



Canadian Aviation
Safety Board

Bureau canadien
de la sécurité aérienne

ENGINEERING BRANCH

SERVICE TECHNIQUE

ENGINEERING REPORT

RAPPORT TECHNIQUE

ATTENTION:

CROWN COPYRIGHT. THIS REPORT IS RELEASED FOR AVIATION SAFETY PURPOSES ONLY, AND MAY BE AMENDED PRIOR TO, OR SUBSEQUENT TO RELEASE OF THE FINAL CASB REPORT. REPRODUCTION OF THIS DOCUMENT, IN WHOLE OR IN PART, MAY BE PERMITTED ON REQUEST TO THE CASB.

AVIS:

DROIT DE PUBLICATION RÉSERVÉ À LA COURONNE. LE PRÉSENT RAPPORT EST PUBLIÉ UNIQUEMENT POUR DES QUESTIONS DE SÉCURITÉ AÉRIENNE, ET PEUT ÊTRE MODIFIÉ AVANT OU APRÈS LA PUBLICATION DU RAPPORT FINAL DU BCAS. CE DOCUMENT PEUT ÊTRE REPRODUIT EN TOTALITÉ OU EN PARTIE SUR DEMANDE ADRESSÉE AU BCAS.

File Reference Numéro de dossier	Number of Pages Nombre de Pages	Appendices Annexes	5	RELEASE OUTSIDE CASB SUBJECT TO REVIEW BY THE ACCESS TO INFORMATION OFFICER.	YES OUI	
540-3 (India)	5	Figures Chiffres	NIL	PUBLICATION HORS DU BCAS SOUMISE À LA RÉVISION DU COORDONNATEUR DE L'ACCÈS À L'INFORMATION.	NO NON	X

ENGINEERING REPORT EP 36/90
RAPPORT TECHNIQUE

FLIGHT RECORDER PLAYBACK

Airbus A320, VT-EPN
Bangalore, India
February 14, 1990

Prepared - Préparé

M.R. Poole, P. Eng. (Flight Recorders Group Chairman)

Reviewed - Révisé

D.J. Langdon, P. Eng. (Chief, Systems Engineering)

Approved - Approuvé

R.G. Hayman, P. Eng.

Director of Engineering - Directeur du service technique

Date Completed - Terminé le

4 Jun 90

1.0 INTRODUCTION

EP 36/90

- 1.1 On February 14, 1990, an Airbus A-320, Indian Airlines flight 605, registration VT-EPN, crashed during a non-precision approach to Bangalore airport.
- 1.2 The aircraft's Digital Flight Data Recorder (DFDR) was hand carried to the Engineering Branch of the Canadian Transportation Accident Investigation and Safety Board (CTAISB) by a team of three officials of the Government of India after a request for playback was made by the Indian Government through the Indian High Commission in Ottawa, Canada. After initial discussions between CTAISB and the Indian team on Monday February 19, 1990, the work of playing back the recorder began on Tuesday, February 20, 1990.
- 1.3 The DFDR was a Fairchild model 17M-800-251 digital recorder (serial number 3768). The DFDR recorded 216 parameters in a standard 64 words per second format.
- 1.5 Flight Recorder Specialists from the National Transportation Safety Board (United States) and from the National Research Council of Canada participated in the playback as advisors to the CTAISB.
- 1.6 At the request of the India Government, this report contains no analysis of the flight in terms of aircraft operation or performance.

2.0 DFDR PLAYBACK

- 2.1 The magnetic tape medium was removed from the DFDR for playback. The tape was cut just before the record heads such that the physical end of the tape represented the end of continuous data. After removal of the tape, the DFDR was powered up to determine the last recorded track. Track #4 (of the six track tape) was determined to be the last recorded track.
- 2.2 At approximately five and a half minutes back into the last flight, an arbitrary reference time was set to zero which is referred to as 'Reference Time' on all of the data plots.
- 2.4 The data were converted to engineering units using the standard conversion equations for this particular aircraft. Data from the maiden flight of VT-EPN was recovered from another tape made avail-

able to the CTAISB by Airbus Industrie to confirm the conversions. The data of the maiden flight played back through CTAISB's system provided the same numerical results and sign conventions as the Airbus Industrie printout of the maiden flight, thus confirming the conversions were the same.

- 2.5 This particular DFDR records the data in 15 bit words which require mapping into 12 bit words prior to conversion to engineering units. For the last five minutes, all of the subframes (one subframe is one second) of data contained the proper number of bits (64 fifteen bit words or 960 bits) except for the subframe corresponding to reference time 329. This subframe was short six bits. The DFDR signal was analyzed and it was evident that the signal had experienced expansion and compression distortion after approximately three quarters of the way through the subframe. This distortion was considered to be as a result of vibrations induced by the aircraft's impact with terrain. The data from this subframe was subsequently recovered through analysis of the DFDR waveform. Additionally, a portion of a second after reference time 331 was also recovered. The recorder was determined to have stopped at 331 25/64. 25 words were recorded in the 64 word format prior to the end of recording.
- 2.6 During the process of mapping the 15 bit data into 12 bit data for the last five and one half minutes, 19 mappings (19 seconds) did not conform to the allowable mapping patterns for this type of code. A subsequent run of the tape, after fine tuning of our playback system for this specific recording, resulted in no bad mappings during the last five and one half minutes.
- 2.7 The data plots and printouts of the last five and one half minutes of flight are attached as Appendix 'A' of this report.
- 2.8 On March 6, 1990, the Indian Government requested additional data from a previous landing at Bangalore. A review of past flights on the 25 hour DFDR revealed that the sixth flight back was also an approach to Bangalore. Data were therefore plotted and printed for the sixth flight back and forwarded to India. These printouts and plots are contained in Appendix 'B' of this report.

3.0 FLIGHT RECONSTRUCTION AND FLIGHT PATH ANALYSIS

- 3.1 A three-dimensional flight reconstruction was made for the final approach to Bangalore. The flight path was determined by integrating the recorded ground speed in the direction of recorded magnetic heading. Appendix 'C' contains examples of figures taken from the flight reconstruction. A VHS (PAL or NTSC) video tape is available depicting various views of the flight in real time with the cockpit voice recording (CVR) synchronized to it.
- 3.2 The CVR tape provided by the Indian Government on Tuesday, April 17, 1990 was played back at the CTAISB laboratory at its standard speed and it was determined that the 400 hertz aircraft power was displaying as 384 hertz. The CVR was therefore played back 4% faster and a copy tape was made while a simultaneous real time code was written to the copy tape. The time code, correlated to DFDR reference time, is shown on the partial CVR transcript provided in Appendix 'D'. The transcript for the CVR was obtained from the Indian Government and was therefore not necessarily the CTAISB's interpretation of the CVR's contents.
- 3.3 The DFDR and the CVR were aligned such that the crash sound on the CVR occurred at reference time 329.8, the time at which an impact occurred on the DFDR as evidenced by the normal acceleration and the distortion of the DFDR waveform signal. This time matched well with the VHF keying and the radio altitude calls by the aircraft.
- 3.4 The altitude for the flight reconstruction was determined by plotting the radio altitude and the pressure altitude on the same scales and attempting to correlate the two (Figures 2a and 2b of Appendix 'A'). The pressure altitude was matched to the radio altitude of 12 feet at time 328 (subtracting 2830 feet). The values of pressure altitude at 329 and 330 were set to the corresponding radio altitude values as the pressure altitude values were obviously in error, probably due to ground effect and impact. The aircraft was 'flown' for the purposes of flight reconstruction, with the pressure altitude, matched to the radio altitude and corrected for the last two pressure altitude values which were determined to be invalid.
- 3.5 The reported description of the crash site suggested

that there were two distinct impacts, the first being a 'light' touchdown of the main gear on relatively flat terrain and the second being a harder hit, just prior to a small hill which the aircraft contacted. Analysis of the DFDR data, (pressure altitude, radio altitude, normal acceleration, and landing gear squat switches) the distorted waveform signal in subframe 329, and the single crash sound on the CVR, indicated that only the first impact was recorded and not the second. The recording continued for about one and one half seconds and then ended, on both recorders, without recording a second impact.

3.6 The normal acceleration data after subframe 329 suggested that the aircraft was in a bounce, after the first impact, when the recording stopped. The first impact was therefore considered sufficient to have caused internal damage to the aircraft, which affected the operation of both recorders. After subframe 329, the side stick pitch controllers for both crew went to exactly the same number (-9.51 degrees). It would be highly coincidental that both side sticks were moved to the same value. It is considered more likely that the aircraft was 'broken' in some manner which caused the system to malfunction. Additionally, the engine values which reflect a spooling up of the engines, deviate from a spool up after subframe 329. The engine values, side stick controller pitch data, lack of a second impact recorded in normal acceleration, single crash sound on the CVR, and lack of a squat switch signal prior to subframe 329, all indicate the the first impact with the ground occurred in subframe 329 and no second impact was recorded. The data could not be fit to a scenario in which subframe 329 was the second impact, just prior to the hill.

3.7 For the purposes of the flight reconstruction the following parameters were displayed as they were perceived to be significantly related to the accident: time; computed airspeed; radio altitude; pitch attitude; both side stick controllers; auto-pilot 1; altitude capture 1; auto throttle speed mode; ground proximity warning system; left and right elevator position; left and right exhaust gas temperature; left and right N2; left and right throttle lever angle; left and right engine pressure ratio command; left and right actual engine pressure; magnetic heading compass; pitch and roll gyro; altimeter and airspeed indicator.

4.0 ADDITIONAL DFDR ASSISTANCE

- 4.1 On Tuesday, April 17, 1990, two representatives from the Indian Government arrived with a second DFDR tape from another A320, VT-EPO. This aircraft was involved in a go-around on February 27, 1990 (flight time 6:10 to 7:55). Within the flight, there were two touch and goes and one go-around. The engine parameters for all three of these cases of engine power application are included in Appendix 'E' of this report.

5.0 CONCLUSIONS

- 5.1 The data were recovered from two DFDR's (VT-EPN and subsequently VT-EPO) as requested by the Indian Government.
- 5.2 The data quality for both recordings was considered excellent.
- 5.3 All of the data were provided in numerical print out format as well as graphical plots. A three-dimensional flight reconstruction was also made of the accident sequence.
- 5.4 The DFDR only recorded one impact which was determined to be the first impact with the ground.

