

DATA LINK TEST AND ANALYSIS SYSTEM/
TCAS MONITOR USER'S GUIDE

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16. Abstract This document is a user's guide for the Data Link Test and Analysis System (DATAS) Traffic Alert and Collision Avoidance System (TCAS) monitor. This is one of a series of published documents on DATAS.					
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EXECUTIVE SUMMARY

This document is a user's guide for the Data Link Test and Analysis System (DATAS) Traffic Alert and Collision Avoidance System (TCAS) monitor application. It provides a brief overall hardware description of DATAS configured as a TCAS Monitor, and an application software user's guide. It is assumed that users are familiar with the message fields of the Mode Select (Mode S) Beacon System and TCAS transmissions.

DATAS is a multipurpose test system designed and fabricated at the Federal Aviation Administration (FAA) Technical Center to test the performance of Mode S Data Link subsystems. It is capable of testing various components of Data Link including: Air Traffic Control Radar Beacon System (ATCRBS) and Mode S transponders, Data Link Processors (DLP), and Data Link subsystem interfaces. It will also provide the capability of Mode S sensor emulation and radio frequency (RF) environment analysis within the frequency range of 950 to 1200 megahertz (MHz).

The TCAS Program Office sponsored this effort to record TCAS Resolution Advisory activity which is occurring in the vicinity of high-traffic airports.

The TCAS Monitor function uses a standard DATAS with the addition of a high power transmitter, a directional horn antenna, and application software. The fixed direction antenna provides an approximate 35 degree beamwidth and the transmitter has a theoretical operating range of 35 miles. In this application, DATAS is programmed to operate like a limited Mode S sensor. Any Mode S equipped aircraft that fly within range of the system will be interrogated with Mode S only all-call interrogations, and once acquired, will be kept on roll-call surveillance. For the TCAS Monitor, roll-call consists of two interrogations sent to each aircraft per scan. These interrogations were selected so the aircraft altitude, ATCRBS ID, TCAS capability, and TCAS sensitivity can be recorded. The occurrence of a conflict will cause a Resolution Advisory to the pilot of a TCAS equipped aircraft. The occurrence of a TCAS Resolution Advisory is signaled to ground Mode S sensors which makes it possible to acquire a copy of the advisory message. Using this protocol, the TCAS Monitor will request and record all occurrences of such advisories. All Mode S transactions are time tagged in the recorded data in order to allow correlation with ARTS III data.

The surveillance scenario implemented was selected in order to maximize the amount of information obtained from each target. The system was also designed so that engineers can preselect certain operational parameters that will limit the number of reinterrogations to nonresponding aircraft, the number of scans to attempt reinterrogations of nonresponding aircraft, and the time between surveillance scans. Such precautions were taken in order to set limits on the amount of interference injected into the air traffic environment.

The TCAS Monitor has been designed to operate as an unmanned system. The data collection procedure can be stopped or started, its status can

be checked, and/or data can be down loaded from a personal computer (PC) at a remote location via a modem. The software design allows the data which has been collected to be stored and analyzed using commercially available data base programs on a PC.

INTRODUCTION

The Traffic Alert and Collision Avoidance System (TCAS) monitor is one of the functions of a multipurpose test system designed to test various Mode S and Data Link system components called the Data Link Test and Analysis System (DATAS). This system was designed and fabricated at the Federal Aviation Administration (FAA) Technical Center. Since DATAS provides radio frequency (RF) capabilities compatible with Air Traffic Control (ATC) surveillance systems in the frequency range of 950 to 1150 megahertz (MHz), it is a natural candidate to perform the TCAS Monitor function.

The TCAS Monitor is designed to record TCAS activity in the air traffic environment. It performs a scaled down Mode S sensor function. Mode S targets are acquired by sending periodic Mode S only all-calls. These targets are then put on roll-call for as long as they are within range of the TCAS Monitor. Surveillance information about each target is recorded and the Downlink Request (DR) field is checked in each reply for an indication that a TCAS Resolution Advisory is active. When an advisory message is active, the TCAS Monitor will acquire the message and store it with the surveillance data.

The system was designed with the intent of allowing the user to accumulate and analyze data using a commercial data base program on a personal computer (PC). The DATAS provides a means of transferring data to an on-board PC in data base compatible format.

SYSTEM CONFIGURATION

The TCAS Monitor consists of a standard DATAS with the addition of a high power transmitter, a directional horn antenna, and the TCAS Monitor application software.

HARDWARE.

Only a high level description of the hardware is provided here in the user's guide. A detailed description is provided in the hardware manual of DATAS.

The DATAS has many different configurations depending on the capability of that particular system. The DATAS which has the TCAS Monitor capability consists of three units: the 68020 computer unit, the DATAS virtual memory extension (VME) unit, and the RF unit (each of which is approximately 19 inches x 12 inches x 19 inches), two video display terminals, and a printer. The three units are contained in a single rack. The printer is optional for the field collection system. The RF unit is connected to a high power transmitter which is housed in its own rack with the required power supplies. The system RF output feeds a standard horn antenna. Figure 1 is a block diagram of the DATAS TCAS Monitor system.

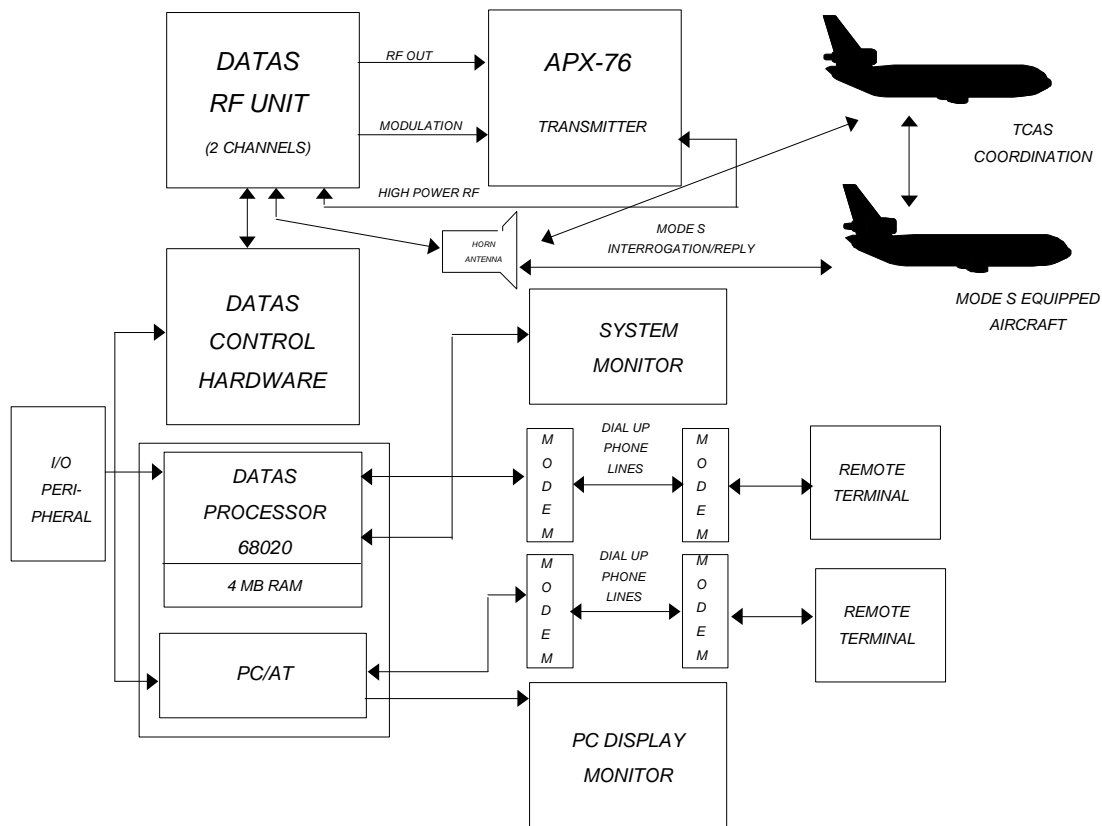


FIGURE 1. DATAS TCAS MONITOR BLOCK DIAGRAM

The DATAS is basically a programmable transmitter/receiver unit with RF output capability in the frequency range of 950 to 1150 MHz. The transmitter has two completely independent channels whose outputs are combined if the high power output is selected. Several RF outputs are available for different applications. The frequencies, pulse widths, and amplitudes of all RF outputs are programmable. However, on the high power transmitter output used for the TCAS Monitor (approximately one kilowatt), only the pulse modulation is programmable. This is a limitation of the transmitter, which is an APX-76 airborne interrogator normally used by the U.S. Air Force for Air Traffic Control Radar Beacon System (ATCRBS) interrogations. This unit has been modified slightly to use the low level RF output and modulation control signals from DATAS to drive the APX-76 transmitter instead of using those signals normally provided by its control unit. This provides the TCAS Monitor with a very reliable transmitter output without an extensive development cycle.

The receiver of DATAS is a single channel and is programmed to operate at a frequency of 1090 MHz when used as a TCAS Monitor. The DATAS

contains sophisticated pulse preprocessing capability which is also programmable. Pulse characteristics such as RF frequency, amplitude, spacing, and pulse widths are stored for each reply pulse. The decoders which detect replies to DATAS interrogations are also programmable and in the TCAS Monitor are set up to decode the arrival of Mode S replies.

The time of arrival of these replies is saved (referenced to a moveable listening "window" which is under program control) in order to provide the radar range of the reply. The Mode S reply code is also stored and sophisticated code correction capability is included in order to overcome interference from ATCRBS replies which may overlap the desired reply.

The TCAS Monitor configuration of DATAS contains two processors. The first is a 68020 processor which performs the normal system functions of DATAS in its role as a limited Mode S sensor as well as the control of the DATAS hardware. The configuration of the hardware, including the RF unit, is under control of the 68020. Any one of several ports (i.e., bench port, high power antenna port, diagnostic port, and medium power antenna port) can be selected for use by the RF receiver under program control. This control is exercised via the VME bus of the 68020 as all DATAS hardware devices were designed to appear the same as "memory" to the 68020 processor.

The second processor of DATAS is a personal computer (PC/AT) which communicates with the DATAS system via the VME bus. It is primarily for data analysis. The data collected via the 68020 can be transferred via the VME bus to the PC where it is manipulated and placed in a format compatible to standard data base program packages. These data are retrievable via modem/phone line interface if desired.

System control is either via the local system console(s) or the modem/phone line interface. The modem/phone line interface is meant primarily for diagnostic purposes. The hardware cards have extensive diagnostic capability built in so that troubles can be diagnosed remotely. Data collection can also be initiated and terminated via the modem/phone line interface, but the high power transmitter cannot be controlled remotely (it must be powered on prior to initiation of data collection via modem).

OPERATING SYSTEMS. The operating system that is installed on the DATAS 68020 processor is the Motorola VERSAdos real-time, multi-tasking/multi-user operating system version 4.61.

The operating system that is installed on the PC system is Microsoft MS-DOS version 3.30.

FUNDAMENTALS OF OPERATION

This section provides an overview of how to prepare the DATAS for operation as a TCAS Monitor. The process of booting the system and setting the time and date are described. If the user is familiar with these procedures he may skip to the next section.

It is not essential that the user be an expert in VERSAdos, but a working knowledge is required to make efficient use of the TCAS Monitor

data collection programs. A set of VERSAdos documentation should be available to the user. This section provides example commands to the VERSAdos operating system. In the examples the user responses are in bold print.

BOOT PROCEDURE.

