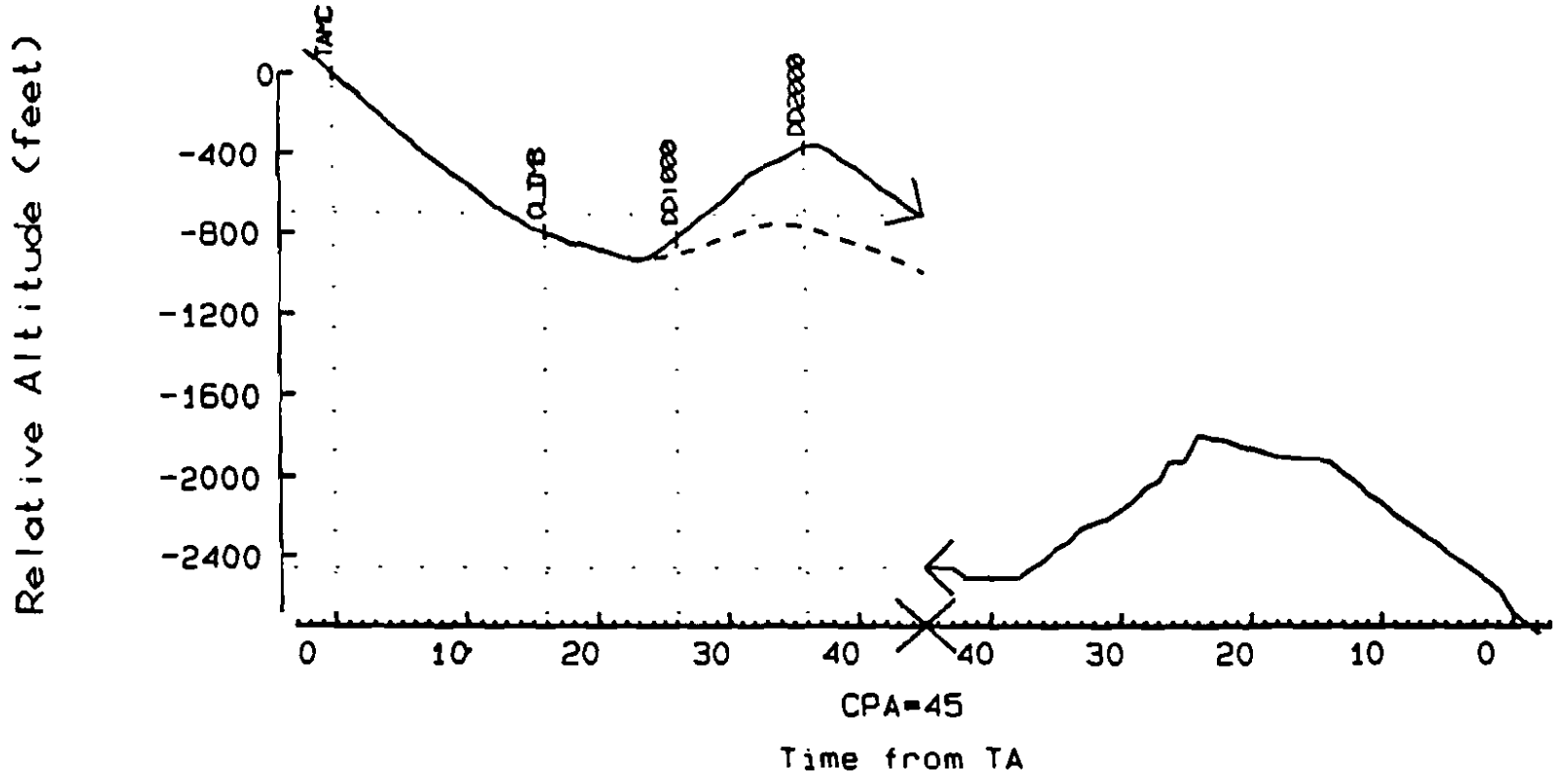
OWN ID: 10746022

RANGE RATE at TA: -494

at CPA: -213

RANGE at CPA: 3821 ft

Alt. Difference with Simulated Pilot Response: 1460 ft



TA TIME: 14:53:38

CPA TIME: 14:54:23

FLIGHT DATE: 09/20/93

Alt. Difference at CPA: 1757 ft

PROCESSED ON: 12/10/93 by ACD-320 FAA Technical Center

>

Encounter ID 284 Filename 8930921A.TRD

ENCOUNTER ID: 284

TARGET ID: 10746022

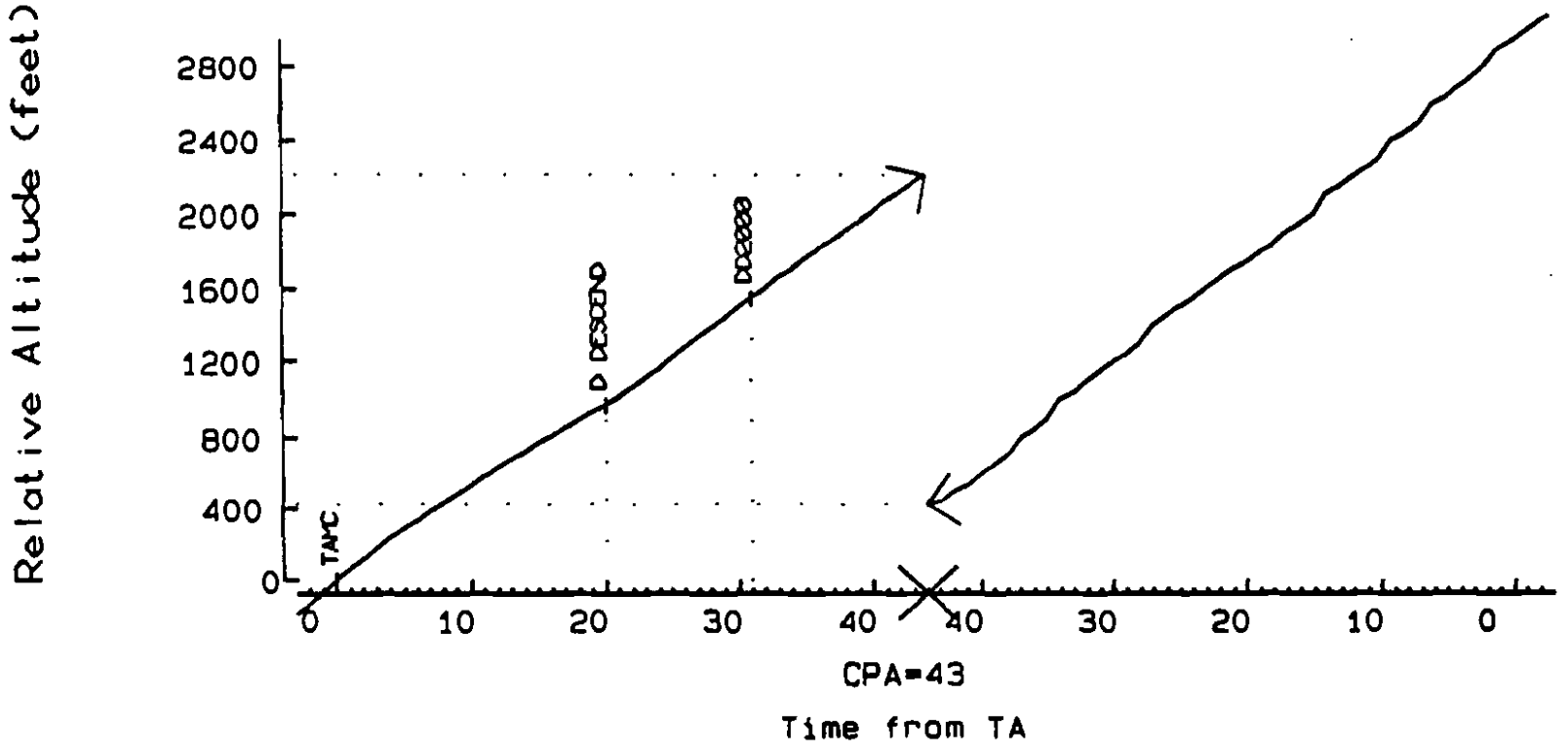
INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

RANGE RATE at TA: -497

at CPA: -19

RANGE at CPA: 5073 ft



TA TIME: 10: 42: 36

CPA TIME: 10: 43: 20

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1778 ft

PROCESSED ON: 12/08/93 by ACO-320 FAA Technical Center

>

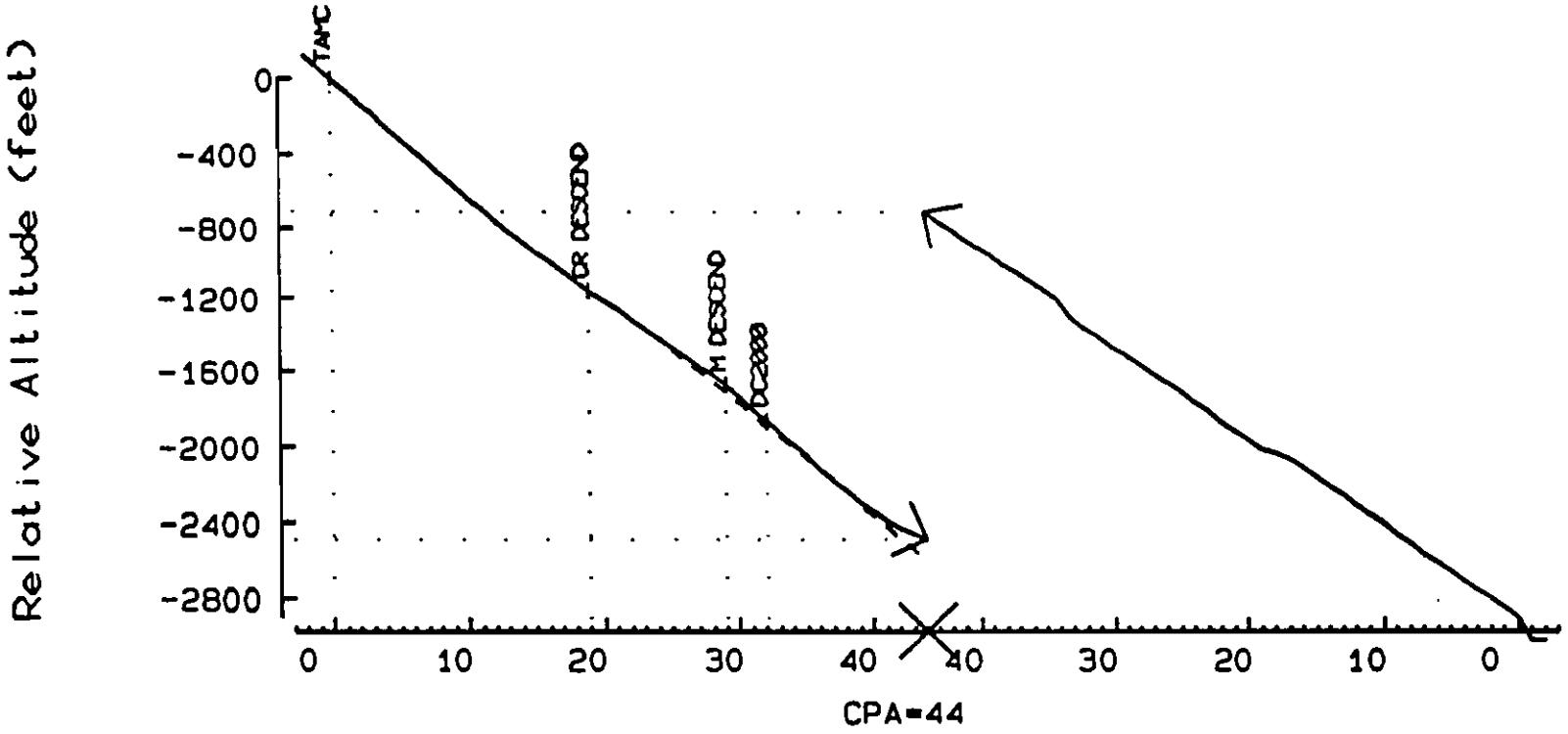
Encounter ID 145 Filename A930921A.TRD

ENCOUNTER ID: 145 RANGE RATE at TA: -495

TARGET ID: 10791495 at CPA: -158

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 4532 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1889 ft



TA TIME: 10:41:46 CPA TIME: 10:42:30

FLIGHT DATE: 09/21/93 Alt. Difference at CPA: 1774 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 473 Filename B930921A.TRD

ENCOUNTER ID: 473

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

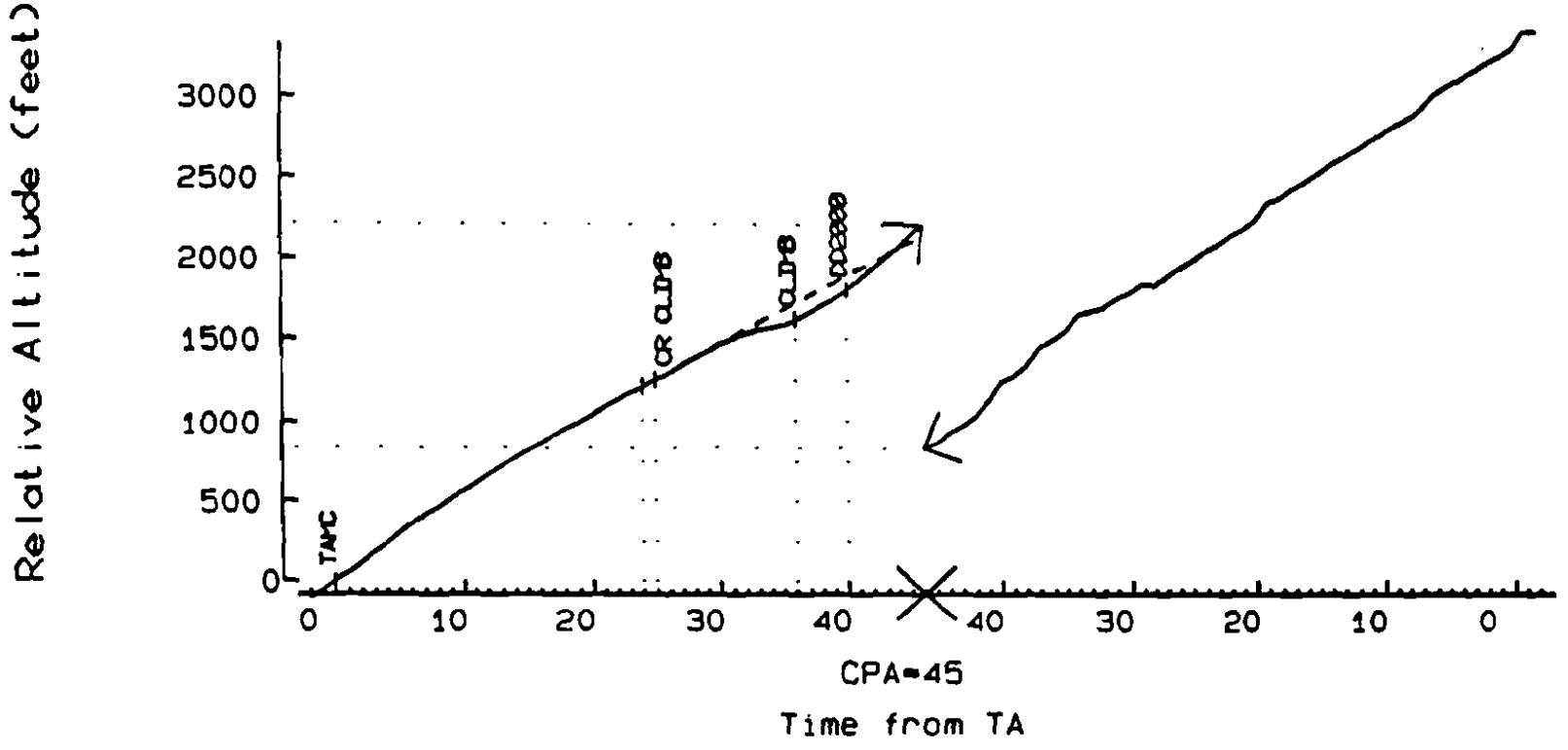
OWN ID: 10791495

RANGE RATE at TA: -532

at CPA: -26

RANGE at CPA: 2703 ft

Alt. Difference with Simulated Pilot Response: 1306 ft



TA TIME: 10: 49: 49

CPA TIME: 10: 50: 35

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1367 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

Encounter ID 232 Filename R930921A.TRD

ENCOUNTER ID: 232

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

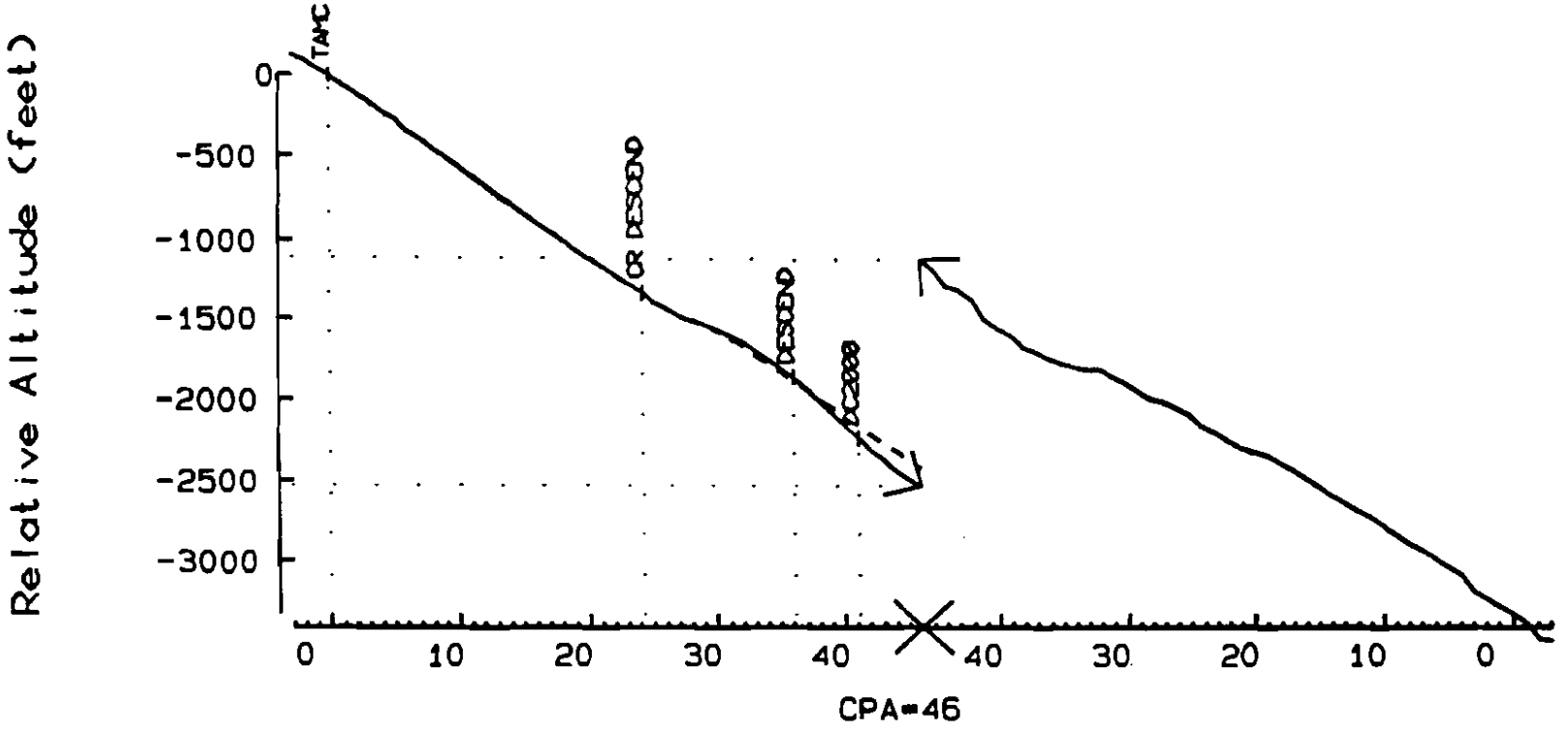
OWN ID: 10746022

RANGE RATE at TA: -523

at CPA: -342

RANGE at CPA: 1725 ft

Alt. Difference with Simulated Pilot Response: 1309 ft



TA TIME: 10:48:59

CPA TIME: 10:49:45

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1430 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

F-90

>

Encounter ID 590 Filename B930921A.TRD

ENCOUNTER ID: 590

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

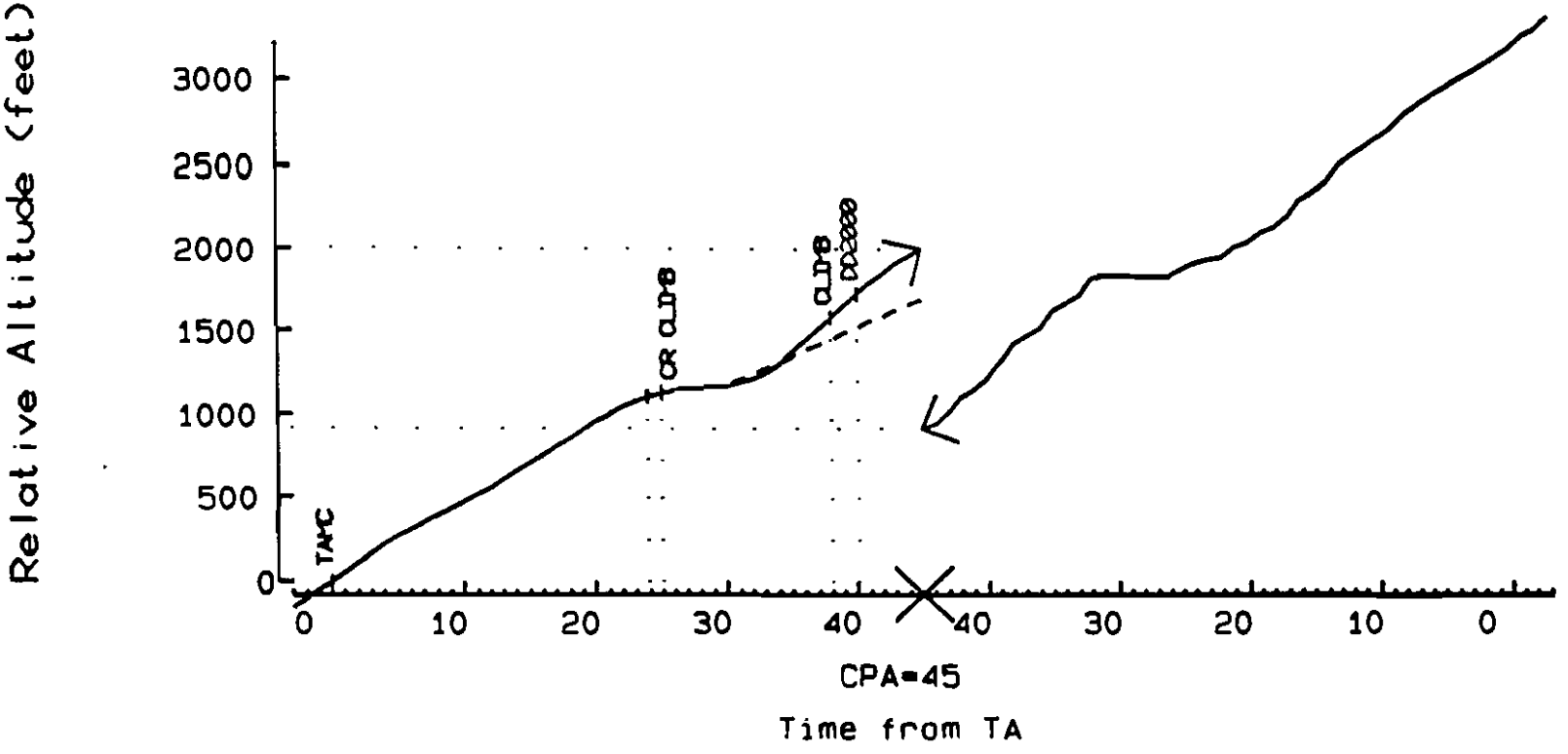
OWN ID: 10791495

RANGE RATE at TA: -500

at CPA: -41

RANGE at CPA: 4028 ft

Alt. Difference with Simulated Pilot Response: 777 ft



TA TIME: 10:56:41

CPA TIME: 10:57:26

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1085 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

F-91

>

Encounter ID 245 Filename R930921A.TRD

ENCOUNTER ID: 245

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

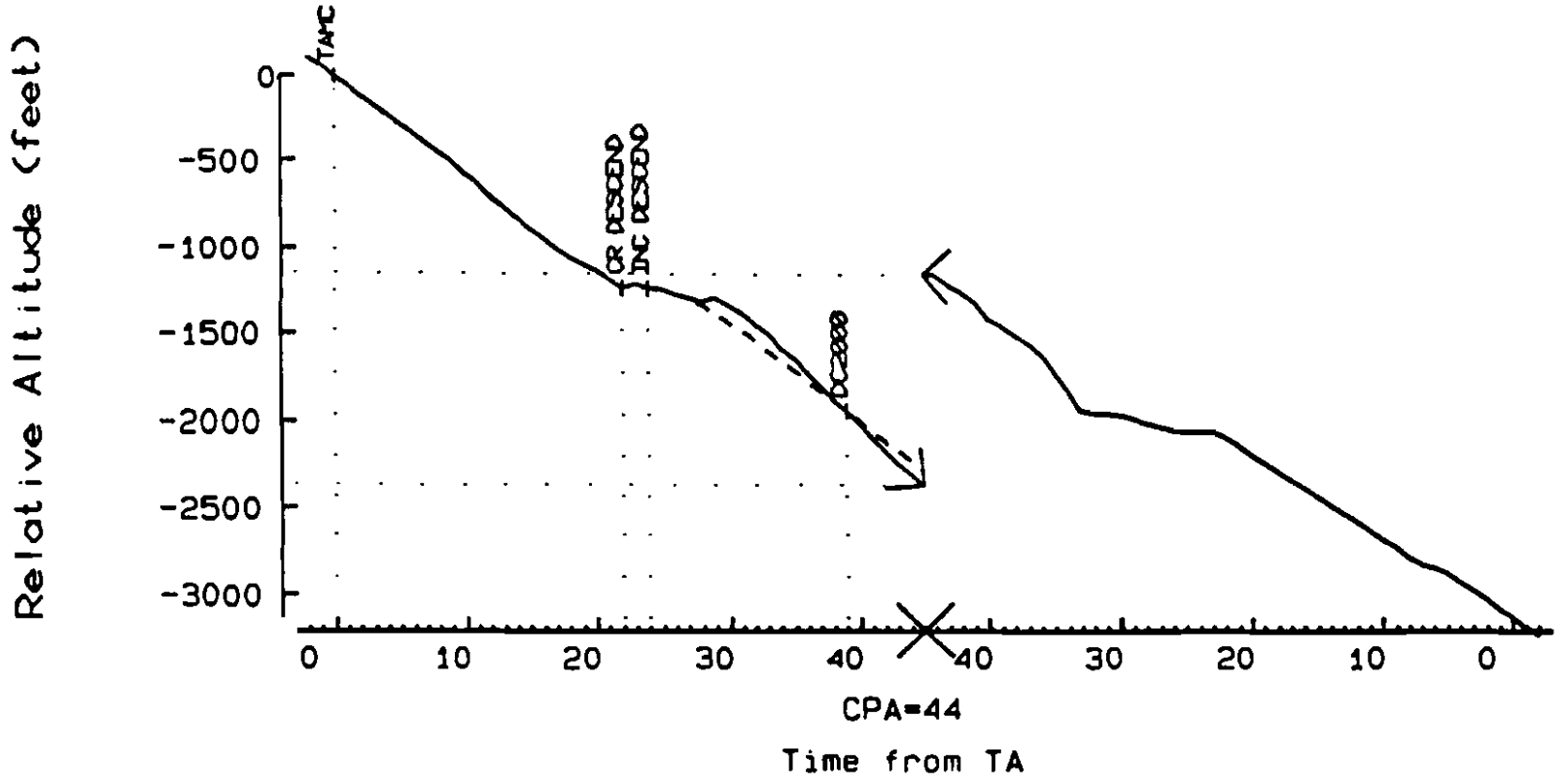
OWN ID: 10746022

RANGE RATE at TA: -487

at CPA: -144

RANGE at CPA: 3542 ft

Alt. Difference with Simulated Pilot Response: 1117 ft



TA TIME: 10:55:52

CPA TIME: 10:56:37

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1209 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

F-92

>

Encounter ID 656 Filename B930921A.TRD

ENCOUNTER ID: 656

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

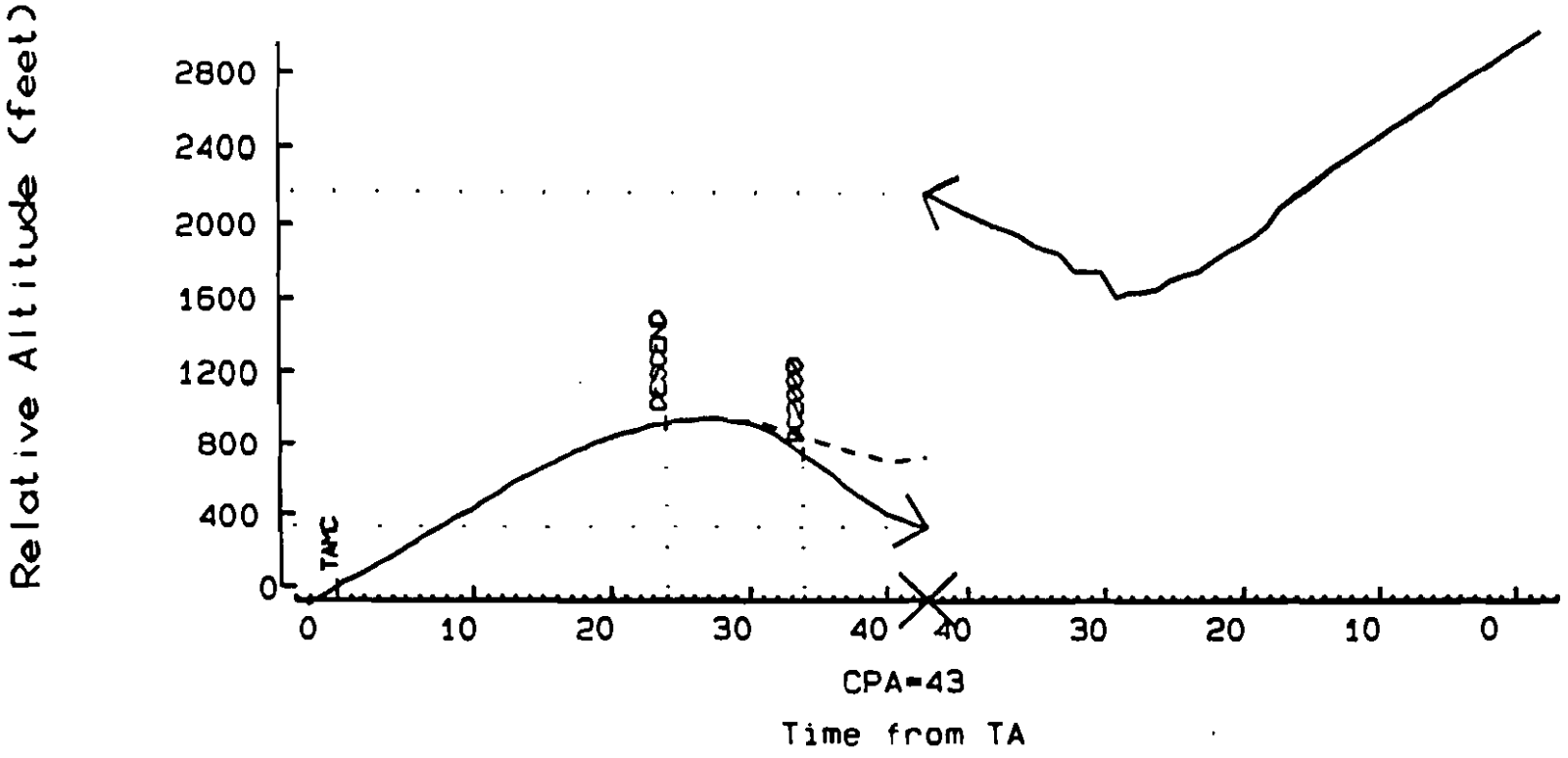
RANGE RATE at TA: -490

at CPA: -78

RANGE at CPA: 3293 ft

Alt. Difference with Simulated Pilot Response: 1465 ft

F-93



TA TIME: 11:03:37

CPA TIME: 11:04:20

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1855 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

Encounter ID 314 Filename R930921A.TRD

ENCOUNTER ID: 314

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

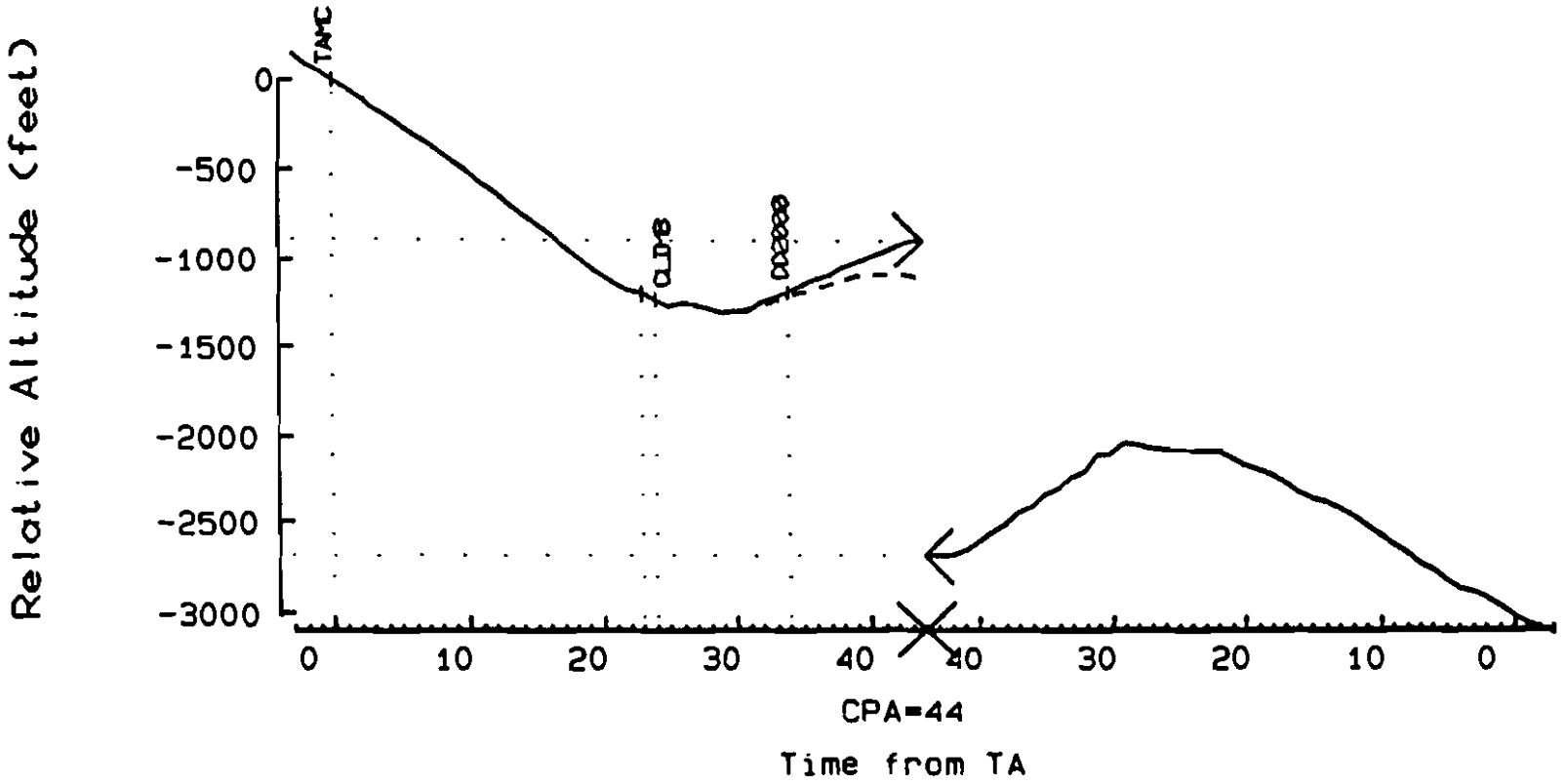
OWN ID: 10746022

RANGE RATE at TA: -487

at CPA: -233

RANGE at CPA: 2691 ft

Alt. Difference with Simulated Pilot Response: 1579 ft



TA TIME: 11:02:47

CPA TIME: 11:03:31

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1806 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 81 Filename 8930921B.TRD

ENCOUNTER ID: 81

TARGET ID: 10746022

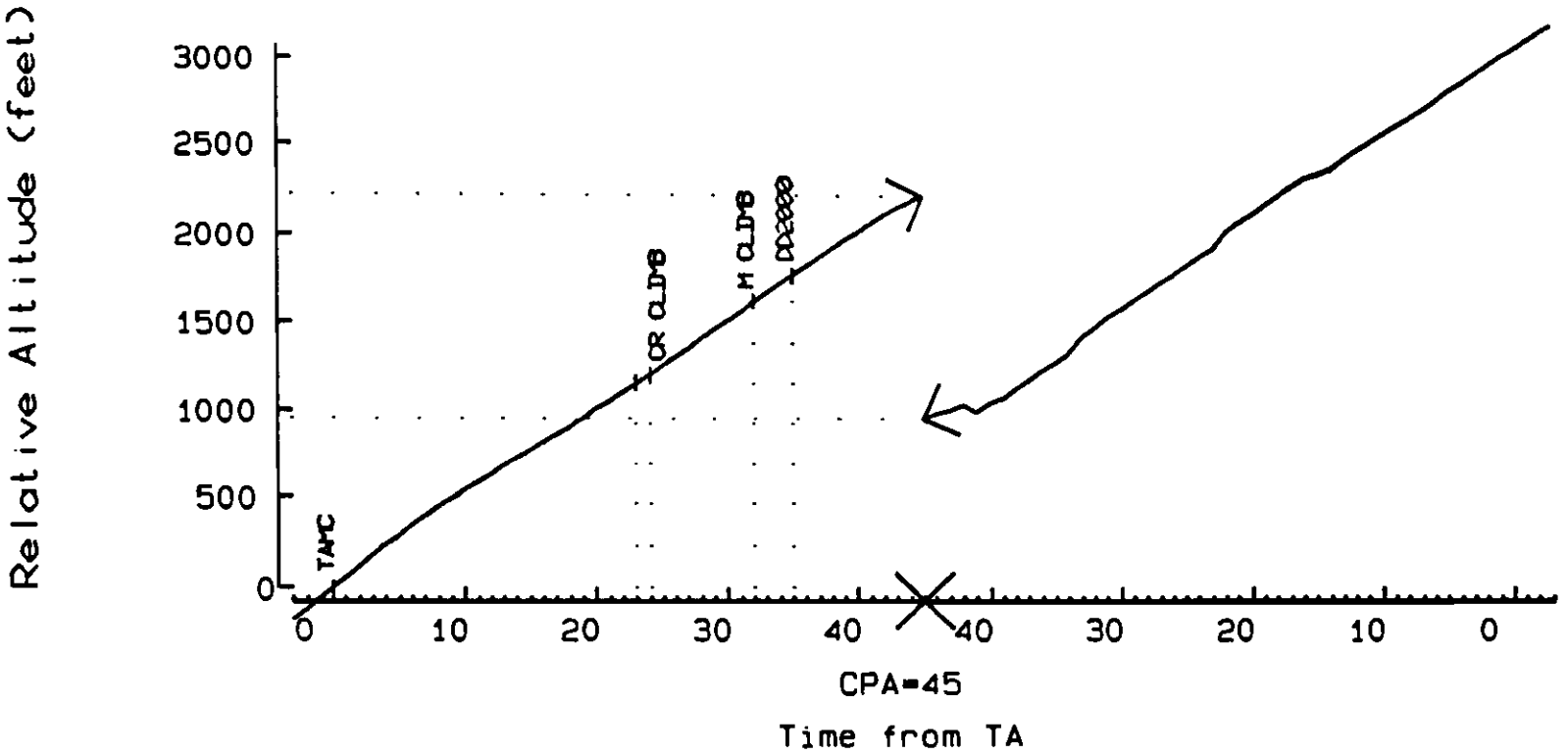
INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

RANGE RATE at TA: -502

at CPA: -172

RANGE at CPA: 1689 ft



TA TIME: 11:10:27 CPA TIME: 11:11:12

FLIGHT DATE: 09/21/93 Alt. Difference at CPA: 1269 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

Encounter ID 351 Filename R930921A.TRD

ENCOUNTER ID: 351

TARGET ID: 10791495

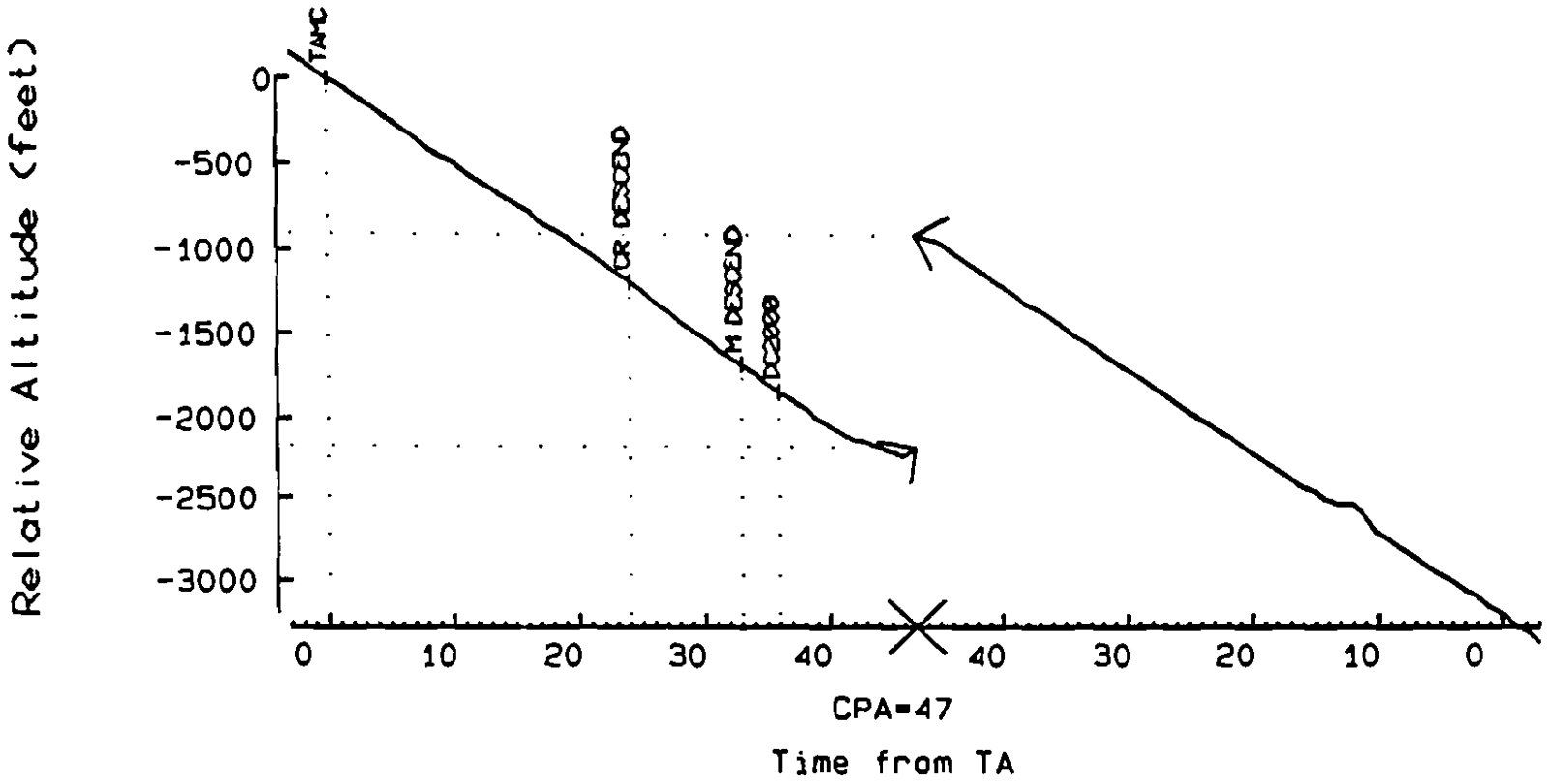
INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

RANGE RATE at TA: -519

at CPA: -323

RANGE at CPA: 1130 ft



TA TIME: 11:09:36 CPA TIME: 11:10:23

FLIGHT DATE: 09/21/93 Alt. Difference at CPA: 1269 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 154 Filename B930921B.TRD

ENCOUNTER ID: 154

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

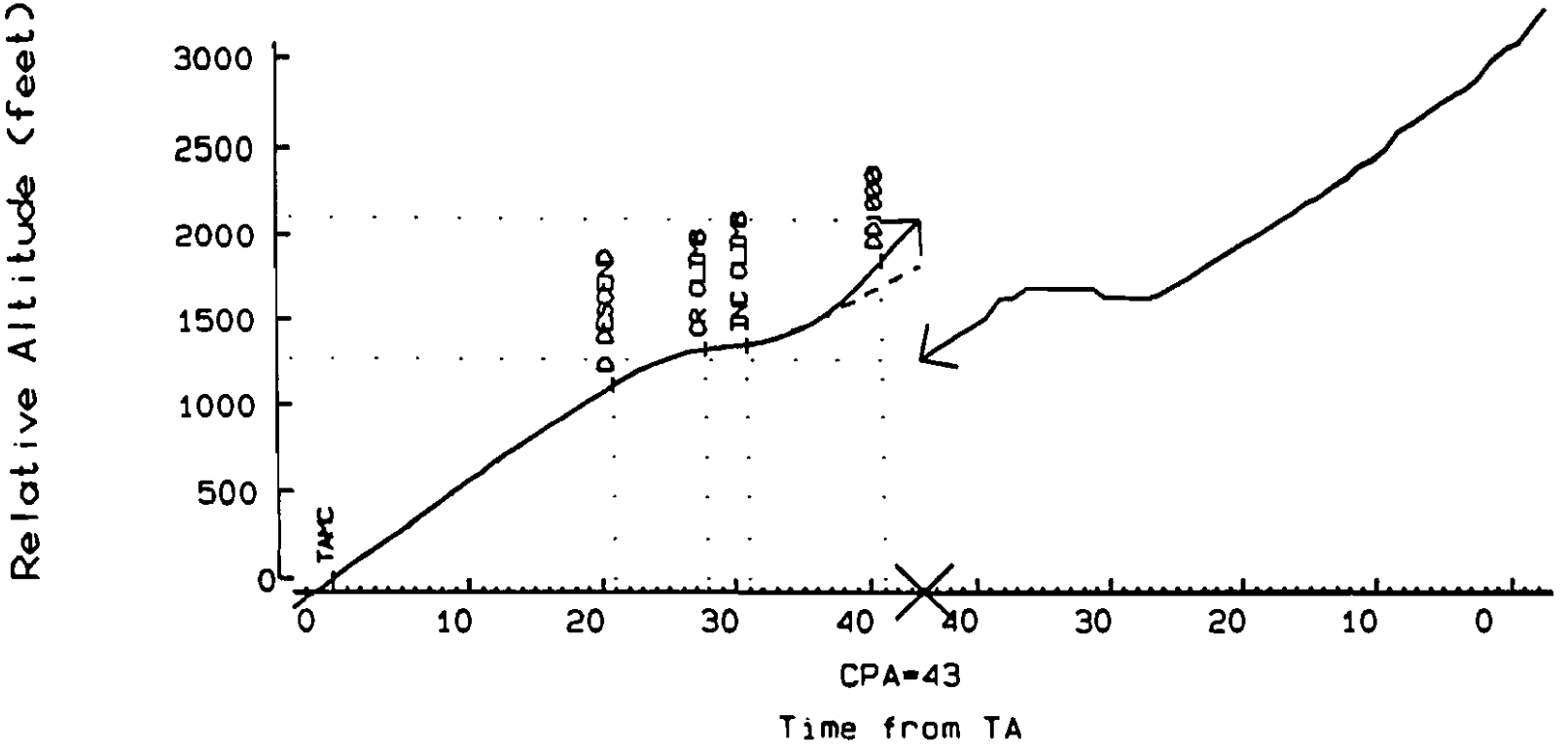
RANGE RATE at TA: -500

at CPA: -100

RANGE at CPA: 4696 ft

Alt. Difference with Simulated Pilot Response: 559 ft

F-97



TA TIME: 11:17:18

CPA TIME: 11:18:02

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 842 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