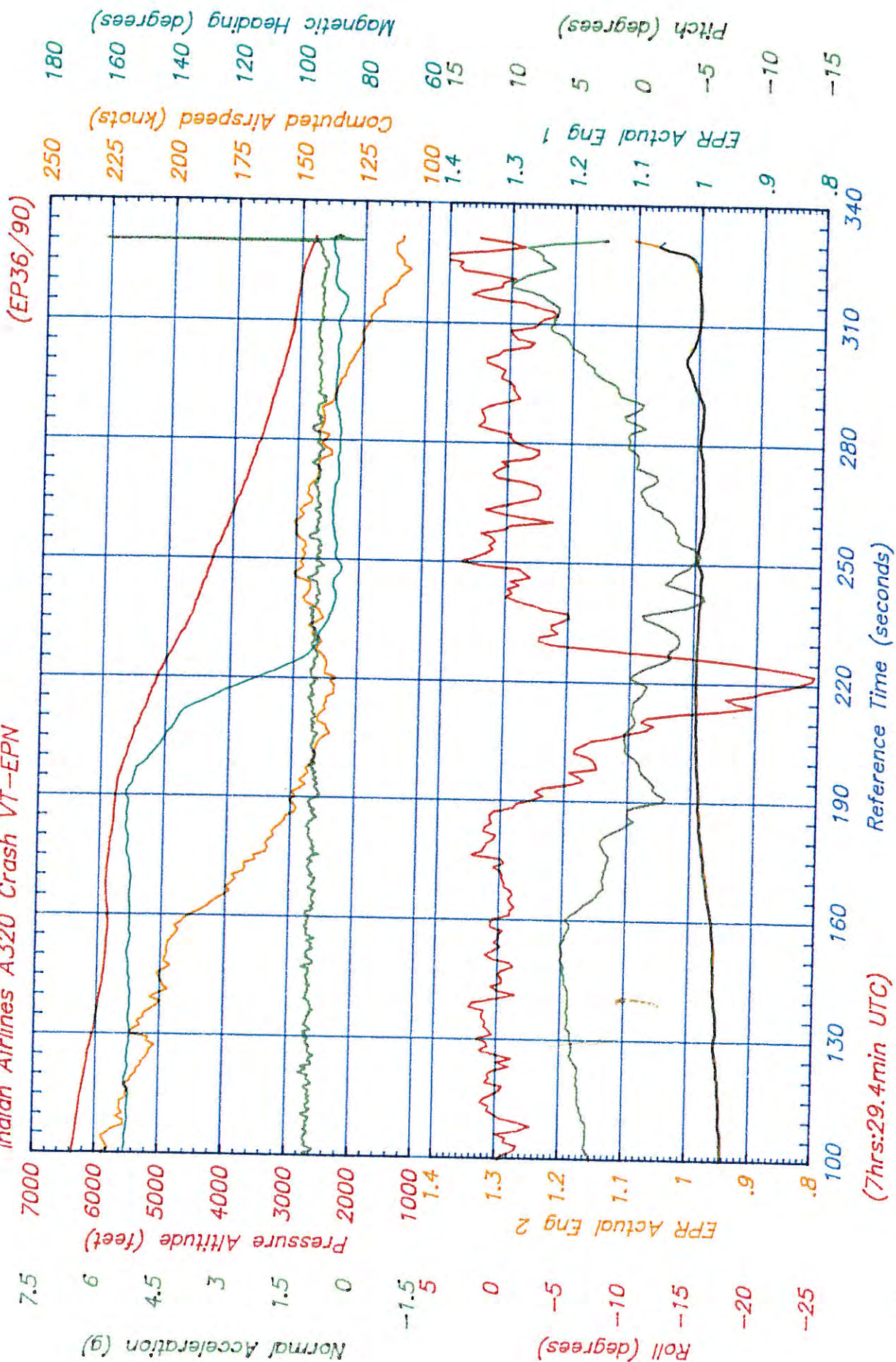
Appendix 'A'

Print out and Plots of Accident Flight

VT-EPN

Figure 1

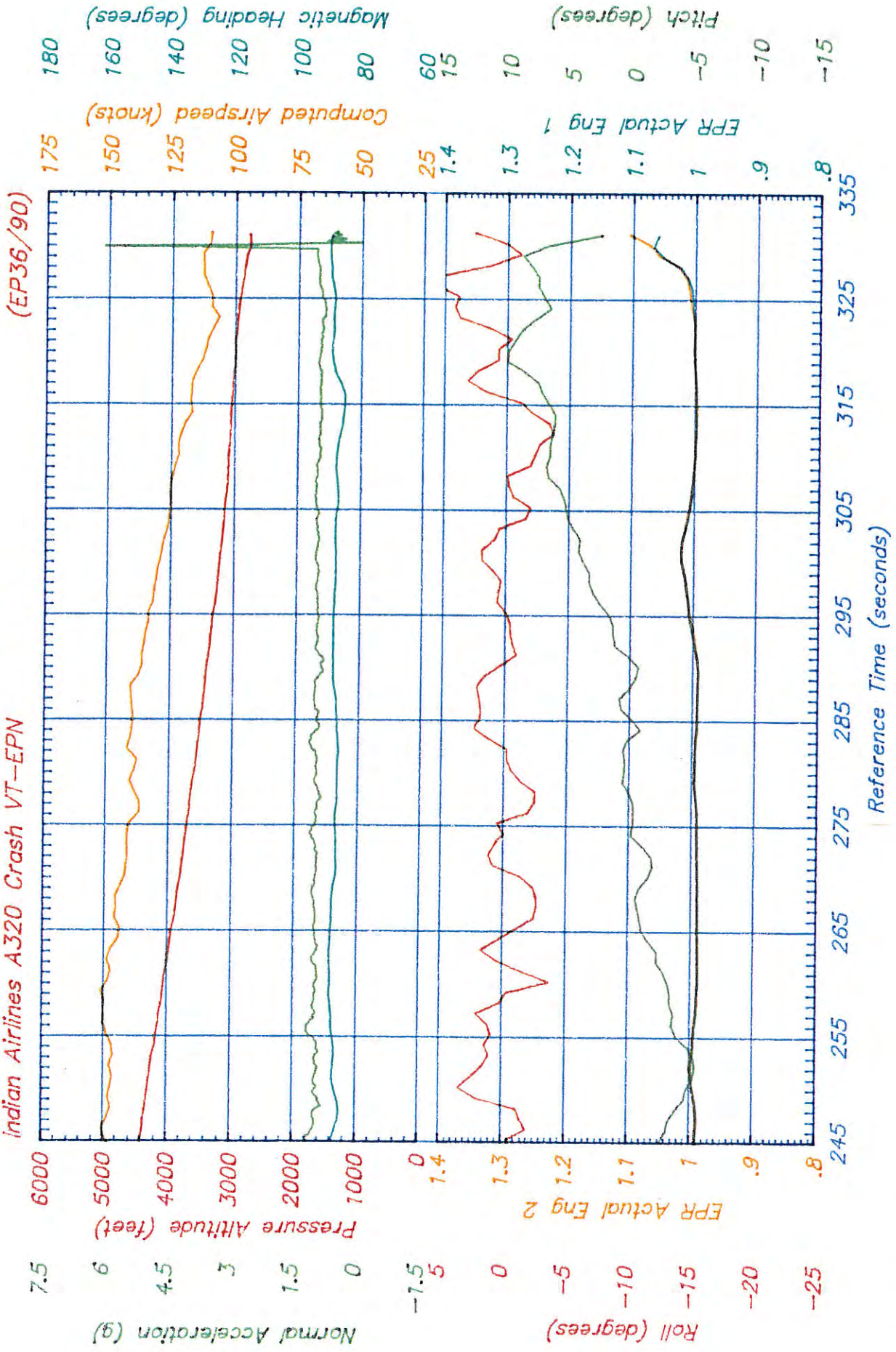
Indian Airlines A320 Crash VT-EPN



Revised Data
Plotted: 14 MAR., 1990

Figure 1a

Indian Airlines A320 Crash VT-EPN

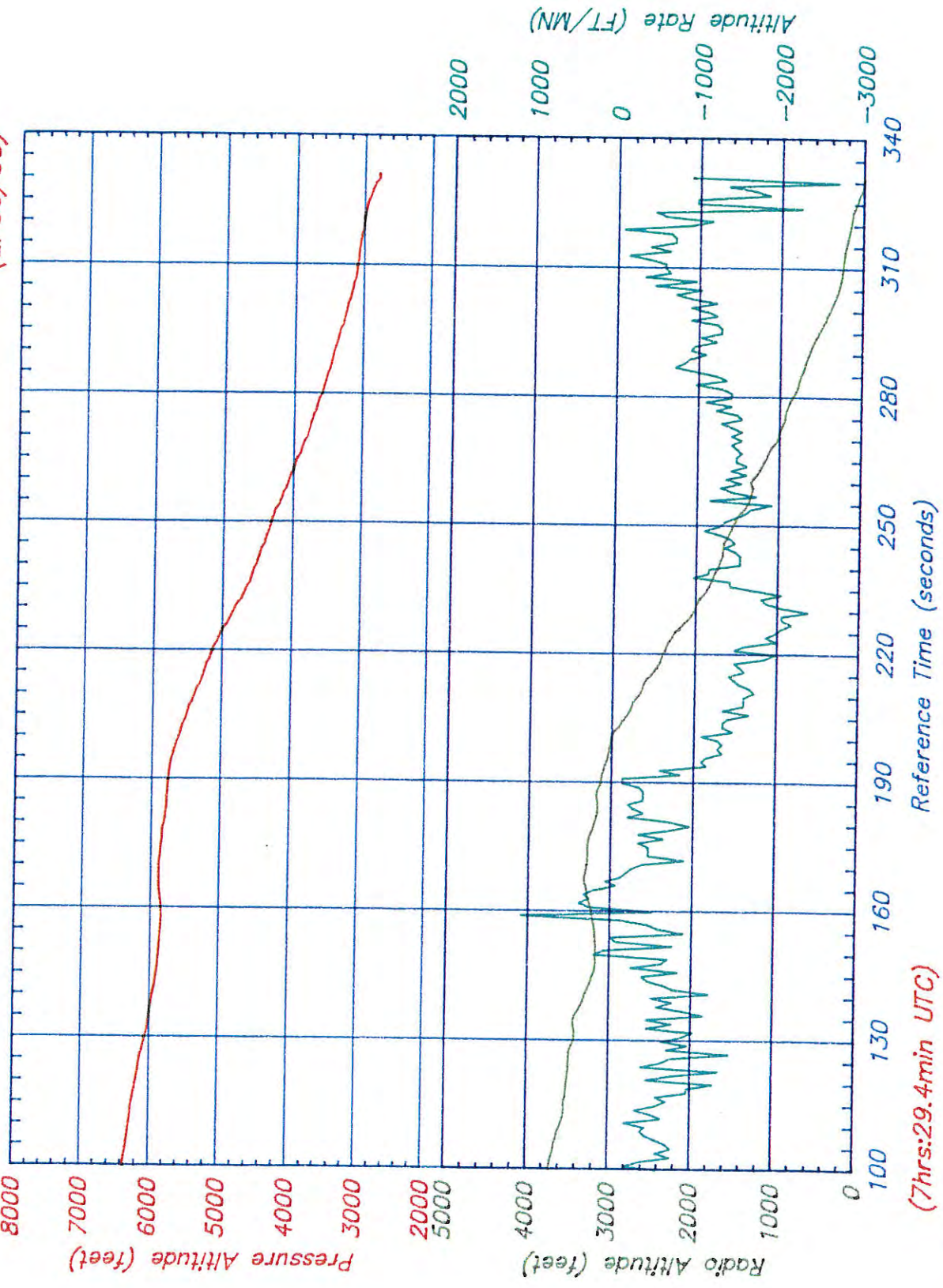


Revised Data
Plotted: 14 MAR., 1990

Figure 2

Indian Airlines A320 Crash VT-EPN

(EP36/90)

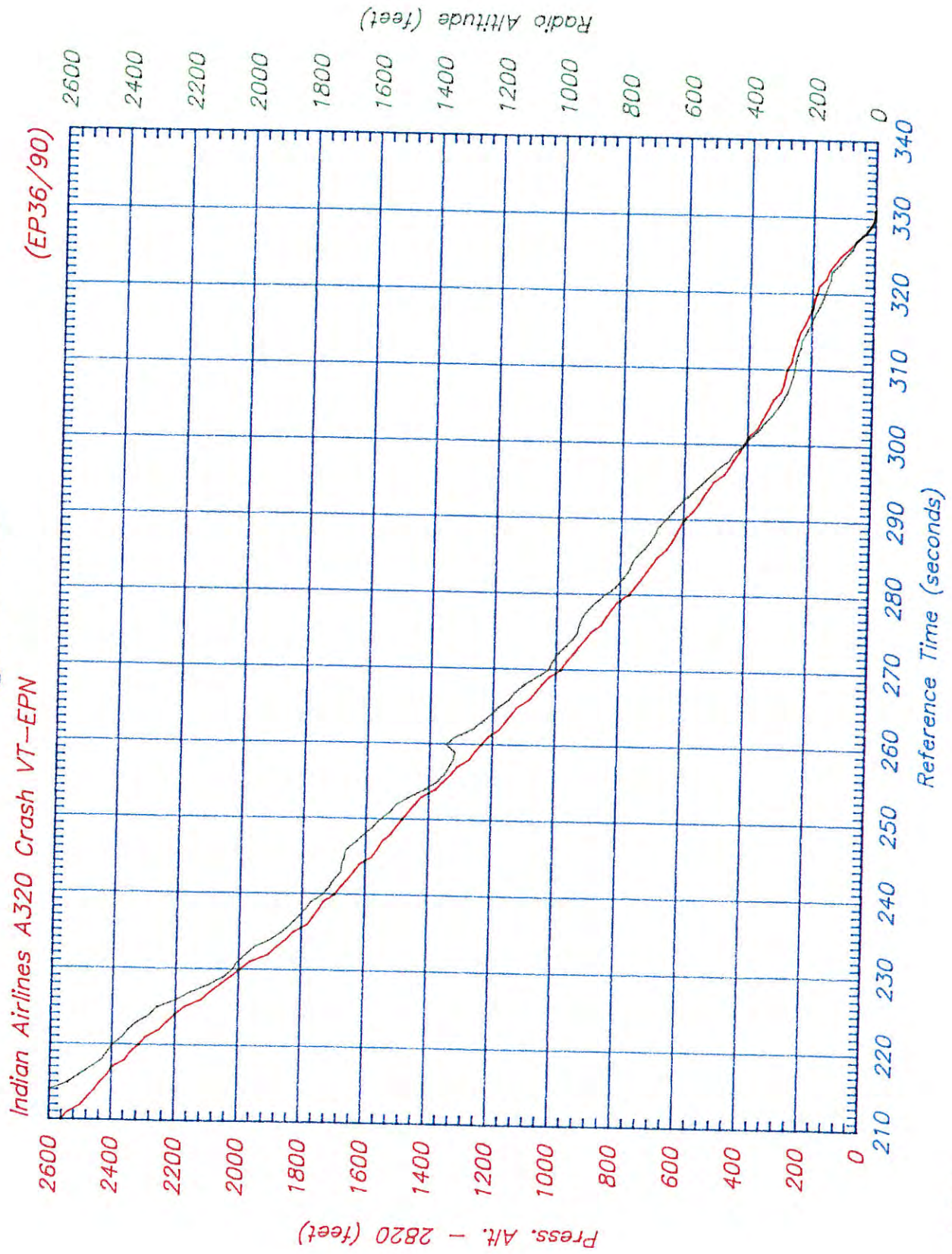


(7hrs:29.4min UTC)