When DATAS is powered on, the DATAS processor will come up under the system debugger. When the system debugger is running the user prompt is "135Bug>." The system needs to be booted up in order to run the TCAS Monitor programs under VERSAdos. In order to boot the system, enter "bo 0 8" at the user prompt. For example:

```
135Bug>bo 0 8
```

The sequence is as follows:

```
IPL loaded at: $00010000
Boot in progress ...
Boot complete
XVERSAdos Version 4.61                8908101152
ENTER DEFAULT SYSTEM VOLUME:USER NO.=<CR>
ENTER DATE (MM/DD/YR)=6/4/90          (Current date)
ENTER TIME (HR:MIN)=11:18              (Current time)
```

Some information will follow on the screen. When a "=" appears on the last line, the operating system command processor is ready for a VERSAdos command.

Following the above procedure, the user will be logged on under user number "0." In order to run the TCAS Monitor programs, the user must be logged on under the same user number where they are located on the disk. The user number where the programs are located should be provided when the system is delivered. In order to change from one user number to another, run the VERSAdos "use" command. For example:

```
=use 401
SYSTEM VOLUME = SYS:
USE DEFAULT VOLUME = SYS:401..
USER NUMBER = 0
USER TASK =
SESSION = 0001
TERMINAL = CN00
OPTION(S) SET =
```

Any nonprivileged VERSAdos command can be executed from any user number by entering the command followed by a carriage return. Any application program that resides within the current user number can be run by entering the name of the program followed by a carriage return.

TIME AND DATE.

Setting the time and date is very important for the TCAS Monitor program. The time and date should be set during the boot procedure, but if it is not, it can be set using VERSAdos commands. The time and date can only be set if the user is logged in under user number "0." If the user number is other than "0," the time and date commands can only be used to verify the settings, and, in which case, either command will yield the same result. For example:

```
=time
  11:21:13 6/4/90
=date
  11:21:16 6/4/90
```

If the time is not set, it will indicate the elapsed time since the system was booted starting at 00:00. If the date was not set, it will show the number of days since the system was booted starting at 1/1/80. The following is an example of when both the time and date were not set:

```
=time
  00:00:56 1/1/80
```

If the user has logged on as user "0," both the time and date commands will allow the user to change the current value. The following is an example of setting both the system time and system date:

```
=time
  00:02:34 1/1/80
ENTER TIME (HR:MIN)=11:28
=date
  11:28:11 1/1/80
ENTER DATE (MM/DD/YR)=6/4/90
=
```

Once the system is booted, the time and date are set, and the proper user number is selected, the user is able to run the TCAS Monitor programs.

TCAS MONITOR PROGRAMS.

The normal TCAS Monitor data collection procedure may require running up to four application programs on the DATAS processor and one application program on the VME PC system. A program is run on either computer by typing the name of the program at the operating system prompt followed by a carriage return. The programs are described in detail throughout this document. The following is a list of the TCAS Monitor application programs:

1. "tcsrecv" - (PC) The PC resident program used to receive TCAS Monitor data from the DATAS processor.
2. "tcssend" - (68020) The 68020 resident program that transfers TCAS Monitor data to the VME PC.

3. "tcsfile" - (68020) Provides data analysis on the DATAS processor.
4. "tcsmenu" - (68020) Menu to select and change the operating parameters (privileged).
5. "tcsmon" - (68020) TCAS Monitor real-time data collection program.

Figures 2 and 3 show software diagrams for both the DATAS processor programs and the PC programs. These diagrams show the relationships between the various programs and their associated files.

The five TCAS Monitor programs are used in various stages of the data collection procedure. To illustrate the use of each program, a typical monitor data collection operation might be as follows:

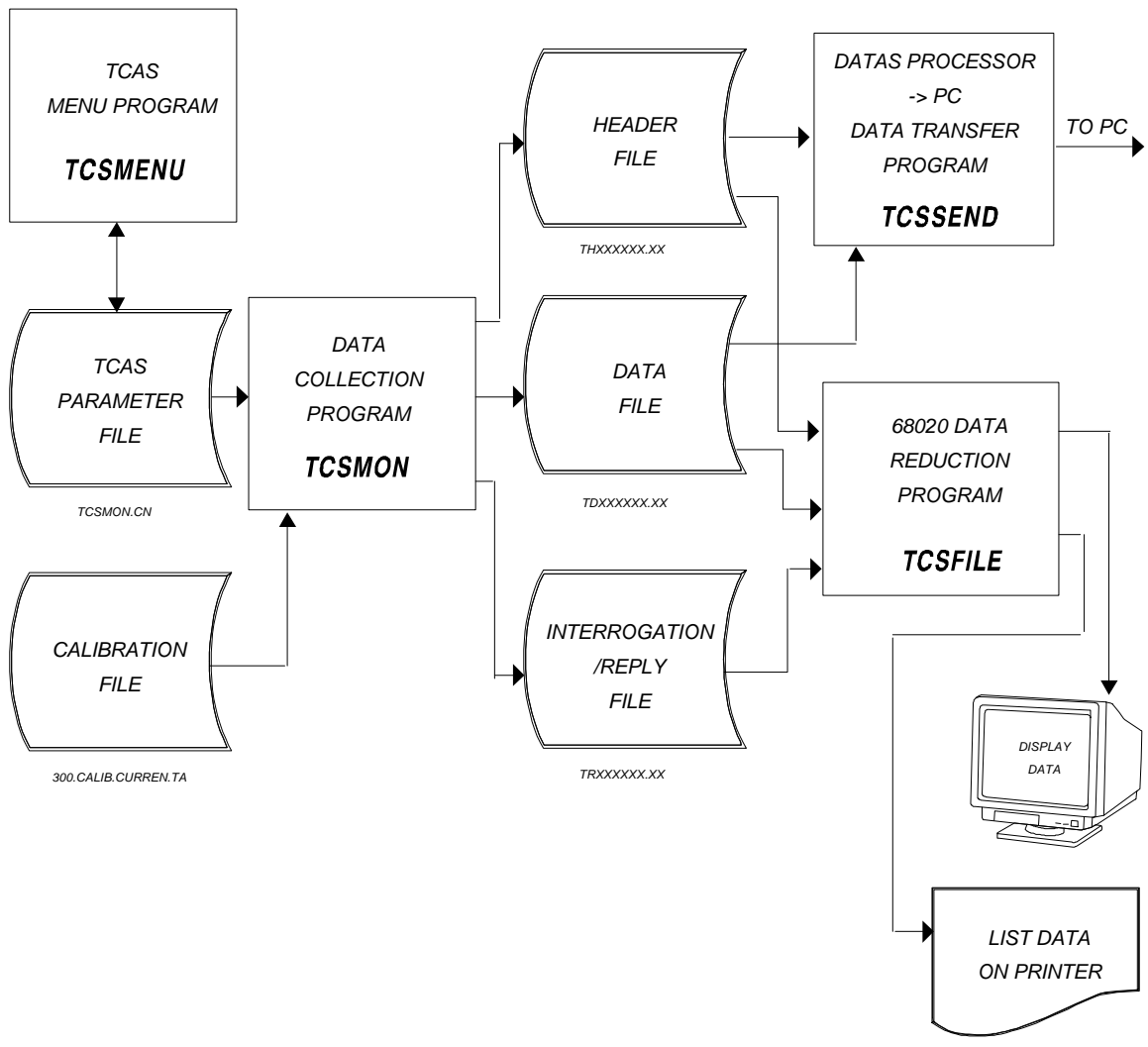


FIGURE 2. TCAS MONITOR DATAS PROCESSOR SOFTWARE DIAGRAM

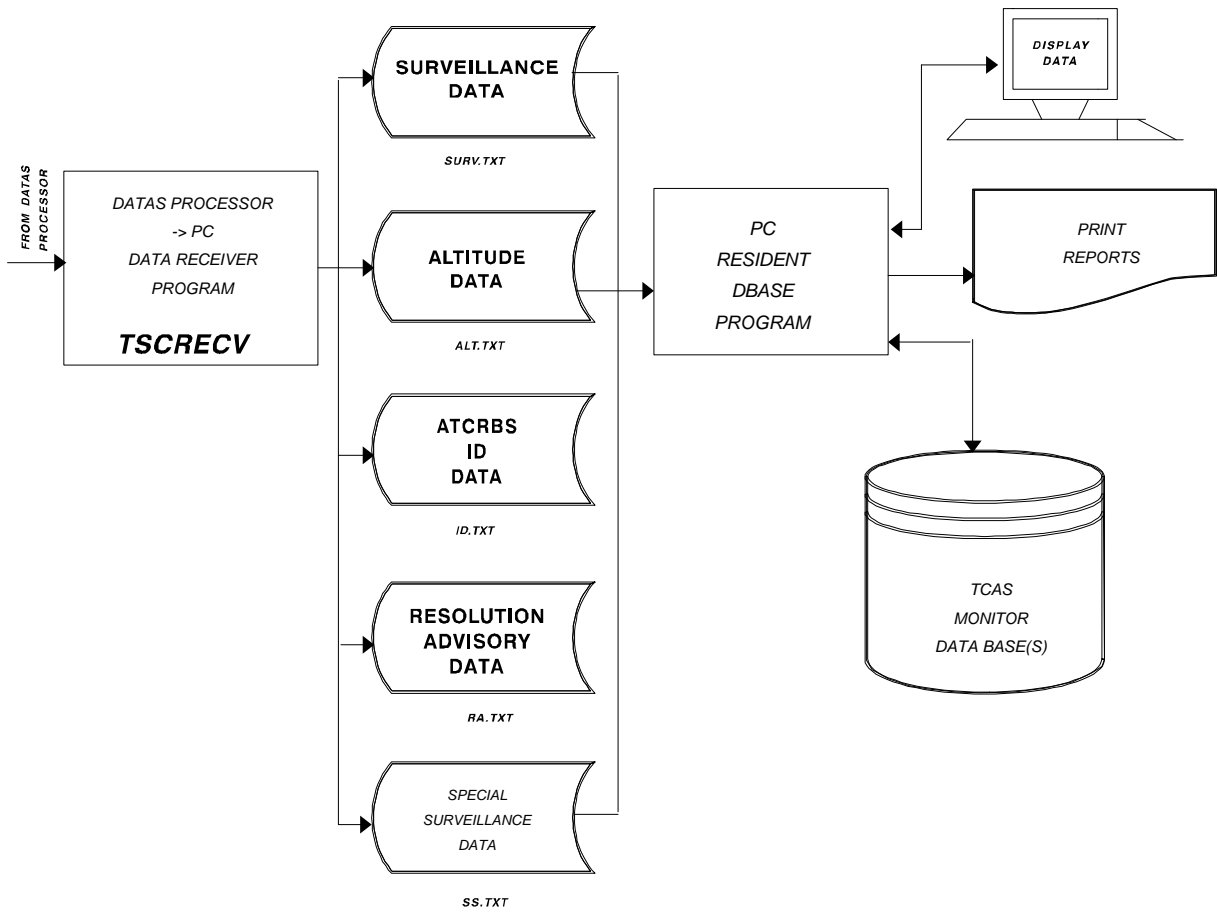


FIGURE 3. TCAS MONITOR PC SOFTWARE DIAGRAM

1. The "tcsmenu" program is run in order to set the operating parameters for the desired configuration. The operating parameters are variables whose values control various aspects of the data collection procedure. They provide flexibility so the user can adapt the TCAS Monitor program to any data collection environment. The parameters are stored in a file that is read by the data collection program. Execution of this program requires privileged access.

