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WHATS-UP (c) Joe Kasser, G3ZCZ, 1990-1991

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WHATS-UP is a tool which allows you to capture, decode, display and extract for analysis telemetry from the following Orbiting Satellites Carrying Amateur Radio (OSCAR).

UoSAT-OSCAR 11 1200 baud ASCII Telemetry,
 AMSAT-OSCAR 13 50 baud RTTY Z blocks Telemetry,
 AMSAT-OSCAR 16, WEBER-OSCAR 18 and LUSAT-OSCAR 19 Binary Tele-
 metry,
 DOVE-OSCAR 17 ASCII TLM packet Telemetry,
 Fuji-OSCAR 20 Status and Telemetry.
 SARA-OSCAR 23 capture binary telemetry only.
 AMSAT-OSCAR 21 packet telemetry.

WHATS-UP will also allow you to automatically capture-to disk morse code telemetry data from Radio-Sputnicks 10 and 11, AMSAT-OSCAR 21 or any other morse code telemetry source.

WHATS-UP will also allow you to process any telemetry data you have from the now re-entered UoSAT-OSCAR 9 and Fuji-OSCAR 12 spacecraft.

WHATS-UP is a table driven program which uses configuration files to allow maximum flexibility. If you have a Kenwood Radio, WHATS-UP will monitor a default frequency, then when a spacecraft comes up over the horizon, WHATS-UP will tune the Radio's VFO A to the spacecraft beacon frequency (plus a pre-settable offset) and set the receive mode for the satellite of interest. If the Radio responds correctly, WHATS-UP will allow you to read back the VFO A frequency during the pass and capture the data to a Doppler measurement file for later import to a spreadsheet. At the end of the pass, WHATS-UP will return the radio to the default frequency and communications mode.

This version of the program is configured for a TNC-1, TNC-2, PK-88, KAM and PK-232. Note, it will not enable you to copy non packet telemetry if you don't have a multi-mode terminal unit. It will intercept the Microsat Binary telemetry from AMSAT-OSCAR 16 (PACSAT), WEBER-OSCAR 18 (WEBERSAT) and LUSAT-OSCAR 19 (LUSAT) and display and process them as if they were DOVE-OSCAR 17 ASCII telemetry. NOTE: AMSAT have STILL NOT FINALIZED or PUBLISHED the Binary Telemetry Format for the Microsats.

The program is distributed as a Shareware product. You may freely copy and share the product for non commercial use, with your friends, classmates, associates and radio hams. If you decide to use the product, you are asked to become a registered user by completing the registration form and sending it, and \$35.00 (drawn on a US Bank please) or equivalent in foreign currency to the author.

Upon receipt of your registration, you will receive one free update disk, telephone and mail (electronic and regular) support.

Please do not use packet radio mail for commercial messages, or even those that may be construed as such by individual SYSOPS through whose BBSs the messages may pass.

This product may not be sold or distributed with another product without the express written permission of Joe Kasser, G3ZCZ. Joe Kasser, G3ZCZ will only support unmodified copies of this software. Your comments and suggestions for changes are however welcome. If you are the first to suggest a change that is implemented, you will be sent a complimentary copy of the disk with the change incorporated.

European Radio Amateur users may register (24.00 Pounds Sterling, includes VAT) and obtain support from Terry Dansey at ReadyCrest Ltd., PO Box 75, Chatham, Kent, ME5 9DL, England. ReadyCrest Ltd. accepts credit cards (Access, Visa, MasterCard and Eurocard). Telephones: Voice 44 (0)634-687168, FAX 44 (0)634-687178, Data (BBS) 44 (0)634-200931.

Potential Commercial and Educational Institution Users please contact Joe Kasser directly for modifications and/or details of Site licensing.

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APPENDIX

1.0 Introduction

WHATS-UP is a tool which provides you the Radio Amateur, or the Educator, with the capability to perform experiments in spacecraft orbital dynamics as well as monitoring the environment onboard several of the Orbiting Satellites Carrying Amateur Radio (OSCAR) during individual passes or over long periods of time.

Spacecraft in the OSCAR series send back volumes of Telemetry daily and apart from the odd Command station, few if any Radio Amateurs or Educators seem to be doing anything with it. Radio Amateurs tend to concentrate on the communications capabilities of the spacecraft and ignore their telemetry completely. If they do listen to a beacon, it's usually just to check that the transponder is on, heaven forbid - to actually copy any data.

The telemetry can tell us a story. It can tell us what is happening to both the spacecraft and its environment. As such it has a tremendous educational potential which has remained just that - a potential for at least the last six years.

Before every satellite launch the equations and format for the spacecraft telemetry are published by AMSAT. The telemetry tells us about the health and welfare of the spacecraft itself, and something about the payload. Spacecraft health and welfare information tells us about the battery, solar cells and on board computer status. Payload information can range from information about transponder loading/utilization to data from instruments that measure the environment of the space in and around the satellite. Battery Telemetry is used by the command stations to determine when the spacecraft can be used, and when the transponders should be shut down. The number of individuals not associated with command stations who have decoded spacecraft telemetry and published their findings can be counted using the fingers of one hand. There's a lot of computing power out there that has the potential to process telemetry and discover something new, but does not have the access to the data. WHATS-UP is an attempt to provide that data to the average Radio Amateur and Educator.

Capturing, decoding and displaying telemetry from orbiting spacecraft in real time, in the classroom, is an excellent way of introducing space science to students. Signals from these spacecraft are downlinked on frequencies that can be received on regular vhf/uhf scanner radio receivers.

WHATS-UP provides an introduction as to how this can be done using readily available low cost equipment. General topics discussed cover telemetry, the spacecraft themselves. Ground station hardware topics include receiving antennas, radio receivers and modems. Software topics discussed include the software used to track the spacecraft and the software used to both decode and display the data in real time as well as that for post pass analysis. Excluding the Personal Computer, a simple

telemetry capturing ground station can be set up for less than \$500.00 in equipment costs.

There is no substitute from the excitement of hands-on experience in awakening an interest in space. While OSCARs in the main, transmit down to the ground (downlink) telemetry in morse code, several of them also utilize standard computer literate digital data schemes such as BAUDOT or ASCII codes. The thrill of receiving a signal from space soon fades however if the data cannot be understood. Even after the data has been decoded, watching the temperatures on-board a spacecraft as it passes overhead is also of little interest, but, what can be made interesting is receiving and capturing the data over many days or even months and looking for trends and relationships.

You can capture telemetry just by listening to a spacecraft and copying morse code by ear writing it down with a pencil on a piece of paper. All you need to do is listen on the correct frequency at the right time and you will hear some signals. Write down what you hear. Apart from the thrill of copying a signal from a satellite, there's not much else to do with the data. While you can look up the conversion equations and get a snapshot of what is happening, it soon becomes tedious and only dedicated souls do it regularly.

When AMSAT were building the Phase 3A spacecraft, personal computing was in its infancy. That was before the Apple 2 or the TRS-80; that was the day of the home built S-100 machine, and the AMSAT-GOLEM-80 Project. At that time, Karl Meinzer, DJ4ZC, had written a native German high level computer language called IPS. This language was very similar to Forth, but contained a multi-tasking kernel. This language was programmed into the spacecraft flight computer and also used in the ground command stations. Using a computer on the spacecraft allowed AMSAT to provide telemetry that could be captured by computer on the ground. While Phase 3A never made it into orbit (the launch vehicle malfunctioned), subsequent spacecraft continued to provide the same facility. Today UoSAT-OSCAR 11 (UO-11), AMSAT-OSCAR 13 (AO-13), UoSAT-OSCAR 14 (UO-14), AMSAT-OSCAR 16 (AO-16), DOVE-OSCAR 17 (DO-17), WEBER-OSCAR 19 (WO-18), LUSAT-OSCAR 19 (LO-19) and Fuji-OSCAR 20 (FO-20) are all sending back telemetry that you can capture with your PC and amateur radio equipment. As most non radio amateurs do not understand morse code, WHATS-UP concentrates on those spacecraft which downlink computer compatible telemetry and can be received with relatively simple equipment.

1.2 Capabilities of WHATS-UP

WHATS-UP contains the following features:

- * Display of spacecraft orbital elements and tracking data.
- * Will automatically set your Kenwood receiver to spacecraft

beacon frequency when the spacecraft comes above your horizon and return it to the default frequency when the pass is over.

- * Audio warning of spacecraft acquisition of signal (AOS) and loss of signal (LOS).
- * Real-time, Interactive and Playback modes.
- * Automatic Capture-to-disk of raw telemetry.
- * Extracts telemetry channel data to a database or spreadsheet readable file for further analysis.
- * Link quality measurement.
- * Capability to display and print the raw telemetry as it is received.
- * Up to 16 user configurable display pages (screens). You set the position on the page (width of engineering unit field, and number of decimal places) that a parameter is displayed at.
- * Wild card page (parameter shows up on all pages).
- * Selectable display of Engineering units or Hex byte for each display page.
- * Display of raw packets (i.e. STATUS)
- * Color changes if a parameter value changed between successive frames.
- * Audio and visual alarms if a telemetry value exceeds, falls below or falls outside a preset limit value(s).
- * Dumb split screen terminal mode with user selectable number of window rows.
- * Customizable colors, PC to TNC baud rate, data parity and stop bits.
- * Default spacecraft configuration files.
- * UTC Time of day clock display (in HH:MM:SS format)

1.2 Program Requirements

IBM PC or clone with at least 256k memory.

A Radio receiver and a TNC with an RS-232 interface is only required for real time data capture.

The program DOES require that the packetized telemetry be received, and captured-to-disk with the packet header on a different line to the contents of the packet (HEADERLINE ON). I also suggest that you turn the date/time stamp on so that you will be able to playback your data and extract selected values and their corresponding time codes into a file that can be read into your spreadsheet program for further trend analysis.

This version (the default) is set up to display all packets as wild cards (i.e. will show up on all pages), and then display several temperatures and solar cell array currents.

By putting the correct parameters in the SPACECRAFT.SYS file, you can set up any of the pages to display any of the telemetry channel data in any row and column in that page.

1.3 Packet Link Quality Measurements

The packet link quality part allows the following to be done. You can define which of the packets you want to display/count (If you just want to count them and not display them, set the page value to 99). You can then view an incrementing count counter each time a selected packet is received. For example, using DOVE-OSCAR 17, you can also display the contents of the STATUS, WASH or BCRXMT packets in any display page. This feature allows you to get an idea of how good your receiving system is.

1.4 Copying Non-packet Telemetry

Packet telemetry, by definition is error free. The RTTY blocks from AMSAT-OSCAR 13 on the other hand may be received with errors. These errors may take the form of garbled or missing characters. If your link is bad, and such hits do occur, you should edit the capture-to-disk file before you playback the telemetry and decode/display the data.

If you get bad data in real time, look at the raw data. You will be able to see the quality of the link.

1.5 Obtaining Updates

It is anticipated that WHATS-UP is going to grow and incorporate features for decoding and displaying data from other spacecraft. Better Microsat binary telemetry decode and display capability will be added when AMSAT announce that the format has stabilized, and sufficient registered users express interest in having it. To stay on the mailing list and receive an update as it is released, register your copy, then send in a disk containing at least 1 Megabytes (zipped) of captured data from the spacecraft of your choice. If you would like to exchange data with other educational institutions or users so as to be able to

analyze more data than you can get on a single pass, indicate that fact and we will try and put you in direct touch with others who are similarly inclined.

1.6 Limit Checking

Limits are only checked for parameters being displayed (in Engineering units). With this approach, you can set up different pages for different on-board subsystems, you can also set up different display pages of the same parameters for daylight, darkness and terminator crossing passes, with different limit values to draw your attention to changes.

1.7 Radio Control

When you first bring up WHATS-UP, it sets the radio VFO A to the beacon frequency of the default spacecraft configuration file (*.SYS). When a selected spacecraft is scheduled to come above your horizon WHATS-UP will tune the radio to the spacecraft's beacon frequency. When the pass is over, WHATS-UP will return the radio to the default frequency. You can thus set up a "dummy" configuration file for your local Packetcluster or voice repeater and monitor that channel as long as the selected spacecraft are below your horizon.

If a pass is taking place, and a second selected spacecraft comes over your horizon, WHATS-UP will tune to its frequency UNLESS the autotrack is disabled. See Section *** for a description of the autotrack feature.

1.8 Using Different Terminal Units and TNCs.

This section briefly covers some of the differences between the various TNCs on the market. To copy PSK signals from Fuji-OSCAR 20 and the microsats, you will need a PSK modem adapter for your TNC. WHATS-UP has no way of checking that it is present.

1.8.1 PK-232

The PK-232 does not have a software selectable TNC radio port. You have to use the switch on the panel. The PK-232 will receive signals from UO-11 properly, only if the hardware modification described in this document is performed.

1.8.2 KAM

The KAM cannot demodulate SARA's 300 baud ASCII or 1200 baud ASCII, so signals from SARA and UO-11 cannot be copied. The KAM 2.85 firmware used to develop WHATS-UP assumes vhf packet on the vhf port, and the non packet modes on the hf port. WHATS-UP 1.20 does not let you switch ports on the KAM.

1.8.3 MFJ-1278

The MFJ-1278 cannot copy SARA's 300 baud ASCII or UO-11's 1200 baud ASCII. WHATS-UP does not change the radio port. You set the radio command in the WHATS-UP.SYS file. If you wish to change the radio port, an option is provided in the Configure TNC Menu.

1.8.4 TNC1, TNC2 and PK-88

These TNCs only copy packet. The other modes will not work.

2.0 Customization

2.1 Bringing WHATS-UP up for the First Time.

WHATS-UP comes configured to use Com1 in the PC as the serial port between the PC and the PK-232, and with the serial port between the PC and the Kenwood Radio DISABLED (Set to 0). WHATS-UP is also configured to assume DOVE as the default spacecraft.

If you type 'WHATS-UP' followed by the 'Enter' key, the program will load and start to do things. If the default serial ports are correct for your system, you need do nothing further, other than change the colors of the windows to your preference.

IF YOU ARE NOT USING A PK-232 YOU MUST DO THE FOLLOWING STEPS in DOS BEFORE, BEFORE you run WHATS-UP for the first time.

- 1 Rename WHATS-UP.SYS to WPK232.SYS.
- 2 If you are using a KAM, then rename WKAM.SYS to WHATS-UP.SYS.
- 3 If you are using an MFJ-1278, then rename WMFJ.SYS to WHATS-UP.SYS.
- 4 If you are using a packet only TNC (TNC1, TNC2 or PK-88), then rename WTNC.SYS to WHATS-UP.SYS.

2.2 Editing the Configuration File.

The configuration file is called WHATS-UP.SYS. You must edit it using option 'S' in the Edit Menu or with an ASCII word processor (in the non document mode) to set up the correct parameters on the RS-232 link between your TNC and your PC. See Section 10 for details of what parameter is on which line of the WHATS-UP.SYS file. If you wish to activate the Radio features, you must select a Radio Port.

Before you make any changes, make sure that you do not try and edit your original, always work from a copy.

These are the minimum set up items to change in the WHATS-UP.SYS file. Refer to Section 9 for fuller details of what items are on which lines. Bring up the Selections menu, then access the Edit Menu. choose the option for editing the WHATS-UP.SYS file. As you enter items on the lines listed below, delete the entries currently in place.

Line 1: Enter your callsign instead of the default one. Use Capital letters (Upper case). If you do not have a callsign, pick a mnemonic that represents your school or organization. You may use up to 10 characters. The callsign entered here, will be shown at the top of the status window, next time you load WHATS-UP, and will also (more important) be appended to your capture-to-disk files to identify the ground station which received the data.

Line 3: Enter the latitude of your location. In the southern hemisphere, use a negative number.

Line 4: Enter the longitude of your station in degrees West of Greenwich in the range 0 to 359.9.

Line 5: Enter the station altitude above sea level in meters. If you don't know, don't change anything.

Line 10: Enter the difference between local time in your PC and UTC. For example, eastern standard time is 5.

Line 15: If you are not using Com1 as the serial port between the PC and the TNC, enter the port number on this line.

Line 16: If you are not using 1200 baud between the PC and the TNC enter the actual value on this line.