Revised Data

Plotted: 14 MAR., 1990

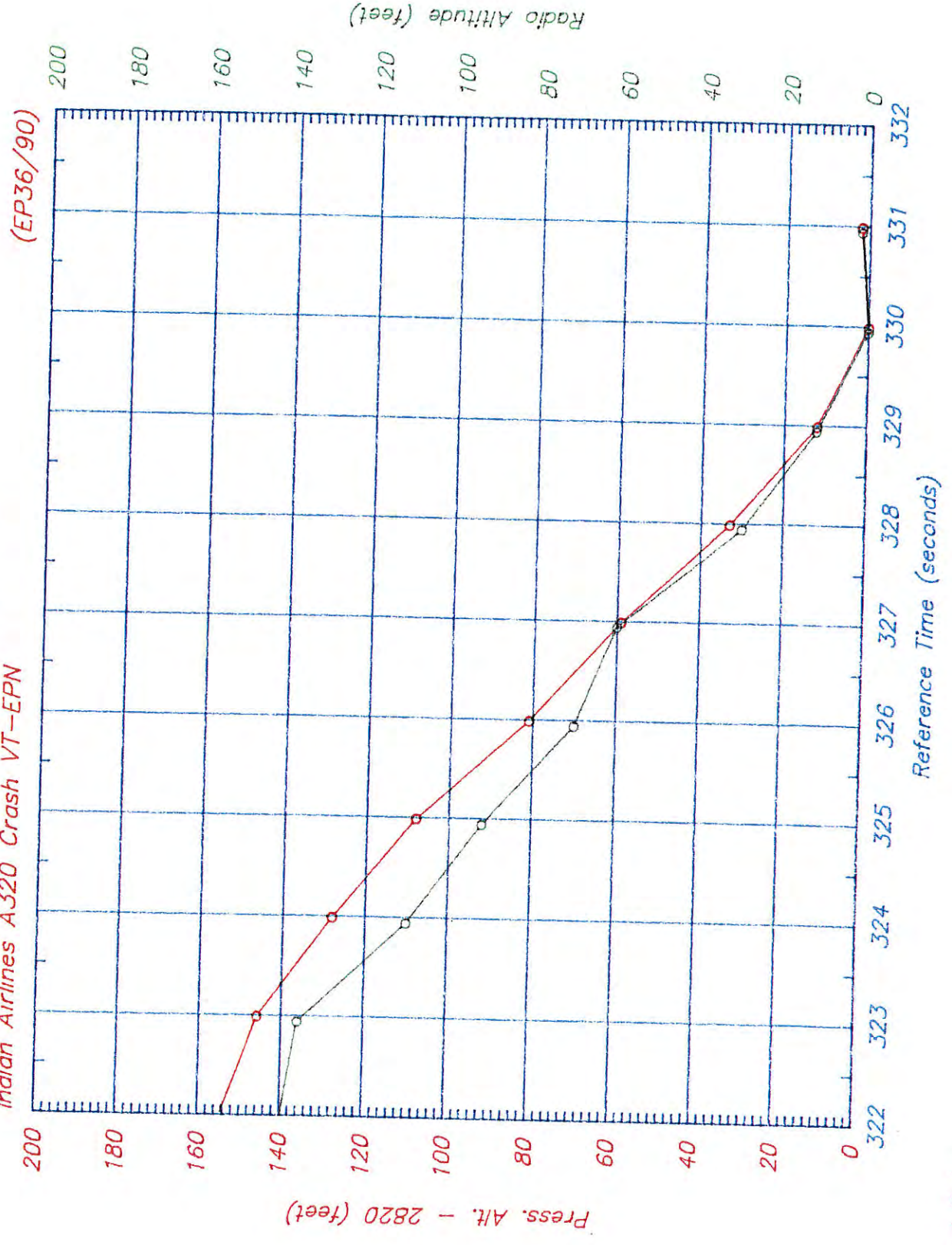
Figure 2a



Revised Data
Plotted: 19 APR., 1990

Figure 2b

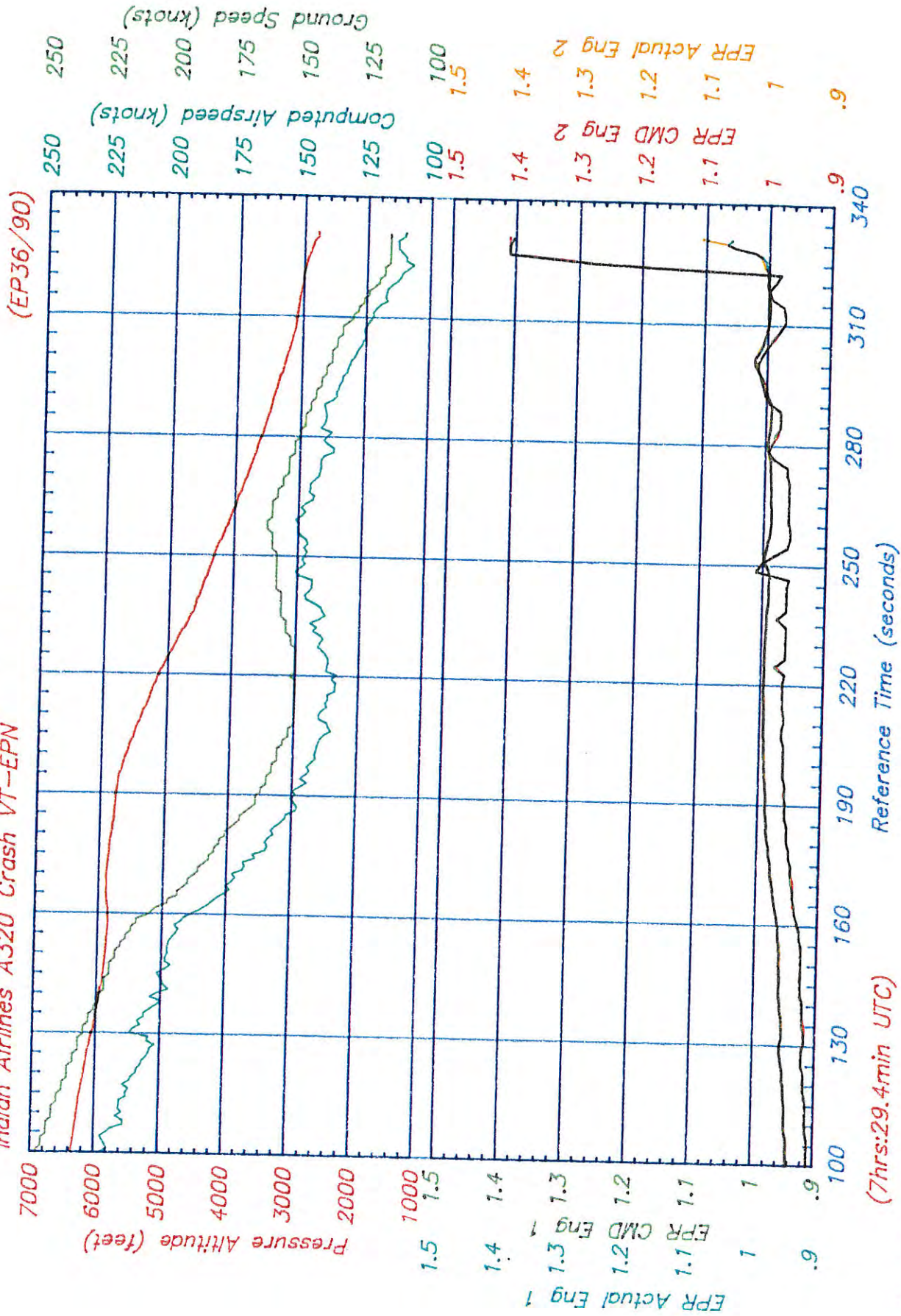
Indian Airlines A320 Crash VT-EPN



Revised Data
Plotted: 19 APR., 1990

Figure 3

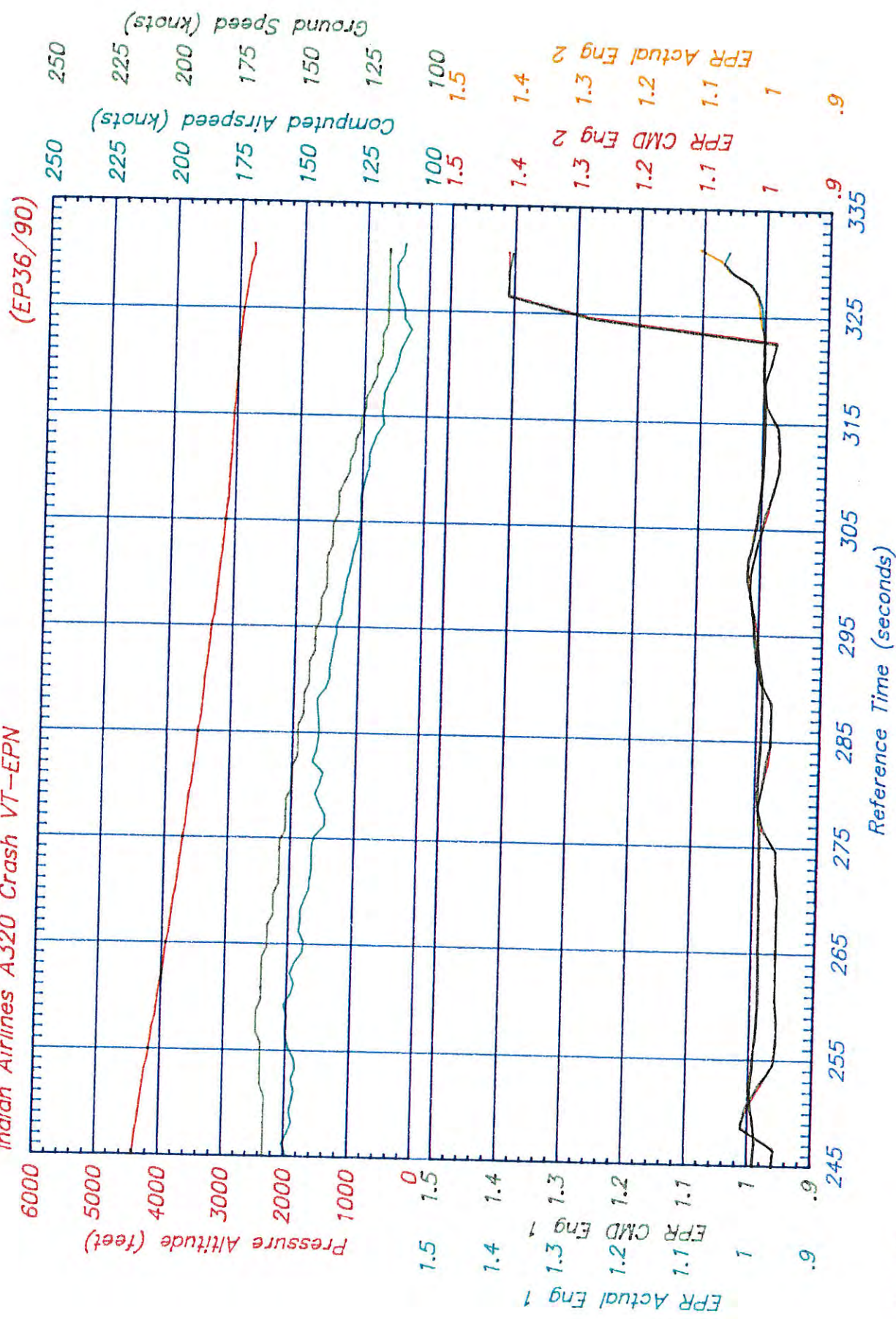