2. The "tcsmon" program is run to perform the data collection process. The data may be stored in the three files: header file, data file, and the interrogation/reply file.

3. Once data collection has been terminated, a quick data analysis can be performed on the DATAS processor by running the "tcsfile" program. This program can be used to print target data and/or interrogation/reply data on the screen or printer.

4. For a more comprehensive data analysis, the data can be sent to the PC system to be used with a commercial data base program. The data is transferred by running the "tcssend" program on the DATAS processor while running the "tcsrecv" program on the PC. The data will be transferred and stored in temporary ASCII files that may be imported by a data base program to append to an existing data base.

TCAS MONITOR OPERATING PARAMETERS

The operating parameters are variables that are used to control various aspects of the data collection procedure. A menu driven program is provided that allows system engineers to change the values of the parameters. The parameters provide the required system flexibility for adapting the TCAS Monitor to variable operating conditions and user requirements in the field data collection environment. The parameter menu program resides in a privileged user area so that only system engineers can change their values.

PARAMETER MENU ("TCSMENU" PROGRAM).

Once the user has gained privileged access, the TCAS Monitor menu program is run by entering the program name "tcsmenu" at the VERSAdos prompt. The program will display the current parameters on the screen (see figure 4). The parameters are stored in the file "tcsmon.cn" under the current user directory. If the TCAS data collection program is run without running the menu program, the parameters will have the same value as previously selected.

Figure 4 shows an example display of the TCAS Monitor menu selection program. The parameters are selected using the arrow keys. The selected parameter is displayed in reverse video. The space-bar key is used to advance each parameter to the next value (actually, any key will work), except the Monitor Location, this requires up to four characters typed in for its value.

```

Select Using Arrow Keys...Change With Space Bar or Key Entry

Monitor Location:  UACY
Scan Rate (seconds):  4
Scan Rate for Active Resolution Adv. (Seconds):  1
All-Call Reply Probability:  1
Interrogator Identifier (IIS):  0
Information Level:  2 - Medium Int./Reply
                    sequence
Information From:  All Mode S Aircraft
Display Information on Screen:  On
Mean Time Between Interrogations (ms):  3
Store data on disk:  Yes
Miss Limit:  3
Scan Limit:  3
Output select:  Bench select

[F5]---Store Parameters & Exit           [F6]---Quit

```

FIGURE 4. TCAS MONITOR PARAMETER MENU PROGRAM

1. "Monitor Location." This parameter requires up to four characters entered, followed by a carriage return. The response to this parameter should be recorded by the data collection personnel because it is used as part of the data file name. An identical response will be required when the data are retrieved. The intention is that the standard four-character identification code for the nearest city to the monitor site be used to help correlate the collected data with the location. This is not a requirement, however, since the response is merely used to identify the data file.

2. "Scan Rate (seconds)." The value can be changed from "1" to "20" using the space-bar key. This is the time in seconds between surveillance scans.

3. "Scan Rate for Active Resolution Adv. (seconds)." The value can be changed from "1" to "20" using the space-bar key. This is the time in seconds between surveillance/TCAS information acquisition scans for targets that have reported Active Resolution Advisories. This value is normally less than the regular scan rate in order to accelerate the information acquisition for priority targets.

4. "All-Call Reply Probability." The values selected are: "1", "1/2", "1/4", "1/8", and "1/16" using the space-bar key. This response determines the value of the Probability of Reply (PR) field of the Mode S all-call interrogation. This field is used to reduce the probability of overlapping replies in high traffic environments.

5. "Interrogation Identifier." The value can be changed from 0 to 15 using the space-bar key. The selected value is sent in the Interrogator Identifier Subfield (IIS) of the surveillance interrogations, and the Interrogator Identification (II) field of the all-call interrogation.

6. "Information Level." The value can be changed with the space-bar key. This parameter determines the amount of information that is stored as the interrogation/reply data. It is intended that interrogation/reply data be recorded only when the system is initially set-up at a test location, or when investigating potential data collection problems. There is no interrogation/reply data recorded for normal TCAS Monitor operation. This parameter has no effect on the TCAS Monitor data collection for the data base programs. The interrogation/reply data can be played back using the TCAS Monitor data summary program (tcsfile). The user is provided with varying amounts of interrogation/reply data that will be collected, since the potential exists for using up large amounts of disk space for relatively short run periods. The selections are: 0 - No Int./Reply storage, 1 = Minimum Int./Reply sequence, 2 = Medium Int./Reply sequence, and 3 = Maximum Int./Reply sequence.

7. "Information From." The value can be changed using the space-bar key. The value of this parameter is relevant only if the Information Level value is greater than zero. This parameter is used to further reduce the amount of interrogation/reply information recorded. The selections are: All Mode S aircraft = will store information from all aircraft that respond to the Mode S interrogations, TCAS Equipped Aircraft = will only store interrogation/reply information from aircraft that indicate TCAS capability in the Reply Information (RI) field, and Aircraft w/ Res. Advisories = will store interrogation/reply information only from aircraft that have issued a Resolution Advisory message.

8. "Display Information On Screen." The value can be changed to ON or OFF using the space-bar key. This parameter selects whether or not the interrogation/reply information will be displayed on the screen during run time. The on screen information should be turned off for unmanned operation because the slow screen display rate can affect the operating speed of the TCAS Monitor.

9. "Mean Time Between Interrogations." The value can range from 2 to 6 using the space-bar key. This value is used to control the Pulse Repetition Frequency (PRF) of the interrogations. The answer, in milliseconds (ms), is the mean time between interrogations. The time will alternate from the mean time -1, to the mean time, to the mean time +1. This is to prevent synchronization with other interrogation sources within range.

10. "Store Data on Disk." The value can be switched between No and Yes using the space-bar key. The TCAS Monitor data storage can be turned off for trouble shooting and system testing purposes.

11. "Miss Limit." (0 - 20) This value determines the number of reinterrogations to send to each aircraft that do not reply. If this number of interrogation pairs is sent without a response during a surveillance scan, it is considered a missed scan.

12. "Scan Limit." (1 - 20) This value determines the number of scans to interrogate a target that has ceased to reply, before dropping the target from the surveillance list.

13. "Output select." This parameter allows the user to select the desired RF port. The available responses are Antenna for normal TCAS Monitor operation, and Bench select for bench testing or debugging the system.

The TCAS menu program can be exited in one of two ways. If the user wishes to store the parameters and exit he should enter the F5 key. If the user wishes to quit the program without storing the parameters in the file he should enter the F6 key.

DATA COLLECTION

This section describes in detail the operation of the TCAS Monitor data collection procedure.

OVERVIEW ("TCSMON" PROGRAM).

Prior to running the TCAS Monitor data collection program it is very important that the system time and date are set. The system date is recorded with each target that responds to a Mode S All-Call interrogation and each interrogation/reply transaction is time tagged using the system time. The system date is also used as part of the data file catalog field in order to help identify data files. The time and date should be set as part of the boot procedure. (See Boot Procedure and Time and Date under Fundamentals of Operation).

The data collection program is run from the VERSAdos prompt by typing "tcsmon" followed by a carriage return. The TCAS Monitor program will go through some initialization procedures and then, unless a problem occurs during initialization, will begin the monitor operation. Figure 5 shows an example of how the display might appear after the TCAS Monitor program has started.

```
TCAS MONITOR SYSTEM ACTIVATED

[ESC] TO TERMINATE

DATAS - TCAS MONITOR PROGRAM

System Initialization

  Reading calibration file...
  Read TCAS Monitor operation parameters from file:"TCSMON.CN"...
  Initialize hardware...
  Set transmitter frequencies to 1030 Mhz...
  Store interrogation timing patterns in hardware...
  System date = 06-01-1990
  System time = 12:10:12
  Initialize linked list...
```

```
Allocate service queue...
Search for data file:  UACY.TD060190.AA  DATA FILE IN USE
Search for data file:  UACY.TD060190.AB  NEW FILE
Open header file:     UACY.TH060190.AB  NEW FILE - LUN=2
Search for reply file: UACY.TR060190.AA  DATA FILE IN USE
Search for reply file: UACY.TR060190.AB  NEW FILE
Initiate 1 second event timer...
Data level #2, each record contains 26 bytes
Set up interrogation timer, 1 ms clock...

TCAS Monitor Activated...
```

FIGURE 5. TCAS MONITOR DATA COLLECTION PROGRAM

After "TCAS Monitor Activated..." appears on the screen, the data collection procedure begins. The program is terminated when the user presses the escape key.

PROGRAM INITIALIZATION.

This section describes the initialization process of the TCAS Monitor data collection program. This information may not be required for system users, but may be important when problems occur in the field or when software changes are required.

The initialization procedure is described in the order of occurrence. The steps correspond to those shown figure 5.

1. "Reading calibration file..." The calibration file (300.calib.curren.ta) is read in order to load the calibration tables with the current values for the transmitter and receiver characteristics. Since the TCAS Monitor utilizes a high power transmitter to achieve maximum transmit range, there is no need to have a calibrated transmit level. The system will transmit at full power. Since reply integrity is made using parity checks, there is no need for a calibrated receiver. However, the Mode S data block offsets (coarse and fine) are read from the calibration file. These offsets are correction factors used to properly position the sync phase reversals within Mode S transmissions.

2. The operating parameters are read from the file "TCSMON.CN." These parameters are set by system engineers to control various operating characteristics of the system.

3. "Initialize hardware." The DATAS hardware unit is configured for the TCAS Monitor operation.

a. The software interrupt timer is turned off.

b. The receiver noise level is determined, and the video threshold level is set to two units above noise.

c. The RF control is set to either bench select for testing the TCAS Monitor in the lab, or for antenna select for field data collection. This selection is determined by the operating parameters.

d. The local oscillator is set to receive 1090 MHz transmissions.

e. The interrupt controller is set to disable interrupts.

f. The transmit control is set to stop immediately for all three transmit channels.

g. The external output control is set. There are four software selectable external signal jacks located on the back of the DATAS hardware rack. These jacks can be used to monitor transmitter activity. The signal present on external jack 4 is also used to drive the high power transmitter. It is required that the Pulse Amplitude Modulation (PAM) signal be selected for jack 4. The TCAS Monitor uses both transmit channels (1 and 2), so the PAM external jack selections are constantly switched between PAM Drive #1 and PAM Drive #2 at run time. The signals provided by the TCAS Monitor are: PAM Drive (1 or 2) on external jack 1, Timing Reference (1 or 2) on external jack 2, Reply Window on external jack 3, and PAM Drive (1 or 2) on external jack 4. See figure 6.

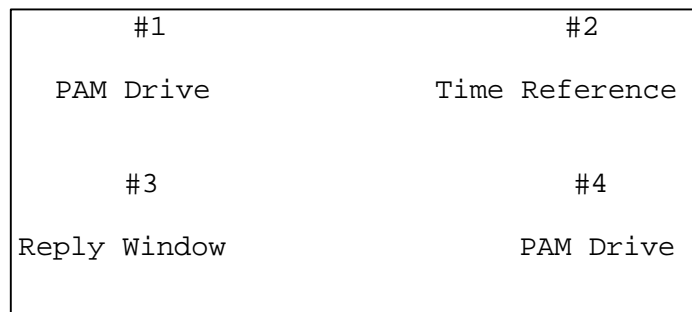


FIGURE 6. EXTERNAL OUTPUT JACKS

h. The raw data control is set for dynamic threshold for received pulses and the initial threshold is set to the level determined in step b. The sample interval control is enabled for pulse lead edge, the sample granularity is 100 nanoseconds (ns), and the time reference for pulse positions is from the lead edge of the reply window.

i. The reply decoders are set so that a decode #1 is an ATCRBS reply and a decode #2 is a Mode S reply. This is a standard decoder setting even though there are no ATCRBS reply decoding with the TCAS Monitor. The decoders are used to indicate the presence of a Mode S preamble within the received pulses.

j. The Mode S reply control is set to store both corrected Mode S reply data and Mode S reply confidence data. The confidence bit threshold, and the confidence validity threshold, which are used to control error correction, are set.

k. The attenuators for both transmit channels one and two are set for maximum output power.

l. The sync phase and data phase delays are initialized for both channels 1 and 2.