Line 20: If you have a compatible radio with RS-232 control capability, enter the port number on this line (usually Port 2).

Read Section 9.1 to see what else to change to make the PC communicate with the TNC and the radio.

Save the file at this time. WHATS-UP will now work for you in its minimal mode. Read the manual to learn about its capabilities and use section 9 when you customize it to suit yourself.

2.3 Starting the program.

You may start the program in three ways as follows.

2.3.1 Default

Type 'whats-up' and return (without the ' ' characters). This brings the program up in the default mode. It will read the whats-up.sys file to determine the spacecraft being monitored, and then prompt you for the mode.

2.3.2 User Chosen spacecraft

Type 'whats-up spacecraft' and return (without the ' ' characters). The program reads the spacecraft.sys file to load the parameters for the Microsat of choice, and then prompts you for the mode.

Examples of the command are :

'WHATS-UP DOVE' or 'WHATS-UP Fuji20'

2.3.3 Custom Mode

Type 'whats-up spacecraft mode' and return (without the ' ' characters). This brings the program up in the custom mode. It will read the whats-up.sys file to determine the spacecraft being monitored, and then start up in the mode you set. Valid modes are 'p', 'i', 'o' and 'r'.

Examples of the command are :

'WHATS-UP DOVE R' or 'WHATS-UP Fuji20 R'

If you place a command line like this in your autoexec.bat file, should you be copying telemetry in an unattended manner and a power failure take place, the system will boot up into the correct WHATS-UP mode when power is restored.

When the program loads, the first thing it does is load the Keplerian data from the default data file and compute the current position of all the spacecraft. The following typical messages will be send during this activity.

```
MIR Loaded
RS-10/11 Loaded
AO-13 Loaded
UO-14 Loaded
AO-16 Loaded
DO-17 Loaded
Computing Next Pass for AO-10
Computing Next Pass for UO-11
Computing Next Pass for MIR
Computing Next Pass for RS-10/11
Computing Next Pass for AO-13
```

```
Computing Next Pass for UO-14
Computing Next Pass for AO-16
Computing Next Pass for DO-17
```

If the default Keplerian data file is not present on the disk, the orbital mode will be disabled. If the default Keplerian data file is empty, WHATS-UP will abort with a Run-Time Error.

2.4 Screen Areas

The screen is divided into four window areas. The Status window occupies the top line. The prompt window occupies the bottom line. Raw data are always shown in the lower data area. This window also shows any outgoing text that you may type at the keyboard or any commands WHATS-UP sends to the TNC. The data area in the top half of the screen contains the processed data (real time and playback), the raw data (interactive) and the orbital data display.

2.5 Setting Up Customized Display Pages

The ability to customize a display page is a unique tool provided by WHATS-UP. This tool allows you to group telemetry information so you can see how the monitor points you are interested in behave, and visually see the changes. You can locate information in any position on the screen and in any color you wish. You can also perform limit checking on the data, and have the "out-of-limit" show up in different colors and generate audible alarms.

Setting up display pages is an orderly procedure using the information contained in Section 9. When you want to customize the displays, make a copy of the supplied spacecraft configuration file and work with it. Look at the format of the file, read Section 9.2 to sure that you understand what is in the file. Use the editor to adjust the items in the spacecraft configuration file. After editing the file, reload the file to enter the changed parameters into WHATS-UP to see the effects of your changes. Repeat this procedure until you are satisfied.

First, from the utilities menu, view the colors and decide on the color scheme for the window and data.

Lay out the display page on graph paper for a screen window of 13 rows by 78 columns.

Decide on the name of the page. If it is a new page enter the name on a new line after the existing pages before the line that ends in an '*' character. Do not delete the '*' character. After you have entered the page name, insert a comma character ',' and a number for the default page color. An example from the DOVE.SYS file for such an entry is shown

below.

PAYLOAD TRANSMITTER/RECEIVERS, 30

2.5.1 Customizing Analog Telemetry Channel Displays.

The next few lines contain the analog telemetry decoding display information. Review Section 9.2 to see what has to be inserted in each of the elements. The analog telemetry lines are terminated with the following line, which must be present even if no data lines are present.

```
'* end of telemetry'
```

2.5.2 Customizing Status Telemetry Channel Displays.

Section 9.2.14 describes the meaning of each item. The status telemetry lines are terminated with the following line, which must be present even if no data lines are present.

```
'* end of status bytes'
```

2.5.3 Customizing Packet Header Displays.

The packet header configuration lines contain the analog telemetry decoding display information. Details of the meaning of each item are given in section 9.2.15. The packet header lines are terminated with the following line, which must be present even if no data lines are present.

```
'* end of packet types'
```

If you want to change the colors that channels out of limit, or channels in which the data changed between telemetry frames are displayed in, you must change the entries in the WHATS-UP.SYS file. 207 is a respectable value for the color to display data for which the limit has been exceeded (flashing white on red background).

3.0 Modes

WHATS-UP is designed to operate in a number of modes as listed below. Each mode has its own type of window display. To change things or select features, touch the 'Esc' key to bring up the top level menu. Menus in WHATS-UP are organized as a hierarchy, each option will take you as deep as necessary to make your selection.

3.1 Standby Mode

The standby Mode presents you with the Modes Menu as

described in Section 4. This mode is activated if you bring up WHATS-UP without specifying a mode in the command line.

3.2 Interactive Mode

The Interactive mode is a dumb terminal. You can use it to give commands to the TNC. You should also use it to set the 'HEADERLINE ON'. In this mode, you will see the raw packets on the channel. You can also use this mode as a regular TNC program (If you do, you ought to get your head examined, because LAN-LINK will do the job much better). The capture-to-disk will turn on when the first packet is copied, and will turn off two minutes after the last.

3.3 Real Time Mode

The Real-time mode converts and displays engineering data. You can display up to 16 (configured by you) pages of information. Information that changes between successive frames, is shown in a different color. Information that has exceeded a preset (by you) limit is shown in an alarm color (default: blinking red). The capture-to-disk will turn on when the first packet is copied, and will turn off two minutes after the last.

3.4 Orbital Dynamics Mode

The orbital dynamics mode gives you a display of the positions of the spacecraft with respect to your location. If the spacecraft are out of range, then you see time related information. If the spacecraft are in range then you also see position related information. The time that the spacecraft comes above your horizon is when you acquire signals. This time is known as Acquisition of Signals (AOS) time. You lose signals when the spacecraft drops below your horizon. This time is known as Loss of Signals (LOS). WHATS-UP allows you to define an early warning time (EWT) (in minutes) before AOS. The period of time between AOS and LOS is known as the pass.

Orbit positional information is only as accurate as your PC clock and the reference Keplerian data supplied by AMSAT and other sources. You can expect an accuracy of within a minute or two if your PC clock is correct. WHATS-UP only provides time displays accurate to within a minute or two. It's not worth going for greater accuracy in most cases.

The information displayed in the orbital mode window are as listed below.

WINDOW	Time till AOS (if out of range, or time till LOS if in range.
AOS	Time of AOS. This item is not displayed if the spacecraft is in range.

LOS Time of LOS.
PASS The amount of time that the pass will last. If
 the spacecraft is in range, then this item
 displays the minutes remaining till LOS.
MA Mean Anomaly, or position of the spacecraft in its
 orbit (see Section 5).
ALT The altitude of the spacecraft above sea level. An
 Up arrow next to it indicates that the altitude is
 increasing, a down arrow, that it is decreasing.

The following information is only displayed for spacecraft
in range.

AZ Azimuth - Pointing angle to spacecraft along
 horizon (0 = North, 90 = East).
EL Elevation - Pointing angle to spacecraft from
 horizon to zenith.
RANGE Distance between your station and the spacecraft.
 An Up arrow next to it indicates that the altitude
 is increasing, a down arrow, that it is
 decreasing.
DPLR Doppler shift on spacecraft's beacon signal.

A typical example of part of the display is shown below.

```
==S/C===WINDOW==AOS===LOS==PASS====MA====ALT====AZ=====EL===RANGE
UO-11   02:05 00:08 00:19 00:11  143      681
AO-13   04:51      02:54 08:01  122    37723  47.92  24.91
=DO-17   03:32 01:35 01:45 00:10  206      792
```

The first column provides information about the automatic
sequencer.

A check mark indicates that the spacecraft is the selected
one for data to be captured.

An equals sign indicates that WHATS-UP is configured to
configure itself to tune to its beacon signal and capture
data at AOS for that spacecraft.

A "less than equals" sign indicates that WHATS-UP is
configured to configure itself to tune to its beacon signal
and capture data at EWT for that spacecraft.

The display is color coded as follows.

Spacecraft out of range are displayed in the default window
color. Spacecraft in range are displayed in the 'in range'
color. Spacecraft within EWT are displayed up in the EXT
color. The spacecraft designator for the next spacecraft to
come in range is displayed in the 'next one up' color.

These colors may be configured to your preference in the
WHATS-UP.SYS file.

3.5 Playback Mode

The Playback mode allows you to play back captured telemetry with 4 speeds (speedy, slow, slower and snail's pace).

3.6 (Data) Extraction Mode

In this mode, data is extracted from a playback file into a file that can be read into a spreadsheet. If you answer the prompt for the default file with a non-existent filename, WHATS-UP will prompt you for individual channel numbers. To terminate the sequence and begin the extract mode, touch the 'Enter' key without entering a channel number.

Note: Start and stop times are text string matches.

3.7 Audio Warnings and Orbit Data Displays

WHATS-UP provides audible warnings in morse code of AOS, LOS and EWT. Each warning consists of a letter followed by the spacecraft designator. An 'A' prefixes AOS, an 'L' prefixes LOS and a 'Q' prefixes EWT.

WHATS-UP also shows orbit data associated with the selected spacecraft in the bottom window. This data which duplicates the line shown in the orbital mode, is there to be used in the real-time and interactive modes.

3.8 Autotrack

An autotrack flag is present in each spacecraft configuration file. The autotrack flag allows you to customize the way WHATS-UP switches radio frequencies and TNC modes. If the autotrack is disabled, WHATS-UP will not switch until after LOS of the satellite currently tracking. If the autotrack flag is enabled, WHATS-UP will switch radio frequency and TNC mode when a new spacecraft is present even if it is currently tracking one. You use the autotrack flag to stop WHATS-UP from switching away from a satellite in the middle of a pass if a new one comes up over the horizon.

If the autotrack flag is disabled, a flashing indicator will be seen next to the spacecraft name in the status window.

WARNING, if you disable the autotrack flag in the default configuration file, or manually load a spacecraft configuration file with the autotrack disabled, WHATS-UP will not change radio frequencies or TNC modes until the next LOS.

4.0 Menus

WHATS-UP provides various features organized in a hierarchy of

menus. To bring up the top menu, touch the 'Esc' key.

4.1 Function Keys

The following function keys are active in the operational modes described in Section 3:

- FK 1 capture to disk Toggle
- FK 2 type of display Engineering Units/Raw Byte Toggle
- FK 3 select display page
- FK 4 Change Doppler frequency display
- Alt-B send a 'Break' to the TNC
- Alt-C connect to another packet station
- Alt-D disconnect from another packet station
- Alt-F flush receiver buffer
- Alt-I autotrack toggle
- Alt-J jump to DOS (shell)
- Alt-P Printer on/off toggle
- Alt-S Sound on/off toggle
- Alt-X Quit Mode
- Alt += debug toggle
- left arrow decreases playback speed
- right arrow increases playback speed.

4.1.1 FK 1 Capture to disk Toggle

This function key turns the capture-to-disk ON if it is off, and turns it OFF if it is on.

4.1.2 FK 2 Type of display Engineering Units/Raw Byte Toggle

This function key changes the real-time, playback telemetry display between raw data and decoded engineering units.

4.1.3 FK 3 select display page

This function key allows you to select a different customized data display page.

4.1.4 FK 4 Change Doppler frequency display

This function key allows you to change the Doppler frequency display between the computed receive frequency and the difference between the satellite beacon frequency and the computed receive frequency.

4.1.5 Alt-B send a 'Break' to the TNC

This function key allows you to send a "break" character to the TNC. You use it if you accidentally put the TNC in the transparent mode.

4.1.6 Alt-C connect to another packet station

This function key prompts you to enter a callsign, then, if you are in the packet communications mode, attempts to connect you to that station.

4.1.7 Alt-D disconnect from another packet station

This function key allows you to disconnect a packet mode connection.

4.1.8 Alt-F flush receiver buffer

This function key allows you to flush the receive buffer.

4.1.9 Alt-I autotrack toggle

This function key allows you to enable or disable the autotrack feature. You use this key to override the default value in the spacecraft configuration file.

4.1.10 Alt-J jump to DOS (shell)

This function key lets you jump into DOS for a while without exiting from WHATS-UP.

4.1.11 Alt-P Printer on/off toggle

This function key lets you turn the printer on and off. If the printer is turned on, any incoming raw data will be echoed to the printer as well as to the screen.

4.1.12 Alt-S Sound on/off toggle

This function key lets you turn the sound on and off.

4.1.13 Alt-X Quit

This function key quits the mode and allows you to terminate WHATS-UP and return to DOS.

4.1.14 Alt += debug toggle

This function key lets you enable and disable the Debug Menu. If the debug menu is enabled, an '*' will be displayed on the left hand side of the status window.

4.1.15 left arrow decreases playback speed

This function key decreases playback speed in the Playback mode.

4.1.16 right arrow increases playback speed.

This function key increases playback speed in the Playback mode.

4.2 Modes menu

When you bring up the Modes menu you will be prompted with the following options.

```
E Extract From Playback File
I Interactive Mode
O Orbital Parameters
P Playback Mode
R Real Time Mode
S Selections Menu
X Exit to Dos
```

Type the letter associated with the option to perform it.

Each of the options are described below.

4.2.1 Extract From Playback File

This option activates the Extraction mode.

4.2.2 Interactive Mode

This option activates the Interactive mode.

4.2.3 Orbital Parameters

This option activates the Orbital mode. This option is only active if Keplerian data files are in the defined directory path.

4.2.4 Playback Mode

This option activates the Playback mode.

4.2.5 Real Time Mode

This option activates the Real-time mode.

4.2.6 Selections Menu

This option brings up the Selections Menu.

4.2.7 Exit to Dos

This option allows you to terminate WHATS-UP and return to DOS.

4.3 Selections Menu

This menu presents you with the following typical options.

- C Change Display Page
- E Edit Menu
- F Files Menu
- H Help Menu
- J Jump to DOS
- M Modes Menu
- O Orbits Menu
- R Radio Menu
- S Spacecraft Menu
- T PK232 Menu
- U Utilities Menu
- X Exit to DOS

4.3.1 Change Display Page

This option allows you to change the display page for the Real-time, Playback and Extraction Modes. It performs the same operation as Function key 3 (F3) when those modes are active.

4.3.2 Edit Menu

This option brings up the Edit Menu.

4.3.3 Files Menu

This option brings up the Files Menu.

4.3.4 Help Menu

This option displays help information for the function keys.

4.3.5 Jump to DOS

This option allows you to jump into a DOS Shell. You return to WHATS-UP by typing the DOS command 'EXIT'.

4.3.6 Modes Menu

This option brings up the Modes Menu.

4.3.7 Orbits Menu

This option brings up the Orbits Menu. This option is only available if an orbit element file (*.AMS or *.2LN) is present.

4.3.8 Radio Menu

This option brings up the Radio Menu if a Kenwood Radio is present and the interface is operational.

4.3.9 Spacecraft Menu

This option brings up the Spacecraft Menu.

4.3.10 TNC or PK232 Menu

This option brings up the TNC Menu.

4.3.11 Utilities Menu

This option brings up the Utilities Menu.

4.3.12 Exit to DOS

This option allows you to terminate WHATS-UP and return to DOS.

4.4 Edit Menu

WHATS-UP contains an ASCII text editor suitable for files less than 64k in size. It is built based on Borland's Turbo Pascal Editor Toolbox and the commands are compatible with Sidekick and Wordstar. A summary of the editor commands is shown below.