Indian Airlines A320 Crash VT-EPN



Revised Data
Plotted: 15 MAR., 1990

Figure 3a

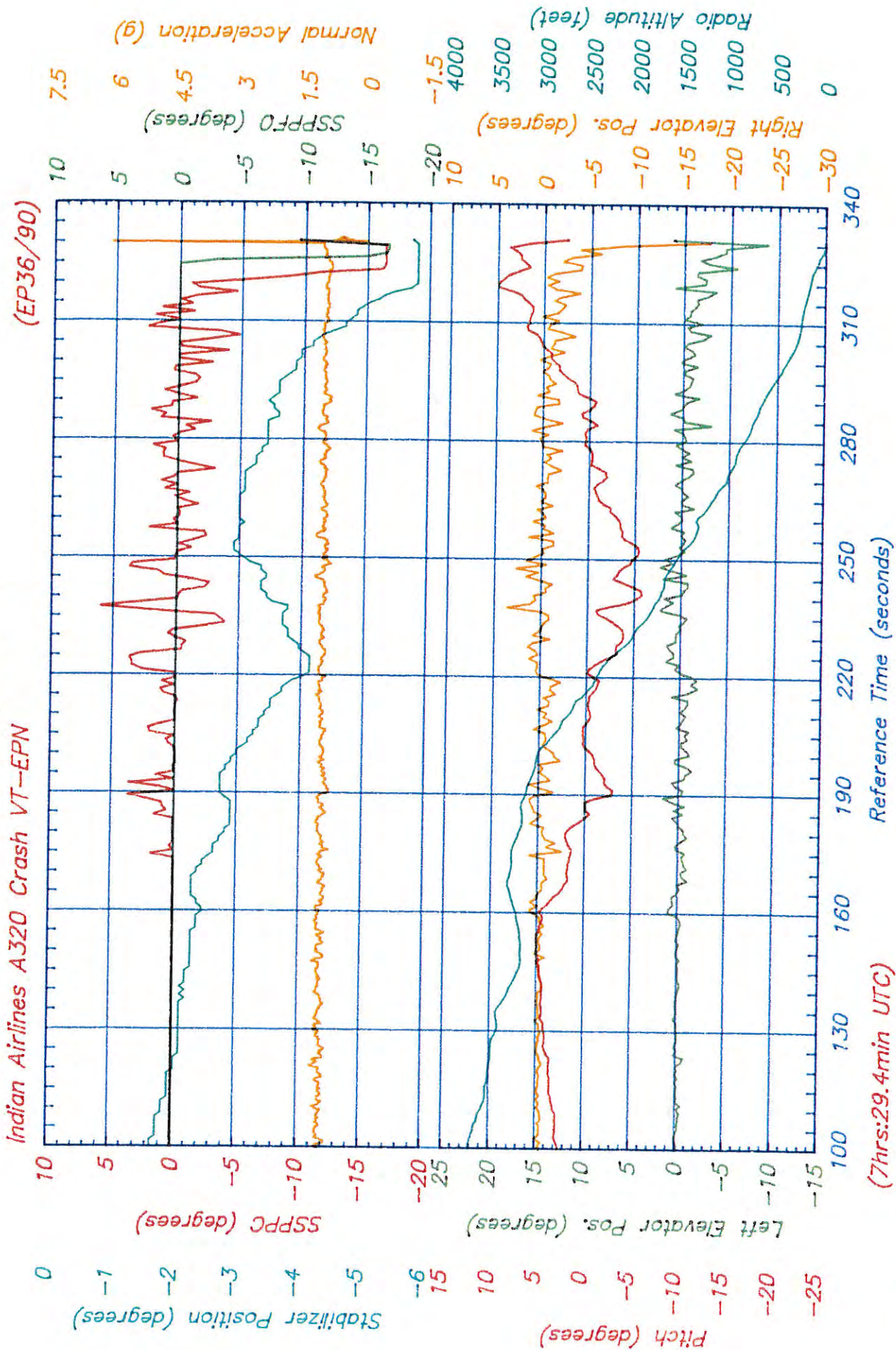
Indian Airlines A320 Crash VT-EPN



Revised Data
Plotted: 14 MAR., 1990

Figure 4

Indian Airlines A320 Crash VT-EPN

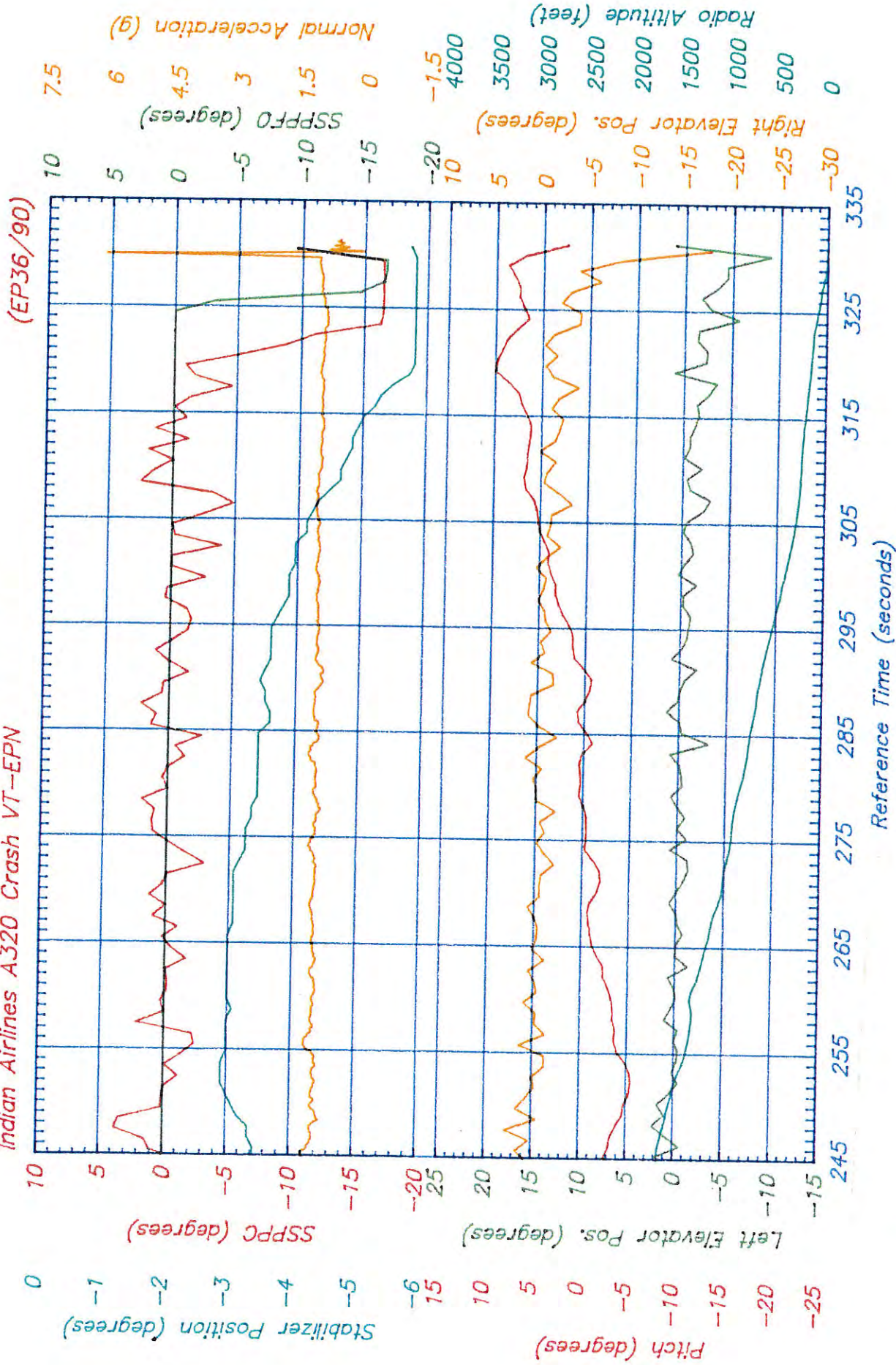


(7hrs:29.4min UTC)