4. The transmitter frequency for channels one and two is set to 1030 MHz.

5. The interrogation timing patterns are stored in the system hardware. The TCAS Monitor program uses channel one for all surveillance interrogations and channel 2 for Mode S only all-call interrogations. The difference is channel 1 uses a narrow reply window that is positioned for an anticipated range for a surveillance target and channel 2 uses a fixed length wide reply window for unknown target ranges.

6. The target list is initialized. The TCAS Monitor program uses a doubly linked list to keep track of surveillance targets. The memory area is acquired and the pointers for these lists are initialized.

7. The asynchronous service queue is allocated. The program uses an asynchronous service queue to provide a 1-second event timer. This event timer is used to time the TCAS Monitor scans.

8. The data and header files are created. If the operating parameters determine that TCAS Monitor data will be stored, a header information file and a data file are created. The system will automatically search for a file that does not already exist.

9. The interrogation/reply file is created. If the operating parameters determine that interrogation/reply data are to be stored (not selected in the example in figure 1), a data file is created. The system will automatically search for a file that does not already exist.

10. The 1-second event timer is initiated. This timer is used to time the TCAS Monitor scans.

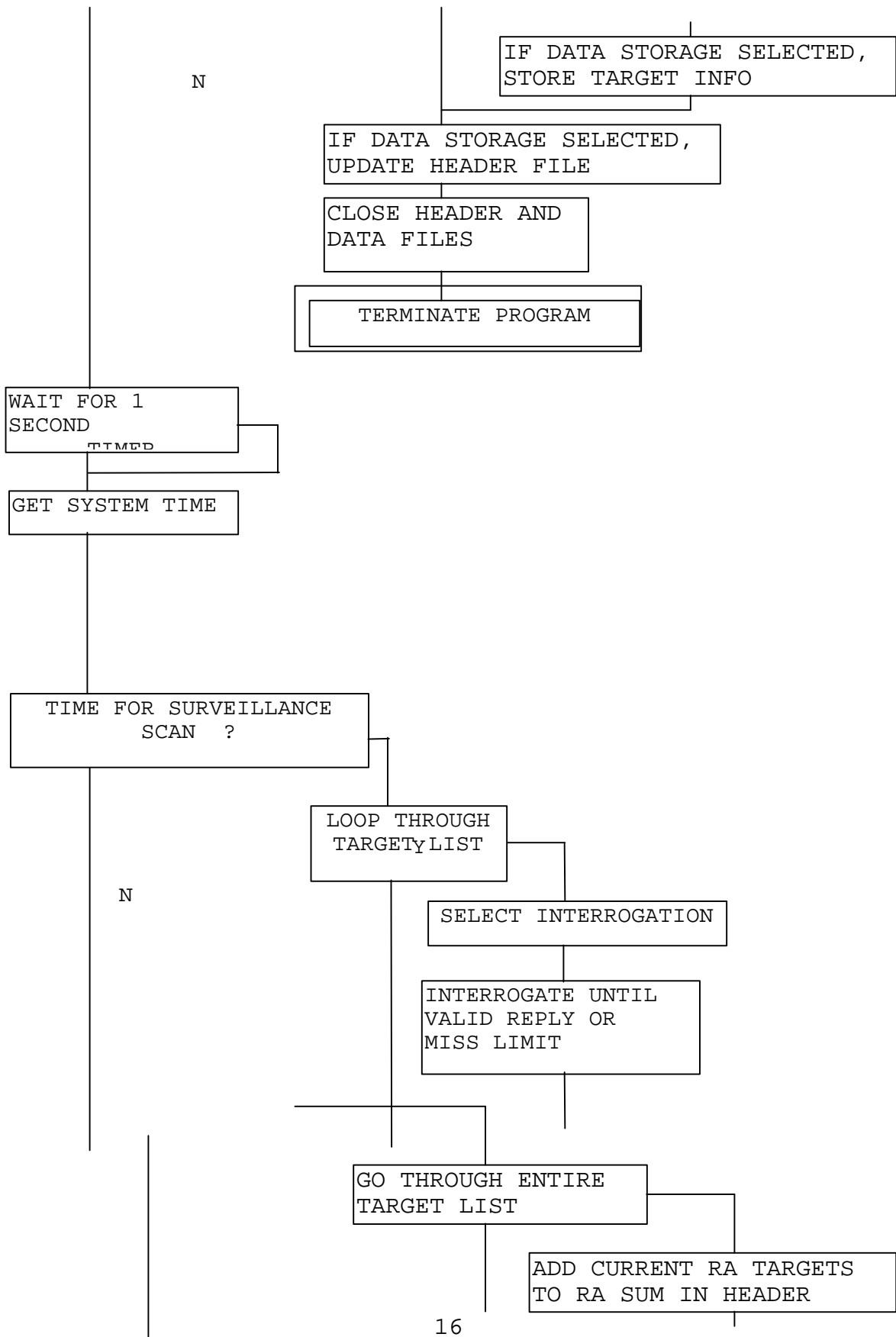
11. A 1-ms interrogation timer is activated. This timer is used to control the PRF of the interrogations.

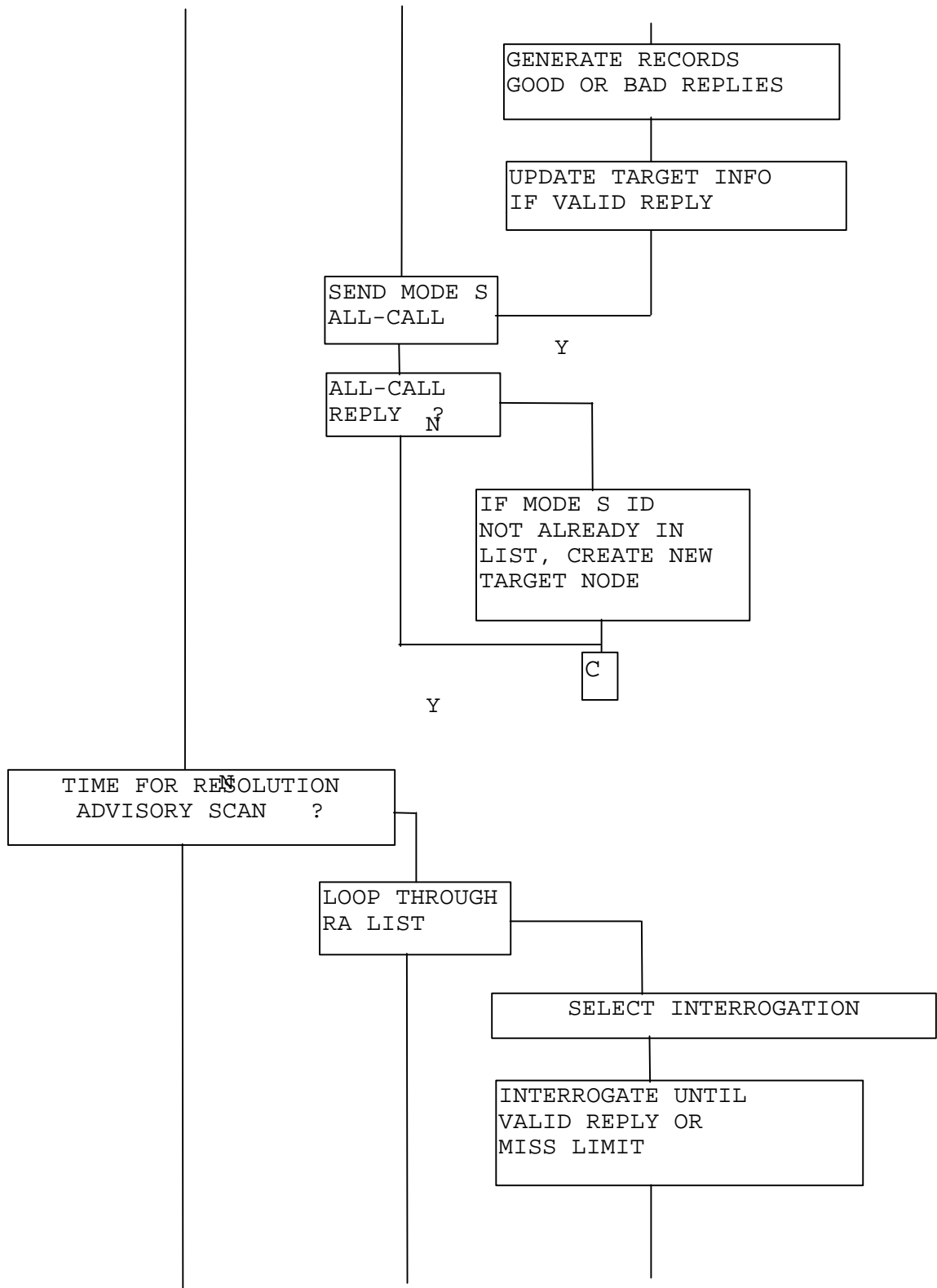
START
THE TCAS MONITOR SCENARIO.

