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DATA REDUCTION PROCEDURES FOR SEA KING HELICOPTER FLIGHT TRIALS--ETC(U)
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DEPARTMENT OF DEFENCE

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

AERONAUTICAL RESEARCH LABORATORIES

MELBOURNE, VICTORIA

Aerodynamics Technical Memorandum 338

DATA REDUCTION PROCEDURES FOR SEA KING HELICOPTER FLIGHT TRIALS

N. E. GILBERT

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DATA REDUCTION PROCEDURES FOR SEA KING HELICOPTER FLIGHT TRIALS

by

N. E. GILBERT

SUMMARY

The data reduction procedures used in obtaining fully processed data from raw flight data for trials on a Sea King Mk.50 helicopter are given. The procedures allow various corrections and calibrations to be applied, removal of noise, and calculation of many additional quantities, some of which are used for kinematic consistency checking purposes. Examples are provided on the running of the various computer programs developed. To assist in the use of the data for validation of the Sea King mathematical model, output is obtained in a form allowing ready comparison between trials and model results on the same graphs.

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CONTENTS

1. INTRODUCTION

Flight trials were conducted in 1979 by the Aeronautical Research Laboratories (ARL) on a Royal Australian Navy Sea King Mk.50 helicopter [1]. The primary aim of the trials was to record data which could be used to validate a mathematical model developed by ARL [2, 3]. The data acquisition system installed allowed 32 channels of data to be recorded on magnetic tape in serial digital form at a maximum sampling frequency of 60 Hz for any channel [4]. The purpose of this document is to describe the data reduction procedures used in obtaining fully processed data from raw flight data.

Section 2 describes how data for each flight record are converted, using a transcriber unit [5] and a transcription computer program, to a disk file form to enable ready processing on the DEC system-10 computer at ARL. The complete data reduction procedure, described in Section 3, may be divided into several stages. These are input and basic processing, correction for drop-outs, correction for instrument and analogue filter time delays, conversion to engineering units, digital filtering, smoothing, calculation of additional quantities, and output. Some of the additional quantities calculated are for kinematic consistency checking purposes [6]. This allows the degree of confidence in the flight data to be assessed and suitable corrections to instrument time lags and calibration constants to be made. Since reference is made to the axes systems in which both measured and calculated quantities are specified, these axes systems and their relative orientation are first defined in Fig. 1.

Examples of the running of the various processing computer programs form the contents of Section 4. These examples show how (a) information (e.g. calibration factors and offsets) is specified on the way in which each channel is processed, (b) the data reduction procedure is checked for correctness step-by-step, and (c) the fully processed data is output in various forms. Because the same general purpose output program [7, 8] is used for data obtained from both the flight trials and mathematical model, comparisons on the same graphs are readily made.

2. TRANSCRIPTION OF FLIGHT DATA FROM NAGRA TAPE TO DEC SYSTEM-10 DISK FILES

Flight data are recorded by the data acquisition system [4] on magnetic tape using a NAGRA tape recorder. The data are in serial form on two parallel tracks, as shown in Fig. 2. The system allows, without sub-multiplexing, 20 channels of data to be recorded in 12-bit form at a sampling frequency of 60 Hz for each channel. However, by sub-multiplexing each of three channels to record two separate quantities at 30 Hz, and each of another three to record four separate quantities at 15 Hz, 32 data source outputs are actually recorded.

In order to process the data on the DEC system-10 computer at ARL, two transcription processes are performed. Firstly, using a specially built transcriber unit [5], the data are converted from twin-track to single-track form, as shown in Fig. 3, and stored on computer compatible 7-track magnetic tape. Secondly, by running the program EFREE, each flight record on the 7-track magnetic tape is converted to a disk file. The program provides an automatic file labelling system whereby the user specifies the first one to three characters of a five character name, with the remaining characters forming a numerical sequence starting at one (e.g. if the first two characters are specified as 4T, the sequence of filenames would be 4T001, 4T002, 4T003,...). On subsequently running EFREE with the same initial character string, existing files are not overwritten and the numerical sequence is continued. Where checksum or parity errors are found, a file is still created, but with nil blocks. The following example † shows the use of EFREE when using a disk pack to store the disk files. In the example, before running EFREE, the 7-track magnetic tape and disk pack SK1 are first mounted and then assigned according to the requirements specified by EFREE. To enable the files to be written directly onto the disk pack, the user's disk area search list must first be modified by running the system program SETSRC. Following conversion of the last complete flight record on the 7-track tape, in attempting to read and transcribe another record, EFREE usually terminates because of an error condition.

```
.PLE CHECK MX MTA/TTR24

MESSAGE TRANSMITTED at 11:41

.PLE CHECK MOUNT DSKPACK SK1

MESSAGE TRANSMITTED at 11:42

.
;;OPR: - ON MTA3
.
;;OPR: - AND SK1 IS MOUNTED

.AS MTA3 MTI                  Assignment required by EFREE
MTA003 assigned
```

† In computer program examples, terminal responses typed by the user are underlined. Comments are shown in a different type face alongside the appropriate terminal message.

```
.REW MTI                Rewind magnetic tape

.AS DSK MTO             Assignment required by EFREE
DSK assigned

.R SETSRC

*T                      Type existing search list
DSKC:, DSKB:, FENCE
*C SK1,DSKC             Add SK1, before DSKC

*T                      Type new search list
SK1:, DSKC:, FENCE, DSKB:
*^C

.RU EFREE

ASSIGN INPUT MAGTAPE AS "MTI" AND OUTPUT MAGTAPE OR
DISK AS "MTO".
OK TO PROCEED? TYPE "C" TO CONTINUE, "S" TO STOP : C

 TYPE IN UP TO 3 CHAR FOR FILENAME : 24     Files 24001 to 24013 written
                                              onto disk pack SK1
?
?Hung device MTA003; UUO at user PC 006741  EFREE terminated by error
                                              condition
.
```

3. DESCRIPTION OF DATA REDUCTION PROCEDURE

The complete data reduction procedure may be divided into a number of separate stages. These are input and basic processing, correction for drop-outs, correction for instrument and analogue filter time delays, conversion to engineering units, filtering, smoothing, calculation of additional quantities, and output. Apart from system programs (e.g. PRINT, PLOTQ), the two computer programs REFINE and TRANS should be used each time data are processed. REFINE reads in and processes the flight data, storing the reduced data in binary form suitable for input to the general purpose output program TRANS [7, 8], which produces tabular and graphical output. Another program, called LABCAL, is used to create, or modify if already existing, a file containing information (e.g. calibrations), required by REFINE, that specifies how each channel is to be processed. The file is referred to as a calibration file. For checking purposes, a further program, called DDMP12, may be used to output raw flight data in both octal and decimal form. In this section, only the processing stages performed by REFINE are outlined. Examples on the running of REFINE, as well as the other three programs, form the contents of Section 4 below.

3.1 Input and Basic Processing

Data are read in the form of 36-bit words, each word combining three successive 12-bit words recorded on NAGRA tape (see Fig. 3). A complete block of 64 36-bit words, representing data for eight complete sampling time intervals, are read into a buffer at a time. If a read error occurs, the complete block is replaced by the block previously read. The original 12-bit words are then extracted from the 36-bit words.

The flight data record is assumed to start when the digital timing word (i.e. clock time) of consecutive frames is sequential. This condition may be satisfied by any of the four possible combinations of clock time for the two tracks over the two consecutive time frames (e.g. time given by Track 1 at first frame and time given by Track 2 at second frame). Previously recorded data are assumed spurious and therefore ignored. Following the start, clock time is defined by incrementing the value at the previous frame. If the actual values read for both tracks differ from their set value, a time error is recorded.

Signals are recorded from the channels in a regular sampling order at equi-spaced time increments throughout each complete sampling time interval of 1/60th second. However, it is assumed that all signals recorded within this sampling interval are at the clock time recorded at the beginning of the interval. Hence, a maximum relative time delay error of close to 1/60th second is tolerated.

Values for channels not recorded at a specific time, because of sub-multiplexing, are obtained by linear interpolation, which sllows a common sampling frequency of 60 Hz to be assumed. To enable interpolation for channels that are sub-multiplexed at the higher rate of 4 to 1, values at up to three time increments before and after the current time increment must be known. Hence, the flight record is reduced by three frames at both beginning and end (i.e. zero time is at the fourth frame).

The actual clock time is replaced by a time count which is set to zero at the beginning (i.e. fourth frame provided no starting delay is specified - see Section 3.8) of the flight record and is incremented by unity at each sampling interval. However, to enable certain checks to be made (see Section 4.2), the five least significant digits (in octal) of the clock time are represented directly as channel 33 without application of a calibration factor and offset.

3.2 Correction for Drop-outs

Having first obtained a flight record free of obvious reading errors, the next stage is to correct for less obvious ones caused by misplaced bits in the 12-bit binary words. These are referred to as 'drop-outs' and can only be detected when one of the most significant bits is misplaced.

For a sequence of signals x_o, x_1, x_2, which includes interpolated values for sub-multiplexed channels, a drop-out is considered to have occurred when

$$| x_2 - x_1 | > k_o + k_1 | x_1 - x_o |$$

where k_o and k_1 are constants determined appropriately by inspection of the flight data. For a 12-bit word, giving an integer value, or count, in the range 0 to 4095, values found generally appropriate were $k_o = 100$ and $k_1 = 5$. When a drop-out occurs, the current value is reset to its previous value, i.e. $x_2 = x_1$. The constants k_o and k_1 are stored for convenience in the calibration file in the location labelled CLOCK TIME, i.e. channel 33. It should be noted that these calibrations are not used in any way for the clock time.

3.3 Correction for Instrument and Analogue Filter Time Delays

Time delays requiring correction are inherent in some instrument outputs and are also introduced by the use of analogue filters in the data acquisition system. Consistent with inaccuracies already accepted by assuming that all signals are at the recorded clock time, these corrections are expressed in terms of complete sampling time intervals.

At present, the only instruments where significant inherent time delays are apparent in the signal output are those recording ground speed (i.e. longitudinal and lateral doppler velocity). As part of the post-flight kinematic consistency checking process [6], comparison of doppler velocity measurements with those obtained on integrating linear accelerometer measurements indicate a time delay correction of 33 sampling intervals (i.e. 0.55s).

Sixth-order analogue Butterworth lowpass filters were used on most channels in the data acquisition system, with cut-off frequencies of 3,6,and 12 Hz, generally corresponding to the sampling frequencies of 15,30, and 60 Hz. A description of the quantities measured, together with their sampling frequency and analogue filter cut-off frequency, are given in Table 1. For the purpose of obtaining data suitable for validation of the Sea King mathematical model [2,3], accurate correction of phase shift is considered necessary only at lower frequencies in the passband of each filter. In this region, the filters used have a reasonably linear phase response (Ref. 9, p.112) so that a constant time delay may be assumed. For the filters with cut-off frequencies of 3,6, and 12 Hz, the corresponding time delays are 12, 6, and 3 sampling intervals.

3.4 Conversion to Engineering Units

To convert each recorded output signal from an integer value x in the range 0 to 4095 to a corresponding value y in engineering units, the signal is first multiplied by a calibration factor c and then added to an offset value d, i.e.

$$y = cx + d$$

These calibration constants were obtained in the first place from manufacturer's specifications and special calibration tests. However, in the light of post-flight analysis (e.g. kinematic consistency checking), some adjustments were made [6].

3.5 Digital Filtering

Digital filtering procedures have been developed [10] to remove noise arising from rotor-induced vibration, such noise being excessive in some channels despite analogue pre-filtering. Digital Butterworth lowpass filters are used, optionally, with characteristics selected to suit the particular variable to be filtered. Phase shift is corrected on the assumption that it is proportional to frequency, i.e. there is a constant time shift. Two standard fifth-order filters have been found adequate for all channels. One has a high attenuation of 50 dB at the rotor frequency of 3.5 Hz, giving a low cut-off frequency of 1.12 Hz, and removes noise at and above the rotor frequency. It is suitable for variables where the energy is confined to relatively low frequencies. The other filter, which has a higher cut-off frequency of 4 Hz, is used alternatively where the high frequency content is significant.

3.6 Smoothing

Another means of removing noise [11] has been incorporated in the data reduction procedure. In the method, referred to as smoothing, each observation is replaced by the value lying on a polynomial curve fitted, using the least squares criterion, through a band of observations centred on the current observation. The implementation described in

Ref. 11[†] allows the time consuming operation of matrix inversion to be replaced by the use of recursive expressions. However, to avoid a significant accumulation of truncation errors with this method, the least squares parameters and covariance matrix are recalculated using matrix inversion after every 150 observations. As with filtering, smoothing for each channel is optional, with appropriate characteristics selected. Though intended as an alternative to filtering, the data may be smoothed following filtering. The main advantage smoothing has over filtering is that no phase shift is introduced. However, for the purpose of removing noise at known frequencies, filtering has been found to be more effective and less time consuming.

3.7 Calculation of Additional Quantities

There are a number of additional quantities that may be derived from the quantities actually measured in the data acquisition system. Some of these quantities are required for validation of the Sea King mathematical model, while others are necessary for confirmation of the consistency of the data itself in the measurement of kinematic quantities. The additional quantities are therefore divided into four groups, which include (1) quantities obtained using pressure measurements from a boom-mounted pitot-static probe, (2) blade angles, (3) Euler angles, and (4) quantities for kinematic consistency checking. Table 2 provides a list of each quantity belonging to the above four groups. Documentation on the calculation of the quantities is given in Ref. 1 for the first two groups and in Ref. 6 for the last two groups. Table 3 summarises the use made in the calibration file of the calibration factors and offsets for these additional quantities together with the measured quantities and clock time.

3.8 Output

The output of all channels for a complete flight record is often not required for reasons of economy of computing time, disk storage space, and hard copy output. The program REFINE therefore allows the user to restrict output to specific channels, either individually or as groups, and to a specific time range and interval. Though presenting proportional savings in disk storage space and hard copy output, these restrictions do not necessarily allow corresponding savings in computing time. The reasons for this are as follows. Firstly, even though some channels may not be required for output, they may still be required to be calculated in order to derive additional quantities dependent on them. Secondly, for an output interval greater than the sampling frequency, it is still necessary to calculate quantities (a) at each sampling time increment when filtering, smoothing, or correcting for time delays, and (b) at up to three time increments before

---

† In Equation (5) Ref. 11, the term subtracted from the covariance matrix should be multiplied by ξ.

and after the current time increment to enable interpolation for channels sub-multiplexed 4 to 1. It should also be noted that every frame of data must be read in up to the starting time, as well as beyond the upper time limit to allow for the maximum accumulated time delay.

Having obtained the required output in binary form from REFINE, the program TRANS is then used to convert the output into tabular and graphical form. Because TRANS is also used in the same way for the output of the Sea King mathematical model, comparisons between flight data and model prediction on the same graph(s) are readily made using the 'REPEAT' command facility. In doing this, however, assigned block numbers, corresponding to those used in the mathematical model, should be used for the flight data instead of channel numbers.

4. EXAMPLES OF USE OF COMPUTER PROGRAMS

The use of the four computer programs LABCAL, DDMP12, REFINE, and TRANS is now illustrated by examples, with the complete processing procedure divided into three stages. Firstly, the use of LABCAL is demonstrated in creating a calibration file and then modifying it. Secondly, initial checks on the correctness of the data reduction procedure are made by comparing uncalibrated data in integer form given directly by DDMP12 with those obtained using REFINE and TRANS. Having once established the correctness of the data reduction procedure, this stage is generally omitted when processing further flight records. Thirdly, subsequent processing is performed, again using REFINE and TRANS, in which various forms of output of fully processed data are produced.