>

Encounter ID 395 Filename R930921A.TRD

ENCOUNTER ID: 395

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

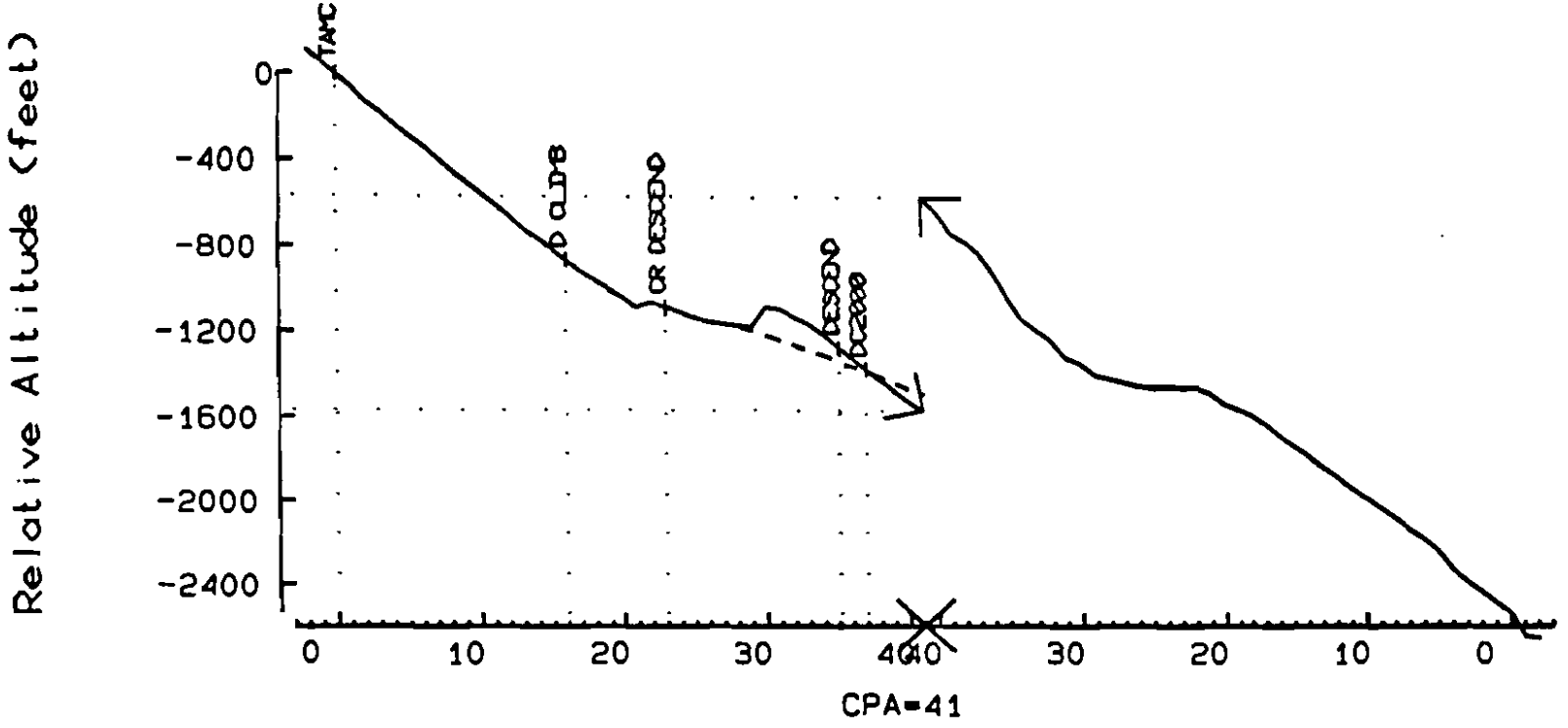
OWN ID: 10746022

RANGE RATE at TA: -495

at CPA: -127

RANGE at CPA: 4192 ft

Alt. Difference with Simulated Pilot Response: 931 ft



TA TIME: 11:16:33

CPA TIME: 11:17:14

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1011 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 293 Filename B930921B.TRD

ENCOUNTER ID: 293

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

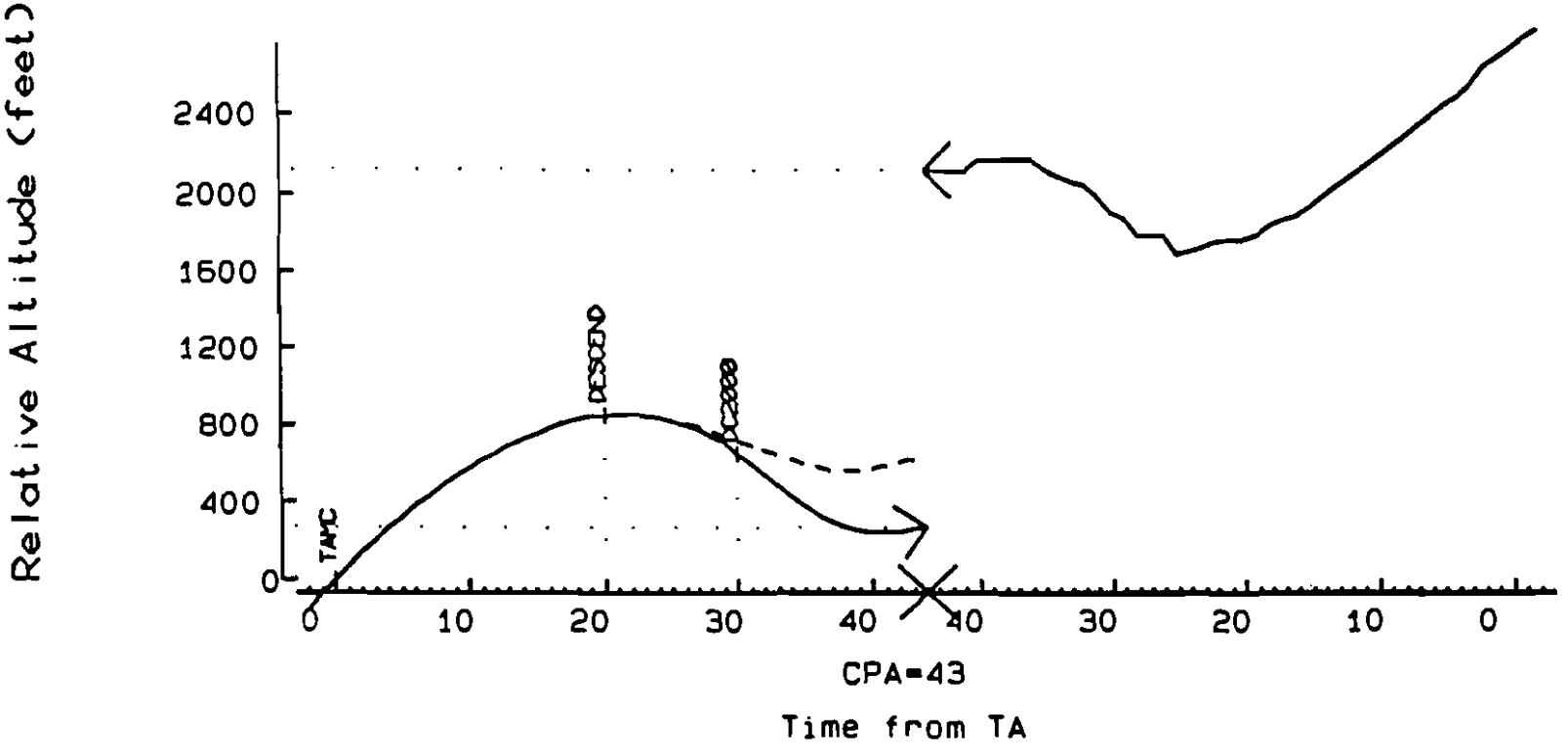
OWN ID: 10791495

RANGE RATE at TA: -490

at CPA: -84

RANGE at CPA: 7844 ft

Alt. Difference with Simulated Pilot Response: 1489 ft



TA TIME: 11:24:32

CPA TIME: 11:25:16

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1861 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

Encounter ID 406 Filename R930921A.TRD

ENCOUNTER ID: 406

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

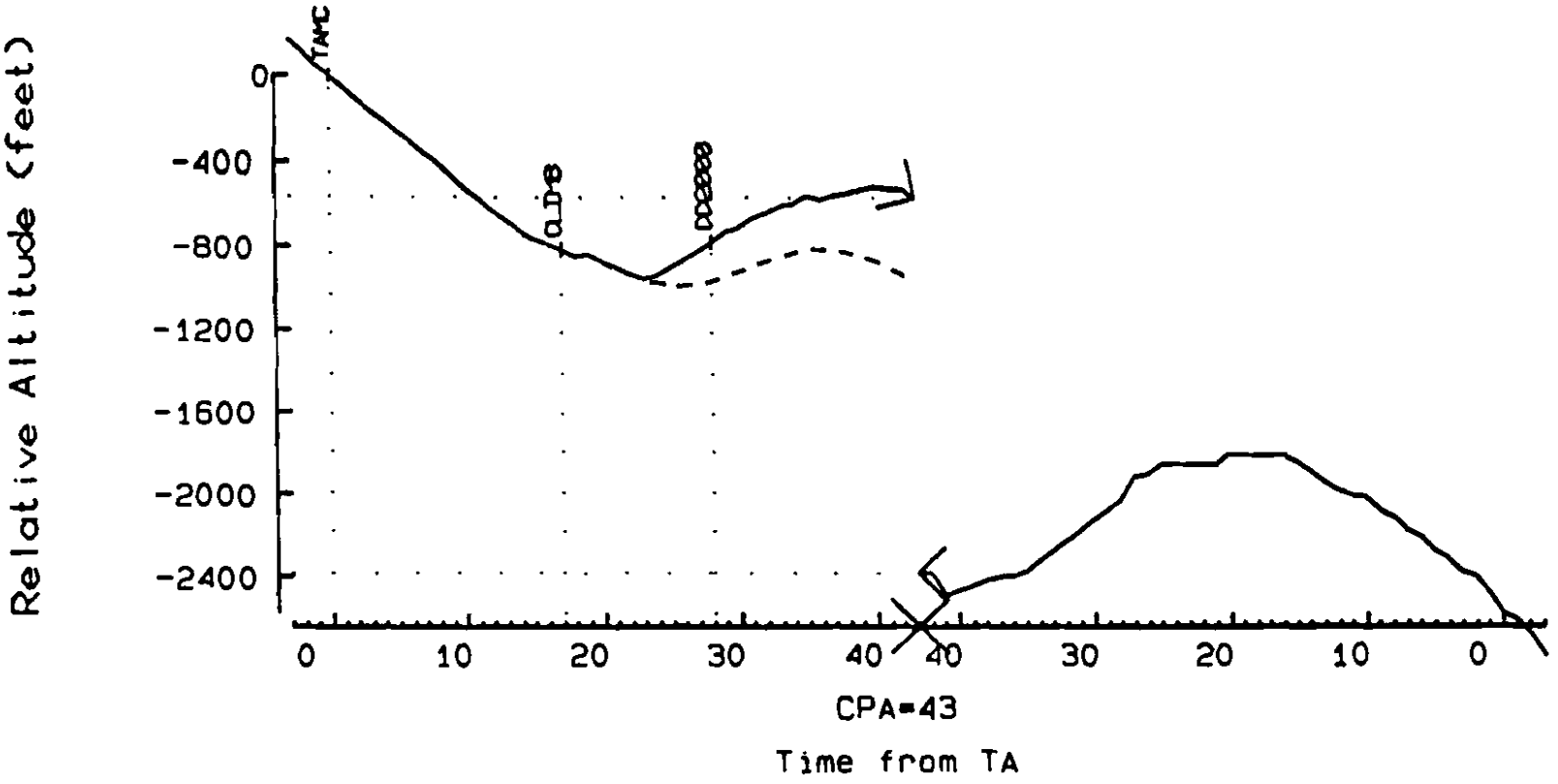
RANGE RATE at TA: -487

at CPA: -103

RANGE at CPA: 7510 ft

Alt. Difference with Simulated Pilot Response: 1419 ft

F-100



TA TIME: 11:23:44

CPA TIME: 11:24:27

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1824 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 428 Filename 89309218.TRD

ENCOUNTER ID: 428

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

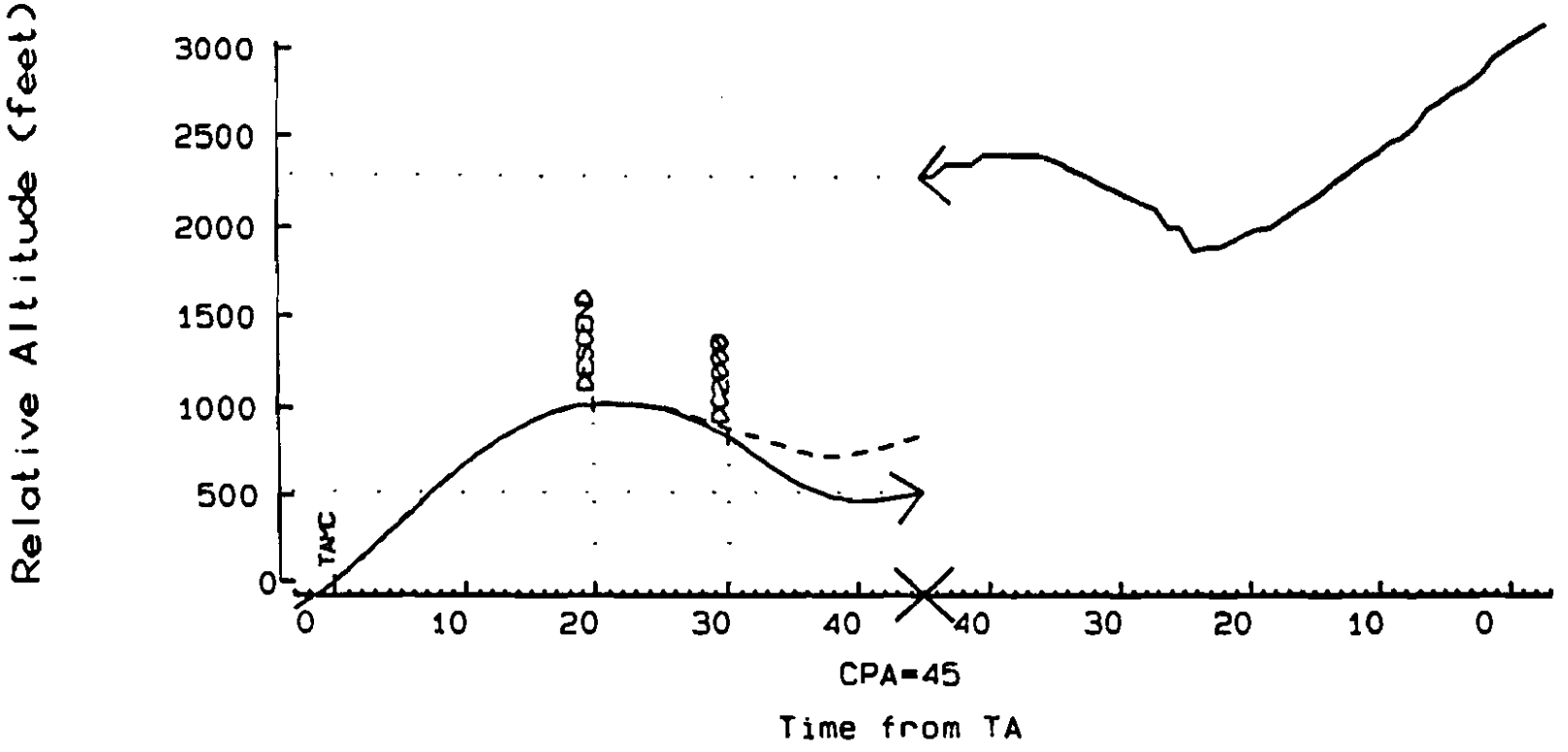
RANGE RATE at TA: -504

at CPA: -59

RANGE at CPA: 3730 ft

Alt. Difference with Simulated Pilot Response: 1449 ft

F-101



TA TIME: 11:30:43 CPA TIME: 11:31:28

FLIGHT DATE: 09/21/93 Alt. Difference at CPA: 1786 ft

PROCESSED ON: 12/08/93 by ACD-320 FAA Technical Center

Encounter ID 420 Filename R930921A.TRD

ENCOUNTER ID: 420

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

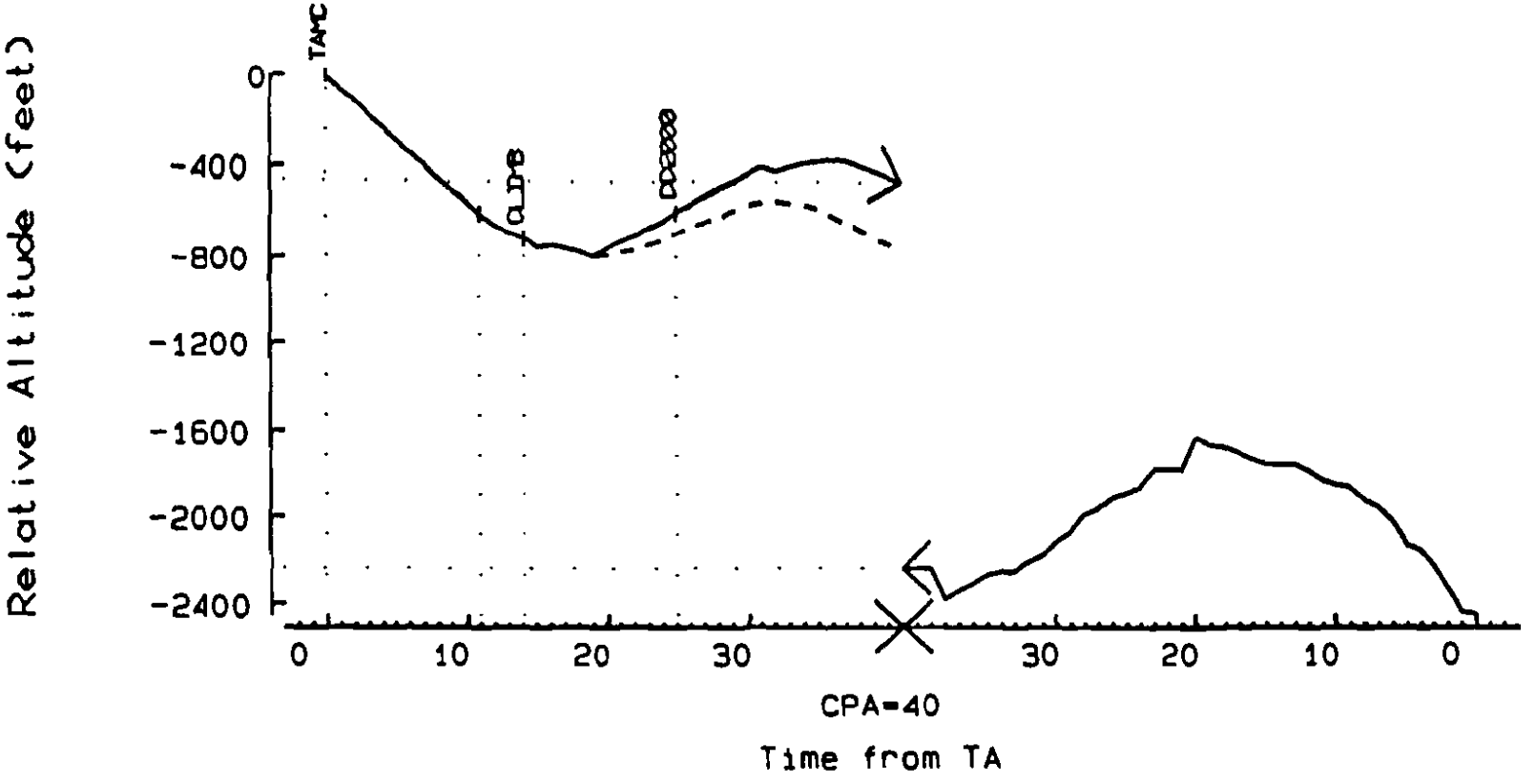
RANGE RATE at TA: -473

at CPA: -225

RANGE at CPA: 3202 ft

Alt. Difference with Simulated Pilot Response: 1470 ft

F-102



TA TIME: 11:29:58

CPA TIME: 11:30:39

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1778 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 165 Filename 8930921C.TRD

ENCOUNTER ID: 165

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

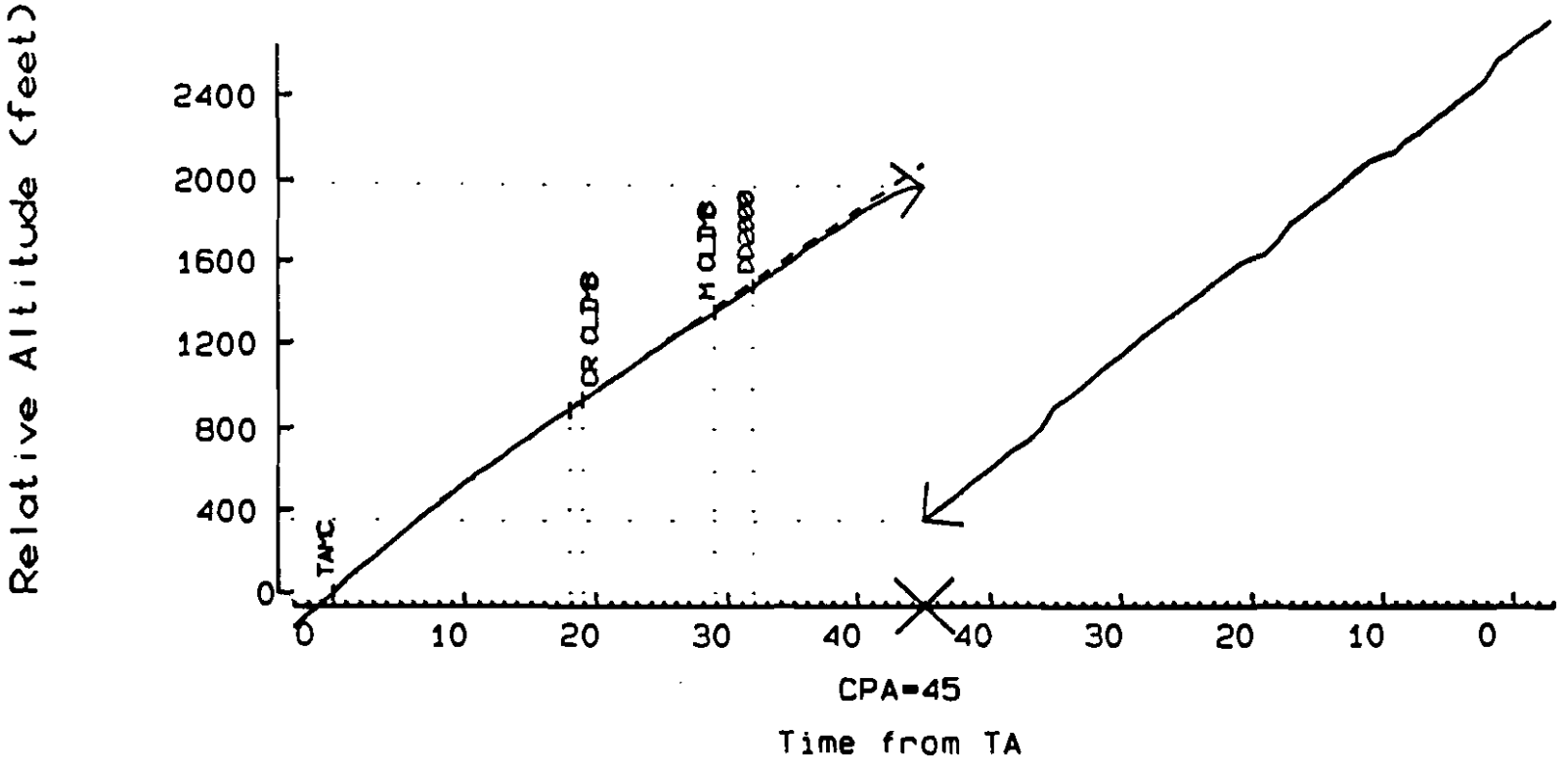
OWN ID: 10791495

RANGE RATE at TA: -480

at CPA: -99

RANGE at CPA: 6015 ft

Alt. Difference with Simulated Pilot Response: 1736 ft



TA TIME: 14: 18: 20

CPA TIME: 14: 19: 05

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1635 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

F-103

>

Encounter ID 73 Filename R9309218.TRD

ENCOUNTER ID: 73

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

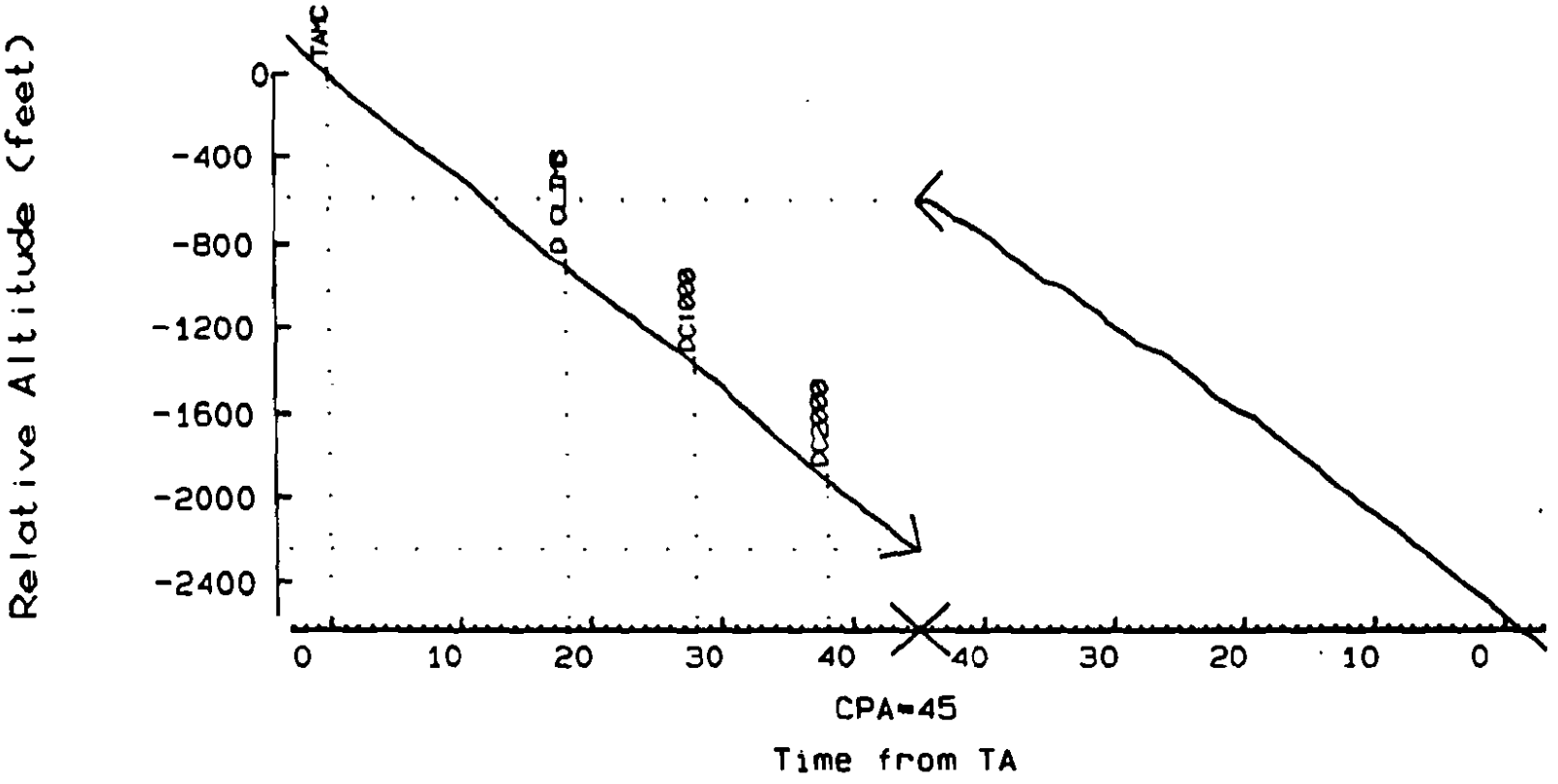
OWN ID: 10746022

RANGE RATE at TA: -469

at CPA: -124

RANGE at CPA: 5602 ft

F-104



TA TIME: 14: 17: 35

CPA TIME: 14: 18: 20

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1657 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 222 Filename B930921C.TRD

ENCOUNTER ID: 222

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

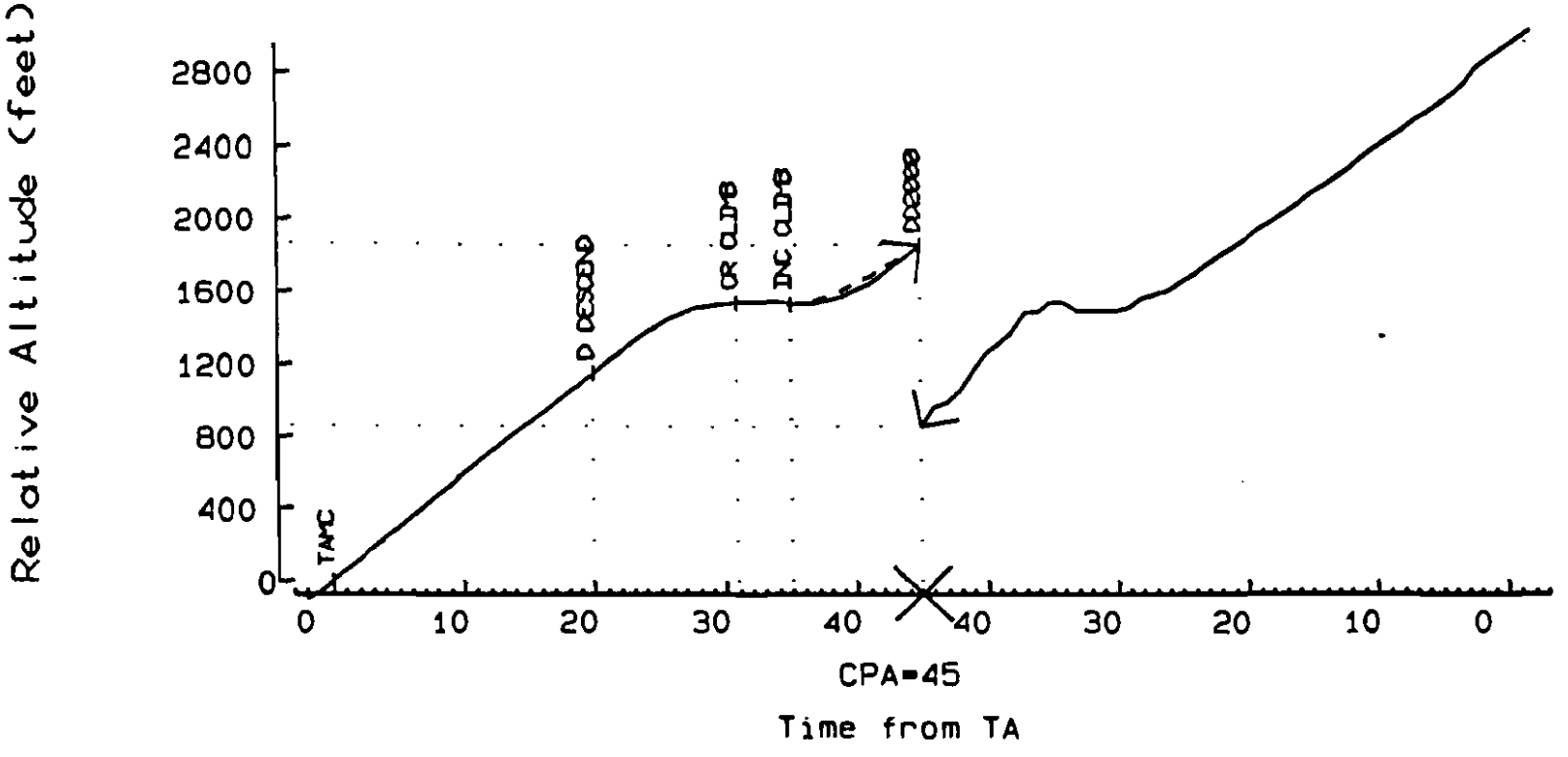
RANGE RATE at TA: -511

at CPA: -210

RANGE at CPA: 1737 ft

Alt. Difference with Simulated Pilot Response: 997 ft

F-105



TA TIME: 14:24:54

CPA TIME: 14:25:39

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1011 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

Encounter ID 95 Filename R9309218.TRO

ENCOUNTER ID: 95

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

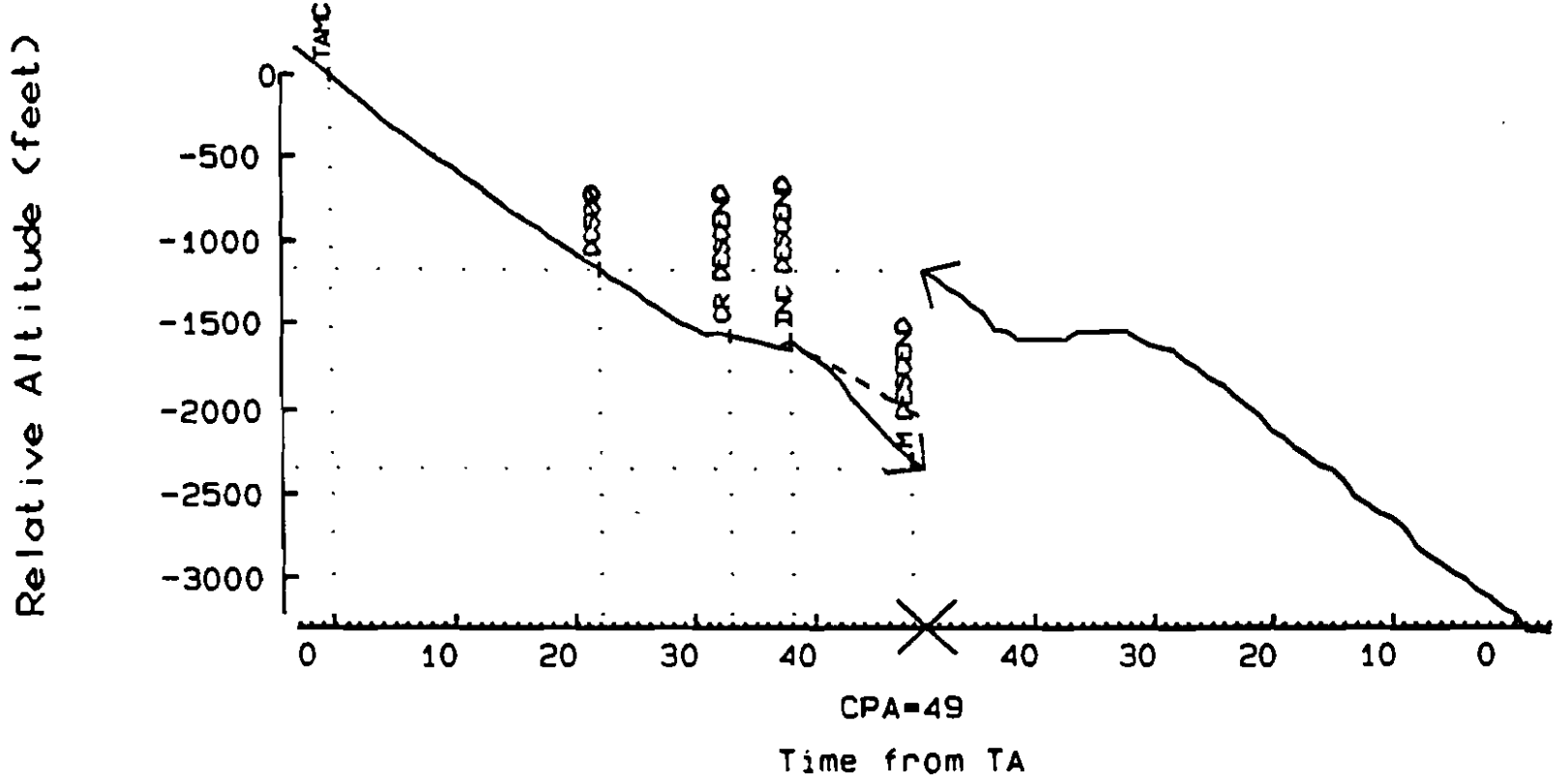
RANGE RATE at TA: -647

at CPA: -358

RANGE at CPA: 601 ft

Alt. Difference with Simulated Pilot Response: 872 ft

F-106



TA TIME: 14:24:06

CPA TIME: 14:24:55

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1176 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 360 Filename B930921C.TRD

ENCOUNTER ID: 360

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

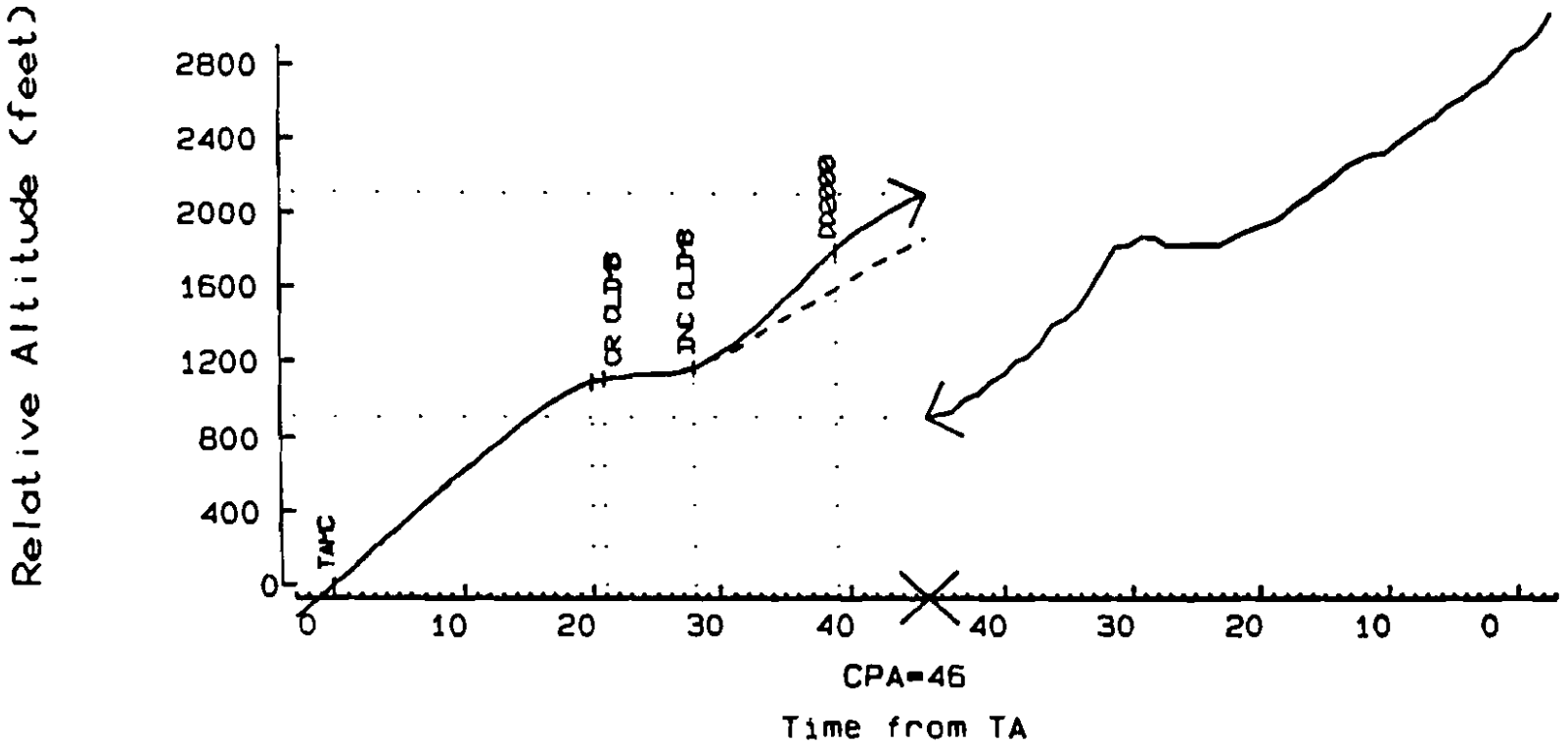
RANGE RATE at TA: -503

at CPA: -194

RANGE at CPA: 1598 ft

Alt. Difference with Simulated Pilot Response: 952 ft

F-107



TA TIME: 14:31:04

CPA TIME: 14:31:50

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1208 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

Encounter ID 109 Filename R9309218.TRD

ENCOUNTER ID: 109

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

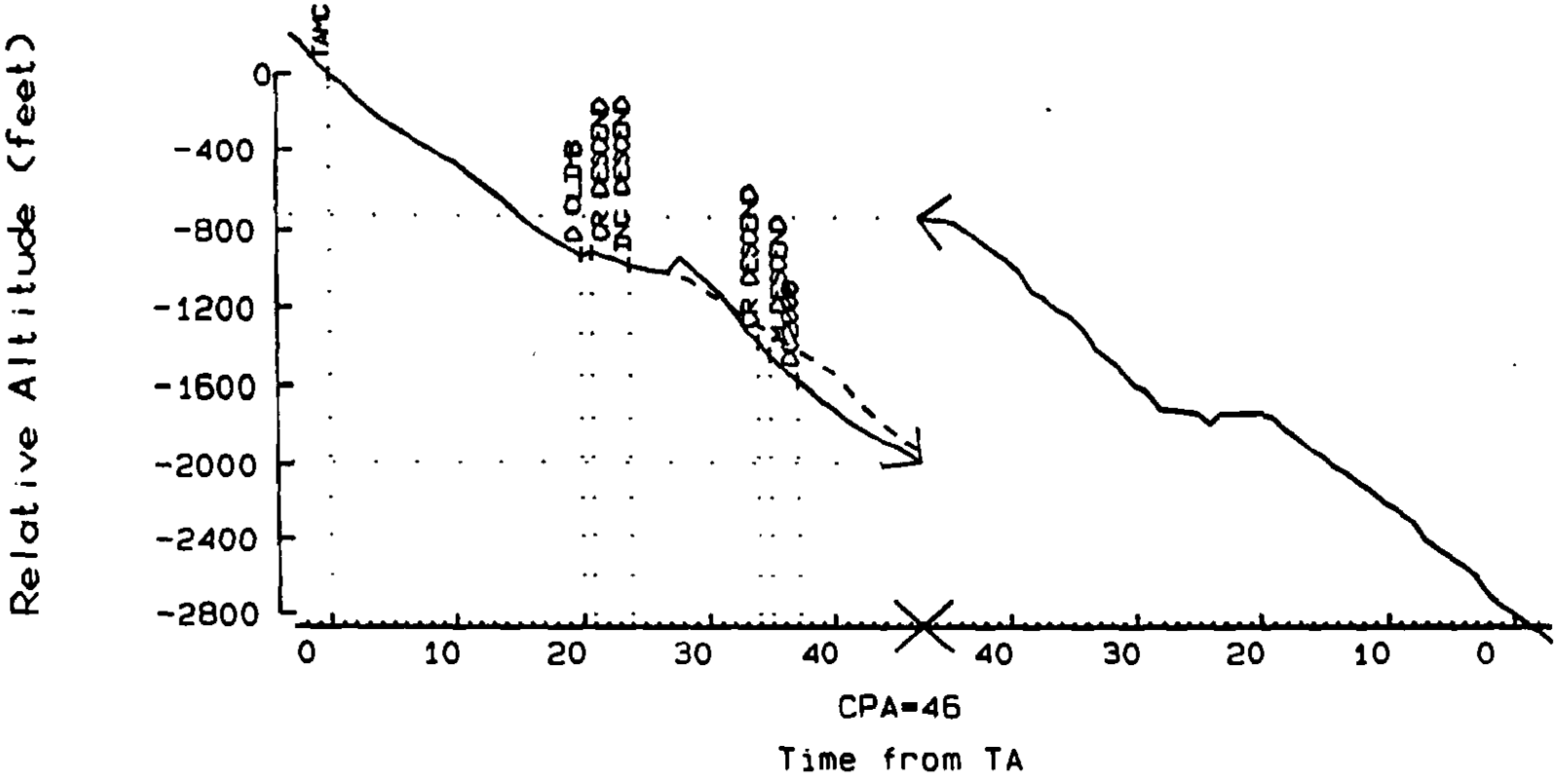
RANGE RATE at TA: -503

at CPA: -242

RANGE at CPA: 1014 ft

Alt. Difference with Simulated Pilot Response: 1209 ft

F-108



TA TIME: 14: 30: 19

CPA TIME: 14: 31: 06

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1272 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 500 Filename 8930921C.TRD

ENCOUNTER ID: 500

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

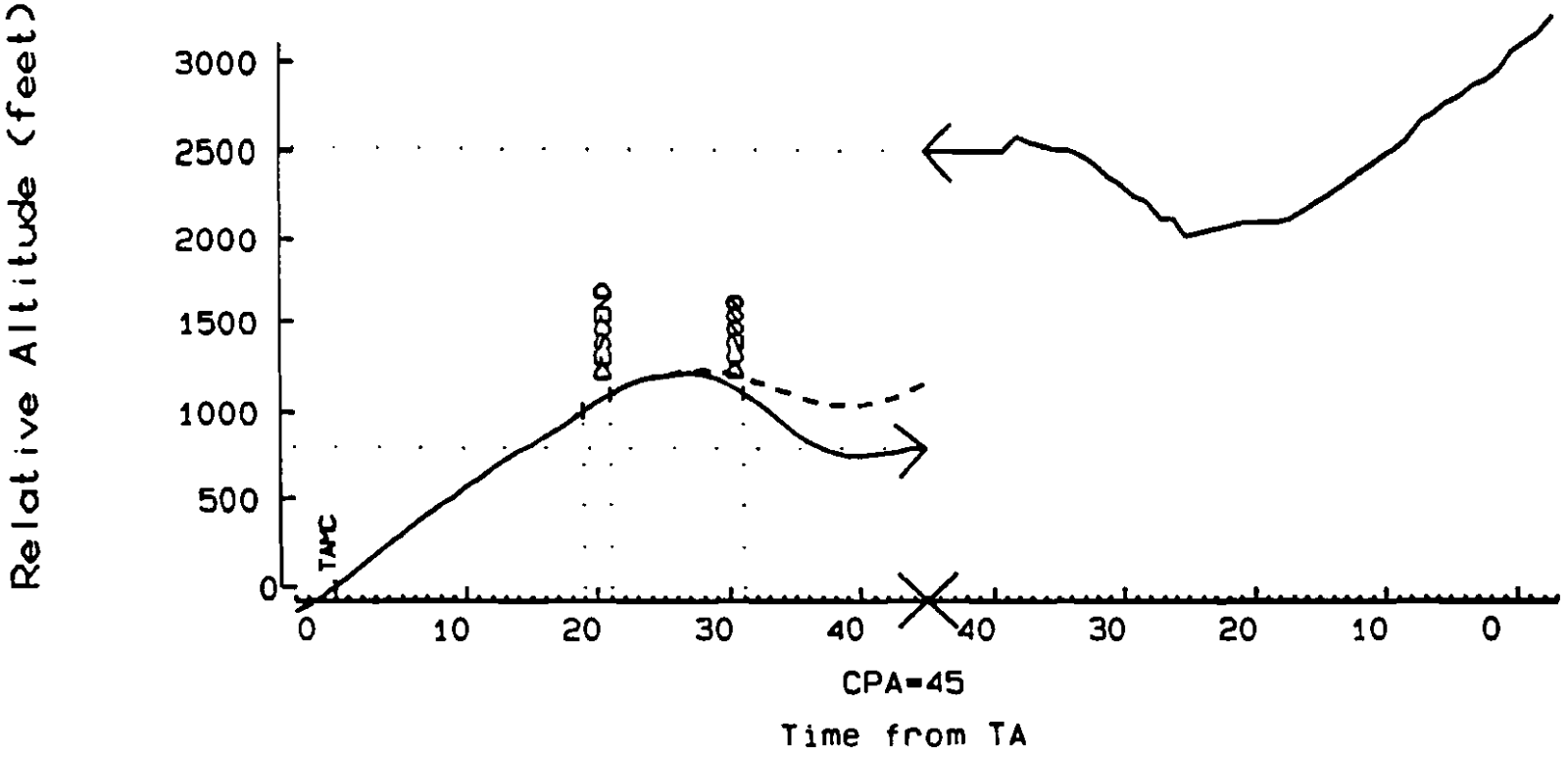
RANGE RATE at TA: -531

at CPA: -158

RANGE at CPA: 3189 ft

Alt. Difference with Simulated Pilot Response: 1343 ft

F-109



TA TIME: 14:37:24

CPA TIME: 14:38:09

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1716 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

Encounter ID 125 Filename R930921B.TRD

ENCOUNTER ID: 125

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

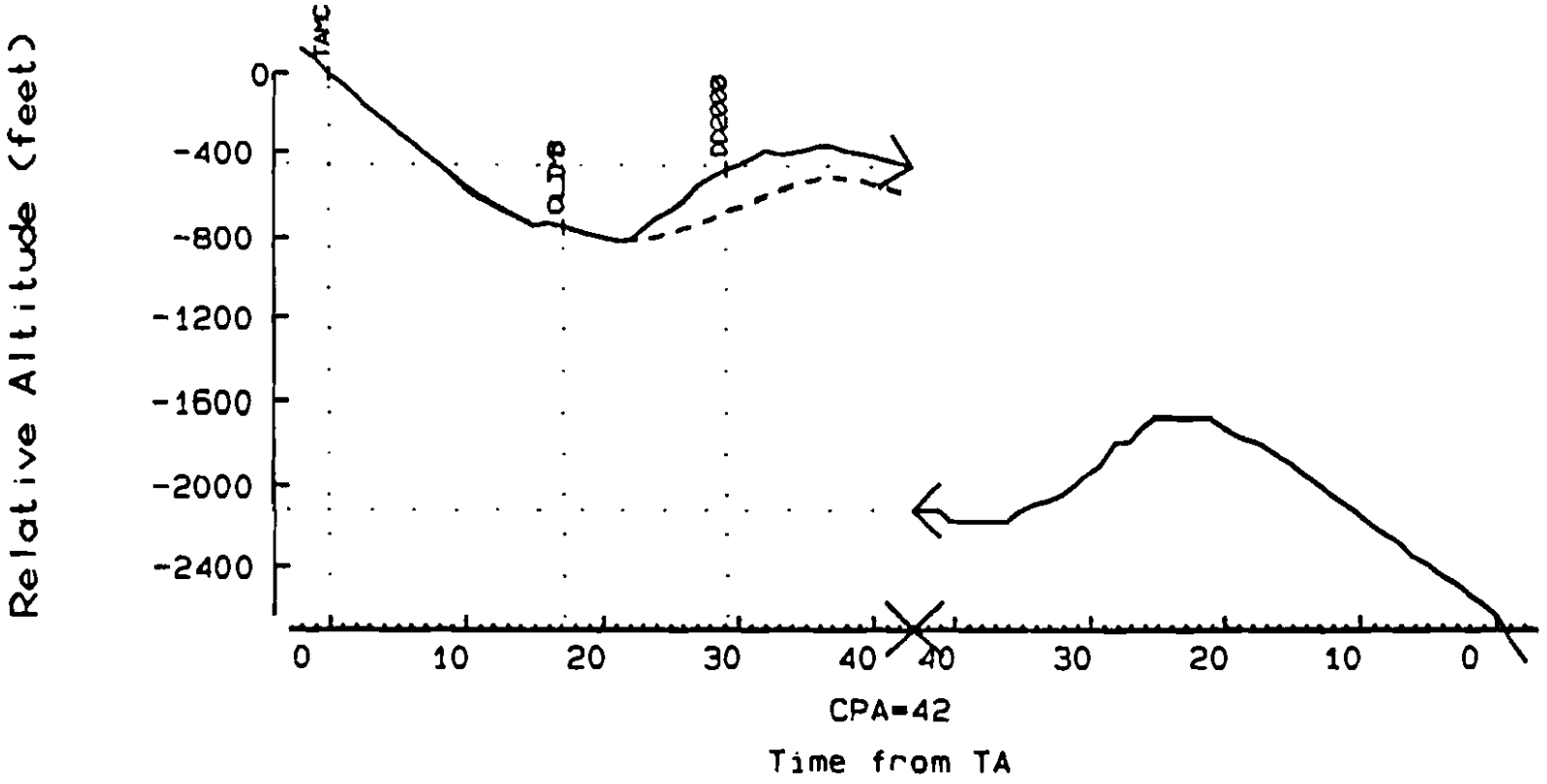
RANGE RATE at TA: -495

at CPA: -222

RANGE at CPA: 2545 ft

Alt. Difference with Simulated Pilot Response: 1528 ft

F-110



TA TIME: 14: 36: 42

CPA TIME: 14: 37: 25

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1662 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 32 Filename B9309210.TRD