Revised Data
Plotted: 14 MAR., 1990

Figure 4a

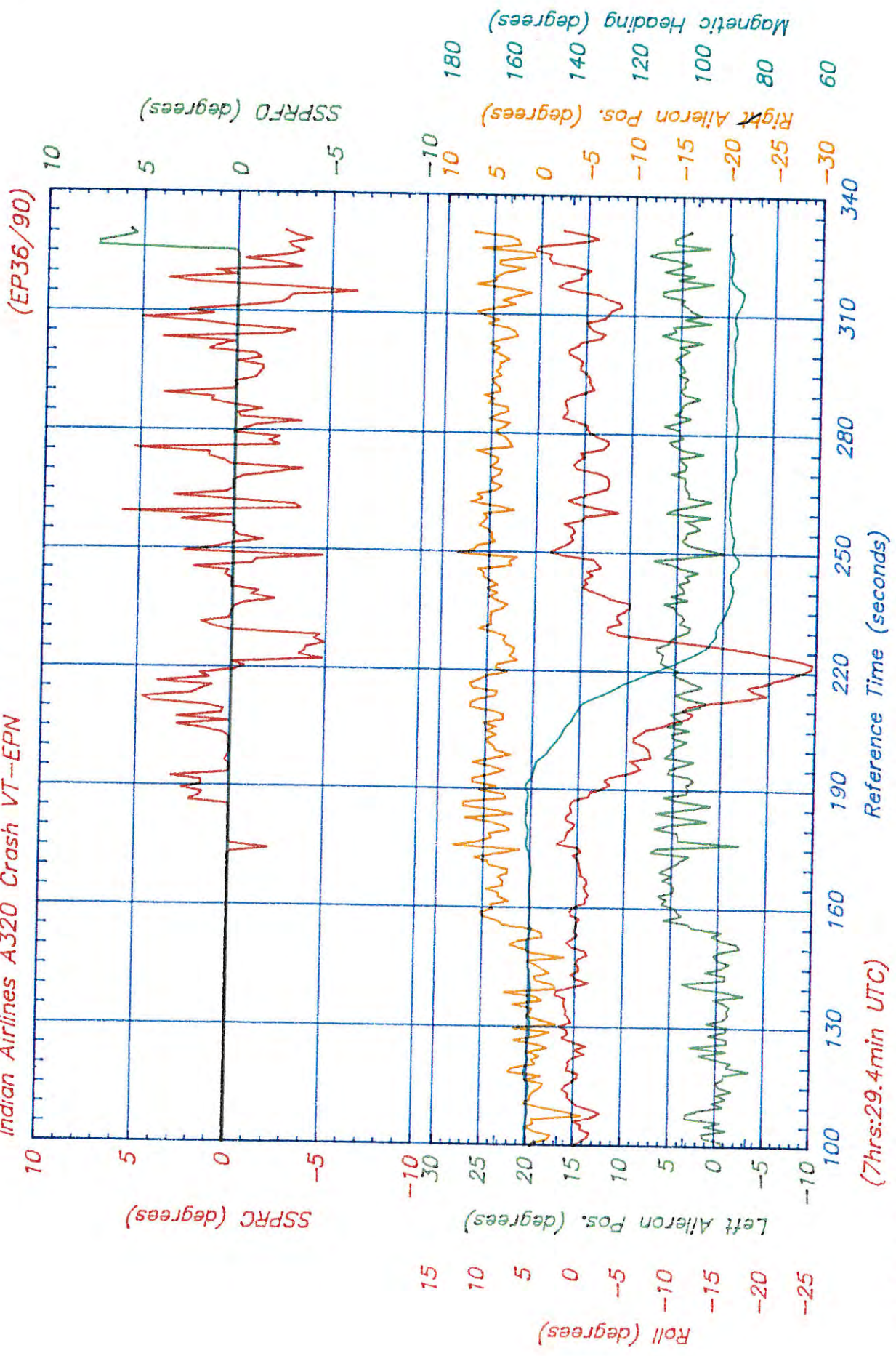
Indian Airlines A320 Crash VT-EPN



Revised Data
Plotted: 15 MAR., 1990

Figure 5

Indian Airlines A320 Crash VT-EPN



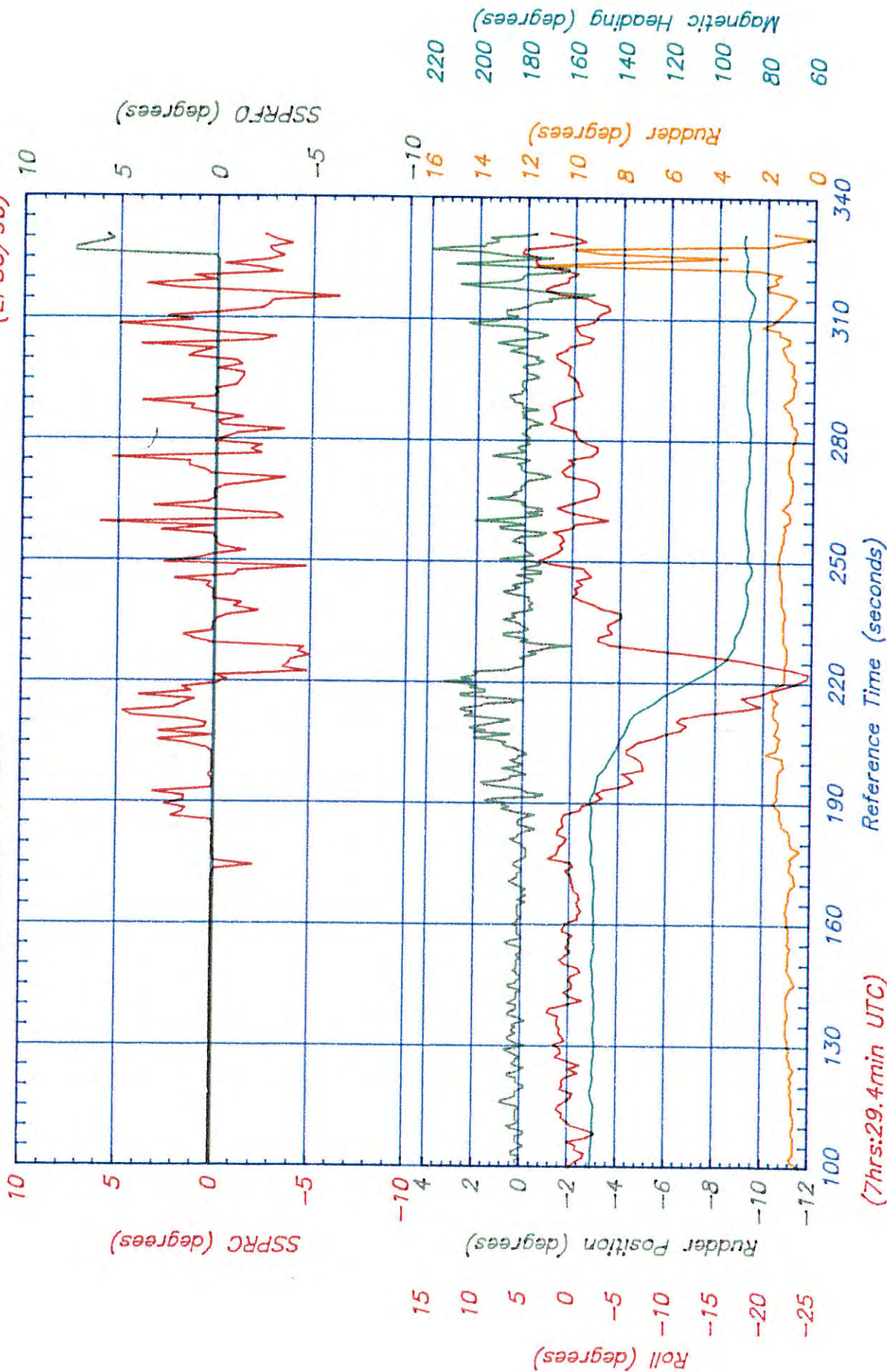
(7hrs:29.4min UTC)

Revised Data
Plotted: 14 MAR., 1990

Figure 6

Indian Airlines A320 Crash VT-EPN

(EP36/90)



(7hrs:29.4min UTC)

Revised Data

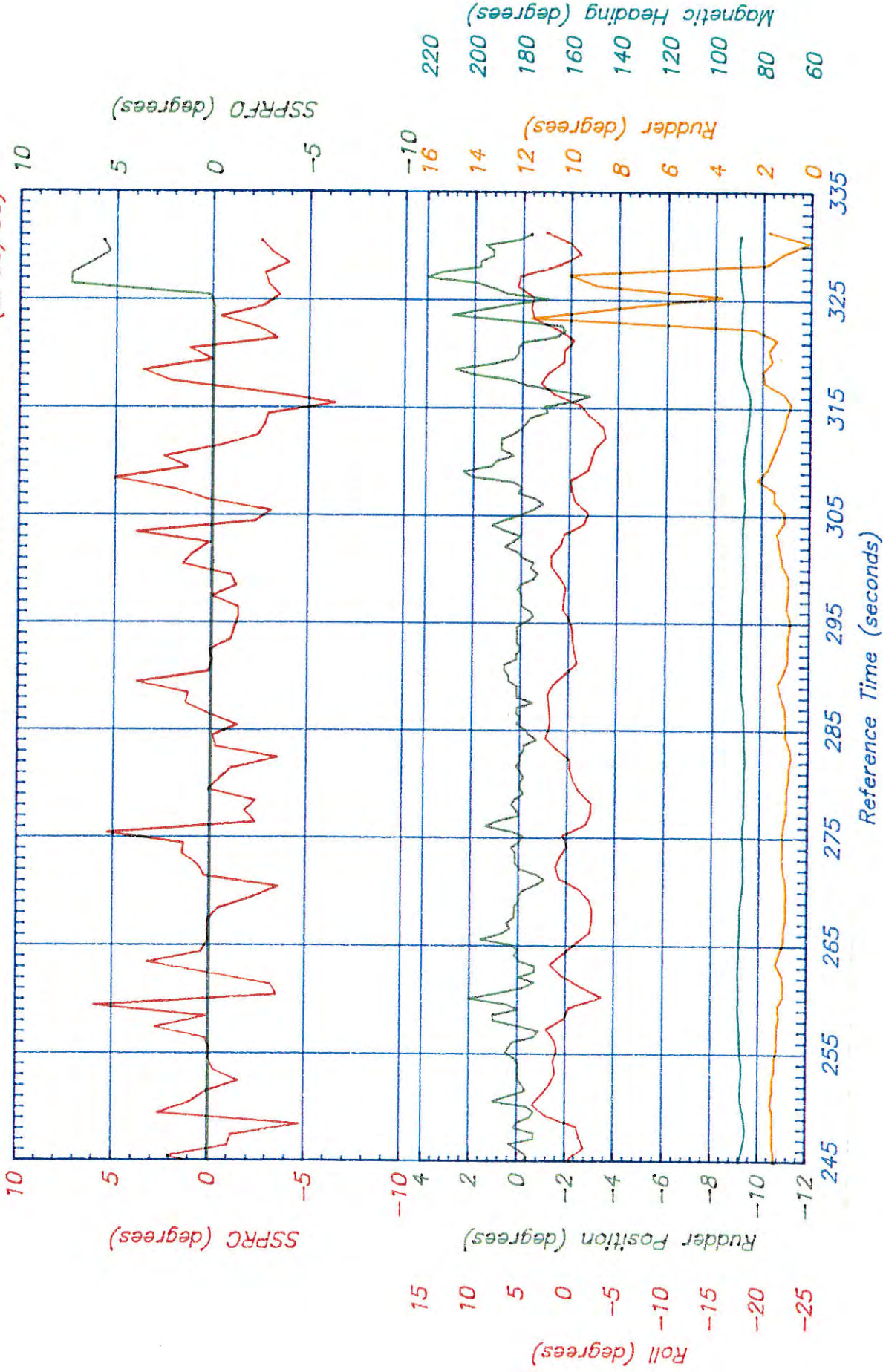
Plotted: 14 MAR., 1990

Engineering Branch/CASB

Figure 6a

Indian Airlines A320 Crash VT-EPN

(EP36/90)