F10 Switch Windows (if more than one window open)

Backspace Delete left char

Del Delete Char

Enter New line

Ins Toggle insert mode

PgUp Move cursor up one page

PgDn Move cursor down one page

^A Move cursor left one word

^C Move cursor down one page

^D Move cursor right one character

^E Move cursor up one line

^F Move cursor right one word

^G Delete one character

^H Delete left one character

^I Tab

^L Find/replace next occurrence

^P Insert a control character into the text

^M New line

^N Insert line

^R Move cursor up one page

^S Move cursor left one character

^T Delete one word after cursor

^V Toggle insert mode

^W Scroll up

^X Move cursor down one line

^Y Delete line at cursor

^Z Scroll down

^K^B Mark beginning of block

^K^C Copy block to position of cursor
^K^D Save file and exit edit
^K^H Hide block marker
^K^K Mark end of block
^K^Q Abandon file and exit edit
^K^R Read file into screen
^K^T Mark single word as block
^K^V Move block to position of cursor
^K^W Write block to disk file
^K^Y Delete block
^K 1..9 Set marker 1 .. 9
^Q^A Find text and replace
^Q^B Move to beginning of block
^Q^C Move to end of file
^Q^D Move to right of line
^Q^E Move to top of window
^Q^F Find text
^Q^I Toggle autoindent mode
^Q^K Move to end of block
^Q^R Move to top of file
^Q^S Move to left of line
^Q^X Move to bottom of window
^Q^Y Delete to end of line
^Q 1..9 Jump to marker 1..9

The following options can be set in the Find/Find and Replace (^Qf and ^Qa) operations.

locates #th occurrence
G global replace
N replace without Y/N question
U ignore upper case/lower case
W match whole words only

Notes

- 1 The ^ key in front of a character identifies the character as a 'control' character. To activate it, hold down the Control key AND the character key.
- 2 Some of the commands require two keystrokes.
- 3 Use ^P to embed a control character in the text. For example, if you are creating a file containing commands to be sent to the TNC, to enter a control-C character into the file, use the ^P^C sequence of keystrokes.

WHILE USING THE EDITOR, WHATS-UP can't receive and process characters from the TNC. All other features ARE INHIBITED OR LOCKED OUT.

The Edit menu allows you to call up the various files for editing as shown by this typical display.

D DOVE.DOP

F Any File
K WHATS-UP.2LN
M c:dove.SYS
P Pick ***.D17 File
R c:910313.D17
S WHATS-UP.SYS
T Two Files
W Arrays
X whats-up.txt
Y Pick ***.SYS File

Type the letter corresponding to your choice.

4.4.1 Edit Doppler File

This option lets you edit the file containing Doppler measurements.

4.4.2 Any File

This option lets you edit any file.

4.4.3 Edit Keplerian Element File

This option lets you edit the default file containing Keplerian data.

4.4.4 Edit Spacecraft Configuration File

This option lets you edit the file containing the spacecraft configuration data, such as display pages, and automatic radio tuning options.

4.4.5 Pick Capture-to-disk File

This option lets you pick a capture-to-disk file to be edited. When you implement this option you will be presented with a list of available files. Move the cursor down to the desired file and push the 'Enter' key.

4.4.6 Edit Capture-to-disk File

This option lets you edit the file containing data captured during the last pass.

4.4.7 Edit WHATS-UP.SYS

This option lets you edit the WHATS-UP.SYS file.

4.4.8 Two Files

This option lets you edit any two files.

4.4.9 Edit Doppler Channel File

This option lets you edit the file containing the channel numbers of the data to be extracted from the raw telemetry, processed and written to disk.

4.4.10 Edit Doppler Data File

This option lets you edit the file containing extracted data.

4.4.11 Pick Spacecraft Configuration File

This option lets you pick a spacecraft configuration file to be edited. When you implement this option you will be presented with a list of available files. Move the cursor down to the desired file and push the 'Enter' key.

4.5 Files Menu

This menu presents you with the following typical options.

- A Change Directory Path
- F Change Playback File
- S Show Data Files
- V View Playback File
- Z Show *.D17 Files
- 1 Show Files for 1 Spacecraft

4.5.1 Change Directory Path

This option allows you to temporarily change the directory path to the capture-to-disk files.

4.5.2 Change Playback File

This option allows you to change the playback file. To select a file, move the cursor down to the desired file and push the 'Enter' key. If you have more files than fit in the window, touch the 'PgDn' key to display another window full.

4.5.3 View Playback File

This option allows you to view the contents of the playback file.

4.5.4 Show Spacecraft Capture-to-disk Files

This option shows you the names of the capture-to-disk files for the chosen spacecraft in the default directory path.

4.5.5 Show Data Files

This option shows you the names of ALL the capture-to-disk files in the default directory path.

4.5.6 Show Files for 1 Spacecraft

This option shows you the names of the capture-to-disk files for a particular chosen spacecraft in the default directory path. It will prompt you for the filetype associated with the spacecraft (e.g. O23, D17).

4.6 Orbits Menu

This menu presents you with the following typical options.

- A Pick AMSAT Format Element Set
- E Edit WHATS-UP.2LN
- L Load Element File
- N Pick NASA 2 Line Element Set
- V View Spacecraft Orbit Elements

4.6.1 Pick AMSAT Format Element Set

This option allows you to change the AMSAT Format Keplerian Element file. To select a file, move the cursor down to the desired file and push the 'Enter' key. If you have more files than fit in the window, touch the 'PgDn' key to display another window full.

4.6.2 Edit Default Keplerian Element File

This option lets you edit the default file containing Keplerian data.

4.6.3 Load Element File

This option loads the data in the element file into WHATS-UP. When you activate the option you will be prompted as follows.

Which Element File ? WHATS-UP.2LN

WHATS-UP will supply the default name, you may overwrite it to supply the name of another file. You use this option to load a file that is not located in the default directory.

4.6.4 Pick NASA 2 Line Element Set

This option allows you to change the 2 Line Format Keplerian Element file. To select a file, move the cursor down to the desired file and push the 'Enter' key. If you have more files than fit in the window,

touch the 'PgDn' key to display another window full.

4.6.5 View Spacecraft Orbit Elements

This option lets you view the data associated with the spacecraft. When you activate this option, you will be presented with a menu window containing a list of spacecraft designators. Move the cursor to the one of interest and touch the 'Enter' key to select it.

If the default element file is in AMSAT format (*.AMS) the two line display is not shown.

A typical display is shown below :-

```
1 20440U 90 5 E 91059.65616971 .00001077 00000-0 44042-3 0 2017
2 20440 98.6806 140.0431 0012003 123.1299 237.1040 14.29083383 57498
```

Catalog ID:	20440	Apogee:	803.312
Element Set:	201	Perigee:	786.093
Epoch Year:	1991	Period:	100.76
Epoch Day:	59.6561697	Semi Major Axis:	7172.862
Drag:	0.00001070		
Inclination:	98.6806	Epoch Age:	22.263
RAAN:	140.0431	Current Date:	81.919
Eccentricity:	0.0012003	Current Orbit #:	6067
Argument of Perigee:	123.1299		
Mean Anomaly:	237.1040		
Mean Motion:	14.2908338		
Epoch Orbit #:	5749		

4.7 Radio Menu

This menu is only present if you have a Kenwood Radio defined as your Radio Receiver for the spacecraft. The menu presents you with the following typical options.

```
D Turn Doppler Tracking ON
F Set New Frequency
I Change Doppler Interval
R Read VFO A Frequency
S Set Default Frequency
V Select VFO A/B
```

4.7.1 Turn Doppler Tracking ON/OFF

This option lets you turn the Doppler tracking on and off.

4.7.2 Set New Frequency

This option lets you set a new (default) frequency into the radio and tune to it.

4.7.3 Change Doppler Interval

This option lets you change the time interval (in minutes) between successive samples of the radio VFO frequency.

4.7.4 Read VFO A Frequency

This option lets you read back the frequency that VFO A is tuned to, and displays it in the status window.

4.7.5 Set Default Frequency

This option lets you set the radio back to the default frequency and tune to it.

4.7.6 Select VFO A/B

This option lets you select between the two VFOs in the radio and tune to it.

4.8 Spacecraft Menu

This menu presents you with the following options.

- C Show DOVE.SYS
- K picK Spacecraft
- M Change Spacecraft
- P Pick Ops. Schedule
- S Show Ops. Schedule

4.8.1 Show Spacecraft Configuration File

This option allows you to display the spacecraft configuration file default settings.

4.8.2 picK Spacecraft

This option allows you to choose another spacecraft from a list. To select one, move the cursor down to the desired one and touch the 'Enter' key. For example, amongst the default files supplied are DOVE.SYS and FUJI.SYS. To select the DOVE or the Fuji-20 spacecraft, move the cursor down to the 'DOVE.SYS' or 'Fuji.SYS' line and touch the 'Enter' key.

4.8.3 Change Spacecraft

This option allows you to choose another spacecraft. To select a another one, enter the name of the spacecraft.sys file. For example, amongst the default files supplied are DOVE.SYS and FUJI.SYS. To select the DOVE or the Fuji-20 spacecraft, type 'DOVE' or 'Fuji'

4.8.4 Pick Ops. Schedule

This option allows you to pick an operations schedule. (A file with the default extension of "OPS".) You would use it to look at the schedule for a spacecraft other than the one currently selected.

4.8.5 Show Ops. Schedule

This option allows you to look at the schedule the spacecraft currently selected.

4.9 TNC Menu

This menu presents you with the following typical options.

- A UoSAT ASCII Beacon
- B Phase 3 RTTY Beacon
- C Set Morse Code (CW)
- M Fuji/MicroSat ASCII Packet
- P FM Packet
- R Select MFJ 1278 Radio Port
- S SARA ASCII Beacon
- T Configure PK232

If you select an option that your TNC cannot perform, you will get an error message.

4.9.1 UoSAT ASCII Beacon

This option will configure the PK-232 to copy the UoSAT-OSCAR 11 telemetry. Note: you require a hardware change in the PK-232 to make sense of the received data.

4.9.2 Phase 3 RTTY Beacon

This option will configure the Multi mode TNC to copy the UoSAT-OSCAR 13 Baudot Beacon.

4.9.3 Set Morse Code (CW)

This option will configure the Multi mode TNC to copy morse code. You use this if you want to copy morse code telemetry. Note the decoding formats are not provided in this program, so you will have to decode the telemetry in some other way, such as by hand or by means of a spreadsheet.

4.9.4 Fuji/MicroSat ASCII Packet

This option will configure the Multi mode TNC to copy the Fuji ASCII format PACKET telemetry. You should not

use WHATS-UP to capture AMSAT/UoSAT binary telemetry because WHATS-UP filters the ^J and ^M (carriage return and line feed characters) from the incoming datastream.

4.9.4 Configure TNC

This option configures the TNC to copy the UI packets transmitted by the Packet spacecraft or any other configuration defined by the parameters at the end of the *.SYS file.

4.9.5 FM Packet

This option will configure the Multi mode TNC to copy the DOVE ASCII format PACKET telemetry. You should not use WHATS-UP to capture AMSAT/UoSAT binary telemetry because WHATS-UP filters the ^J and ^M (carriage return and line feed characters) from the incoming datastream.

4.9.6 SARA ASCII Beacon

This option will configure the PK-232 to copy the SARA ASCII format 300 baud binary telemetry. You should not use WHATS-UP to capture AMSAT/UoSAT binary telemetry because WHATS-UP filters the ^J and ^M (carriage return and line feed characters) from the incoming data stream. At this time no data has been published about decoding the telemetry from SARA-OSCAR 23.

4.9.6 Select MFJ-1278 Radio Port

This option lets you change the MFJ Radio port. WHATS-UP does not change it at any other time.

4.10 Utilities Menu

This menu presents you with the following typical options.

- A Change Directory Path
- D Show Space on Disk
- R Reset Header Counters
- S Show Defaults
- Z Show Files
- * Show Color Chart
- ! Reconfigure WHATS-UP

4.10.1 Change Directory Path

This option allows you to temporarily change the directory path to the spacecraft capture-to-disk, configuration and schedule files.

4.10.2 Show Space on Disk

This option allows you to see how much space is left on a disk with exiting from the program.

4.10.3 Reset Header Counters

This option applies to spacecraft transmitting packetized telemetry. When activated, the option resets the packet counters to zero. Use this before a pass to see how many packets of each type are received during the pass.

4.10.4 Show Defaults

This option allows you to display the WHATS-UP default settings.

4.10.5 Show Files

This option lets you display the files in the default directory path. Use this if WHATS-UP tells you that a file does not exist and you are sure that it does.

4.10.6 Show Color Chart

This option allows you to display the color combinations. Use this to see what how the different color combinations appear on your screen, note the numbers associated with each color, then exit from the program and edit the WHATS-UP.SYS file using your editor in its ASCII (non document) mode to change the colors to those you desire.

4.10.7 Reconfigure WHATS-UP

This option reloads the configurations from the WHATS-UP.SYS file. Use it after editing the file to see the effect of your changes.

4.10.8 Enable/Disable TNC Port

This option lets you enable and disable the PC serial port to the TNC. Use it to stop WHATS-UP taking control of the port in multi-tasking environments, so you can run LAN-LINK in one window, and the Orbit Dynamics display of WHATS-UP in another.

4.11 Debug Menu

This menu is only active when the debug flag is enabled. The menu presents you with the following typical options.

```
@ Sound CW String
D Turn Debug OFF
F Set Frequency
```

- I Interrogate Radio
- S Show Defaults
- T Talk to Radio
- V Speak Frequency
- W Identify Radio

4.11.1 Sound CW String

This option asks you to enter some characters at the keyboard. When you do so, it then sounds them off in morse code. You use this option to adjust the speed of the morse code used in the AOS, LOS and EWT signals.

4.11.2 Turn Debug OFF

This option lets you turn the debug flag off.

4.11.3 Set Frequency

This option lets you enter a frequency into the selected VFO.

4.11.4 Interrogate Radio

This option lets you enter a manual command into the radio and see the reply returned by the radio.

4.11.5 Show Defaults

This option allows you to display the WHATS-UP default settings.

4.11.6 Talk to Radio

This option lets you enter a manual command into the radio.

4.11.7 Speak Frequency

This option commands the voice module in the radio to announce the frequency it is tuned to.

4.11.8 Identify Radio

This option lets you enter the 'identify' command into the radio and see the reply returned by the radio.

5.0 Orbital Elements

5.1 Basics

As an object moves in space it is subject to gravity. The object itself has mass and attracts other objects and is at the same time attracted by the mass in the other objects.

Sir Isaac Newton formulated the law of gravity, which can be described in the following manner.

All bodies attract each other with a force called gravitational attraction. The strength of the mutual attraction between two bodies is dependent on their masses, and the distance between the bodies. In fact the closer together that the two bodies are, the greater is the mutual attraction. Mathematically this can be expressed as the gravitational attraction between two bodies is directly proportional to their masses and is inversely proportional to the square of the distance between them.

Planet Earth is an object moving in space and exerts a gravitational force. It pulls anything close to it towards the center of the Earth at an increasing speed. An increasing speed is known as acceleration. The acceleration due to gravity at the surface of the Earth is given the value of 1 Gravity (G).

5.2 Orbital Trajectories

If the Planet pulls everything towards itself, what keeps things in orbit around it? For example, if you throw a rock up into the air, gravity and air resistance (drag) slow it down and it falls back to Earth. If you shoot a bullet towards the horizon it will travel much further than the stone did, but will still fall to Earth (unless it hits something first).

If you launch a rocket towards the horizon, the rocket will accelerate as long as the fuel lasts. When the rocket fuel is exhausted, the rocket will continue to travel in a straight line until other forces alter its path. If the rocket is low enough, the molecules of air or the atmospheric drag tends to slow it down. At any height it will still be pulled back by gravity. The force of gravity always acts towards the center of the Earth. On its own the rocket will travel in a straight line. Gravity acting downwards will curve the path of the rocket around the Earth.

The force of gravity will pull the rocket away from its horizontal path and cause it to fall in a downwards direction. Now the surface of the Earth is also curved and also curves away in a downwards direction. If speed of the rocket is such that the rate of descent (due to the gravitational attraction of the Earth) is equal to the curvature of the Earth, the rocket will always remain at the same height, namely, it will be in a circular orbit. If the rocket does not have enough speed it will gradually fall back to Earth, and if it has more speed, it will tend to rise above the Earth.