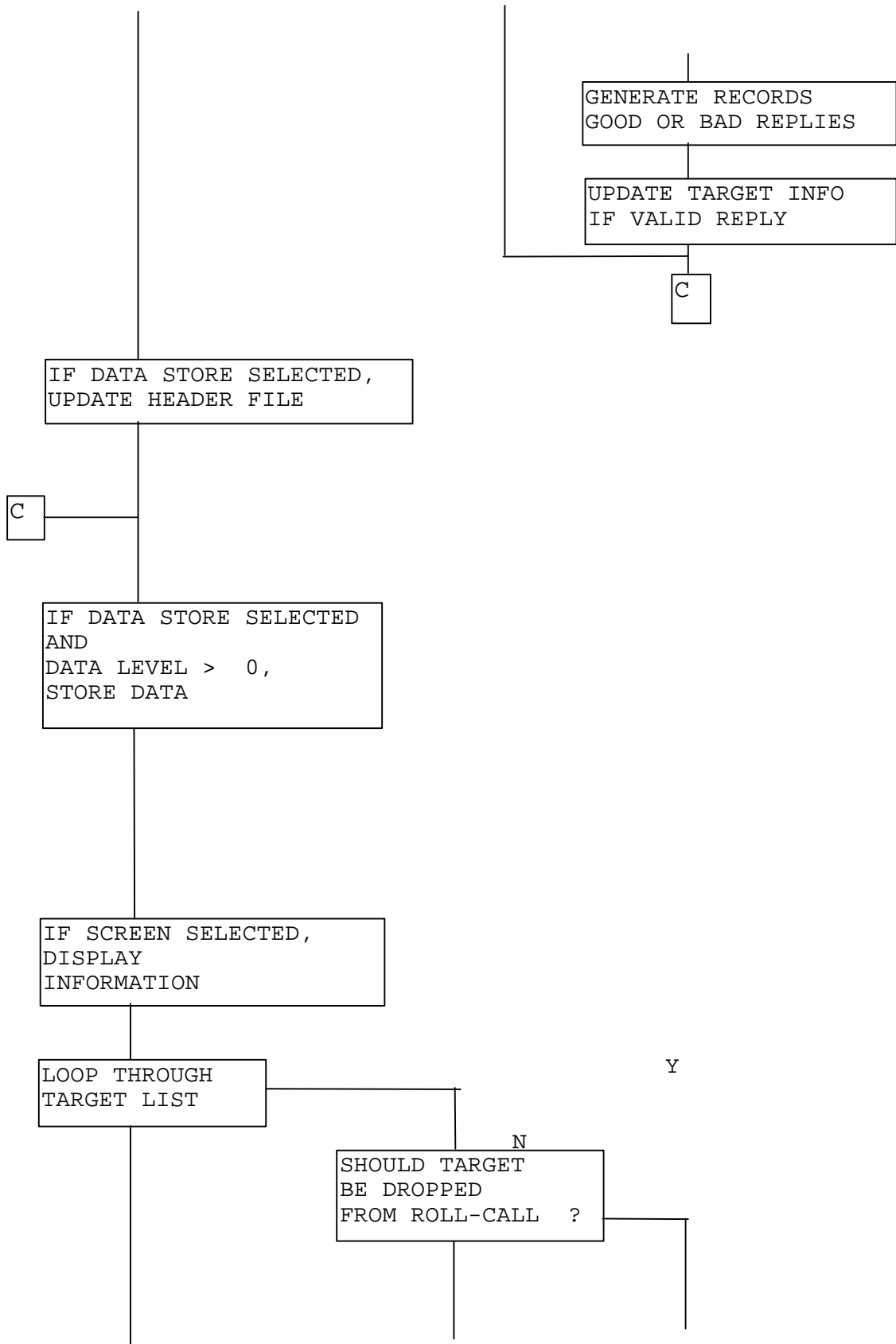
Once the system initialization is complete, the TCAS Monitor is activated. The TCAS Monitor will repeat its interrogation scenario continuously until an escape key is entered. The following flow diagram represents the interrogation scenario:

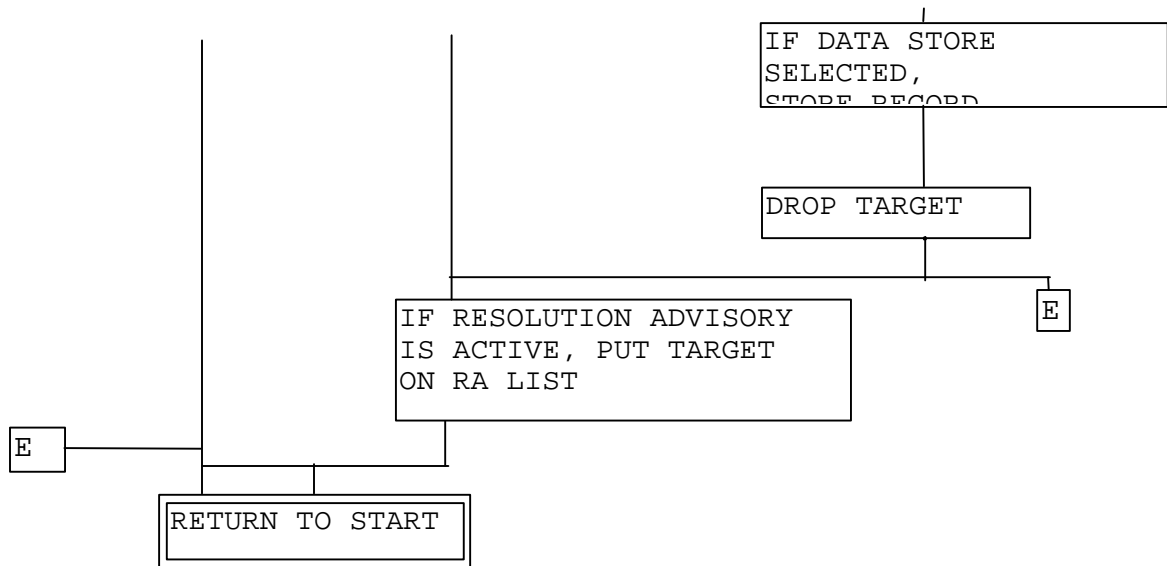
Y

... Escape terminates program









The interrogation scenario begins with a test of an escape key entry from the keyboard. The escape key is used to terminate the program. If an escape key was entered, the program immediately ceases sending any interrogations. All information from remaining surveillance targets is added to the summary information and to the data files if data storage has been selected. All data files are closed and the program is terminated.

If there was no escape key the TCAS Monitor proceeds with the interrogation scenario. The program waits for the 1-second timer to increment. The number of seconds that have passed since the last surveillance scan are compared to the surveillance scan rate. If they are equal, it is time for a surveillance scan.

During a surveillance scan, the program traverses a linked list which contains information for each target that is currently on roll-call. Each target is interrogated with a surveillance interrogation with an Uplink Field (UF) code of 5, and a special surveillance interrogation with a UF code of 0. These two interrogation types were chosen to maximize the amount of information obtained from each target. There are three possible types of surveillance interrogations. The type of interrogation is determined by the information in the linked list from the previous scan. If the target has an Active Resolution Advisory (ARA), the interrogation will contain a Reply Request (RR) field of 19, and a Designator Identification (DI) field of 7 in order to obtain the ARA information. If there is no ARA, and the extended capability message has not been obtained, the RR field will contain 17 in order to get the extended capability report. If neither of the previous cases is true, the interrogation is a standard UF 5 surveillance interrogation. In all cases, the Protocol (PC) field is a 1 to keep the target locked out to all-call interrogations.

The reply window is 144 microseconds (μ s) wide for all surveillance replies. This allows 120 ms for a reply (the same width is used when a long or short reply is expected) and 24 ms extra to allow for

movement of the aircraft between scans. The previous reply delay is used to position the reply window so the reply is expected in the center of the window (center is based on a 120 μ s reply). This will allow up to approximately 1 mile of movement directly towards or away from the antenna between scans. If the scan rate is every 4 seconds, the TCAS Monitor can track aircraft moving up to 900 miles per hour.

Each target is interrogated up to the number of tries indicated by the Miss Limit parameter until it replies, for both the surveillance and special surveillance interrogations. If it does not reply to the surveillance interrogation in that amount of tries, it is counted as a missed scan.

The PRF of the interrogations is controlled by one of the operating parameters. The Mean Interrogation Time, which can be set from the TCAS menu program, can range from 2 to 6 ms. This value determines the mean time between interrogations. The actual time between interrogations will vary by 1 ms in both directions in order to break possible synchronization with other interrogation sources. The subsequent high PRF (166 - 500) is acceptable since each aircraft will only reply a maximum of two times per scan.

A reply is considered valid if the DATAS hardware declares a Mode S decode and either there is no parity error, or the Mode S hardware successfully corrected a parity error. In order for the hardware to declare a decode, a Mode S preamble must occur within the reply window. The parity check and error correction circuits are provided with the Mode S ID of the target that is expected to reply, and are triggered by the decode. When a valid reply is detected, the target information in the linked list is updated, including the reply delay which will be used in the following scan for reply window positioning.

Following the surveillance interrogations is the all-call interrogation(s). The number of all-call interrogations sent is determined by the PR field of the all-call interrogations. The value of the PR field is user selectable as one of the operating parameters. A number of all-calls equaling at least half of the inverse of the reply probability is sent. For example, if the reply probability is 1/8, there will be four all-call interrogations. This is to insure that in crowded environments, new targets will be acquired within at most two scans.

When an all-call reply is detected, the linked list is searched to verify that the reported Mode S ID does not match an existing surveillance target. Although the TCAS Monitor employs the non-selective lockout protocol, this search is performed so the system does not rely on the lockout mechanism working properly. If it is a new target, it is added to the surveillance target linked list.

When the required number of seconds have passed, a Resolution Advisory scan is started. A Resolution Advisory scan is the same as a surveillance scan with respect to reply window positioning and what is required for a valid reply. However, a Resolution Advisory scan only sends one interrogation to each target (the interrogation is still repeated up to the required number of times for no reply situations) that has reported an ARA. The purpose of including a Resolution Advisory scan in addition to the surveillance scan, is to have an accelerated scan rate for those targets that have active Resolution Advisories (default is one per second, since Resolution Advisory messages are updated once per second). The interrogation used is a request for the TCAS information (RR=19, DI=7) and a UF code of 4 is used so that the reply will contain the altitude.

Between scans, the data files are updated if data storage has been selected. The interrogation/reply data is displayed on the screen, if the operating parameters indicate to do so. The target list is traversed, and any targets that have not replied in the number of scans determined by the scan limit parameter are dropped from the list, and any remaining targets that have reported an ARA in the previous scan are added to the Resolution Advisory scan list. If any of the targets have reached the storage limit per target record for either Resolution Advisory data, altitude data, ATCRBS ID data, or special surveillance data, the current record is stored in the data file, and a new record is issued for that target. The interrogation scenario is repeated until an escape key is entered.

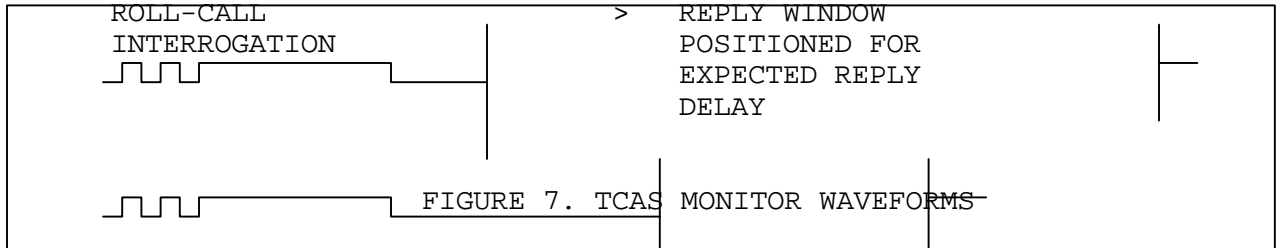
INTERROGATIONS.

WAVEFORMS. The waveform for all six interrogations used by the TCAS Monitor is a short Mode S with a reply window. The only variation in the waveform for the TCAS Monitor is the position of the reply window for roll-call interrogations. The reply window for all-call interrogations is fixed in relation to the interrogation and is large enough to accommodate a reply from a target anywhere in the range of the TCAS Monitor. The reply window for roll-call interrogations is large enough for a long reply with an extra 24 μ s to allow for movement of the aircraft. Figure 7 illustrates the two waveform types. The reply delay of the previous reply is used to position the reply window so that it starts 12 μ s before the expected reply time. This reply window position will allow for a long Mode S reply and approximately 1 mile of movement towards or away from the systems antenna between scans. The reply window is the same length when a short reply is expected.

ALL-CALL
INTERROGATION

FIXED-LENGTH LONG REPLY WINDOW
ALLOWS FOR REPLY FROM TARGETS
WITHIN RANGE OF TCAS MONITOR

➤ FIXED-LENGTH
SHORT



INTERROGATION DATA. Since there are only six different interrogations needed by the TCAS Monitor, they are stored in static memory and used as needed. The values of the IIS, II, and PR fields are determined by the site ID and probability of reply selected in the operating parameters. Their values are set during initialization of the data collection program. The only variable field during run time is the address parity fields of the surveillance interrogations. The interrogations are as follows:

<u>INT. TYPE</u>	<u>INT. DATA</u>				
[0]	UF=0	RL=0	CL=0	AQ=0	
[1]	UF=4	PC=1	RR=19	DI=7	SD: IIS=VARIABLE
[2]	UF=5	PC=1	RR=0	DI=0	SD: IIS=VARIABLE
[3]	UF=5	PC=1	RR=17	DI=0	SD: IIS=VARIABLE
[4]	UF=5	PC=1	RR=19	DI=7	SD: IIS=VARIABLE
[5]	UF=11	PR=VARIABLE	II=VARIABLE		

AP=FFFFFF(hex)

Fields not shown are set to "0."

