TSPI DATA PROCESSING IN THE TELEMETRY ENVIRONMENT

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ABSTRACT

Most test ranges are required to process both telemetry and Time Space Position Information (TSPI) data in real time. Using the Integrated Flight Data Processing System (IFDAPS) at Edwards AFB as an example, this paper identifies some of the basic differences between telemetry and TSPI data processing and discusses methods of integrating the two types of processing. Included for consideration in the integrated processing are data acquisition, measurement displays, recording, derived measurement computations using both types of data, and post flight merging of telemetry and TSPI data. Data processing is discussed in a concurrent, multiple operation environment using separate, integrated processors.

INTRODUCTION

CSC has submitted papers at several telemetry conferences describing the Integrated Flight Data Processing System (IFDAPS) being developed for the AFFTC at Edwards AFB, CA. These papers and associated presentations emphasize the substantial telemetry data processing capabilities of IFDAPS. But, IFDAPS also has a significant capability to process Time Space Position Information (TSPI) data from radars and optical sensors in a real-time environment. These capabilities include data acquisition from up to 32 sensors; concurrent processing of data from multiple operations; high resolution, real time graphics displays; mission-specific data processing; recording of raw, corrected and derived measurements; multistation trajectory estimations using real-time Kalman filter techniques; and the ability to transfer data between the TSPI and telemetry data processors.

The baseline IFDAPS consists of four Acquisition and Display Subsystems (ADS), two Control and Storage Subsystems (CSS), two Display and Analysis Subsystems (DAS) and one Range Control Station (RCS). The IFDAPS has been carefully designed to provide maximum flexibility for the flight test engineer. Once activated in support of a mission, the System Control Console operator is prompted every step of the way through system initialization, setup and mission operation. The operator interface is provided through dual color graphics terminals where the initialization setup and operation of all nine IFDAPS subsystems can be accomplished and controlled. During test support, flight test engineers and analysts will have access in real time to data in the incoming bit stream at one of the four ADSs located up front in the system architecture. Each of these ADS suites provides high-speed shared memory, via asynchronous memory links, to two CSS processors and two super high-speed DASs. The CSS processors provide the interface to the System Control Console operator terminals and function as the system controllers during mission support operations. As telemetry data is ingested and placed in the ADS shared memory, it is made available to the CSS processors via asynchronous memory links for recording on 300 and 600 megabyte disks. Each DAS processor has access to the same shared memory data by way of additional asynchronous memory link connections to each ADS. Each DAS provides a dual-user color graphics display subsystem and is capable of executing user written display analysis programs. All graphics display terminals are provided with screen hardcopy capabilities. The RCS processor is provided to handle theTSPI parameters received from tracking sensors such as radars and cinetheodolites.

The RCS provides two dual-user graphics subsystems capable of displaying map and terrain data and other aircraft track and positioning data associated with a mission. Maps and tracking information can be displayed on large-screen displays for added visibility.

All of the processing suites in IFDAPS are connected to each other with both classified and unclassified HYPERchannel Network links. These links are used for distributing initial system setup files and parameters used to load the system front end telemetry definition and host processor tables. The RCS uses this link to exchange data with the ADS processors and to send data to CSS for history recording. Other system administrative message traffic is handled on these links during mission support activities and system postflight support operations.

The IFDAPS is structured around Gould/SEL 32 series processors. The ADS processors are 32/7780’s, the CSS processors are 32/6750’s, the DAS processors are 32/8750’s and the RCS processor is a 32/8780. The specific hardware configuration of each subsystem is presented in Reference 1.

The specific data flow and processing of TSPI data will be discussed with regard to data acquisition, data processing, data recording, data transfer, and data display.

TSPI DATA ACQUISITION

TSPI data can be input to IFDAPS in two ways. The primary method is to accept data from the Position Information Processing System (PIPS). PIPS is a Government owned system consisting of communications equipment, a Computer Interface (CI) processor, and a Central Command and Status Console (CCSC). The communications equipment receives/transmits TSPI acquisition data from/to 32 associated range instrument subsystems and off-range data destinations. The TSPI tracking data and data from other sources are reformatted by the CI and transmitted to the RCS in a fixed-length data block of 823 24-bit words at a rate of 96K words/sec every 100 msec. The data block includes IRIG Phase II tracking data from up to 32 sensors plus other discrete, event and control data. The CI also receives data from the RCS and generates outgoing TSPI acquisition data for the range instrument subsystems. The interface between PIPS and the RCS consists of a SEL High Speed Device (HSD) interface configured as half duplex and modified to convert the PIPS RS-422 output signal to an HSD input and the HSD output to an RS-422 signal for input to PIPS. The HSD loads the data directly into the memory of the RCS host processor.

An alternative method for ingesting TSPI data is to receive the data directly from the tracking sensor as PCM data. The data are transmitted through a modem directly to the Aydin Monitor Systems Model 335 Bit Synchronizer as a bi-phase-L signal at 2.4K bits per second. The signal is then passed to the Aydin Monitor Systems Model 1126B Stored Program Decommutator where the incoming data are decommutated based on the standard IRIG Phase II 240-bit format. The data are then passed to the Aydin Monitor Systems Model 595 Data Compressor as one of five possible input sources and into the Gould-SEL Fast Multiplexer System (FMS) where it is made available to the shared fast memory within the ADS host processors. This is the same input sequence used to support all telemetry PCM streams input to IFDAPS.