4.1 Creating or Modifying Calibration File

The program LABCAL has been written to enable the calibration file required in a specific format by REFINE to be easily created, and then modified. In making modifications, the particular variable, or group of variables, to be modified is specified using a key number. These numbers are defined, when appropriate, by the terminal responses of LABCAL. The following example shows how such a file (Fig. 4), restricted here to four channels for brevity, may first be created.

```
.RU LABCAL

NUMBER OF CHANNELS (excluding TIME) = 4
CALIBRATION FILENAME = CAL4
[Creating new calibration file]
[To exit, type EXIT for label; unspecified information
 then stored as zeroes or blanks]
[If computer crashes, unspecified information stored as
 zeroes or blanks; re-run and modify]
[To include exceptions, re-run and modify]

TITLE (2 lines of 60 chrs)
:TEST CALIBRATION FILE
:4 CHANNELS ONLY
TIME LABEL (2 lines of 10 chrs)
:   TIME
:    (S)
TIME CAL FACTOR, OFFSET = 0.016667,0

[For no set plot limits, answer by typing "c-r"]

*** CHANNEL  1 ***
LABEL (2 lines of 10 chrs)
:  CHAN 1
:_
CAL FACTOR, OFFSET = 1,0
ASSIGNED BLK NUMBER = 1
PLOT LIMITS (LOWER, UPPER) = 0,10
FILTER FREQ (Hz), ATTENUATION (dB) = 3.5,50
NO. POLES = 5
NO. PNTS SMOOTHED, NO. PARAMS = _

*** CHANNEL  2 ***
LABEL (2 lines of 10 chrs)
:  CHAN 2
:_
CAL FACTOR, OFFSET = 0.12,-0.4
ASSIGNED BLK NUMBER = 5
PLOT LIMITS (LOWER, UPPER) = _
FILTER FREQ (Hz), ATTENUATION (dB) = _
NO. POLES = _
NO. PNTS SMOOTHED, NO. PARAMS = 9,2

*** CHANNEL  3 ***
LABEL (2 lines of 10 chrs)
:EXIT

STOP

END OF EXECUTION
CPU TIME: 2.00  ELAPSED TIME: 2:46.38
EXIT

.
```

In the above example, calibration information is specified only for the first two channels. By typing 'EXIT' for the first line of the label of channel 3, the unspecified information for channels 3 and 4 is stored as zeroes or blanks. To complete the calibration file (Fig. 5), it may be modified by again running LABCAL as follows.

```
.RU LABCAL


NUMBER OF CHANNELS (excluding TIME) = 4
CALIBRATION FILENAME = CAL4
[Calibration file already exists]

ARE MODIFICATIONS REQRD : Y
[Type Key no.; = 0 (all vars); = 1 (label - inc. title);
               = 2 (cal factor, offset); = 3 (assigned no.);
               = 4 (plot limits); = 5 (filter characteristics);
               = 6 (smoothing characteristics); = 7 (exceptions);
               = 8 (channel no.)]
[Channel no. -1 denotes TIME, -2 denotes TITLE]

KEY NUMBER = 0

CHANNEL NUMBER = 3
LABEL (2 lines of 10 chrs)
:  CHAN 3
:_
CAL FACTOR, OFFSET = 8.3,0.001
ASSIGNED BLK NUMBER = 24
PLOT LIMITS (LOWER, UPPER) = _
FILTER FREQ (Hz), ATTENUATION (dB) = 4.0,3.0
NO. POLES = 5
NO. PNTS SMOOTHED, NO. PARAMS = 9,3

CHANNEL NUMBER = 4
LABEL (2 lines of 10 chrs)
:  CHAN 4
:_
CAL FACTOR, OFFSET = 0.00254,-0.003
ASSIGNED BLK NUMBER = 2
PLOT LIMITS (LOWER, UPPER) = -2,2
FILTER FREQ (Hz), ATTENUATION (dB) = _
NO. POLES =_
NO. PNTS SMOOTHED, NO. PARAMS = _

CHANNEL NUMBER = _

ARE MODIFICATIONS REQRD : N

STOP

END OF EXECUTION
CPU TIME: 1.50  ELAPSED TIME: 8.24
EXIT
```

Because all the variables were required to be specified for channels 3 and 4 in the above example, a key number of 0 was used. Generally, when further modifications are required, one variable needs to be changed for one or more channels. For key numbers 1,2,3,5, and 6, the individual terminal messages typed by the program are identical to those given in the above example. For other key numbers, i.e. 4,7, and 8, further explanation is now given.

For key number 4, as well as being able to specify plot limits directly as above, they may be read from a specified disk file, in the format of a scale limits file for TRANS, i.e. TRANS.SCA or TRANS.SCL file. This facility allows plot limits that have been modified, or created, on running TRANS, to overwrite the limits originally specified in the calibration file.

Exceptions for calibration factors and offsets appropriate to a particular flight can only be specified by using key number 7. The exceptions are listed at the end of the calibration file.

It may be necessary to insert or delete quantities in the calibration file, thus requiring an incremental change in all channel numbers following the change. Key number 8 allows a range of channel numbers to be incremented by a constant amount, positive or negative. New quantities may then be inserted using a test editing program such as TECO. It should be noted that when using key number 8, the channel numbers in the exceptions list are unaffected and will need to be edited separately.

The following example illustrates the use of key numbers 4,7, and 8, with the resulting calibration file shown in Fig. 6.

```
.TYPE TRANS.SCA
   1  0.0000E+00  2.0000E+01
   3 -5.0000E+00  5.0000E+00

.RU LABCAL


NUMBER OF CHANNELS (excluding TIME) = 4
CALIBRATION FILENAME = CAL4
[Calibration file already exists]

ARE MODIFICATIONS REQRD : Y
[Type Key no.; = 0 (all vars); = 1 (label - inc. title);
               = 2 (cal factor, offset); = 3 (assigned no.);
               = 4 (plot limits); = 5 (filter characteristics);
               = 6 (smoothing characteristics); = 7 (exceptions);
               = 8 (channel no.)]
[Channel no. -1 denotes TIME, -2 denotes TITLE]
```

```
KEY NUMBER = 4
ARE PLOT LIMITS TO BE READ FROM DSK : N

CHANNEL NUMBER = 2
PLOT LIMITS (LOWER, UPPER) = -50,0

CHANNEL NUMBER = _

ARE MODIFICATIONS REQRD : Y
[Type Key no.; = 0 (all vars); = 1 (label - inc. title);
               = 2 (cal factor, offset); = 3 (assigned no.);
               = 4 (plot limits); = 5 (filter characteristics);
               = 6 (smoothing characteristics); = 7 (exceptions);
               = 8 (channel no.)]
[Channel no. -1 denotes TIME, -2 denotes TITLE]

KEY NUMBER = 4
ARE PLOT LIMITS TO BE READ FROM DSK : Y
FILENAME = TRANS.SCA
ARE ASSIGNED BLK NUMBERS USED : N

ARE MODIFICATIONS REQRD : Y
[Type Key no.; = 0 (all vars); = 1 (label - inc. title);
               = 2 (cal factor, offset); = 3 (assigned no.);
               = 4 (plot limits); = 5 (filter characteristics);
               = 6 (smoothing characteristics); = 7 (exceptions);
               = 8 (channel no.)]
[Channel no. -1 denotes TIME, -2 denotes TITLE]

KEY NUMBER = 7

CHANNEL NUMBER, FLIGHT NUMBER = 4,2
CAL FACTOR, OFFSET = 0.0254,-0.015

CHANNEL NUMBER, FLIGHT NUMBER = _

ARE MODIFICATIONS REQRD : Y
[Type Key no.; = 0 (all vars); = 1 (label - inc. title);
               = 2 (cal factor, offset); = 3 (assigned no.);
               = 4 (plot limits); = 5 (filter characteristics);
               = 6 (smoothing characteristics); = 7 (exceptions);
               = 8 (channel no.)]
[Channel no. -1 denotes TIME, -2 denotes TITLE]

KEY NUMBER = 8

CHANNEL NUMBER LIMITS; LOWER, UPPER = 3,4
ADJUSTMENT FOR EACH CHANNEL = 2

ARE MODIFICATIONS REQRD : N

STOP

END OF EXECUTION
CPU TIME: 2.70  ELAPSED TIME: 15.78
EXIT
```

4.2 Initial Check on Uncalibrated Data

In order to be able to check each stage of the data reduction procedure for correctness, a large degree of flexibility has been incorporated into REFINE. As a starting point in the checking process, the program DDMP12 is first used to obtain a tabulation (or dump) of unprocessed flight data in both octal and equivalent 12-bit decimal words. It should be noted that DDMP12 operates in terms of 128 36-bit word blocks, which are twice the size of the previously defined flight data blocks. Hence each block dumped will represent data for 16 time increments. For flight record 15025, a dump of the first block, given in Fig. 7, is obtained as follows.

```
.RU DDMP12

Input File ? : 15025
Block numbers you want dumped ? (Specify range. e.g. 4-7) : 1-1
Output File ? : 15025.DMP

END OF EXECUTION
CPU TIME: 0.79  ELAPSED TIME: 44.98
EXIT

.
```

Each line of the dump represents one frame or time increment. Individula words may be identified using the single-track form description in Fig. 3 and the sub-multiplexing key in Fig. 2. The program REFINE is then used with appropriate options selected for minimal processing to enable a comparison of results, given on running TRANS, with those already given by the dump. The new results will of course be formatted differently, with interpolated values shown for channels not recorded at a specific time because of sub-multiplexing. The calibration file CAL used when running REFINE for all flight data is shown in Fig. 8. However, for minimal processing, only the labelling information is actually required from this file.

The following example shows the use of REFINE and TRANS in producing minimally processed output, given in Fig. 9, for selected channels at the beginning of flight record 15025. Clock time, represented by channel 33 as the five least significant digits in octal, allows ready comparison between Fig. 7 and 9. Because the calibration factors and offsets are ignored, the units given in the channel labels are inappropriate.

In the example, it is assumed that the flight data file needs transferring from a specific area on the disk pack SK1 to the user's own disk area.

```
.PLE CHECK MOUNT DSKPACK SK1

MESSAGE TRANSMITTED at 16:37

.
;;OPR: - OK MOUNTED
 - - - - - - - - - - - - - - - - - - - - - - -
.R SETSRC


*T
DSKC:, DSKB:, FENCE
*A SK1:/NOWRITE                                   or   .COPY /X=SK1:[1031,1063]15025

*T
DSKC:, DSKB:, SK1:/NOWRITE, FENCE
*^C


.COPY /X=[1031,1063]15025
 - - - - - - - - - - - - - - - - - - - - - - -

.RU REFINE


INPUT DATA FILENAME = 15025
".DAT" OUTPUT FILENAME (w/o ext) = _        15025.DAT by default
TITLE (2 lines of 60 chrs)
:_                                          15025 by default
:RAW DATA IN COUNTS - NO DELAYS
ARE ASSIGNED BLK NUMBERS REQRD : N
CALIBRATION FILENAME = CAL
FLIGHT NUMBER = 3
DOES CHANNEL 18 MEASURE TORQUE : N
OUTPUT INTERVAL (in 60'ths of sec; e.g. 12 for 0.2 sec) = 1
STARTING TIME DELAY, NO. BLKS FIRST IGNORED = 0,0
TIME LIMIT = 0.3
IS FILTERING REQRD : N
IS SMOOTHING REQRD : N
ARE INSTRUMENT & ANALOGUE FILTER DELAY ADJUSTMENTS REQRD : N
ARE SCALES AND OFFSETS REQRD : N
ARE PLOT LIMITS REQRD : N
ARE DROP-OUTS TO BE CORRECTED : N
```

```
ARE ALL CHANNELS REQRD : N
CHANNEL NUMBERS REQRD FOR FOLLOWING GROUPS
[Set first value -ve if excluding]
[Set first value to -100 if none excluded]
  Instumentation data    ( 1 to 33) : 13,17,18,21,23,26,28,33
  Boom calculations      (34 to 40) : _
  Blade angles           (41 to 45) : _
  Euler angles           (46 to 47) : _
  Kinematic consistency  (48 to 70) : _
DATE =  2-Apr-82
TIME = 13:19
No. time corrections =    0           ┐
No. blocks replaced =    0            │ Error corrections in 15025.ERR
No. drop-out corrections =    0       ┘
STOP  000001

END OF EXECUTION
CPU TIME: 3.98  ELAPSED TIME: 23.24
EXIT

.RU PUB:TRANS


[TRANS version date 12-NOV-80]

I/P FILENAME = 15025

15025
RAW DATA IN COUNTS - NO DELAYS

I/P FILE RECORDED ON  2-Apr-82 AT 13:19

INTEGN INT = 0.0000E+00; RUN CPU TIME =  0.00 SEC.

TIME FROM 0.0000E+00 TO 3.0000E-01 IN STEPS OF 1.6667E-02

*PRC

PRINTING IN COLUMNS :

BLKS
A

IS O/P TO TTY REQRD : N

*GOE

** RUNNING **


*EXI

END OF EXECUTION
CPU TIME: 1.12  ELAPSED TIME: 2.70
EXIT
```

Having verified the correctness of the minimally processed data in Fig. 9, the various stages in the data reduction procedure may be verified one at a time. Though such checks have been performed, only the results of the next stage of the process are presented. Fig. 10 shows the data as in Fig. 9, except that instrument and analogue filter time delays are included. The clock time is now correctly referenced only to the channel(s) with the maximum time delay. In this case, channel 21 has a total time delay of 39 sampling increments (0.65s), which means adding 47 (in octal) to the clock time in Fig. 9 to arrive at the value in Fig. 10.