If the rocket continues to burn fuel the speed of the rocket increases and the path it takes rises away from the surface of the Earth. When the fuel is exhausted, gravity is still there and still slows down the rocket. As it slows down its path curves more sharply until at its furthest point (apogee) it is travelling parallel to the surface of the Earth. It is however travelling slower than the speed necessary to maintain a circular orbit at that altitude and starts to curve back towards the Earth. The force of gravity now acts in a downward and (slightly) forward direction and speeds up the rocket until at its lowest point (perigee) it once again is travelling parallel to the surface of the Earth but now has enough speed to rise away from the surface. This process repeats each time around and produces an elliptical orbit. (In this orbit, the center of the Earth is one focus of the ellipse.

To place a satellite into an orbit, it must be given the right amount of speed for the desired orbital altitude so that the orbital velocity at apogee is such that it just balances the gravitational pull of the Earth. Since the force of gravity decreases with altitude, the orbital velocity is also different at different altitudes. Any rocket can lift a small mass to a much higher altitude than it can lift a large mass. How much and how high will depend on the rocket itself.

5.3 Types of orbits

Different orbits are used for different purposes. Circular and elliptical orbits come in various forms depending on the angle that the plane of the orbit makes with the equator of the Earth. This angle is known as the angle of inclination of the orbit (with respect to the equator). A polar orbit has an angle of inclination such that the spacecraft in that orbit can see the polar regions of the Earth. A geostationary orbit is one which has an angle of inclination parallel to the equator and an altitude of 22,240 miles (35,790 km) and the spacecraft moves in its orbit at the same speed as a point on the surface of the Earth below it. The spacecraft thus appears to be stationary with respect to the Earth below it.

The direction in which the satellite moves around the Earth determines the type of orbit. One which travels along its orbit in the same direction as the rotation of the Earth (eastwards) is said to be in a direct or prograde orbit. One which travels against the rotation of the Earth (westwards) is said to be in a retrograde orbit.

The movement of an object in space can be described mathematically. In the early 17th century, the only known objects in space were the Sun, the Moon, the Planets, a few comets and the stars. It was then that Johannes Kepler

formulated three laws that first described the movement of the Planets about the Sun.

Kepler's Laws are stated in the following paragraphs.

1. Each Planet revolves about the Sun in an orbit that forms a circumference of an ellipse with the Sun at one focus of the ellipse.
2. The line from the center of the Sun to the center of the Planet (called the radius vector) sweeps out equal areas in equal periods of time as the Planet travels along the circumference of the ellipse.
3. The square of the time taken for a Planet to travel around the circumference of the ellipse (period of revolution of the orbit of a Planet) is proportional to the cube of the mean distance of the Planet from the Sun.

In the first law, the focus within the Sun is actually at the center of mass of the Earth-Sun system and not at the center of the Sun.

5.4 Orbital Elements

The position of an object in space can be expressed in terms of its relationship with other bodies. Each orbit can be described in terms of a number of parameters which supply enough information to accurately locate the satellite. Six basic parameters are used to describe the position of a satellite in an elliptical orbit are described in the following paragraphs. They are Angle of inclination, Right Ascension of Ascending Node (RAAN), Eccentricity, Semimajor Axis, Argument of Perigee and Epoch time of Ascending Node. Consider each one in turn.

5.5 Angle of Inclination.

The angle of inclination of an orbit is the angle between the plane of the orbit and the equator of the Earth. A satellite moving in a direct orbit has an angle of inclination between 0 and 90 degrees, one moving in a retrograde orbit has an angle of inclination of between 90 and 180 degrees.

The maximum northern and southern latitudes reached by a satellite are equal to the angle of inclination of its orbit.

5.6 Right Ascension of Ascending Node (RAAN).

While the spacecraft is moving around the Earth, the Earth is at the same time rotating on its own axis, and is itself

travelling in an orbit about the Sun. The Right Ascension of Node is needed as a fixed reference point in the sky.

Astronomers use the term celestial sphere to describe the sky for two reasons. First, from where we are standing on the surface of the Earth, the sky seems to be painted on the inside surface of a sphere (with the stars in fixed positions on the sphere). Second, have you ever known scientists to use a short commonly used word when they can use long ones?

The orbital plane of a spacecraft intersects the equatorial plane of the Earth in two places (one on each side of the globe). A line drawn between these two points and continued out to the celestial sphere is called the line of nodes. The two points on the line of nodes where the planes intersect are called the point of nodes. Most globes (and maps) show the north pole upwards. When the spacecraft crosses the equatorial plane (passes above the equator) going northward it is ascending from south to north and that node point is known as the ascending node. Conversely when the satellite continues on its way and travels half way around the world it crosses the other node on the equatorial plane descending to the southern hemisphere. This second node is called the descending node.

The Earth is in an inclined orbit around the Sun, just like a satellite is in orbit around the Earth. The Earth has an ascending and descending node around the Sun, in a similar manner to a spacecraft in orbit around the Earth. The orbital plane of the Earth is known as the Ecliptic. The direction in space from the center of the Earth through the intersection of the ecliptic and the Earth's equatorial plane out to the celestial sphere is called the vernal equinox or the First Point of Aries because it points to the constellation of Aries (which is so far away that (for all practical purposes) it is in fixed direction).

The angle between the line of nodes for the ascending node of the orbit of the spacecraft continued out to the celestial sphere and the vernal equinox when measured in an easterly (right as opposed to westerly/left) direction along the earth's equator is defined as the Right Ascension of the Ascending Node (RAAN).

5.7 Eccentricity and Semimajor Axis

In a circle, the radius of the circumference is constant. This means that an object travelling along the circumference is always at a constant distance from the center or focus of the circle. The general shape of an orbit is an ellipse. Unlike a circle, an ellipse has two focal points. The distance between each of the focal points of the ellipse and an object on the circumference is constant. A line through

the two focal points and the circumference is called the Semimajor Axis. The longest line perpendicular (at 90 degrees to) the semimajor axis passing through the circumference of the ellipse is called the Semiminor Axis.

The mathematical term describing the overall shape of an ellipse is called Eccentricity. When the eccentricity of an ellipse is 0 the length of the semimajor axis is equal to the length of the semiminor axis and the shape being described is a circle. A value of eccentricity greater than 0 means that there is a difference between the lengths of the axes and the shape of the ellipse flattens out. Eccentricity describes the shape of the orbit and the length of the semimajor axis describes the size of the orbit. If these two parameters are known, the apogee and perigee values for the orbit can be calculated.

5.8 Decay Rate

The Earth has an atmosphere. It is dense at ground level and thins out with increasing altitude. The Earth's gravity attracts the molecules of gas in the atmosphere and stops them from escaping. As the satellite travels along its elliptical orbit around the Earth, its altitude changes. When it is close to perigee, it bumps into molecules of air. The lower it gets the greater the drag on it by the air. When the orbital radius decreases as a result of drag, the potential energy of the spacecraft also decreases as it comes closer to the earth. This decrease in potential energy reappears in the form of heat energy imparted to the atmosphere and to the skin of the spacecraft, and in an increase of the kinetic energy of the spacecraft. It is this latter that causes the velocity of the spacecraft to speed up.

The rate of change of speed through the atmosphere at the perigee pass will depend on the type of orbit and on the altitude of the perigee point. In general, satellites with low perigee points will be more affected than satellites with higher perigee points. The effect of this over the long term is to lower the apogee point. Over the long term, the satellite tends to spend more time in the denser parts of the atmosphere which then tends to circularize the orbit (at the perigee) at which point the air drag acts continuously on the spacecraft and the orbit disintegrates. The rate of change of the orbit measured at a particular epoch is called the decay rate.

5.9 Argument of Perigee.

A line drawn between the perigee of an elliptical orbit and the center of the Earth is called the line of perigee. This line also passes through the apogee and is the semimajor axis of the orbit. The angle between the line of perigee

and the line of nodes is called the argument of perigee. It is a measurement of the angular distance between them and is measured in the ascending direction from the line of nodes. The argument of perigee thus establishes the position of the ellipse itself within the orbital plane.

5.10 Epoch Time (of Ascending Node) and Revolution Number.

The Epoch time is a time when the satellite crosses its perigee point. This time is given as a Julian date, and is the reference time for when the orbital elements are valid. The Epoch Revolution or orbit number is the orbit number (since first perigee crossing) for which the element set is valid.

5.11 The Mean Motion.

The mean motion a satellite is a measurement of the number of orbits completed in a day. It is equal to twice the value of PI divided by the time that the spacecraft takes to complete one revolution of its orbit (orbital period).

5.12 The Catalog Number

The catalog number is the number given to the object.

5.13 Mean Anomaly

As the satellite travels along its orbit, its position changes. The angle (measured in the direction of forward rotation) between the position of the spacecraft and the line of perigee is called the true anomaly. The speed of the spacecraft is different at different parts of the orbit. Calculations are simpler if the speed is considered to be constant. The constant value is the average speed of the spacecraft in its orbit. The mean anomaly is the hypothetical position of the satellite in its orbit (along the ellipse) if it is assumed to be travelling at its average speed.

5.14 Anticipated Spacecraft Lifetimes

There is not much point in setting up equipment to receive data from these spacecraft if they are not going to be around for a reasonable amount of time. Past experience points to three main factors limiting the operational life of an OSCAR, namely orbital decay, battery life, and total radiation dosage.

5.14.1 Orbital Decay

The last OSCAR to plunge back into the earth's atmosphere while still active was UoSAT-OSCAR 9. It was launched into a 500km orbit, and lasted eight years. A chart in the

Satellite Experimenter's Handbook shows a lifetime of 40000-50000 days for spacecraft at the Microsat altitude, or some where around 120 years; so orbital decay is not our main worry. There has been some concern about AMSAT-OSCAR 13's orbit, which is expected to decay somewhere between 1992 and 1995. AMSAT however are currently planning a replacement spacecraft so the investment in receiving equipment will not be in vain.

5.14.2 Battery lifetime.

Battery breakdown has caused the demise of all amateur spacecraft except UoSAT-OSCAR 9. OSCARs 1, 2 and 3 were limited to whatever charge was in the batteries when launched. Once Solar cells and nickel-cadmium batteries were flown, the limiting factor became the number of times the battery cells could be charged and discharged.

The batteries in OSCAR spacecraft in low earth orbit have lasted between five and eight years. UO 9 was still looking good when it re-entered the earth's atmosphere after 8 years. UoSAT-OSCAR 11, launched in March, 1984, has batteries with the same part number as those used in the Microsats. These latter batteries were procured in much the same manner, and were matched and tested by the same group of VITA volunteers in Canada that performed the function for UoSAT-OSCAR 11. The batteries on UoSAT-OSCAR 11 have shown no signs of weakening after almost six years in orbit, so the prognosis for UoSAT-OSCAR 11 and the Microsats looks good.

5.14.3 Radiation Damage.

Anything above the protection of the atmosphere is subjected to exposure to the radiation due to the direct and secondary effects of high energy particles, from the sun and elsewhere. The part of the spacecraft most susceptible to such damage is the memory in the on-board-computer (OBC). Such damage manifests itself as a bit flipping from a 0 to a 1 or from a 1 to a 0, which is correctable. Since the memory chips used are byte-wide, many types of single-chip failures can be avoided in a manner analogous to locking out bad sectors on a hard disk. UoSAT-OSCAR 11, which uses somewhat similar technology chips, has survived almost six years despite a failure of one small section of memory several years ago.

Another part of the OBC is the controller itself which is susceptible to a particle hitting it in a place that causes uncorrectable errors, such as a wrong operation internal to the microprocessor, or a CMOS latchup which can result in a high current being drawn which overheats the part and destroys it.

The spacecraft are more likely to fail due to the cumulative effects of this constant bombardment, which is known as total dose. Once the total dose reaches a certain point, the gates in the transistors that make up the computer and its memories will no longer switch. This situation has occurred in AMSAT-OSCAR 10. Predicting when this might occur is difficult because of lack of knowledge concerning two things; the total radiation dose in this orbit and the tolerance limits for the parts used.

The MicroSats are in a much more benign orbit than AMSAT-OSCAR 10 which with its 4000 km perigee, spends more time in the Van Allen radiation belts than was planned. AMSAT-OSCAR 10's memories therefore failed sooner than hoped, but the other electronics, the transponders, batteries, and solar arrays live on. Through no-longer actively attitude controlled, its transponders are still usable many weeks of the year when its batteries are being charged by the sun.

AMSAT-OSCAR 13 is in a better orbit with a lower perigee, and should not suffer radiation degradation before other effects shorted its lifespan.

6.0 The Spacecraft

OSCAR spacecraft downlink signals in the amateur 145 MHz and 430 MHz bands modulated by means of Frequency Shift Keying (FSK), Frequency Modulation (FM) or Phase Shift Keying (PSK). Some of the characteristics of the downlinks of suitable OSCARs currently operational are shown in Table 6-1. UoSAT-OSCAR 11 and AMSAT-OSCAR 13 send back BAUDOT or ASCII data while AMSAT-OSCAR 16, DOVE-OSCAR-17, WEBER-OSCAR 18, LUSAT-OSCAR 19 and Fuji-OSCAR 20 downlink packetized telemetry.

Table 6-1 Some of the Characteristics of OSCAR Downlinks.

Spacecraft	Beacon Frequency (MHz)	Modulation Type	Data	Note
UO-11	145.825	FM	ASCII 1200 Baud	1
	435.025	FM	ASCII 1200 Baud	1
AO-13	145.812	FSK	BAUDOT 50 Baud	2
		PSK	ASCII 400 Baud	2
	435.651	FSK	BAUDOT 50 Baud	2
		PSK	ASCII 400 Baud	2
AO-16	437.025	PSK	AX.25 1200 Baud	3
	437.025	PSK	AX.25 1200 Baud	3
DO-17	145.825	FM	ASCII 1200 Baud	
WO-18	437.100	PSK	AX.25 1200 Baud	3
	437.075	PSK	AX.25 1200 Baud	3
LO-19	437.150	PSK	AX.25 1200 Baud	3
	437.125	PSK	AX.25 1200 Baud	3
FO-20	435.912	PSK	AX.25 1200 Baud	
SO-23	145.955	FM	ASCII 300 Baud	4

Notes

1. Spacecraft also broadcasts bulletins and Various Telemetry formats.
2. Spacecraft downlink modulation is changed according to a pre-published schedule.
3. Alternate (back up) beacon frequency, may be used on Wednesdays.
4. Binary telemetry with ASCII identification.

Before discussing the equipment needed to receive signals from the spacecraft, a brief word about the spacecraft themselves is in order. Since these OSCARs rode into space as secondary payloads, the orbits that they are in are close to those of the primary payload and are not optimized for amateur radio communications. The exception is AMSAT-OSCAR 13 which contained a motor which was used by radio amateurs to boost the spacecraft from the orbit the rocket placed it in into its operational orbit. The ones that are in low earth orbits can be received with simple equipment, but are in range for short periods of time, AMSAT-OSCAR 13 in an elliptical orbit is in range for many hours each day, but needs more sophisticated receiving equipment. The orbital parameters of the OSCARs under discussion are shown in Table 6-2.

Table 6-21 Orbital Parameters of the OSCARs

Spacecraft	Apogee (km)	Perigee (km)	Inclination (Degrees)	Period (Minutes)
UoSAT-OSCAR 11	699	670	98.0	98.3
AMSAT-OSCAR 13	39,000	2,500	26.1	686.65 [1]
AMSAT-OSCAR 16	804	780	98.7	100.8
DOVE-OSCAR 17	804	780	98.7	100.8
WEBER-OSCAR 18	804	780	98.7	100.8
LUSAT-OSCAR 19	804	780	98.7	100.8
FUJI-OSCAR 20	1,745	912	99.05	112.0
SARA-OSCAR 23	774	768	98.5	100.3

Notes

- 1 686.65 minutes is 11 hrs, 26 min.

6.1 Receiving system components

Consider the different components or building blocks that are used in the different receiving configurations.