REPLY DATA.

Table 1 shows the information which is relevant to the TCAS Monitor that is obtained from each reply type. The TCAS Monitor was designed to obtain the maximum amount of information for each surveillance target. The reply fields examined should contain all information that is at least remotely related to the occurrence of a Resolution Advisory. Whenever possible, the TCAS Monitor does not rely on the integrity of a reply field in order to attempt to extract information from surveillance targets. i.e., an attempt is made to acquire the extended capability report regardless of the value of the capability (CA) field, and an available Resolution Advisory message is extracted from a target regardless of the value of the capability or reply information fields. Table 2 defines the information contained in the reply fields.

TABLE 1. REPLY DATA FIELDS

<u>Int. Type</u>	<u>Reply Fields</u>
0	VS, SL, RI, AC
1	FS, DR, ID, MB:BDS, ARA, RAC, CLI
2	FS, DR, ID
3	FS, DR, ID, MB:BDS, BCS
4	FS, DR, ID, MB:BDS, ARA, RAC, CLI
5	CA, AA

FILES.

There may be up to three files generated by the TCAS Monitor data collection program depending on the operating parameters. If the parameters are set to store the TCAS Monitor data on disk, the program will generate two files; a header file, which contains information about the collected data, and the actual data file. These two files contain the information that will eventually go to the data base on the PC system. If the parameters are set to store interrogation/reply data, this information will be stored in a third file.

FILE NAMES. All three file names use the location identifier and the current date as part of the file name. This is intended to make searching for specific data files easier. The file names have the following format:

TABLE 2. REPLY DATA FIELDS DEFINITION

<u>Field</u>	<u>Description</u>	<u>Content</u>																																								
AA	Announced Address 24 bits (9-32)	Mode S Address																																								
AC	Altitude Code 13 bits (20-32)	Pressure Altitude																																								
CA	Capability 3 bits (6-8)	0 = No communications capability 1 = Comm. A and Comm. B capability 2 = Comm. A, Comm. B, and Uplink ELM capability 3 = Comm. A, Comm. B, Uplink, and Downlink ELM Capability																																								
DR	Downlink Request 5 bits (9-13)	0 = No downlink request 1 = Request to send Comm-B message 2 = TCAS information available 3 = TCAS information available and Request to send Comm-B message 4 = Comm-B Broadcast #1 available 5 = Comm-B Broadcast #2 available 6 = TCAS information available and Comm-B Broadcast #1 available 7 = TCAS information available and Comm-B Broadcast #2 available 8-15 are not assigned 16-31 are Comm-D protocol																																								
FS	Flight Status 3 bits (6-8)	<table border="1"> <thead> <tr> <th>Code</th> <th>Alert</th> <th>SPI</th> <th>Airborne</th> <th>On ground</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>no</td> <td>no</td> <td>yes</td> <td>no</td> </tr> <tr> <td>1</td> <td>no</td> <td>no</td> <td>no</td> <td>yes</td> </tr> <tr> <td>2</td> <td>yes</td> <td>no</td> <td>yes</td> <td>no</td> </tr> <tr> <td>3</td> <td>yes</td> <td>no</td> <td>no</td> <td>yes</td> </tr> <tr> <td>4</td> <td>yes</td> <td>yes</td> <td></td> <td>either</td> </tr> <tr> <td>5</td> <td>no</td> <td>yes</td> <td></td> <td>either</td> </tr> <tr> <td colspan="5">6, 7 are not assigned</td> </tr> </tbody> </table>	Code	Alert	SPI	Airborne	On ground	0	no	no	yes	no	1	no	no	no	yes	2	yes	no	yes	no	3	yes	no	no	yes	4	yes	yes		either	5	no	yes		either	6, 7 are not assigned				
Code	Alert	SPI	Airborne	On ground																																						
0	no	no	yes	no																																						
1	no	no	no	yes																																						
2	yes	no	yes	no																																						
3	yes	no	no	yes																																						
4	yes	yes		either																																						
5	no	yes		either																																						
6, 7 are not assigned																																										
ID	Identification	contains 4096 identification code 13 bits (20-32) as set by the pilot																																								
MB	Comm-B message	BDS code (8 bits, 33-40) identifies 56 bits (33-88) the message, BDS1 = 1, BDS2 = 0 - Extended Capability Report																																								

TABLE 2. REPLY DATA FIELDS DEFINITION (Continued)

<u>Field</u>	<u>Description</u>	<u>Content</u>
		CFS (4 bits, 41-44)
		ACS (20 bits, 45-64)

BCS (16 bits, 65-80) bits 69,70
 report on-board resolution
 capability: 0=None, 1=Vertical
 only, 2=Vertical and Horizontal
 ECS (8 bits, 81-88)

BDS1 = 3, BDS2 = 0 - Resolution
 Advisory Report
 ARA (14 bits, 41-54) - Active
 Resolution Advisories

Bit Resolution Advisory

- 41 Climb
- 42 Don't descend
- 43 Don't descend faster than 500 fpm
- 44 Don't descend faster than 1000 fpm
- 45 Don't descend faster than 2000 fpm
- 46 Descend
- 47 Don't climb
- 48 Don't climb faster than 500 fpm
- 49 Don't climb faster than 1000 fpm
- 50 Don't climb faster than 2000 fpm
- 51 Turn left
- 52 Turn right
- 53 Don't turn left
- 54 Don't turn right

RAC (4 bits, 55-58) - Resolution
 Advisory Complements

Bit Resolution Advisory Complement

- 55 Don't descend
 - 56 Don't climb
 - 57 Don't turn left
 - 58 Don't turn right
- 0 = active, 1 = inactive

CLI (1 bit, 59) - Coordination lock
 Indicator
 0 = TCAS aircraft is not currently in
 1 = TCAS aircraft is currently in a
 coordination lock state

RI Reply Information 0 = No TCAS
 1 = Undefined
 TABLE 2. REPLY DATA FIELDS DEFINITION (Continued)

<u>Field</u>	<u>Description</u>	<u>Content</u>
4 bits (14-17)		2 = TCAS equipped with resolution capability inhibited 3 = TCAS equipped with vertical resolution capability 4 = TCAS equipped with vertical and horizontal resolution capability 5-7 ? 8-14 = Airspeed information

8. The number of valid replies received for each type interrogation types 0 - 5).

9. The number of replies that had parity errors corrected for each type (interrogation types 0 - 5).

10. The number of replies that had uncorrectable parity errors for each type (interrogation types 0 - 5).

11. The number of aircraft that reported being airborne (VS = 0), and the number of aircraft that reported being on the ground (VS = 1). The appropriate count is incremented when the first special surveillance reply for a target is received, or when the value of this field changes in the special surveillance reply.

12. The number of aircraft that reported each sensitivity level (SL = 0 - 6). The appropriate count is incremented when the first special surveillance reply for a target is received, or when the value of this field changes in the special surveillance reply.

13. The number of aircraft that reported each reply information type (RI = 0 - 5). The appropriate count is incremented when the first special surveillance reply for a target is received, or when the value of this field changes in the special surveillance reply.

14. The number of aircraft that reported each capability (CA = 0 - 3).

15. The total number of aircraft put on roll-call (includes repeat aircraft).

16. The total number of aircraft that reported resolution advisories (includes repeats).

DATA FILE. The data file contains accumulated information about each aircraft that was put on surveillance roll-call. This file contains information that can be transferred to the PC data base. The data file contains the following information:

1. Mode S address.
2. Extended capability report, valid only if extended capability status flag indicates that it was acquired.
3. Time of day when all-call response occurred.
4. Date of all-call response.
5. Time of day when the last roll-call response occurred.
6. Reply delay of first reply.
7. Reply delay of last reply.
8. Status fields:

- a. Capability (CA Field).
- b. Reply information (RI FIELD), from latest special surveillance reply.
- c. Extended Capability Flag (0=Not acquired,1=Acquired).
- d. Resolution Advisory overflow flag, indicates if more Resolution advisories occurred than able to store in one record (0=NO, 1=YES).
- e. Altitude overflow flag, indicates if there were more variations in the reported altitude than able to store in one record (0=NO, 1=YES).
- f. ATCRBS ID overflow flag, indicates if there were more ATCRBS ID's reported than able to store in one record (0=NO, 1=YES).
- g. Special Surveillance (DF-0) overflow flag, indicates if the subfields in a DF-0 reply (VS, SL, RI) changed more than able to store in one record (0=NO, 1=YES).

10. Resolution Advisory information:

- a. Resolution Advisory count (for this record)
- b. Up to 10 each of:
 - Resolution Advisory
 - Start time
 - End time

11. Altitude information:

- a. Altitude count (for this record)
- b. Up to 10 each of:
 - Altitude
 - Start time
 - End time

12. ATCRBS ID information:

- a. ATCRBS ID count (for this record)
- b. Up to 10 each of:
 - ATCRBS ID
 - Start time
 - End time

13. Special surveillance information:

- a. Special surveillance count (for this record)
- b. Up to 10 each of:
 - Special surveillance message
 - Start time

End time

INFORMATION/REPLY FILE. This file contains interrogation and reply data in the sequence that it occurred in real time. The amount of information that is stored in each record depends on the information level parameter value. This value is determined by the system engineers with the TCAS menu program (TCSMENU). If a value of 0 is entered there will be no information reply file. Values of 1, 2, or 3 will result in having an interrogation reply file where the higher the value, the more information that is stored. The information stored is as follows:

1. Level 1: Minimum interrogation/reply storage.

- a. Time of reply (time of day)
- b. Date of reply
- c. Mode S address
- d. Capability (CA field)
- e. Resolution Advisory Flag (0=RA not available, 1=RA available)
- f. Interrogation type (0 - 5)
- g. Reply Status (0=valid, 1=parity error corrected, 2=parity error uncorrected, 3=no reply)

2. Level 2: Moderate interrogation/reply storage.

- a. Time of reply (time of day)
- b. Date of reply
- c. Mode S address
- d. Reply data
- e. Reply delay
- f. Interrogation type (0 - 5)
- g. Reply Status (0=valid, 1=parity error corrected, 2=parity error uncorrected, 3=no reply)

3. Level 3: Maximum interrogation/reply storage.

- a. Time of reply (time of day)
- b. Date of reply
- c. Mode S address
- d. Interrogation status
- e. Interrogation data
- f. Reply status
- g. Uncorrected reply data
- h. Corrected reply data
- i. Confidence data
- j. Decode status
- k. Reply delay
- l. Mean reply amplitude of first four reply pulses (preamble)
- m. System status

TCAS MONITOR DATA ANALYSIS

It is intended that the TCAS Monitor data analysis be performed using a commercial data base program on a PC system. Programs are provided to transfer data to the on board VME PC system in ASCII format to be

imported by a data base program. However, software has been provided to perform some data analysis on the DATAS processor. This section will describe both types of data analysis procedures.

DATAS PROCESSOR DATA ANALYSIS.