4.3 Subsequent Processing

Assuming that all stages of the data reduction procedure have been checked for correctness, REFINE may now be used with confidence to obtain fully processed data. The following example illustrates many of the capabilities of REFINE used together with TRANS in producing tabular and graphical output. Files containing filter characteristics and velocity iteration information are produced by REFINE in the example. The user should refer to Refs. 10 and 6 respectively for further information on the quantities printed. An additional 34 (in octal) should now be added to the clock time in Fig. 10 because of the additional time delay of 28 sampling increments (0.467 s) due to digital filtering (actual delay calculated is 0.459 s).

```
.RU REFINE


INPUT DATA FILENAME = 15025
".DAT" OUTPUT FILENAME (w/o ext) = _
TITLE (2 lines of 60 chrs)
:_
:_
ARE ASSIGNED BLK NUMBERS REQRD : N
CALIBRATION FILENAME = CAL
FLIGHT NUMBER = 3
DOES CHANNEL 18 MEASURE TORQUE : N
OUTPUT INTERVAL (in 60'ths of sec; e.g. 12 for 0.2 sec) = 6
STARTING TIME DELAY, NO. BLKS FIRST IGNORED = 0,0
TIME LIMIT = 8            zero or blank gives complete record
IS FILTERING REQRD : Y
IS OUTPUT OF FILTER CHARACTERISTICS REQRD : Y
ARE DIGITAL FILTER DELAY ADJUSTMENTS REQRD : Y
IS SMOOTHING REQRD : N
ARE INSTRUMENT & ANALOGUE FILTER DELAY ADJUSTMENTS REQRD : Y
ARE SCALES AND OFFSETS REQRD : Y
ARE PLOT LIMITS REQRD : Y
ARE DROP-OUTS TO BE CORRECTED : N
ARE ALL CHANNELS REQRD : Y
DATE =  5-Apr-82
TIME = 09:39
IS VELOCITY ITERATION INFORMATION REQRD : Y
ARE ANY FAULTY DATA TO BE REPLACED BY ALTERNATIVELY DERIVED DATA : N
```

```
No. time corrections =    0
No. blocks replaced =   0
No. drop-out corrections =   0
STOP  000001

END OF EXECUTION
CPU TIME: 1:33.78        ELAPSED TIME: 4:10.26
EXIT

.RU PUB:TRANS


[TRANS version date 12-NOV-80]

I/P FILENAME = 15025

15025

I/P FILE RECORDED ON  5-Apr-82 AT 09:39

INTEGN INT = 0.0000E+00; RUN CPU TIME =  0.00 SEC.

TIME FROM 0.0000E+00 TO 7.4000E+00 IN STEPS OF 1.0000E-01

*SCA

BLK NO. -1 DENOTES INDEP VARIABLE

ARE PLOT SCALE LIMITS TO BE READ FROM DSK : Y

IS TTY LISTING OF LIMITS REQRD : N

ARE MODIFICATIONS REQRD : Y

BLK, LOWER, UPPER
15,-20,20
21,40,80
29,20,60
37,1900,2100
38,60,100
39,0,20
50,-10,10
54,-10,10
55,-10,10
57,-10,10
58,-10,10
60,40,80
63,40,80
64,1900,2100
67,-10,10

*LIST

BLOCK LIST NUMBER = 1

LIST OF BLOCK NUMBERS = 1,2,3,16,5,6,7,27
```

```
BLOCK LIST NUMBER = 2

LIST OF BLOCK NUMBERS = 8,11,17,15,10,18,29,30

BLOCK LIST NUMBER = 3

LIST OF BLOCK NUMBERS = 12,13,14,41,42,45,44

BLOCK LIST NUMBER = 4

LIST OF BLOCK NUMBERS = 21,22,37,38,39,40,4,9

BLOCK LIST NUMBER = 5

LIST OF BLOCK NUMBERS = 54,55,56,57,58,59,62,63

BLOCK LIST NUMBER = _

*TIM

TIME PARAMS; LOWER, UPPER, INTERVAL = 0,8,0.5

*PRC

PRINTING IN COLUMNS :

BLKS
13,17,18,21,23,26,28,33

IS O/P TO TTY REQRD : N

*SCA

BLK NO. -1 DENOTES INDEP VARIABLE

ARE PLOT SCALE LIMITS TO BE READ FROM DSK : Y

IS TTY LISTING OF LIMITS REQRD : N

ARE MODIFICATIONS REQRD : N

*SPA

IS SPACING BETWEEN PLOTS REQRD : N
- - - - - - - - - - - - - - - - - - - - - - - - -
*PLS        Output to 15025.PLT (see Fig. 14)

STRIP PLOTS :

BLKS
L1
_

TO SPECIFY NO. OF X UNITS/INCH, TYPE 0 FOR X             Repeated for block
                                                          lists L2 - L5
LENGTH OF AXES IN INCHES; X, Y = 0,1
```

```
MIN X, NO. OF X UNITS/INCH = 0,2

ARE SYMBOLS REQRD FOR PLOTS : N

LINE KEY (0 GIVES DEFAULT) = 0

*GOE

** RUNNING **
   |
   |
   |
*EXI

END OF EXECUTION
CPU TIME: 22.84 ELAPSED TIME: 4:1.94
EXIT

.
```

For kinematic consistency checking, with alternatively derived quantities shown on the same graphs, TRANS may be run again as follows.

```
.RU PUB:TRANS


[TRANS version date 12-NOV-80]

I/P FILENAME = 1502.

15025

I/P FILE RECORDED ON  5-Apr-82 AT 10:04

INTEGN INT = 0.0000E+00; RUN CPU TIME =  0.00 SEC.

TIME FROM 0.0000E+00 TO 7.4000E+00 IN STEPS OF 1.0000E-01

*SCA

BLK NO. -1 DENOTES INDEP VARIABLE

ARE PLOT SCALE LIMITS TO BE READ FROM DSK : Y
```

```
IS TTY LISTING OF LIMITS REQRD : N

ARE MODIFICATIONS REQRD : N

*SPA

IS SPACING BETWEEN PLOTS REQRD : N

*PLO                          See Fig. 15

[PLS/O Output, for this run, going to DSK:15025.PLO]

OVERLAY PLOTS :

BLKS
46,68

BLKS TO DETERMINE Y SCALE
46

TO SPECIFY NO. OF X UNITS/INCH, TYPE 0 FOR X

LENGTH OF AXES IN INCHES; X, Y = 0,2

MIN X, NO. OF X UNITS/INCH = 0,2

ARE SYMBOLS REQRD FOR PLOTS : N

LINE KEY (0 GIVES DEFAULT) = 0

*GOE

** RUNNING **

*EXI

END OF EXECUTION
CPU TIME: 30.64  ELAPSED TIME: 6:51.10
EXIT

.
```

Repeated for blocks

15,69
47,70
11,51
8,52
17,53
21,60
22,61
37,64

On subsequently re-running REFINE with the same ".DAT" output filename, the existing filenames 15025.DAT and 15025.ERR are first renamed to OLD.DAT and OLD.ERR respectively.

5. CONCLUDING REMARKS

Data reduction procedures used in obtaining fully processed data from raw flight data for trials on a Sea King Mk.50 helicopter have been presented. The trials were conducted for the purpose of validating the Sea King mathematical model. The procedures may be divided into a number of stages, which allow various corrections and calibrations to be applied, removal of noise using digital filtering or 'least squares' smoothing, and calculation of many additional quantities. Some of these quantities are required for validation of the mathematical model, while others are necessary for confirmation of the consistency of the data itself in the measurement of kinematic quantities. The use of the various computer programs developed has been illustrated by examples. The two principle programs, REFINE and TRANS, should be used each time data are processed. REFINE reads in and processes the flight data, storing the reduced data in binary form suitable for input to the general purpose output program TRANS, which produces tabular and graphical output. With REFINE, the facility for excluding one or more processing stages has been found very useful in checking the correctness of each of these stages. TRANS, which is also used to obtain output for the mathematical model, has been found sufficiently versatile in providing multi-curve plots on the same graph. These plots may represent more than one variable in a single flight data record, as required when checking for kinematic consistency, or the same variable from a number of different files, as when comparing flight trials data with mathematical model results.

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TABLE 1

Quantities measured by data acquisition system

Channel number	Quantity measured	Symbol	Sampling freq.(Hz)	Analogue filter cut-off freq.(Hz)
1	Cyclic stick position - pitch	θ_{stk}	60	12
2	Cyclic stick position - roll	ϕ_{stk}	60	12
3	Collective stick position	θ_{Cstk}	60	12
4	Angle of attack	α	60	12
5	Fore-aft (pitch) push-pull rod position	d_{auxp}	60	3+
6	Lateral (roll) push-pull rod position	d_{auxr}	60	12
7	Collective (altitude) push-pull rod position	d_{auxa}	60	12
8	Pitch rate	q	60	12
9	Sideslip angle	β	60	12
10	Roll attitude	ϕ'	60	12
11	Roll rate	p	60	12
12	Longitudinal acceleration	a_{long}	60	12
13	Lateral acceleration	a_{lat}	60	12
14	Vertical acceleration	a_{vert}	60	12
15	Pitch attitude (Euler angle)	θ	30	6
16	Yaw pedal position	d_{ped}	30	6
17	Yaw rate	r	30	6
18*	Yaw attitude (heading)	ψ'	30	-
19	Lateral cable angle	ϕ_{cH}	30	6
20	Longitudinal cable angle	θ_{cH}	30	6
21	Doppler longitudinal velocity	u'	15	6
22	Doppler lateral velocity	v'	15	6
23	Boom probe dynamic pressure	q_b	15	12
24	Radio altitude (raw)	h_{rad}	15	3
25	Radio altitude (smooth)	$\bar{h}_{rad}$	15	3
26	Boom probe absolute pressure	p_b	15	3
27	Yaw push-pull rod position	d_{auxy}	15	12†
28	Ambient temperature	T_{amb}	15	-

TABLE 1 (CONT.)

Channel number	Quantity measured	Symbol	Sampling freq. (Hz)	Analogue filter cut-off freq. (Hz)
29	Torque - Engine 1	Q_1	15	-
30	Rotor r.p.m.	N_R	15	-
31	Towed probe dynamic pressure	q_t	15	3
32	Boom probe - towed probe differential pressure	Δp	15	3
33	Clock time - in octal (5 least signif. digits)	t_{clock}	60	-

* Switch selectable alternative measurement of 'Torque - Engine 2' (Q_2)

† Filters inadvertently interchanged.

Notes:

1. Push-pull rod positions represent auxiliary servo displacements.
2. Acceleration measurements include gravitational effects.
3. Pitch and roll attitude are relative to the vertical (hence roll attitude is not an Euler angle).
4. Linear accelerations and angular velocities are in body axes.
5. Doppler velocities are in moving earth axes.
6. Cable angles are measured with respect to the funnel axis of symmetry.

TABLE 2

Additional quantities calculated

Channel number	Quantity calculated	Symbol	Group
34	Airspeed from boom probe at standard sea level conditions, corrected for position error	V_c	1
35	Altimeter setting [12]	QNH	1
36	Sea level temperature	T_o	1
37	Altitude from boom probe static pressure	h_b	1
38	True airspeed at aircraft altitude	V_A	1
39	Wind velocity	V_W	1
40	Direction from which wind is coming	ψ_W	1
41	Longitudinal cyclic blade pitch angle	B_{1s}	2
42	Lateral cyclic blade pitch angle	A_{1s}	2
43	Collective blade pitch angle	θ_C	2
44	Tail rotor collective blade pitch angle	θ_T	2
45	Collective blade pitch angle at 75% rotor radius position	θ_{C75}	2
46	Yaw Euler angle	ψ	3
47	Roll Euler angle	ϕ	3
48	Yaw Euler angle derivative - by differentiation	$\dot{\psi}_D$	4
49	Pitch Euler angle derivative - by differentiation	$\dot{\theta}_D$	4
50	Roll Euler angle derivative - by differentiation	$\dot{\phi}_D$	4
51	Roll rate - by differentiation	p_D	4
52	Pitch rate - by differentiation	q_D	4
53	Yaw rate - by differentiation	r_D	4
54	Longitudinal inertial acceleration	a_x	4
55	Lateral inertial acceleration	a_y	4
56	Vertical inertial acceleration	a_z	4
57	Longitudinal velocity derivative	$\dot{u}$	4
58	Lateral velocity derivative	$\dot{v}$	4
59	Vertical velocity derivative	$\dot{w}$	4
60	Longitudinal velocity - by integration (in moving earth axes)	u'_I	4

TABLE 2 (CONT.)

Channel number	Quantity Calculated	Symbol	Group
61	Lateral velocity - by integration (in moving earth axes)	v'_I	4
62	Vertical velocity - by integration (in moving earth axes)	w'_I	4
63	Horizontal velocity magnitude $(u'^2_I+v'^2_I)^{\frac{1}{2}}$	V'_I	4
64	Height - by integration	h_I	4
65	Yaw Euler angle derivative	$\dot{\psi}$	4
66	Pitch Euler angle derivative	$\dot{\theta}$	4
67	Roll Euler angle derivative	$\dot{\phi}$	4
68	Yaw Euler angle - by integration	ψ_I	4
69	Pitch Euler angle - by integration	θ_I	4
70	Roll Euler angle - by integration	ϕ_I	4

Notes: 1. Linear accelerations, linear velocity derivatives, and angular velocities are in body axes, unless otherwise stated.

2. Euler angles are measured with respect to earth axes.

TABLE 3

Use of calibration factors and offsets

Channel number(s)	Use
1 - 32	Standard, i.e. $y = cx + d$
33	Drop-out correction constants (see Section 3.2) with $c = k_o$, $d = k_1$
34	Airspeed given by $y = c\ y(23) + d$ where dynamic pressure $q_b = y(23)$
35	Altimeter setting given by $y = c = QNH$
36	Sea level temperature given by $y = c = T_o$
37	d = offset for altitude obtained from boom probe static pressure
38 - 53	No use made, i.e. $c = d = 0$
54 - 56	$d(54) - d(56)$ give offset displacement coordinates of accelerometers from c.g. position [6]
57 - 70	No use made, i.e. $c = d = 0$

Note: x = output signal (integer value 0 - 4095)

y = output signal (engineering units)

c = calibration factor

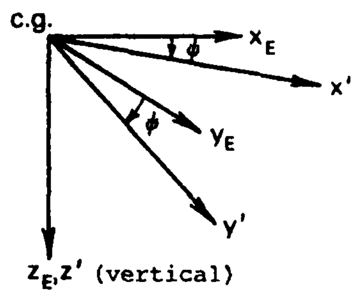
d = offset

Number in brackets following any of above symbols specifies particular channel.

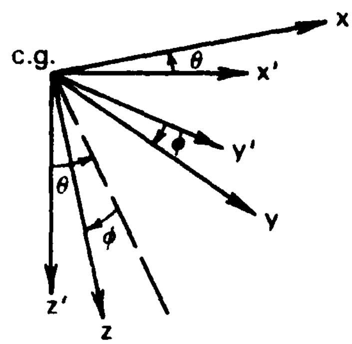
Axes $x_E\ y_E\ z_E$ – earth (inertial) axes

$x'\ y'\ z'$ – moving earth axes

$x\ y\ z$ – body (helicopter fuselage) axes



a) Moving earth axes relative to earth axes (earth axes translated such that origin is at c.g.)



b) Body axes relative to moving earth axes

Notes:

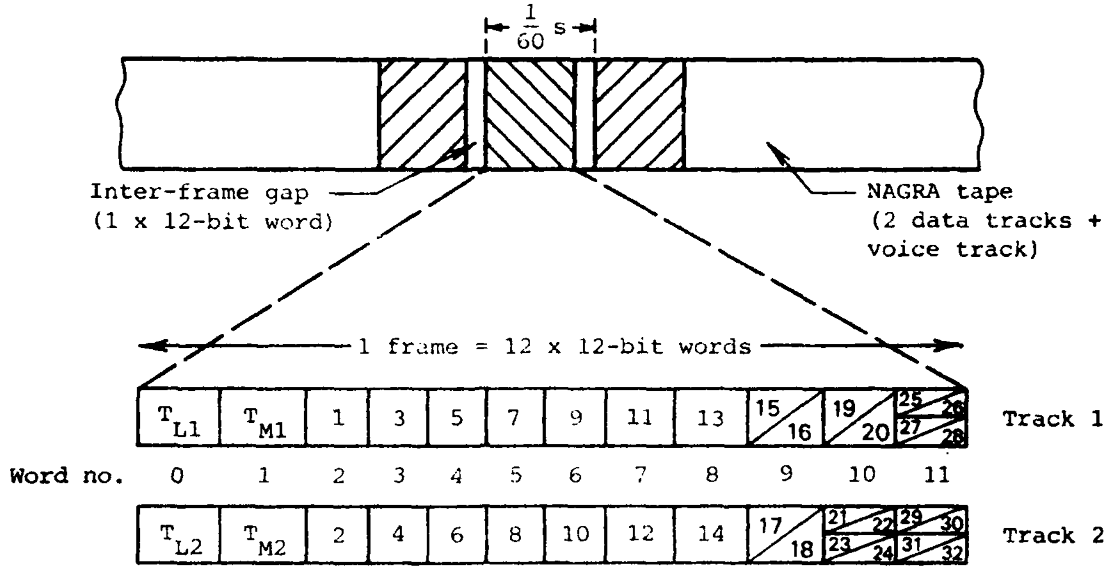
1. All axes systems are right-handed orthogonal.

2. Horizontal x' axis always lies in fuselage longitudinal plane of symmetry (positive forward).

3. Moving earth axes coincide with earth axes at initial time.

4. Orientation of body axes relative to earth axes are defined in conventional way for aircraft, i.e. sucessive rotations in yaw ψ, pitch θ, and roll ϕ. Moving earth axes represent first intermediate stage, i.e. rotation in yaw ψ.

FIG. 1 Definition of axes systems and their relative orientation.