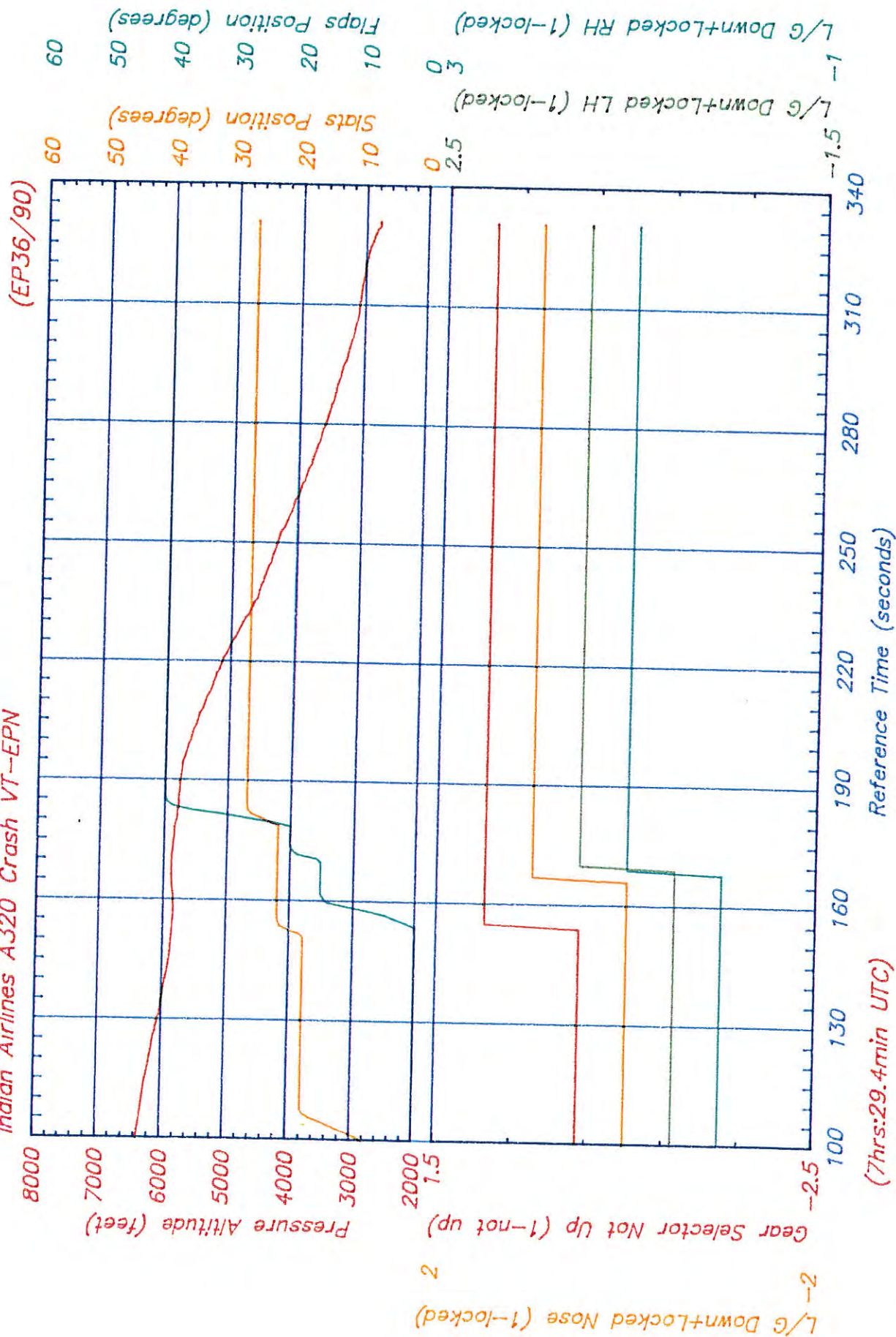
Revised Data

Plotted: 14 MAR., 1990

Engineering Branch/CASB

Figure 7

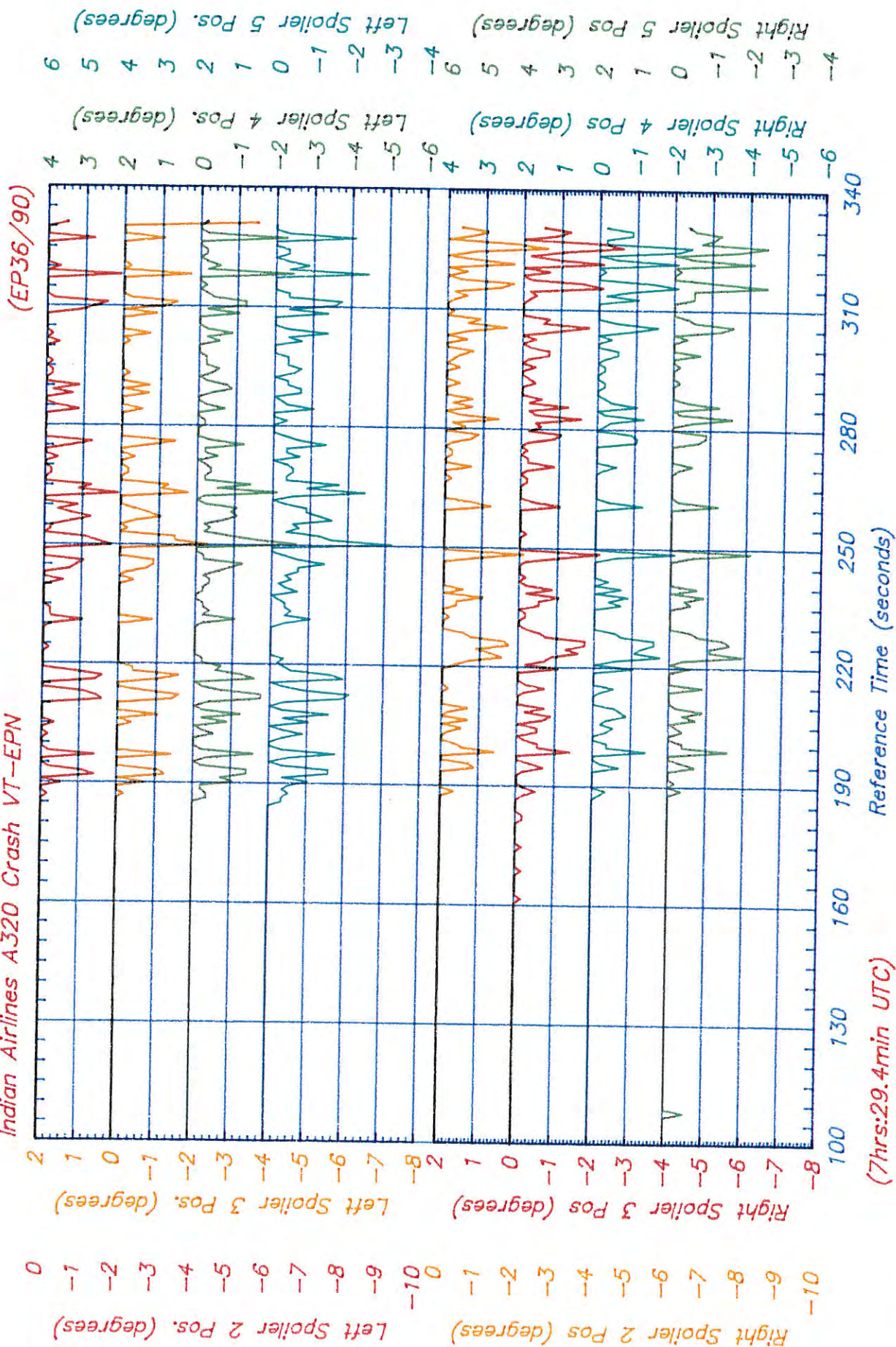
Indian Airlines A320 Crash VT-EPN



Revised Data
Plotted: 14 MAR., 1990

Figure 8

Indian Airlines A320 Crash VT-EPN



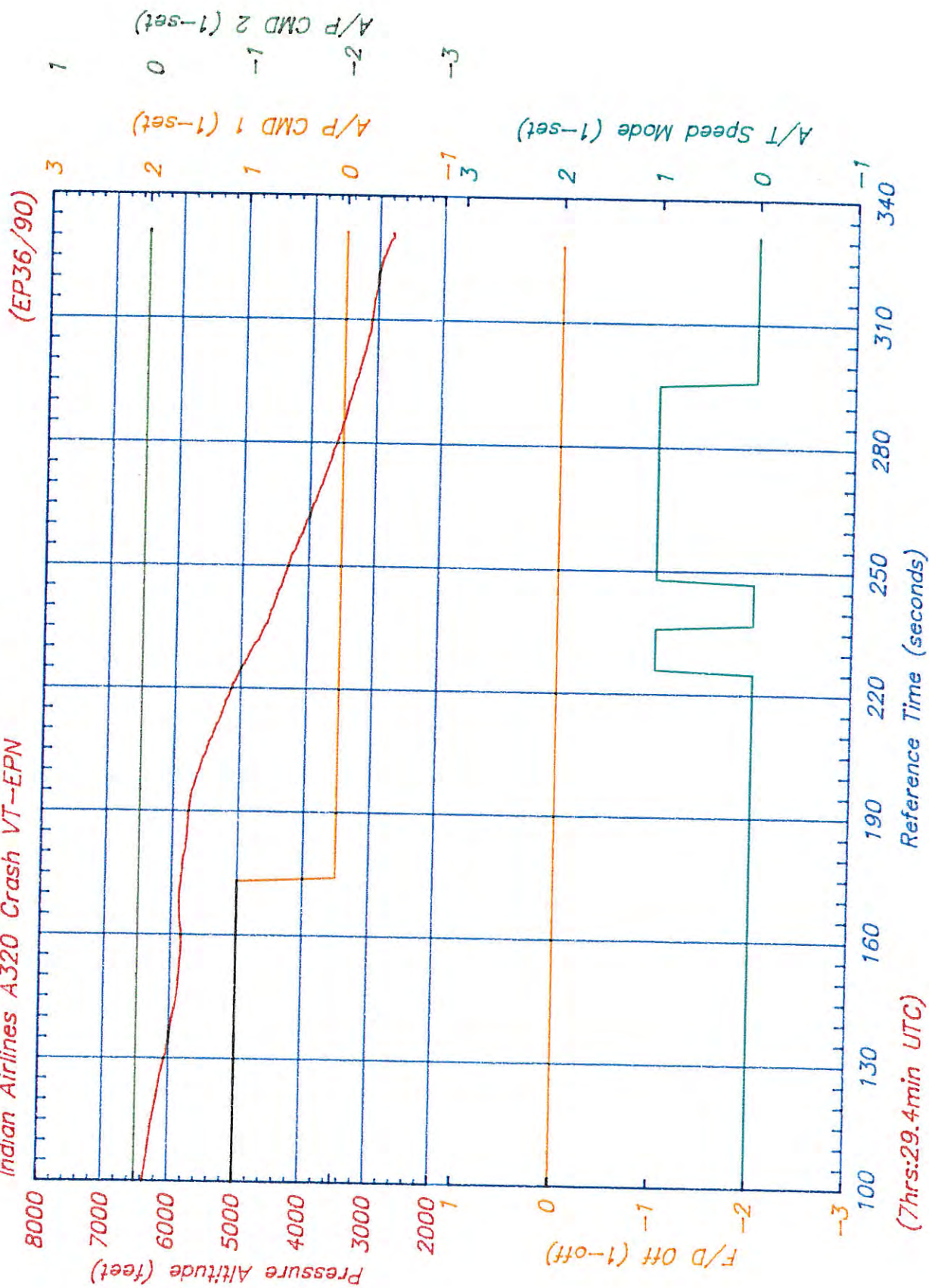
(7hrs:29.4min UTC)