6.1.1 Antennas

Antennas receive signals, and each kind of antenna has some degree of directive and polarization. When the spacecraft

risers above the local horizon, the ground station experiences acquisition of signals (AOS). At this time the ground station is receiving signals coming from a particular direction (azimuth). As the spacecraft rises in the sky, the elevation angle of the received signals changes, until the spacecraft drops below the observer's horizon and the ground station experiences loss of signals (LOS). As seen from the ground, the spacecraft rises from a horizon in one direction, travels in an arc across the sky and sets at a different horizon in a different direction. Each pass for each spacecraft is different. Antennas for receiving signals from spacecraft must thus be able to receive signals coming in from almost any angle.

Antennas in this context, fall into two categories, omnidirectional and rotatable. The simple turnstile antenna is horizontally polarized and has a good response to signals arriving from high angles and can be built for about \$2.00. The ground plane and J Pole antennas are vertically polarized and have a good response to signals arriving from low angles. These antennas however do not have much gain. Yagi Beam Antennas however have gain with respect to the turnstile or ground plane, but only in specific directions. You can think of the gain in some directions as being moved into the direction that the antenna is pointed at. The gain of the antenna depends on the number of elements in the antenna, and the higher the gain, the narrower the area of the gain (lobe) is. Consequently, these beam antennas must be moved to keep the spacecraft in the main lobe of the antenna. Since the need for keeping the antenna pointed at the spacecraft depends on the beam width of the antenna, the lower the gain of the antenna the less accurate the tracking need be. Luckily the orbits help out in this respect. UoSAT-OSCAR 11 in low earth orbit, which means it is fast moving, needs only a small amount of gain, so TV style rotators can be employed to point antennas with between 2 and 4 elements, while AMSAT-OSCAR 13 which is in an elliptical orbit, moves so slowly for nearly 8 of its 11 hour orbit, that again, TV style rotators can be used to point higher gain antennas with between 8 and 11 elements.

Building your own antennas is an easy and worthwhile project. Antennas for these OSCARS are simple and not very critical with respect to the materials used. They can in fact be built from recycled junk.

6.1.2 Receivers

There are two kinds of Receivers, namely FM and linear. FM receivers are used for reception of the FM signals from DOVE and UoSAT-OSCAR 11, while linear receivers are needed for reception of the FSK and PSK signals from the other spacecraft. All vhf/uhf scanner radios are FM receivers. The linear receivers need single side band (SSB) capability,

something normally found in short wave communication receivers. As a result of the growing popularity of amateur satellite communications, suitable vhf/uhf transmitter-receivers (transceivers) have been on the market for several years, however these transceivers are expensive listing in the \$800 to \$1200 range. An alternative approach to reception is to use a short wave communications receiver listing around \$500 together with a front end downconverter which lists at under \$100. The short wave radio can also be used to tune in, not only the world of amateur radio, but news broadcasts from overseas; a totally different are of classroom activity.

"Expensive" is a relative term. These days, many people think nothing of spending \$1000 on a stereo system or on equipment for photography or other hobbies.

6.1.3 Terminal Units or Modems

Digital radio links work much in the same way as digital signals are transferred over the telephone line. However in this case, instead of a phone wire, a radio link is used. Both links use modems to convert the serial input/output digital RS-232 signals of the computer to the audio tones used on the communications link.

Packet radio signals are demodulated by a radio modem known as a Terminal Node Controller (TNC). The device is connected in between the radio and the computer and provides hams with two way digital communications. A packet only TNC lists for between \$120 and \$200. For reception of the PSK signals from AMSAT-OSCAR 16, WEBER-OSCAR 18, LUSAT-OSCAR 19 and Fuji-OSCAR 20, PSK Modems are available either as add-ons to a regular TNC or as standalone units, listing between \$150 and \$700.

The BAUDOT Radio Teletypewriter (RTTY) signals from AMSAT-OSCAR 13 can be demodulated by an RTTY Terminal Unit. These devices are listed at between \$100 and \$300. On the other hand a multi-mode communications controller listing between \$250 and \$700 can be used for AMSAT-OSCAR 13 as well as DOVE and the other spacecraft. AMSAT-OSCAR 13 downlinks BAUDOT because that is the most commonly used digital communications mode used by radio amateurs at high frequencies (short waves)

The modem for UoSAT-OSCAR 11 is a little more difficult, as its ASCII encoding is the reverse of the standard used in the U.S.A. This is because the spacecraft was built in the UK and its use of tones to represent data reflects the encoding used in a popular tape interface (in the UK) at the time the spacecraft was built (1982- 1984). Still a do-it-yourself circuit needs a few integrated circuits, is simple to build, easy to test, and very low cost (under \$50).

Summarizing the costs of the items mentioned above, the list prices fall between a low and high cost depending on the amount you wish to pay. The summary is shown in Table 6-3. It should be noted that the high price items may not be better than the cheaper ones, particularly in the educational environment. This table is of course only a guide, since you will probably end up with something in between.

Table 6-3 Range of Equipment List Prices

Item	Low Price	High Price
Antenna	\$2.00	\$100.00
Receiver	\$100.00	\$1200.00
Radio Modem (TU/TNC)	\$150.00	\$700.00
Tracking Software	\$25.00	\$350.00
Telemetry Decoding Software	\$35.00	\$35.00

TOTAL	\$312.00	\$2385.00

Consider the equipment needed to receive signals from each of the spacecraft in turn.

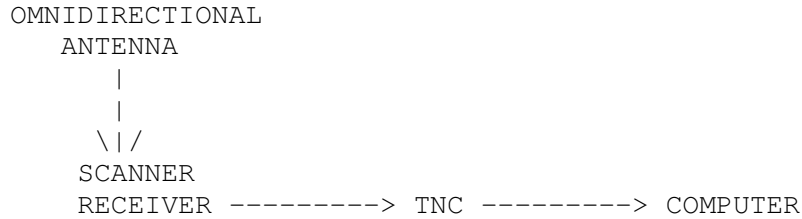
6.2 Receiving Signals from DOVE

DOVE (DO-17) which transmits on a frequency 145.825 MHz is the easiest spacecraft to receive usable signals from. This frequency is available on most hand held scanners, and signals are strong enough to be heard on nothing more than the simple antenna provided with the scanning radio when it is purchased. However, the thrill of receiving satellite signals wears off very quickly without any means to know what those signals mean.

A somewhat better system is needed for reliable regular reception of usable signals. A basic receiving system for DOVE is shown in Figure 6.1. DOVE's signals are strong enough that the ground station does not need a tracking antenna; an omnidirectional antenna is sufficient. The antenna can be a ground plane, a turnstile or a J-pole design. A preamplifier should be used to compensate for any losses in the cable between the antenna and the receiver, or any fades in the strength of the received signals. Any scanning radio which receives narrow band FM can be used as the receiver. This is the same type of modulation used on the public service channels. If the scanner can hear the police and other services and can tune to 145.825 MHz, then it is capable of receiving signals from DOVE. The digital signals from DOVE are encoded as audio tones and need a modem to convert them to the RS-232 digital signals that can be interfaced to the serial port of a PC. This type of

modem is known in Radio Amateur circles as a Terminal Unit (TU).

Figure 6.1 Basic Receiving System for DOVE-OSCAR 17.



The signals are sent as packets using a modified version of the X.25 protocol called AX.25. Radio Amateurs use this protocol for communications, and DOVE employs it for telemetry transmission purposes so that any Radio Amateur equipped for packet radio communications is also equipped for receiving signals from DOVE.

6.3 Receiving Signals from UoSAT-OSCAR 11

The same basic radio receiving system used to receive signals from DOVE can be used to copy the telemetry from UoSAT-OSCAR 11. This spacecraft however has a lower powered transmitter than that of DOVE and consequently has a weaker signal strength on the ground. This lower signal level, coupled with the fact that the modulation is plain ASCII data means that errors will be seen in the received data due to signal fades. Better antennas are needed for reliable reception, and antennas that track or move and always point at the spacecraft are desirable.

The TU used for UoSAT-OSCAR 11 is different to that used for DOVE due to the different data encoding (ASCII instead of AX.25).

6.4 Receiving Signals from AMSAT-OSCAR 13

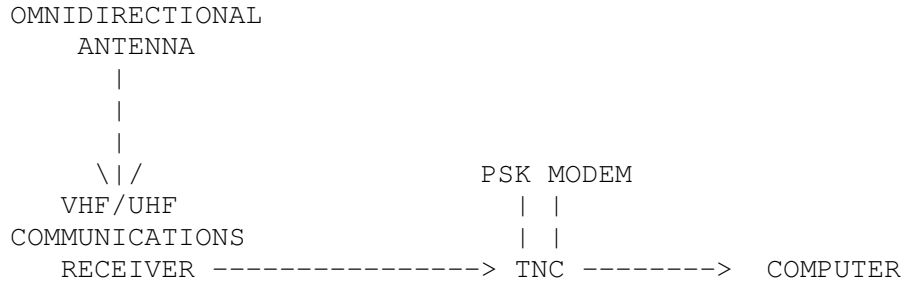
So far all the spacecraft considered have been low earth orbits. AMSAT-OSCAR 13 however is in an elliptical orbit with a high apogee. It also downlinks telemetry as BAUDOT and ASCII data. While signals from this spacecraft can be heard on the simple DOVE type of receiving configuration with an omnidirectional receiving antenna, the signals are weak and barely audible, i.e. they are in the noise and cannot be received in usable form without a tracking antenna.

6.5 Receiving PSK Modulated Signals in the 70 cm Band

Receiving signals from AMSAT-OSCAR 16, WEBER-OSCAR 18 and LUSAT-OSCAR 19 as well as from Fuji-OSCAR 20 requires somewhat more complex equipment. These spacecraft transmit

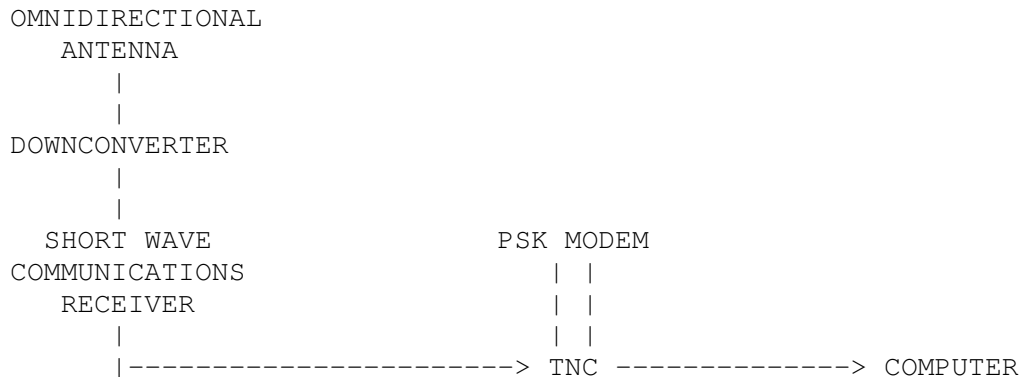
on downlink frequencies in the 70 cm or 430 MHz band. As they use PSK, the receiver has to be a conventional communications receiver. This can be either a communications receiver designed for that frequency range, or a conventional short wave receiver with a front end down converter. A PSK modem attached to the TU is also required. Typical receiving configurations for these satellites are shown in Figures 6-2 and 6-3.

Figure 6-2 Basic Receiving System for PSK Modulation.



The difference between the two approaches is that the first uses a communications receiver designed for the 70 cm band; the second approach uses a general short wave receiver and a front end down converter.

Figure 6-3 Alternate Basic Receiving System for PSK Modulation.



6.6 Receiving Signals from SARA-OSCAR 23.

To receive signals from SARA all you need is a 2 m FM radio. SARA downlinks on 145.955 MHz. Its signal is weaker than both UO-2 and DO-17. SARA's telemetry uses 300 baud ASCII wide shift. The tones it uses comply with the old Byte Magazine audio cassette data storage format. The modulation sense (1's and 0's) are compatible to UO-1 and are inverted with respect to UO-2. SARA's data can thus be demodulated on

an unmodified PK-232 as well as a UoSAT Modem, or even an old Byte audio tape interface. SARA transmits binary telemetry in a cycle that takes 2 minutes and 48 seconds. The sequence starts with an ASCII identification (as shown in the received example below) followed by many lines of binary data.

```
93162 NOISY LE GRAND CEDEX FRANCE
SATELLITE AMATEUR DE RADIOASTRONOMIE
ECOUTE DE L'ACTIVITE DECAMETRIQUE DE JUPITER
FX0SAT FX0SAT FX0SAT
CYCLE nxhw
```

All the telemetry relates to the Radio Astronomy Experiment and voltages and temperatures. The information for decoding and processing the telemetry should be published shortly.

Once the telemetry decoding information is published, you will have an opportunity to analyze and correlate the downlink data and perhaps discover something new. SARA, albeit a simple satellite, may have provided amateurs with a tool to make new discoveries in radio astronomy in the 2 to 15 MHz range of the spectrum.

Reception Reports of SARA are welcome and will be QSL'd as soon as possible. Send reports via the bureau to ON1KHP who is serving as SARA's QSL Manager, or direct to BELAMSAT (AMSAT-Belgium), c/o Patrick Hamptaux, Thier Des Critchions 2, B-4600-Chenee, Belgium.

7.0 Decoding Spacecraft Telemetry

Apart from UoSAT-OSCAR 11, WEBER-OSCAR 18 and SARA-OSCAR 23, none of the OSCAR spacecraft are designed for "Science" purposes. Their telemetry consists of spacecraft housekeeping parameters, monitoring on-board temperatures, voltages and currents. While much use can be made of these data, there isn't much real science data available. Even the scientific spacecraft are in the main unusable by the average listener because information about the scientific payload is not readily available. Let's make a start with these spacecraft, then look to a follow on activity. An OSCAR does not have to be a separate spacecraft. The Soviet Union has provided their amateurs with payload space aboard two of their weather satellites [8]. NASA could do the same for an amateur scientific spacecraft which would monitor radiation, the earth's magnetic field and solar activity; such data being of use to radio amateurs for predicting propagation and providing schools with data about the earth's environment. NASA has a 'Mission to Planet Earth' project to provide an Earth Observation Platform in 1997. An attached secondary payload to that platform, transmitting packetized scientific telemetry data (with well publicized formats) in the 145 MHz amateur band or in the 136 MHz scientific band could really bring not only the space program, but the educational and scientific use of space, into every

educational institution in the country. In the mean time, this section discusses the usable OSCAR spacecraft and their telemetry and the corresponding decoding equations.

The satellites have been built by different organizations at different times and each uses different data formats. SARA uses a 300 baud ASCII format. DOVE and Fuji-OSCAR 20 transmit in an ASCII Packet format, yet while DOVE transmits the data in Hexadecimal format, Fuji-OSCAR 20 uses Decimal Format. AMSAT-OSCAR 16, WEBER-OSCAR 18 and LUSAT-OSCAR 19 transmit their telemetry in pure binary format. By using packetization, the data quality is checked in the link itself and bad packets are not normally passed to the computer from the TNC. AMSAT-OSCAR 13 does not have any error checking at all, so it is up to the receiving station to visually inspect the data before trying to convert it to engineering units. UoSAT-OSCAR 11 also transmits its telemetry as ASCII text, but the designers of the spacecraft recognized that the downlink was prone to error and incorporated a checksum in its data format.

This section discusses the data formats and decoding equations associated with several of the OSCAR spacecraft.

7.1 DOVE (DOVE-OSCAR 17)

DOVE-OSCAR 17 was launched January 22, 1990. Its prime mission is to provide an easily received Digital Orbiting Voice Encoded beacon for educational and scientific use. Dr. Torres 'Junior' de Castro, PY2BJO sponsored the DOVE experiment. DOVE-OSCAR 17 is licensed in Brazil with the callsign PT2PAZ. DOVE-OSCAR 17 was built by AMSAT, occupies less than a cubic foot of space, masses 8.5 kg and contains a V40 microprocessor and 8 Megabytes of RAM. Essentially it is a loaded PC Clone in orbit. AMSAT-OSCAR 16, DOVE-OSCAR 17, WEBER-OSCAR 18 and LUSAT-OSCAR 19 are commonly known as Microsats and were constructed as a set by AMSAT during 1989. Each of the Microsats contains bar magnets which align them along the earth's magnetic field and is spun around that axis by photon pressure from the sun acting on the communication antennas which are painted white on one side and black on the other.