Notes:

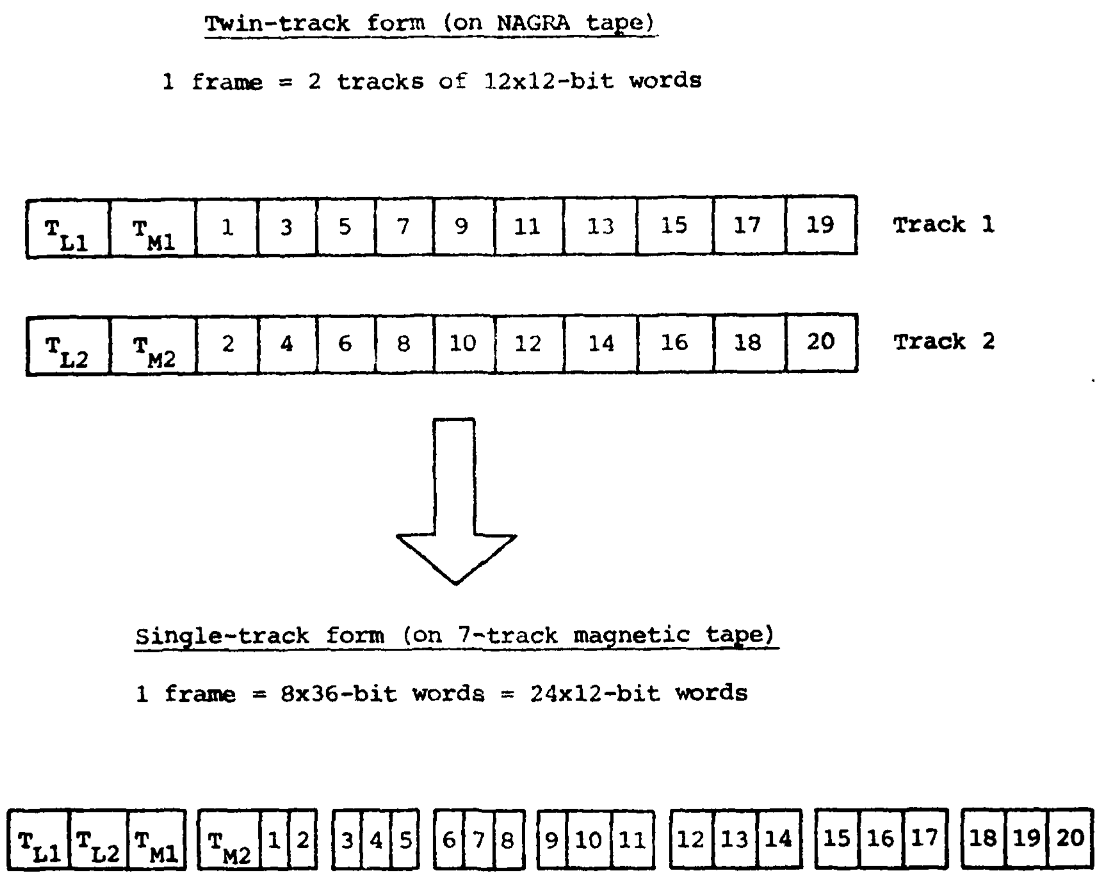
1. Numbers shown in each word box are transducer channel numbers (i.e. after sub-multiplexing).

2. First 2 words of any frame on each track form a digital timing word when reversed in order (T_{L1} is 'least' signif. word, T_{M1} is 'most' signif. word, both for Track 1).

3. Last 3 words of any frame on each track are sub-multiplexed either 2:1 or 4:1 depending on 2 least significant bits of digital timing word as follows:-

Timing bits	Least signif. timing digit (octal)	Channels recorded	
		Track 1	Track 2
00	0 or 4	15 19 25	17 21 29
01	1 or 5	16 20 26	18 22 30
10	2 or 6	15 19 27	17 23 31
11	3 or 7	16 20 28	18 24 32

FIG. 2 Format of data as recorded on NAGRA tape recorder.



Note: Numbers shown in each word box are channel numbers before sub-multiplexing.

FIG. 3 Conversion of data from twin-track to single-track form.

TITLE (2 lines of 60 chrs)
TEST CALIBRATION FILE
4 CHANNELS ONLY
[Channel no. -1 denotes time]

Channel No.	Label	Cal Factor, Offset	Assigned No.	Plot Limits (Lower,Upper)	Filter Characteristics (Freq, Atten) (No. Poles)	Smoothing Characteristics (No. Pts Smoothed) (No. Params)
-1	TIME	1.6667E-02				
	(S)	0.0000E+00				
1	CHAN 1	1.0000E+00	1	0.0000E+00	3.5000E+00 5.0000E+01	
		0.0000E+00		1.0000E+01	5	
2	CHAN 2	1.2000E-01	5			9
		-4.0000E-01				2
3		0.0000E+00	0			
		0.0000E+00				
4		0.0000E+00	0			
		0.0000E+00				

EXCEPTIONS

Channel No.	Flight No.	Cal Factor	Offset

FIG. 4 Newly created calibration file CAL4

TITLE (2 lines of 60 chrs)
TEST CALIBRATION FILE
4 CHANNELS ONLY
[Channel no. -1 denotes time]

Channel No.	Label	Cal Factor, Offset	Assigned No.	Plot Limits (Lower,Upper)	Filter Characteristics (Freq, Atten) (No. Poles)		Smoothing Characteristics (No. Pts Smoothed) (No. Params)
-1	TIME	1.666 E-02					
	(S)	0.0000E+00					
1	CHAN 1	1.0000E+00	1	0.0000E+00	3.5000E+00	5.0000E+01	
		0.0000E+00		1.0000E+01	5		
2	CHAN 2	1.2000E-01	5				9
		-4.0000E-01					2
3	CHAN 3	8.3000E+00	24		4.0000E+00	3.0000E+00	9
		1.0000E-03			5		3
4	CHAN 4	2.5400E-03	2	-2.0000E+00			
		-3.0000E-03		2.0000E+00			

EXCEPTIONS

Channel No.	Flight No.	Cal Factor	Offset

FIG. 5 Initially modified calibration file CAL4

TITLE (2 lines of 60 chrs)
TEST CALIBRATION FILE
4 CHANNELS ONLY
[Channel no. -1 denotes time]

Channel No.	Label	Cal Factor, Offset	Assigned No.	Plot Limits (Lower, Upper)	Filter Characteristics (Freq, Atten) (No. Poles)		Smoothing Characteristics (No. Pts Smoothed) (No. Params)
-1	TIME	1.6667E-02					
	(S)	0.0000E+00					
1	CHAN 1	1.0000E+00	1	0.0000E+00	3.5000E+00	5.0000E+01	
		0.0000E+00		2.0000E+01	5		
2	CHAN 2	1.2000E-01	5	-5.0000E+01			9
		-4.0000E-01		0.0000E+00			2
5	CHAN 3	8.3000E+00	24	-5.0000E+00	4.0000E+00	3.0000E+00	9
		1.0000E-03		5.0000E+00	5		3
6	CHAN 4	2.5400E-03	2	-2.0000E+00			
		-3.0000E-03		2.0000E+00			

EXCEPTIONS

Channel No.	Flight No.	Cal Factor	Offset
4	2	2.5400E-02	-1.5000E-02

FIG. 6 Subsequently modified calibration file CAL4

File:15025 Block - 1 13:30 9-Mar-82

***** Octal Dump *****

173217320015	001547633554	421636673430	417441414173	356137273747	377537773465	374736675464	454235463777
173317330015	001547633554	421636703427	417341414172	356337303744	400037703465	343773110101	000034323732
173417340015	001547643551	421736723426	417341414172	356637303754	377637573465	374737035465	173300004676
173517350015	001547643554	421736733427	417341414162	356537303755	377237723464	343673120100	347235422735
173617360015	001547643557	421736733427	417341414160	357037273726	377240013463	374637055463	454335503777
173717370015	001547643562	421636663427	417341414206	357137273714	377440103465	343673070100	000034373732
174017400015	001547633567	421636633427	417441414204	357037303732	377340153466	374636745470	173600004673
174117410015	001547613570	421636663426	417341414176	356537303750	377440143465	343773110102	347335372731
174217420015	001547623572	421636703426	417441414203	356637273741	400040103467	374636605477	453235473777
174317430015	001547613571	421636663426	417741404201	356737273745	400140043470	344373110102	000034403732
174417440015	001547613570	421636663425	417641414176	356537233750	400040003465	374536645500	174000004701
174517450015	001547623567	421736713426	417741414213	356537263732	400037663463	345373120102	350035432737
174617460015	001547623567	421736703426	420041414213	356737263732	377737663467	374537015472	455635473777
174717470015	001547643570	421736653425	420141414147	356637263757	377137743465	346573120102	000034133732
175017500015	001547653571	422036703425	420241414133	356337253763	377140063464	374537055463	174000004676
175117510015	001547653571	421737103425	420241414175	356337253747	377640113466	347473110103	347535422734

***** 12-bit bytes (decimal) *****

986, 986,	13	13,2547,1900	2190,1975,1816	2172,2145,2171	1905,2007,2023	2045,2047,1845	2023,1975,2868	2402,1894,2047
987, 987,	13	13,2547,1900	2190,1976,1815	2171,2145,2170	1907,2008,2020	2048,2040,1845	1823,3785, 65	0,1819,2010
988, 988,	13	13,2548,1897	2191,1978,1814	2171,2145,2170	1910,2008,2028	2046,2039,1845	2023,1987,2869	987, 0,2494
989, 989,	13	13,2548,1900	2191,1979,1815	2171,2145,2162	1909,2008,2029	2042,2042,1844	1822,3786, 64	1850,1890,1501
990, 990,	13	13,2548,1903	2191,1979,1815	2171,2145,2160	1912,2007,2006	2042,2049,1843	2022,1989,2867	2403,1896,2047
991, 991,	13	13,2548,1906	2190,1974,1815	2171,2145,2182	1913,2007,1996	2044,2056,1845	1822,3783, 64	0,1823,2010
992, 992,	13	13,2547,1911	2190,1971,1815	2172,2145,2180	1912,2008,2010	2043,2061,1846	2022,1980,2872	990, 0,2491
993, 993,	13	13,2545,1912	2190,1974,1814	2171,2145,2174	1909,2008,2024	2044,2060,1845	1823,3785, 66	1851,1887,1497
994, 994,	13	13,2546,1914	2190,1976,1814	2172,2145,2179	1910,2007,2017	2048,2056,1847	2022,1968,2879	2394,1895,2047
995, 995,	13	13,2545,1913	2190,1974,1814	2175,2144,2177	1911,2007,2021	2049,2052,1848	1827,3785, 66	0,1824,2010
996, 996,	13	13,2545,1912	2190,1974,1813	2174,2145,2174	1909,2003,2024	2048,2048,1845	2021,1972,2880	992, 0,2497
997, 997,	13	13,2546,1911	2191,1977,1814	2175,2145,2187	1909,2006,2010	2048,2038,1843	1835,3786, 66	1856,1891,1503
998, 998,	13	13,2546,1911	2191,1976,1814	2176,2145,2187	1911,2006,2010	2047,2038,1847	2021,1985,2874	2414,1895,2047
999, 999,	13	13,2548,1912	2191,1973,1813	2177,2145,2151	1910,2006,2031	2041,2044,1845	1845,3786, 66	0,1803,2010
1000,1000,	13	13,2549,1913	2192,1976,1813	2178,2145,2139	1907,2005,2035	2041,2054,1844	2021,1989,2867	992, 0,2494
1001,1001,	13	13,2549,1913	2191,1992,1813	2178,2145,2173	1907,2005,2023	2046,2057,1846	1852,3785, 67	1853,1890,1500

FIG. 7 File 15025.DMP giving dump of first block of flight record 15025

TITLE (2 lines of 60 chrs)
FLIGHT 5 WITH EXCEPTIONS FOR OTHER FLIGHTS AT END. CH 16 MAY
BE SET (IN REFINE) TO TORQUE(2) USING CAL CONSTS FOR CH 19
(Channel no. -1 denotes time)

Channel No.	Label	Cal Factor, Offset	Assigned No.	Plot Limits (Lower, Upper)	Filter Characteristics (Freq, Atten) (No. Poles)	Smoothing Characteristics (No. Pts Smoothed) (No. Params)
-1	TIME (S)	1.6667E-02 0.0000E+00				
1	PITCH STK (DEG)	1.0690E-02 -2.2100E+01	276	-1.0000E+01 1.0000E+01		
2	ROLL STK (DEG)	1.0690E-02 -2.4600E+01	277	-1.0000E+01 1.0000E+01		
3	COLL STK (DEG)	-5.4900E-03 2.0700E+01	278	0.0000E+00 2.0000E+01		
4	PITCH VANE (DEG)	-4.4700E-02 8.7300E+01	504	-2.0000E+01 2.0000E+01	3.5000E+00 5.0000E+01 5	
5	F-A PPR (FT)	-4.3330E-05 9.8300E-02	505	-5.0000E-02 5.0000E-02		
6	LAT PPR (FT)	4.9000E-05 -1.2750E-01	506	-5.0000E-02 5.0000E-02		
7	COLL PPR (FT)	6.3080E-05 -1.5800E-02	507	0.0000E+00 2.0000E-01		
8	PITCH RATE (DEG/S)	-1.5000E-02 3.2700E+01	279	-1.0000E+01 1.0000E+01	3.5000E+00 5.0000E+01 5	17 3
9	SSLIP VANE (DEG)	-4.4700E-02 8.7300E+01	509	-2.0000E+01 2.0000E+01	3.5000E+00 5.0000E+01 5	
10	ROLL ATT (DEG)	2.0750E-02 -4.2300E+01	510	-2.0000E+01 2.0000E+01	3.5000E+00 5.0000E+01 5	17 3
11	ROLL RATE (DEG/S)	-3.0300E-02 6.1440E+01	280	-2.0000E+01 2.0000E+01	3.5000E+00 5.0000E+01 5	17 3
12	LONG ACC (FT/S**2)	-1.5880E-01 3.2570E+02	512	-1.0000E+01 1.0000E+01	3.5000E+00 5.0000E+01 5	
13	LAT ACC (FT/S**2)	-1.5710E-01 3.2180E+02	513	-1.0000E+01 1.0000E+01	3.5000E+00 5.0000E+01 5	
14	VERT ACC (FT/S**2)	1.5710E-01 -3.2185E+02	514	-4.0000E+01 -2.0000E+01	3.5000E+00 5.0000E+01 5	
15	PITCH ATT (DEG)	-2.1000E-02 4.4600E+01	282	-2.0000E+01 2.0000E+01	3.5000E+00 5.0000E+01 5	17 3
16	YAW PEDAL (FT)	1.8190E-04 -3.8800E-01	72	-1.0000E-01 1.0000E-01		
17	YAW RATE (DEG/S)	1.6400E-02 -3.3090E+01	281	-1.0000E+01 1.0000E+01	3.5000E+00 5.0000E+01 5	17 3
18	YAW ATT (DEG)	8.8400E-02 -6.9000E+01	518	-2.0000E+02 2.0000E+02	3.5000E+00 5.0000E+01 5	17 3
19	LAT C ANG (DEG)	-1.3940E-02 3.6700E+01	285	-1.0000E+01 1.0000E+01	3.5000E+00 5.0000E+01 5	
20	LONG C ANG (DEG)	5.5400E-03 -1.1100E+01	286	-1.0000E+01 1.0000E+01	3.5000E+00 5.0000E+01 5	
21	LONG DOPP (KN)	-6.6400E-02 1.3600E+02	287	0.0000E+00 1.0000E+02	3.5000E+00 5.0000E+01 5	
22	LAT DOPP (KN)	-3.6400E-02 7.4000E+01	288	-2.0000E+01 2.0000E+01	3.5000E+00 5.0000E+01 5	
23	DYN PRESS (PSI)	-9.5500E-05 3.6600E-01	523	0.0000E+00 4.0000E-01	3.5000E+00 5.0000E+01 5	
24	RAD ALT RW (FT)	-2.6600E-01 5.5300E+02	289	0.0000E+00 4.0000E+02	3.5000E+00 5.0000E+01 5	
25	RAD ALT SM (FT)	-1.6300E-01 3.3500E+02	525	0.0000E+00 4.0000E+02	3.5000E+00 5.0000E+01 5	
26	ABS PRESS (PSI)	-9.2500E-04 1.5800E+01	526	1.3000E+01 1.5000E+01	3.5000E+00 5.0000E+01 5	
27	YAW PPR (FT)	4.9000E-05 -1.1250E-01	527	-5.0000E-02 5.0000E-02		