Some basic comparisons between the telemetry data input and the TSPI data input include the following: 1) telemetry data rates may be 5 megabits per second per PCM stream whereas the TSPI PCM stream it 2.4 kilobits per second, 2) due to the high data rates of the telemetry data, data compression is required to reduce or eliminate duplicate values, 3) both types of data require Engineering Unit (EU) conversion, although more complex algorithms may be required to obtain the telemetry measurements, 4) TSPI input data require additional processing such as coordinate conversion, differentiation or integration to produce useful measurements, 5) TSPI input data types are constant whereas telemetry input may vary from mission to mission, 6) TSPI data is associated with a specific reference site while telemetry data is vehicle oriented, and 7) telemetry data provides information about the on-board systems of a test vehicle, while TSPI data provides an assessment of vehicle performance independent of the on-board systems.

TSPI DATA PROCESSING

The processing of TSPI data proceeds quite differently when input from PIPS to the RCS as when it is input directly from a sensor to an ADS. When input to the ADS, the range, azimuth and elevation data from a single sensor is converted to latitude, longitude and height and made available for display at a rate of once per second. As with other telemetry measurements, these data are also available for use by Data Analysis Programs (DAPS) generated by users and executed in real time.

Data input to the RCS goes through a series of rigorous data processing steps to reduce the effects of tracking data noise, systematic and atmospheric induced errors, data dropouts, and time biases. Control of these processes can be established either prior to a mission through the use of Run File Generator (RFG) software to build the appropriate control tables, or it is available in real time through the use of keyboard command input. The RCS can support the input of time, range, azimuth and elevation data at 20 samples per second (sps) from 32 sensors providing support on five separate missions with five targets per mission. Assignment of sensors to support specific operations and targets can also be established either prior to a mission or during a mission through real-time commands. The RCS provides support in several modes including real time, recall, simulation and playback of PIPS data. All of these modes can be supported simultaneously.

Once the input sensor data has been corrected for tracking errors, it is processed through a Square Root Information Filter (SRIF) to compute position, velocity and acceleration data. These state vector data can be computed based on data from a single sensor or from multiple sensors tracking the same target. Selection of which sensors are included and weighting factors for each sensor measurement can be controlled through real-time commands. If available from an ADS, Inertial Navigation System (INS) data can also be used to develop a vehicle state vector, and the INS velocity data can be used by the SRIF during periods of complete sensor data dropout. The state vector output from the SRIF is referred to as a track. The RCS can process up to 25 tracks concurrently with a limitation of 250 input measurements per second (i.e., each range, azimuth and elevation is a separate measurement). Each set of track data is used to compute 22 vehicle performance parameters such as ground velocity, rate of climb, dive angle, total acceleration, etc.

The RCS supports several specific types of missions including Bomb Drop (actually includes any type of projectile), Weather Balloon, Parachute Drop, and Intercept. Each of these mission types requires a specific set of initialization parameters and output measurements. As with other control data, the initialization parameters can be specified in the run file prior to a mission or during real time through the use of keyboard commands. Each target has a designated multifunction solution (vehicle state vector or track based on multiple sensor inputs to the SRIF) that is used to compute mission measurement data at a rate of once per second. These data include such parameters as Time to Release, Instantaneous Impact Point (IIP) and Impact Uncertainty for Bomb Drop missions; Rate of Closure and Intercept Heading for Intercept missions; Wind Speed and Direction at one thousand foot intervals for Weather Balloon missions; and parachute IIPs based on main chute or drogue chute only and current winds aloft.

TSPI DATA RECORDING

As with all other IFDAPS processed data, TSPI data recording is done by the CSS processors. IFDAPS has the capability of recording raw input data, corrected measurement data and a composite file of all real-time commands with their associated response. All recording is handled on an operation-by-operation basis. History files are established and opened by CSS at operation initialization time based on parameters specified in the run file. TSPI data input and processed by an ADS are made available to the CSS through an Asynchronous Memory Link (AML) developed by Data Engineering, Inc. (DEI). In this manner, TSPI data are recorded in the same files as telemetry data. TSPI data input and processed by the RCS are passed to the CSS over the HYPERchannel and recorded in separate raw, measurement and composite history files. Raw or measurement data from these separate files can be merged with telemetry data using a non-real-time utility program.

Data available for recording from the RCS include raw input data, corrected tracking data, and vehicle performance parameters for each track. Recording rates and the selection of specific parameters to be recorded can be controlled through real-time commands as well as the actual initiation and termination of the recording for each individual operation. Additionally, the RCS provides the capability to record special “smoother” parameters output by the SRIF and used after mission termination for a second filter pass. Output data from this second filter pass provide finalized mission information to a user shortly after mission termination.