ENCOUNTER ID: 32

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

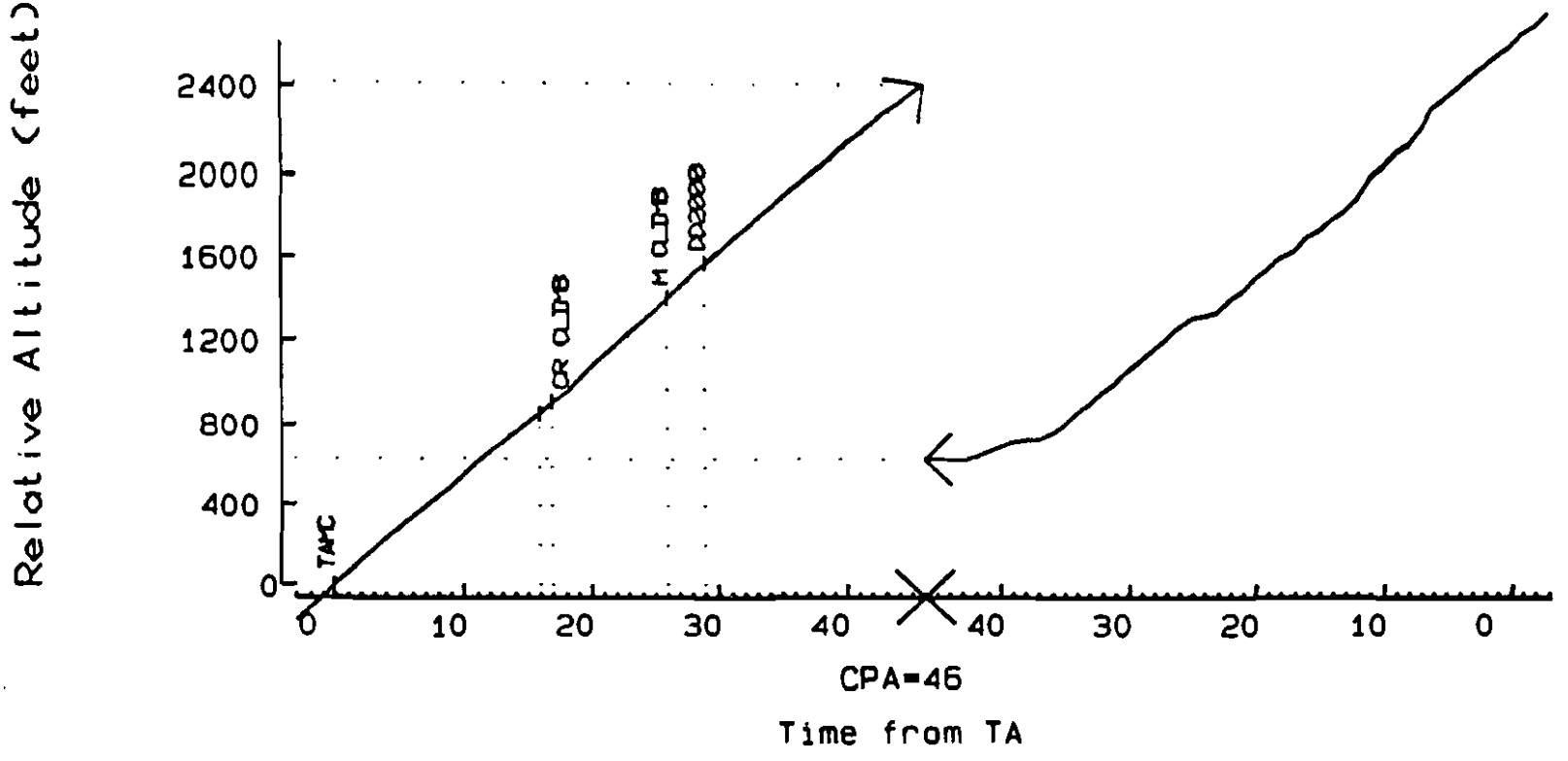
OWN ID: 10791495

RANGE RATE at TA: -491

at CPA: -68

RANGE at CPA: 6215 ft

F-111



TA TIME: 14: 44: 15 CPA TIME: 14: 45: 01

FLIGHT DATE: 09/21/93 Alt. Difference at CPA: 1785 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

Encounter ID 143 Filename R9309218.TRD

ENCOUNTER ID: 143

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

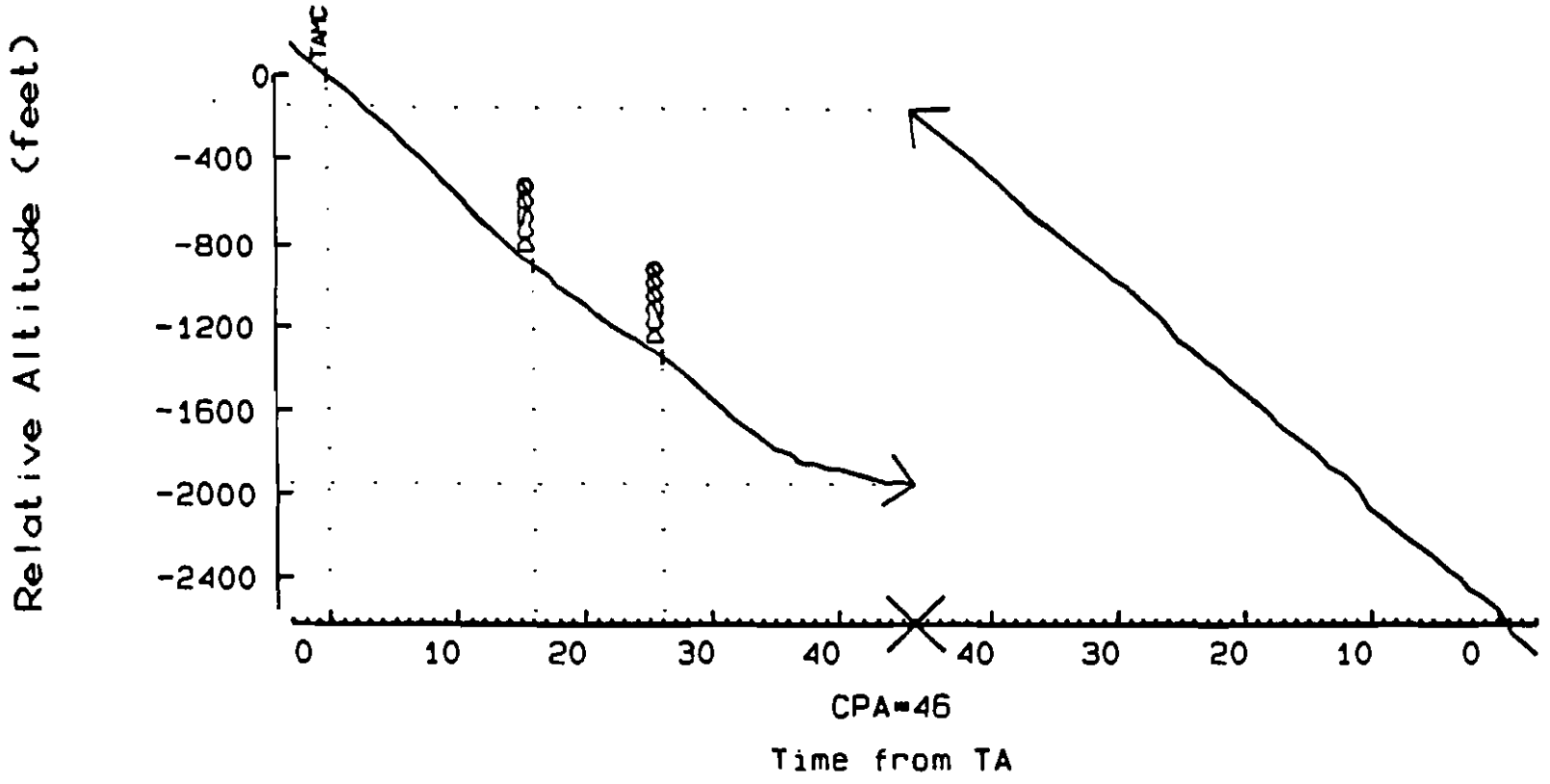
OWN ID: 10746022

RANGE RATE at TA: -502

at CPA: -158

RANGE at CPA: 5675 ft

F-112



TA TIME: 14: 43: 30 CPA TIME: 14: 44: 16

FLIGHT DATE: 09/21/93 Alt. Difference at CPA: 1794 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 123 Filename B930921D.TRD

ENCOUNTER ID: 123

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

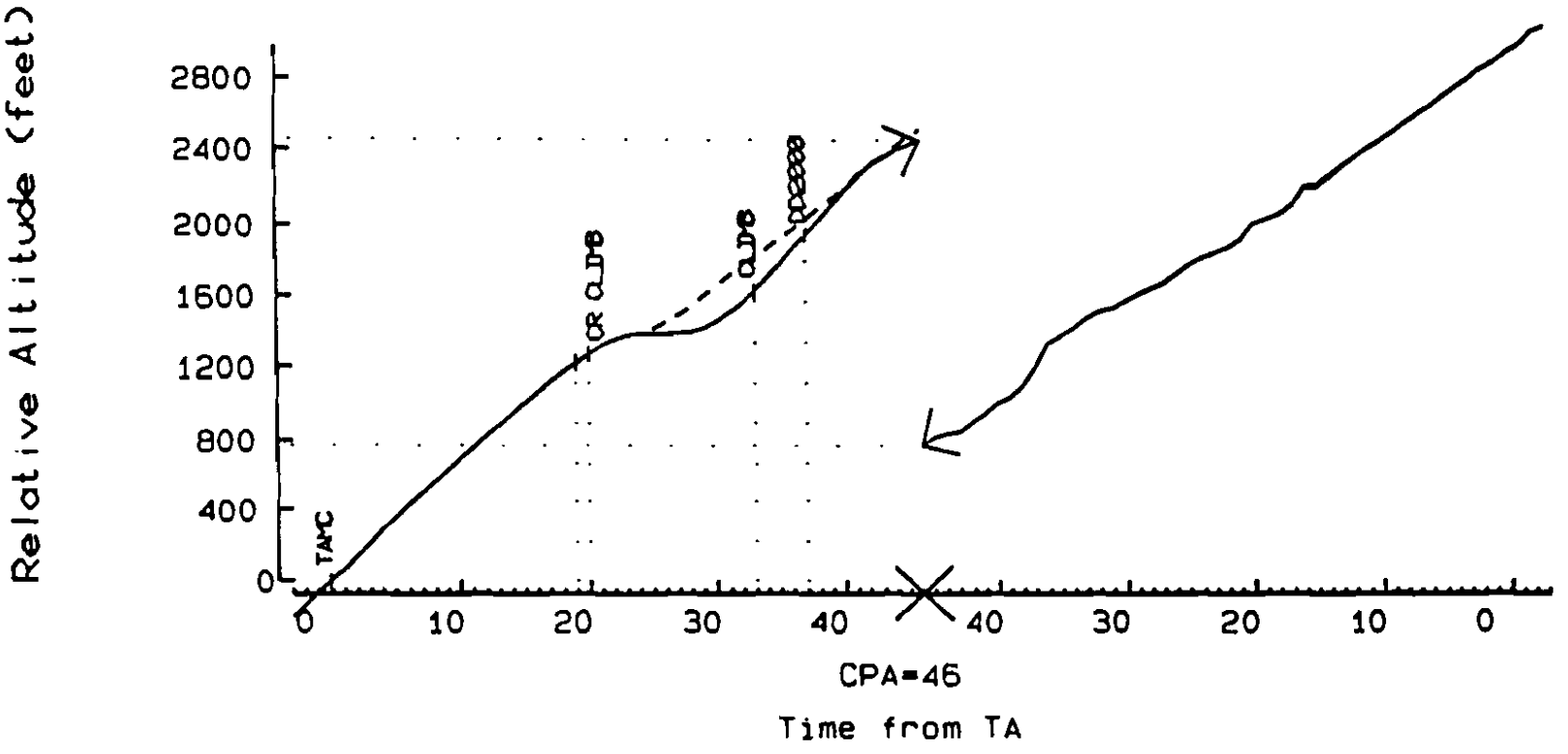
RANGE RATE at TA: -511

at CPA: -146

RANGE at CPA: 2400 ft

Alt. Difference with Simulated Pilot Response: 1746 ft

F-113



TA TIME: 14:50:44

CPA TIME: 14:51:30

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1678 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

Encounter ID 191 Filename R930921B.TRD

ENCOUNTER ID: 191

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

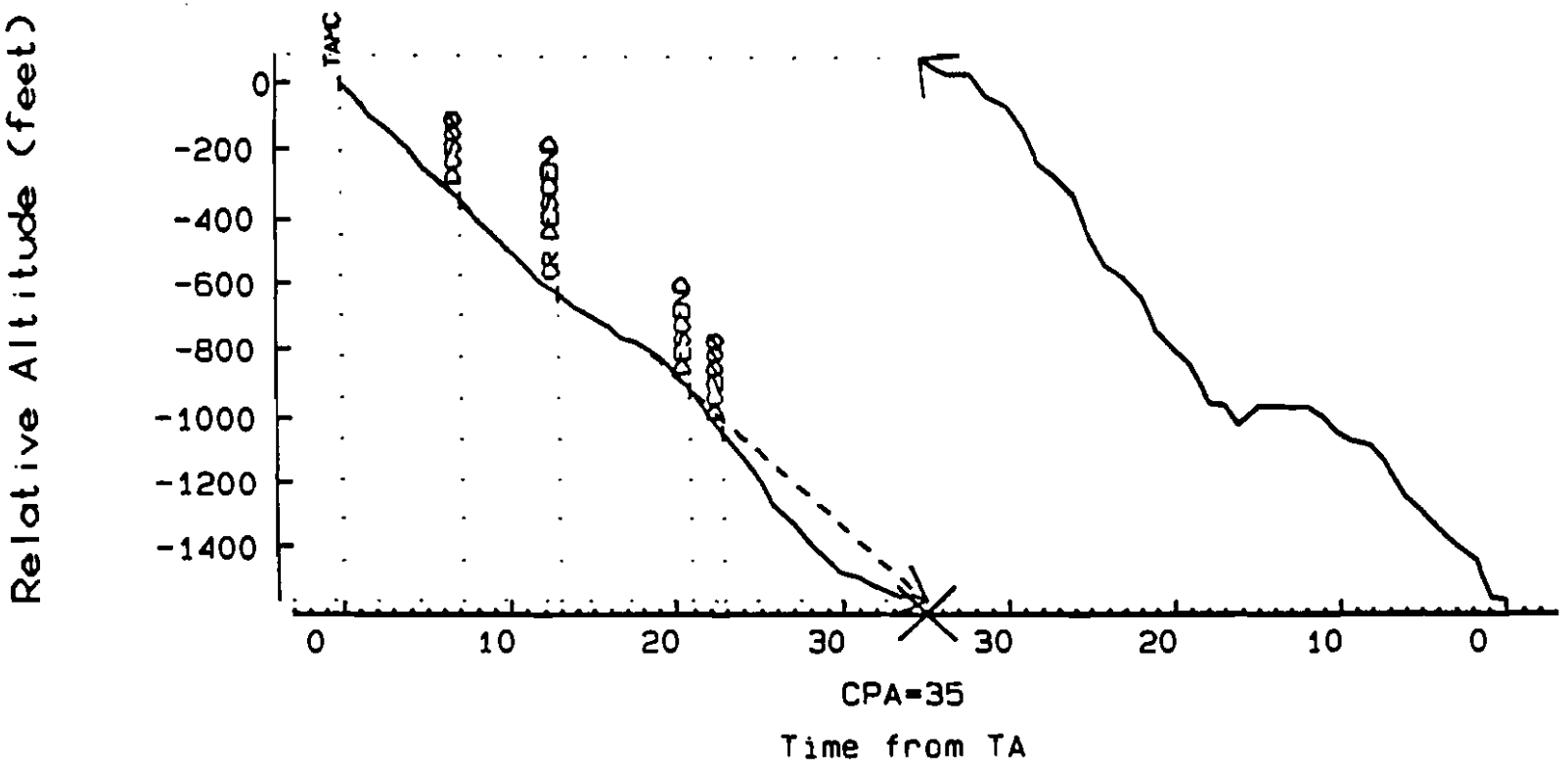
RANGE RATE at TA: -436

at CPA: -219

RANGE at CPA: 1859 ft

Alt. Difference with Simulated Pilot Response: 1651 ft

F-114



TA TIME: 14:50:11

CPA TIME: 14:50:46

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1646 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 258 Filename B9309210.TRD

ENCOUNTER ID: 258

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

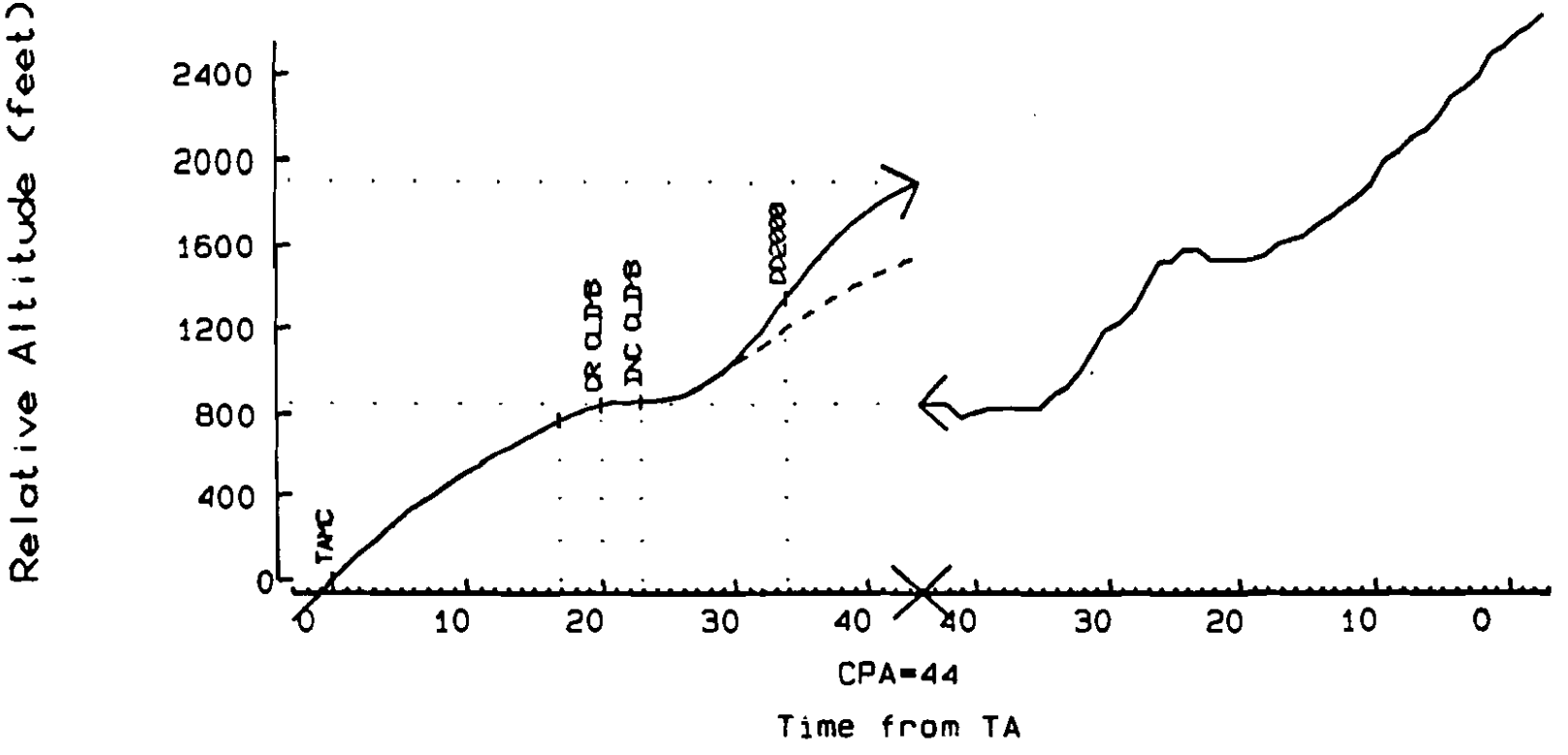
RANGE RATE at TA: -492

at CPA: -39

RANGE at CPA: 4216 ft

Alt. Difference with Simulated Pilot Response: 697 ft

F-115



TA TIME: 14:57:28

CPA TIME: 14:58:12

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1050 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

Encounter ID 225 Filename A9309218.TRD

ENCOUNTER ID: 225

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

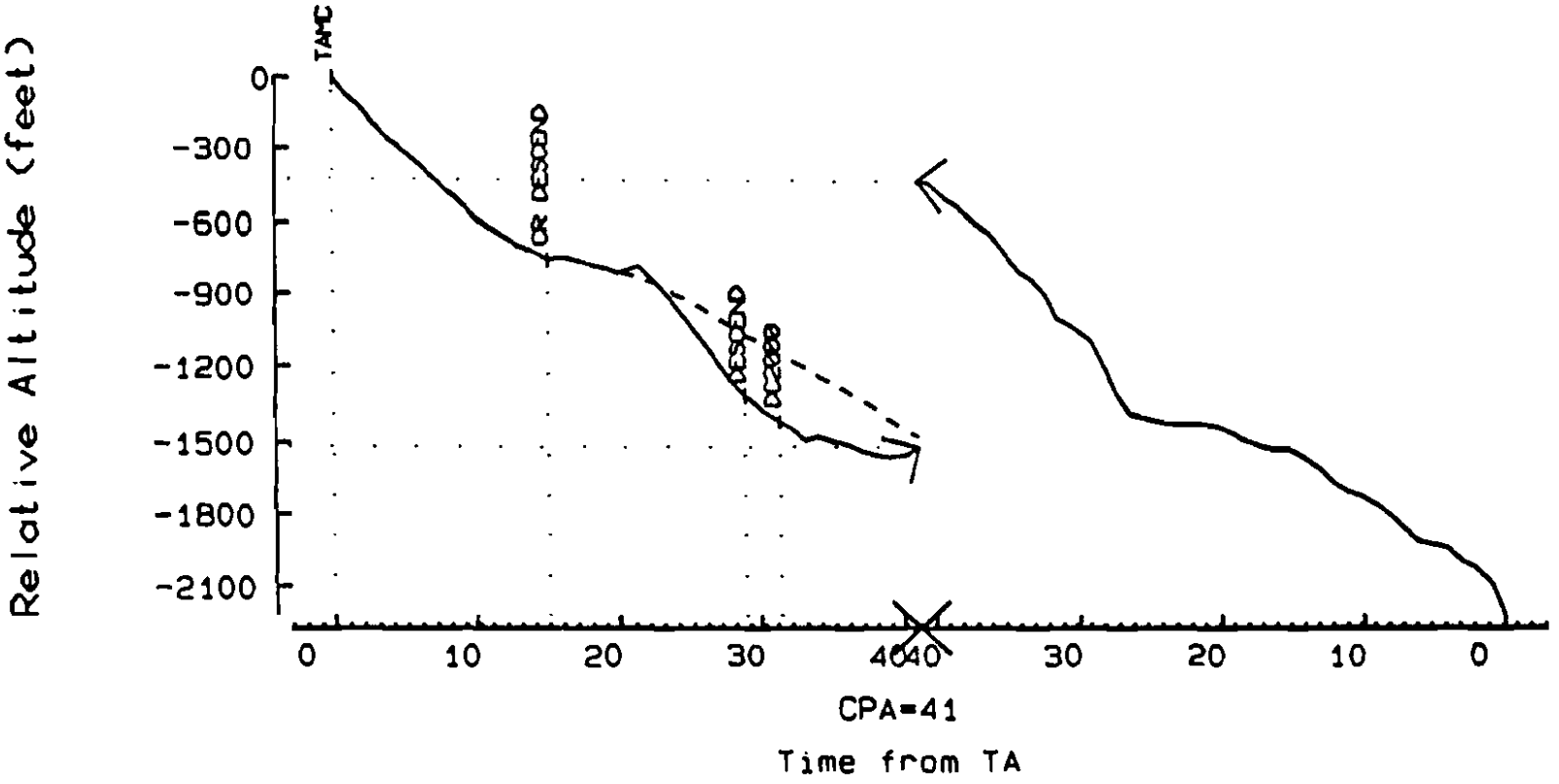
OWN ID: 10746022

RANGE RATE at TA: -473

at CPA: -184

RANGE at CPA: 3718 ft

Alt. Difference with Simulated Pilot Response: 1049 ft



TA TIME: 14:56:46

CPA TIME: 14:57:27

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1091 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

F-116

>

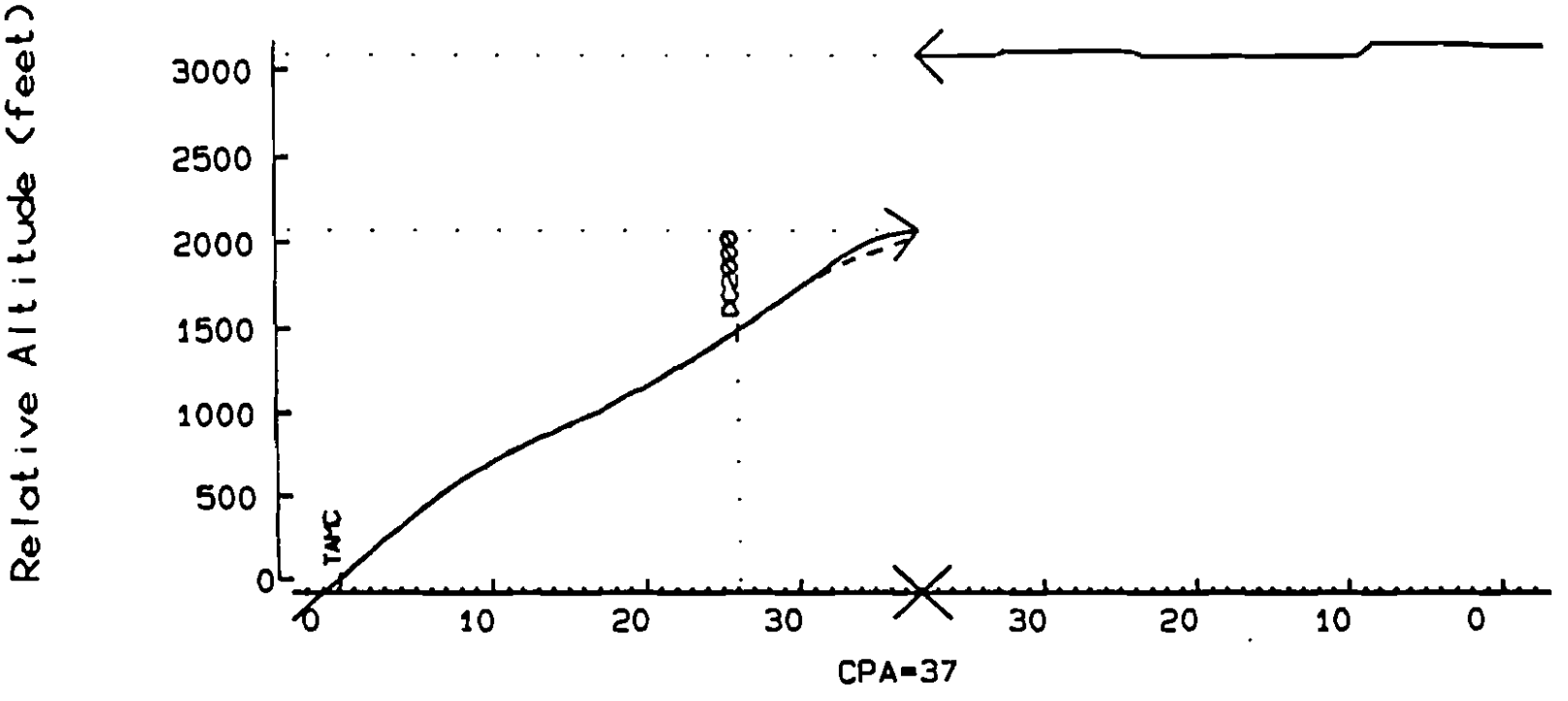
Encounter ID 443 Filename B930922A.TRD

ENCOUNTER ID: 443 RANGE RATE at TA: -601

TARGET ID: 10746022 at CPA: -92

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 4247 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1056 ft



TA TIME: 10: 32: 08 CPA TIME: 10: 32: 46

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 1025 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

F-117

>

Encounter ID 238 Filename R930922A.TRD

ENCOUNTER ID: 238

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

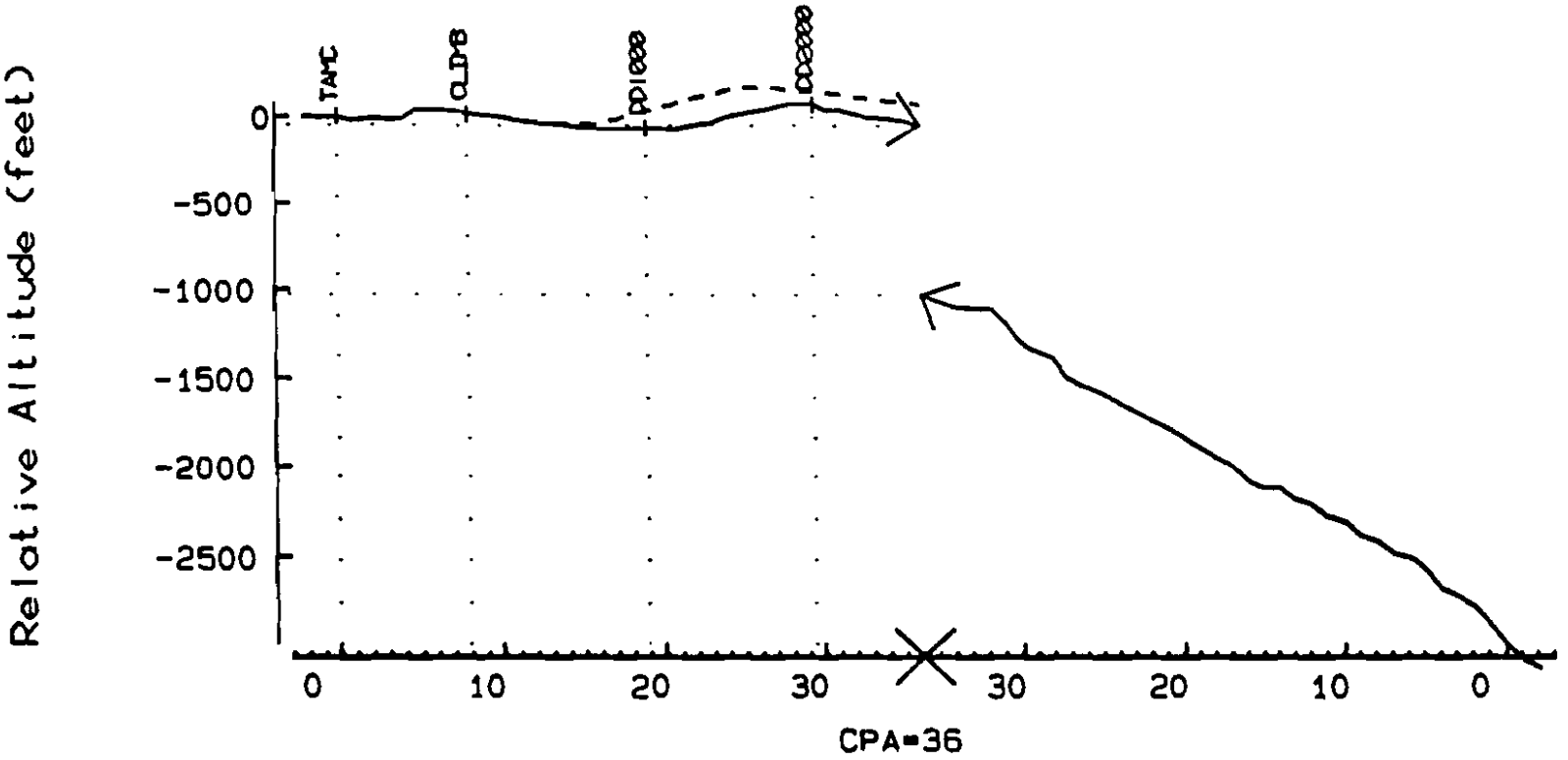
OWN ID: 10746022

RANGE RATE at TA: -585

at CPA: -345

RANGE at CPA: 3718 ft

Alt. Difference with Simulated Pilot Response: 1096 ft



TA TIME: 10:31:11

CPA TIME: 10:31:47

FLIGHT DATE: 09/22/93

Alt. Difference at CPA: 981 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

F-118

>

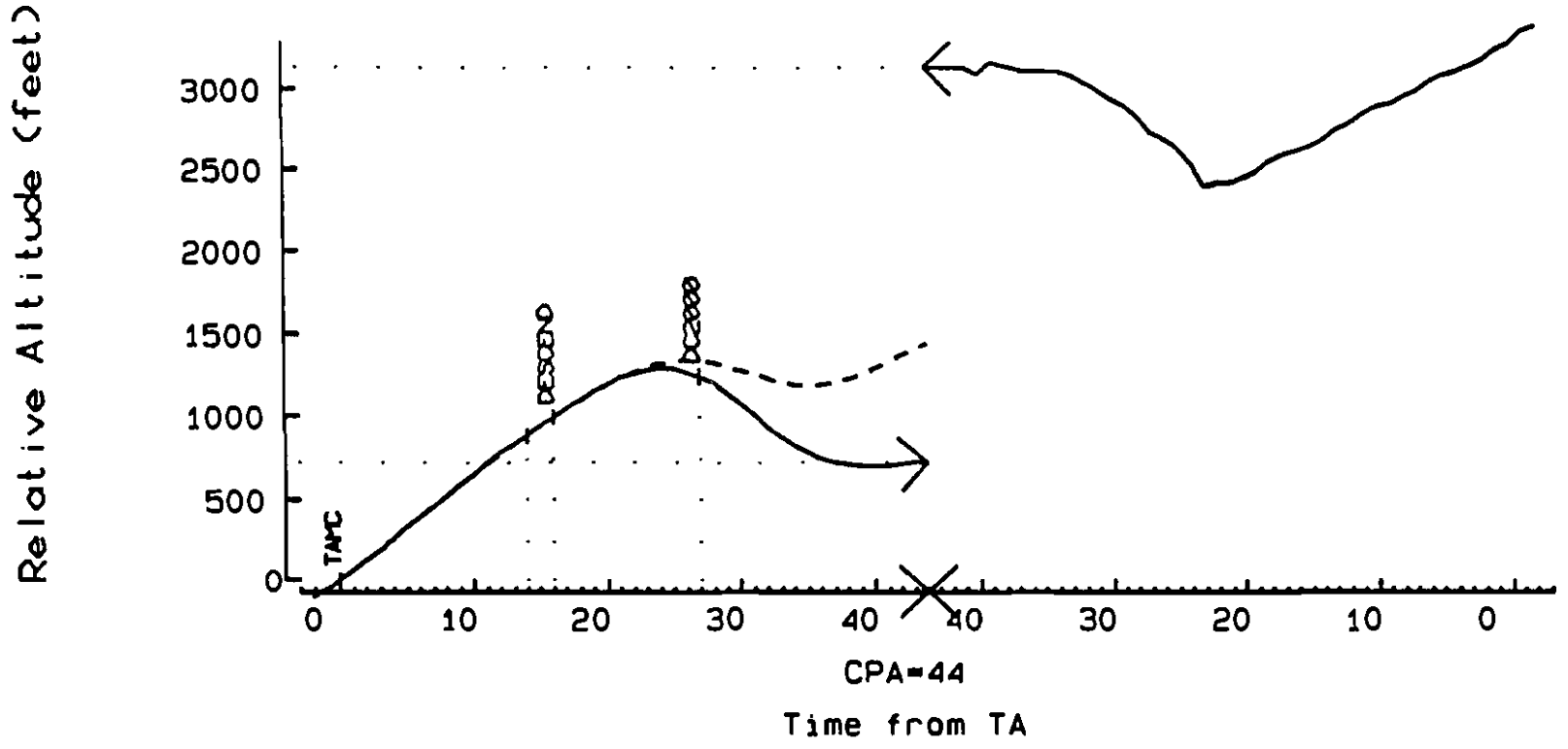
Encounter ID 550 Filename B930922A.TRD

ENCOUNTER ID: 550 RANGE RATE at TA: -620

TARGET ID: 10746022 at CPA: -47

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 3068 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1692 ft



TA TIME: 10: 38: 29 CPA TIME: 10: 39: 13

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 2408 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

F-119

>

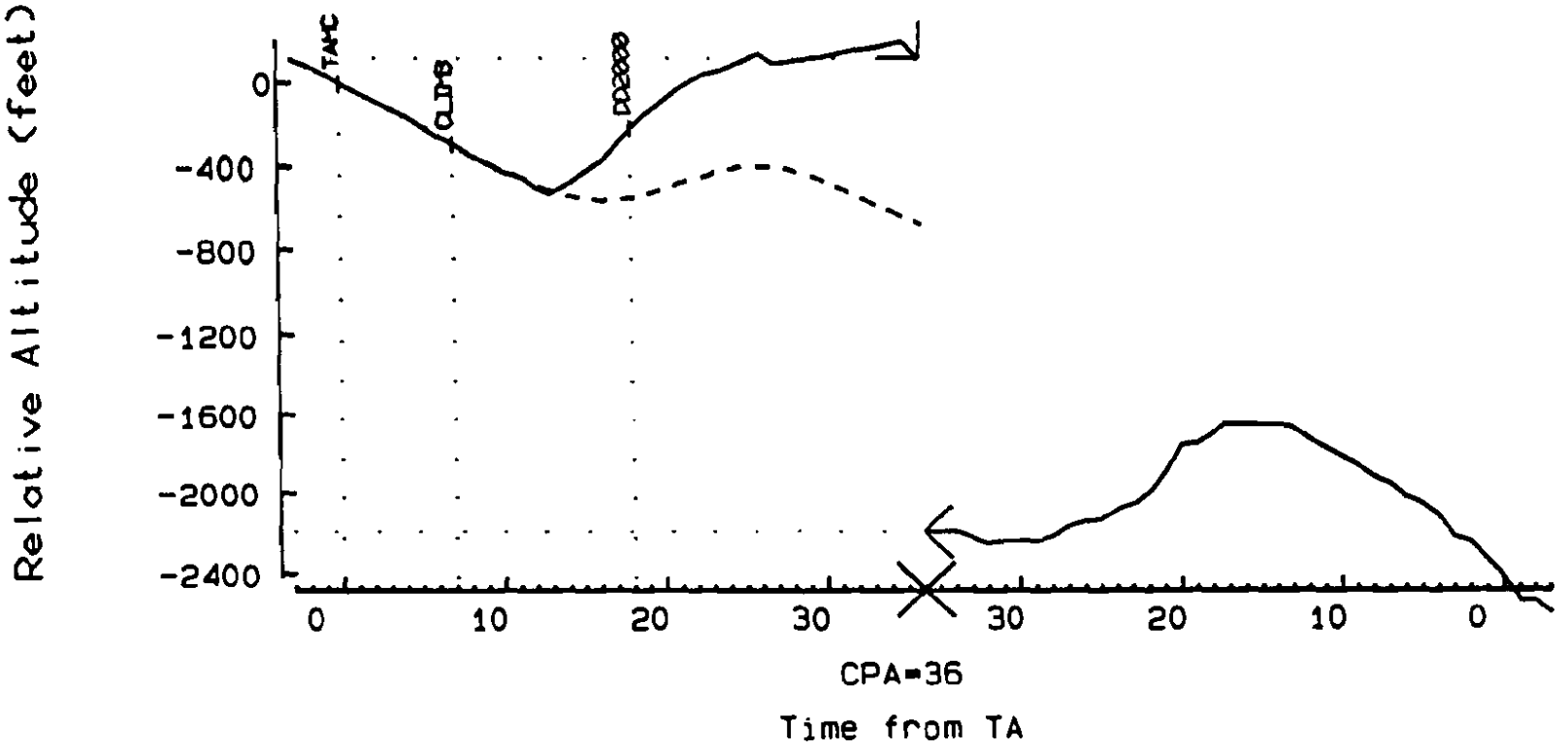
Encounter ID 327 Filename R930922A.TRD

ENCOUNTER ID: 327 RANGE RATE at TA: -610

TARGET ID: 10791495 at CPA: -268

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2296 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1522 ft



TA TIME: 10:37:39 CPA TIME: 10:38:15

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 2320 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

F-120

Encounter ID 849 Filename B930922A.TRD

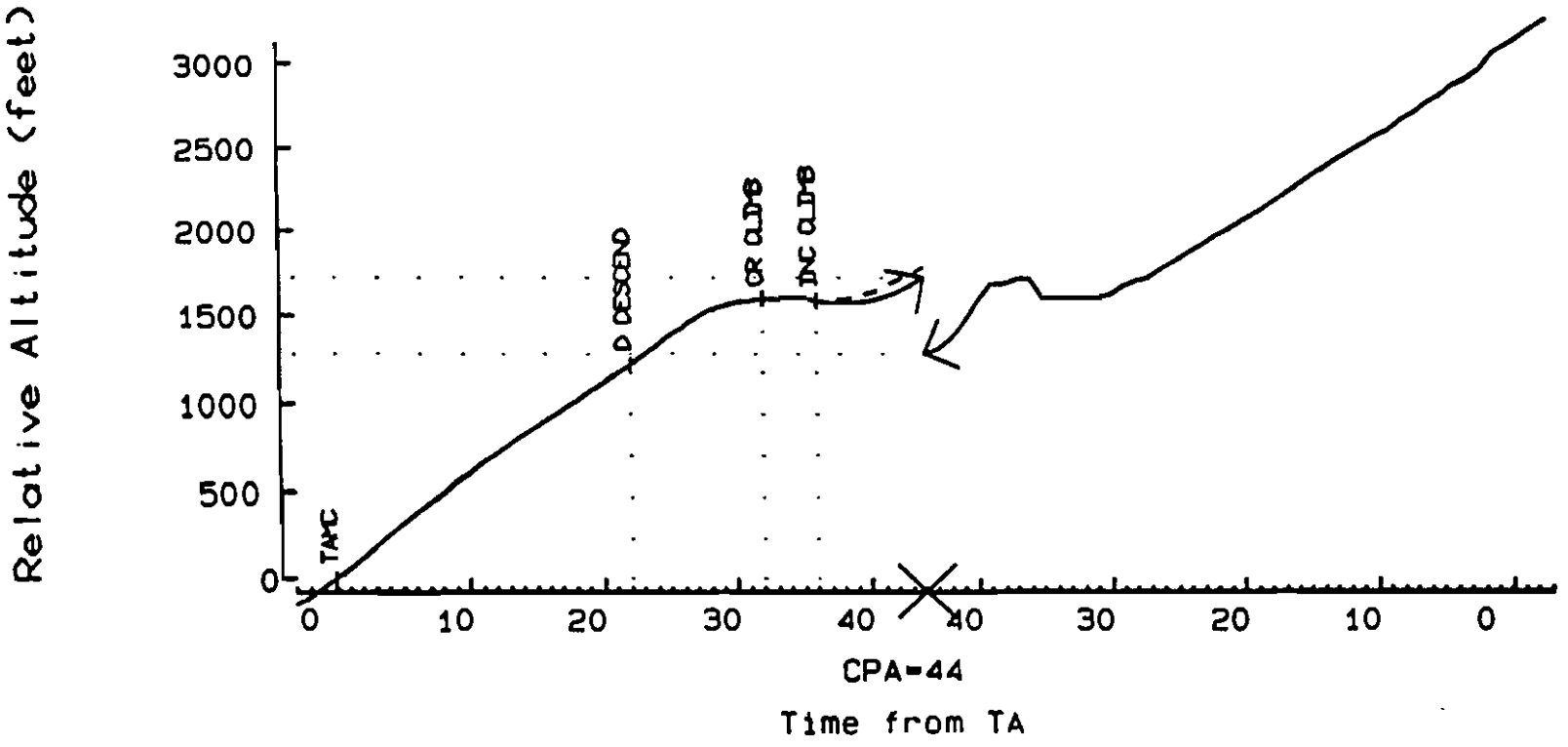
ENCOUNTER ID: 849 RANGE RATE at TA: -596

TARGET ID: 10746022 at CPA: -130

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 8500 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 518 ft

F-121



TA TIME: 10: 44: 26 CPA TIME: 10: 45: 10

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 456 ft

PROCESSED ON: 12/09/93 by ACO-320 FAA Technical Center

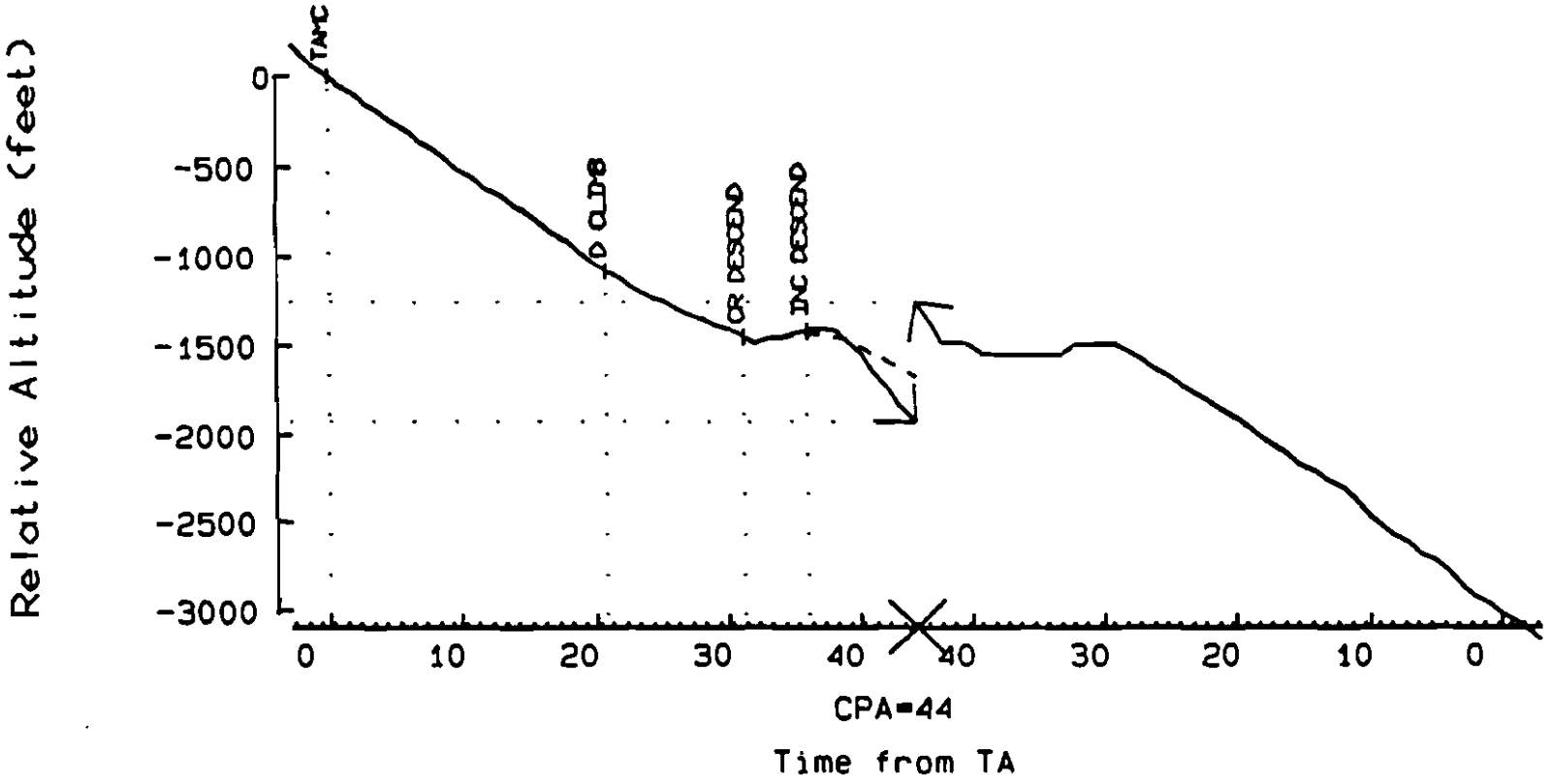
Encounter ID 372 Filename R930922A.TRD

ENCOUNTER ID: 372 RANGE RATE at TA: -593

TARGET ID: 10791495 at CPA: -153

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 8093 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 412 ft



TA TIME: 10: 43: 29 CPA TIME: 10: 44: 13

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 664 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