FIG. 8 Calibration file CAL used for all flight data

28	AMB TEMP	1.2200E-02	528	1.0000E+01	3.5000E+00	5.0000E+01
	(DEG C)	-1.1000E+01		3.0000E+01		5
29	TORQUE(1)	-3.9300E-02	212	4.0000E+01	3.5000E+00	5.0000E+01
	(PERCENT)	1.4110E+02		8.0000E+01		5
30	ROTOR RPM	1.1450E-02	290	1.0200E+02	3.5000E+00	5.0000E+01
	(PERCENT)	8.5200E+01		1.0600E+02		5
31	TOWED DYN	-1.3890E-04	531	0.0000E+00	3.5000E+00	5.0000E+01
	(PSI)	5.1000E-01		4.0000E-01		5
32	TOWED DIFF	-4.8800E-05	532	0.0000E+00	3.5000E+00	5.0000E+01
	(PSI)	1.0000E-01		1.0000E-01		5
33	CLOCK TIME	5.0000E+00	533			
	(OCTAL)	1.0000E+02				
34	AIRSPEED	2.0620E+02	534	0.0000E+00		
	(KN)	7.5000E+00		1.0000E+02		
35	QNH	1.0230E+03	535			
	(MB)	0.0000E+00				
36	S L TEMP	[illegible]	536			
	(DEG C)	0.0000E+00				
37	ALTITUDE	0.0000E+00	291	0.0000E+00		
	(FT)	2.7000E+02		4.0000E+03		
38	T.A.S.	0.0000E+00	538	0.0000E+00		
	(KN)	0.0000E+00		1.0000E+02		
39	WIND VEL	0.0000E+00	539	0.0000E+00		
	(KN)	0.0000E+00		4.0000E+01		
40	WIND DIRN	0.0000E+00	540	-1.8000E+02		
	(DEG)	0.0000E+00		1.8000E+02		
41	BIS	0.0000E+00	292	-1.0000E+01		
	(DEG)	0.0000E+00		1.0000E+01		
42	AIS	0.0000E+00	293	-1.0000E+01		
	(DEG	0.0000E+00		1.0000E+01		
43	THETA C	0.0000E+00	294	1.0000E+01		
	(DEG)	0.0000E+00		2.0000E+01		
44	THETA T	0.0000E+00	295	0.0000E+00		
	(DEG)	0.0000E+00		2.0000E+01		
45	THETA C 75	0.0000E+00	296	0.0000E+00		
	(DEG)	0.0000E+00		1.0000E+01		
46	PSI	0.0000E+00	284	-[illegible].0000E+01		
	(DEG)	0.0000E+00		2.0000E+01		
47	PHI	0.0000E+00	283	-2.0000E+01		
	(DEG)	0.0000E+00		2.0000E+01		
48	PSI DOT D	0.0000E+00	548	-1.0000E+01		
	(DEG/S)	0.0000E+00		1.0000E+01		
49	THE DOT D	0.0000E+00	549	-1.0000E+01		
	(DEG/S)	0.0000E+00		1.0000E+01		
50	PHI DOT D	0.0000E+00	550	-2.0000E+01		
	(DEG/S)	0.0000E+00		2.0000E+01		
51	P D	0.0000E+00	551	-2.0000E+01		
	(DEG/S)	[illegible]		2.0000E+01		
52	Q D	0.0000E+00	55[illegible]	-1.0000E+01		
	(DEG/S)	0.0000E+00		1.0000E+01		
53	R D	0.0000E+00	55[illegible]	-[illegible].0000E+01		
	(DEG/S)	0.0000E+00		1.0000E+01		
54	A X	0.0000E+00	554	-5.0000E+00		
	(FT/S**2)	[illegible]		5.0000E+00		
55	A Y	0.0000E+00	555	-5.0000E+00		
	(FT/S**2)	0.0000E+00		5.0000E+00		
56	A Z	0.0000E+00	556	-1.0000E+01		
	(FT/S**2)	0.0000E+00		1.0000E+01		
57	U DOT	0.0000E+00	35	-5.0000E+00		
	(FT/S**2)	0.0000E+00		5.0000E+00		
58	V DOT	0.0000E+00	36	-5.0000E+00		
	(FT/S**2)	0.0000E+00		5.0000E+00		
59	W DOT	0.0000E+00	37	-1.0000E+01		
	(FT/S**2)	0.0000E+00		1.0000E+01		

FIG. 8 (cont.)

60	U DSH I	0.0000E+00	560	0.0000E+00
	(KN)	0.0000E+00		1.0000E+02
61	V DSH I	0.0000E+00	561	-2.0000E+01
	(KN)	0.0000E+00		2.0000E+01
62	W DSH I	0.0000E+00	562	-1.0000E+01
	(KN)	0.0000E+00		1.0000E+01
63	HOR VEL I	0.0000E+00	[illegible]	0.0000E+00
	(KN)	0.0000E+00		1.0000E+02
64	H I	0.0000E+00	[illegible]	0.0000E+00
	(FT)	0.0000E+00		1.0000E+03
65	PSI DOT	0.0000E+00	565	-1.0000E+01
	(DEG/S)	0.0000E+00		1.0000E+01
66	THE DOT	0.0000E+00	566	-1.0000E+01
	(DEG/S)	[illegible]		1.0000E+01
67	PHI DOT	0.0000E+00	567	-2.0000E+01
	(DEG/S)	0.0000E+00		2.0000E+01
68	PSI I	0.0000E+00	568	-2.0000E+01
	(DEG)	0.0000E+00		2.0000E+01
69	THE I	0.0000E+00	569	-2.0000E+01
	(DEG)	[illegible]		2.0000E+01
70	PHI I	0.0000E+00	570	-2.0000E+01
	(DEG)	0.0000E+00		2.0000E+01

EXCEPTIONS

Channel No.	Flight No.	Cal Factor	Offset
15	1	-3.2200E-02	[illegible].5600E+01
18	1	8.8400E-02	[illegible]
26	1	-8.9800E-04	1.5530E+01
31	1	-1.3890E-04	5.1000E-[illegible]
32	1	-4.8800E-[illegible]	1.0000E-01
35	1	1.0150E+03	0.0000E+00
37	1	0.0000E+00	-1.6000E+02
18	2	8.8400E-02	-1.3600E+02
26	2	-9.0800E-04	1.5670E+01
31	2	0.0000E+00	0.0000E+00
32	2	0.0000E+00	0.0000E+00
35	2	1.0030E+03	0.0000E+00
36	2	1.4000E+01	0.0000E+00
37	2	0.0000E+00	7.0000E+01
8	3	-1.5000E-02	3.2800E+01
11	3	-3.0300E-02	6.1240E+01
18	3	8.8400E-02	-1.3000E+02
31	3	0.0000E+00	0.0000E+00
32	3	0.0000E+00	0.0000E+00
35	3	1.0270E+03	0.0000E+00
36	3	1.0000E+01	0.0000E+00
37	3	0.0000E+00	2.3000E+02
11	4	-3.0300E-02	6.1370E+01
18	4	8.8400E-02	-2.0800E+02
31	4	0.0000E+00	0.0000E+00
32	4	0.0000E+00	0.0000E+00
35	4	1.0250E+03	0.0000E+00
37	4	0.0000E+00	1.9000E+02
18	5	8.8400E-02	-6.7000E+01
31	6	0.0000E+00	0.0000E+00
32	6	0.0000E+00	0.0000E+00
35	6	1.0200E+03	0.0000E+00
36	6	1.9000E+01	0.0000E+00
37	6	0.0000E+00	0.0000E+00
9	7	-4.4700E-02	8.8300E+01
18	7	8.8400E-02	-8.3000E+01
31	7	0.0000E+00	0.0000E+00
32	7	0.0000E+00	0.0000E+00
35	7	1.0200E+03	0.0000E+00
36	7	1.3000E+01	0.0000E+00
37	7	0.0000E+00	1.6000E+02

FIG. 8 (cont.)

15025
RAW DATA IN COUNTS - NO DELAYS

RECORDED ON 2-Apr-82 AT 13:19 INTEGN INT = 0.0000E+00 RUN CPU TIME = 0.00 SEC.

BLK NUMBER =	13	17	18	21	23	26	28	33
TIME (S)	LAT ACC (FT/S**2)	YAW RATE (DEG/S)	YAW ATT (DEG)	LONG DOPP (KN)	DYN PRESS (PSI)	ABS PRESS (PSI)	AMB TEMP (DEG C)	CLOCK TIME (OCTAL)
0.0000E+00	2.0420E+03	1.9880E+03	3.7860E+03	9.8775E+02	2.4028E+03	1.8900E+03	1.8205E+03	5.1735E+04
1.6667E-02	2.0490E+03	1.9890E+03	3.7845E+03	9.8850E+02	2.4030E+03	1.8893E+03	1.8218E+03	5.1736E+04
3.3333E-02	2.0560E+03	1.9845E+03	3.7830E+03	9.8925E+02	2.4008E+03	1.8885E+03	1.8230E+03	5.1737E+04
5.0000E-02	2.0610E+03	1.9800E+03	3.7840E+03	9.9000E+02	2.3985E+03	1.8878E+03	1.8233E+03	5.1740E+04
6.6667E-02	2.0600E+03	1.9740E+03	3.7850E+03	9.9050E+02	2.3963E+03	1.8870E+03	1.8235E+03	5.1741E+04
8.3333E-02	2.0560E+03	1.9680E+03	3.7850E+03	9.9100E+02	2.3940E+03	1.8890E+03	1.8238E+03	[illegible]
1.0000E-01	2.0520E+03	1.9700E+03	3.7850E+03	9.9150E+02	2.3990E+03	1.8890E+03	1.8240E+03	[illegible]
1.1667E-01	2.0480E+03	1.9720E+03	3.7855E+03	9.9200E+02	2.4040E+03	1.8900E+03	1.8198E+03	[illegible]
1.3333E-01	2.0380E+03	1.9785E+03	3.7860E+03	9.9200E+02	2.4090E+03	1.8910E+03	1.8135E+03	5.1745E+04
1.5000E-01	2.0380E+03	1.9850E+03	3.7860E+03	9.9200E+02	2.4140E+03	1.8908E+03	1.8083E+03	[illegible]
1.6667E-01	2.0440E+03	1.9870E+03	3.7860E+03	9.9200E+02	2.4138E+03	1.8905E+03	1.8030E+03	[illegible]
1.8333E-01	2.0540E+03	1.9890E+03	3.7855E+03	9.9200E+02	2.4135E+03	1.8903E+03	1.8108E+03	5.1750E+04
2.0000E-01	2.0570E+03	1.9865E+03	3.7850E+03	9.9200E+02	2.4133E+03	1.8900E+03	1.8165E+03	5.1751E+04
2.1667E-01	2.0570E+03	1.9840E+03	3.7855E+03	9.9200E+02	2.4130E+03	1.8898E+03	1.8263E+03	5.1752E+04
2.3333E-01	2.0540E+03	1.9825E+03	3.7860E+03	9.9200E+02	2.4090E+03	1.8895E+03	1.8340E+03	5.1753E+04
2.5000E-01	2.0490E+03	1.9810E+03	3.7860E+03	9.9200E+02	2.4050E+03	1.8893E+03	1.8293E+03	5.1754E+04
2.6667E-01	2.0470E+03	1.9850E+03	3.7860E+03	9.9225E+02	2.4010E+03	1.8890E+03	1.8245E+03	5.1755E+04
2.8333E-01	2.0460E+03	1.9890E+03	3.7855E+03	9.9250E+02	2.3970E+03	1.8893E+03	1.8198E+03	5.1756E+04
3.0000E-01	2.0440E+03	1.9945E+03	3.7850E+03	9.9275E+02	2.4030E+03	1.8895E+03	1.8150E+03	5.1757E+04

FIG. 9 File 15025.COL showing minimally processed data for selected channels at beginning of flight record 15025

15025
RAW DATA IN COUNTS - WITH DELAYS

RECORDED ON 2-Apr-82 AT 15:05 INTEGN INT = 0.0000E+00 RUN CPU TIME = 0.00 SEC.

BLK NUMBER =	13	17	18	21	23	26	28	33
TIME (S)	LAT ACC (FT/S**2)	YAW RATE (DEG/S)	YAW ATT (DEG)	LONG DOPP (KN)	DYN PRESS (PSI)	ABS PRESS (PSI)	AMB TEMP (DEG C)	CLOCK TIME (OCTAL)
0.0000E+00	2.0610E+03	1.9700E+03	3.7860E+03	1.0010E+03	2.3985E+03	1.8900E+03	1.8205E+03	5.2004E+04
1.6667E-02	2.0600E+03	1.9720E+03	3.7845E+03	1.0003E+03	2.3963E+03	1.8898E+03	1.8218E+03	5.2005E+04
3.3333E-02	2.0560E+03	1.9785E+03	3.7830E+03	9.9950E+02	2.3940E+03	1.8895E+03	1.8230E+03	5.2006E+04
5.0000E-02	2.0520E+03	1.9850E+03	3.7840E+03	9.9875E+02	2.3990E+03	1.8893E+03	1.8233E+03	5.2007E+04
6.6667E-02	2.0480E+03	1.9870E+03	3.7850E+03	9.9800E+02	2.4040E+03	1.8890E+03	1.8235E+03	5.2010E+04
8.3333E-02	2.0380E+03	1.9890E+03	3.7850E+03	9.9750E+02	2.4090E+03	1.8893E+03	1.8238E+03	5.2011E+04
1.0000E-01	2.0380E+03	1.9865E+03	3.7850E+03	9.9700E+02	2.4140E+03	1.8895E+03	1.8240E+03	5.2012E+04
1.1667E-01	2.0440E+03	1.9840E+03	3.7855E+03	9.9650E+02	2.4138E+03	1.8898E+03	1.8188E+03	5.2013E+04
1.3333E-01	2.0540E+03	1.9825E+03	3.7860E+03	9.9600E+02	2.4135E+03	1.8900E+03	1.8135E+03	5.2014E+04
1.5000E-01	2.0570E+03	1.9810E+03	3.7860E+03	9.9600E+02	2.4133E+03	1.8898E+03	1.8083E+03	5.2015E+04
1.6667E-01	2.0570E+03	1.9850E+03	3.7860E+03	9.9600E+02	2.4130E+03	1.8895E+03	1.8030E+03	5.2016E+04
1.8333E-01	2.0540E+03	1.9890E+03	3.7355E+03	9.9600E+02	2.4090E+03	1.8893E+03	1.8108E+03	5.2017E+04
2.0000E-01	2.0490E+03	1.9945E+03	3.7850E+03	9.9600E+02	2.4050E+03	1.8890E+03	1.8185E+03	5.2020E+04
2.1667E-01	2.0470E+03	2.0000E+03	3.7855E+03	9.9550E+02	2.4010E+03	1.8890E+03	1.8263E+03	5.2021E+04
2.3333E-01	2.0460E+03	2.0005E+03	3.7860E+03	9.9500E+02	2.3970E+03	1.8890E+03	1.8340E+03	5.2022E+04
2.5000E-01	2.0440E+03	2.0010E+03	3.7860E+03	9.9450E+02	2.4030E+03	1.8890E+03	1.8293E+03	5.2023E+04
2.6667E-01	2.0440E+03	1.9960E+03	3.7860E+03	9.9400E+02	2.4090E+03	1.8890E+03	1.8245E+03	5.2024E+04
2.8333E-01	2.0480E+03	1.9910E+03	3.7855E+03	9.9350E+02	2.4150E+03	1.8890E+03	1.8198E+03	5.2025E+04
3.0000E-01	2.0540E+03	1.9880E+03	3.7850E+03	9.9300E+02	2.4210E+03	1.8890E+03	1.8150E+03	5.2026E+04