DATA TRANSFER

Being an integrated system, IFDAPS allows data transfer between any two processors in the system. Most real-time data transfer is accomplished using shared memory between the ADS, DAS and CSS processors. These data include measurements, display parameters, control parameters and recording data. Data can also be transferred in either real time or non-real time using Network System Corporation’s NETEX software to pass data files over the HYPERchannel. The HYPERchannel is used to pass status information from all processors to the CSS, and it is the only method available to transfer data to or from the RCS. The RCS uses the HYPERchannel to transfer recording data to the CSS and to exchange telemetry and.TSPI data with ADS processors. This exchange of data allows the

ADS to use TSPI data parameters as telemetry measurements for computation and display. It also allows the RCS to display alphanumeric telemetry measurement data, to use the INS data for flight path estimations, and to use such parameters as aircraft attitude measurements for IIP calculations. Figure 1 shows a minimum IFDAPS distributed system.

DATA DISPLAY

One of IFDAPS major capabilities is the sophisticated display of real-time data. Telemetry data can be displayed at the ADS and DAS using either low resolution alphanumeric terminals provided by Human Designed Systems, Inc.; intermediate resolution, color graphics terminals provided by Tektronix, Inc.; or high resolution color graphics devices provided by Megatek Corporation. All of these devices can be used as control terminals using the IFDAPS real-time command interface described in Reference 2. Except for status and directory information, telemetry displays are completely constructed by the user prior to a mission using IFDAPS Support Language (ISL) to define the displays in the run file. These displays can include alphanumeric data, time history plots, cross plots, scrolling strip charts, bar charts and discrete annunciators. Users can make the display as simple or as complex as they like.

Due to the limited number of TSPI measurements and the specific type of information they represent, all TSPI data displays at the RCS are based on fixed formats. The RCS uses only the high resolution, 1024 x 1024, color graphics Megatek terminals for display purposes. Each terminal has the same real-time command interface as the telemetry terminals but with a set of commands unique to TSPI data processing. The RCS provides the following types of displays:

a. <u>RCS Status</u> - The RCS Status Display (Figure 2) identifies the current state of the RCS processor. It presents the operations that are currently being supported along with key processing information relative to each operation. It displays the status of each terminal connected to the RCS and also identifies other IFDAPS processors supporting the RCS.

b. <u>PIPS Input Status</u> - The PIPS Input Status display (Figure 3) presents the status of all 32 Front End Processor (FEP) channels associated with the PIPS input data. For each channel, information is presented that identifies how the data are assigned to be processed and the actual raw data being received for the channel.

c. Operation Status - The Operation Status display (Figure 4) presents all the control and status information associated with a particular operation. Data presented includes identification and processing controls for each target and for each sensor assigned to support the operation. This display also includes the current raw data being received for each sensor.

d. Measurement Recording Status - The Measurement Recording Status display (Figure 5) is an operation specific display that identifies which measurements are being recorded for each target and the current recording rate.

e. Trajectory Information - The Trajectory Information display (Figure 6) is designed to provide information associated with the multistation solution on a specific target, the status of the SRIF and a quick assessment of the sensors providing input data to the SRIF.

f. Sensor Evaluation - The Sensor Evaluation display (Figure 7) provides information necessary to evaluate the current tracking status of a particular sensor. This includes scrolling residual charts of range, azimuth and elevation as well as such factors as sync losses and percentage of points rejected by the editor and the filter.

g. Standard Track - The Standard Track display (Figure 8) is the primary real-time TSPI display. This display consists basically of two areas, a measurement area and a map area. The RCS provides the capability in non-real time to build and record digital map information from Defense Mapping Agency data and/or data from a digitizing pad connected to the Megatek. The digital map can be recalled in real time for use as background display information. Position data for up to five targets can be dynamically displayed (5 sps update rate) over the background map. The capabilities to pan, zoom and change maps are available. Measurement parameters associated with each displayed target (color coordinated) are presented in the measurement window. The measurements displayed are selectable by real-time command. Telemetry measurements received from an ADS or DAS are also presented in this area.

h. Mission Initialization Parameters - This display is the same format as the Standard Track display. The initialization parameters for a specific type of mission (e.g., Bomb Drop, Intercept, etc.) are presented in the measurement area for review and modification by the operator.

i. Mission Display - This display consists of an overlay to the Standard Track display. Associated with a particular type of mission are specific display features and parameters output from mission processing. The mission output parameters, such as

Release Point, Time to Release and Range to Release for Bomb Drop missions, are displayed in the measurement area. Mission display features, such as Altitude Trace, Target Point and the Run-In Line for a Bomb Drop mission, are overlayed onto the map area.

The RCS can also transmit TSPI display data directly to an ADS over the HYPERchannel, thus allowing one of the ADS Megatek terminals to be used as an RCS display terminal. Positional display data can also be transmitted to an ADS for output to X-Y Milgo plotboards.

SUMMARY

The IFDAPS offers not only an advanced state-of-the-art telemetry processing capability, but it also provides a complete range operation control capability to satisfy range safety and mission performance evaluation requirements. IFDAPS provides a means of combining telemetry and TSPI data processing in a real-time, multiple-operational environment.