The TCAS Monitor file access program (tcsfile) is used to produce a summary of the information collected with the TCAS Monitor on the DATAS processor. The data can be viewed on the screen or printed. The program provides access to the target summary data, which is information about each aircraft acquired by the TCAS Monitor, or interrogation/reply data, which is information from each interrogation and reply as it occurred in real time. The target summary data is the data that are sent to the PC system, but the interrogation/reply data are only available on the DATAS processor. The program provides some data reduction capabilities. The user can elect to view the entire data file, only information regarding a specific target (Mode S address), or only activity that occurred within a specified time range.

In order to run the TCAS summary program, type "tcsfile" followed by a carriage return at the VERSAdos prompt. The program will produce a menu as shown in figure 8. The cursor is moved between menu selections using the arrow keys. The function key F5 is used to exit the program, and the function key F6 is used to execute the data summary process.

The first three items on the menu, Location Identifier, Date, and Data File Extension, are used to identify the data file for access. For these three items, the information must be entered followed by a carriage return. The location identifier is the four-character identification code that was entered in the TCAS menu program prior to the data collection. The date field refers to the date when the program was started (provided the system date was set correctly). The data file extension is the two-character file extension that was assigned to the data file by the data collection program.

TCAS MONITOR FILE SUMMARY PROGRAM

Location Identifier:_

Date: (MM/DD/YY):

Data File Extension:

Data File Type: Data Summary File

Output Device: Screen

Data Selection: Entire File

F5 To Exit ----- F6 To Execute

FIGURE 8. TCAS MONITOR FILE SUMMARY PROGRAM

The remaining menu entries determine the type of data summary that will be produced. The Data File Type entry allows the user to choose between Data Summary File and Interrogation/Reply File by pressing the spacebar key. If the user selects Data Summary File, the program will produce a target data summary report from the records in the specified file. This type of report will show a block of the surveillance information for each target that qualified for data storage. If the user selects Interrogation/Reply File, the program will show interrogation and reply data in the sequence in which it occurred.

The Output Device entry allows the user to choose whether the summary data will go to the screen or the printer by pressing the spacebar key.

The Data Selection entry gives the user three choices for how much of the data file to summarize by pressing the spacebar key. The Entire File response will provide a summary of the entire contents of the file selected. The Time Range response will allow the user to reproduce data collected only during a specified time range. The Specific Mode S ID response will reproduce only data associated with a specified Mode S ID. The Specific Mode S ID response will post an additional prompt for the Mode S ID of the target. The user will type in the six digit hexadecimal response. The Time Range response will post four additional prompts to allow the user to enter the time and dates for which to produce data.

Figure 9 shows an example of a completed "tcsfile" program menu. The first three responses indicate that the data was collected in Atlantic City, starting on December 29, 1989, and the data file extension was AA. The data file type response indicates that the interrogation/reply data will be reproduced. The output device selected is the printer. The remaining responses indicate that the user has chosen only to reproduce the interrogations and replies that occurred on December 30, between 11:36:40 and 11:56:30. Once the user presses the F6 key the data will begin to be printed.

TARGET SUMMARY DATA.

The Target Summary Data is information that is acquired about aircraft that were encountered by the TCAS Monitor. The information comes from the header file and the data file. The information can be presented on the screen or by the printer in the following format (example):

TCAS MONITOR FILE SUMMARY PROGRAM

Location Identifier: UACY

Date: (MM/DD/YY): 12/29/89

Data File Extension: AA

Data File Type: Interrogation/Reply File

Output Device: Printer

Data Selection: Time Range

Start Date (MM/DD/YY): 12/30/89

Start Time (HH:MM:SS): 11:36:40

End Date (MM/DD/YY): 12/30/89

End Time (HH:MM:SS): 11:56:30

F5 To Exit ----- F6 To Execute

FIGURE 9. TCAS MONITOR FILE SUMMARY PROGRAM
WITH COMPLETED MENU

Information from header file:UACY.TH112890.AD

TCAS MONITOR DATA SUMMARY

SYSTEM START: 11-28-1990 ... 02:53:19

SYSTEM STOP: 11-28-1990 ... 13:10:43

SYSTEM OPERATION INFORMATION

Monitor Location: UACY

Scan Rate (seconds): 5

Scan Rate for Active Resolution Adv. (seconds): 1

All-Call Reply Probability: 1/2

Interrogator Identifier (IIS): 0

Information Level: 3 - Maximum

Int./Reply sequence

Information From: All Mode S Aircraft

Display information on screen: On

Mean Time Between Interrogations (ms): 3

Store data on disk: Yes

Miss Limit: 3

Scan Limit: 3

Output select: Antenna

TCAS Monitor Version: 1

TCAS MONITOR AIRCRAFT SUMMARY INFORMATION

INT.	#VALID	#CORRECTED	#UNC.
TYPE #SENT	REPLIES	REPLIES	REPLIES
0 3069	728	114	541
1 587	77	0	8
2 2443	761	107	591

3	248	24	7	25
4	38	16	0	3
5	2122	31	14	27

THE NUMBER OF AIRCRAFT THAT REPORTED...

VERTICAL STATUS(VS): Airborne=38, On ground=1

SENSITIVITY LEVEL(SL): 0=15 1=10 2=0 3=0 4=1 5=11 6=2 7=0

REPLY INFORMATION(RI): No TCAS=26 TCAS w/ RES. CAP. INHIBITED=3
 TCAS w/ V. ONLY=12 TCAS w/ V.& H.=0

CAPABILITY(CA): (0)No Comm.=15 (1)Comm. A&B=29
 (2)Comm. A,B&C=0 (3)Comm. A,B,C&D=1

TOTAL A/C ON ROLL-CALL=45 TOTAL A/C w/ RA=2
 Information from data file:UACY.TD112890.AD
 AIRCRAFT INTERROGATION/REPLY INFORMATION

TARGET SUMMARY

DATE:11-28-1990

Mode S ID:a34e40 Surveillance time from: 03:47:47 to: 03:49:17

Initial range: 29.239 Final range: 31.327 (nm)
 Transponder capability (CA): 1
 Extended Capability: BDS1: 1 BDS2: 0 CFS: 0 ACS:10000 BCS:0000
 ECS:00

1 resolution advisorie(s):

...MESSAGE.....FROM.....TO....
 BDS1: 3 BDS2: 0 ARA:0100 RAC:0 CLI:0 03:48:00 03:48:18

3 altitude(s) reported:

...MESSAGE.....FROM.....TO....
 ALT= 18700 03:47:52 03:47:52
 ALT= 18400 03:47:57 03:48:27
 ALT= 18000 03:48:32 03:49:17

1 ATCRBS ID(s) reported:

...MESSAGE.....FROM.....TO....
 ID=2262 03:47:52 03:49:17

1 special surveillance report(s):

...MESSAGE.....FROM.....TO....
 VS=0 SL=1 RI=0 03:47:52 03:49:17

(end of example data)

The target summary data displays information from the header file including the time and date on which data collection began and ended, and the operating parameter values.

The data displays a summation of the aircraft activity that occurred. The five columns show the number of interrogations sent for each type, as well as the number of valid, corrected, and uncorrected replies of

each type (the section Interrogation Data defines the interrogation types).

The vertical status report shows the number of aircraft that reported being on ground and the number reported being in the air.

The number of aircraft that reported each possible sensitivity level (0-7) is displayed.

The reply information shows the various TCAS capabilities reported.

The vertical status, sensitivity level, and the reply information counts show the number of each value reported by each unique target, and the count is incremented when a target changes its reporting value.

The capability report shows the number of aircraft that report each capability value as indicated in the all-call reply.

The data also show the total number of aircraft that were put on roll-call and the total number that issued a Resolution Advisory.

The target summary data displays information about each aircraft that was put on surveillance roll-call. There may be more than one target summary for an aircraft if the aircraft was dropped from surveillance and then reacquired, or if one of the information fields was filled for a record. The summary shows the Mode S address, the time and date the aircraft was on surveillance, the initial and final range, the reported capability, and the extended capability report if it was acquired. The data also show the resolution advisories, altitudes, ATCRBS ID's, and special surveillance information reported for each target.

INTERROGATION/REPLY FILES.

The interrogation/reply data are displayed in the order that it occurred. The format of the interrogation/reply data depends on the information level selected prior to when the data were collected. There are three information levels possible, 1, 2, and 3. Information level 1 provides the least information and information level 3 provides the most.

INFORMATION LEVEL 1. The following shows an example of interrogation/reply data with information level 1 selected:

```
06/19/90 11:11:43 - INTER:(5)58000000ffffff - VALID REPLY CA: 0
06/19/90 11:11:47 - INTER:(3)29440000001400 - VALID REPLY CA: 0
06/19/90 11:11:47 - INTER:(0)00000000001400 - VALID REPLY CA: 0
06/19/90 11:11:51 - INTER:(2)29000000001400 - VALID REPLY CA: 0
06/19/90 11:11:51 - INTER:(0)00000000001400 - VALID REPLY CA: 0
```

The data contains the following information:

```
06/19/90 11:11:47 - INTER:(2)29000000001400 - VALID REPLY CA: 0
```

DATE	TIME	INTERROGATION TYPE	INTERROGATION DATA	REPLY STATUS	CAPABILITY
------	------	-----------------------	-----------------------	-----------------	------------

1. Date - the date of the interrogation/reply transaction.
2. Time - the time of the interrogation/reply transaction in military time.
3. Interrogation type - values of 0 through 5, indicates which of the six interrogations that was sent.
4. Interrogation data - displays the interrogation data in hexadecimal format. The last six digits are the Mode S address. These data are not the actual interrogation data read from hardware; it is a facsimile of the data which are produced here by knowing the interrogation type. The variable subfields such as II, IIS, and PR are shown to contain 0, when in actuality they may have contained some other value.
5. Reply status - One of the following messages will be displayed: Valid Reply, PE Corrected (Parity Error that was corrected), PE Uncorrected (Parity Error that was not corrected), or No Reply.
6. Capability - The transponder capability (CA) reported in the DF 11 reply.

INFORMATION LEVEL 2. Information level 2 contains the same information as level 1 with the addition of the reply data. The following shows an example of interrogation/reply data with information level 2 selected:

```
06/19/90 11:14:40-INTER:(5)58000000ffffff- REP:5800140038010d00000000
06/19/90 11:14:44-INTER:(3)29440000001400- REP:a9001fbf10000000000000
06/19/90 11:14:44-INTER:(0)00000000001400- REP:04000000afe14c00000000
06/19/90 11:14:48-INTER:(2)29000000001400- REP:29001fbf4882fd00000000
06/19/90 11:14:48-INTER:(0)00000000001400- REP:04000000afe14c00000000
The data contains the following information:
```

```
06/19/90 11:14:48-INTER:(2)29000000001400- REP:29001fbf4882fd00000000
```

DATE	TIME	INTERROGATION TYPE	INTERROGATION DATA	REPLY STATUS	REPLY DATA
------	------	-----------------------	-----------------------	-----------------	---------------

1. Date - the date of the interrogation/reply transaction.
2. Time - the time of the interrogation/reply transaction in military time.
3. Interrogation type - values of 0 through 5, indicates which of the six interrogations that was sent.

4. Interrogation data - displays the interrogation data in hexadecimal format. The last six digits are the Mode S address. These data are not the actual interrogation data read from hardware; it is a facsimile of the data which is produced here by knowing the interrogation type. The variable subfields such as II, IIS, and PR are shown to contain 0, when in actuality they may have contained some other value.

5. Reply status - One of the following messages will be displayed: REP (Valid reply), PEC (Parity Error that was corrected), PE Uncorrected (Parity Error that was not corrected), or No Reply.