Revised Data

Plotted: 14 MAR., 1990

Figure 9

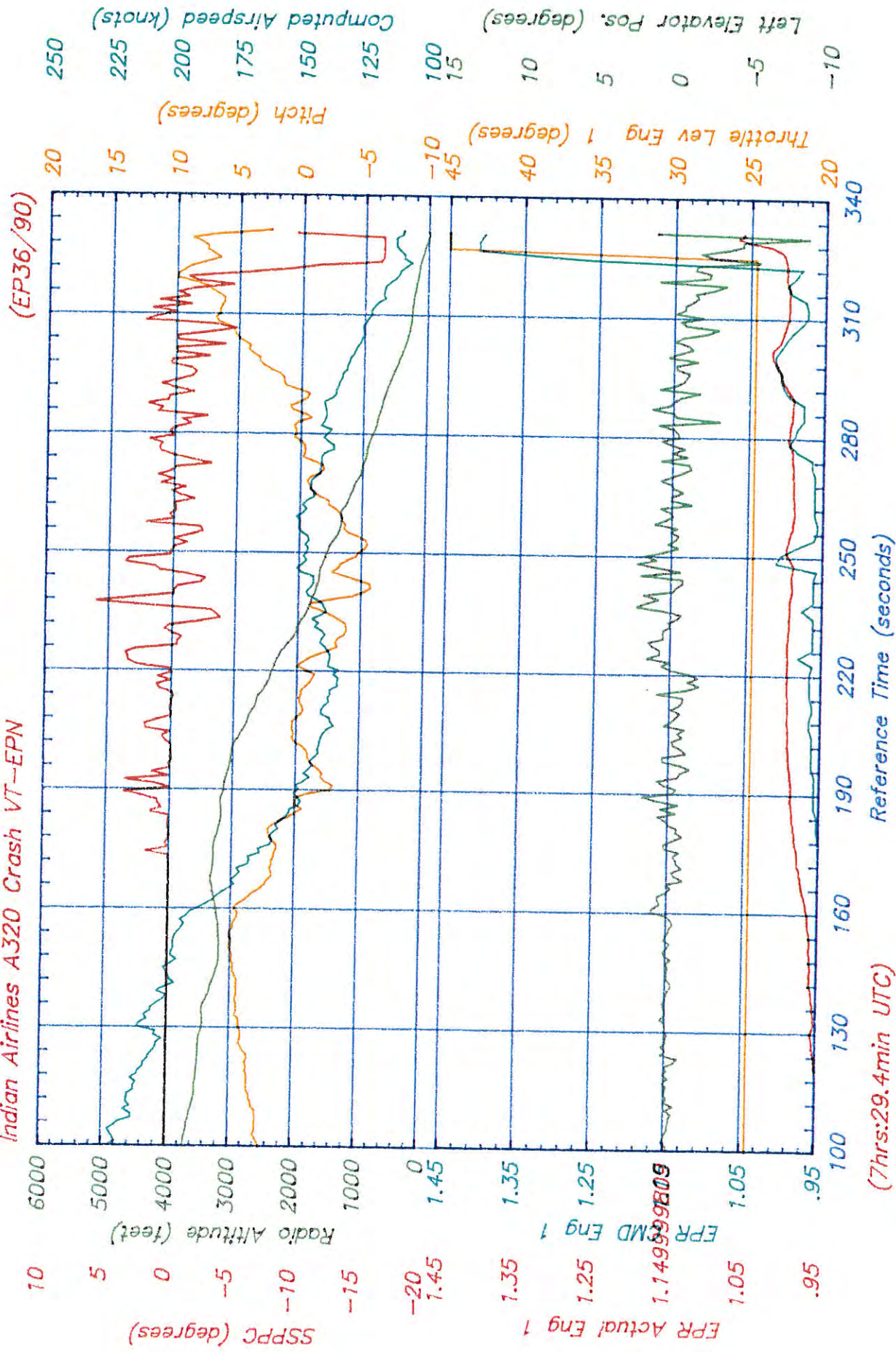
Indian Airlines A320 Crash VT-EPN



Revised Data
Plotted: 14 MAR., 1990

Figure 10

Indian Airlines A320 Crash VT-EPN

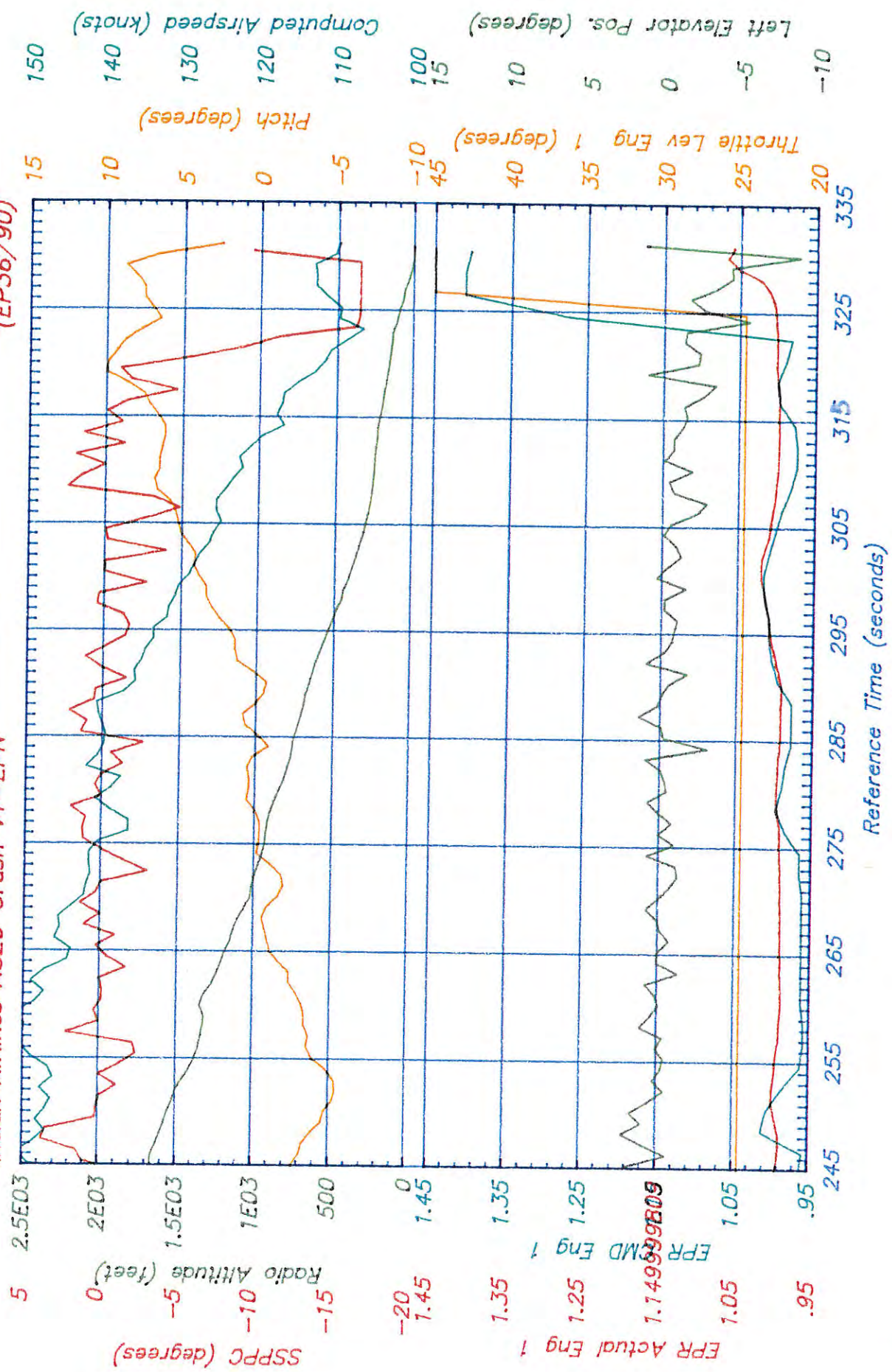


Revised Data
Plotted: 15 MAR., 1990

Plot 10a

Indian Airlines A320 Crash VT-EPN

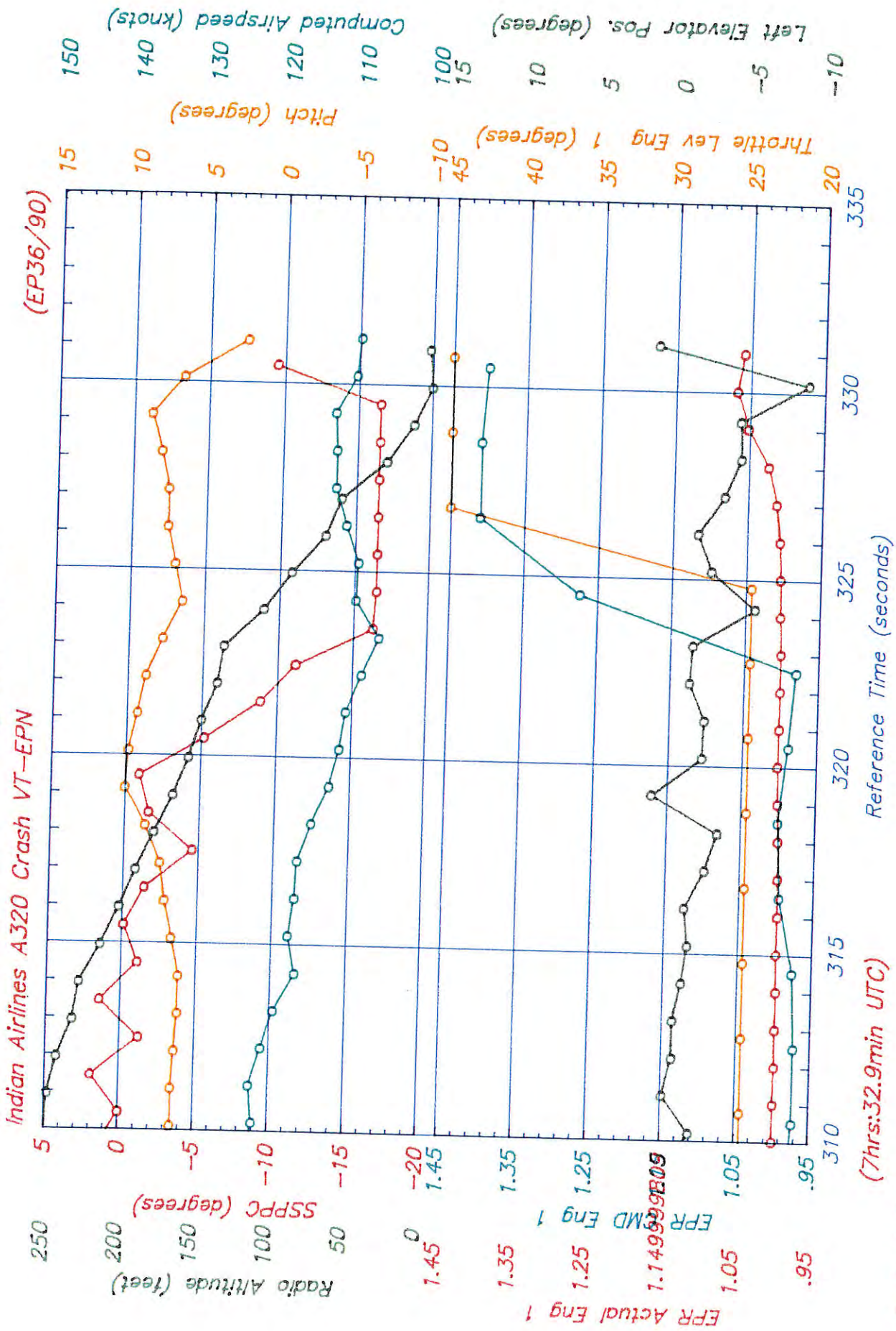
(EP36/90)