REFERENCES

1. Fanus, Dick, “IFDAPS: A Hardware Overview”, SFTE 15th Annual Symposium Proceedings, 1984.

2. McCauley, Bob, “IFDAPS: A Software Overview”, SFTE 15th Annual Symposium Proceedings, 1984.

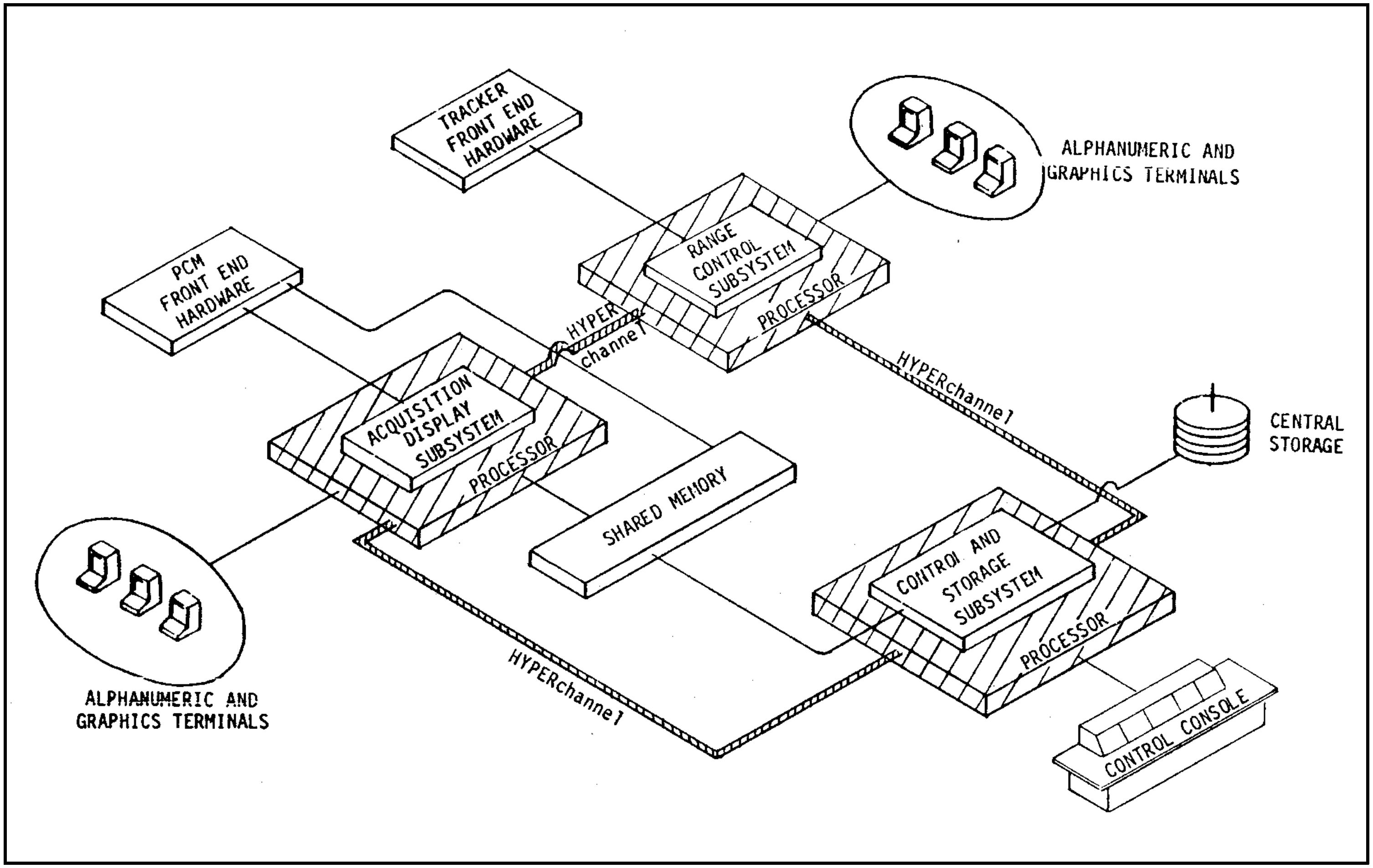

Figure 1. Minimum IFDAPS Distributed System

13:36: 3 OP=INT1 UNCLASSIFIED RCS STATUS
05/02/85 MT=INTERCEPT RNGE AZ EL
MD=REAL TIME

OP NUM	OP MODE	MISSION	CURRENT STATE	TIME INIT	MEAS SEC	ASSIGNED SENSORS	PIPS OUTPUT	HIST REC
INT1	REALTIME	INTRCEPT	ENABLED	13:28:15	70	6	YES	NO
BOMB	REALTIME	BOMB	INIT	13:33: 3	0	3	NO	NO
SIM1	SIM	FLY BY	ENABLED	13:33:15	30	2	YES	NO
TOTALS					100	11		

TERM ID	STATUS	OP NUM	POSITION	USER
A	ACTIVE	SIM1	OP CONTROLLER	REED
B	ACTIVE	INT1	TSPI ENGINEER	JESS
C	ACTIVE	INT1	RCS CONTROLLER	WYN
D	ACTIVE	NONE	UNASSIGNED	NONE
E	INACTIVE			
F	INACTIVE			