FIG. 10 Data as in Fig. 9 but with instrument and analogue filter time delays included

```
*** FILTER CHARACTERISTICS ***

CHANNEL NO. =  4
NO. OF POLES = 5    FREQ = 3.500    ATTEN = 50.000    FC = 1.1181
TIME DELAY = 0.458617    OMEGA = 2.2240685391784D+01    OMEGAC = 7.0331292892882D+00
NUMERATOR COEFFS   =      1      5      10      10      5      1
DENOMINATOR COEFFS =    1.7478224133541D+06  -8.0769814534886D+06   1.4953389527402D+07  -1.3862462739192D+07
  6.4345340695383D+06  -1.1962698176138D+06

CHANNEL NO. =  8
NO. OF POLES = 5    FREQ = 3.500    ATTEN = 50.000    FC = 1.1181
TIME DELAY = 0.458617    OMEGA = 2.2240685391784D+01    OMEGAC = 7.0331292892882D+00
NUMERATOR COEFFS   =      1      5      10      10      5      1
DENOMINATOR COEFFS =    1.7478224133541D+06  -8.0769814534886D+06   1.4953389527402D+07  -1.3862462739192D+07
  6.4345340695383D+06  -1.1962698176138D+06
```

FIG. 11 Filter characteristics file 15025.FCH (limited to first two filtered channels)

TIME	NITN	UDOT	VDOT	WDOT	UI	VI	WI	UERR	VERR	WERR
0.0000E+00	1	-1.5368E-01	9.8065E-01	6.5475E-01	1.1759E+02	1.0985E+01	4.5381E+00	0.0000E+00	0.0000E+00	0.0000E+00
1.6667E-02	1	-1.7495E-01	9.2711E-01	6.5006E-01	1.1758E+02	1.1001E+01	4.5490E+00	2.7390E-03	1.5898E-02	1.0957E-02
1.6667E-02	2	-1.7510E-01	9.2708E-01	6.5006E-01	1.1758E+02	1.1001E+01	4.5490E+00	9.5367E-07	2.3842E-07	0.0000E+00
3.3333E-02	1	-1.9645E-01	8.7305E-01	6.3521E-01	1.1758E+02	1.1016E+01	4.5598E+00	3.0966E-03	1.5001E-02	1.0711E-02
3.3333E-02	2	-1.9659E-01	8.7302E-01	6.3521E-01	1.1758E+02	1.1016E+01	4.5598E+00	9.5367E-07	2.3842E-07	0.0000E+00
5.0000E-02	1	-2.1790E-01	8.1880E-01	6.2034E-01	1.1758E+02	1.1030E+01	4.5702E+00	3.4542E-03	1.4099E-02	1.0453E-02
5.0000E-02	2	-2.1804E-01	8.1877E-01	6.2033E-01	1.1758E+02	1.1030E+01	4.5702E+00	9.5367E-07	3.5763E-07	0.0000E+00
6.6667E-02	1	-2.3920E-01	7.6471E-01	6.0557E-01	1.1757E+02	1.1043E+01	4.5804E+00	3.8099E-03	1.3196E-02	1.0216E-02
6.6667E-02	2	-2.3932E-01	7.6468E-01	6.0557E-01	1.1757E+02	1.1043E+01	4.5804E+00	9.5367E-07	3.5763E-07	5.9605E-08
8.3333E-02	1	-2.6023E-01	7.1112E-01	5.9106E-01	1.1757E+02	1.1055E+01	4.5904E+00	4.1628E-03	1.2298E-02	9.9719E-03
8.3333E-02	2	-2.6034E-01	7.1108E-01	5.9105E-01	1.1757E+02	1.1055E+01	4.5904E+00	9.5367E-07	3.5763E-07	5.9605E-08
1.0000E-01	1	-2.8086E-01	6.5837E-01	5.7689E-01	1.1757E+02	1.1067E+01	4.6001E+00	4.5099E-03	1.1412E-02	9.7328E-03
1.0000E-01	2	-2.8096E-01	6.5833E-01	5.7689E-01	1.1757E+02	1.1067E+01	4.6001E+00	9.5367E-07	3.5763E-07	5.9605E-08
1.1667E-01	1	-3.0095E-01	6.0682E-01	5.6318E-01	1.1756E+02	1.1077E+01	4.6096E+00	4.8494E-03	1.0543E-02	9.5006E-03
1.1667E-01	2	-3.0101E-01	6.0679E-01	5.6317E-01	1.1756E+02	1.1077E+01	4.6096E+00	9.5367E-07	3.5763E-07	5.9605E-08
1.3333E-01	1	-3.2035E-01	5.5678E-01	5.4998E-01	1.1756E+02	1.1087E+01	4.6189E+00	5.1785E-03	9.6964E-03	9.2763E-03
1.3333E-01	2	-3.2044E-01	5.5674E-01	5.4997E-01	1.1756E+02	1.1087E+01	4.6189E+00	9.5367E-07	3.5763E-07	5.9605E-08
1.5000E-01	1	-3.3889E-01	5.0853E-01	5.3735E-01	1.1755E+02	1.1096E+01	4.6280E+00	5.4941E-03	8.8773E-03	9.0610E-03
1.5000E-01	2	-3.3897E-01	5.0848E-01	5.3734E-01	1.1755E+02	1.1096E+01	4.6280E+00	9.5367E-07	4.7684E-07	5.9605E-08
1.6667E-01	1	-3.5642E-01	4.6230E-01	5.2531E-01	1.1754E+02	1.1104E+01	4.6368E+00	5.7945E-03	8.0899E-03	8.8554E-03
1.6667E-01	2	-3.5650E-01	4.6225E-01	5.2530E-01	1.1754E+02	1.1104E+01	4.6368E+00	9.5367E-07	4.7684E-07	5.9605E-08
1.8333E-01	1	-3.7280E-01	4.1827E-01	5.1387E-01	1.1754E+02	1.1111E+01	4.6455E+00	6.0778E-03	7.3377E-03	8.6596E-03
1.8333E-01	2	-3.7287E-01	4.1822E-01	5.1387E-01	1.1754E+02	1.1111E+01	4.6455E+00	0.0000E+00	4.7684E-07	5.9605E-08
2.0000E-01	1	-3.8792E-01	3.7660E-01	5.0305E-01	1.1753E+02	1.1118E+01	4.6540E+00	6.3400E-03	6.6235E-03	8.4743E-03
2.0000E-01	2	-3.8798E-01	3.7655E-01	5.0304E-01	1.1753E+02	1.1118E+01	4.6540E+00	0.0000E+00	4.7684E-07	5.9605E-08

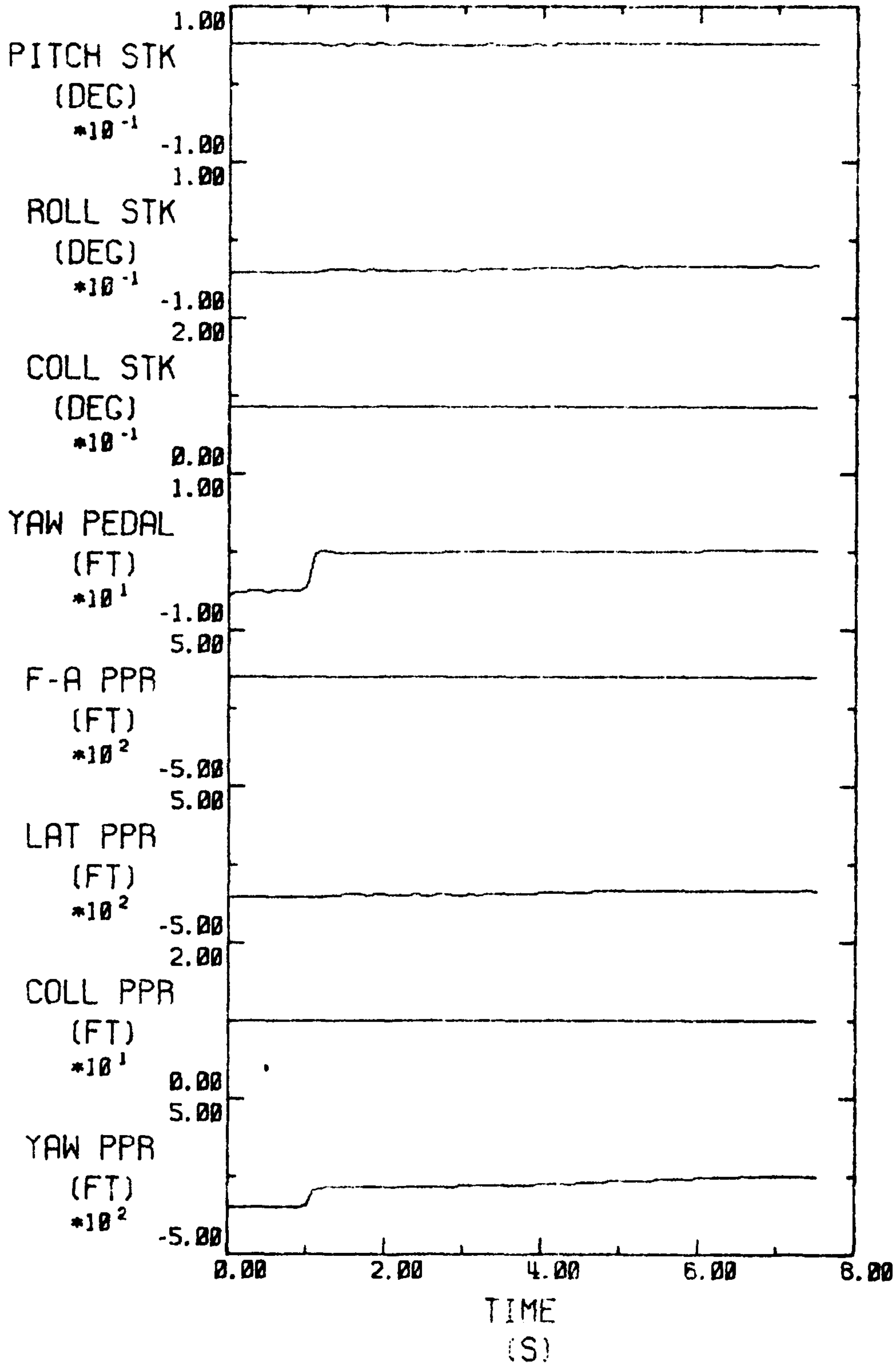
FIG. 12 Velocity iteration information file REFINE.VEL (limited to initial 0.2s)

15025

RECORDED ON 5-Apr-82 AT 09:39 INTEGN INT = 0.0000E+00 RUN CPU TIME = 0.00 SEC.

BLK NUMBER =	13	17	18	21	23	26	28	33
TIME	LAT ACC	YAW RATE	YAW ATT	LONG DOPP	DYN PRESS	ABS PRESS	AMB TEMP	CLOCK TIME
(S)	(FT/S**2)	(DEG/S)	(DEG)	(KN)	(PSI)	(PSI)	(DEG C)	(OCTAL)
0.0000E+00	2.3185E-01	-5.4677E-01	-1.5535E+02	6.9627E+01	1.3644E-01	1.4052E+01	1.1207E+01	5.2040E+04
5.0000E-01	-1.5648E-01	-3.7973E-01	-1.5539E+02	7.0365E+01	1.3533E-01	1.4052E+01	1.1246E+01	5.2076E+04
1.0000E+00	-8.7564E-01	-8.7124E-01	-1.5574E+02	6.9689E+01	1.3584E-01	1.4052E+01	1.1249E+01	5.2134E+04
1.5000E+00	-2.3815E+00	-4.1212E+00	-1.5687E+02	6.8734E+01	1.3680E-01	1.4052E+01	1.1318E+01	5.2172E+04
2.0000E+00	-1.5426E+00	-3.4494E+00	-1.5950E+02	6.8548E+01	1.3714E-01	1.4052E+01	1.1227E+01	5.2230E+04
2.5000E+00	-2.2088E+00	-4.9433E+00	-1.6210E+02	6.7692E+01	1.3950E-01	1.4052E+01	1.1295E+01	5.2266E+04
3.0000E+00	-2.7415E+00	-3.9380E+00	-1.6426E+02	6.7328E+01	1.3894E-01	1.4046E+01	1.1224E+01	5.2324E+04
3.5000E+00	-3.0847E+00	-2.5012E+00	-1.6584E+02	6.7255E+01	1.3738E-01	1.4046E+01	1.1237E+01	5.2362E+04
4.0000E+00	-2.9387E+00	-1.5699E+00	-1.6676E+02	6.7512E+01	1.3720E-01	1.4044E+01	1.1257E+01	5.2420E+04
4.5000E+00	-2.7123E+00	-1.4416E+00	-1.6746E+02	6.6787E+01	1.3588E-01	1.4043E+01	1.1212E+01	5.2456E+04
5.0000E+00	-2.3423E+00	-1.8888E+00	-1.6833E+02	6.6710E+01	1.2986E-01	1.4041E+01	1.1266E+01	5.2514E+04
5.5000E+00	-2.3060E+00	-3.1400E+00	-1.6964E+02	6.5497E+01	1.2865E-01	1.4039E+01	1.1227E+01	5.2552E+04
6.0000E+00	-2.8125E+00	-4.2108E+00	-1.7158E+02	6.3986E+01	1.2341E-01	1.4035E+01	1.1230E+01	5.2610E+04
6.5000E+00	-2.9622E+00	-4.8639E+00	-1.7377E+02	6.1907E+01	1.1827E-01	1.4028E+01	1.1211E+01	5.2646E+04
7.0000E+00	-2.9281E+00	-5.1404E+00	-1.7624E+02	6.0575E+01	1.1290E-01	1.4023E+01	1.1223E+01	5.2704E+04