Unfortunately a combination of two on-board hardware failures and lack of available manpower in AMSAT (a volunteer organization for all practical purposes) have kept DOVE's voice off the air. At this time DOVE only transmits packet telemetry. DOVE-OSCAR 17 transmits telemetry in several different transfer packets as shown in Figure 7-1.

Figure 7-1 A typical example of a DOVE-OSCAR 17 Telemetry Frame.

```
23-Jan-91 02:49:23 DOVE-1*>TIME-1:
PHT: uptime is 173/00:36:26. Time is Wed Jan 23 02:47:30 1991
```

```
23-Jan-91 02:49:26 DOVE-1*>TLM:
```

```
00:59 01:59 02:87 03:31 04:59 05:5A 06:6E 07:52 08:6D 09:72 0A:A2
0B:DC 0C:E9 0D:D8 0E:02 0F:26 10:CC 11:A8 12:01 13:04 14:AD 15:94
16:98 17:94 18:96 19:98 1A:94 1B:91 1C:9B 1D:98 1E:25 1F:5F 20:BA
```

```
23-Jan-91 02:49:27 DOVE-1*>TLM:
21:95 22:82 23:24 24:1E 25:2A 26:01 27:02 28:02 29:01 2A:02 2B:02
2C:01 2D:29 2E:02 2F:9E 30:CA 31:9E 32:11 33:CE 34:C4 35:9A 36:A8
37:A6 38:B6
```

```
23-Jan-91 02:49:28 DOVE-1*>STATUS:
80 00 00 8F 00 18 CC 02 00 B0 00 00 0C 0E 3C 05 0B 00 04 04
```

```
23-Jan-91 02:49:28 DOVE-1*>LSTAT:
I P:0x3000 o:0 l:13081 f:13081, d:0
```

```
23-Jan-91 02:49:28 DOVE-1*>WASH:
wash addr:0680:0000, edac=0xd6
```

Telemetry data are transmitted in 57 (3A hex) channels in two segments in the TLM packets. The format is AA:BB where 'AA' is the hexadecimal channel number and 'BB' the hexadecimal value of the telemetry at the time it was sampled.

The telemetry decoding equations for DOVE are shown in Table 7.1-1. The Equations are in the form of a quadratic equation,

$$Y = A*N^2 + B*N + C$$

where: N = Telemetry Count (00 - FF);
A, B, C = Equation Coefficients;
Y = Result (In Specified Units).

Note N must be converted from hexadecimal to decimal units before performing the calculation. A sample decoded page is shown in Table 7.1-2.

Table 7.1-1 DOVE Telemetry Decoding Equations

Spacecraft: DOVE-1:

Rev: 1
Date: 1/7/90

HEX	Description:	C: ccccccccc	B: bbbbbbbbbbb	A: aaaaaaaaaaa	Units: uuuuuu
0	Rx E/F Audio (W)+0.000		+0.0246	0.000	V(p-p)
1	Rx E/F Audio (N)+0.000		+0.0246	0.000	V(p-p)
2	Mixer Bias V: +0.000		+0.0102	0.000	Volts
3	Osc. Bias V: +0.000		+0.0102	0.000	Volts
4	Rx A Audio (W):+0.000		+0.0246	0.000	V(p-p)
5	Rx A Audio (N):+0.000		+0.0246	0.000	V(p-p)
6	Rx A DISC: +10.427		-0.09274	0.000	kHz
7	Rx A S meter: +0.000		+1.000	0.000	Counts
8	Rx E/F DISC: +9.6234		-0.09911	0.000	kHz

9	Rx E/F S meter:	+0.000	+1.000	0.000	Counts
A	+5 Volt Bus:	+0.000	+0.0305	0.000	Volts
B	+5V Rx Current:	+0.000	+0.000100	0.000	Amps
C	+2.5V VREF:	+0.000	+0.0108	0.000	Volts
D	8.5V BUS:	+0.000	+0.0391	0.000	Volts
E	IR Detector:	+0.000	+1.000	0.000	Counts
F	LO Monitor I:	+0.000	+0.000037	0.000	Amps
10	+10V Bus:	+0.000	+0.05075	0.000	Volts
11	GASFET Bias I:	+0.000	+0.000026	0.000	Amps
12	Ground REF:	+0.000	+0.0100	0.000	Volts
13	+Z Array V:	+0.000	+0.1023	0.000	Volts
14	Rx Temp:	+101.05	-0.6051	0.000	Deg. C
15	+X (RX) temp:	+101.05	-0.6051	0.000	Deg. C
16	Bat 1 V:	+1.7932	-0.0034084	0.000	Volts
17	Bat 2 V:	+1.7978	-0.0035316	0.000	Volts
18	Bat 3 V:	+1.8046	-0.0035723	0.000	Volts
19	Bat 4 V:	+1.7782	-0.0034590	0.000	Volts
1A	Bat 5 V:	+1.8410	-0.0038355	0.000	Volts
1B	Bat 6 V:	+1.8381	-0.0038450	0.000	Volts
1C	Bat 7 V:	+1.8568	-0.0037757	0.000	Volts
1D	Bat 8 V:	+1.7868	-0.0034068	0.000	Volts
1E	Array V:	+7.205	+0.07200	0.000	Volts
1F	+5V Bus:	+1.932	+0.0312	0.000	Volts
20	+8.5V Bus:	+5.265	+0.0173	0.000	Volts
21	+10V Bus:	+7.469	+0.021765	0.000	Volts
22	BCR Set Point:	-8.762	+1.1590	0.000	Counts
23	BCR Load Cur:	-0.0871	+0.00698	0.000	Amps
24	+8.5V Bus Cur:	-0.00920	+0.001899	0.000	Amps
25	+5V Bus Cur:	+0.00502	+0.00431	0.000	Amps
26	-X Array Cur:	-0.01075	+0.00215	0.000	Amps
27	+X Array Cur:	-0.01349	+0.00270	0.000	Amps
28	-Y Array Cur:	-0.01196	+0.00239	0.000	Amps
29	+Y Array Cur:	-0.01141	+0.00228	0.000	Amps
2A	-Z Array Cur:	-0.01653	+0.00245	0.000	Amps
2B	+Z Array Cur:	-0.01137	+0.00228	0.000	Amps
2C	Ext Power Cur:	-0.02000	+0.00250	0.000	Amps
2D	BCR Input Cur:	+0.06122	+0.00317	0.000	Amps
2E	BCR Output Cur:	-0.01724	+0.00345	0.000	Amps
2F	Bat 1 Temp:	+101.05	-0.6051	0.000	Deg. C
30	Bat 2 Temp:	+101.05	-0.6051	0.000	Deg. C
31	Baseplt Temp:	+101.05	-0.6051	0.000	Deg. C
32	FM TX#1 RF OUT:	+0.0256	-0.000884	+0.0000836	Watts
33	FM TX#2 RF OUT:	-0.0027	+0.001257	+0.0000730	Watts
34	PSK TX HPA Temp:	+101.05	-0.6051	0.000	Deg. C
35	+Y Array Temp:	+101.05	-0.6051	0.000	Deg. C
36	RC PSK HPA Temp:	+101.05	-0.6051	0.000	Deg. C
37	RC PSK BP Temp:	+101.05	-0.6051	0.000	Deg. C
38	+Z Array Temp:	+101.05	-0.6051	0.000	Deg. C
39	S band TX Out:	-0.0451	+0.00403	0.000	Watts
3A	S band HPA Temp:	+101.05	-0.6051	0.000	Deg. C

Table 7.1-2 Sample Decoded (General Housekeeping) Page of DOVE Telemetry

PHT: uptime is 177/12:34:12. Time is Sun Jan 27 14:45:16 1991

-X Array Cur	: 0.174 A	Array V	:22.829 V
+X Array Cur	: 0.000 A	+Z Array V	:23.836 V
-Y Array Cur	: 0.000 A	Ext Power Cur	: 0.000 A
+Y Array Cur	: 0.000 A	BCR Input Cur	: 0.480 A
-Z Array Cur	: 0.000 A	BCR Output Cur	: 0.314 A
+Z Array Cur	: 0.251 A	BCR Set Point	: 119
IR Detector	: 56	BCR Load Cur	: 0.241 A
+Z Array Temp	: 3.0 C		
+Y Array Temp	: 4.8 C	Battery 1 V	: 1.330 V
		Battery 2 V	: 1.346 V
+2.5V VREF	: 2.506 V	Battery 3 V	: 1.337 V
Ground REF	: 0.020 V	Battery 4 V	: 1.325 V
		Battery 5 V	: 1.350 V
Bat 1 Temp	: 3.0 C	Battery 6 V	: 1.431 V
Bat 2 Temp	: -24.8 C	Battery 7 V	: 1.343 V
TX#1 RF OUT	: 0.0 W	Battery 8 V	: 1.344 V
TX#2 RF OUT	: 3.7 W		

The TIME-1 packets identify the time that the data were downlinked. The Uptime value in the time packet tells you how long the software has been running (since last upload).

The STATUS packets contain information about spacecraft on-board status. These bytes, have in the past, been changed by AMSAT without prior or post notification to the radio amateur community. The LSTAT packet contains engineering status information which has not been published other than that the last value "d:0" means the spacecraft is not set up as a digipeater.

The WASH packets provide engineering information about the on-board RAM memory.

7.2 UoSAT-OSCAR 11

UoSAT-OSCAR 11 which was launched March 1, 1984, is similar to and is a follow on to the now re-entered UoSAT-OSCAR 9. It was designed and built at the Department of Electronic and Electrical Engineering at the University of Surrey, England. It was built to develop scientific experimentation and space education. While much invaluable experience has been received by the UoSAT people, not much has been published in the general educational and radio amateur press about its on-board experiments and telemetry data formats. As such, apart from a small group of dedicated users, UoSAT-OSCAR 11 seems to have been ignored by the majority of radio amateurs and educational institutions.

UoSAT-OSCAR 11 carries four on-board experiments:- a Digital Communications Experiment, a Space Dust Experiment, a Charge Coupled Device (CCD) Video Camera Experiment and a Digitaltalker Experiment.

The Digital Communications Experiment demonstrated the concept of store-and-forward digital communications using spacecraft in low earth orbit. The Space Dust Experiment measures the impact of dust particles, and calculates the momentum of the particles. The CCD Video Camera Experiment takes pictures of the earth at a resolution of 384 x 256 pixels with 128 gray levels. This experiment does not seem to have returned any usable pictures. The Digitalker Experiment provides clear digitized voice using a fixed vocabulary and is switched on from time to time.

UoSAT-OSCAR 11 transmits a number of different types of telemetry. WHATS-UP can only decode and display the real-time telemetry. Should you tune in signals from UoSAT-OSCAR 11, you may get anything. Hang in there, sooner or later it will transmit real-time telemetry, if not on one pass, then on the next. The real-time telemetry is transmitted as 1200 baud ASCII data using FSK. The sense of the modulation is inverted with respect to convention due to the wide popularity of a BBC computer tape interface (which used the inverted modulation) in England at the time the spacecraft was built. This means that either a special modem has to be built to receive the data or the PK-232 has to be modified before it will copy signals from UoSAT-OSCAR 11. This modification is needed because the PK-232 RXR parameter does not work above 300 baud due to a hardware limitation. This modification performs the equivalent of the RXR operation in hardware by taking advantage of an unused inverter inside the PK-232.

What has to be done is to wire U15 pins 1 and 2 to a switch in series with the output to JP4. Adding a green LED to show the state of the switch (at a glance) is optional. The steps are as follows:

1. Drill a 1/4 inch hole in the front panel of the PK-232 above the red DCD LED.
2. Mount a Double Pole Double Throw (SPDT) switch on the front panel of the PK-232 where it will not interfere with other components (near the upper left corner by the AEA logo above the threshold control).
3. Carefully cut the circuit board trace connecting U15's pin 6 to the inside pin of JP4. This trace is easiest to cut where it comes out from under R20 on the top (component side) of the PC board. Be sure to double check that this is the correct trace with an ohm meter. Cut with care (with a sharp X-acto knife) so adjacent traces are not touched.
4. Solder a jumper wire between U15's pins 1 and 6.
5. Connect the center of one pole on this switch to the inner pin of JP4 or the trace that goes to it (which was cut to disconnect it from U15 pin 6).

6. Connect the corresponding switch contact which will be hardware "RXR OFF" to U15 pin 6.
7. Connect the corresponding switch contact which will be hardware "RXR ON" to U15 pin 2.
8. Mount a green LED on the front panel of the PK-232 above the red DCD LED.
9. Wire one leg of the LED to the other pole of the switch, the other end to a 1K ohm resistance (test the LED first to make sure you wire it the correct way).
10. Wire the other end of the resistance to +12V near the voltage regulator. Do not wire it to the battery backup voltage (if the LED stays lit when you turn the PK-232 off, you wired it wrongly).
11. Wire one side of the switch to ground so the green LED lights when the REVERSE position is selected.

To copy the UoSAT-OSCAR 11 FM AFSK ASCII Telemetry on 145.825 Mhz set the new hardware RXR switch in the "reverse" position. Be sure to return your RXR switch to "normal" when you want to return to regular operation, as this switch is in the signal path in all modes when the PK-232's internal modem is used.

A typical telemetry frame starts with a non printing ASCII character (1E hexadecimal) followed by the identification and date. The date code can be deciphered using the following YYMMDDWHMMSS format where YY is the last two digits of the year, MM, the month, DD, the day of the month, W, the day of the week (Sunday = 0), the remainder being hours, minutes and seconds. All times are given in UTC. A blank line follows, then follow seven lines worth of ten channels per line. The format of each line is as shown below.

NNDDDCNNDDDCNNDDDCNNDDDCNNDDDCNNDDDCNNDDDCNNDDDCNNDDDC

where NN is the channel number, DDD the data and C a checksum to validate the data. The checksum is needed because there is no error checking built into the link. Each channel thus comprises six digits. The checksum is computed for each channel by 'exclusive or'ing (XOR) each nibble (4 bits) of each of the 6 characters in that channel. A zero result means that the data was received correctly, a non-zero result means the data was corrupted. Figure 7.2-1 contains an example of the raw UoSAT-OSCAR 11 data showing some of the errors due to noise on the downlink.

Figure 7.2-1 Example of a Received Raw UoSAT-OSCAR 11 Telemetry Data Frame

```
00519D0141370267650361400404660503;4 6019E07045608040C08036C
10519C11298312000313056114069A15529A 6188 175452185905195058
20519F21220322662223000124001725000726093E27541528564D294681
30519E31041732287C33568B34007035217236276637393D38426B39455E
40649F41117242647343061044162545000146000247444748454949422x
50456251108D52634653284p54663215000056p00357451258447A59460E
60826A615FC1625F4A63334164440265160466174267700668000E69000F
UOSAT-2          9101281004625
```

7.3 AMSAT-OSCAR 13

AMSAT-OSCAR 13 which was launched June 15, 1988 was built as a joint venture between radio amateurs in the U.S.A. and in Germany organized as the Radio Amateur Satellite Corporation (AMSAT). AMSAT-OSCAR 13 is a spin stabilized long life long range radio amateur communications satellite which provides daily intercontinental communications capability for hours at a time. It contains a number of analog and digital transponders with communications links on several frequencies. An on-board computer based on the RCA 1802 microprocessor controls the spacecraft and generates the downlink telemetry. Schedules are published in the amateur radio press which provide information as to which transponder is active at any time during the orbit. AMSAT-OSCAR 13 also contains a motor which was used by radio amateurs to boost the spacecraft from the orbit the rocket placed it in into its operational orbit.

AMSAT-OSCAR 13 transmits telemetry in a number of ways on two beacons. The two meter beacon is on a frequency of 145.812 MHz and carries CW, 50 baud RTTY, and 400 baud PSK telemetry according to a published schedule. WHATS-UP can only decode and display the 50 baud RTTY telemetry which is transmitted in the form of Z blocks shown in Table 7.3-1. The block is identified as a 'Z' block by the letter 'Z' before the words "HI. THIS IS AMSAT OSCAR 13" which identify the spacecraft.

The block starts with the letter 'Z' in the first line. Time and status information follows, then the first telemetry channel begins several lines down and is shown with the value of 193. Six lines of telemetry, each line containing ten values are transmitted, with a blank line separating the two halves. Following the telemetry lines, the spacecraft may transmit plain text information of general interest. Although the Z block only contains 60 channels, the equations for decoding all 128 of the telemetry channels are presented in Table 7-3.2 in which the Channel Numbers are shown in Hexadecimal.