IFDAPS PROC	OP NUM	TSPI FUNCTION
NONE	NONE	NO

Figure 2. RCS Status Display

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                                          UNCLASSIFIED       PIPS INPUT STATUS
13:32:26  OP=INT1                                            RNGE           AZ          EL
05/02/85  MT=INTERCEPT
          MD=REAL TIME

------ASSIGNMENTS-------      ---------------------STATUS---------------------
FEP NAME TGT TK   OPNUM       NAME      TIME       RANGE  AZIMUTH ELEVATION * TRK
--- ---- --- --  --------     ---- ------------ ------- ------- --------- ----
  1
  2
  3 C1   111  M   INT1         C1   0: 1: 1.461       0 100.662    18.345  SKIN
  4 C15  111  M   INT1         C15  0: 1: 1.461       0  91.248     7.977  SKIN
  5
  6
  7 R41  111  M   INT1         R41  0: 1: 1.461  140039 103.409     9.134  BECN
  8
  9 C3   222  M   INT1                                                     DROP
 10 C4   222  M   INT1                                                     DROP
 11 DIR  222  M   INT1         DIR  0: 1: 1.461   92337 142.673    14.683  BECN
 12
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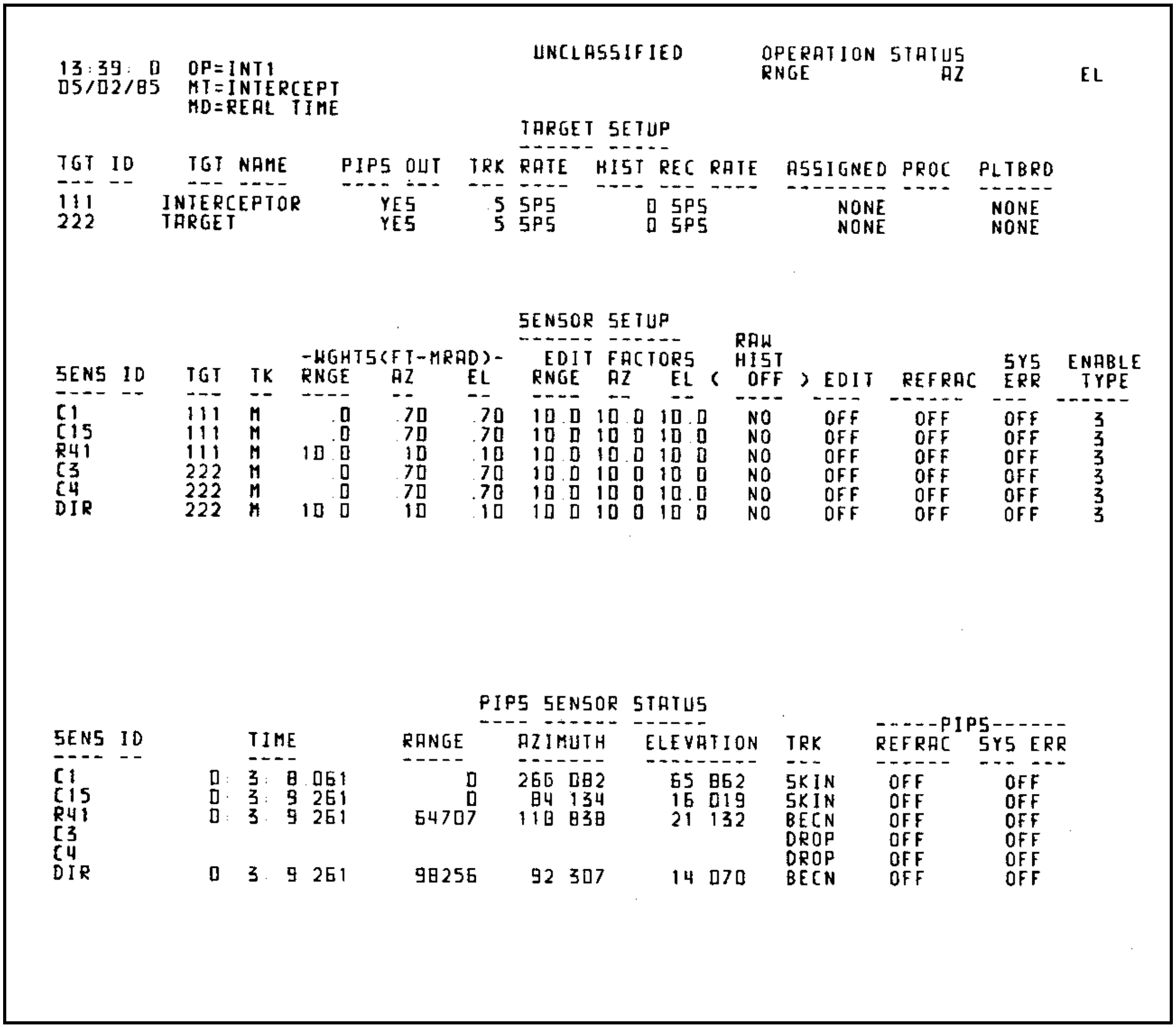
```

Figure 3. PIPS Input Status Display



13:39: 0 OP=INT1
05/02/85 MT=INTERCEPT
MD=REAL TIME

UNCLASSIFIED

OPERATION STATUS
RNGE AZ EL

TARGET SETUP

TGT ID	TGT NAME	PIPS OUT	TRK RATE	HIST REC RATE	ASSIGNED PROC	PLTBRD
111	INTERCEPTOR	YES	5 SPS	0 SPS	NONE	NONE
222	TARGET	YES	5 SPS	0 SPS	NONE	NONE

SENSOR SETUP

			-WGHTS(FT-MRAD)-			EDIT FACTORS			RAW HIST			SYS	ENABLE
SENS ID	TGT	TK	RNGE	AZ	EL	RNGE	AZ	EL (	OFF)	EDIT	REFRAC	ERR	TYPE
C1	111	M	.0	.70	.70	10.0	10.0	10.0	NO	OFF	OFF	OFF	3
C15	111	M	.0	.70	.70	10.0	10.0	10.0	NO	OFF	OFF	OFF	3
R41	111	M	10.0	.10	.10	10.0	10.0	10.0	NO	OFF	OFF	OFF	3
C3	222	M	.0	.70	.70	10.0	10.0	10.0	NO	OFF	OFF	OFF	3
C4	222	M	.0	.70	.70	10.0	10.0	10.0	NO	OFF	OFF	OFF	3
DIR	222	M	10.0	.10	.10	10.0	10.0	10.0	NO	OFF	OFF	OFF	3

PIPS SENSOR STATUS

						-----PIPS------	
SENS ID	TIME	RANGE	AZIMUTH	ELEVATION	TRK	REFRAC	SYS ERR
C1	0:3:8.061	0	266.082	65.862	SKIN	OFF	OFF
C15	0:3:9.261	0	84.134	16.019	SKIN	OFF	OFF
R41	0:3:9.261	64707	118.838	21.132	BECN	OFF	OFF
C3					DROP	OFF	OFF
C4					DROP	OFF	OFF
DIR	0:3:9.261	98256	92.307	14.070	BECN	OFF	OFF

Figure 4. Operations Status Display