F-122

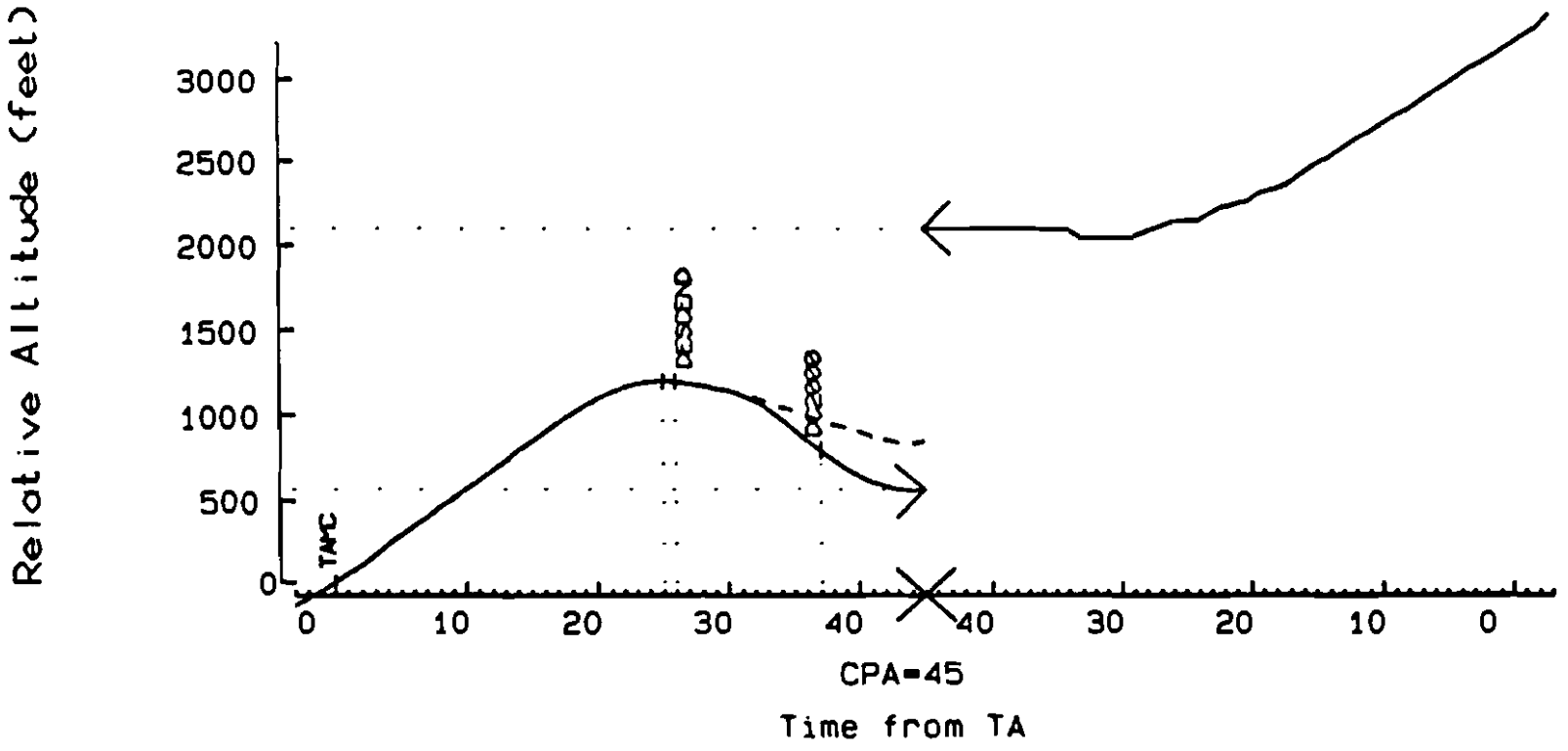
Encounter ID 948 Filename B930922A.TRD

ENCOUNTER ID: 948 RANGE RATE at TA: -604

TARGET ID: 10746022 at CPA: -36

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 4472 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1259 ft



TA TIME: 10: 49: 36 CPA TIME: 10: 50: 21

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 1538 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

F-123

>

Encounter ID 429 Filename R930922A.TRO

ENCOUNTER ID: 429

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

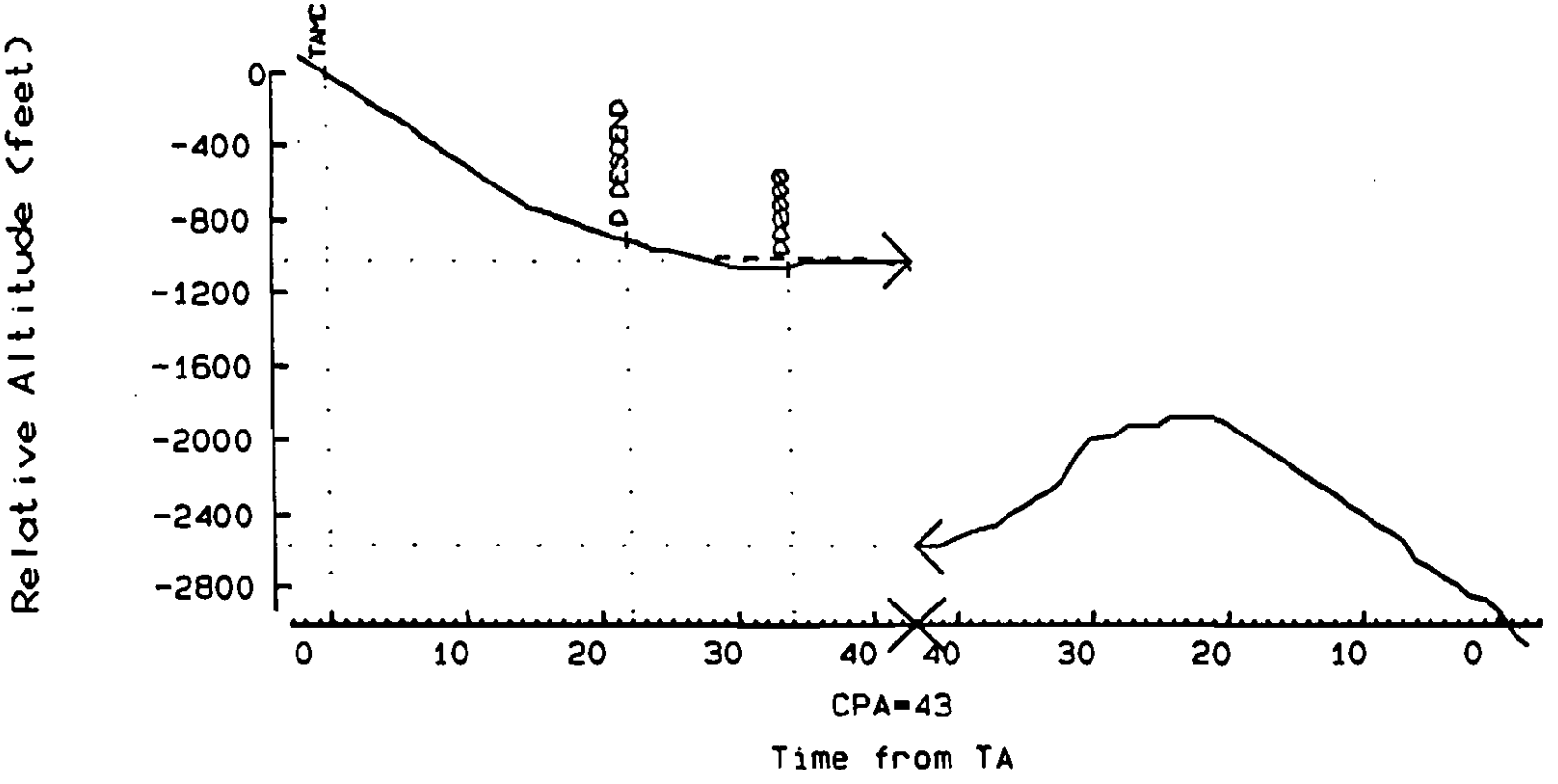
RANGE RATE at TA: -631

at CPA: -222

RANGE at CPA: 3834 ft

Alt. Difference with Simulated Pilot Response: 1513 ft

F-124



TA TIME: 10: 48: 40

CPA TIME: 10: 49: 23

FLIGHT DATE: 09/22/93

Alt. Difference at CPA: 1558 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 1157 Filename B930922A.TRD

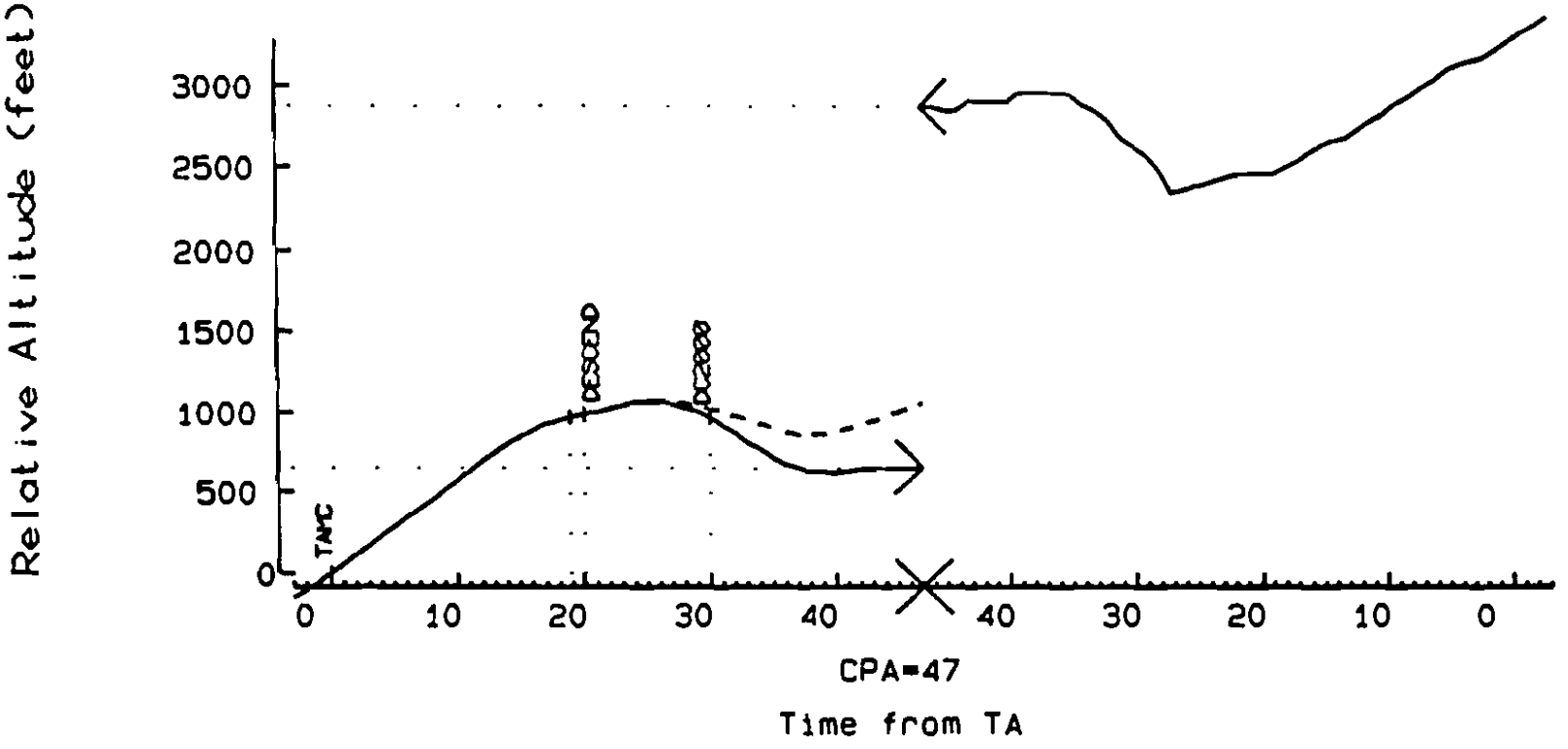
ENCOUNTER ID: 1157 RANGE RATE at TA: -614

TARGET ID: 10746022 at CPA: -8

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2460 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1811 ft

F-125



TA TIME: 11:01:07 CPA TIME: 11:01:54

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 2223 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

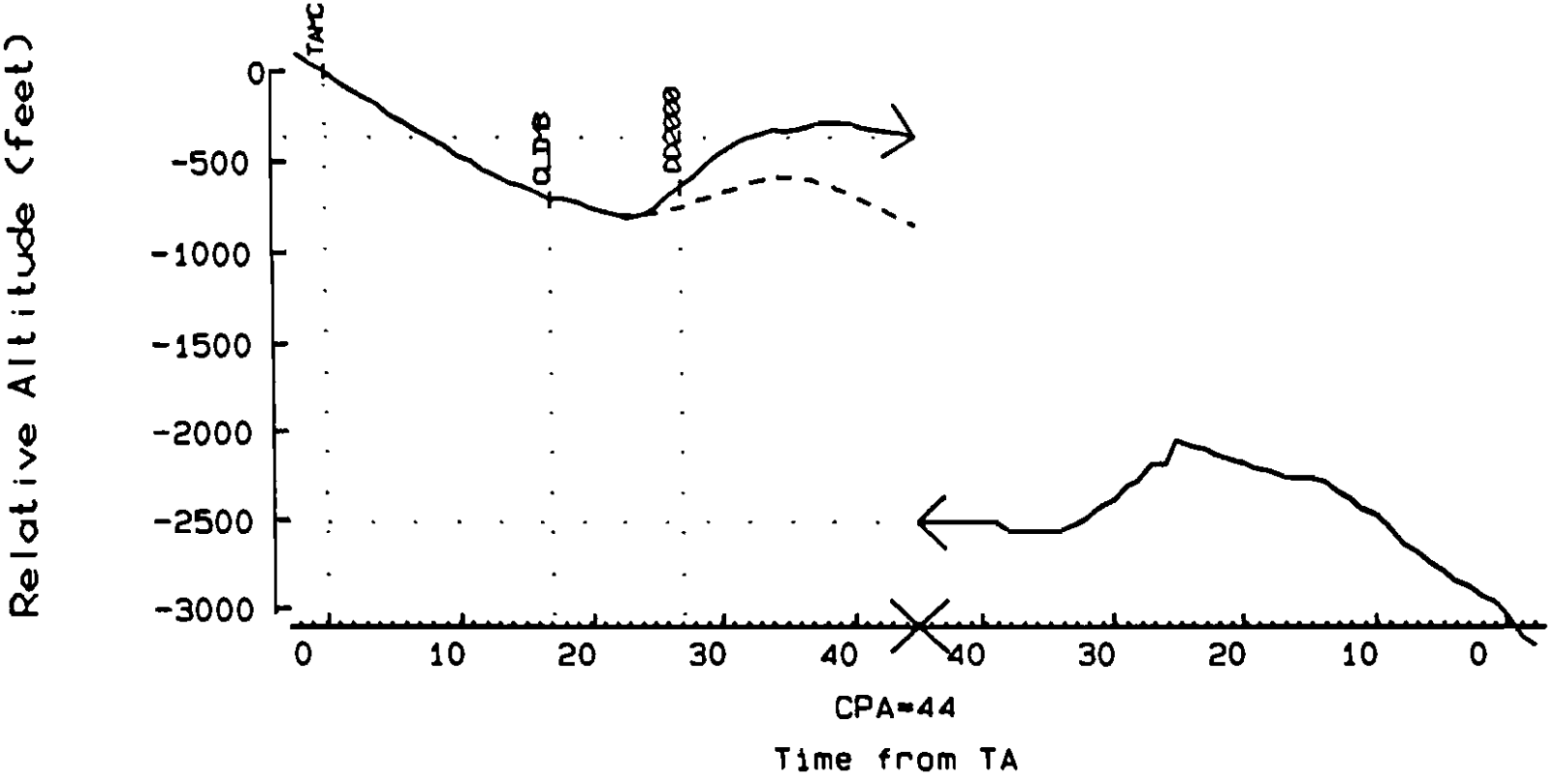
Encounter ID 454 Filename R930922A.TRD

ENCOUNTER ID: 454 RANGE RATE at TA: -598

TARGET ID: 10791495 at CPA: -445

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 1142 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1662 ft



TA TIME: 11:00:11 CPA TIME: 11:00:56

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 2148 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

F-126

>

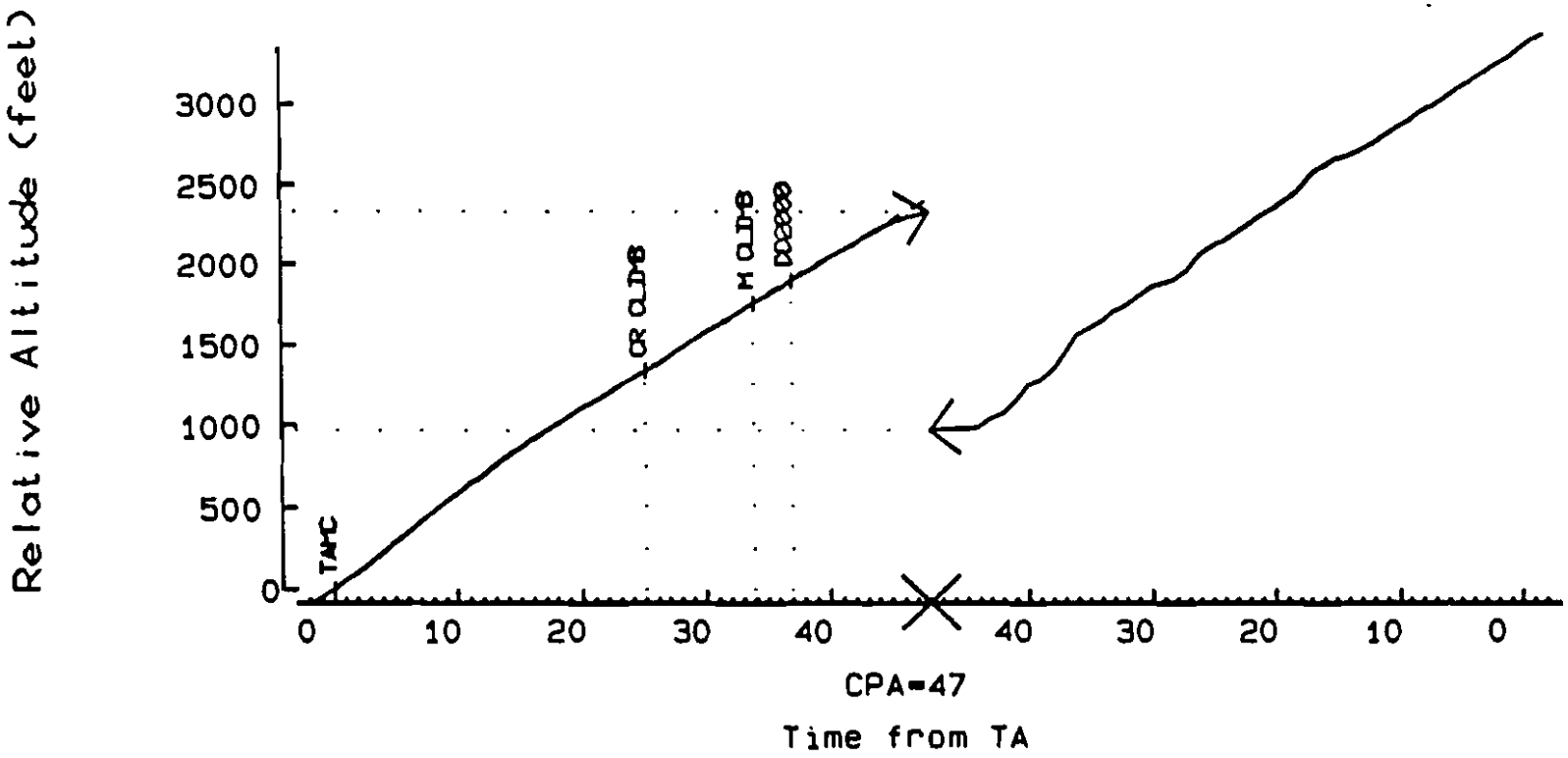
Encounter ID 81 Filename B9309228.TRD

ENCOUNTER ID: 81 RANGE RATE at TA: -618

TARGET ID: 10746022 at CPA: -31

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 3609 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1441 ft



TA TIME: 11:07:13 CPA TIME: 11:08:01

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 1362 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

F-127

>

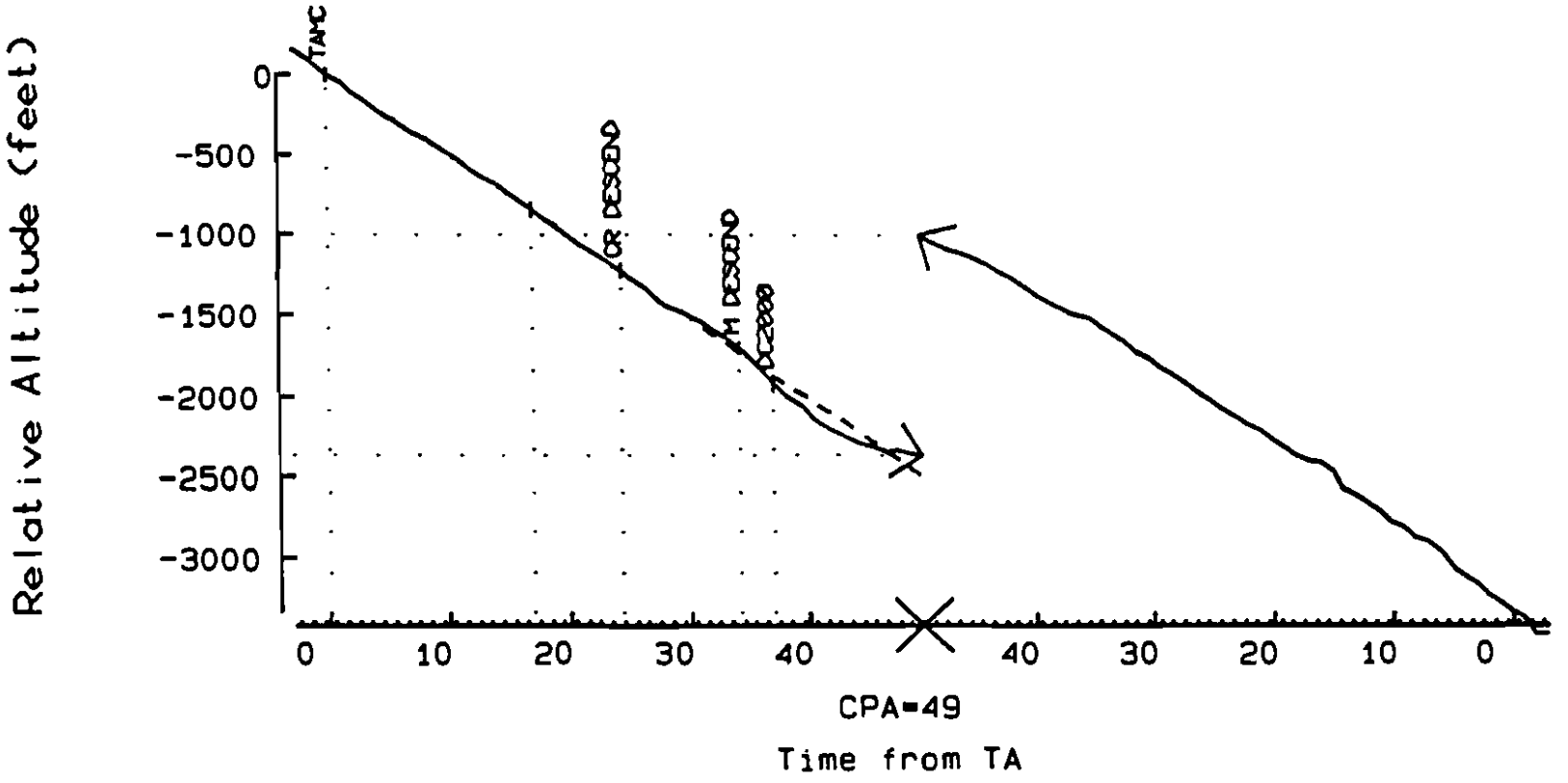
Encounter ID 467 Filename R930922A.TRO

ENCOUNTER ID: 467 RANGE RATE at TA: -621

TARGET ID: 10791495 at CPA: -259

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 3007 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1496 ft



TA TIME: 11:06:15 CPA TIME: 11:07:04

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 1372 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

F-128

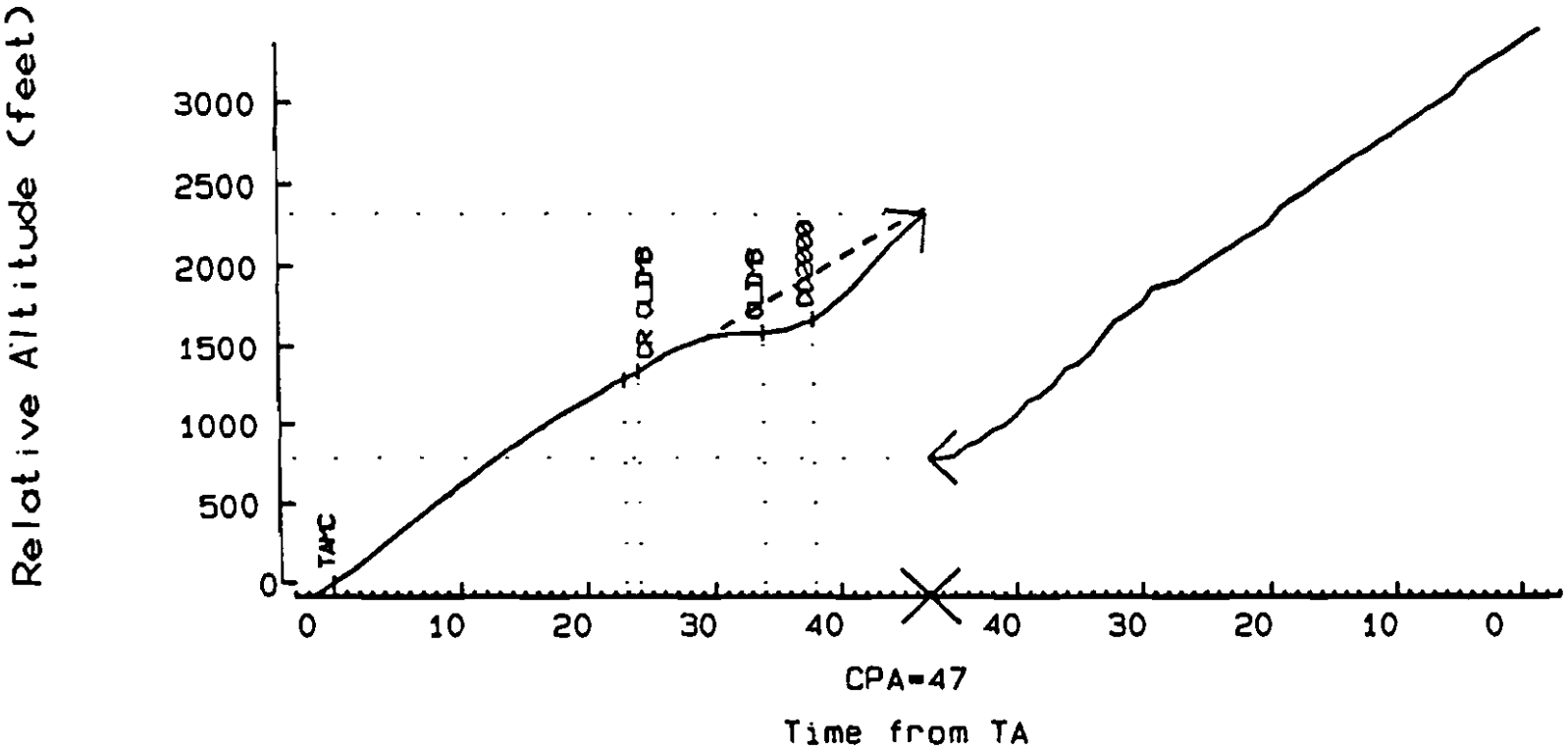
Encounter ID 272 Filename B9309228.TRD

ENCOUNTER ID: 272 RANGE RATE at TA: -618

TARGET ID: 10746022 at CPA: -132

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2782 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1577 ft



TA TIME: 11:12:58 CPA TIME: 11:13:45

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 1541 ft

PROCESSED ON: 12/09/93 by ACO-320 FAA Technical Center

F-129

>

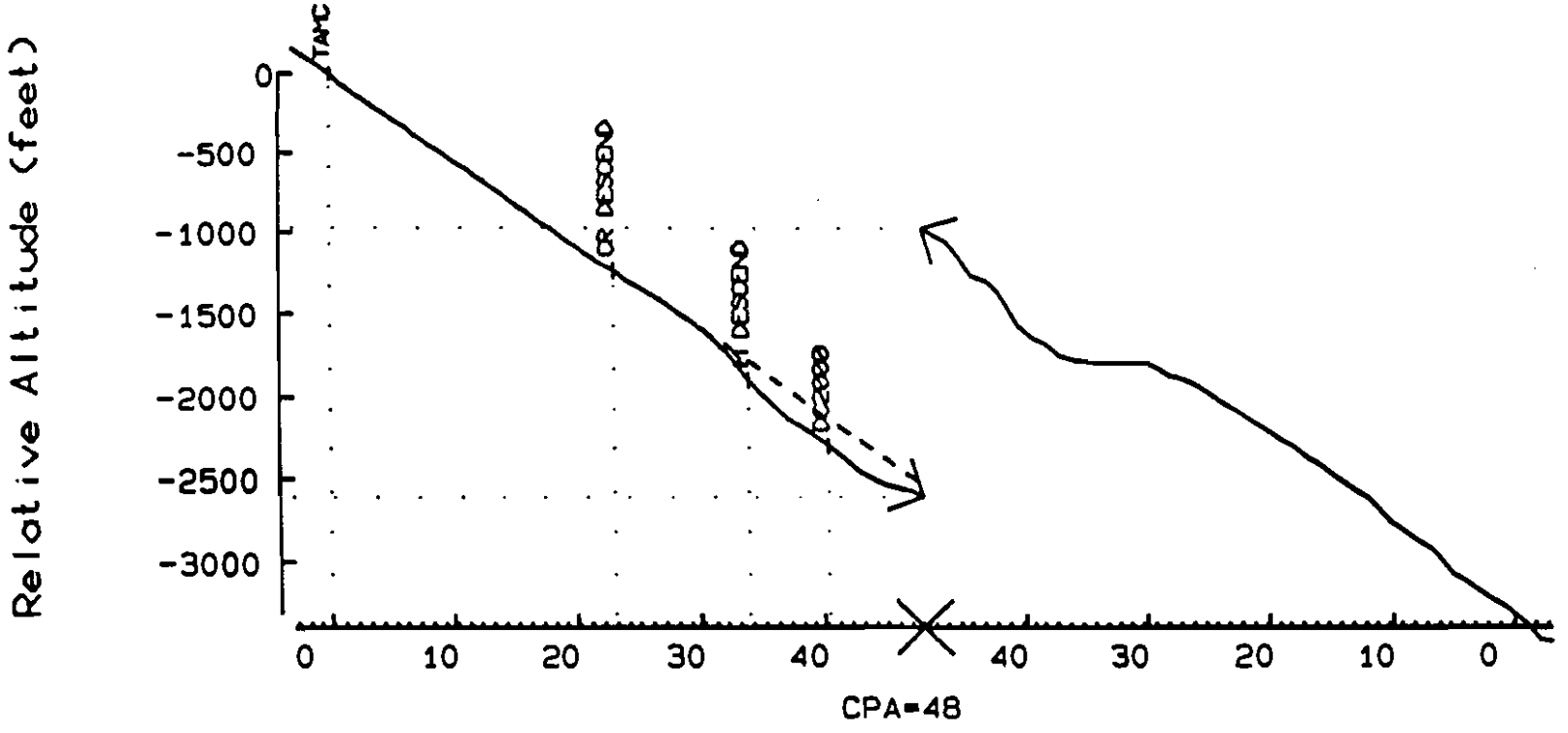
Encounter ID 497 Filename R930922A.TRD

ENCOUNTER ID: 497 RANGE RATE at TA: -628

TARGET ID: 10791495 at CPA: -263

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2053 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1585 ft



TA TIME: 11:12:00 CPA TIME: 11:12:48

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 1644 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

F-130

>

Encounter ID 412 Filename B930922B.TRD

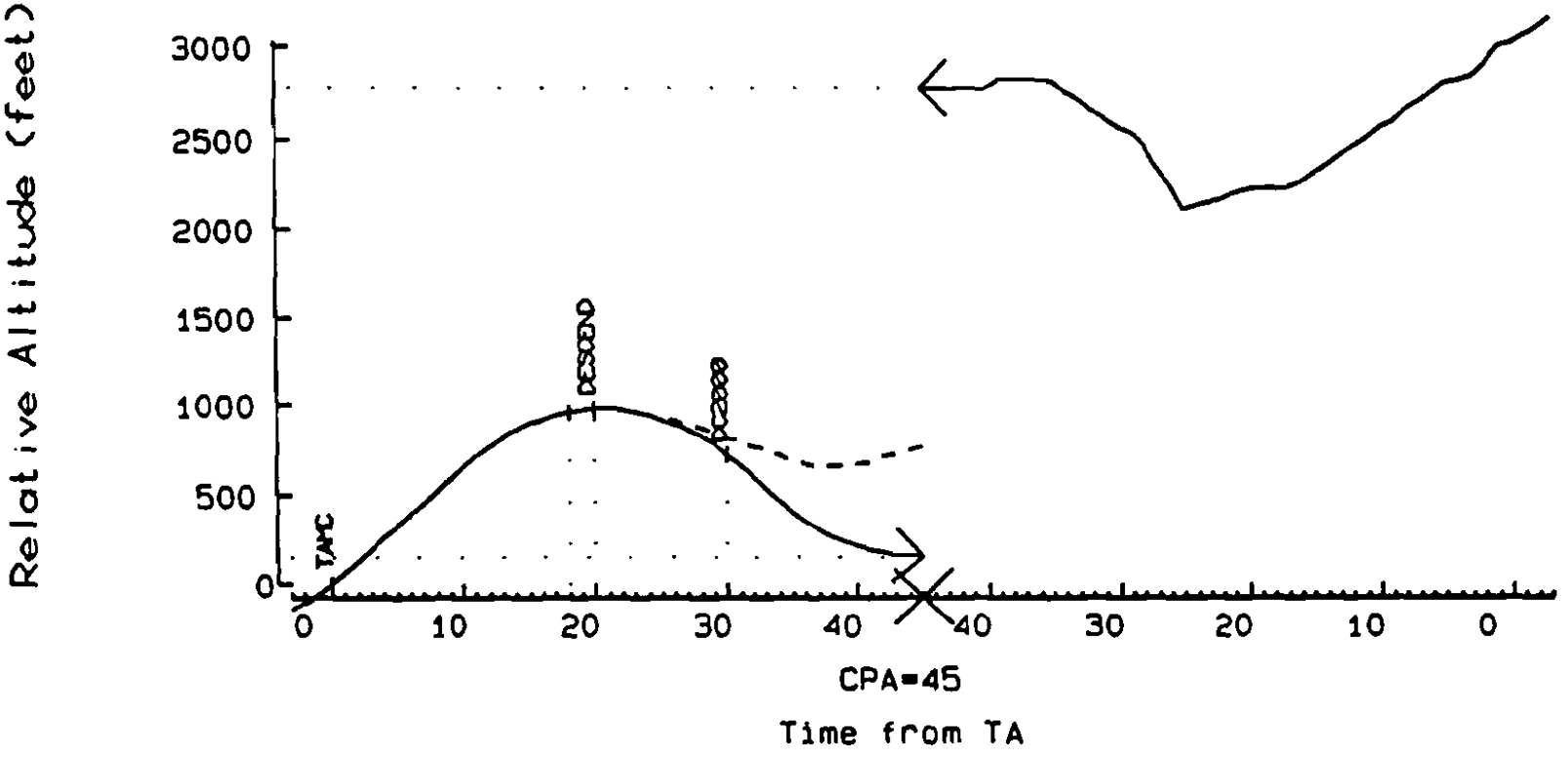
ENCOUNTER ID: 412 RANGE RATE at TA: -597

TARGET ID: 10746022 at CPA: -110

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 6744 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 2025 ft

F-131



TA TIME: 11:18:43 CPA TIME: 11:19:28

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 2634 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

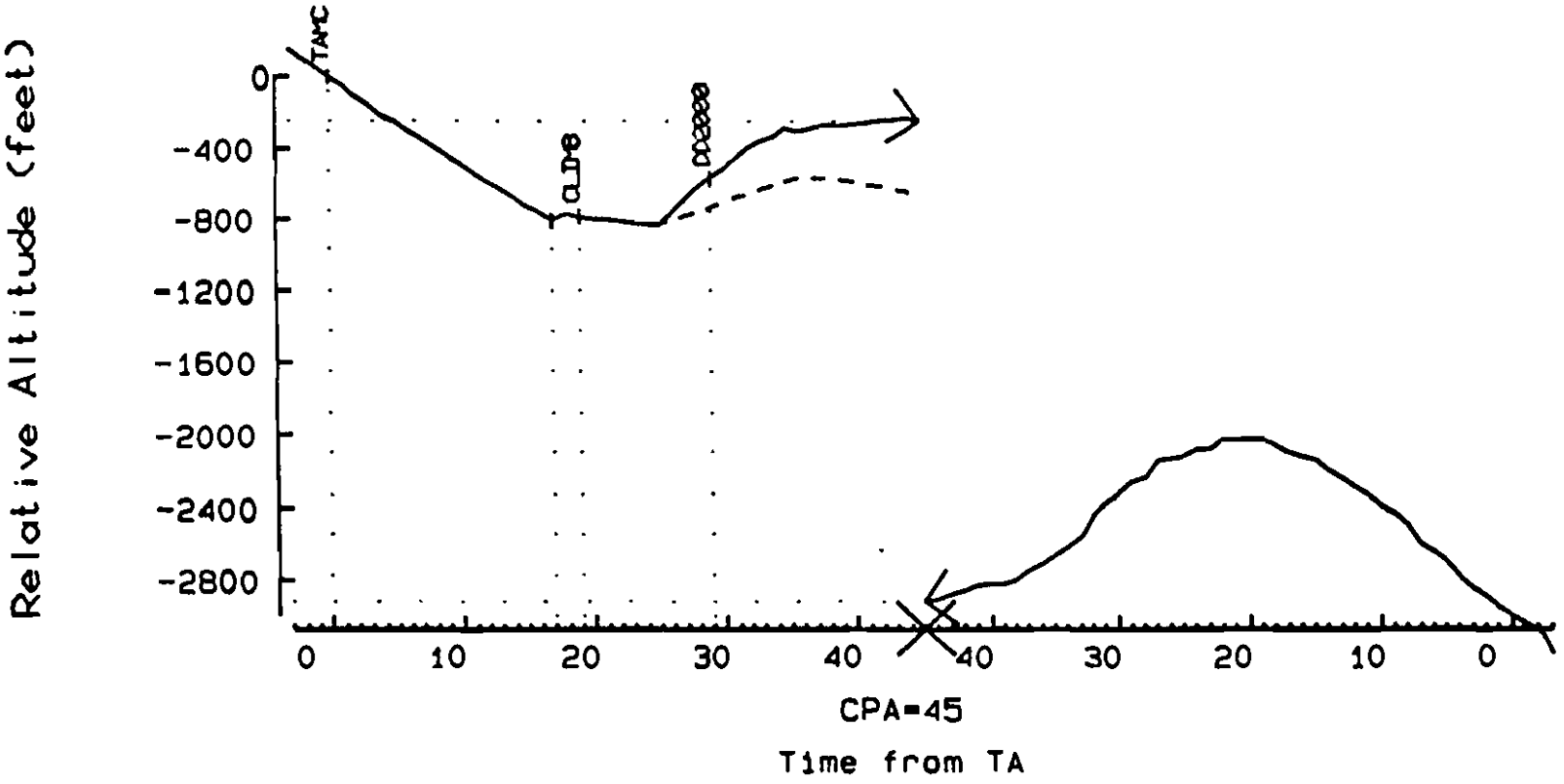
Encounter ID 511 Filename R930922A.TRD

ENCOUNTER ID: 511 RANGE RATE at TA: -592

TARGET ID: 10791495 at CPA: -182

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 6288 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 2260 ft



TA TIME: 11:17:45 CPA TIME: 11:18:30

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 2683 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

F-132

>

Encounter ID 467 Filename 89309228.TRD

ENCOUNTER ID: 467

TARGET IO: 10746022

INTRUDER EQUIPAGE: TCAS II

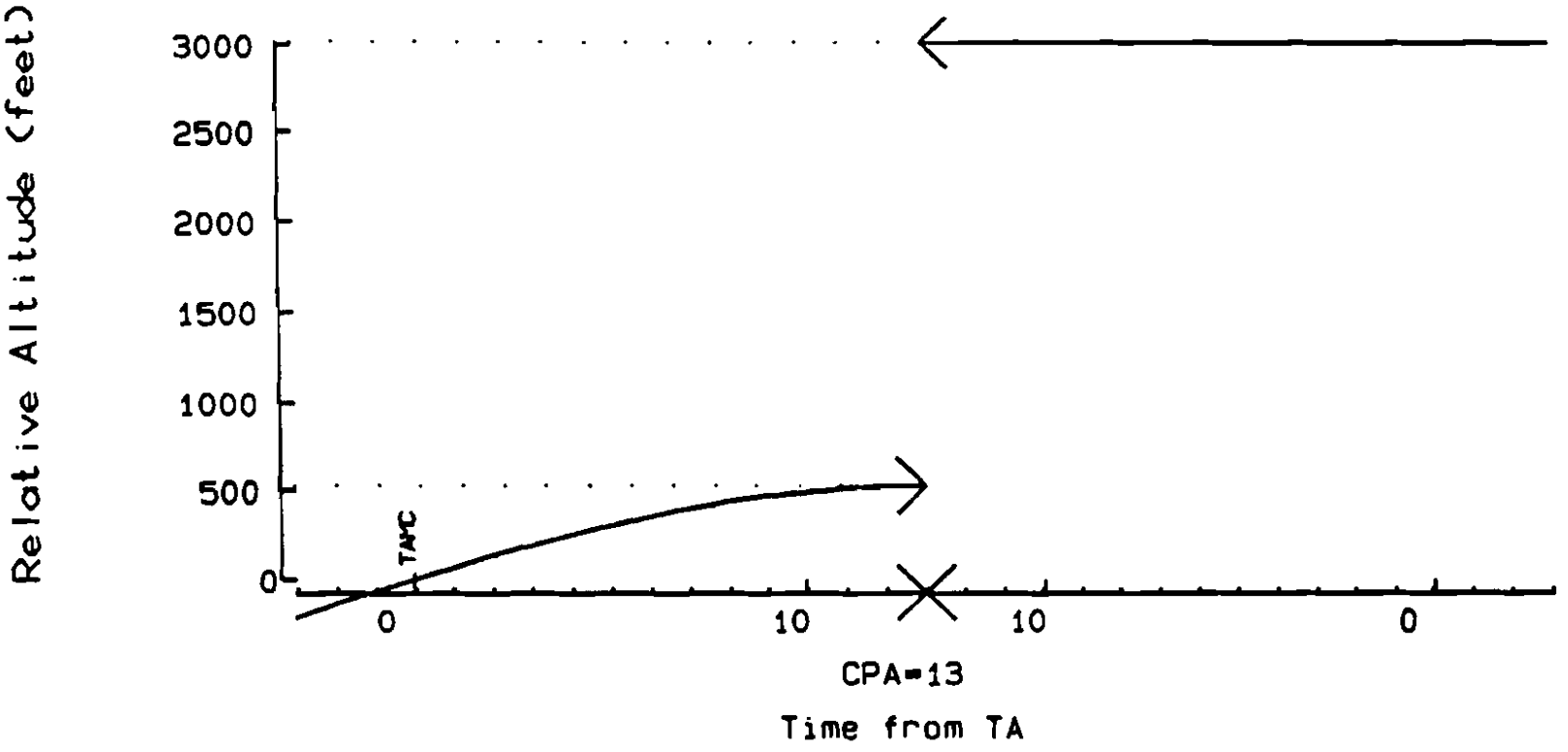
OWN IO: 10791495

RANGE RATE at TA: -614

at CPA: -602

RANGE at CPA: 25926 ft

F-133



TA TIME: 11:24:32

CPA TIME: 11:24:45

FLIGHT DATE: 09/22/93

Alt. Difference at CPA: 2485 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

Encounter ID 534 Filename R930922A.TRD

ENCOUNTER ID: 534

TARGET IO: 10791495

INTRUDER EQUIPAGE: TCAS II

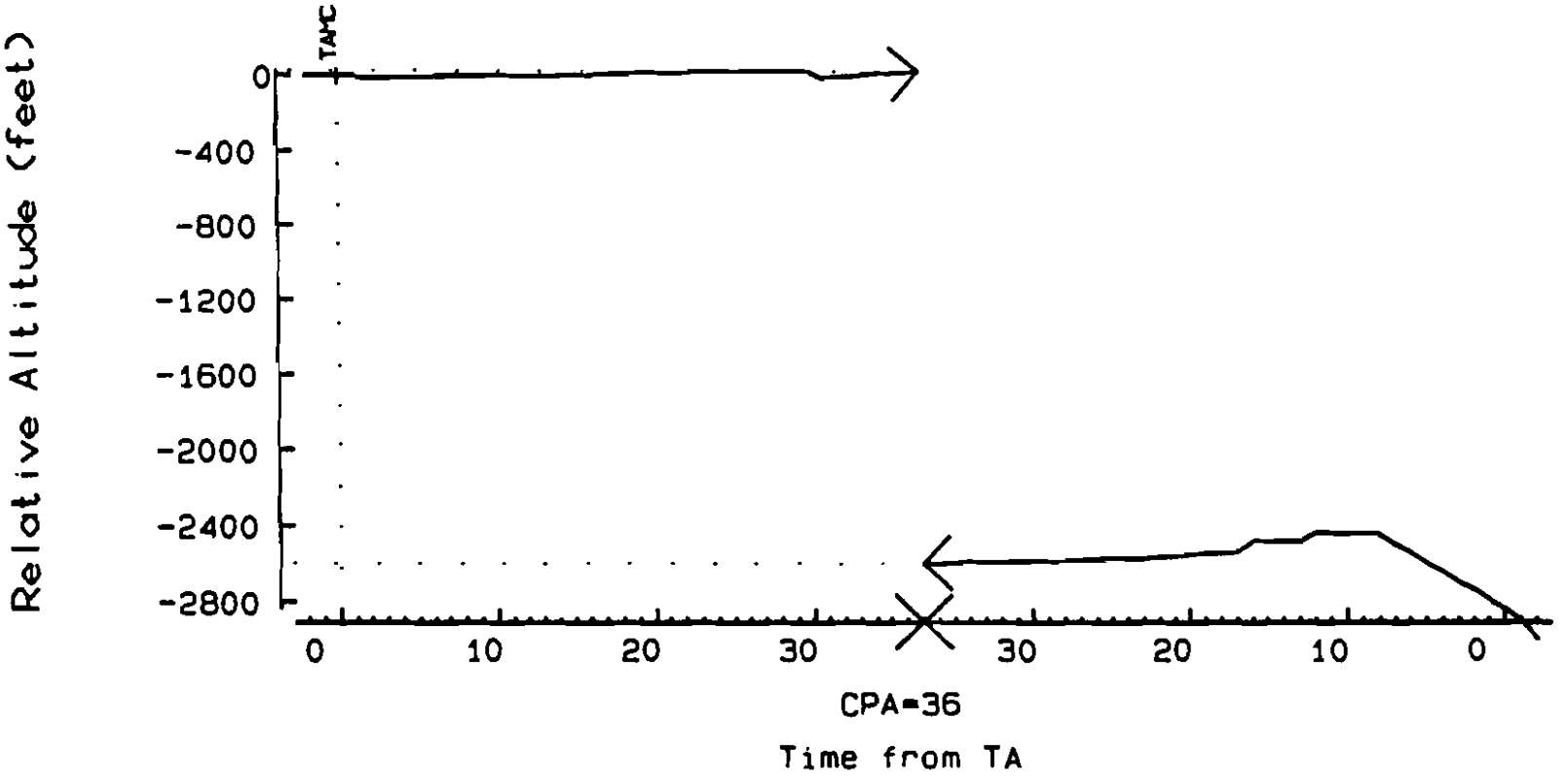
OWN ID: 10746022

RANGE RATE at TA: -615

at CPA: -349

RANGE at CPA: 1780 ft

F-134



TA TIME: 11:23:36

CPA TIME: 11:24:13

FLIGHT DATE: 09/22/93

Alt. Difference at CPA: 2627 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 725 Filename B9309228.TRD