The Bytes in the block are identified in the followings ways:

- C - unsigned count (0 to +255)
- Cs - signed count (-128 to +127, 2s complement)

Cx - signed count (+63 to -192, #3F=+63, #FF=-1, #80=-128,
#7F=-129, #40=-192, modified 2s complement)

All temperature channels are decoded identically using the equation $T = (C-120)/1.71$ (in Degrees Centigrade). All channels measuring currents use a linear equation with different calibrations constants. Three equations are used providing maximum current values of 1A, 2.5A and 5A, as follows:

1A: $I = (C-15)*4.854 \text{ mA}$
2.5A: $I = (C-15)*12.135\text{mA}$
5A: $I = (C-15)*24.27 \text{ mA}$

Table 7.3-1 AMSAT-OSCAR 13 RTTY Telemetry Block

```
Z  HI. THIS IS AMSAT OSCAR 13
    05.02.54  8661
.0086  .0000  .07B9

64  6   0   1   16  218 1

193 170 158 143 181 144 147 140 200 7
147 7   7   7   165 29  100 7   149 7
10  7   145 115 34  7   153 129 122 180

152 73  7   145 137 55  7   183 136 151
7   154 137 169 211 142 127 100 9   140
161 7   173 149 150 154 14  131 127 210
HI THIS IS AMSAT OSCAR 13 08SEP90
NEW AO13 SCHEDULE FROM 17OCT90 AFTER MOVE TO LON 180  LAT 0
MODE B  MA 000 TO 095
MODE JL MA 095 TO 125
MODE LS MA 125 TO 130
MODE S  MA 130 TO 135
MODE BS MA 135 TO MA 140
MODE B  MA 140 TO 256
```

Table 7.3-2 AMSAT-OSCAR 13 Telemetry Decoding Equations

#	Label	Equation	Remarks
00	Uin-BCR	$U = (C-10) * 167\text{mV}$	U-Panel: +0.6V @ 0.35A +0.7V @ 1A
01	Tx-PWRout-L	Average power = $(261-C)^2 / 724 \text{ Watts}$	rectified envelope voltage.
02	T-Rx-U	Temp	Mode-B receiver temperature.
03	---		
04	Uout-BCR	$U = (C-10) * 79.5\text{mV}$	BCR output voltage.
05	---		
06	T-TX-U	Temp	Mode-B transmitter temperature.
07	I-14V-ST	5A	Transponder separation bus.
08	U-10V-C	$U = (C-10) * 53.2\text{mV}$	Computer supply

09	Press He-Hi	off	Helium tank pressure.
0A	T-IHU	Temp	Integrated Housekeeping Unit
0B	I-14V-S	1A	Separation bus, 14V that Supplies torquer and LIU.
0C	BCR-Oscill1	>~6=OK	BCR status. No count = not working. Typically C=80.
0D	Press He-Lo	off	Helium regulator output.
0E	T-BCR	Temp	Battery Charge Regulator.
0F	I-10V-C	1A	10V continuous power supply.
10	BCR-Oscill2	As channel 0C	
11	Press Tank	off	N2O4 tank pressure.
12	T-SEU	Temp	Sensor Electronics Unit
13	IbatCharge	2.5A	Positive Current to battery.
14	L-Sensor (A)	$U = (C-10) * 8.53mV$	Light-Sensor Antenna Side.
15	Motor Valve	off	
16	T-ABAT1	Temp	Auxiliary battery 1
17	I-BCR-OUT	5A	14V line to battery and other consumers.
18	L-Sensor (M)	$U = (C-10) * 8.53mV$	Light-Sensor Motor Side.
19	---		
1A	T-ABAT2	Temp	Auxiliary battery 2
1B	I-BCR-IN	Equivalent to total current of all panels, not available due to sensor failure.	
1C	Spin rate	$C > 131$, Spin rate = $479 / (C-109) - 2$ rpm $C \leq 131$, Spin rate = $(131-C) * 0.85 + 20$ rpm Sensor angular position oscillator. Lock indication channel #47.	
1D	Rx-L-AGC	$\text{Gain reduction} = (C-75)^2 / 1125$ dB	
1E	T-MBAT	Temp	Mean battery (normally in use)
1F	I-Panel6	1A	Solar panel 6
20	Tx-PWRout-U	$\text{Average power} = (287-C)^2 / 1796$ Watts As channel 01.	
21	T-He-Tank	Temp	
22	T-Panel1	Temp	
23	I-Panel5	1A	
24	Rx-U-AGC	$\text{Gain reduction} = (C-71)^2 / 2465$ dB	
25	T-Tx-L	Temp	Mode-JL transmitter.
26	T-Panel3	Temp	
27	I-Panel4	1A	
28	---		
29	T-Rx-L	Temp	Mode-L receiver.
2A	T-Panel5	Temp	
2B	I-Panel3	1A	
2C	U-14V-ST	$U = (C-10) * 66.8mV$	Transponder separation bus.
2D	T-RUDAK	Temp	RUDAK temperature.
2E	T-top	Temp	Arm 1, Antenna side.
2F	I-Panel2	1A	
30	U-9V-U	$U = (C-10) * 54mV$	Internal 9 volt bus from Mode-B transponder.
31	T-wall-arm2	Temp	
32	T-bottom	Temp	Arm 1, Motor side.
33	I-Panel1	1A	

```

34  ---
35  T-wall-arm1      Temp
36  T-N2O4           Temp
37  ---
38  U-ABAT           U=(C-10)*78.5mV  Auxiliary battery.
39  T-S-xpnder       Temp             Mode-S transponder.
3A  T-L-Sensor       Temp             Light sensor antenna side.
3B  ---
3C  U-9V-L          U=(C-10)*45.4mV  As channel 30, Mode-L
3D  T-AZ50-Tank      Temp
3E  T-nutation damper Temp           Arm 3.
3F  ---
.cp10
40  ES-Sensitivity 2MUX0              Earth Sensor sensitivity
                                     threshold.
                                     bit  significance
                                     0 LSB  20mV
                                     1      37mV      Hysteresis 200mV
                                     2      75mV      Threshold  600mV
                                     3      150mV
                                     4      300mV
                                     5      600mV
                                     6      1.2V
                                     7 MSB  2.4V

41  Antenna/SERI    2MUX1              Antenna relays and SERI
                                     resistors.
                                     bit  significance
                                     0 LSB  Hi-gain  2m  to U
                                     1      Hi-gain 70cm to L
                                     2      --+ SERI-1  load resistor for
                                     3      -+! SERI-2  both Light-Sensors
                                     !! resistance
                                     00  7.5 Ohm
                                     01  3.9 Ohm
                                     10  2.3 Ohm
                                     11  5.9 Ohm

42  RUDAK-Status    2MUX2              IN-B (ex Motor-PWR).
                                     C=82, Standard-ROS (S)
                                     C=78, Emergency-ROS (N, Not-ROS)
                                     C=80, Primitive-ROS (P)

43  S&RUDAK-CNTL    2MUX3              Mode-S and RUDAK interface.
                                     bit  significance
                                     0 LSB  RUDAK OFF
                                     1      "    NMI/
                                     2      "    Byte Clock
                                     3      "    Byte count reset
                                     4      ---
                                     5      Mode-S Beacon ON
                                     6      "    Squelch defeated
                                     7 MSB  "    Squelch Hi Sensitivity

```

44	BCR-Sin	2MUX4	Array voltage offset. U=29.1+(Cs*100)mV (16.3V...41.8V)
45	BCR-Sout	2MUX5	Battery knee voltage offset. U=14.98+(Cx*20)mV (11.14...16.2V = 192...63)
46	BCR-relays	2MUX6	
		bit	significance
		0 LSB	BCR-2 ON
		1	Auxiliary battery charging
		2	Auxiliary battery connected, Main battery disconnected.
47	SS-1	C=255 or C=0, PLL locked	Sun-Sensor angular position oscillator, Slit antenna side.
48	SS-2	Time offset from SS-1	
49	Flag-SS	C=1, SS-1	Sun sensor data.
		C=2, SS-2	
4A	SPIN-RAW		Raw spin count (1/256).

.lm27

4B	Sensor-control	bit	significance (OUT4)
		0 LSB	--+ MUX-CTRL for sensor elec. module
		1	--+!
			!!
			00 - Sun data
			01 - spin ref./spin counter
			10 - ES lower beam
			11 - ES upper beam
		2	Earth sensor positive edge select. (Strobes value of spin count at transition.)
		3	Motor Instrumentation ON. (Pressure sensors, motor valve indicator.)
		4	0.3V Sun Sensor Sensitivity
		5	0.6V " " "
		6	1.2V " " "
		7 MSB	2.4V " " "
			(Max. threshold #F = 1 solar constant)

4C	SS-correction		
4D	Last ES-A	Z	last ES-pulse Antenna side.
4E	"	O#	(Orbit number and MA value)
4F	Last ES-M	Z	last ES-pulse Motor side.
50	"	O#	(Orbit number and MA value)
.lm21			
51	Lockoutrange		Within +- C counts from sun sensor pip, earth sensor handler ignores data (Spin count 1 circle = 256 counts.)
52	ES-A		Strobed spin count at edge selected, Antenna Side beam.
53	Update Flag1		Indicates update, Antenna Side beam.
54	ES-M		As channel 52 Motor Side beam.

```

55  Update Flag2      As channel 53      "      "      "
56  S/C STATUS        bit  significance
                        0 LSB LIU power ON
                        1    S/A plug status 0=Safe, 1=Arm
                        2    RUDAK-out (lock)
                        3    Mode-S Squelch open
                        4    ---
                        5    Memory Soft error Counter
                        6    "      "      "
                        7 MSB  "      "      "

57  ---
58  ---
59  ---
5A  ---
5B  N                 no of 20ms per dot, morse speed.
5C  n                 running count of units for morse.
5D  ---
5E  TRANSPONDER       bit  significance (OUT7)
                        0 LSB GB OFF
                        1    GB FSK (1=+170Hz)
                        2    DPSK OFF
                        3    EB ON
                        4    --+ PSK source
                        5    -+! for GB (EB: don't care)
                           !!
                           00 - no PSK
                           01 - ranging
                           10 - EB source
                        6    Low power transponder ON
                        7 MSB Passband OFF (Beacons and Mode-J +3dB)

5F  ---
60  MODUS             bit  significance (magnet control)
                        0    magnet system ON
                        1    underspin magnet
61  M-Soll            magnet vector desired angle to the despun sun
                        (clockwise as seen from top, 1 circle = 256)
62  M-Out             bit significance (OUT3, also L,S,J control)
                        0 LSB polarity Arm 1
                        1    polarity Arm 2
                        2    polarity Arm 3
                        3    Magnet power ON
                        4    Mode-J ON
                        5    ---
                        6    Mode-S ON
                        7 MSB Mode-L ON
63  O-FRAC-lo         Fractional Z increment in 20ms
64  O-FRAC-hi         Counts down to 0 from preset
                        value. 255th Z has different
                        value of O-FRAC. ~7000
                        counts/Z.

65  O/256             Z from perigee
66  O#-lo             Orbit number
67  O#-hi
68  UHR               10ms      UTC

```


69		sec	
6A		min	
6B		hour	
6C		day	1st January 1978 = AMSAT day 0.
6D		256day	
6E	SU0	10ms	IPS stopwatch 0.
6F		sec	
70		min	
71		min*256	
72	SU1	10ms	IPS stopwatch 1.
73		sec	
74		min	
75		min*256	
76	SU2	10ms	IPS stopwatch 2.
77		sec	
78		min	
79		min*256	
7A	SU3	10ms	IPS stopwatch 3.
7B		sec	
7C		min	
7D		min*256	
7E	Event-Lo		Used as event ID word in
7F	Event-Hi		intermediate buffer.

7.4 AMSAT-OSCAR 16, WEBER-OSCAR 18 and LUSAT-OSCAR 19

AMSAT-OSCAR 16, WEBER-OSCAR 18 and LUSAT-OSCAR 19 were launched January 22, 1990 together with DOVE-OSCAR 17. AMSAT-OSCAR 16 and LUSAT-OSCAR 19 are designed to provide a platform for experiments with digital store-and-forward communications techniques as a follow-on to the Digital Communications Experiment of UoSAT-OSCAR 11. LUSAT-OSCAR 19 is sponsored by AMSAT in Argentina. WEBER-OSCAR 18 is an engineering project of the Center for Aerospace Studies at Weber State University in Utah. It has the capability for digital communications but is not used as such. It contains an on-board video camera which has returned pictures of the earth using a non standard format picture transmission format. WEBER-OSCAR 18 also carries a number of experiments. The Spectrometer experiment is designed to observe the spectrum of sunlight reflected off the earth's atmosphere and surface. The Particle Impact Detector is a piezoelectrical crystal mounted on the side of the spacecraft which produces an output voltage each time a microparticle impact occurs. The Magnetometer Experiment contains two orthogonal flux gate magnetometers. As they were not calibrated they can only provide information about relative changes in the magnetic environment of the spacecraft. As in the case of UoSAT-OSCAR 11, data about the experiments and their telemetry calibrations is lacking in the general amateur radio press.

These spacecraft downlink telemetry in the 437MHz band similar to that of DOVE but using a BINARY format in an unpublished and apparently "changeable at any time without notice" sequence.

WHATS-UP intercepts the binary telemetry and converts it to a pseudo DOVE format as shown in Table 7.4-1 before decoding and displaying the information. The decoding equations first published by AMSAT in The AMSAT Journal are given in Tables 7.4-2, 7.4-3 and 7.4-4.

Table 7.4-1 Example of Pseudo DOVE Display of Intercepted Binary Telemetry and other intercepted Microsat Packets

27-Jan-91 17:04:22 LUSAT-1*>AMARG:
Jan 23, 1600Z.