```
13:39:32  OP=INT1                               UNCLASSIFIED      MEAS  RECORDING STATUS
05/02/85  MT=INTERCEPT                                            RNGE           AZ           EL
          MD=REAL TIME

                                                     TARGET IDS AND NAMES
OP RECORDING  OFF                                    ------ --- --- -----
                             111             222
                         INTERCEPTOR   TARGET
                         -----------   -----------
  TRK RATE                  5 SPS         5 SPS
  REC RATE                 20 SPS        20 SPS
  TGT RECORDING             OFF           OFF
MEASUREMENT NAMES
----------- -----
  ACCELERATION
    TOTAL                    --            --
    TANG AIR                 --            --
    TANG GRND                --            --
  ALTITUDE
    MSL                      --            --
    GEODETIC                 --            --
  AZIMUTH                    --            --
  CLIMB RATE                 --            --
  COR SENSOR DATA            --            --
  COURSE
    MAGNETIC                 --            --
    TRUE                     --            --
  DIVE ANGLE                 --            --
  FLT PATH ANGLE             --            --
  GEOD LOCATION              --            --
  HEADING
    MAGNETIC                 --            --
    TRUE                     --            --
  RANGE
    GROUND                   --            --
    SLANT                    --            --
  STATE
    POSITION                 --            --
    VELOCITY                 --            --
    ACCELERATION             --            --
  VELOCITY
    GROUND                   --            --
    TOTAL                    --            --
    AIR                      --            --
                             --            --
                             --            --
```

Figure 5. Measurement Recording Status Display

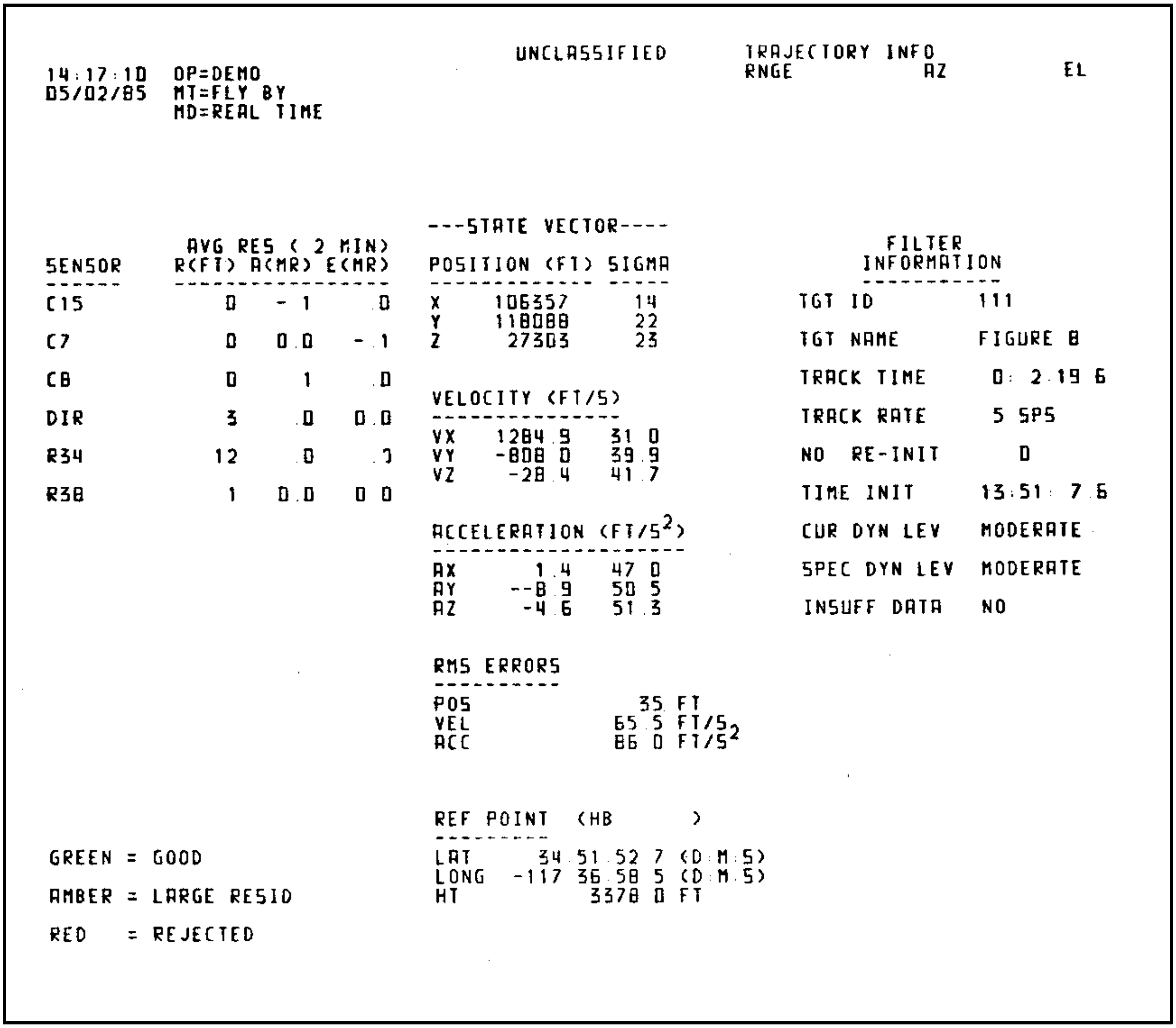


Figure 6. Trajectory Information Display

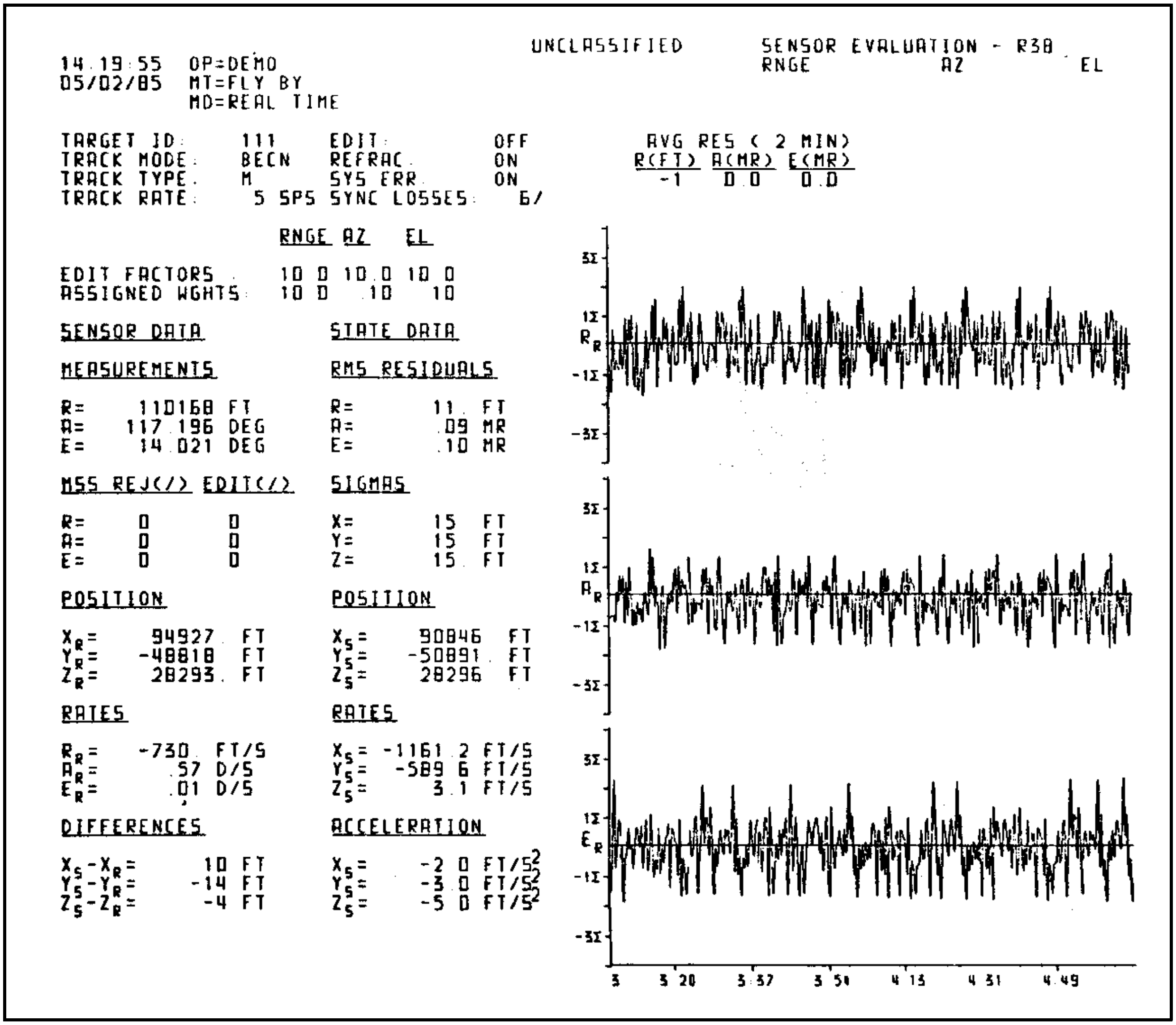


Figure 7. Sensor Evaluation Display

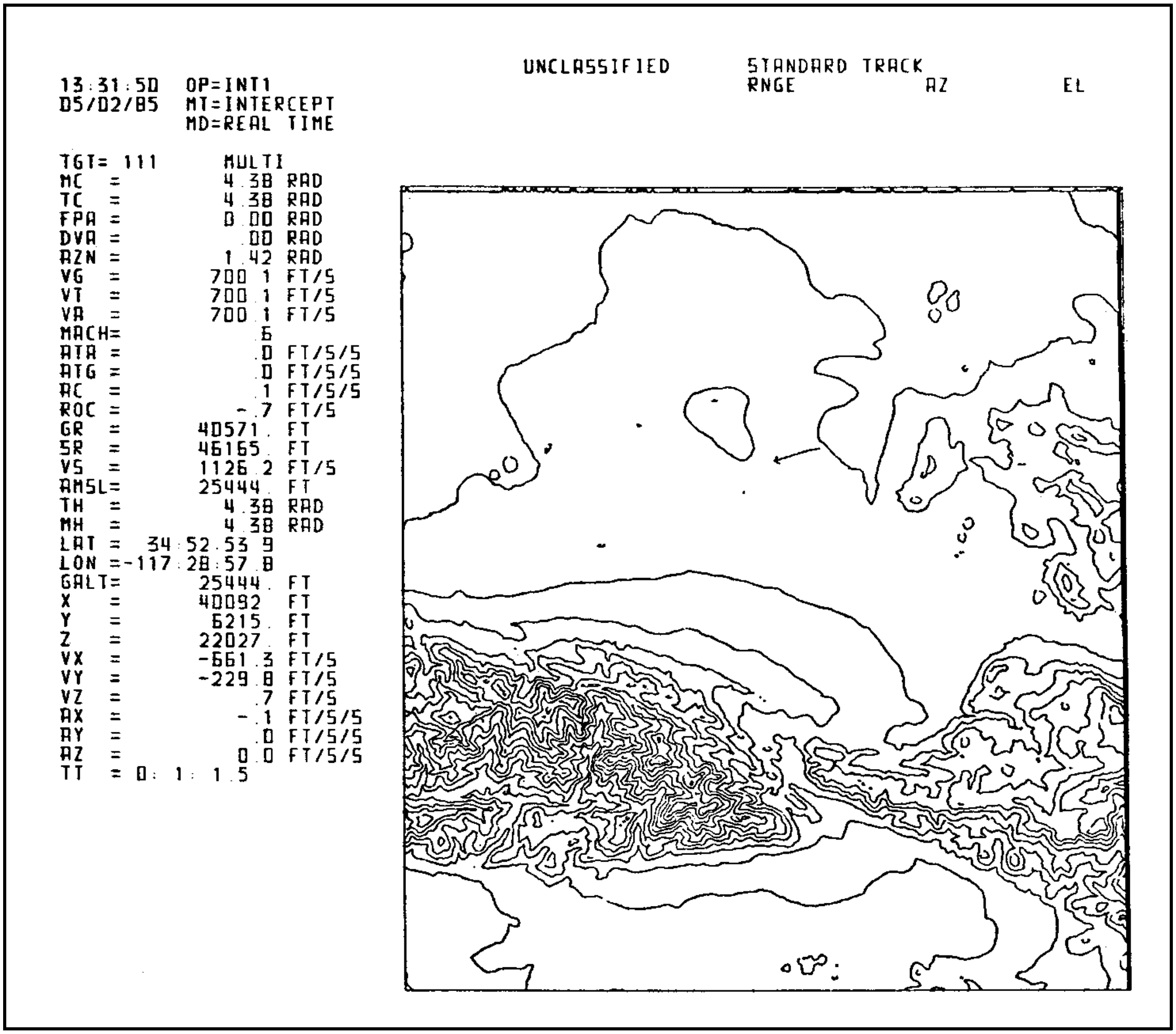


Figure 8. Standard Track Display