FIG. 13 File 15025.COL showing fully processed data



15025

FIG. 14a Fully processed data for block list 1

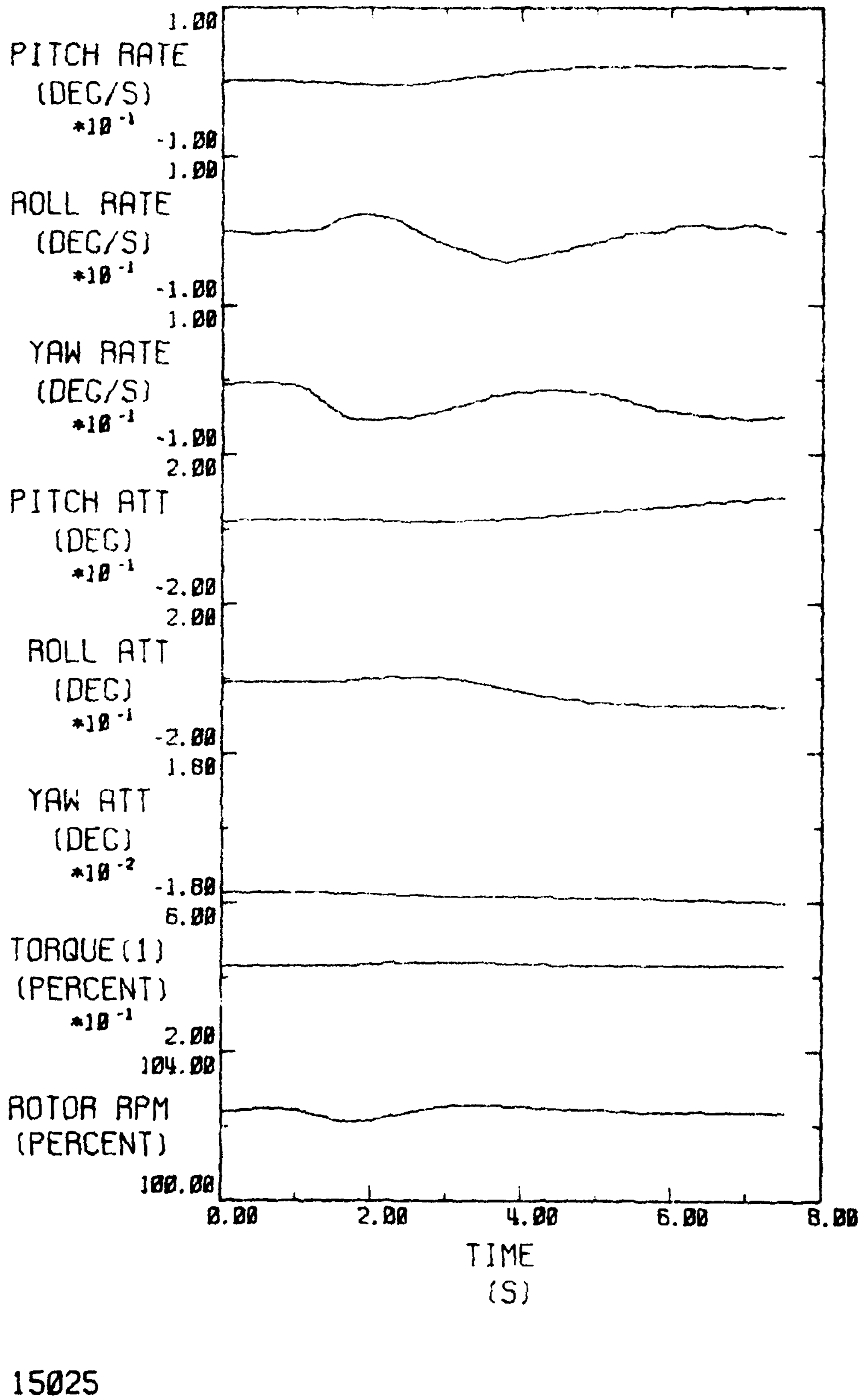


FIG. 14b Fully processed data for block list 2

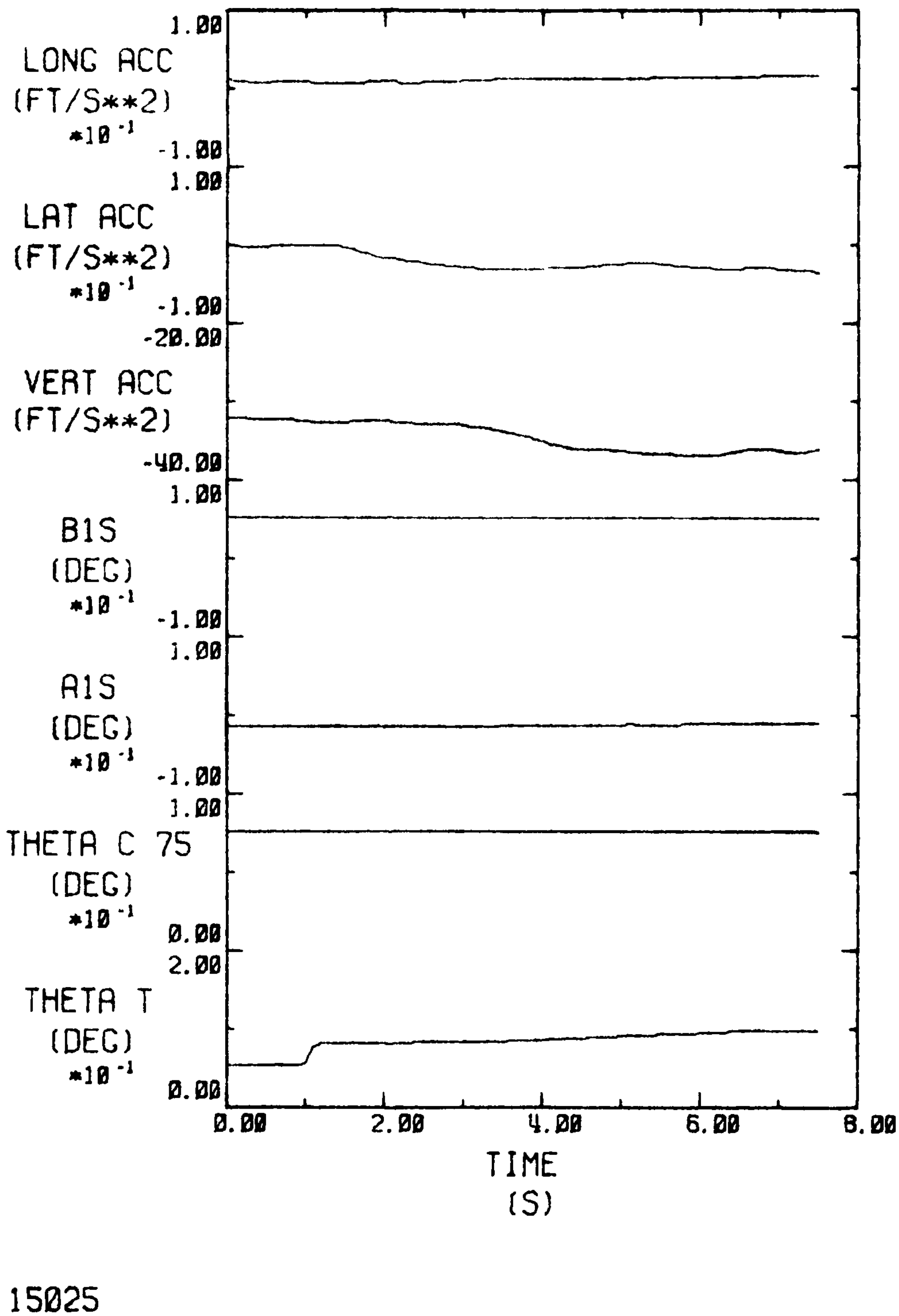
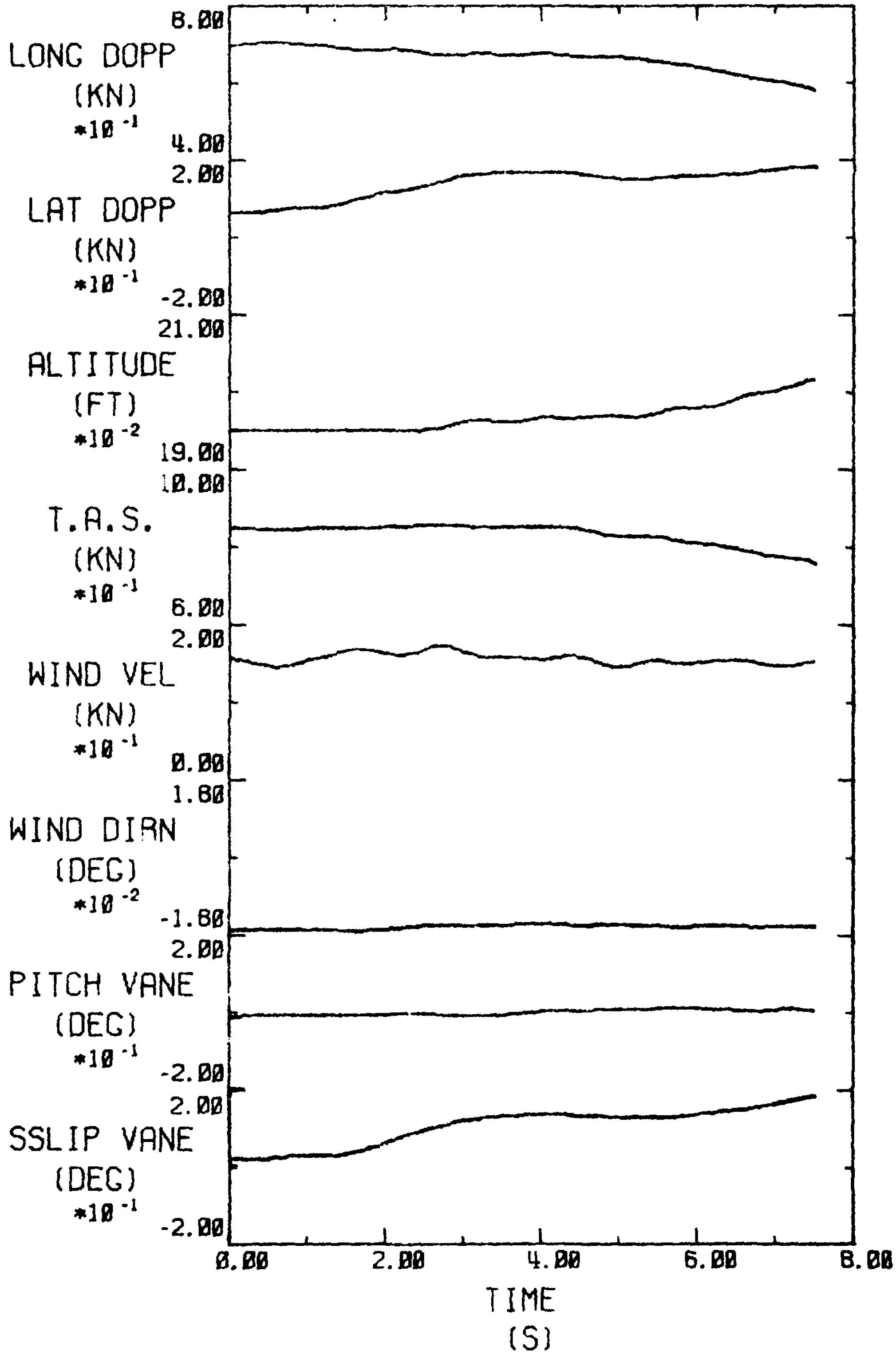