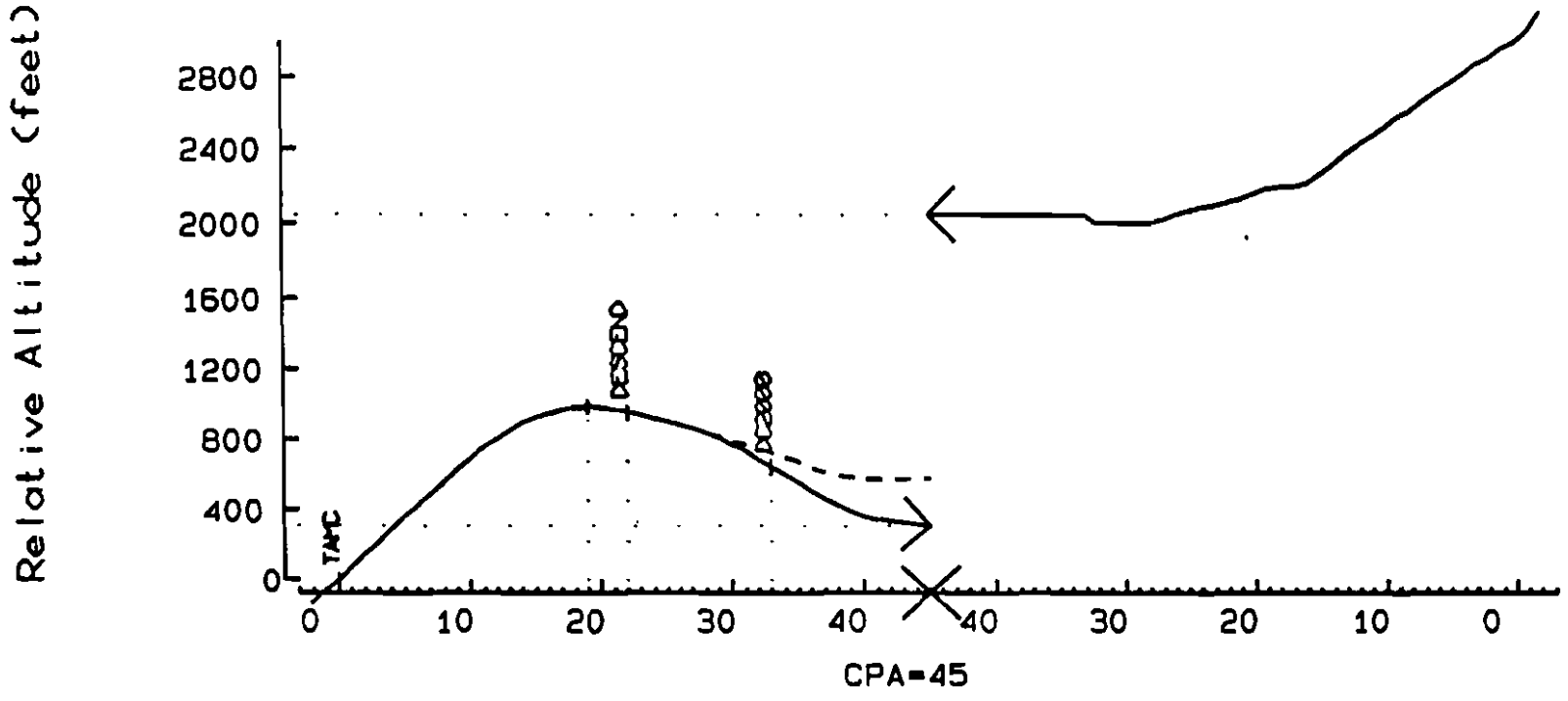
ENCOUNTER ID: 725 RANGE RATE at TA: -593

TARGET ID: 10746022 at CPA: -80

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 10487 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1467 ft

F-135



TA TIME: 11:30:11 CPA TIME: 11:30:56

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 1739 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

Encounter ID 548 Filename R930922A.TRD

ENCOUNTER ID: 548

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

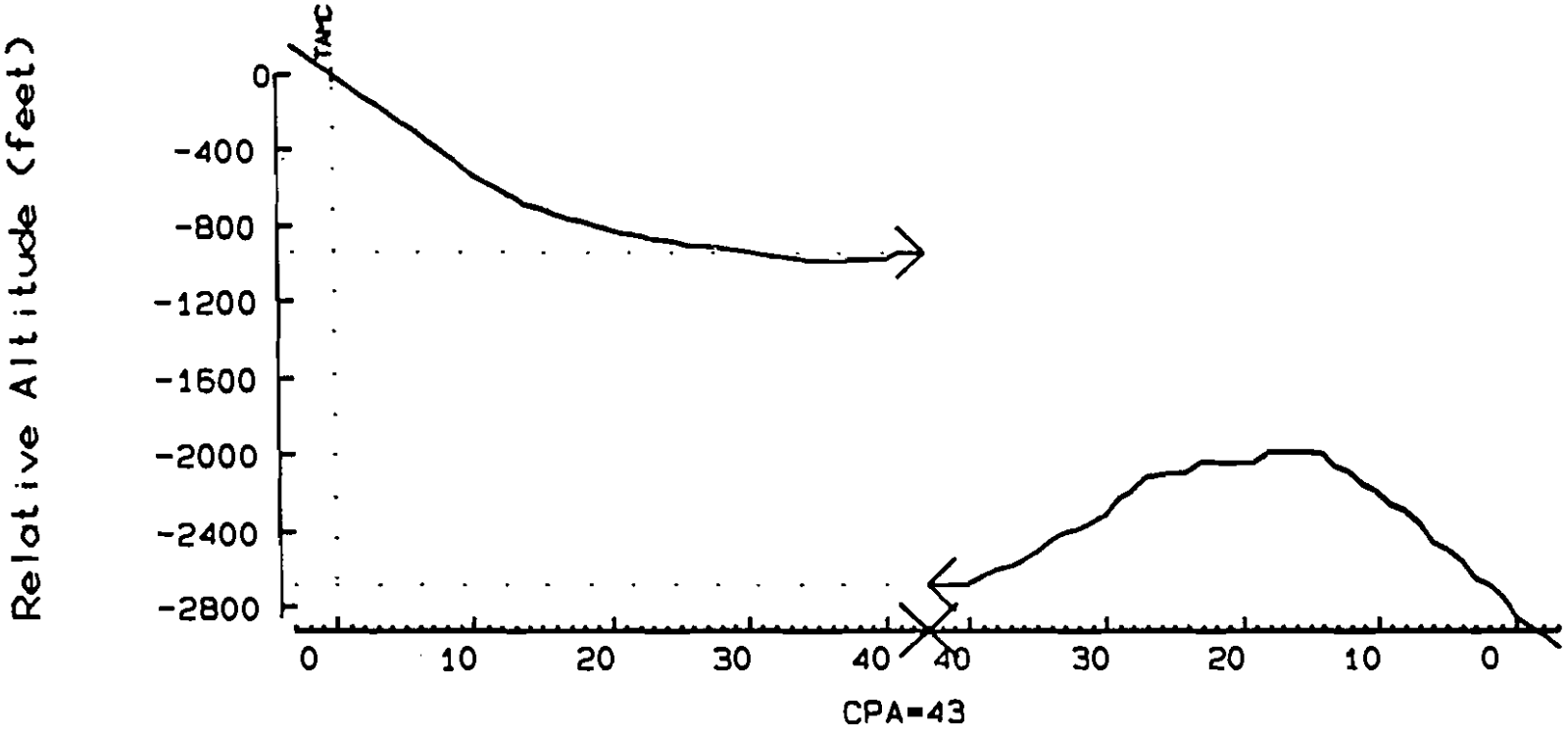
OWN ID: 10746022

RANGE RATE at TA: -582

at CPA: -128

RANGE at CPA: 10165 ft

F-136



TA TIME: 11:29:15 CPA TIME: 11:29:58

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 1746 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 449 Filename B930922C.TRD

ENCOUNTER ID: 449

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

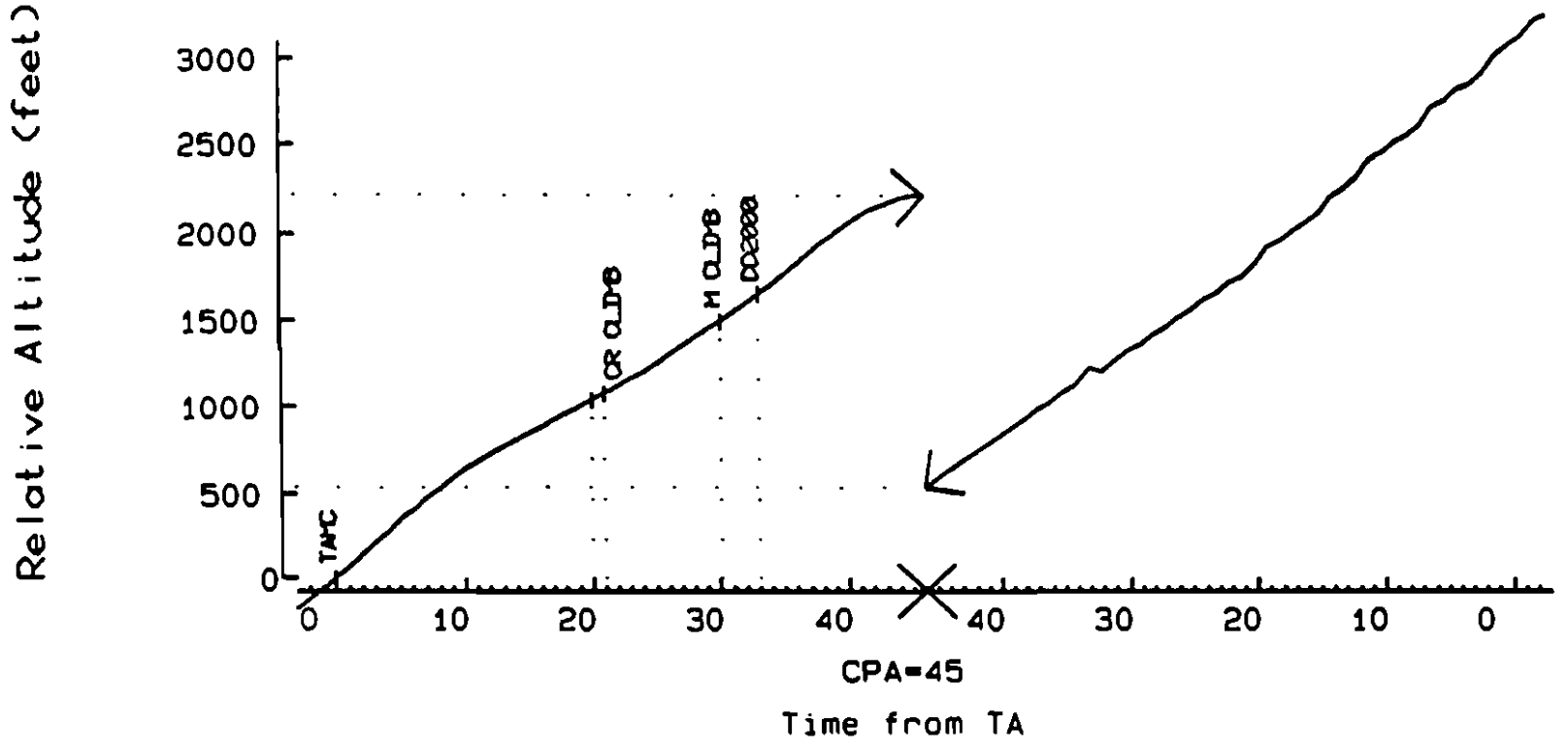
OWN ID: 10791495

RANGE RATE at TA: -598

at CPA: -49

RANGE at CPA: 2697 ft

F-137



TA TIME: 14:03:35 CPA TIME: 14:04:21

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 1694 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

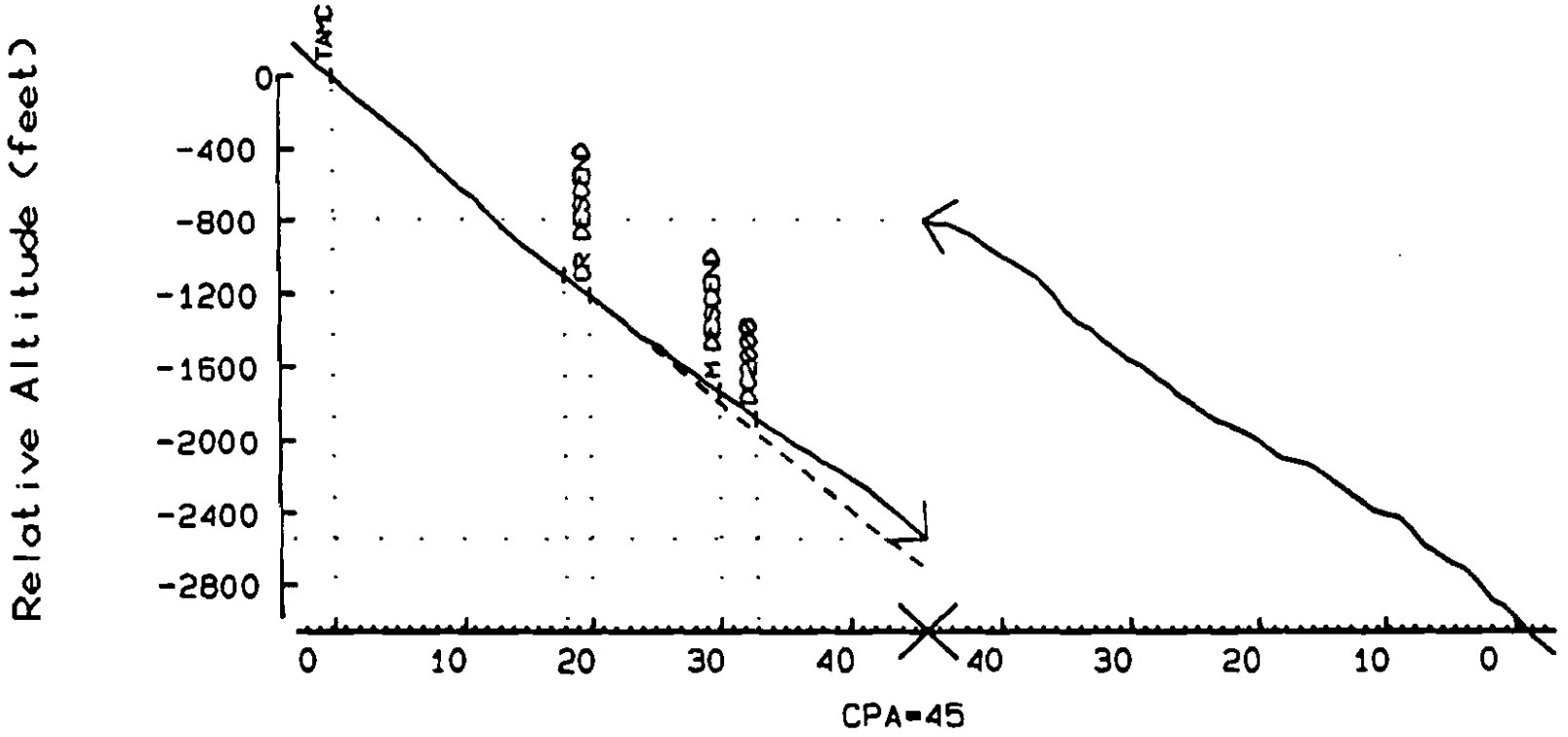
Encounter ID 143 Filename R9309228.TRD

ENCOUNTER ID: 143 RANGE RATE at TA: -591

TARGET ID: 10791495 at CPA: -405

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 1537 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1931 ft



TA TIME: 14:02:35 CPA TIME: 14:03:21

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 1749 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

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>0

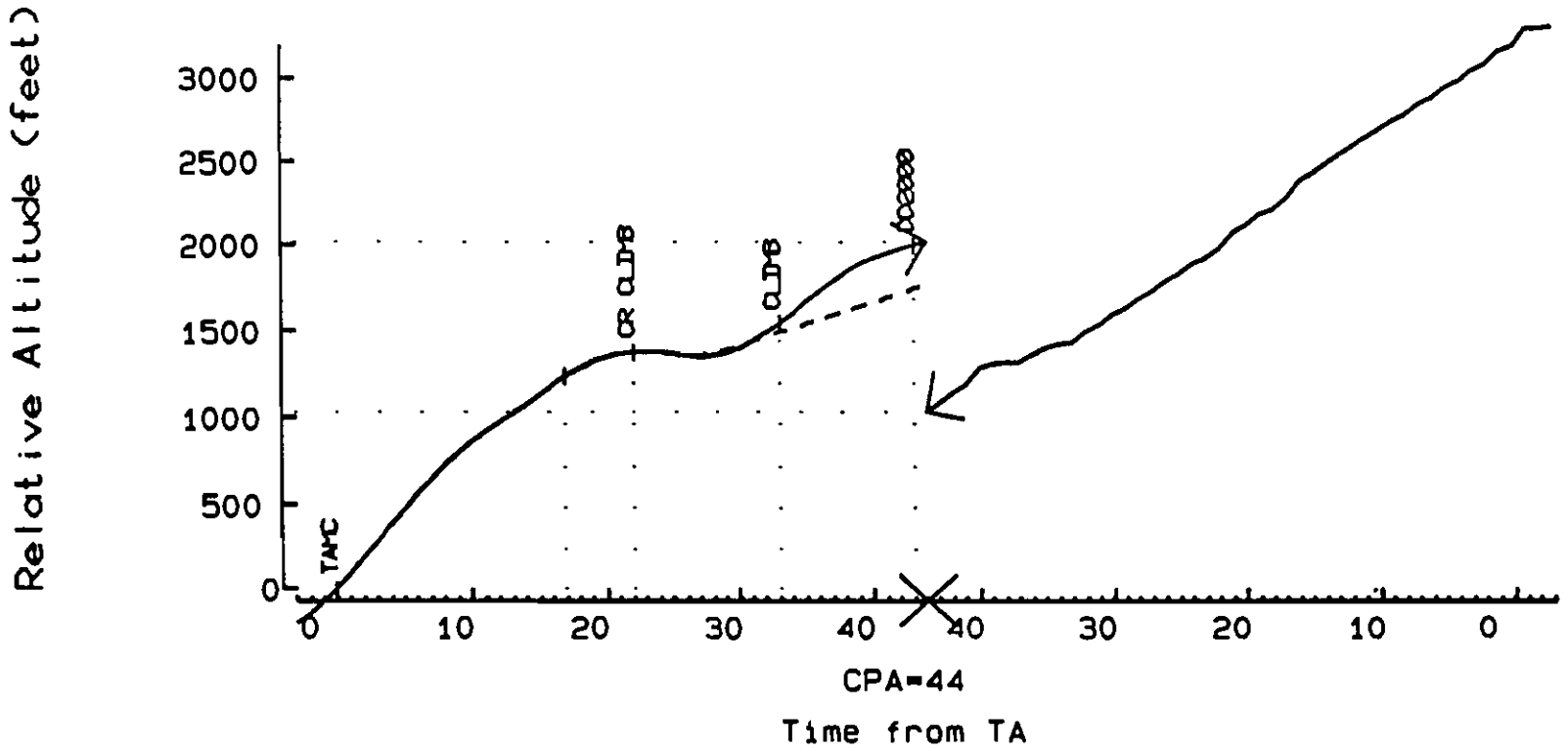
Encounter ID 569 Filename B930922C.TRO

ENCOUNTER ID: 569 RANGE RATE at TA: -620

TARGET ID: 10746022 at CPA: -96

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 5820 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 725 ft



TA TIME: 14:09:36 CPA TIME: 14:10:20

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 978 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

F-139

>

Encounter ID 225 Filename R9309228.TRO

ENCOUNTER ID: 225

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

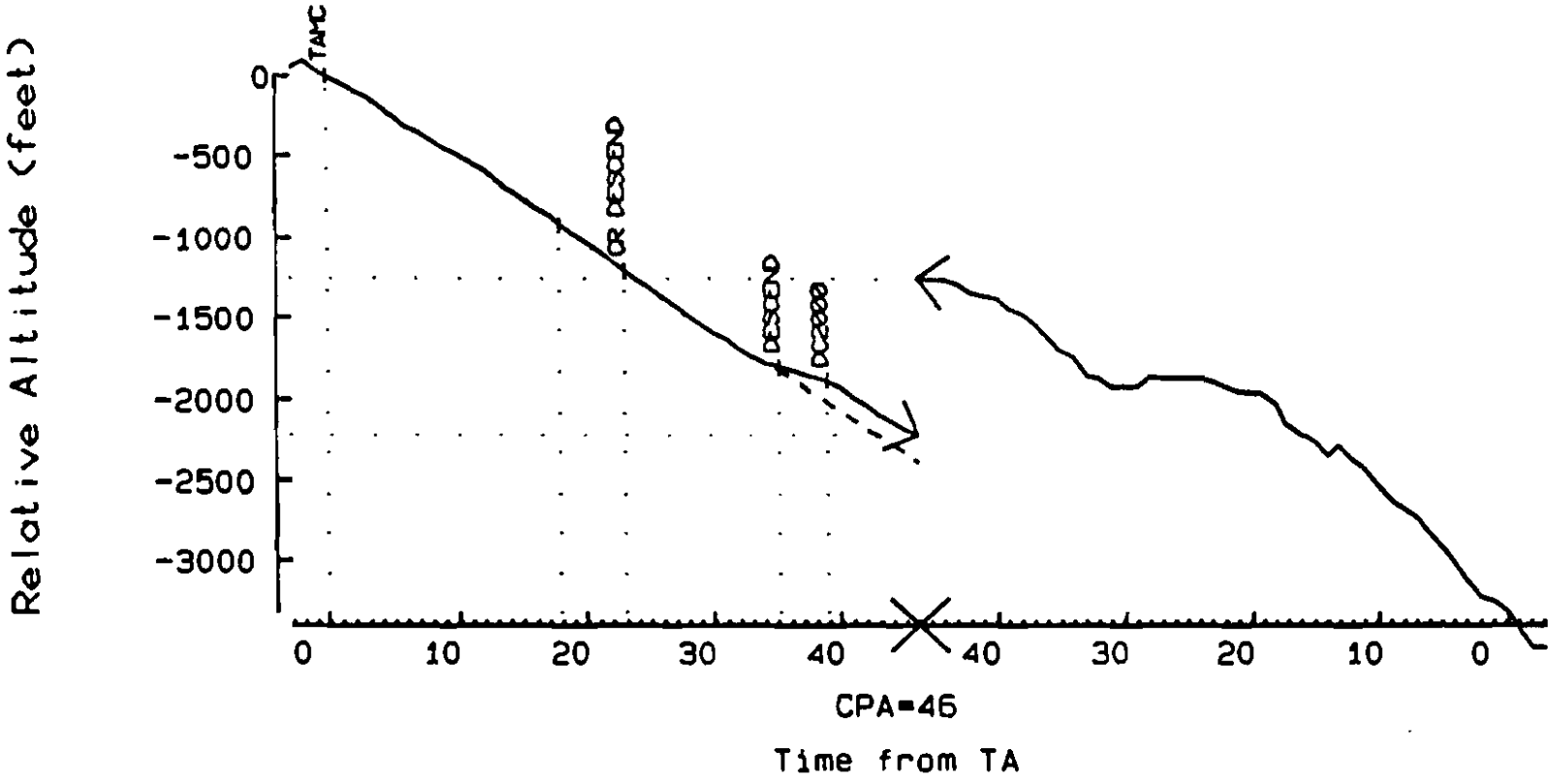
RANGE RATE at TA: -634

at CPA: -198

RANGE at CPA: 5371 ft

Alt. Difference with Simulated Pilot Response: 1130 ft

F-140



TA TIME: 14:08:34

CPA TIME: 14:09:20

FLIGHT DATE: 09/22/93

Alt. Difference at CPA: 969 ft

PROCESSED ON: 12/13/93 by ACO-320 FAA Technical Center

>

Encounter ID 706 Filename B930922C.TRD

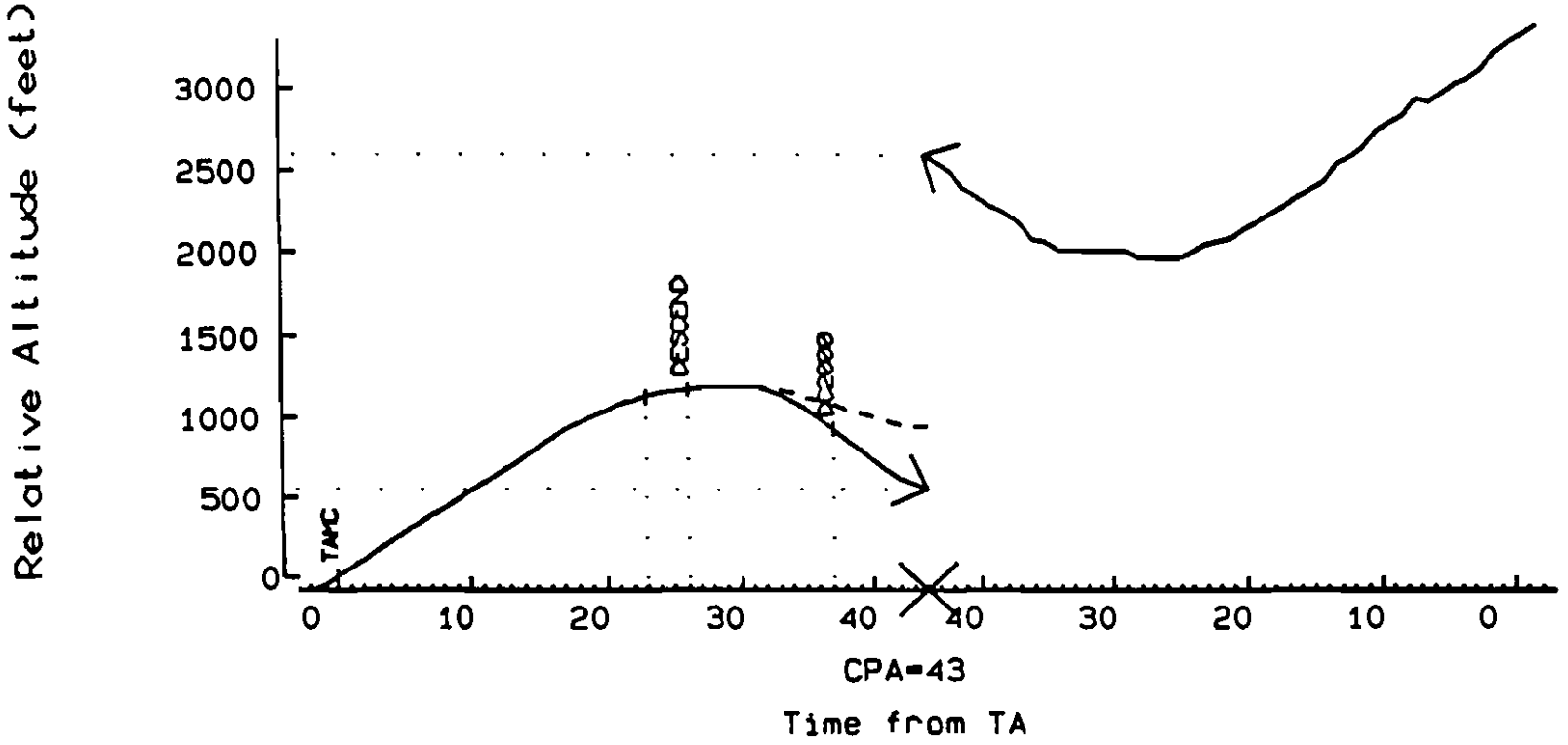
ENCOUNTER ID: 706 RANGE RATE at TA: -612

TARGET ID: 10746022 at CPA: -126

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 5365 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1656 ft

F-141



TA TIME: 14: 15: 22 CPA TIME: 14: 16: 06

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 2043 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

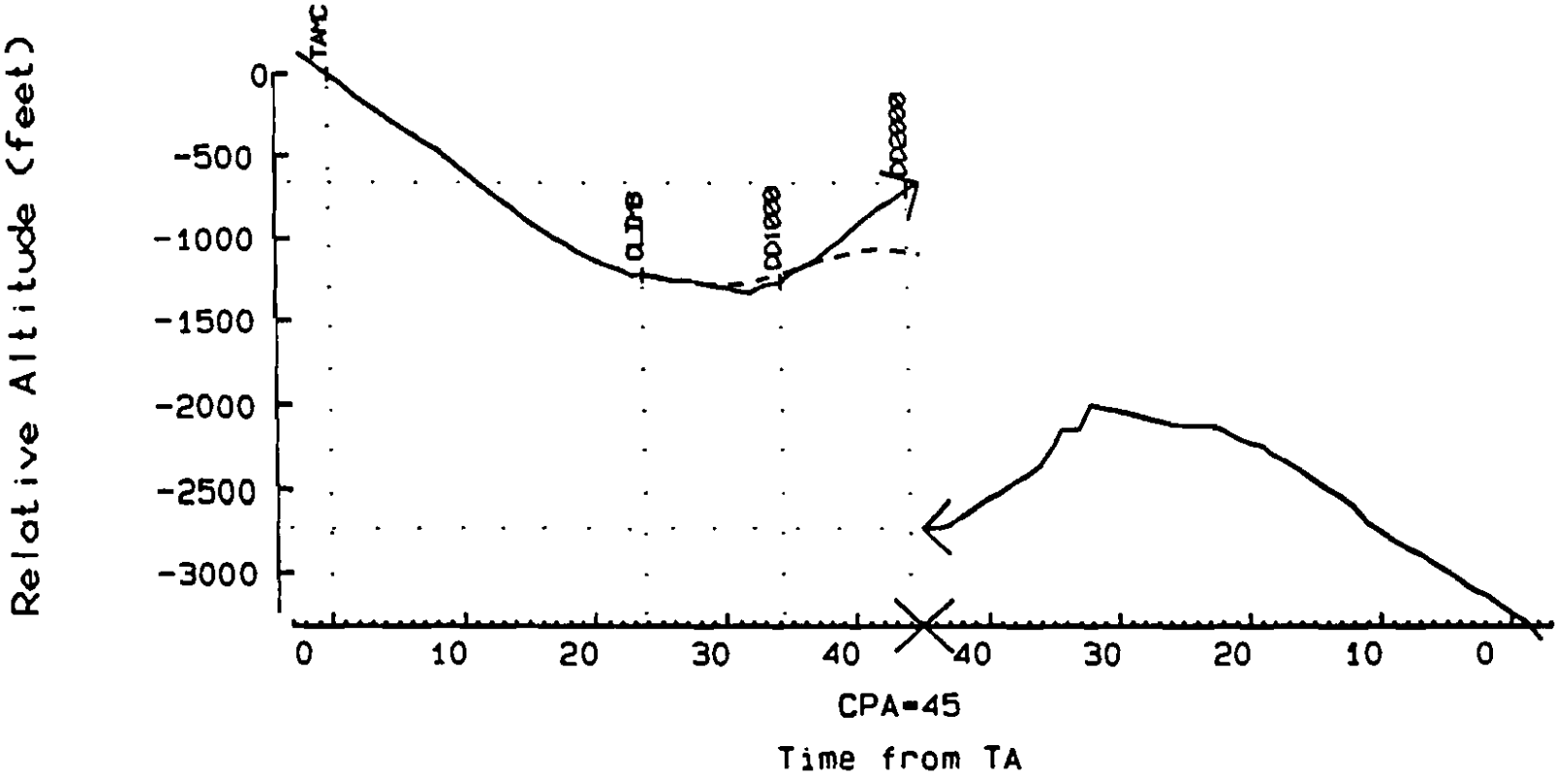
Encounter ID 225 Filename R930922B.TRD

ENCOUNTER ID: 225 RANGE RATE at TA: -615

TARGET ID: 10791495 at CPA: -189

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 4836 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1628 ft



TA TIME: 14: 14: 22 CPA TIME: 14: 15: 07

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 2068 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

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>

Encounter ID 807 Filename 8930922C.TRD

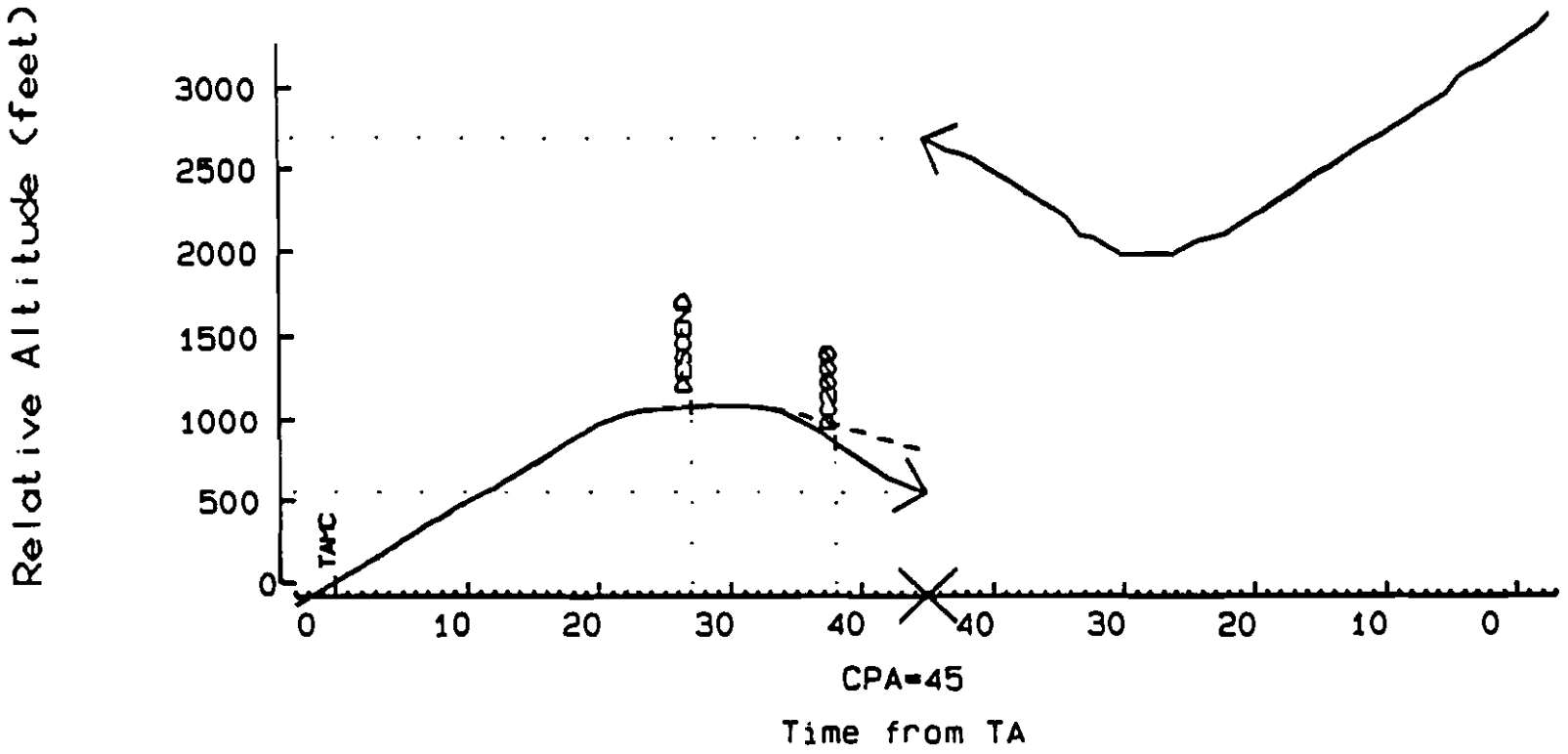
ENCOUNTER ID: 807 RANGE RATE at TA: -613

TARGET ID: 10746022 at CPA: -115

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 6373 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1886 ft

F-143



TA TIME: 14:20:52 CPA TIME: 14:21:37

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 2137 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

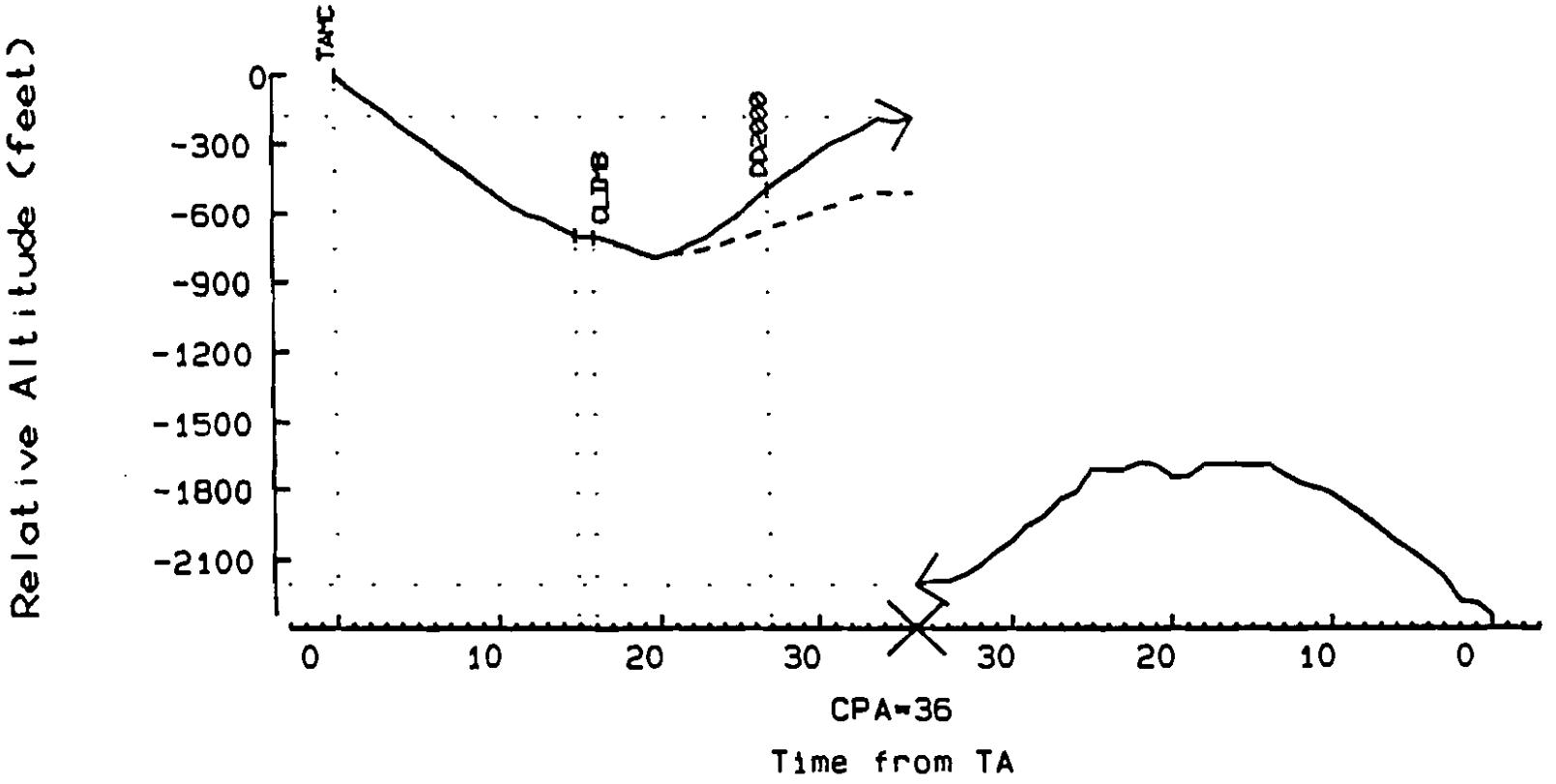
Encounter ID 333 Filename R930922B.TRD

ENCOUNTER ID: 333 RANGE RATE at TA: -618

TARGET ID: 10791495 at CPA: -205

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 5930 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1697 ft



TA TIME: 14:20:01 CPA TIME: 14:20:37

FLIGHT DATE: 09/22/93 Alt. Difference at CPA: 2024 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

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>

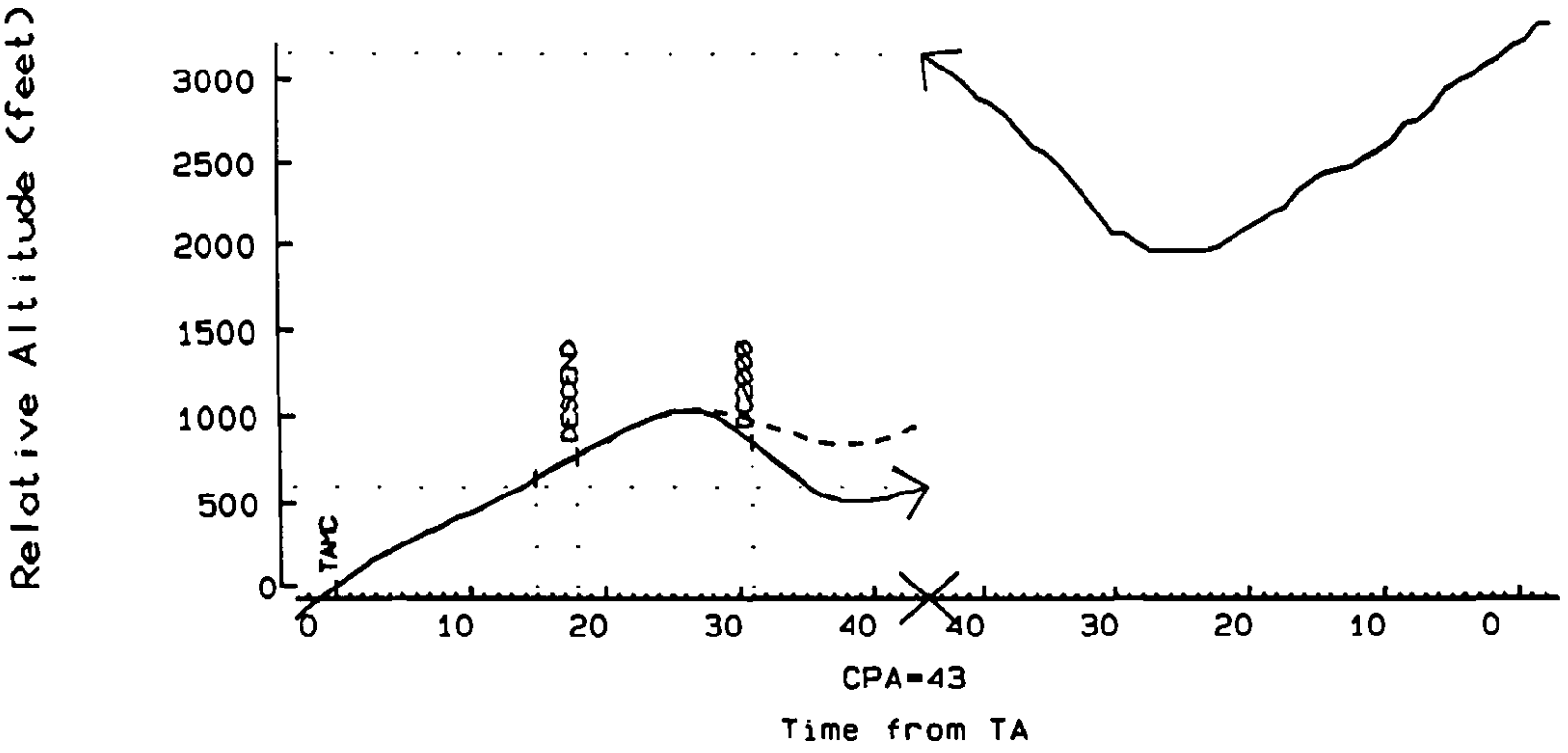
Encounter ID 258 Filename 8930923A.TRD

ENCOUNTER ID: 258 RANGE RATE at TA: -587

TARGET ID: 10746022 at CPA: -141

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 4557 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 2194 ft



TA TIME: 10: 15: 16 CPA TIME: 10: 16: 00

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 2572 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

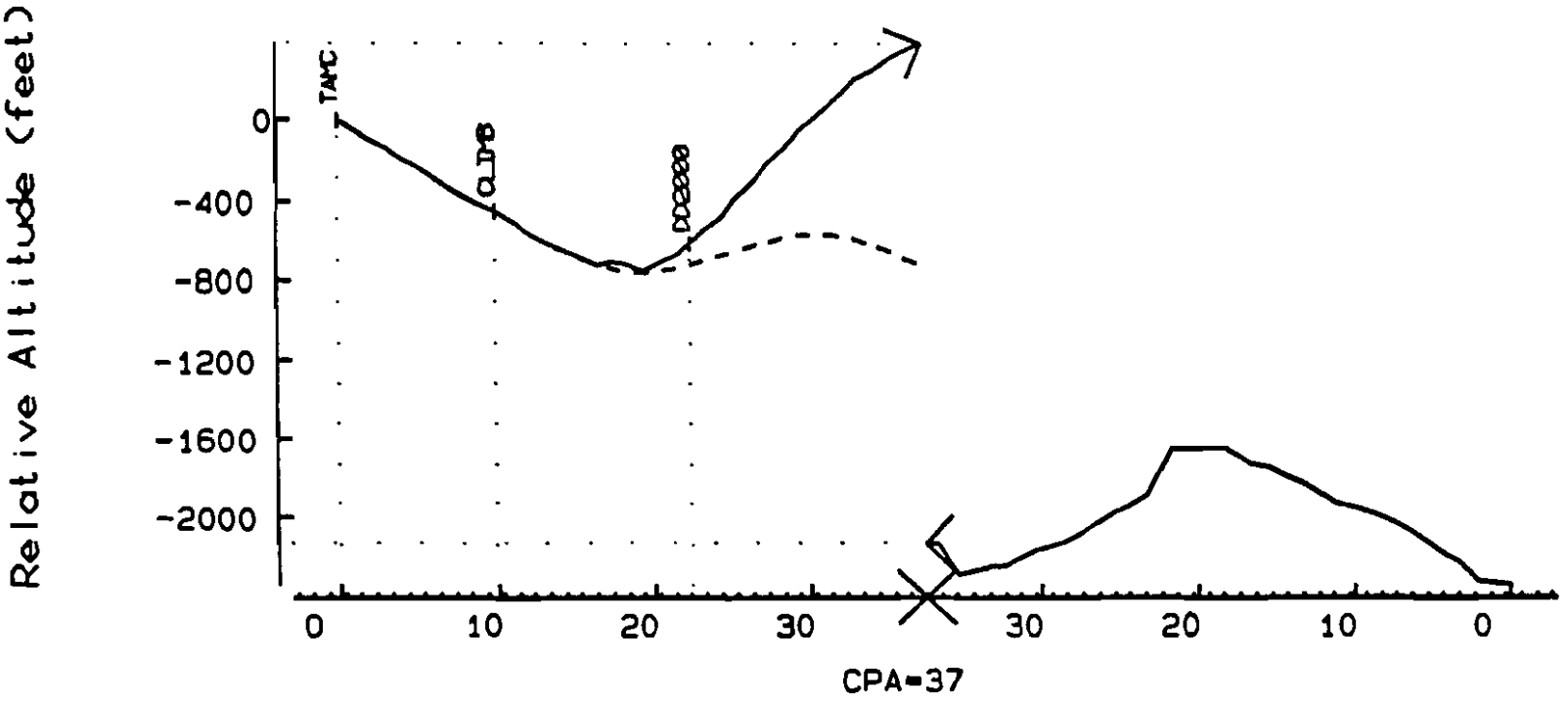
Encounter ID 119 Filename R930923A.TRD

ENCOUNTER ID: 119 RANGE RATE at TA: -588

TARGET ID: 10791495 at CPA: -298

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 3894 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1396 ft



TA TIME: 10: 14: 17 CPA TIME: 10: 14: 54

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 2532 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

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>

Encounter ID 475 Filename B930923A.TRD

ENCOUNTER ID: 475 RANGE RATE at TA: -617

TARGET ID: 10746022 at CPA: -296

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2041 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 2065 ft

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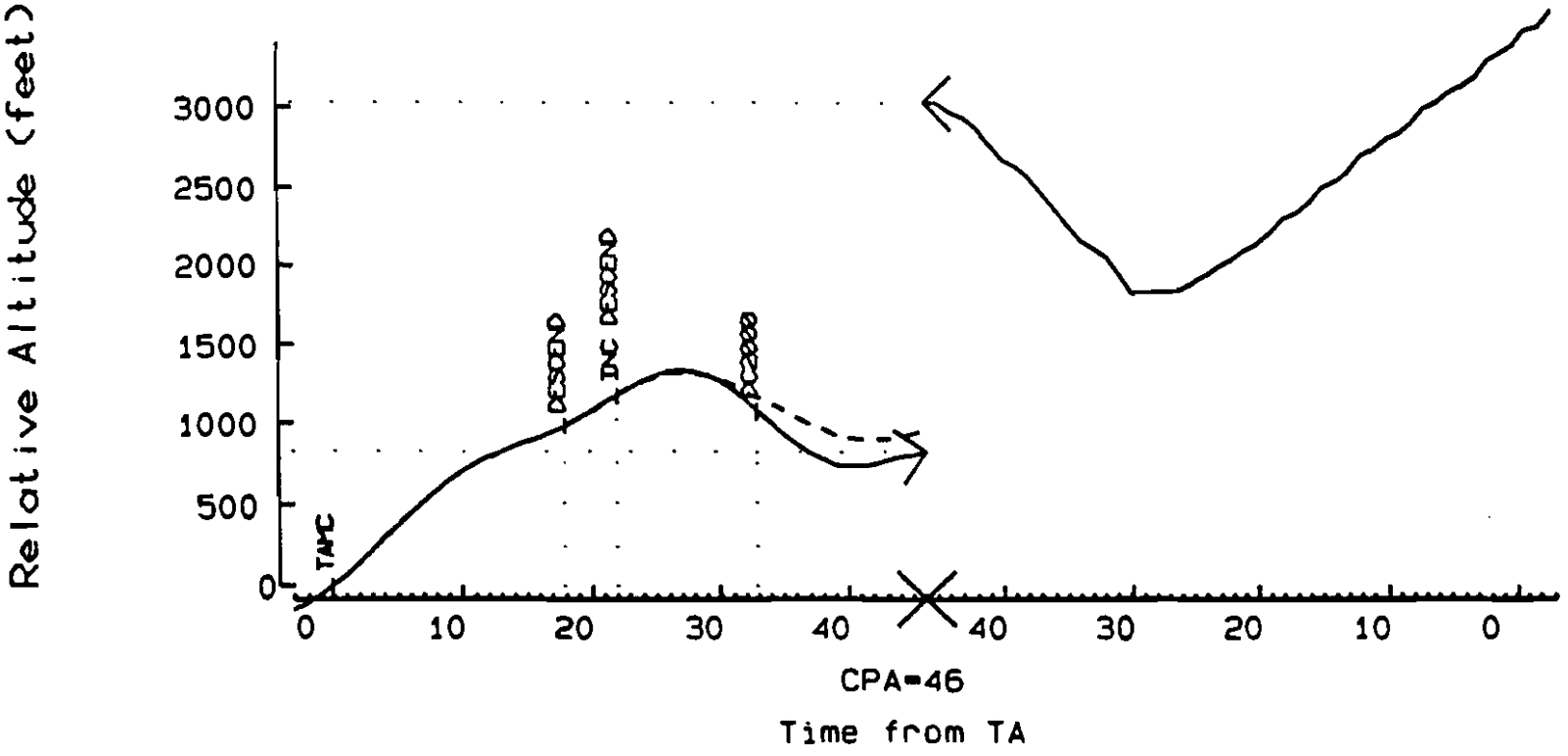


TA TIME: 10: 21: 18 CPA TIME: 10: 22: 04

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 2205 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