6. Reply data - The actual reply data are shown in hexadecimal format. This field is the same length whether it was a long or short reply. If the reply was long, the data shows the reply data without the address parity field. If the reply was short, the entire reply is displayed including the address parity field, and the last eight digits are meaningless.

INFORMATION LEVEL 3. Information level 3 shows all the information available for each interrogation and reply. The following is an example of information level 3 data:

```
06/19/90 08:29:05 - SYS ST:00000001 INT ST:5960 REP ST:80000000
DECODE STATUS=0 - DECODE PRESENT
INTER:58000000ffffff
UNC. REPLY:5800140038010d00000000fee19f000 REPLY DATA PRESENT
COR. REPLY:5800140038010d00000000fee19f000 GOOD PARITY, VALID DECODE
CONF. DATA:ffffffffffff00ffffffffffff000 CORR. OK, CONF. OK
DF=11 CA=0 AA=001400
RANGE: 12.80 nm MEAN PREAMBLE POWER: 26
```

```
06/19/90 08:29:09 - SYS ST:00000001 INT ST:5960 REP ST:81001400
DECODE STATUS=0 - DECODE PRESENT
INTER:29880000001400
UNC. REPLY:a9001fbf10000000000000fee19f000 REPLY DATA PRESENT
COR. REPLY:a9001fbf100000000000000fee19f000 GOOD PARITY, VALID DECODE
CONF. DATA:ffffffffffffffffffff000 CORR. OK, CONF. OK
DF=21 FS=1 DR=0 UM=0 ID=7777 BDS1=1 BDS2=0 CFS=0 ACS=00000 BCS=0000 ECS=00
RANGE: 12.10 nm MEAN PREAMBLE POWER: 29
```

```
06/19/90 08:29:09 - SYS ST:00000001 INT ST:5960 REP ST:80001400
DECODE STATUS=0 - DECODE PRESENT
INTER:00000000001400
UNC. REPLY:04000000afe14c00000000fee19f000 REPLY DATA PRESENT
COR. REPLY:04000000afe14c00010000fee19f000 GOOD PARITY, VALID DECODE
CONF. DATA:ffffffffffff00ffffffffffff000 CORR. OK, CONF. OK
DF= 0 VS=1 SL=0 RI=0 AC=0
RANGE: 12.10 nm MEAN PREAMBLE POWER: 31
```

The data contains the following information:

```
06/19/90 08:29:09 - SYS ST:00000001 INT ST:5960 REP ST:80001400
```

DATE	TIME	SYSTEM STATUS	INTERROGATION STATUS	REPLY STATUS
DECODE STATUS=0 - DECODE PRESENT				
INTER:0000000001400				

INTERROGATION DATA				
UNC. REPLY:04000000afe14c00000000fee19f000				REPLY DATA PRESENT
COR. REPLY:04000000afe14c00010000fee19f000				GOOD PARITY, VALID DECODE
CONF. DATA:ffffffffffffffff00ffffffffffff000				CORR. OK, CONF. OK

REPLY DATA & CONFIDENCE DATA			REPLY STATUS	

DF= 0 VS=1 SL=0 RI=0 AC=0 _____ DECODED REPLY
RANGE: 12.10 nm MEAN PREAMBLE POWER: 31

1. Date - the date of the interrogation/reply transaction.
2. Time - the time of the interrogation/reply transaction in military time.
3. System status - TCAS Monitor status bits, 32 bits shown in hex Format:
 - Bit 0 1=PRF error
 - Bit 1 1=Reply window position error
 - Bits 2-31 unused
4. Interrogation status
 - Word that precedes the DPSK data, 16 bits displayed in hexadecimal has the following format:
 - Bit 0 Interrogation length (1 = long)
 - Bits 4 - 9 Sync Phase Delay (1ns increments)
 - Bits 10 -15 Data Phase Delay (1ns increments)
5. Reply status - Mode S reply data status word. 32 bits displayed in hexadecimal. The decoded reply status is displayed next to the reply data has the following format:
 - Bit 31 1 = Valid data, reply data is present
 - Bit 30 1 = Bad parity
 - Bit 29 1 = Bad parity, unsuccessful correction
 - Bit 28 1 = Correction attempted but failed
 - Bit 27 1 = Confidence data failed to meet threshold
 - Bits 25,26 Spare
 - Bit 24 Expected reply length, 1 = long reply
 - Bits 0-23 Expected Mode S address of reply
6. Decode status - -1 - DEC ERR = Decode error
 - 0 - DECODE PRESENT = Decode present
 - 1 - NO DECODE" = No decode

7. Interrogation data - DPSK data from hardware in hexadecimal format.
8. Reply data - The uncorrected reply data (UNC. REPLY), corrected reply data (COR. REPLY), and the confidence data (CONF. DATA), in hexadecimal format.
9. Decoded reply - The value of the relevant reply data fields.
10. Range - The approximate range of the aircraft in nautical miles.
11. Mean preamble power - The mean reply power of the first four pulses in the raw data area. Value is from 0-255.

PC SYSTEM DATA ANALYSIS.

The TCAS Monitor was developed with the intention that the acquired data would be kept in a commercial data base on a PC. Software is provided to transfer data collected on the DATAS processor to the VME resident PC system. As part of the transfer process the data are converted to ASCII formatted text, which is compatible with most relational data base packages. The text files can be imported using the data base program.

DATAS PROCESSOR TO PC DATA TRANSFER (TCSSEND AND TCSRECV PROGRAMS). The TCSSEND and TCSRECV programs are used to transfer TCAS Monitor data from the DATAS processor to the VME PC. The transfer process requires that the tcssend program be run on the DATAS processor and the tcsrecv program be run on the PC concurrently. It does not matter which program is started first because there is handshaking communication between both systems that disallows data transfer until both programs are running. To run the program on the PC system, enter tcsrecv. The initialization will try to establish a communication link with the 68020 via handshaking protocol. To run the data transfer program on the DATAS processor, enter tcssend at the VERSAdos prompt. The screen will appear as in figure 10. This menu is provided so the user can enter the information required to locate the data file. The location identifier, the date of when the data collection program was started, and the file extension must be entered before the data transfer can be started. Pressing the F6 key will initiate the data transfer process. If the tcssend program is started before the tcsrecv, or the PC is not responding, the message "Establish 68020--PC Link...[ESC] To Cancel will appear as in figure 10. The program is waiting for the PC program to be run, or an escape key from the user to abort the transfer attempt.

TEXT FILES. The data transfer process creates five text files on the PC. The files are as follows:

1. SURV.TXT - Surveillance information, one record for each surveillance target.
2. ALT.TXT - Altitude information, one record for each altitude reported by each target.

TCAS MONITOR FILE --->PC DATA BASE TRANSFER PROGRAM

Location Identifier: UACY

Date: (MM/DD/YY): 05/04/90
File Extension: AA

Establish 68020--PC Link...[ESC] To Cancel
[F5] TO Exit ----- [F6] To Execute

FIGURE 10. TCAS MONITOR 68020 TO PC FILE TRANSFER PROGRAM

3. ID.TXT - ATCRBS ID information, one record for each ATCRBS ID reported by each target.
4. RA.TXT - Resolution Advisory information, one record for each TCAS RA reported by each target.
5. SS.TXT - Special Surveillance information, one record for each unique special surveillance report for each target.

The files are in ASCII format with no delimiter separation between fields. The data base should be designed so that each field corresponds directly with the fields in the file for position and width. Preliminary test data were imported using Ashton-Tate dbase IV version 1.0. The dbase IV structure identifies the field positions and widths. The data base structures from the dbase IV data are as follows:

SURV.TXT --> SURV.DBF

Field	Field Name	Type	Width	Description
1	VERSION	Numeric	2	Program version
2	LOCATION	Character	4	Test location
3	SCAN_RATE	Numeric	2	Surveillance scan rate in seconds
4	RA_SCN_RAT	Numeric	2	Resolution scan rate in seconds
5	PR	Numeric	1	Probability of reply (PR field)
6	IIS	Numeric	2	Interrogator identifier subfield
7	MN_INTR_TM	Numeric	2	Mean time between interrogations
8	MS_ID	Character	6	Mode S ID
9	EC_BDS1	Numeric	2	BDS1 field
10	EC_BDS2	Numeric	2	BDS2 field
11	EC_CFS	Numeric	2	CFS field
12	EC_ACS	Character	5	ACS field (hexadecimal value)
13	EC_BCS	Character	4	BCS field (hexadecimal value)
14	EC_ECS	Character	2	ECS field (hexadecimal value)
15	AC_TIME	Numeric	6	All-call reply time
11	AC_DATE	Date	8	All-call date
12	LAST_R_TIM	Numeric	6	Last response time
13	INIT_RNGE	Float	4.1	Initial range (nautical miles)
14	LAST_RNGE	Float	4.1	Final range (nautical miles)
15	CA	Numeric	1	Capability
16	RI	Numeric	2	Reply information
17	EC_FLAG	Numeric	1	Ext. Cap. flag
18	RA_COUNT	Numeric	3	Resolution Advisory count
19	ALT_COUNT	Numeric	3	Altitude count

20	ID_COUNT	Numeric	3	ATCRBS ID count
21	SS_COUNT	Numeric	3	Special surv. count
Total			83	

ALT.TXT --> ALT.DBF

Field	Field Name	Type	Length	Description
1	LOCATION	Character	4	Test location
2	MS_ID	Character	6	Mode S ID
3	ALTITUDE	Numeric	6	Altitude
4	ALT_DATE	Date	8	Date
5	STRT_TIME	Numeric	6	Start time
6	END_TIME	Numeric	6	End time
7	AC_DATE	Date	8	All-call date
8	AC_TIME	Numeric	6	All-call reply time
Total			51	

ID.TXT --> ID.DBF

Field	Field Name	Type	Length	Description
1	LOCATION	Character	4	Test location
2	MS_ID	Character	6	Mode S ID
3	ATCRBS_ID	Numeric	4	ATCRBS ID
4	ID_DATE	Date	8	Date
5	STRT_TIME	Numeric	6	Start time
6	END_TIME	Numeric	6	End time
7	AC_DATE	Date	8	All-call date
8	AC_TIME	Numeric	6	All-call reply time
Total			49	

RA.TXT --> RA.DBF

Field	Field Name	Type	Length	Description
1	LOCATION	Character	4	Test location
2	MS_ID	Character	6	Mode S ID
3	RA_BDS1	Numeric	2	BDS1 field
4	RA_BDS2	Numeric	2	BDS2 field
5	RA_ARA	Character	4	ARA field (hexadecimal value)
6	RA_RAC	Character	1	RAC field (hexadecimal value)
7	RA_CLI	Numeric	1	CLI field
8	RnnA_DATE	Date	8	Date
9	STRT_TIME	Numeric	6	Start time
10	END_TIME	Numeric	6	End time
11	AC_DATE	Date	8	All-call date
12	AC_TIME	Numeric	6	All-call reply time
Total			55	

SS.TXT --> SS.DBF

Field	Field Name	Type	Length	Description
1	LOCATION	Character	4	Test location
			42	

2	MS_ID	Character	6	Mode S ID
3	VS	Numeric	1	VS field
4	SL	Numeric	1	SL field
5	RI	Numeric	2	RI field
6	SS_DATE	Date	8	Date
7	STRT_TIME	Numeric	6	Start time
8	END_TIME	Numeric	6	End time
9	AC_DATE	Date	8	All-call date
10	AC_TIME	Numeric	6	All-call reply time
Total			49	