Revised Data
Plotted: 15 MAR., 1990

Engineering Branch/CASB

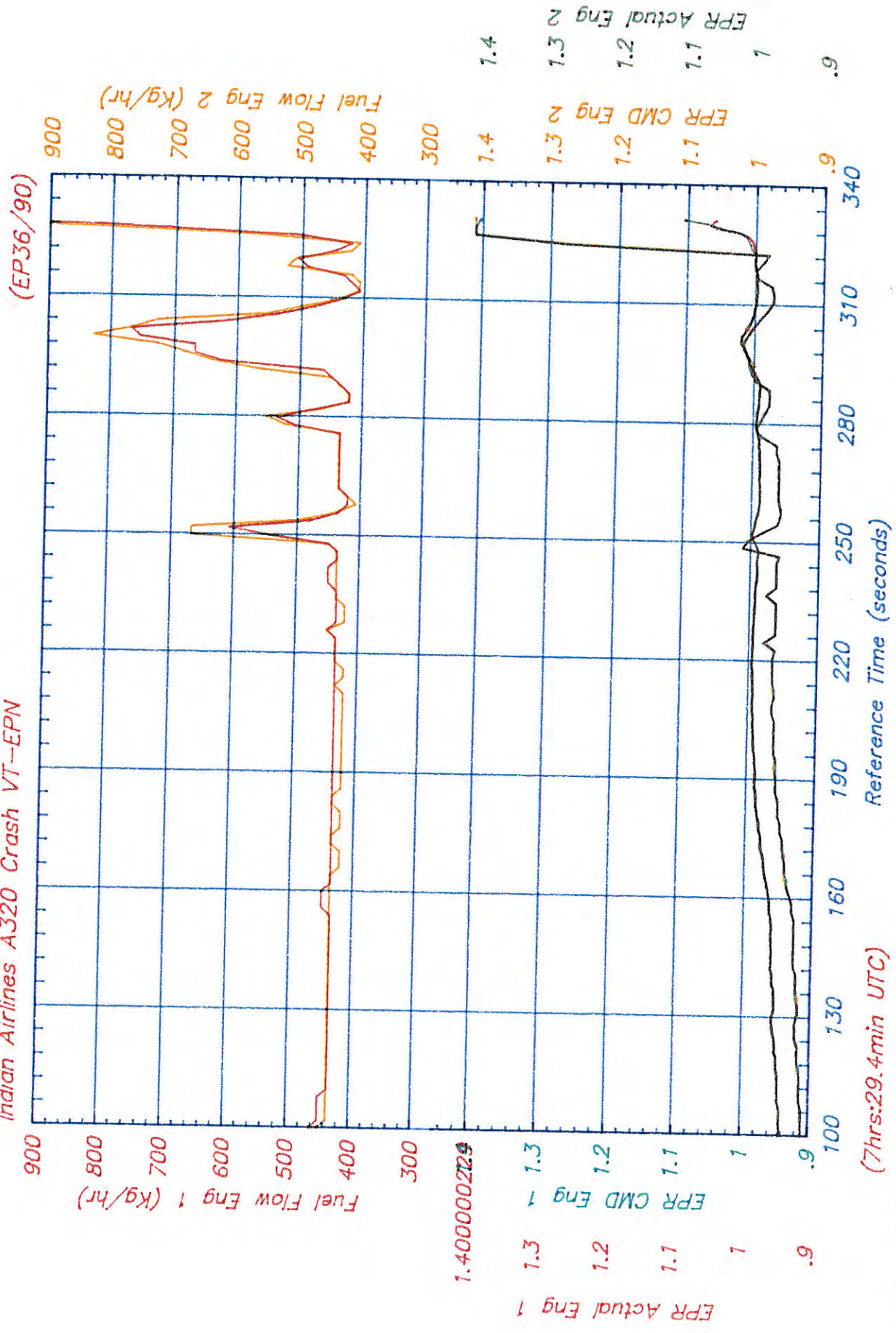
Figure 10b



Revised Data
Plotted: 21 MAR., 1990

Figure 11

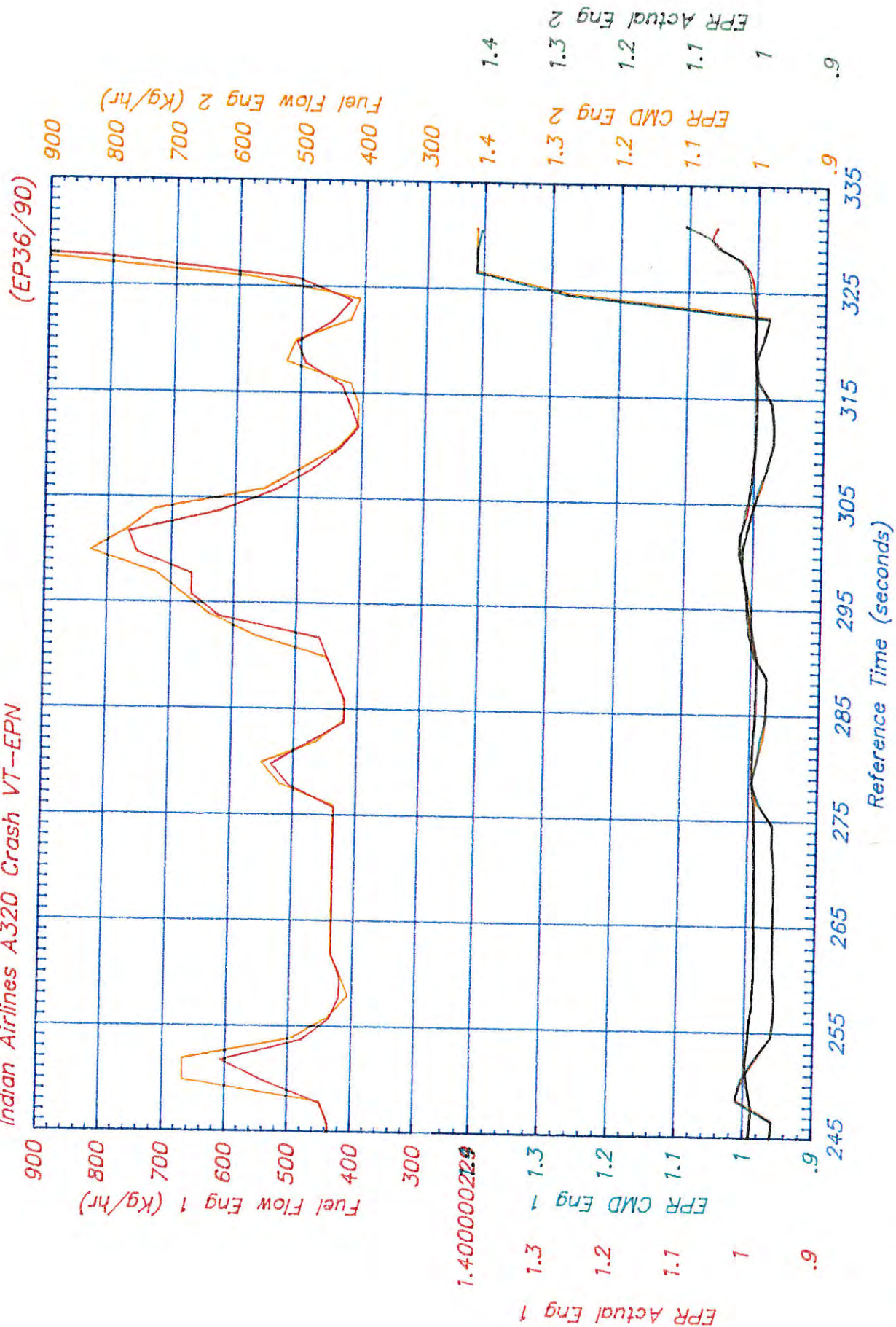
Indian Airlines A320 Crash VT-EPN



Revised Data
Plotted: 15 MAR., 1990

Figure 11a

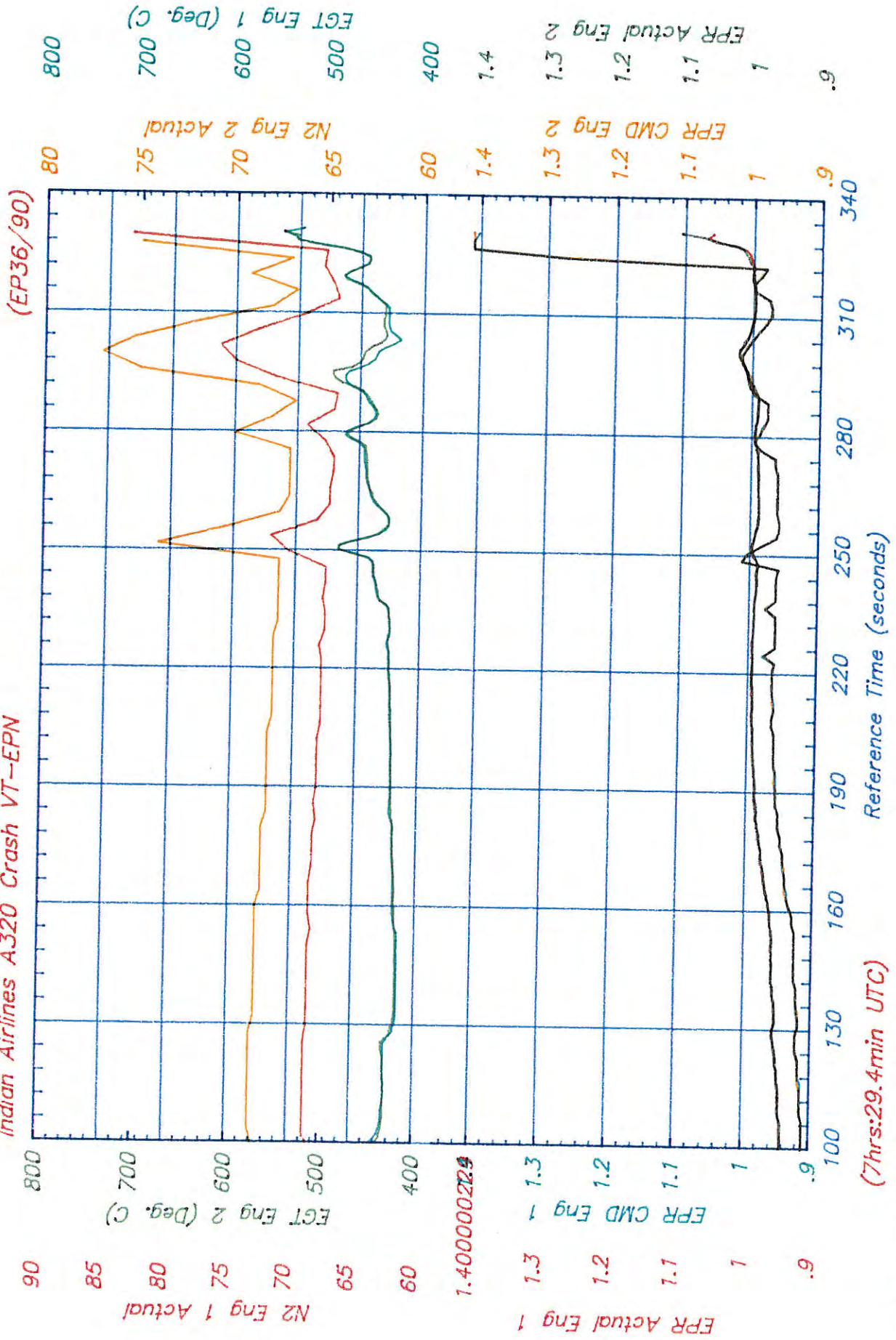
Indian Airlines A320 Crash VT-EPN



Revised Data
Plotted: 15 MAR., 1990

Figure 12

Indian Airlines A320 Crash VT-EPN

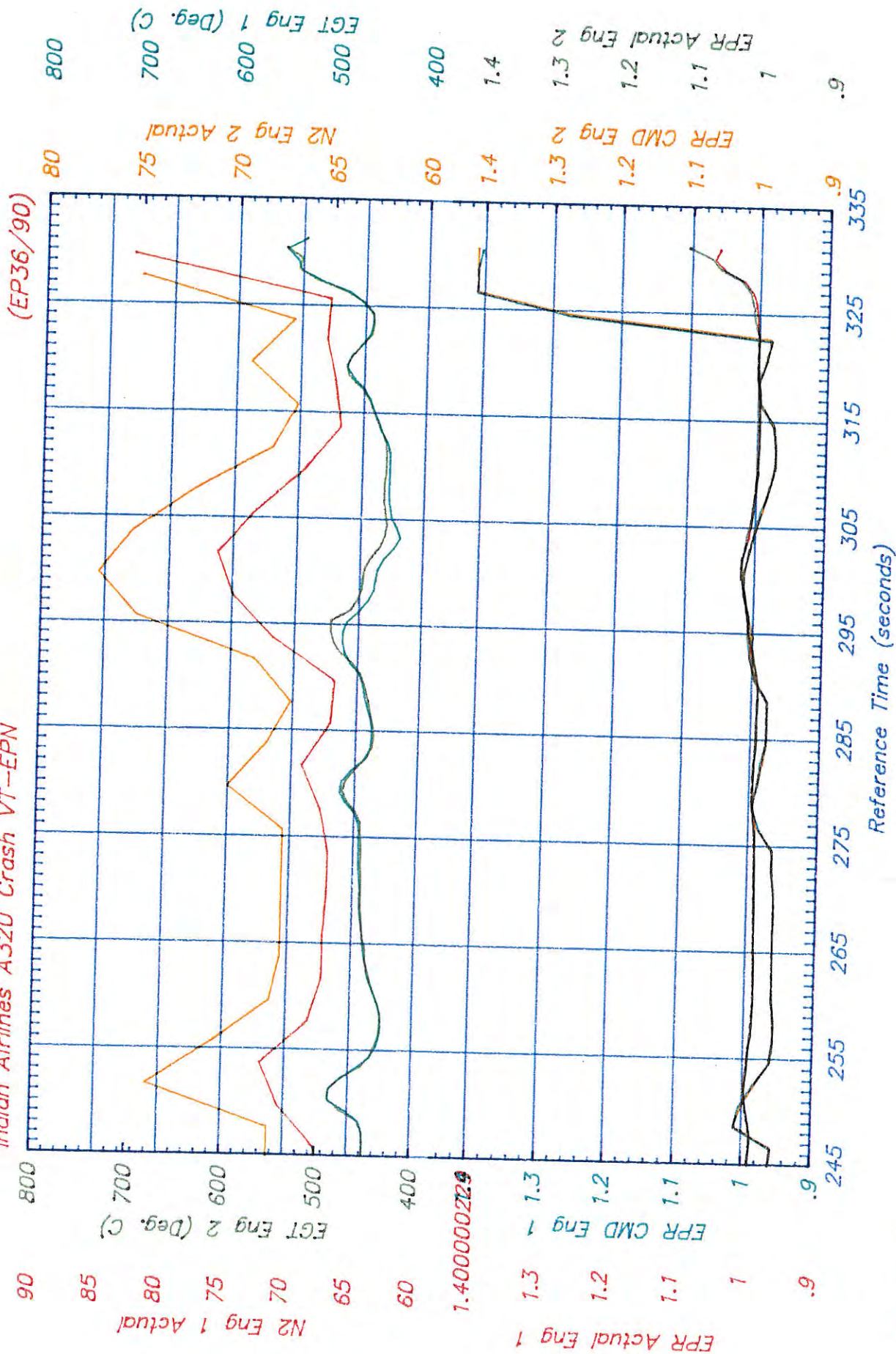


(7hrs:29.4min UTC)

Revised Data
Plotted: 15 MAR., 1990

Figure 12a

Indian Airlines A320 Crash VT-EPN



Revised Data
Plotted: 15 MAR., 1990