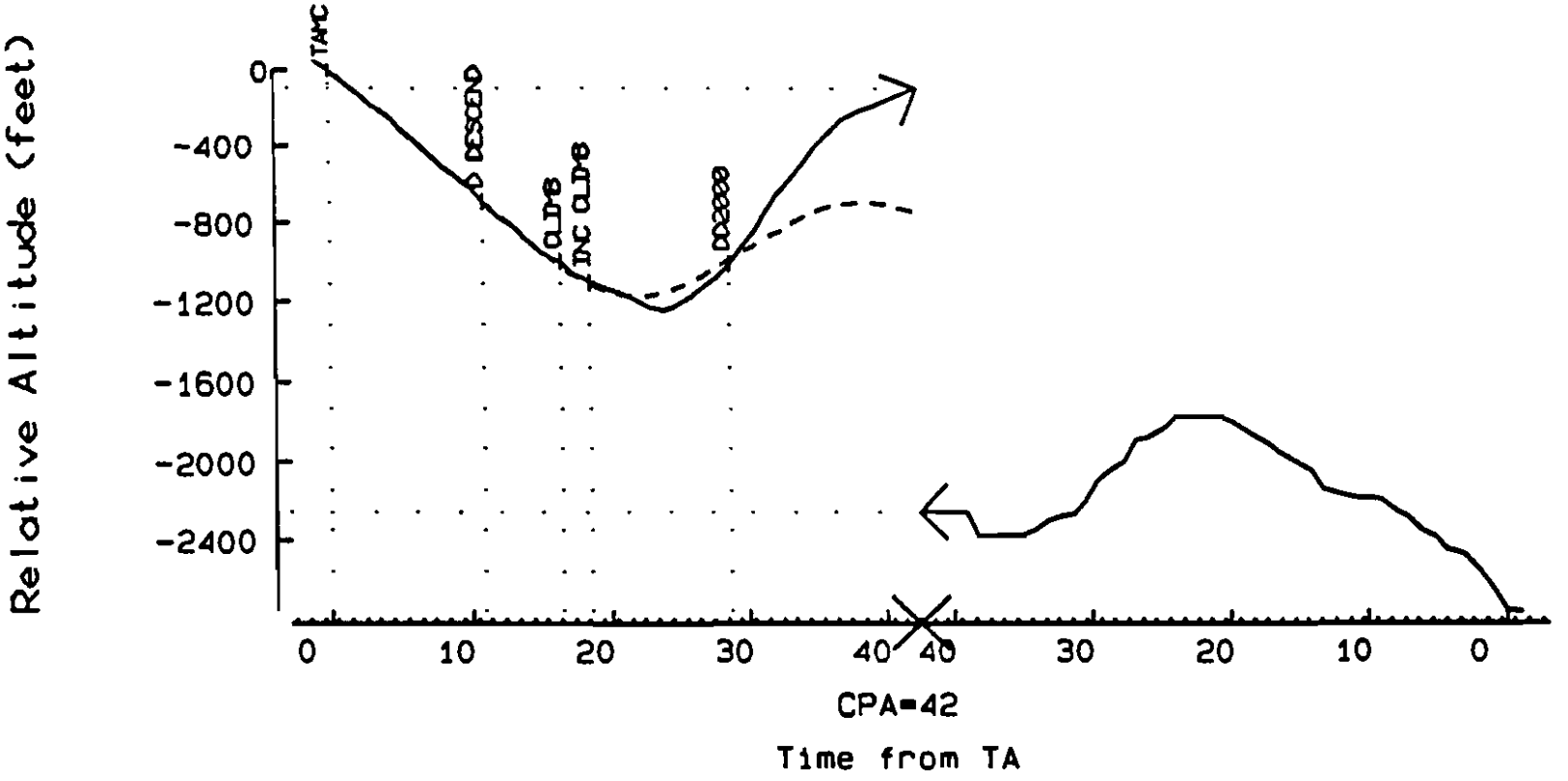
Encounter ID 145 Filename R930923A.TRD

ENCOUNTER ID: 145 RANGE RATE at TA: -638

TARGET ID: 10791495 at CPA: -491

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 644 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1508 ft



TA TIME: 10: 20: 16 CPA TIME: 10: 20: 58

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 2159 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

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>

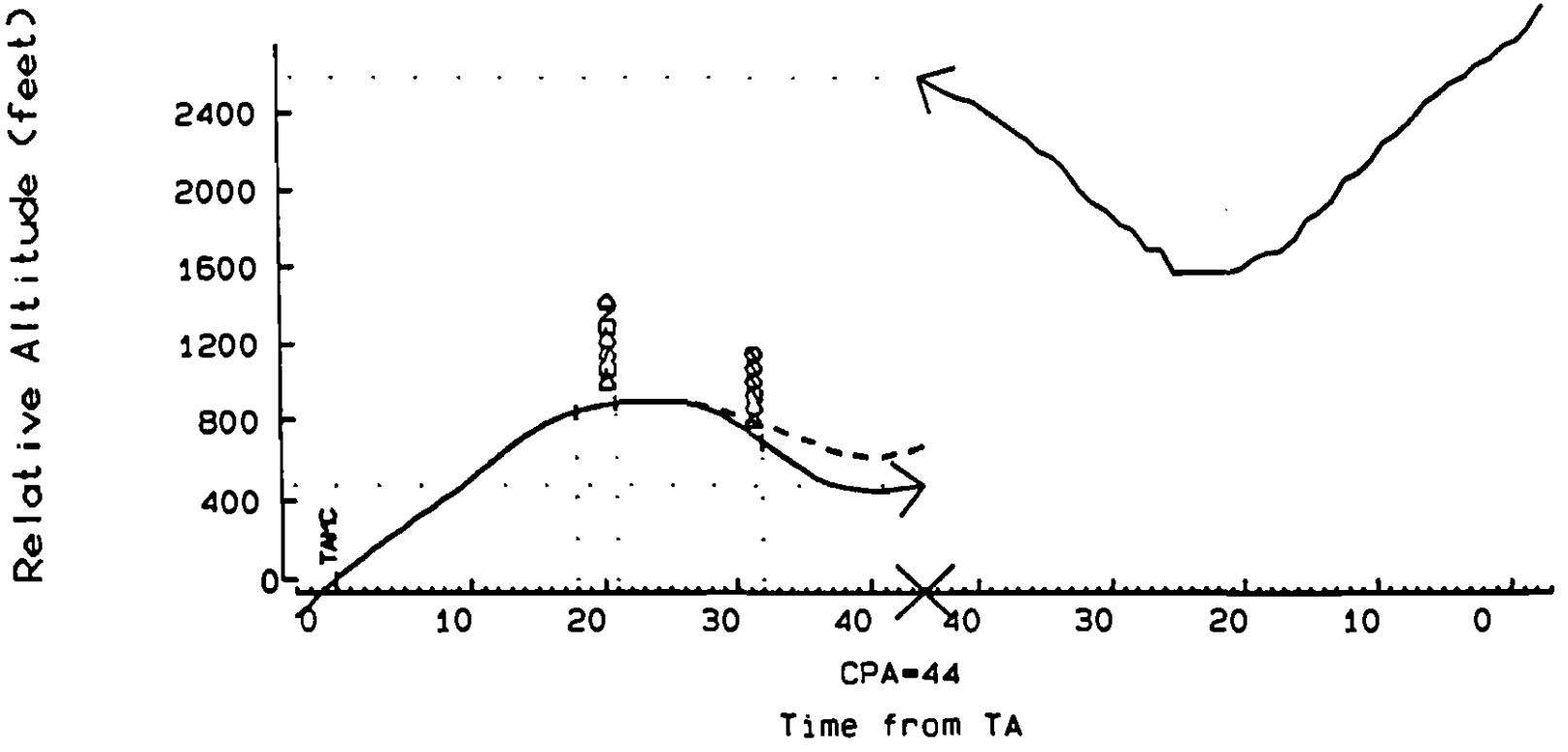
Encounter ID 579 Filename B930923A.TRD

ENCOUNTER ID: 579 RANGE RATE at TA: -591

TARGET ID: 10746022 at CPA: -94

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 3979 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1909 ft



TA TIME: 10:27:12 CPA TIME: 10:27:56

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 2103 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

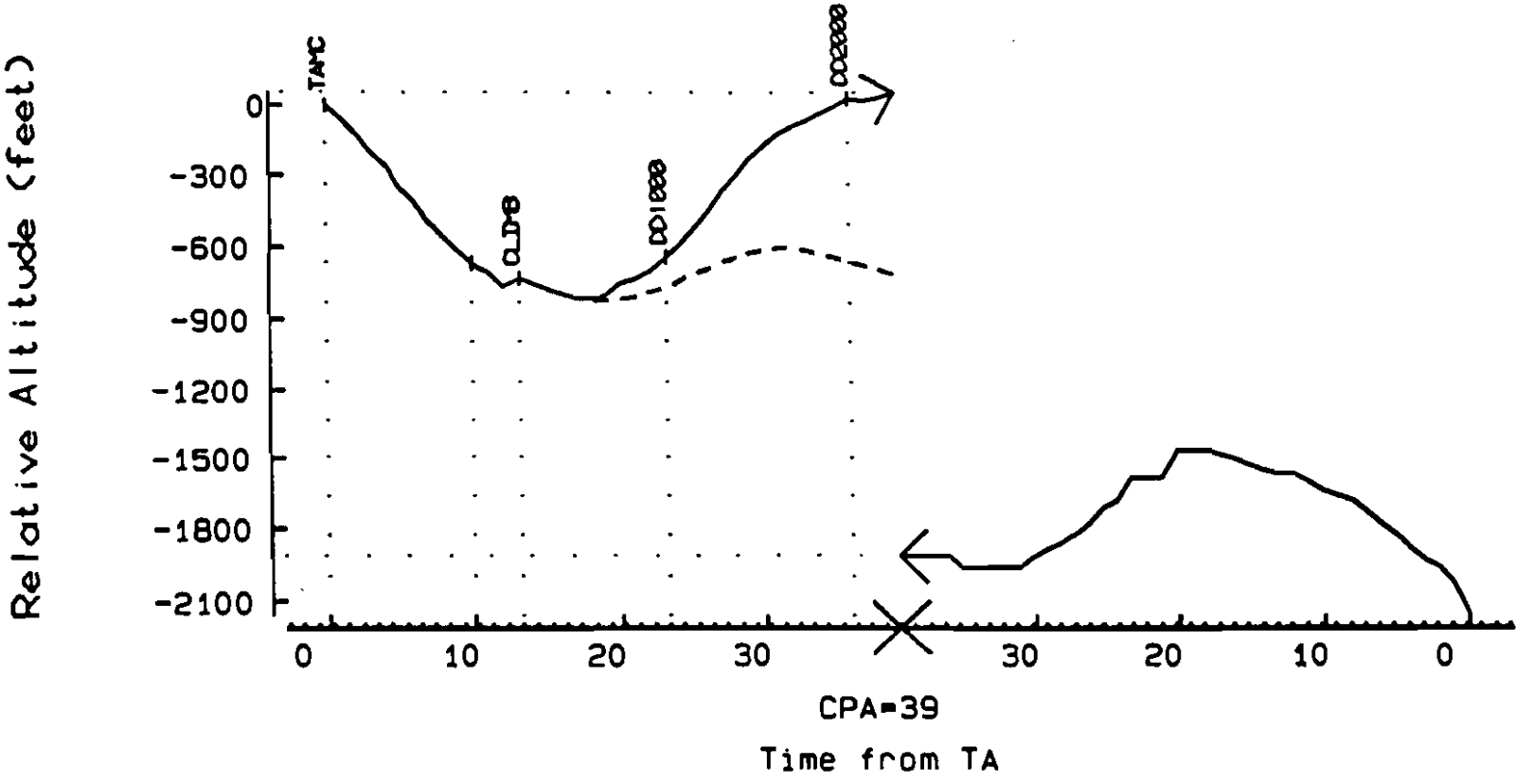
Encounter ID 168 Filename R930923A.TRD

ENCOUNTER ID: 168 RANGE RATE at TA: -619

TARGET ID: 10791495 at CPA: -199

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 3384 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1202 ft



TA TIME: 10:26:11 CPA TIME: 10:26:50

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 1971 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

F-150

>

Encounter ID 1113 Filename B930923A.TRD

ENCOUNTER ID: 1113 RANGE RATE at TA: -594

TARGET ID: 10746022 at CPA: -128

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2861 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 1026 ft

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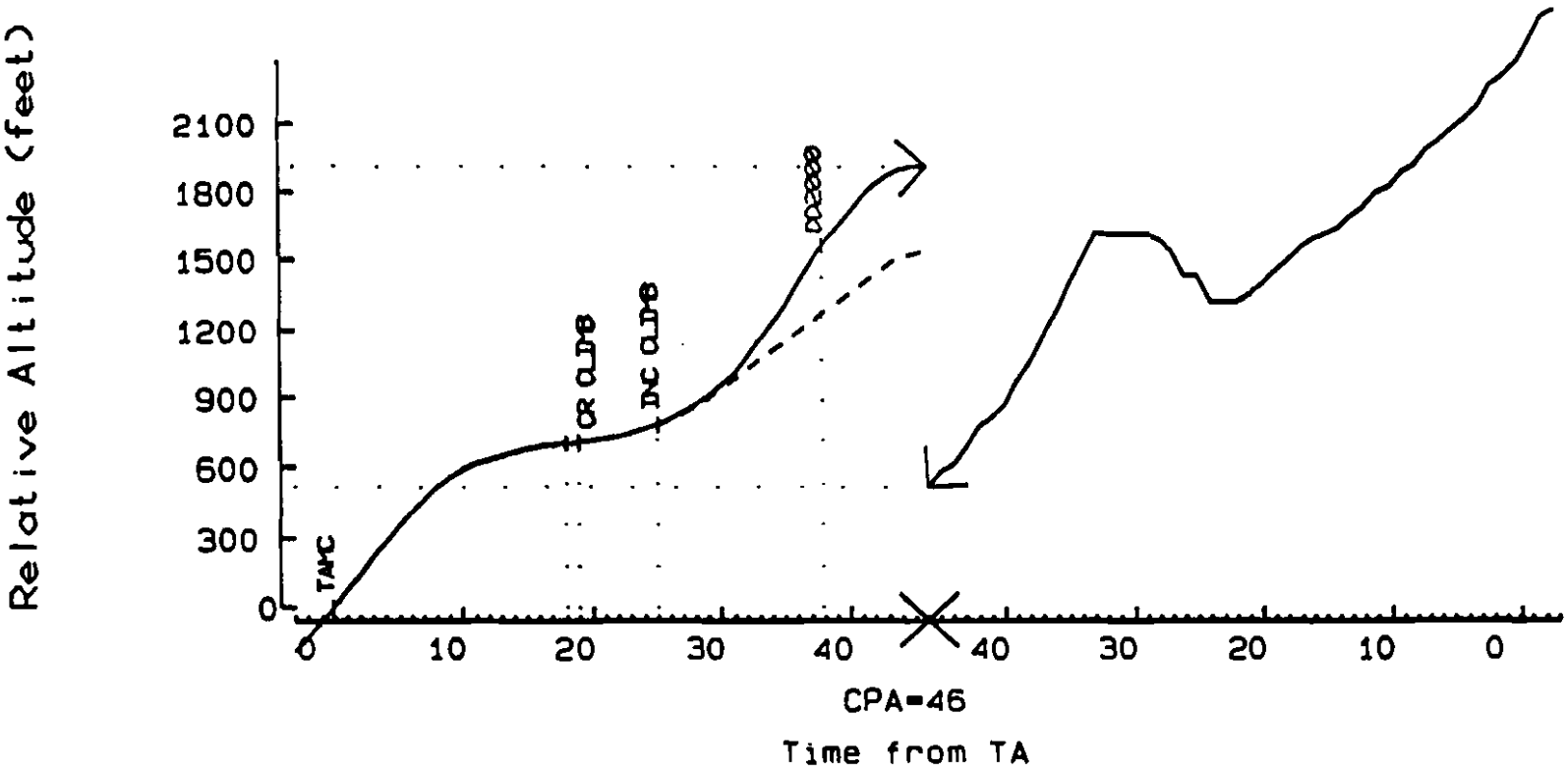


TA TIME: 10: 44: 30 CPA TIME: 10: 45: 16

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 1392 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

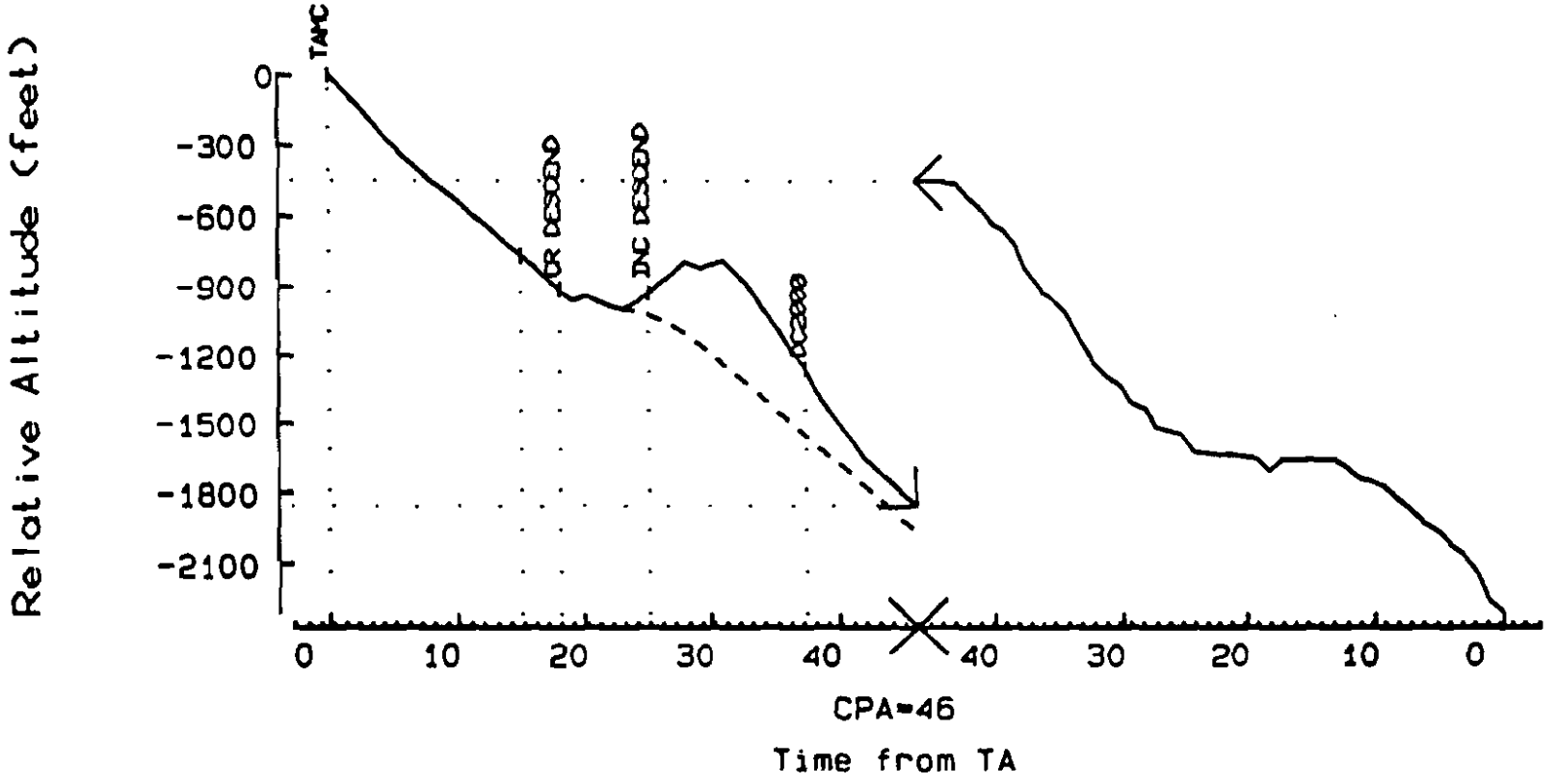
Encounter ID 243 Filename R930923A.TRD

ENCOUNTER ID: 243 RANGE RATE at TA: -617

TARGET ID: 10791495 at CPA: -264

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 2284 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 1517 ft



TA TIME: 10: 43: 24 CPA TIME: 10: 44: 10

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 1401 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

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>

Encounter ID 25 Filename B930923B.TRD

ENCOUNTER ID: 25

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

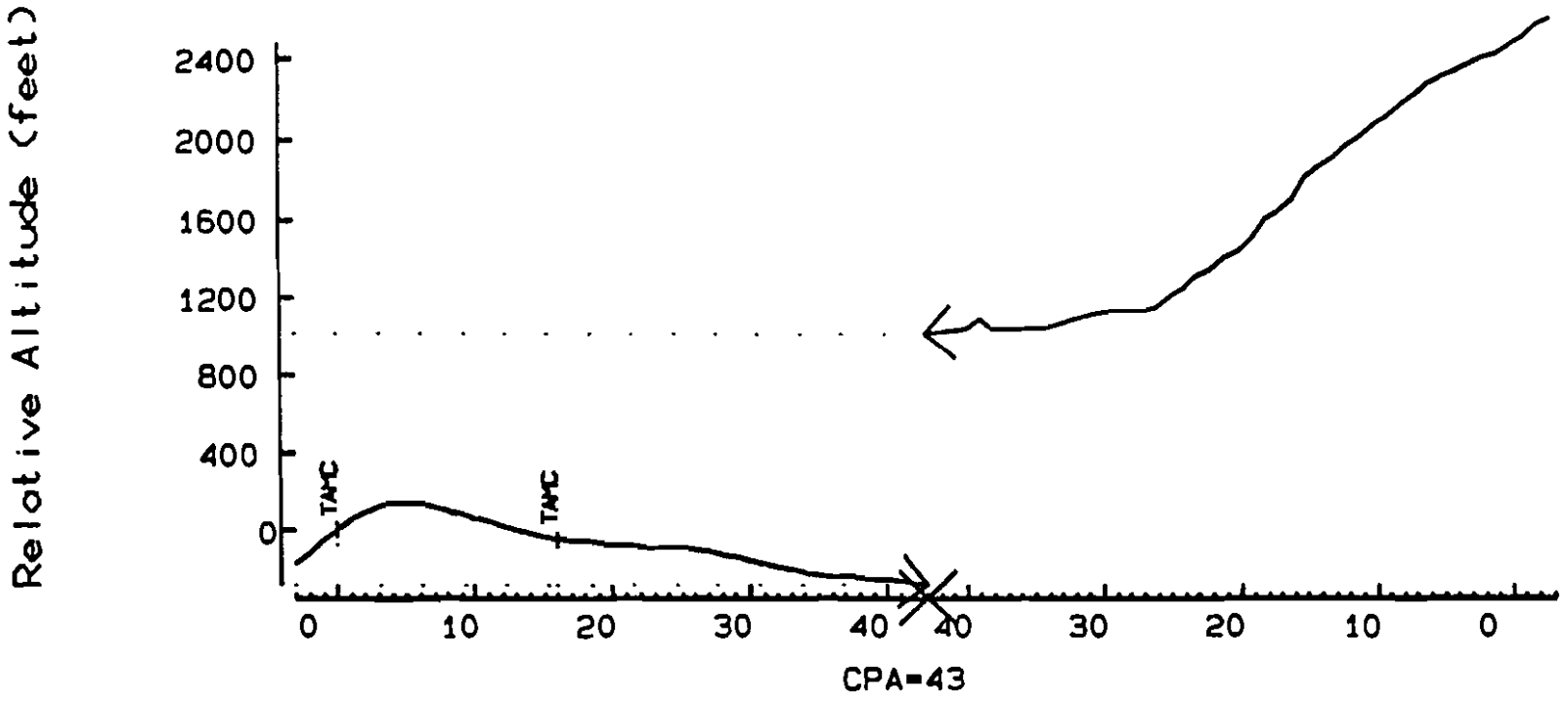
OWN ID: 10791495

RANGE RATE at TA: -601

at CPA: 105

RANGE at CPA: 2807 ft

F-153



TA TIME: 10:50:53

CPA TIME: 10:51:36

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1293 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

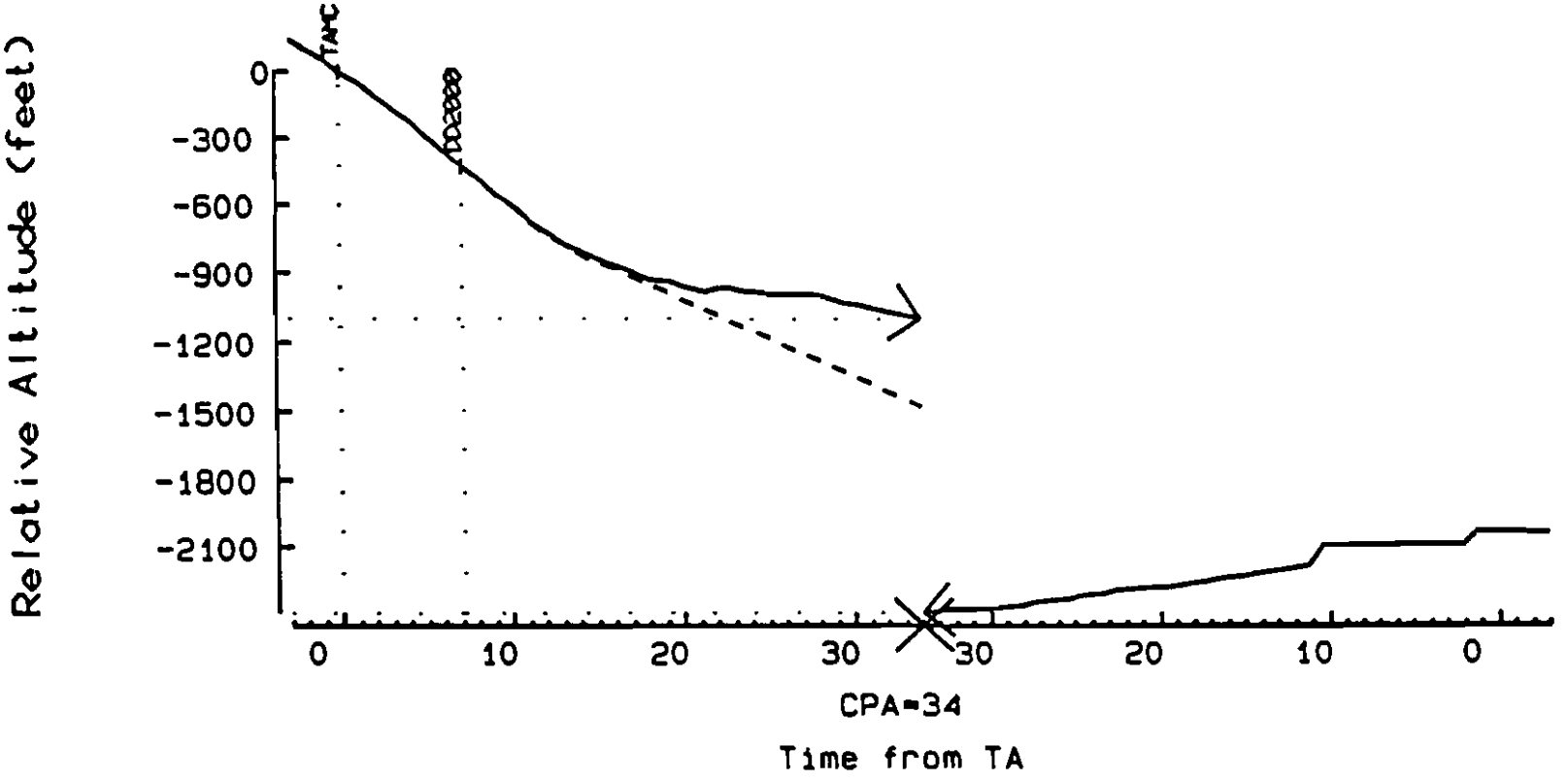
Encounter ID 309 Filename R930923A.TRD

ENCOUNTER ID: 309 RANGE RATE at TA: -610

TARGET ID: 10791495 at CPA: -302

INTRUDER EQUIPAGE: TCAS II RANGE at CPA: 1889 ft

OWN ID: 10746022 Alt. Difference with Simulated Pilot Response: 911 ft



TA TIME: 10: 49: 56 CPA TIME: 10: 50: 30

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 1298 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

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>

Encounter ID 201 Filename 89309238.TRD

ENCOUNTER ID: 201

TARGET ID: 10746022

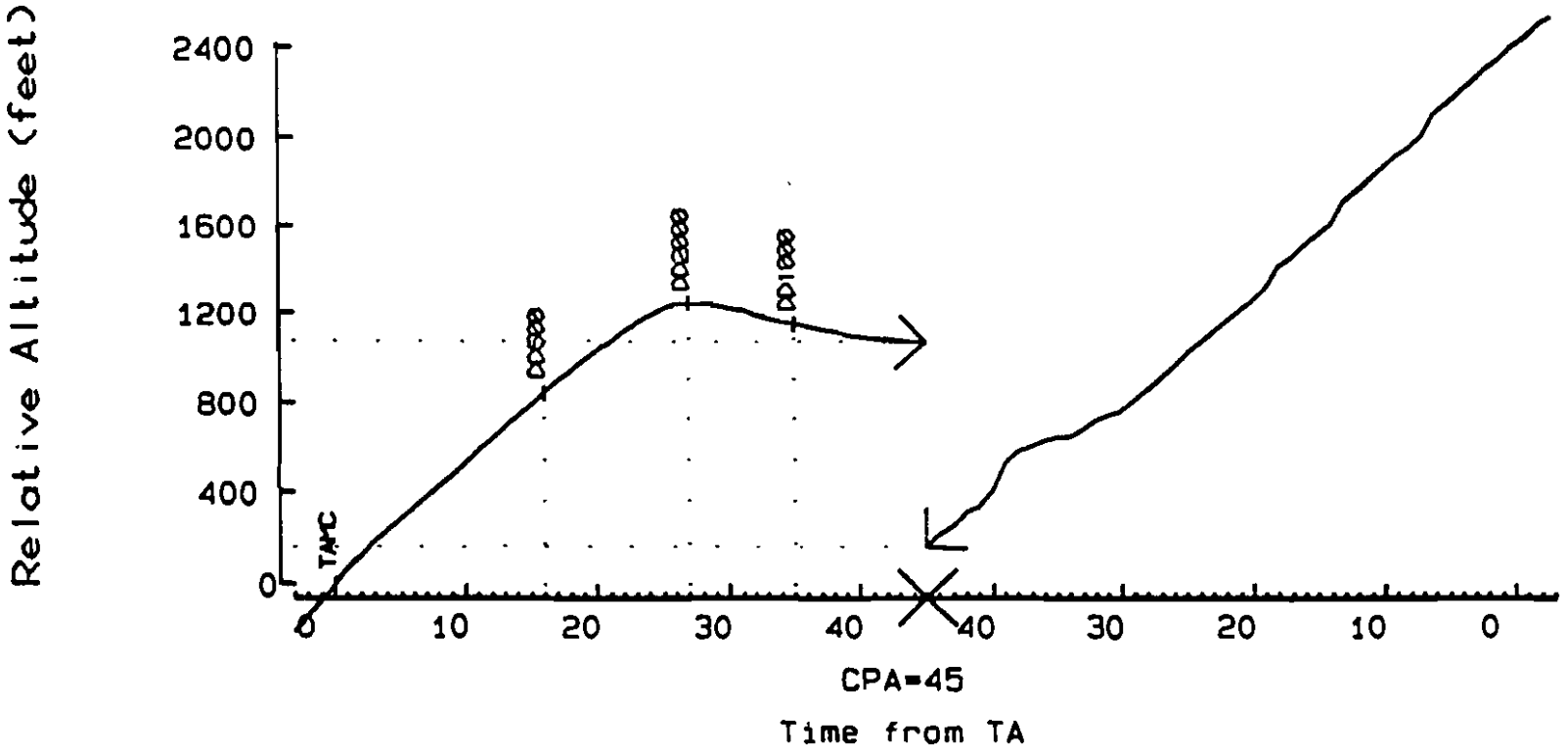
INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

RANGE RATE at TA: -599

at CPA: -138

RANGE at CPA: 2813 ft



TA TIME: 10:56:20 CPA TIME: 10:57:05

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 906 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

Encounter IO 338 Filename R930923A.TRD

ENCOUNTER ID: 338

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

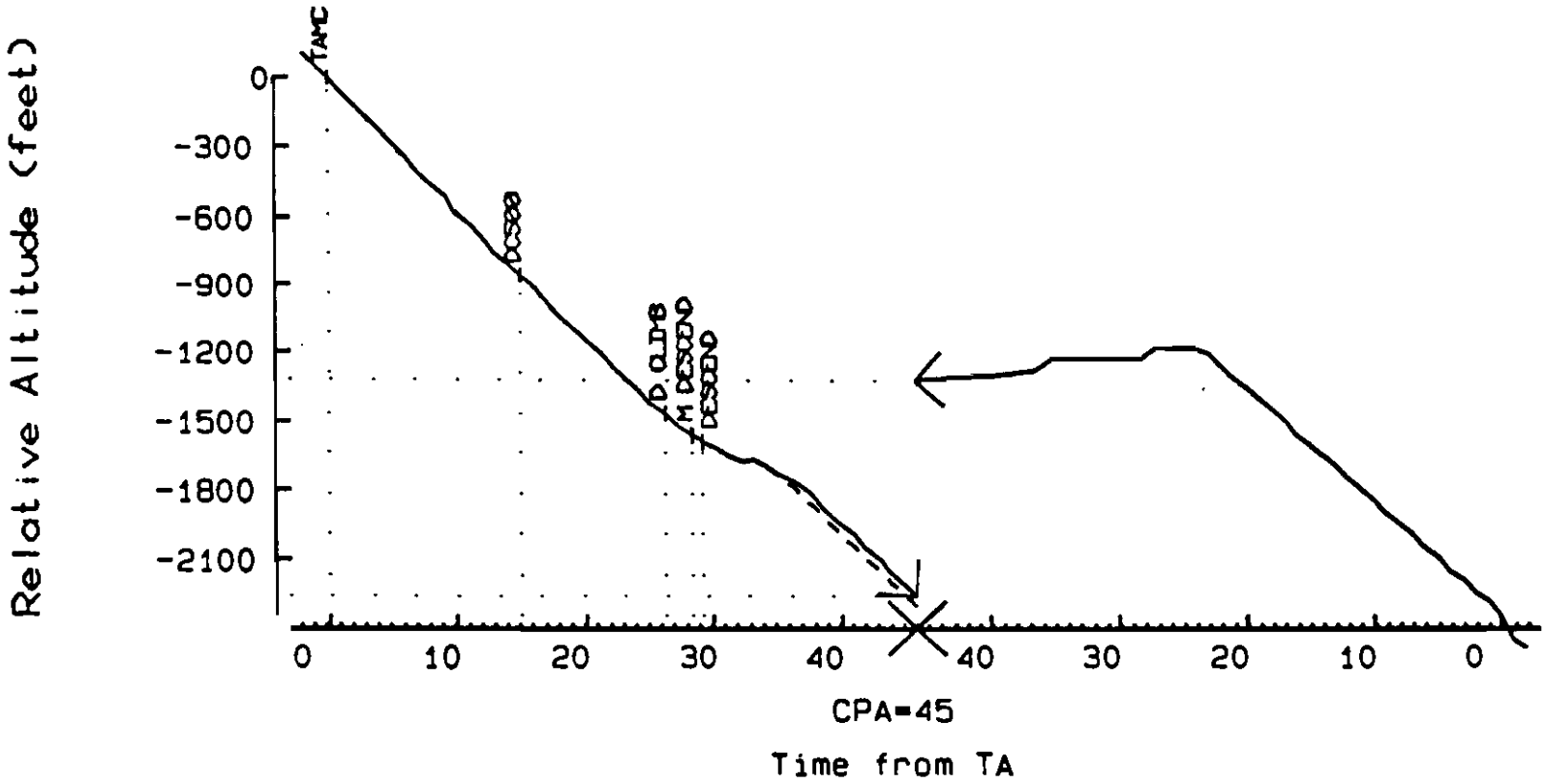
OWN ID: 10746022

RANGE RATE at TA: -599

at CPA: -332

RANGE at CPA: 2229 ft

Alt. Difference with Simulated Pilot Response: 986 ft



TA TIME: 10:55:14

CPA TIME: 10:56:00

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 941 ft

PROCESSED ON: 12/13/93 by ACO-320 FAA Technical Center

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>

Encounter ID 337 Filename 89309238.TRD

ENCOUNTER ID: 337

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

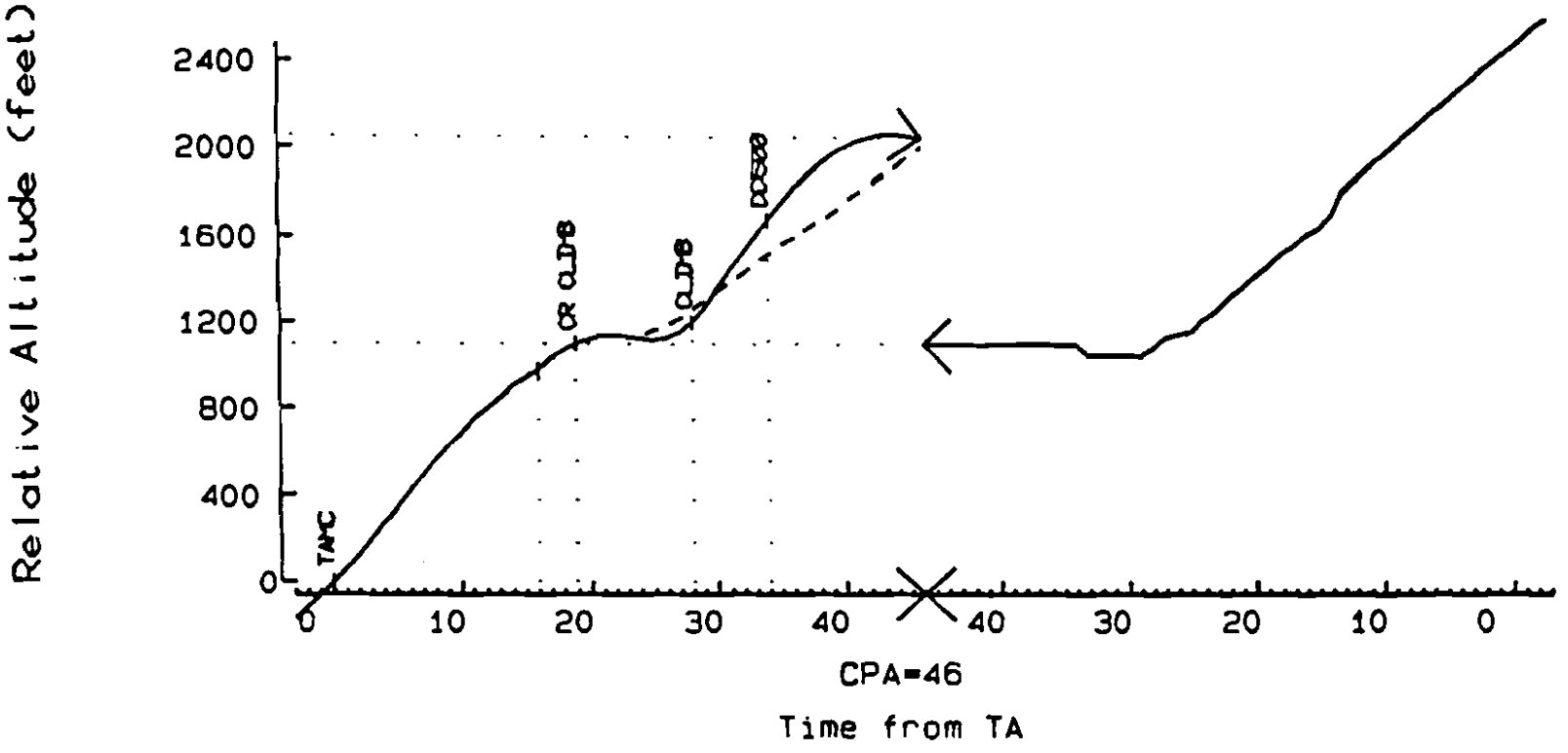
OWN ID: 10791495

RANGE RATE at TA: -597

at CPA: -311

RANGE at CPA: 874 ft

Alt. Difference with Simulated Pilot Response: 913 ft



TA TIME: 11:07:45

CPA TIME: 11:08:31

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 953 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

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>

Encounter ID 434 Filename A930923A.TRD

ENCOUNTER ID: 434

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

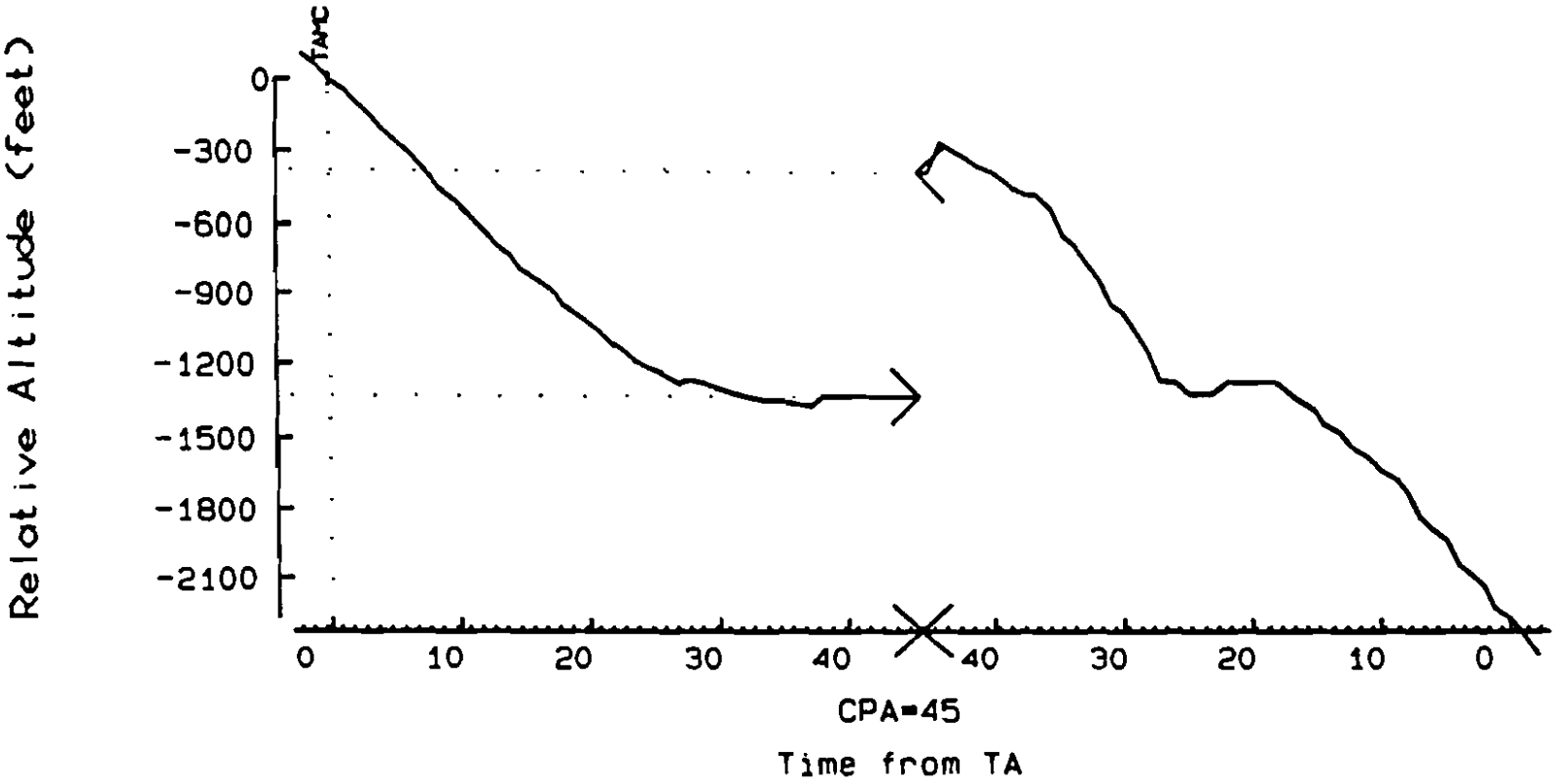
OWN ID: 10746022

RANGE RATE at TA: -591

at CPA: -324

RANGE at CPA: 297 ft

F-158



TA TIME: 11:06:40 CPA TIME: 11:07:26

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 945 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 447 Filename B930923B.TRO

ENCOUNTER ID: 447

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

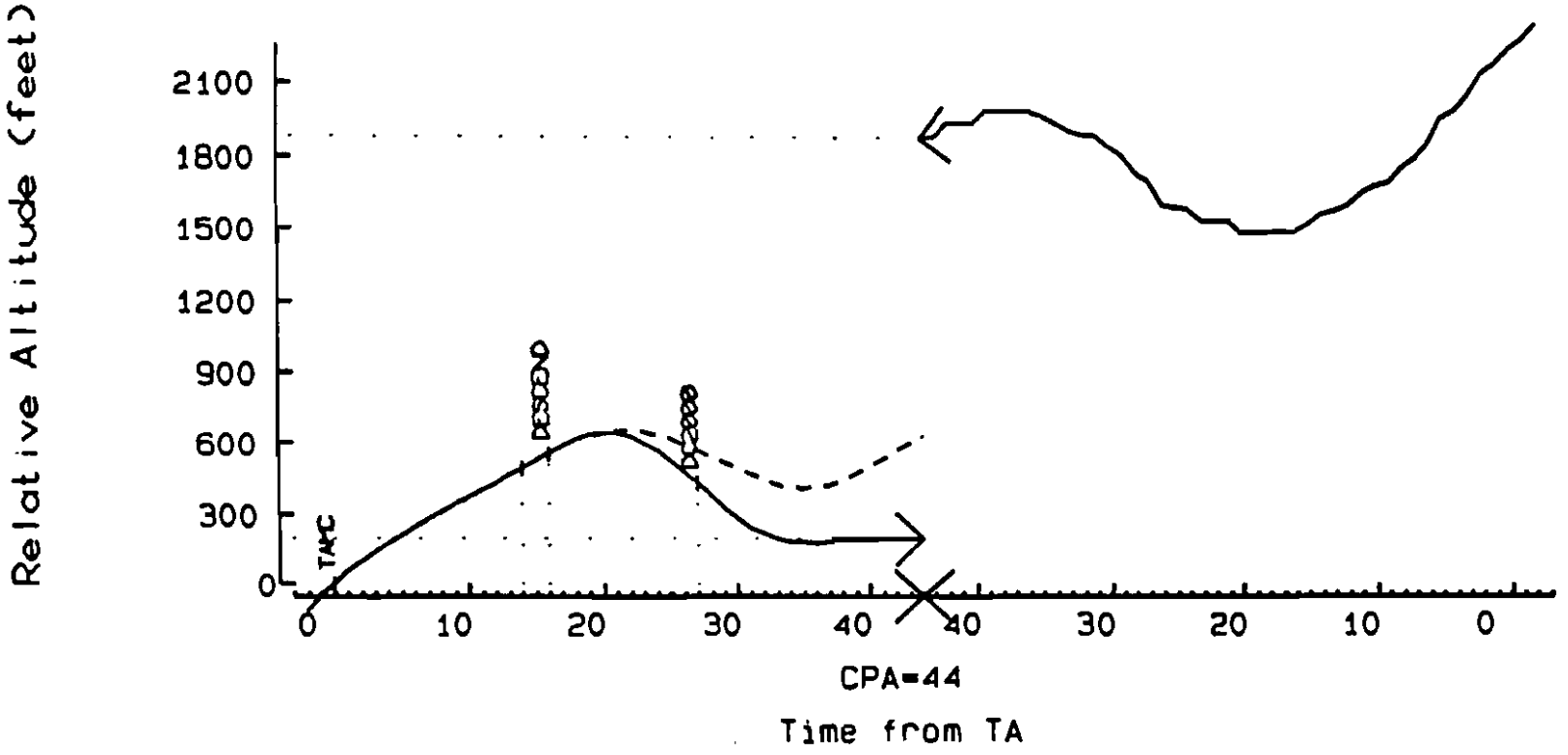
RANGE RATE at TA: -605

at CPA: -120

RANGE at CPA: 2624 ft

Alt. Difference with Simulated Pilot Response: 1250 ft

F-159



TA TIME: 11:13:44

CPA TIME: 11:14:28

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1688 ft

PROCESSED ON: 12/09/93 by ACO-320 FAA Technical Center

>

Encounter ID 534 Filename R930923A.TRD

ENCOUNTER ID: 534

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

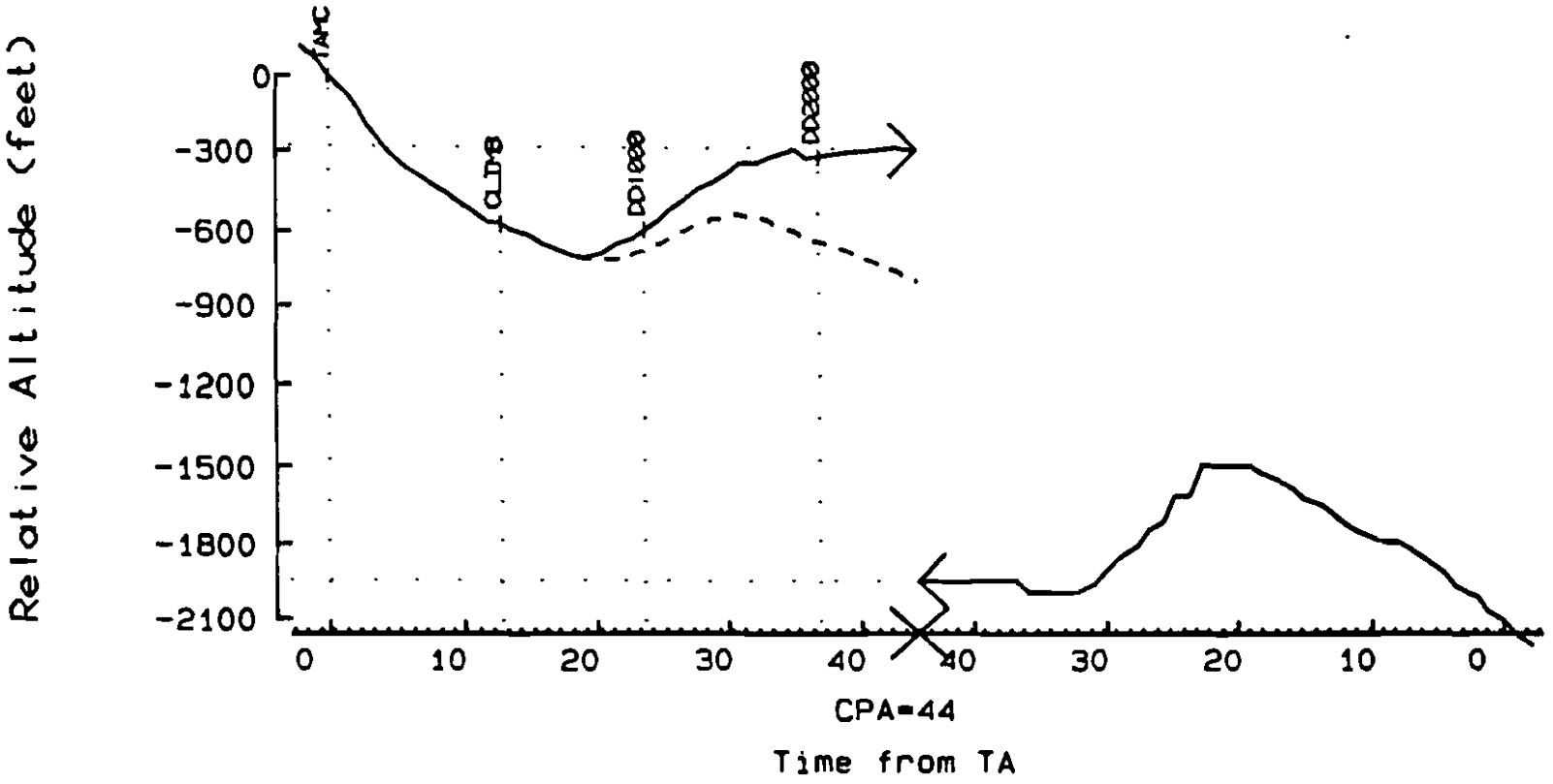
RANGE RATE at TA: -598

at CPA: -244

RANGE at CPA: 1950 ft

Alt. Difference with Simulated Pilot Response: 1146 ft

F-160



TA TIME: 11:12:39

CPA TIME: 11:13:23

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1661 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 680 Filename B9309238.TRD