FIG. 14c Fully processed data for block list 3



15025

FIG. 14d Fully processed data for block list 4

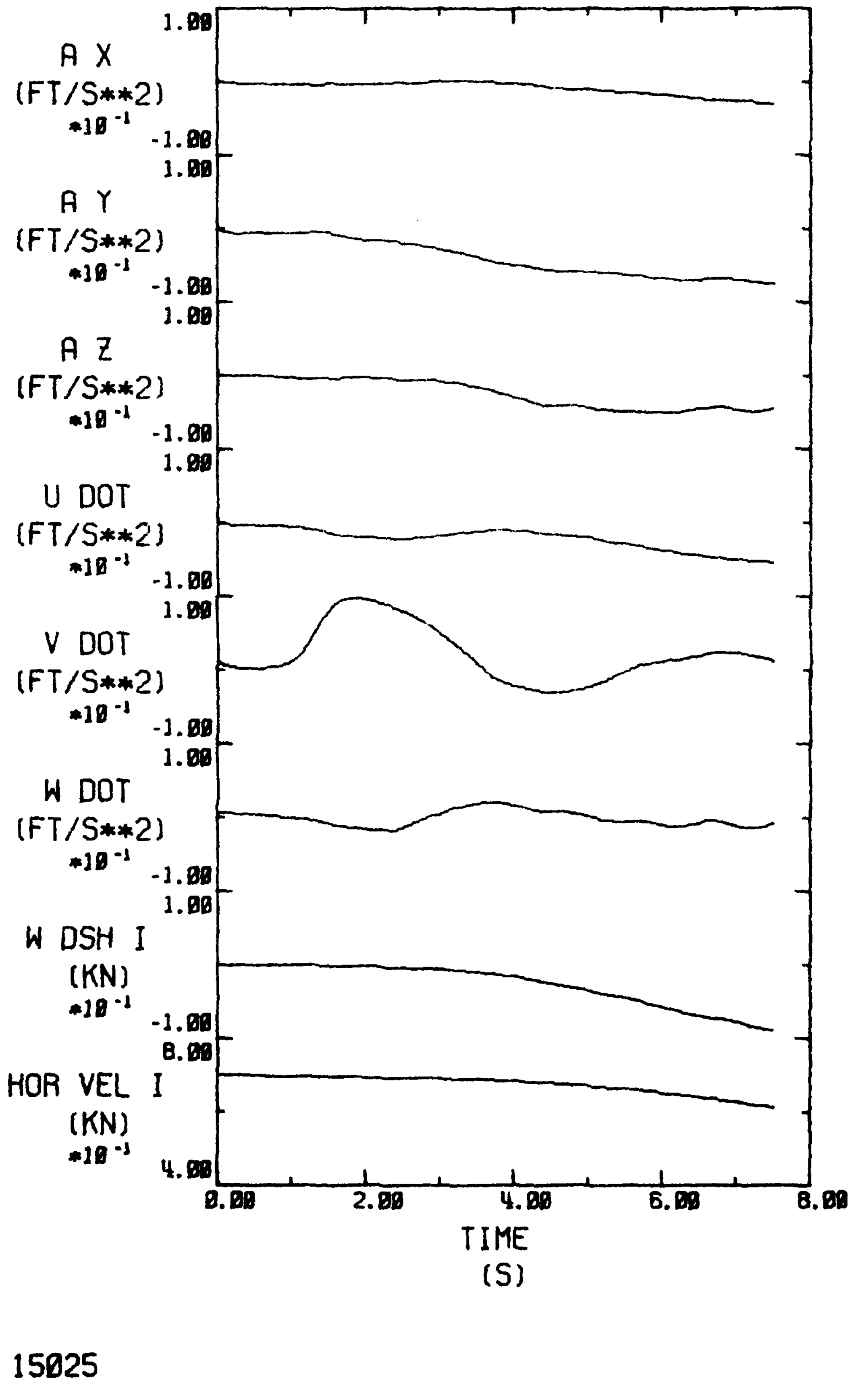


FIG. 14e Fully processed data for block list 5

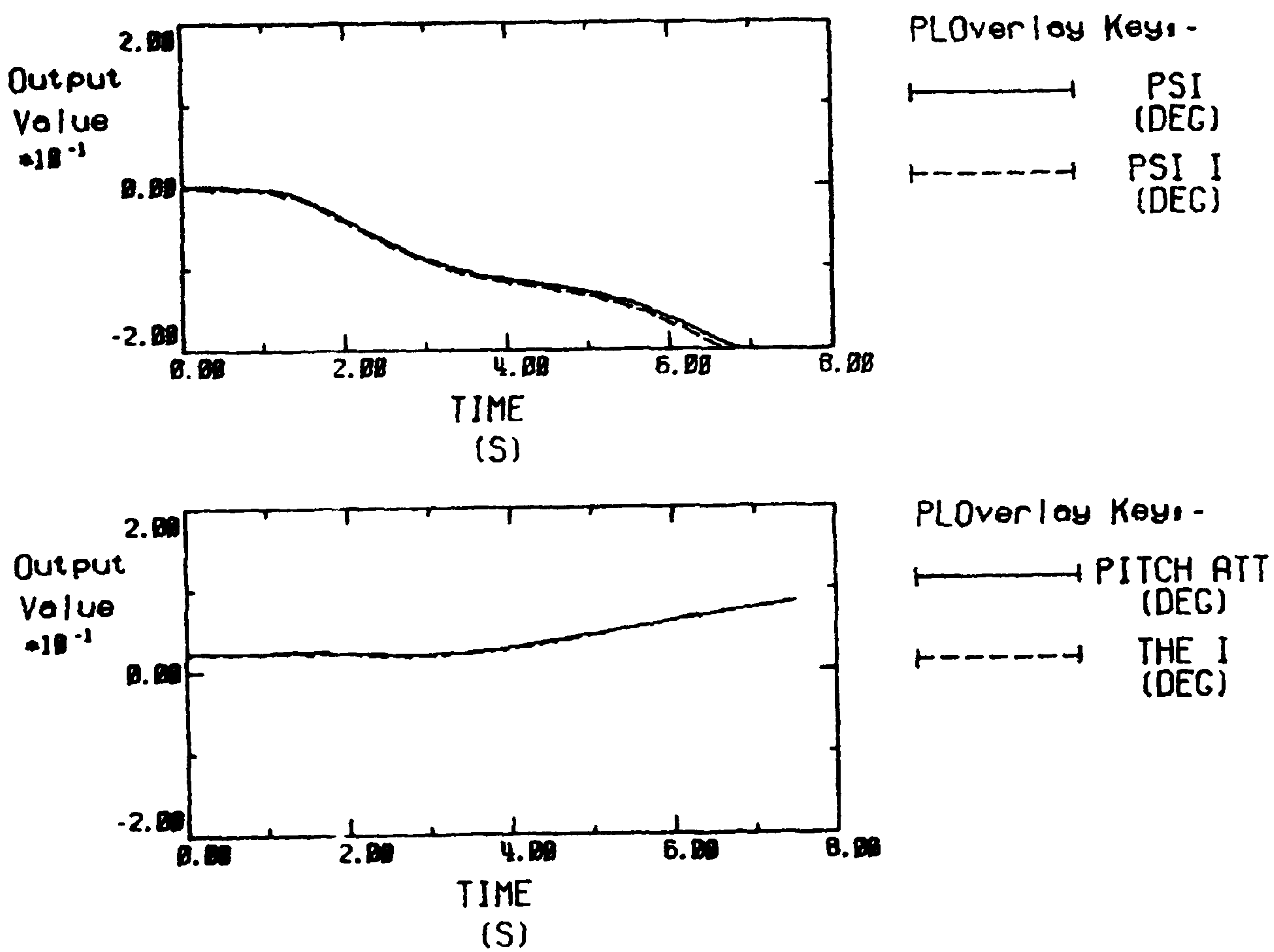


FIG. 15a Kinematic consistency checking for yaw and pitch Euler angles

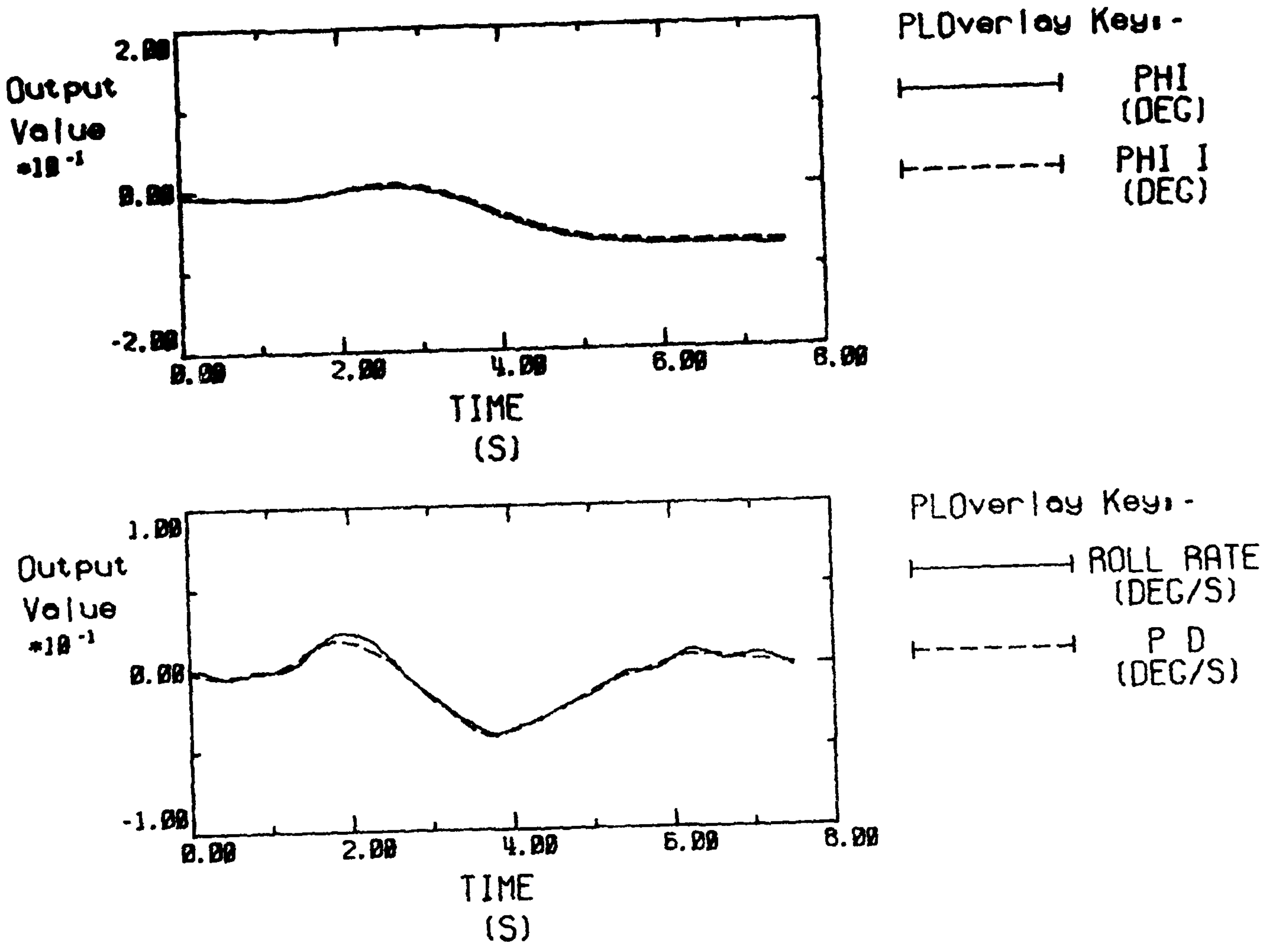


FIG. 15b Kinematic consistency checking for roll Euler angle and roll rate

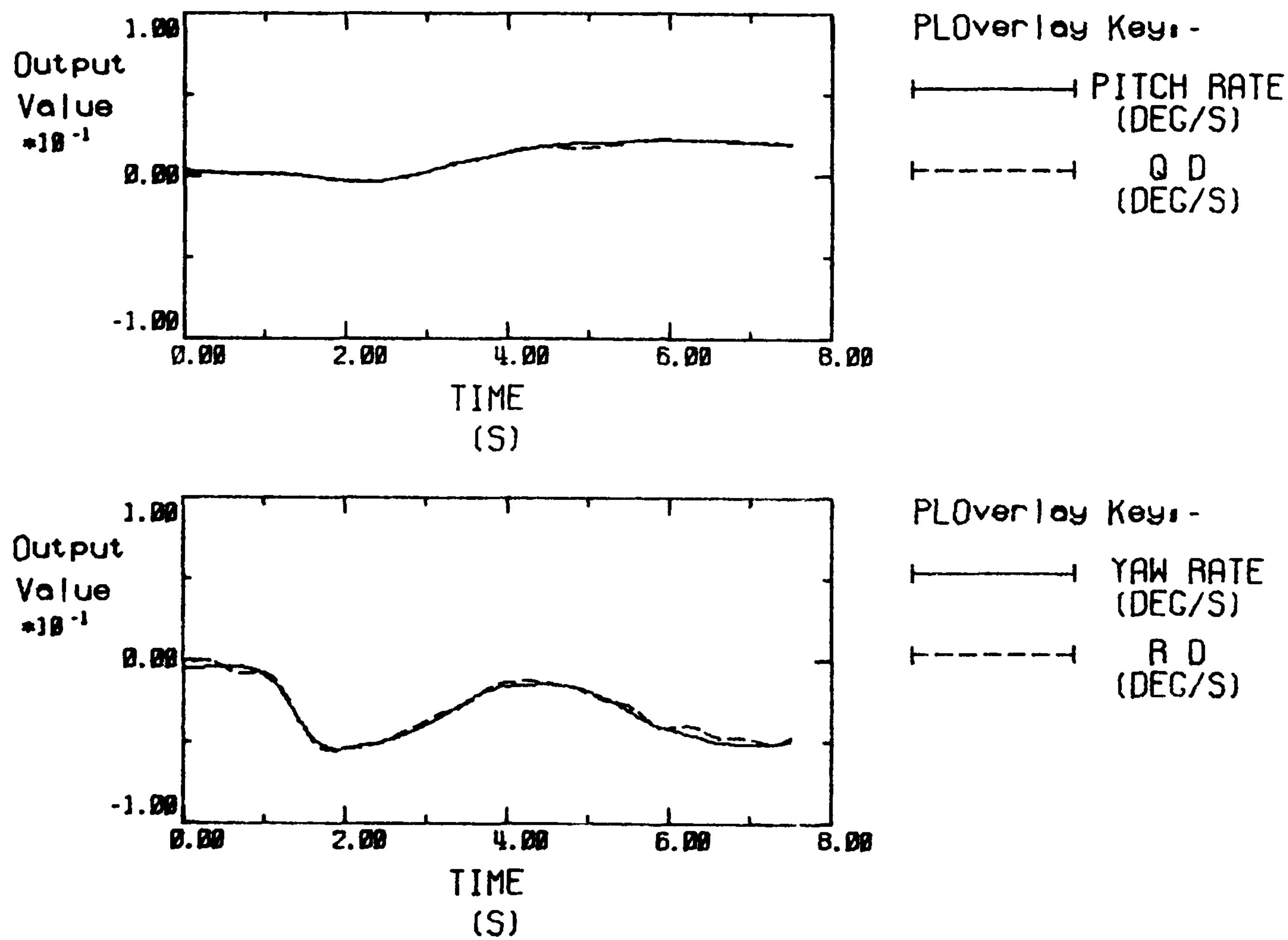


FIG. 15c Kinematic consistency checking for pitch and yaw rates

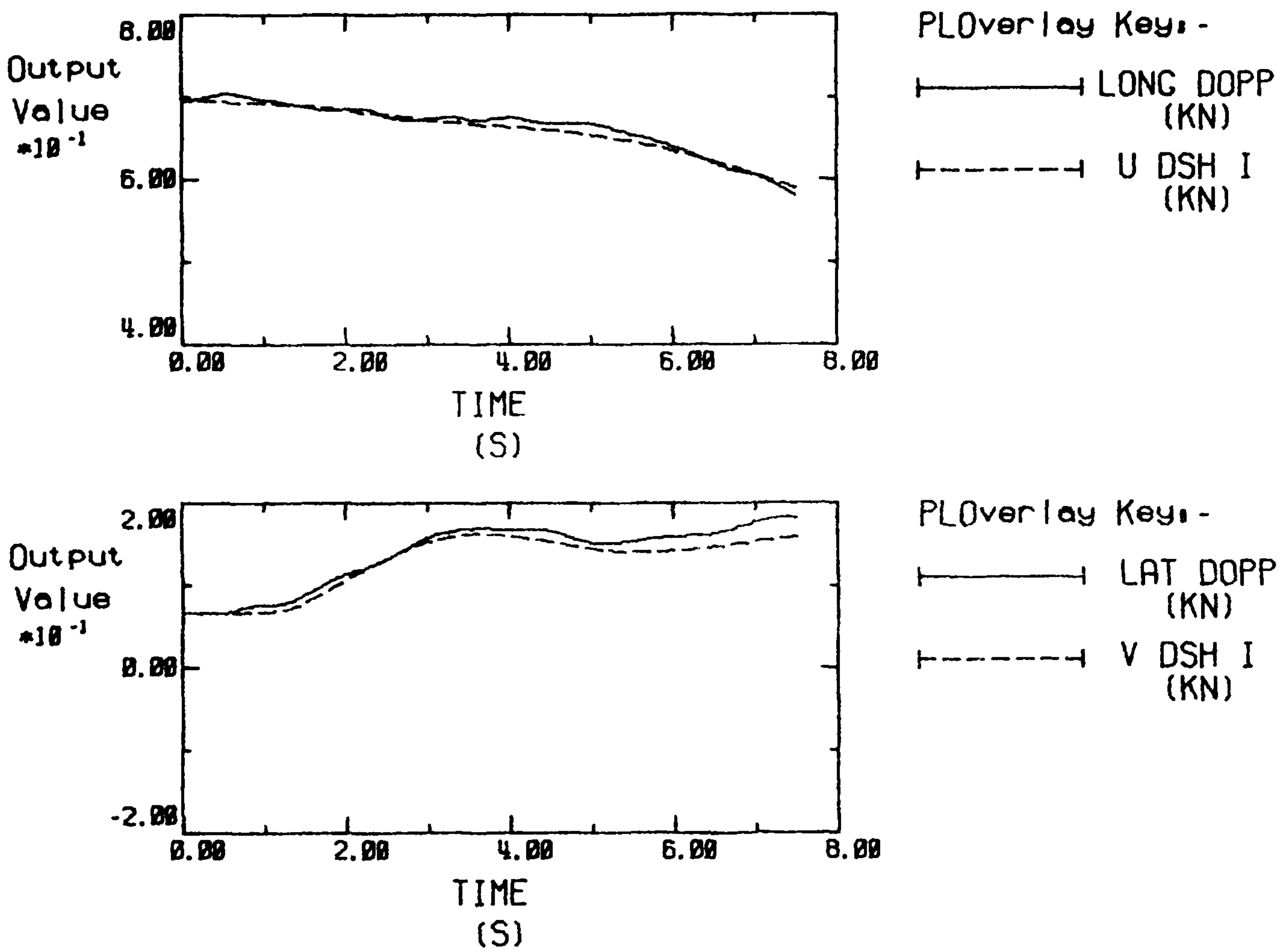


FIG. 15d Kinematic consistency checking for longitudinal and lateral velocity

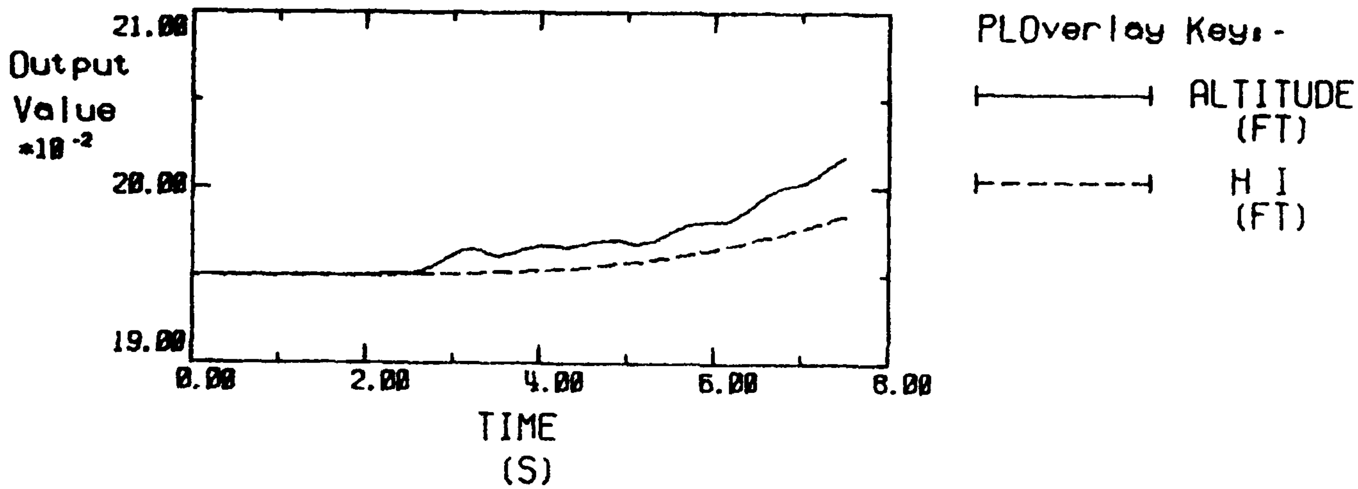


FIG. 15e Kinematic consistency checking for height

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16.Abstract

The data reduction procedures used in obtaining fully processed data from raw flight data for trials on a Sea King Mk. 50 helicopter are given. The procedures allow various corrections and calibrations to be applied, removal of noise, and calculation of many additional quantities, some of which are used for kinematic consistency checking purposes. Examples are provided on the running of the various computer programs developed. To assist in the use of the data for validation of the Sea King mathematical model, output is obtained in a form allowing ready comparison between trials and model results on the same graphs.

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