ENCOUNTER ID: 680

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

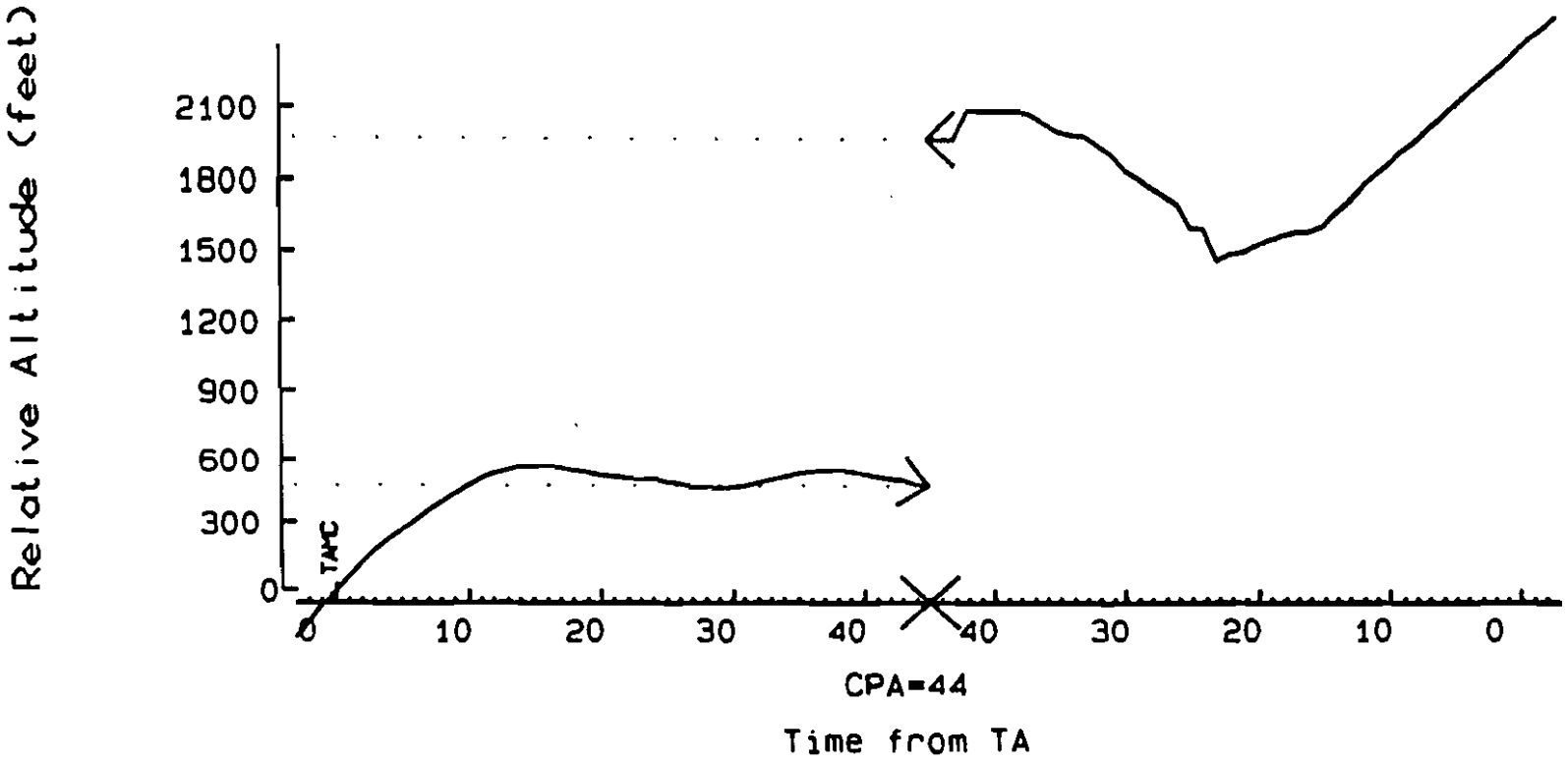
OWN ID: 10791495

RANGE RATE at TA: -599

at CPA: -130

RANGE at CPA: 3888 ft

F-161



TA TIME: 11:19:36 CPA TIME: 11:20:21

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 1498 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

Encounter ID 547 Filename R930923A.TRD

ENCOUNTER ID: 547

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

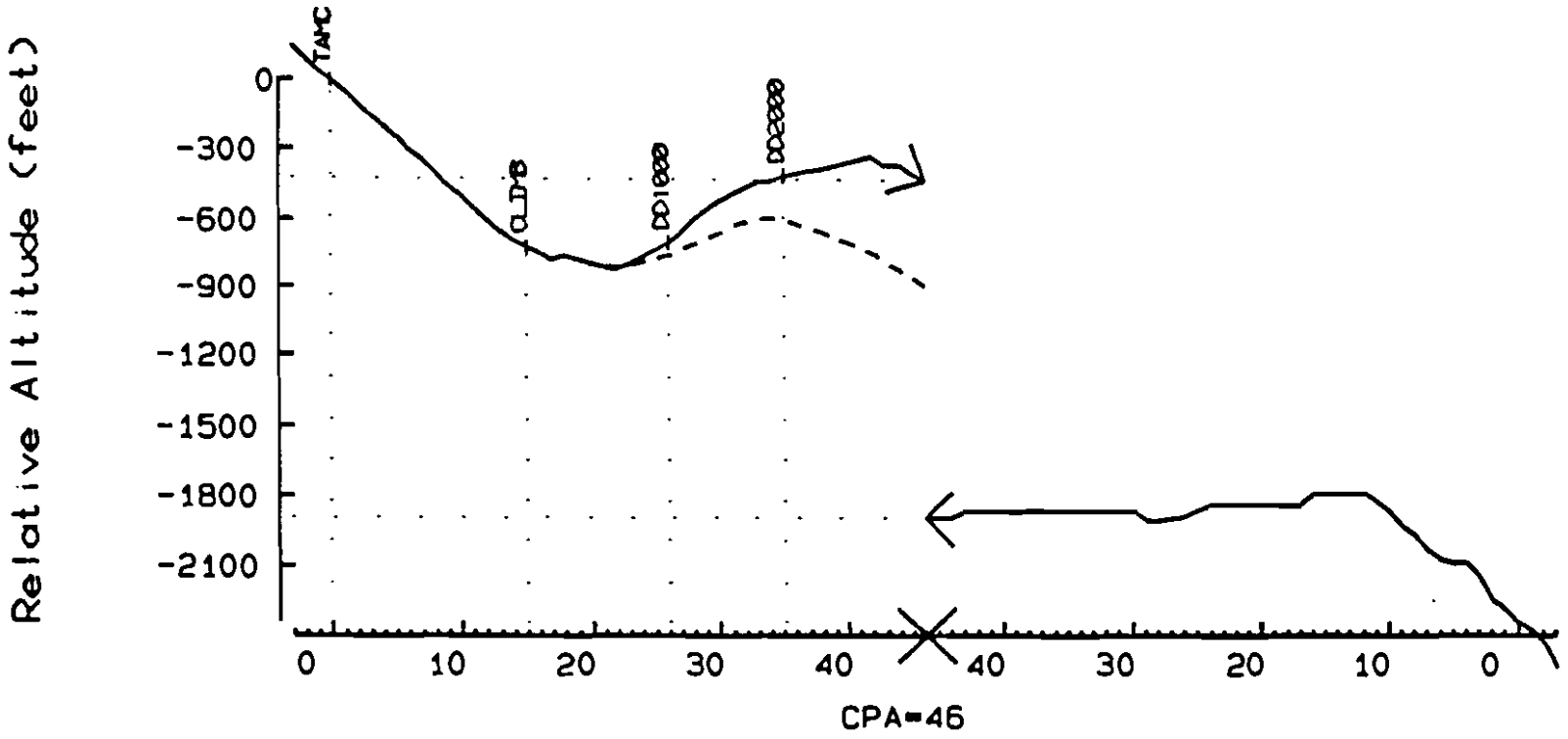
RANGE RATE at TA: -601

at CPA: -200

RANGE at CPA: 3262 ft

Alt. Difference with Simulated Pilot Response: 1008 ft

F-162



TA TIME: 11:18:30

CPA TIME: 11:19:16

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1474 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 456 Filename B930923C.TRD

ENCOUNTER ID: 456

TARGET ID: 10746022

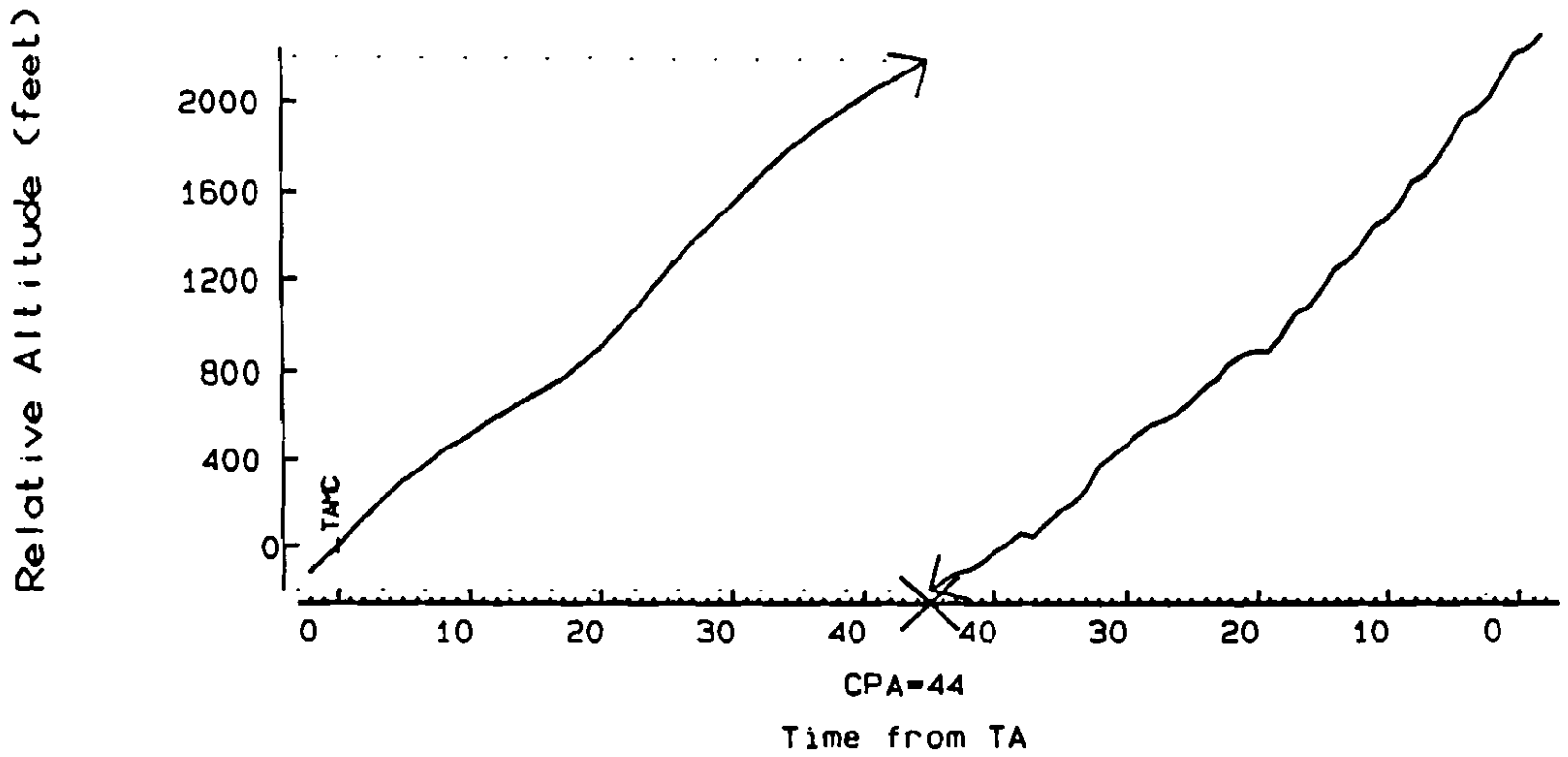
INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

RANGE RATE at TA: -595

at CPA: -51

RANGE at CPA: 3669 ft



TA TIME: 14:00:19 CPA TIME: 14:01:04

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 2420 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

Encounter ID 217 Filename R930923B.TRD

ENCOUNTER ID: 217

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

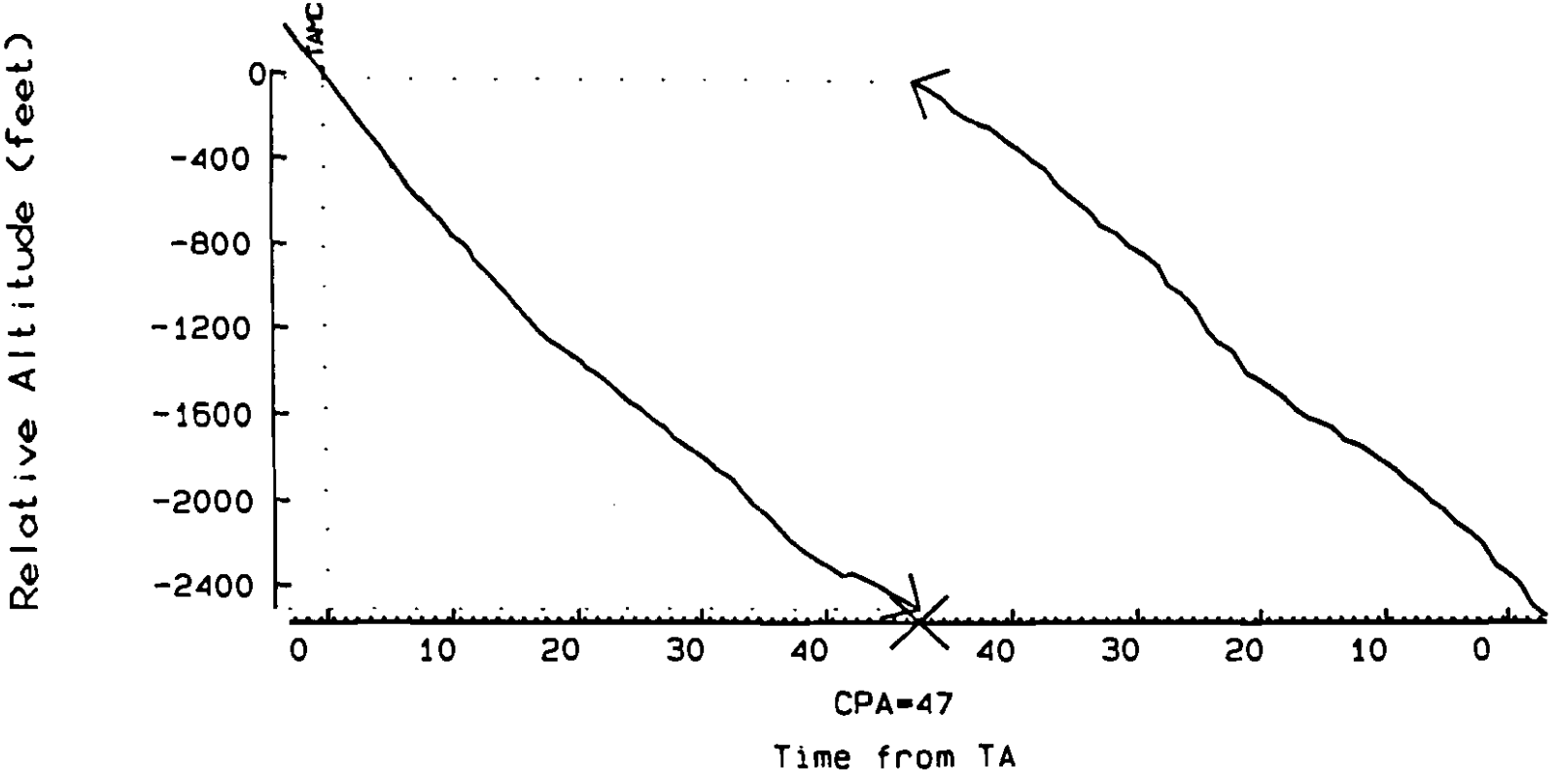
OWN ID: 10746022

RANGE RATE at TA: -603

at CPA: -171

RANGE at CPA: 3068 ft

F-164



TA TIME: 13:59:08

CPA TIME: 13:59:55

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 2492 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 649 Filename B930923C.TRD

ENCOUNTER ID: 649

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

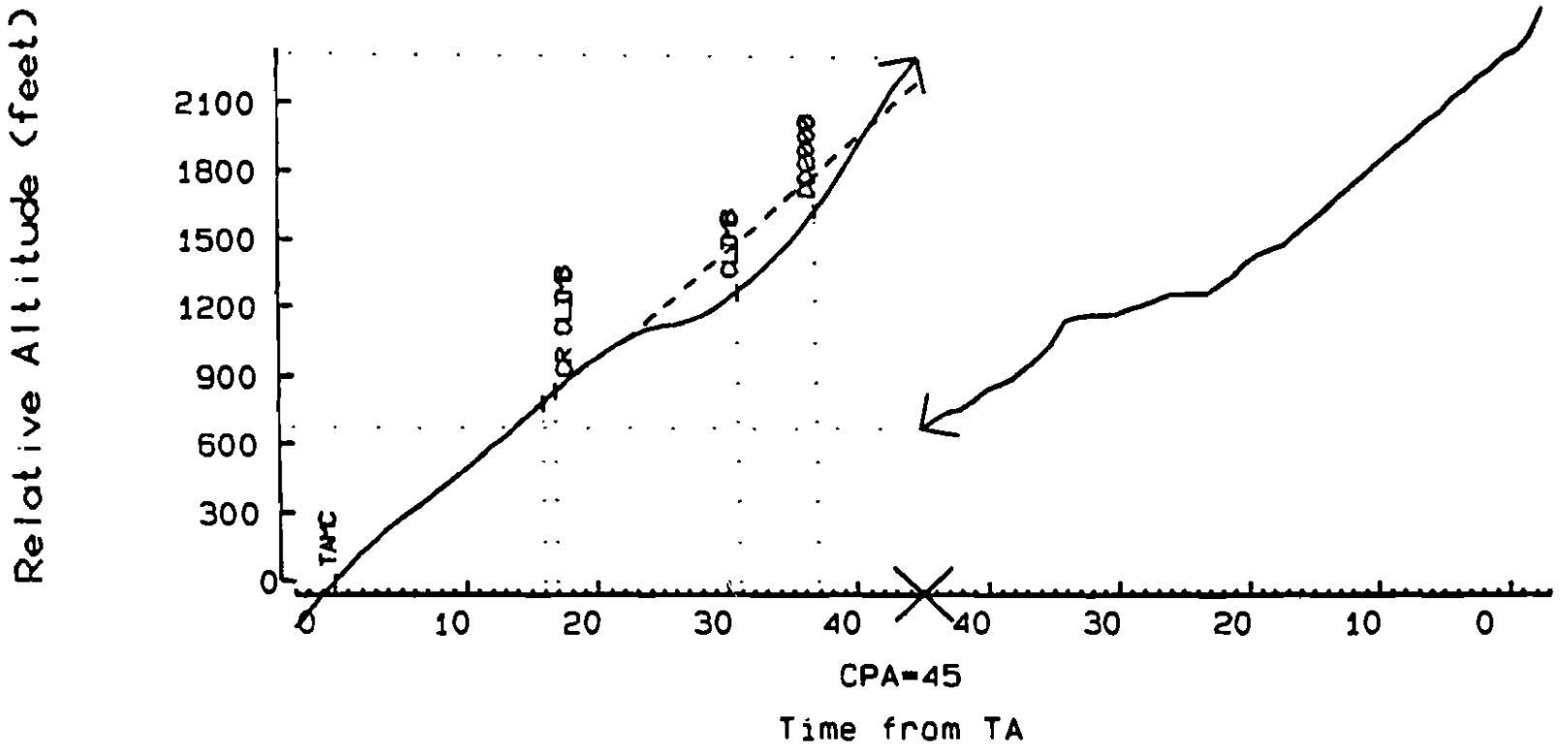
RANGE RATE at TA: -592

at CPA: -46

RANGE at CPA: 3676 ft

Alt. Difference with Simulated Pilot Response: 1520 ft

F-165



TA TIME: 14:06:37

CPA TIME: 14:07:22

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1644 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

Encounter ID 274 Filename R930923B.TRD

ENCOUNTER ID: 274

TARGET ID: 10791495

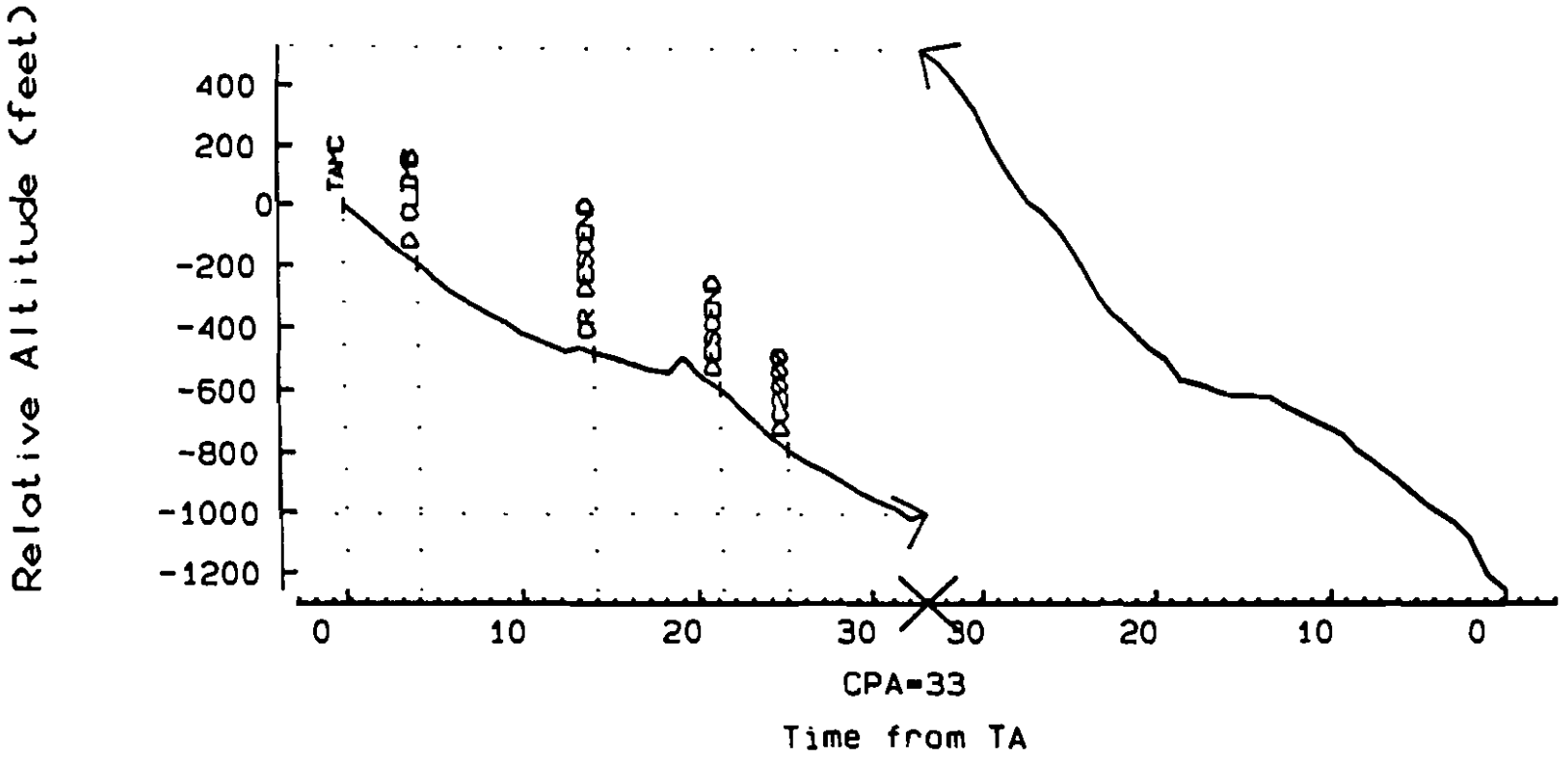
INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

RANGE RATE at TA: -500

at CPA: -269

RANGE at CPA: 3068 ft



TA TIME: 14:05:39 CPA TIME: 14:06:12

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 1537 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 895 Filename 8930923C.TRD

ENCOUNTER ID: 895

TARGET ID: 10746022

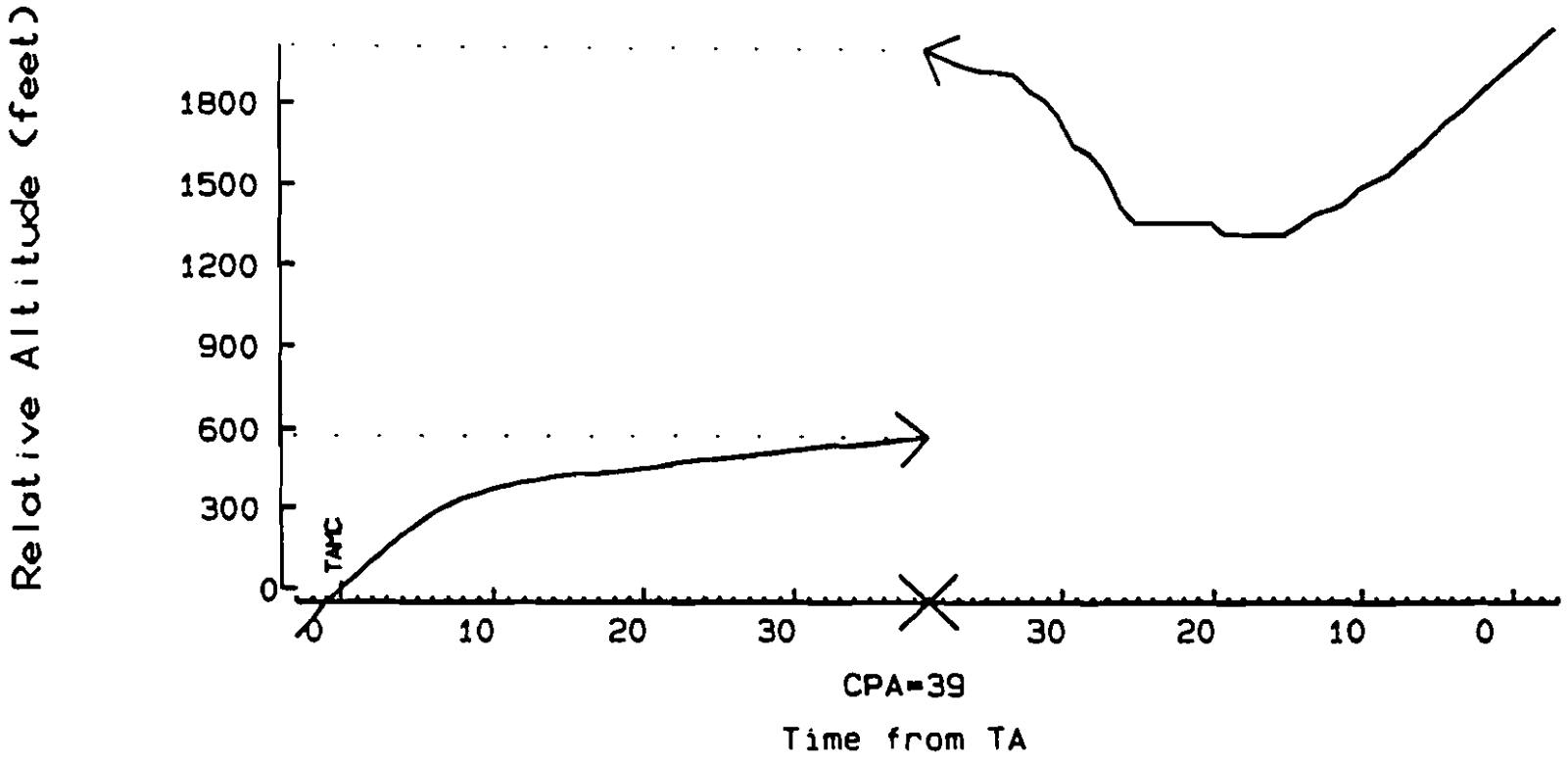
INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

RANGE RATE at TA: -570

at CPA: -63

RANGE at CPA: 16077 ft



TA TIME: 14: 12: 13 CPA TIME: 14: 12: 52

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 1439 ft

PROCESSED ON: 12/09/93 by ACO-320 FAA Technical Center

>

Encounter ID 304 Filename R9309238.TRD

ENCOUNTER ID: 304

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

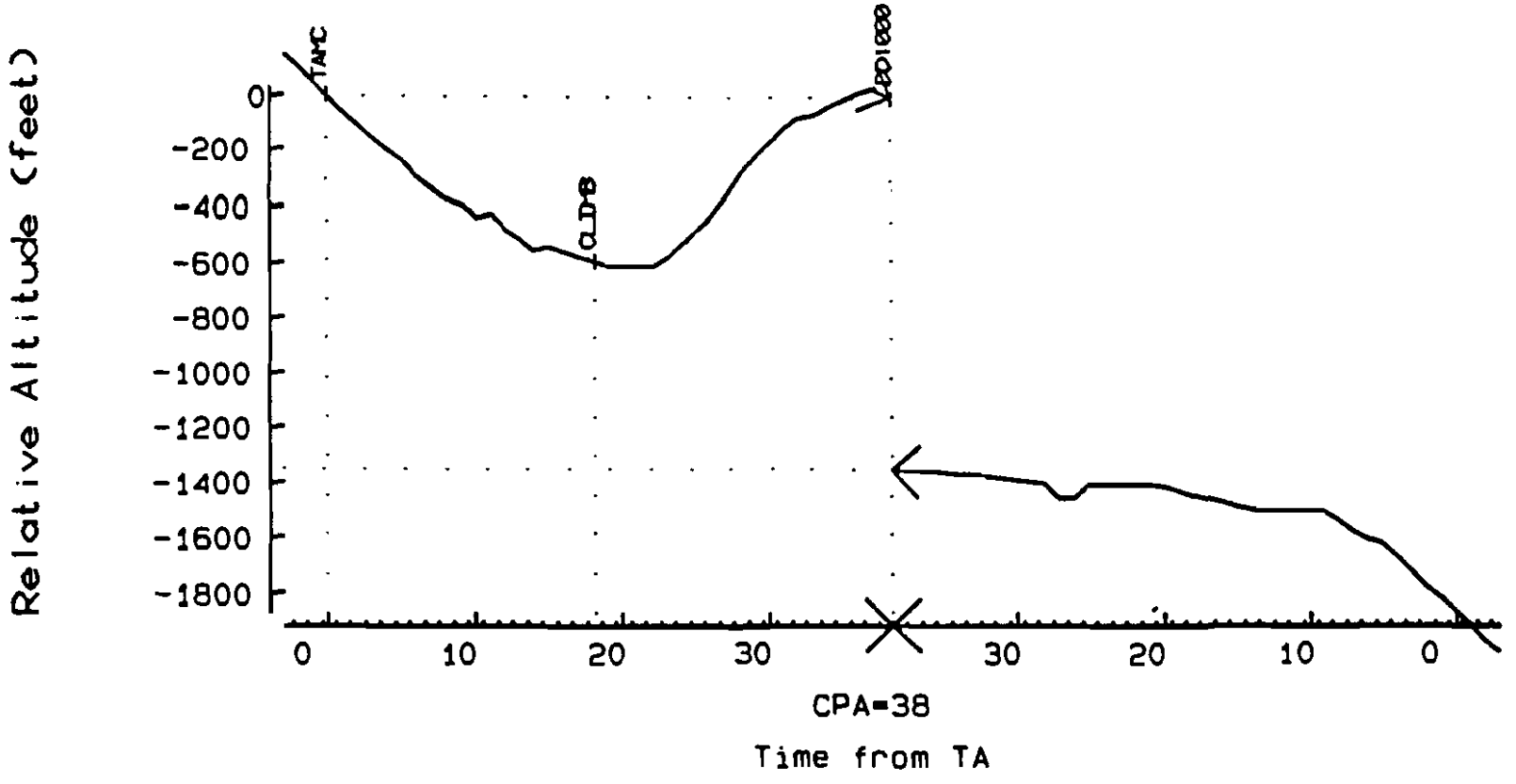
OWN ID: 10746022

RANGE RATE at TA: -550

at CPA: -90

RANGE at CPA: 15749 ft

Alt. Difference with Simulated Pilot Response: 1400 ft



TA TIME: 14:11:04

CPA TIME: 14:11:42

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1350 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

F-168

>

Encounter ID 924 Filename B930923C.TRD

ENCOUNTER ID: 924

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

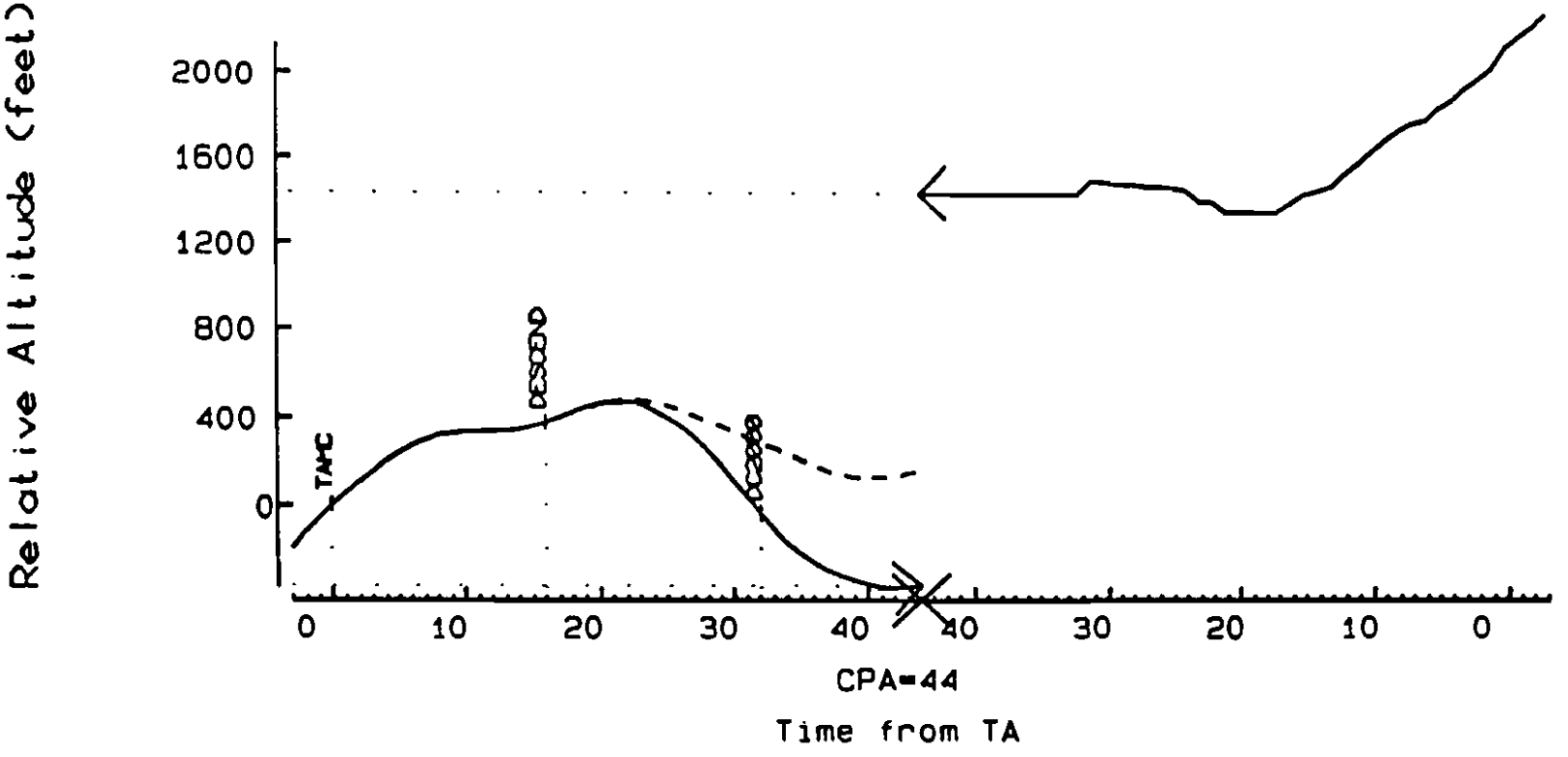
OWN ID: 10791495

RANGE RATE at TA: -592

at CPA: -144

RANGE at CPA: 3809 ft

Alt. Difference with Simulated Pilot Response: 1289 ft



TA TIME: 14: 17: 19

CPA TIME: 14: 18: 03

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1822 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

F-169

>

Encounter ID 395 Filename R9309238.TRD

ENCOUNTER ID: 395

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

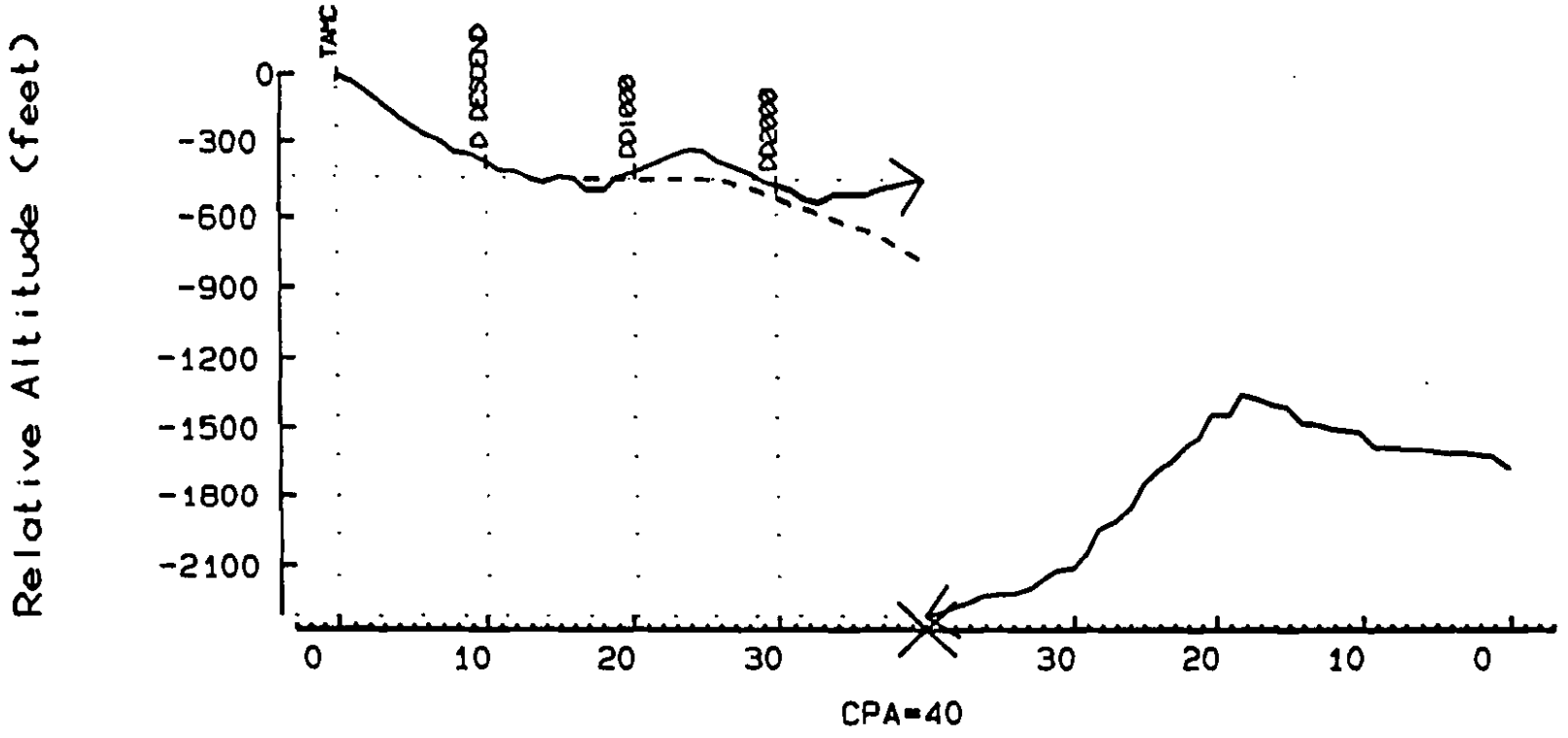
OWN ID: 10746022

RANGE RATE at TA: -581

at CPA: -288

RANGE at CPA: 3183 ft

Alt. Difference with Simulated Pilot Response: 1544 ft



TA TIME: 14: 16: 14

CPA TIME: 14: 16: 54

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1874 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

F-170

>

Encounter ID 60 Filename 89309230.TRD

ENCOUNTER ID: 60

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

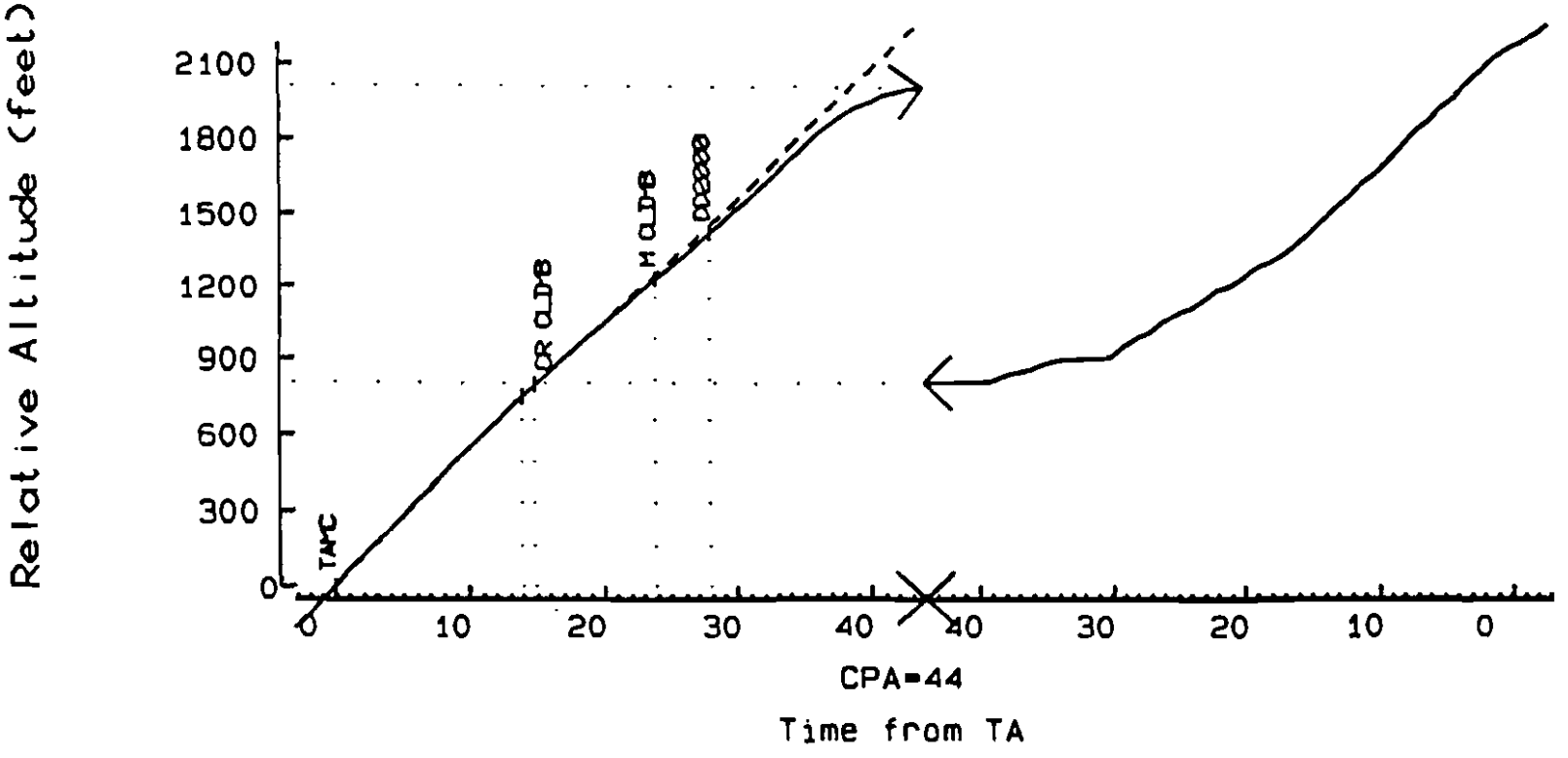
RANGE RATE at TA: -576

at CPA: -95

RANGE at CPA: 4945 ft

Alt. Difference with Simulated Pilot Response: 1477 ft

F-171



TA TIME: 14: 23: 21

CPA TIME: 14: 24: 05

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1204 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

Encounter ID 447 Filename R9309238.TRD

ENCOUNTER ID: 447

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

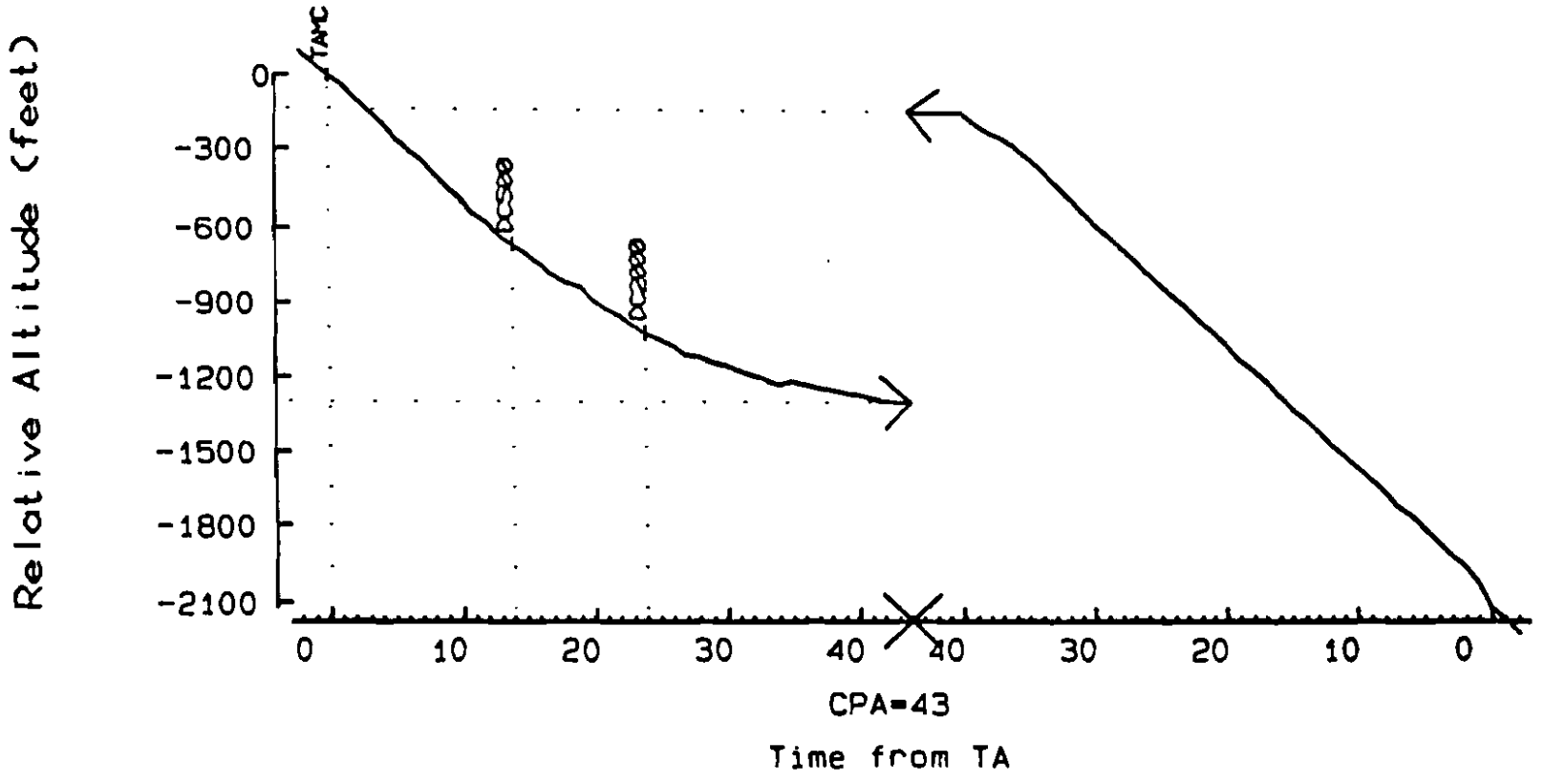
OWN ID: 10746022

RANGE RATE at TA: -563

at CPA: -213

RANGE at CPA: 4380 ft

F-172



TA TIME: 14: 22: 12 CPA TIME: 14: 22: 56

FLIGHT DATE: 09/23/93 Alt. Difference at CPA: 1156 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 134 Filename B930923D.TRD

ENCOUNTER ID: 134

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

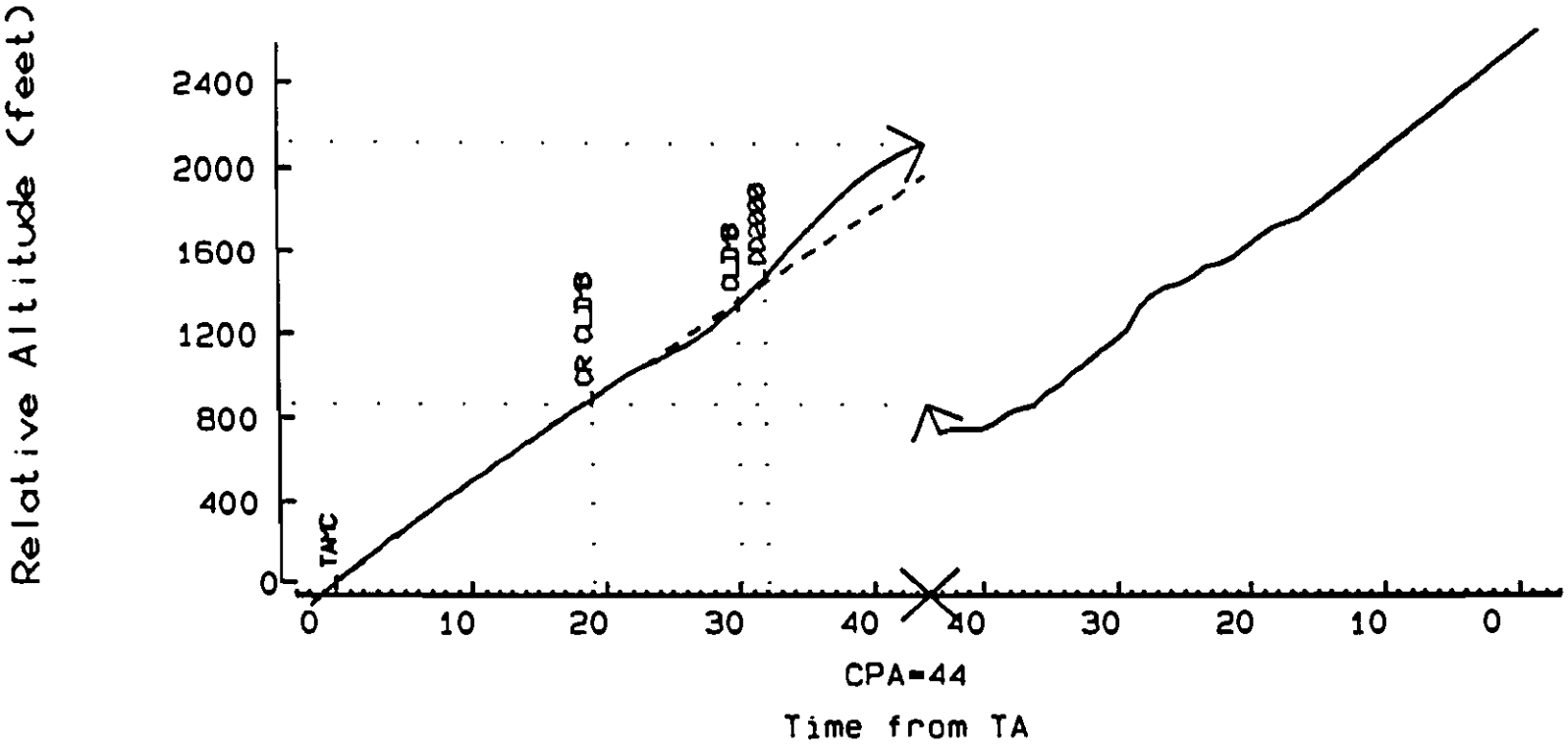
RANGE RATE at TA: -603

at CPA: -209

RANGE at CPA: 1889 ft

Alt. Difference with Simulated Pilot Response: 1109 ft

F-173



TA TIME: 14: 29: 21

CPA TIME: 14: 30: 05

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1250 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

Encounter ID 535 Filename R9309238.TRD

ENCOUNTER ID: 535

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

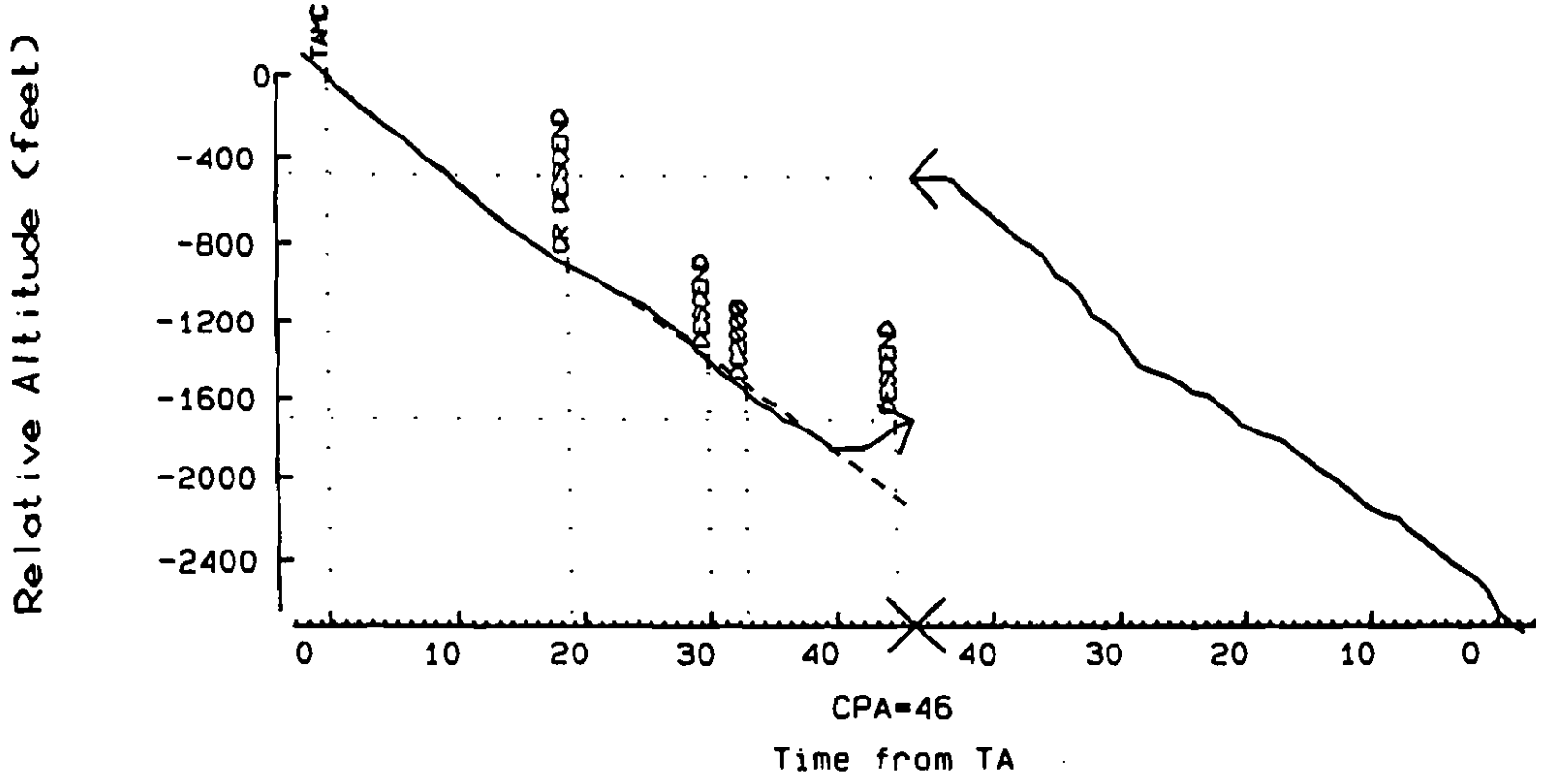
RANGE RATE at TA: -602

at CPA: -267

RANGE at CPA: 1196 ft

Alt. Difference with Simulated Pilot Response: 1683 ft

F-174



TA TIME: 14:28:11

CPA TIME: 14:28:57

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1220 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 346 Filename 89309230.TRD

ENCOUNTER ID: 346

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

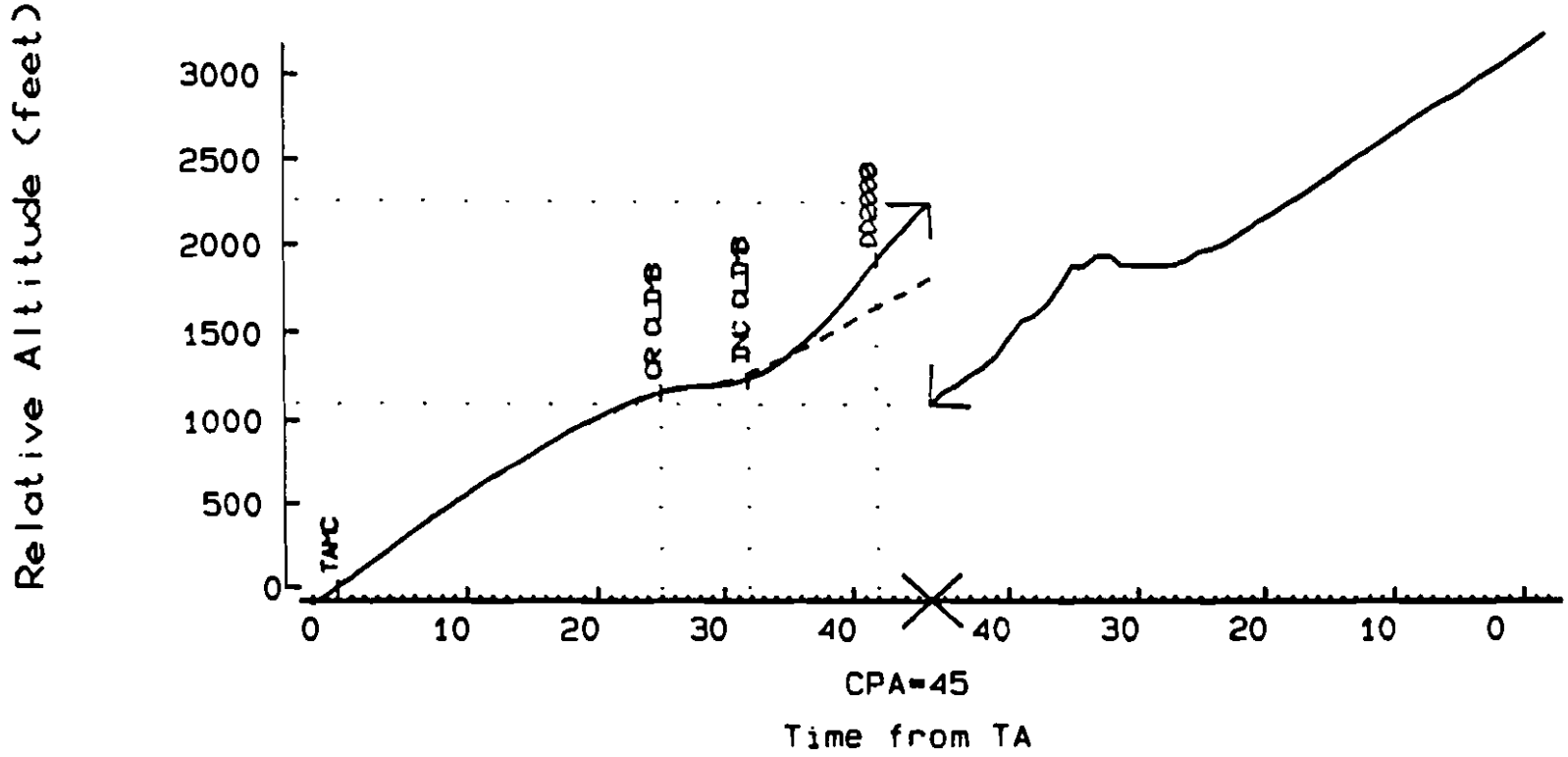
OWN IO: 10791495

RANGE RATE at TA: -599

at CPA: -72

RANGE at CPA: 6094 ft

Alt. Difference with Simulated Pilot Response: 713 ft



TA TIME: 14:34:51

CPA TIME: 14:35:37

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1169 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

Encounter ID 622 Filename R9309238.TRD

ENCOUNTER ID: 622

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

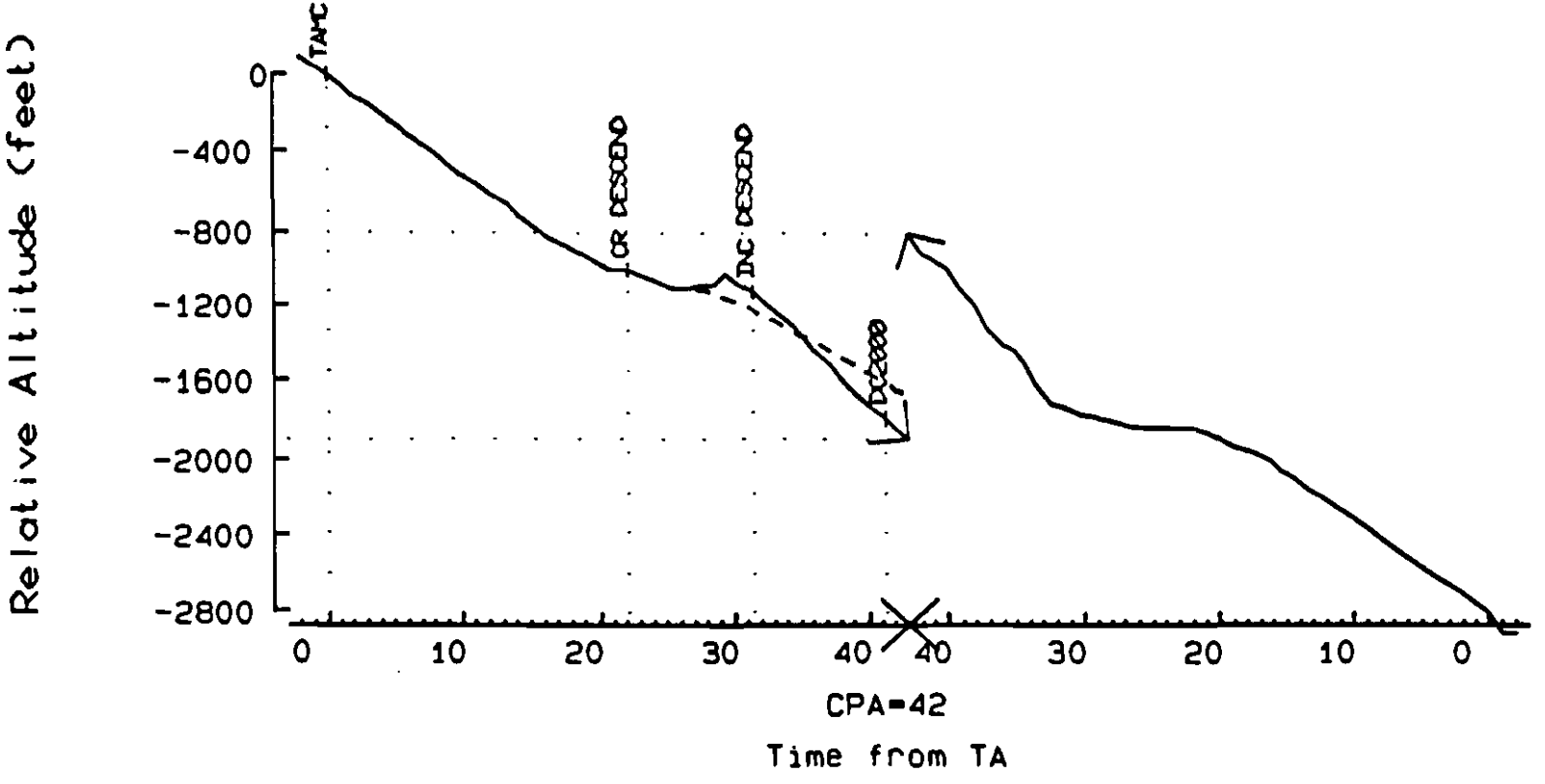
OWN ID: 10746022

RANGE RATE at TA: -577

at CPA: -220

RANGE at CPA: 5565 ft

Alt. Difference with Simulated Pilot Response: 881 ft



TA TIME: 14: 33: 45

CPA TIME: 14: 34: 28

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1090 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

F-176

>

Encounter ID 437 Filename B9309230.TRD

ENCOUNTER ID: 437

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10791495

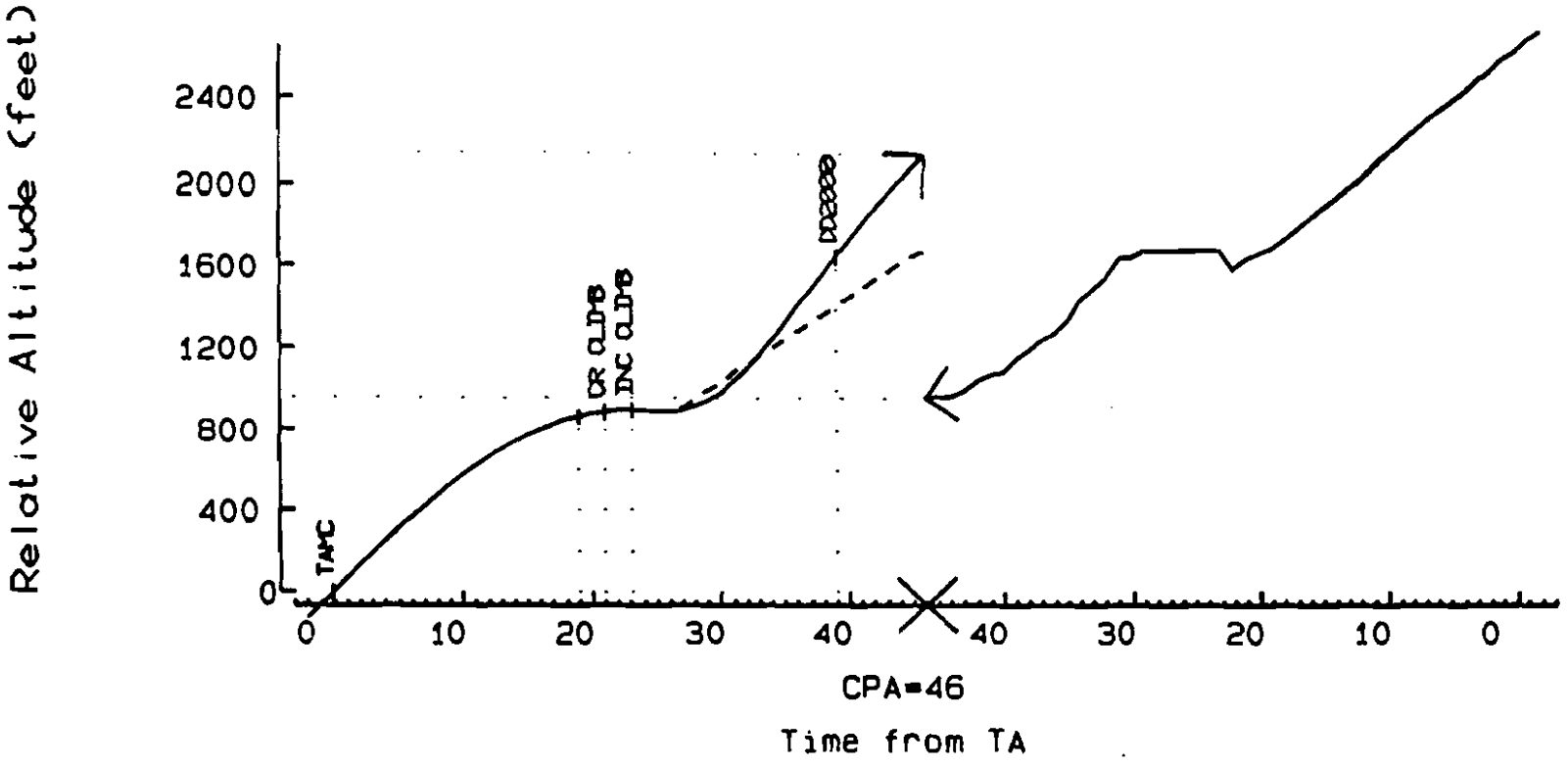
RANGE RATE at TA: -602

at CPA: -75

RANGE at CPA: 3038 ft

Alt. Difference with Simulated Pilot Response: 728 ft

F-177



TA TIME: 14: 40: 46

CPA TIME: 14: 41: 32

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1183 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

Encounter ID 723 Filename R9309238.TRD

ENCOUNTER ID: 723

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

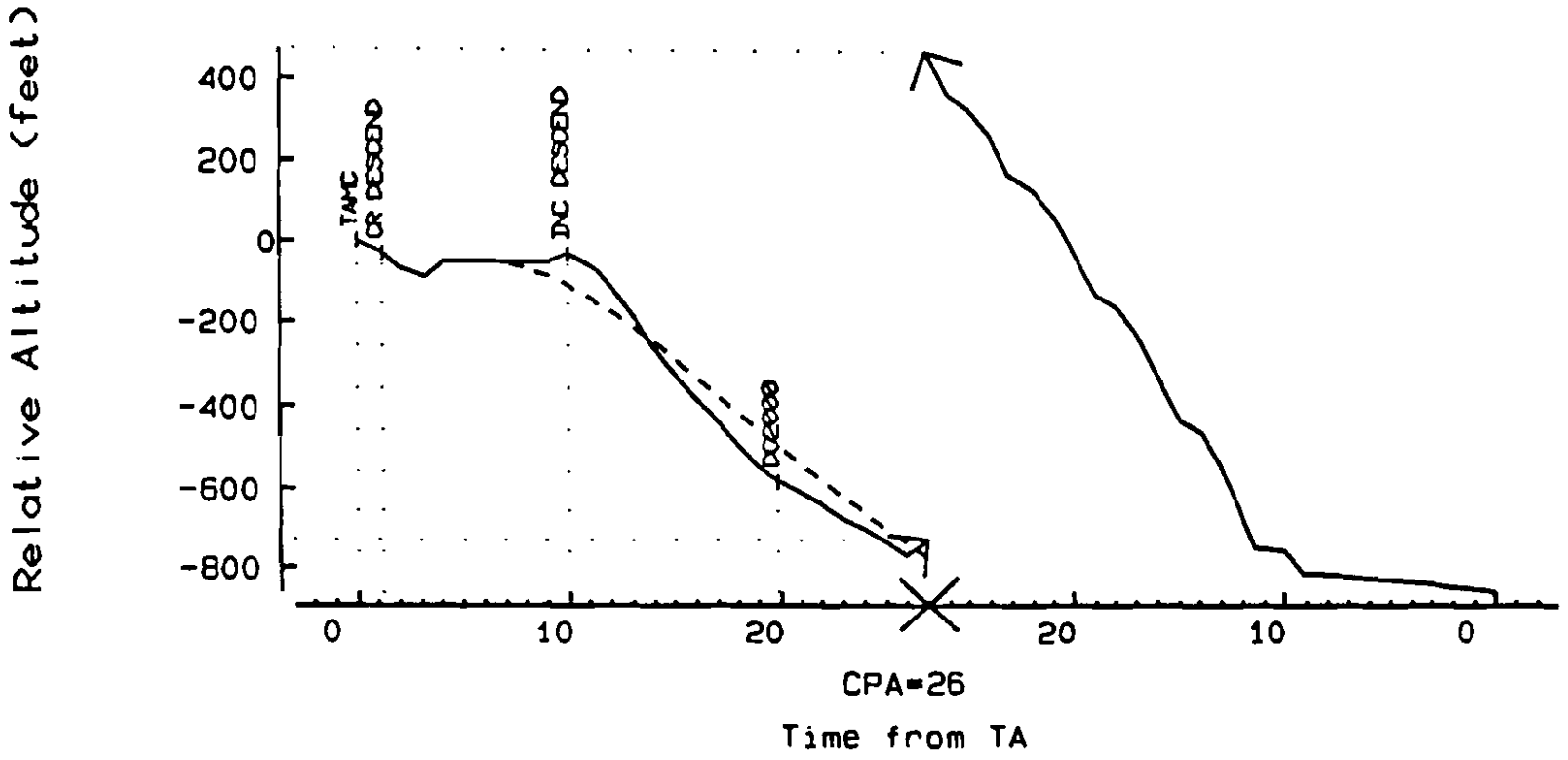
RANGE RATE at TA: -581

at CPA: -287

RANGE at CPA: 2387 ft

Alt. Difference with Simulated Pilot Response: 1245 ft

F-178



TA TIME: 14: 39: 56

CPA TIME: 14: 40: 23

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 1201 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

>

Encounter ID 616 Filename B930923D.TRD

ENCOUNTER ID: 616

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

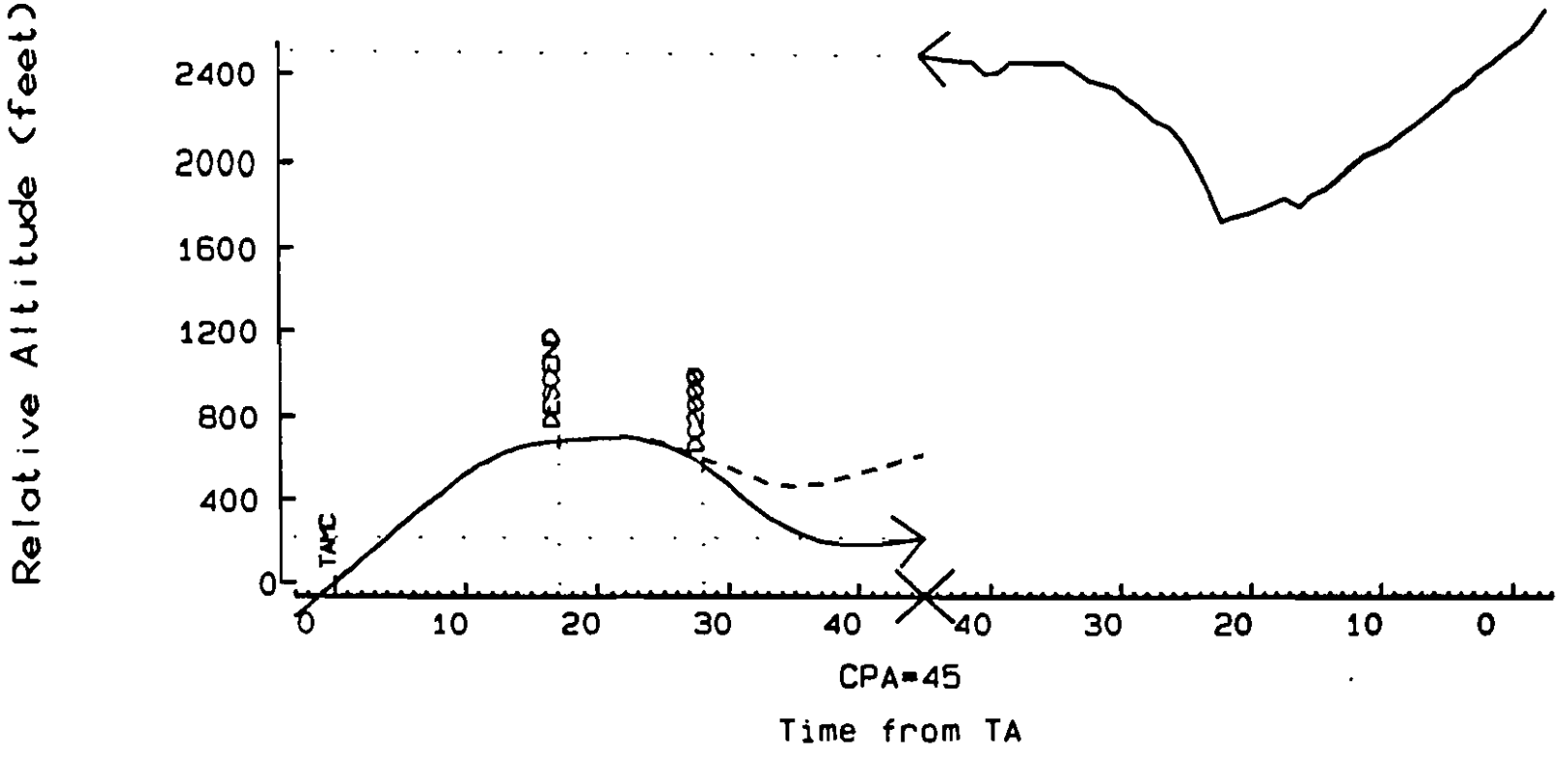
OWN ID: 10791495

RANGE RATE at TA: -604

at CPA: -87

RANGE at CPA: 3092 ft

Alt. Difference with Simulated Pilot Response: 1880 ft



TA TIME: 14:46:28

CPA TIME: 14:47:13

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 2281 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

Encounter ID 743 Filename R9309238.TRO

ENCOUNTER ID: 743

TARGET ID: 10791495

INTRUDER EQUIPAGE: TCAS II

OWN ID: 10746022

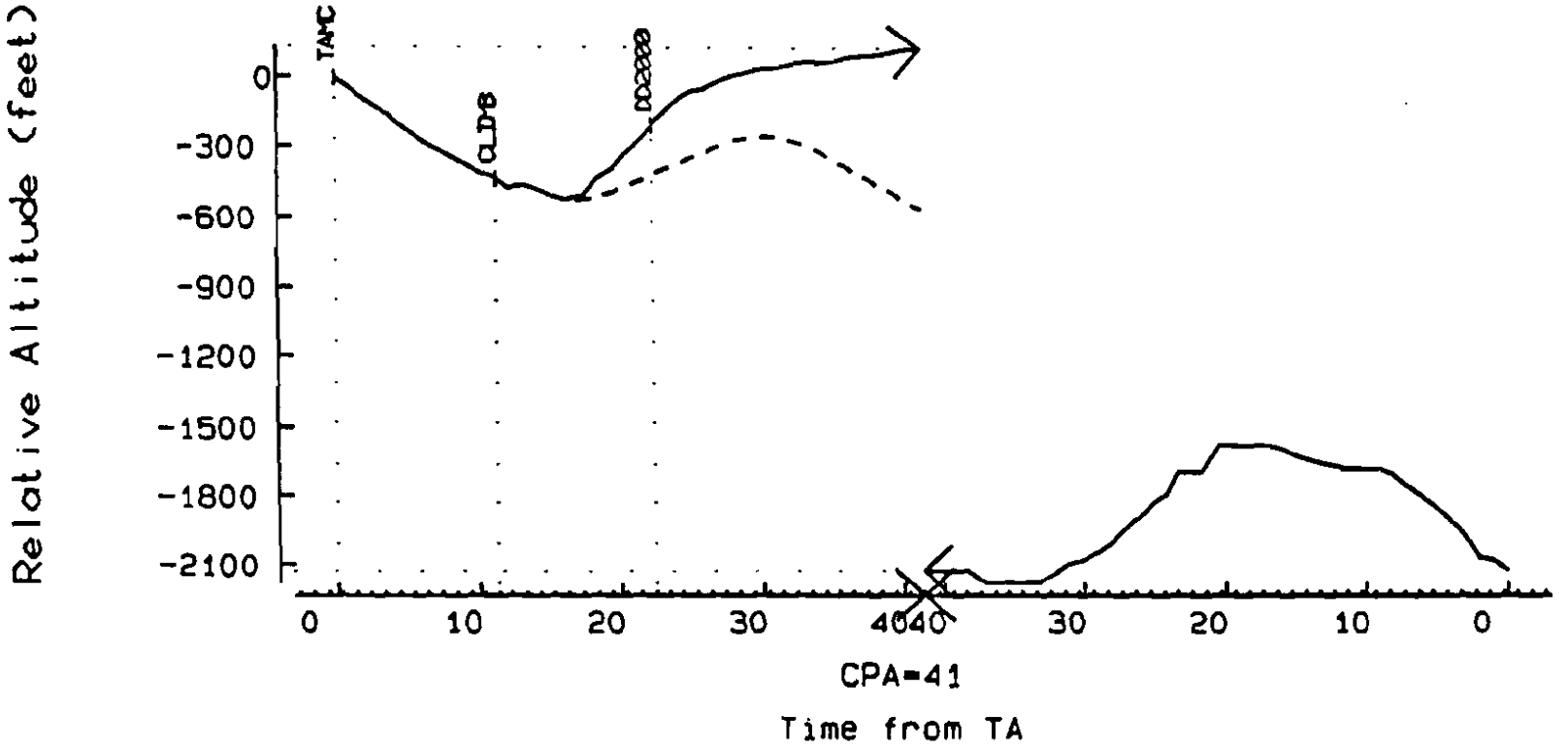
RANGE RATE at TA: -582

at CPA: -296

RANGE at CPA: 2527 ft

Alt. Difference with Simulated Pilot Response: 1571 ft

F-180



TA TIME: 14:45:23

CPA TIME: 14:46:04

FLIGHT DATE: 09/23/93

Alt. Difference at CPA: 2264 ft

PROCESSED ON: 12/13/93 by ACD-320 FAA Technical Center

Encounter ID 3 Filename B9309208.TRD

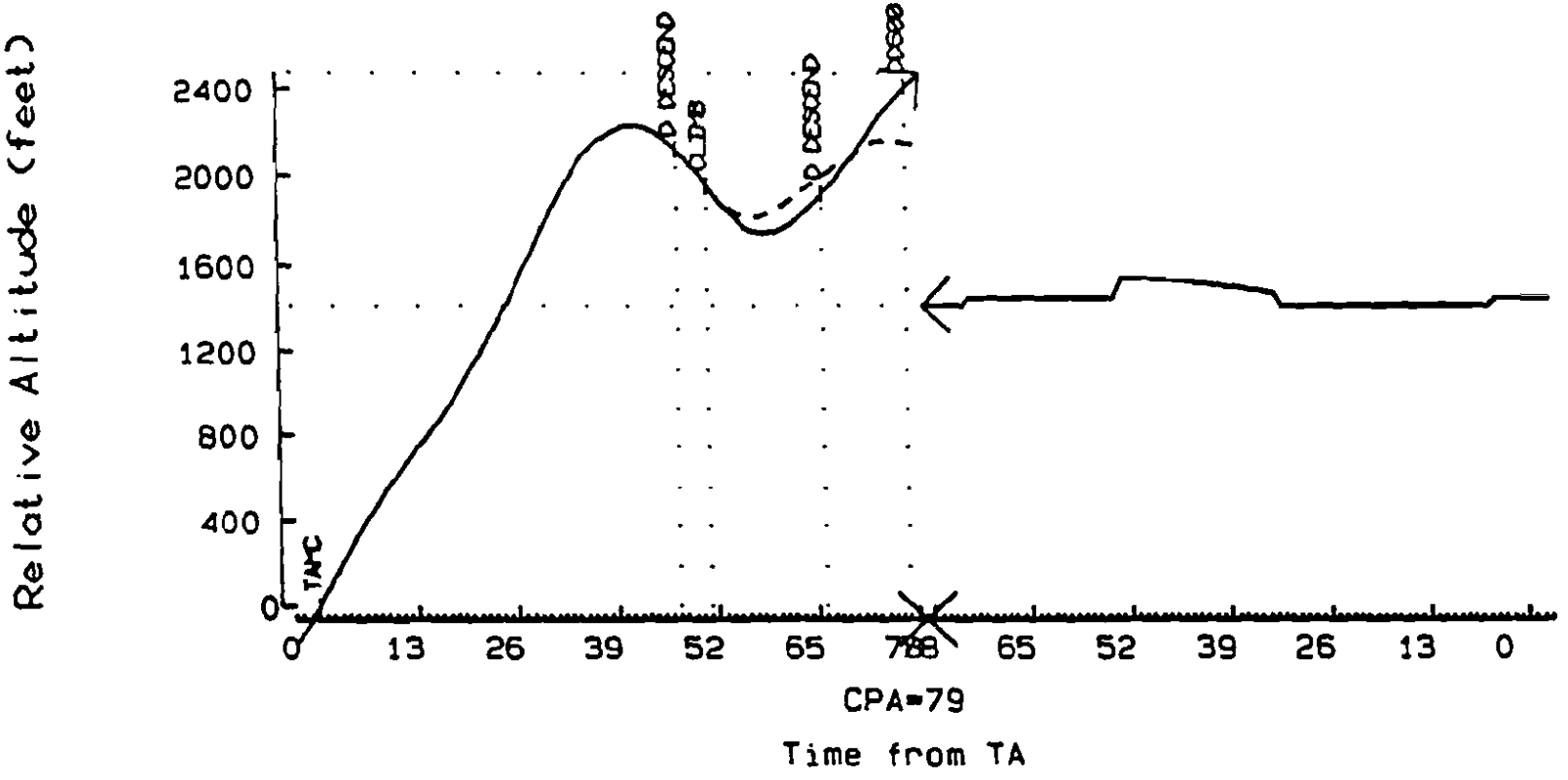
ENCOUNTER ID: 3 RANGE RATE at TA: -105

TARGET ID: -1 at CPA: -306

INTRUDER EQUIPAGE: ATCRBS RANGE at CPA: 3542 ft

OWN ID: 10791495 Alt. Difference with Simulated Pilot Response: 731 ft

F-181



TA TIME: 14: 43: 01 CPA TIME: 14: 44: 20

FLIGHT DATE: 09/20/93 Alt. Difference at CPA: 1065 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

>

Encounter ID 302 Filename B9309210.TRD

ENCOUNTER ID: 302

TARGET ID: 10746022

INTRUDER EQUIPAGE: TCAS II

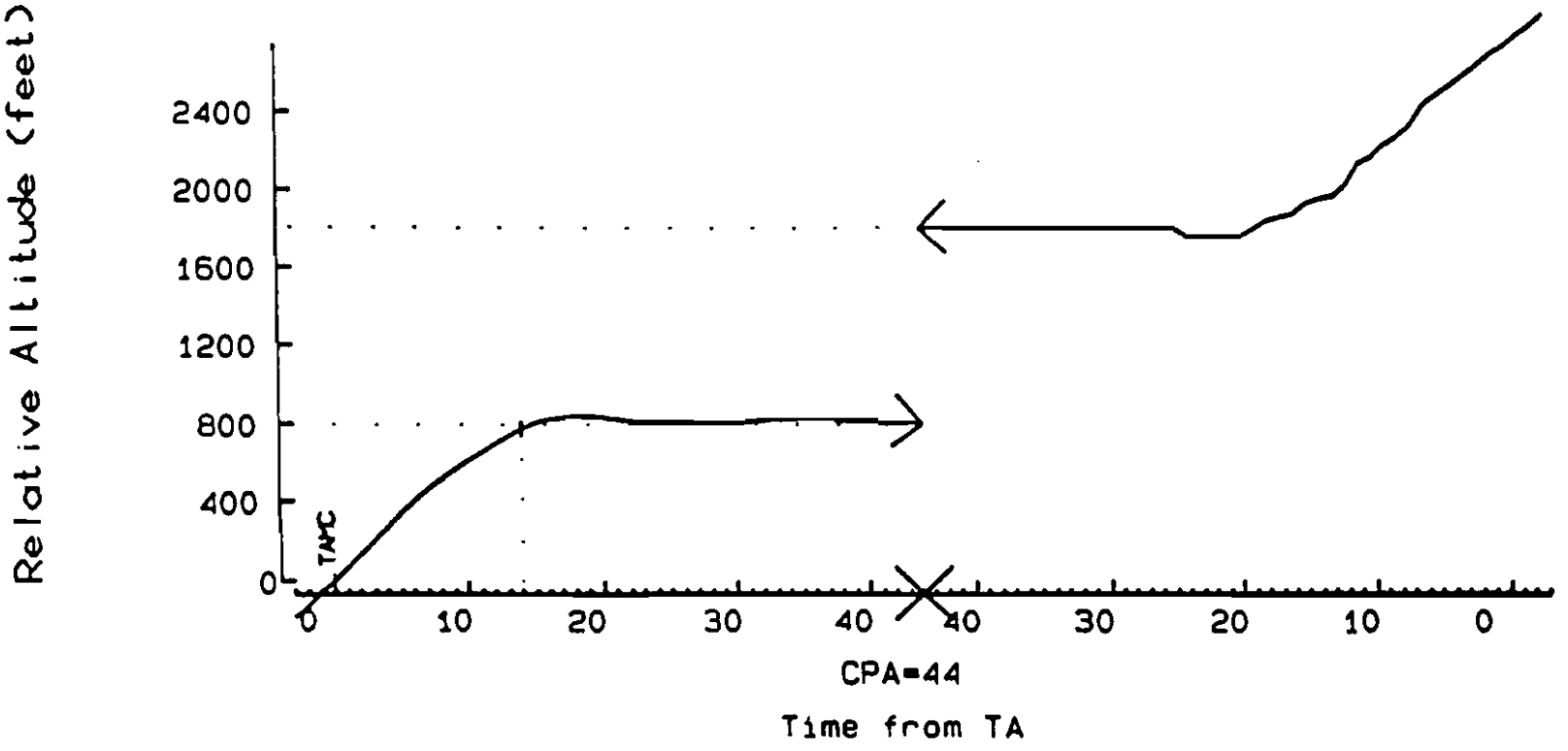
OWN ID: 10791495

RANGE RATE at TA: -500

at CPA: -203

RANGE at CPA: 1579 ft

F-182



TA TIME: 15: 03: 54

CPA TIME: 15: 04: 38

FLIGHT DATE: 09/21/93

Alt. Difference at CPA: 1010 ft

PROCESSED ON: 12/09/93 by ACD-320 FAA Technical Center

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APPENDIX G

Analysis of Unplanned Crossing Encounters

This appendix is an edited version of a memo on this topic written by Kathryn Ciaramella.

G.1 ANALYSIS OF UNPLANNED CROSSING ENCOUNTERS

The V6.04A flight demonstration consisted of four different geometry setups. Run 1 had the two aircraft with opposite and equal vertical rates with no level-off planned. Run 2 had the two aircraft with opposite and equal vertical rates with a co-altitude level-off planned. Run 3 had the two aircraft with opposite and equal vertical rates with an 800 foot level-off planned. Run 4 had the two aircraft with opposite and equal vertical rates with a 1000 foot level-off planned. Had the encounters been executed exactly as planned, Runs 1 and 2 were expected to generate crossing advisories, while Runs 3 and 4 were expected to generate non-crossing advisories. Due to variations in the encounter geometry, the actual flights consisted of the following crossing and non-crossing advisories:

RUN 1: 22 times 17 cross; 5 non-cross
RUN 2: 21 times 18 cross; 3 non-cross
RUN 3: 23 times 6 cross; 17 non-cross
RUN 4: 21 times 2 cross; 19 non-cross

The widespread belief in the TCAS community was that v6.04a of the TCAS II logic would eliminate crossing advisories, whereas in actuality, it further biased against them. As such, the participating pilots were concerned with the nine occurrences of crossing RAs in runs 3 and 4. These nine runs were analyzed. The recorded data from both aircraft was examined for each of the runs to see:

- which aircraft selected the RA
- if the RA was deferred; Was it due to firmness or defer display
- what was the RA trigger
- if V6.04A was tested
- the vertical rates of each aircraft at the time of RA selection
- why a crossing RA was selected
- the relative time each aircraft received an RA
- if it was possible to have the perception that the crossing RA was chosen after the level off was complete

For all 9 cases the V6.04A logic was exercised. The crossing RAs were delayed until the relative altitude was less than 850 feet even though the range and altitude tests were satisfied. The aircraft issued RAs within 1 second of each other. Of the 18 crossing RAs there were 16 MAINTAIN rate RAs.

G.1.1 ANALYSIS OF RUN 4

There were 2 out of 26 runs that produced a crossing RA.

9/14/93 14:44 (Plots F-41 and F-42) The high id TCAS selected the crossing RA with OWN tracked vertical rate = 2579 fpm and INTRUDER tracked vertical rate = -2819 fpm and then deferred display for 2 seconds. Thus, at the time of RA selection, both planes had significant tracked vertical rates. When the high id issued its MAINTAIN rate RA, OWN tracked vertical rate = 1970 fpm and INTRUDER tracked vertical rate = -1260 fpm. When the low id issued its MAINTAIN rate RA,

it's OWN tracked vertical rate = -1608 fpm and INTRUDER tracked vertical rate = 3000 fpm. The RAs were not issued until the planes were less than 800 ft apart vertically. (The high id aircraft overshot the planned level-off altitude by 200 ft.)

Several things about this encounter may have made it appear to the pilot of the high id aircraft that the INTRUDER had leveled off. The INTRUDER had significantly slackened its vertical rate at the time of the RA issue, as the tracked vertical rate was -1260 fpm. It's possible that, due to tracker and pilot response delays, this rate was even lower. Nevertheless, both planes still tracked significant vertical rates when the RAs were issued.

9/23/93 10:43 (Plots F-151 and F-152) In the second case, the high id TCAS selected the crossing CLIMB RA when OWN tracked vertical rate = 738 fpm and INTRUDER tracked vertical rate = -2606 fpm. It then deferred display for 1 second. When the high id issued its RA, OWN tracked vertical rate = 650 fpm and INTRUDER tracked vertical rate = -2606 fpm. When the low id issued its MAINTAIN rate RA, it's OWN tracked vertical rate = -2893 fpm and INTRUDER tracked vertical rate = 0 fpm.

In this case, the high id aircraft was at its planned level-off altitude and nearing level (tracked vertical rate = 738 fpm. The pseudocode defines level as less than 600 fpm) when the RA was selected. When the low id issued its crossing RA the intruder was tracked as level. The crossing RA was necessary because of the coordinated RA received from the other aircraft. The low id (descending) aircraft overshot its planned level-off altitude by 200 feet, bringing the aircraft closer than the planned 1000 feet separation and causing the crossing RA.

G.1.2 ANALYSIS OF RUN 3

There were 7 out of 22 runs that produced a crossing RA.

In 4 cases, the TCAS selected the crossing RA when OWN tracked vertical rate > 2200 fpm and INTRUDER tracked vertical rate > 2500 fpm. At the time the RA was issued neither level-off was complete. These runs are:

9/15/93 9:50 Plots F-45 and F-46
9/21/93 10:55 Plots F-91 and F-92
9/21/93 14:30 Plots F-107 and F-108
9/21/93 14:56 Plots F-115 and F-116

9/20/93 14:35 (Plots F-79 and F-80) In this case, the high id TCAS selected the crossing MAINTAIN rate RA when OWN tracked vertical rate = 2272 fpm and INTRUDER tracked vertical rate = -2826 fpm. It then deferred display for 1 second. When the high id issued its RA, OWN tracked vertical rate = 2205 fpm and INTRUDER tracked vertical rate = -2836 fpm. When the low id issued its MAINTAIN rate RA, OWN vertical rate = -1639 fpm and INTRUDER vertical rate = 2857 fpm. Both aircraft had significant tracked vertical rates when the RAs were issued.

9/23/94 14:39 (Plots F-177 and F-178) In this case, the high id TCAS selected the crossing RA when OWN tracked vertical rate = 1588 fpm and INTRUDER tracked vertical rate = -2903 fpm. It then deferred display for 2 seconds. At the time of RA selection, the intruder's level-off was not detected. When the high id issued its CLIMB RA, OWN tracked vertical rate = 1145 fpm and INTRUDER tracked vertical rate = -2788 fpm. When the low id issued its MAINTAIN rate RA, OWN tracked vertical rate = -2146 fpm and INTRUDER tracked vertical rate = 432 fpm (level).

The high id TCAS selected the crossing RA when both aircraft had reached their level-off altitudes but the intruder still had a tracked vertical rate = -2903 fpm, which was held for an additional 4 seconds. TCAS selected a crossing RA against a non-level threat. From the low id TCAS perspective, the selecting aircraft has leveled-off (vertical rate 432 fpm), but, due to RA coordination, must issue a complimentary crossing RA.

9/23/93 14:33 (Plots F-175 and F-176) In this case, the low id TCAS selected and issued the crossing RA when OWN tracked vertical rate = -2120 fpm and INTRUDER tracked vertical rate = 2857 fpm. At the time of RA selection, no level-offs were detected. When the high id TCAS issued its RA, OWN tracked vertical rate = 1795 fpm and INTRUDER tracked vertical rate = -2864 fpm.

G.2 CONCLUSIONS

This data supports V6.04A is operating as designed. In flight, it is nearly impossible to set up each encounter with the accuracy required to exactly re-create the results from the simulations of runs 1-4.

There is evidence that pilot perceptions of crossing RAs being issued after the intruder aircraft had leveled-off were correct in 3 encounters. When the RA is selected by the high Mode S id TCAS, and there is a subsequent RA deferral period of up to 2 seconds, the vertical rates used to select the RA sense may be significantly reduced by the time the RA is issued for either aircraft. In three of these analyzed encounters, the non-selecting, low Mode S id, descending aircraft issue its crossing RA when the intruder aircraft was near level.