AART driver loaded.
Reload will continue in a short time

73, LU7XAC
AMARG Control Team

27-Jan-91 16:41:50 PACSAT-1*>TIME-1:
PHT: uptime is 004/10:14:01. Time is Sun Jan 27 16:40:51 1991

27-Jan-91 16:41:54 PACSAT-1*>AMSAT:
Jan 22, 8:03 UTC - Reload in progress. Digi on. No BBS till the weekend.
NK6K

27-Jan-91 16:41:54 PACSAT-1*>LSTAT:
I P:0x3000 o:0 l:13884 f:13884, d:1 st:0
27-Jan-91 16:42:48 N8ITP>PACSAT-1*>N8ITP [C]
27-Jan-91 16:42:50 N8ITP>PACSAT-1*>N8ITP (UA)
27-Jan-91 16:42:55 N8ITP>PACSAT-1*>N8ITP:
test1122334455

27-Jan-91 17:04:22 LUSAT-1*>BCRXMT:
vmax=762169 battop=766771 temp=218292

27-Jan-91 17:06:31 LUSAT-1*>LSTAT:
I P:0x3000 o:0 l:13417 f:13417, d:0 st:2

27-Jan-91 17:06:38 LUSAT-1*>TIME-1:
PHT: uptime is 005/14:48:41. Time is Sun Jan 27 17:05:33 1991

27-Jan-91 17:06:41 LUSAT-1*>TLM:
00:DC 01:0E 02:30 03:0F 04:3A 05:10 06:DE 07:11 08:84 09:12
0A:00 0B:13 0C:E4 0D:14 0E:A9 0F:15 10:A8 11:16 12:6C 13:17
14:64 15:18 16:69 17:19 18:69 19:1A 1A:66 1B:1B 1C:6D 1D:1C
1E:5F 1F:1D 20:62 21:1E 22:D9 23:1F 24:62 25:20 26:BA 27:21
28:B0 29:22 2A:79 2B:23 2C:2C 2D:24 2E:24 2F:25 30:28 31:00

14-Feb-91 03:02:48 N4HY>LUSAT-1*>N4HY [D]
14-Feb-91 03:02:49 N4HY>LUSAT-1*>N4HY (UA)
14-Feb-91 03:03:09 LUSAT-1*>COMLUS:
COMMAND 9 ACK

14-Feb-91 03:06:51 LUSAT-1*>STATUS:
31 34 2D 46 65 62

Table 7.4.2 AMSAT-OSCAR 16 Telemetry Decoding Equations

Spacecraft: PACSAT-1:

Rev:

Date: 7/25/91

Equations are in the form: $Y = A \cdot N^2 + B \cdot N + C$

where:

N = Telemetry Count (00 - FF)

A, B, C = Equation Coefficients

Y = Result (In Specified Units)

HEX	Description:	C: ccccccccc	B: bbbbbbbbb	A: aaaaaaaaa	Units: uuuuuu
0	Rx D DISC:	+9.202	-0.08990	0.000	kHz
1	Rx D S meter:	+0.000	+1.000	0.000	Counts
2	Rx C DISC:	+9.179	-0.09277	0.000	kHz
3	Rx C S meter:	+0.000	+1.000	0.000	Counts
4	Rx B DISC:	+9.837	-0.08838	0.000	kHz
5	Rx B S meter:	+0.000	+1.000	0.000	Counts
6	Rx A DISC:	+9.779	-0.09144	0.000	kHz
7	Rx A S meter:	+0.000	+1.000	0.000	Counts
8	Rx E/F DISC:	+10.817	-0.09911	0.000	kHz
9	Rx E/F S meter:	+0.000	+1.000	0.000	Counts
A	+5 Volt Bus:	+0.000	+0.0305	0.000	Volts
B	+5V Rx Current:	+0.000	+0.000250	0.000	Amps
C	+2.5V VREF:	+0.000	+0.0108	0.000	Volts
D	+8.5V Bus:	+0.000	+0.0391	0.000	Volts
E	IR Detector:	+0.000	+1.000	0.000	Counts
F	LO Monitor I:	+0.000	+0.000037	0.000	Amps
10	+10V Bus:	+0.000	+0.0500	0.000	Volts
11	GASFET Bias I:	+0.000	+0.000026	0.000	Amps
12	Ground REF:	+0.000	+0.0100	0.000	Volts
13	+Z Array V:	+0.000	+0.1023	0.000	Volts
14	Rx Temp:	+101.05	-0.6051	0.000	Deg. C
15	+X (RX) temp:	+101.05	-0.6051	0.000	Deg. C
16	Bat 1 V:	+1.8225	-0.0038046	0.000	Volts
17	Bat 2 V:	+1.9418	-0.0046890	0.000	Volts
18	Bat 3 V:	+1.8699	-0.0041641	0.000	Volts
19	Bat 4 V:	+1.7403	-0.0032880	0.000	Volts
1A	Bat 5 V:	+1.8792	-0.0042492	0.000	Volts
1B	Bat 6 V:	+2.0499	-0.0054532	0.000	Volts
1C	Bat 7 V:	+1.9062	-0.0045331	0.000	Volts
1D	Bat 8 V:	+1.7536	-0.0033192	0.000	Volts
1E	Array V:	+8.055	+0.06790	0.000	Volts
1F*	+5V Bus:	+2.864583	4.090715E-2	-1.930042E-4	Volts
20*	+8.5V Bus:	+7.720951	+8.25979E-3	-1.76254E-5	Volts
21*	+10V Bus:	+8.882535	+1.39771E-2	0.000	Volts
22	BCR Set Point:	-6.1130	+1.1270	0.000	Counts
23	BCR Load Cur:	-0.0477	+0.00767	0.000	Amps
24	+8.5V Bus Cur:	-0.00179	+0.000894	0.000	Amps
25	+5V Bus Cur:	-0.00104	+0.00406	0.000	Amps

26	-X Array Cur:	-0.00995	+0.00243	0.000	Amps
27	+X Array Cur:	-0.02370	+0.00254	0.000	Amps
28	-Y Array Cur:	-0.02220	+0.00273	0.000	Amps
29	+Y Array Cur:	-0.01810	+0.00259	0.000	Amps
2A	-Z Array Cur:	-0.02230	+0.00221	0.000	Amps
2B	+Z Array Cur:	-0.02000	+0.00232	0.000	Amps
2C	Ext Power Cur:	-0.02000	+0.00250	0.000	Amps
2D*	BCR Input Cur:	-2.103334E-2	+3.382738E-3	0.000	Amps
2E*	BCR Output Cur:	-7.146611E-3	-5.247935E-5	4.878499E-5	Amps
2F	Bat 1 Temp:	+101.05	-0.6051	0.000	Deg. C
30	Bat 2 Temp:	+101.05	-0.6051	0.000	Deg. C
31	Baseplt Temp:	+101.05	-0.6051	0.000	Deg. C
32	PSK TX RF Out:	-0.0291	+0.00361	+0.0000869	Watts
33	RC PSK TX Out:	+0.0055	+0.00172	+0.0001180	Watts
34	PSK TX HPA Temp:	+101.05	-0.6051	0.000	Deg. C
35	+Y Array Temp:	+101.05	-0.6051	0.000	Deg. C
36	RC PSK HPA Temp:	+101.05	-0.6051	0.000	Deg. C
37	RC PSK BP Temp:	+101.05	-0.6051	0.000	Deg. C
38	+Z Array Temp:	+101.05	-0.6051	0.000	Deg. C
39	S band HPA Temp:	0.00	1.0000	0.000	Counts
3A	S band TX Out:	-0.0088	+0.00435	0.000	Watts

* Revised in this release

Table 7.4.3 WEBER-OSCAR 18 Telemetry Decoding Equations

Spacecraft: WEBER-1:

Rev: 1

Date: 1/7/90

Equations are in the form: $Y = A \cdot N^2 + B \cdot N + C$

where:

N = Telemetry Count (00 - FF)

A, B, C = Equation Coefficients

Y = Result (In Specified Units)

HEX	Description:	C: ccccccccc	B: bbbbbbbbb	A: aaaaaaaaa	Units: uuuuuu
0	Rx D DISC:	+11.087	-0.08949	0.000	kHz
1	Rx D S meter:	+0.000	+1.000	0.000	Counts
2	Rx C DISC:	+10.322	-0.09448	0.000	kHz
3	Rx C S meter:	+0.000	+1.000	0.000	Counts
4	Rx B DISC:	+10.348	-0.09004	0.000	kHz
5	Rx B S meter:	+0.000	+1.000	0.000	Counts
6	Rx A DISC:	+11.387	-0.09535	0.000	kHz
7	Rx A S meter:	+0.000	+1.000	0.000	Counts
8	Rx E/F DISC:	+10.746	-0.09348	0.000	kHz
9	Rx E/F S meter:	+0.000	+1.000	0.000	Counts
A	+5 Volt Bus:	+0.000	+0.03523	0.000	Volts
B	+5V Rx Current:	+0.000	+0.000234	0.000	Amps
C	+2.5V VREF:	+0.000	+0.0133	0.000	Volts
D	8.5V BUS:	+0.000	+0.0524	0.000	Volts
E	IR Detector:	+0.000	+1.000	0.000	Counts
F	LO Monitor I:	+0.000	+0.000033	0.000	Amps
10	+10V Bus:	+0.000	+0.0767	0.000	Volts
11	GASFET Bias I:	+0.000	+0.000026	0.000	Amps
12	Ground REF:	+0.000	+0.0100	0.000	Volts
13	+Z Array V:	+0.000	+0.1023	0.000	Volts
14	Rx Temp:	+100.01	-0.5980	0.000	Deg. C
15	+X (RX) Temp:	+100.01	-0.5980	0.000	Deg. C
16	Bat 1 V:	+1.8292	-0.0037196	0.000	Volts
17	Bat 2 V:	+1.8202	-0.0036943	0.000	Volts
18	Bat 3 V:	+1.8050	-0.0036721	0.000	Volts
19	Bat 4 V:	+1.8576	-0.0038979	0.000	Volts
1A	Bat 5 V:	+1.8095	-0.0037439	0.000	Volts
1B	Bat 6 V:	+1.8979	-0.0041754	0.000	Volts
1C	Bat 7 V:	+1.8246	-0.0038126	0.000	Volts
1D	Bat 8 V:	+1.7486	-0.0030475	0.000	Volts
1E	Array V:	+7.800	+0.06790	0.000	Volts
1F	+5V Bus:	+1.838	+0.0312	0.000	Volts
20	+8.5V Bus:	+5.793	+0.0184	0.000	Volts
21	+10V Bus:	+7.650	+0.0250	0.000	Volts
22	BCR Set Point:	-6.1963	+1.1277	0.000	Counts
23	BCR Load Cur:	-0.0405	+0.00620	0.000	Amps
24	+8.5V Bus Cur:	+0.00384	+0.000830	0.000	Amps
25	+5V Bus Cur:	-0.00763	+0.00394	0.000	Amps

26	-X Array Cur:	-0.00140	+0.00210	0.000	Amps
27	+X Array Cur:	+0.00946	+0.00226	0.000	Amps
28	-Y Array Cur:	-0.01018	+0.00224	0.000	Amps
29	+Y Array Cur:	-0.01168	+0.00239	0.000	Amps
2A	-Z Array Cur:	-0.01516	+0.00237	0.000	Amps
2B	+Z Array Cur:	-0.02111	+0.00239	0.000	Amps
2C	Ext Power Cur:	-0.02000	+0.00250	0.000	Amps
2D	BCR Input Cur:	-0.02189	+0.00332	0.000	Amps
2E	BCR Output Cur:	-0.03019	+0.00327	0.000	Amps
2F	Bat 1 Temp:	+100.01	-0.5980	0.000	Deg. C
30	Bat 2 Temp:	+100.01	-0.5980	0.000	Deg. C
31	Baseplate Temp:	+100.01	-0.5980	0.000	Deg. C
32	PSK TX RF Out:	+0.2104	-0.01203	+0.0001786	Watts
33	RC PSK TX Out:	+0.0340	-0.00969	+0.0002198	Watts
34	PSK TX HPA Temp:	+100.01	-0.5980	0.000	Deg. C
35	+Y Array Temp:	+100.01	-0.5980	0.000	Deg. C
36	RC PSK HPA Temp:	+100.01	-0.5980	0.000	Deg. C
37	RC PSK BP Temp:	+100.01	-0.5980	0.000	Deg. C
38	+Z Array Temp:	+0.0000	+1.0000	0.000	Counts

Table 7.4.5 LUSAT-OSCAR 19 Packet Telemetry Decoding Equations

Spacecraft: LUSAT-1:

Rev: 1

Date: 1/7/90

Equations are in the form: $Y = A*N^2 + B*N + C$

where:

N = Telemetry Count (00 - FF)

A, B, C = Equation Coefficients

Y = Result (In Specified Units)

HEX	Description:	C: ccccccccc	B: bbbbbbbbb	A: aaaaaaaaa	Units: uuuuuu
0	Rx D DISC:	+9.802	-0.08779	0.000	kHz
1	Rx D S meter:	+0.000	+1.000	0.000	Counts
2	Rx C DISC:	+8.429	-0.09102	0.000	kHz
3	Rx C S meter:	+0.000	+1.000	0.000	Counts
4	Rx B DISC:	+9.291	-0.08317	0.000	kHz
5	Rx B S meter:	+0.000	+1.000	0.000	Counts
6	Rx A DISC:	+9.752	-0.08310	0.000	kHz
7	Rx A S meter:	+0.000	+1.000	0.000	Counts
8	Rx E/F DISC:	+10.110	-0.08610	0.000	kHz
9	Rx E/F S meter:	+0.000	+1.000	0.000	Counts
A	+5 Volt Bus:	+0.000	+0.0305	0.000	Volts
B	+5V Rx Current:	+0.000	+0.000250	0.000	Amps
C	+2.5V VREF:	+0.000	+0.0108	0.000	Volts
D	8.5V BUS:	+0.000	+0.0391	0.000	Volts
E	IR Detector:	+0.000	+1.000	0.000	Counts
F	LO Monitor I:	+0.000	+0.000037	0.000	Amps
10	+10V Bus:	+0.000	+0.0508	0.000	Volts
11	GASFET Bias I:	+0.000	+0.000026	0.000	Amps
12	Ground REF:	+0.000	+0.0100	0.000	Volts
13	+Z Array V:	+0.000	+0.1023	0.000	Volts
14	Rx Temp:	+93.24	-0.5609	0.000	Deg. C
15	+X (RX) Temp:	+93.24	-0.5609	0.000	Deg. C
16	Bat 1 V:	+1.7343	-0.0029740	0.000	Volts
17	Bat 2 V:	+1.7512	-0.0032113	0.000	Volts
18	Bat 3 V:	+1.7790	-0.0034038	0.000	Volts
19	Bat 4 V:	+1.7286	-0.0030036	0.000	Volts
1A	Bat 5 V:	+1.8114	-0.0036960	0.000	Volts
1B	Bat 6 V:	+1.7547	-0.0032712	0.000	Volts
1C	Bat 7 V:	+1.7151	-0.0030739	0.000	Volts
1D	Bat 8 V:	+1.6846	-0.0028534	0.000	Volts
1E	Array V:	+8.100	+0.06790	0.000	Volts
1F	+5V Bus:	+2.035	+0.0312	0.000	Volts
20	+8.5V Bus:	+5.614	+0.0184	0.000	Volts
21	+10V Bus:	+7.650	+0.0250	0.000	Volts
22	BCR Set Point:	+3.7928	+1.0616	0.000	Counts
23	BCR Load Cur:	-0.0244	+0.00628	0.000	Amps
24	+8.5V Bus Cur:	+0.00412	+0.000773	0.000	Amps
25	+5V Bus Cur:	+0.02461	+0.00438	0.000	Amps
26	+X Array Cur:	-0.01614	+0.00232	0.000	Amps
27	-X Array Cur:	-0.01158	+0.00238	0.000	Amps

28	-Y Array Cur:	+0.00278	+0.00206	0.000	Amps
29	+Y Array Cur:	+0.00136	+0.00218	0.000	Amps
2A	-Z Array Cur:	+0.00370	+0.00209	0.000	Amps
2B	+Z Array Cur:	-0.00793	+0.00216	0.000	Amps
2C	Ext Power Cur:	-0.02000	+0.00250	0.000	Amps
2D	BCR Input Cur:	-0.00901	+0.00283	0.000	Amps
2E	BCR Output Cur:	+0.00663	+0.00344	0.000	Amps
2F	Bat 1 Temp:	+93.24	-0.5609	0.000	Deg. C
30	Bat 2 Temp:	+93.24	-0.5609	0.000	Deg. C
31	Baseplt Temp:	+93.24	-0.5609	0.000	Deg. C
32	PSK TX RF Out:	+0.1059	+0.00095	+0.0000834	Watts
33	RC PSK TX Out:	+0.0178	+0.00135	+0.0000833	Watts
34	PSK TX HPA Temp:	+93.24	-0.5609	0.000	Deg. C
35	+Y Array Temp:	+93.24	-0.5609	0.000	Deg. C
36	RC PSK HPA Temp:	+93.24	-0.5609	0.000	Deg. C
37	RC PSK BP Temp:	+93.24	-0.5609	0.000	Deg. C
38	+Z Array Temp:	+93.24	-0.5609	0.000	Deg. C
39	LU Bcn Temp A:	+93.24	-0.5609	0.000	* Deg. C
3A	LU Bcn Temp D:	+93.24	-0.5609	0.000	** Deg. C
3B	Coax Rly Stat:	+0.000	+1.0000	0.000	Counts
3C	Coax Rly Stat:	+0.000	+1.0000	0.000	Counts

* Note 1: Thermistor located near box center adjacent to LU thermistor channel no. 5.

** Note 2: Thermistor located near -X face of box on the experiment baseplate.

LUSAT-OSCAR 19 also transmits 8 channels of CW telemetry, at 12 W.P.M. with reduced morse code (to save about 44% power). The format of the telemetry is:

E LUSAT HI HI NL 111 222 333 444 555 666 777 888

where:

E is a calibration point to measure the output power.

NL:N is the EPROM version number. There are 7 copies of the program in the EPROM, to prevent crashes or hang ups due to degradation effects. The on board computer automatically loads a valid version, and N indicates which version was loaded.

L is the result of an internal RAM memory test by the 6805 microprocessor. If L=0, the RAM is "OK". If L=E, an Error was detected.

The telemetry decoding equations for the LUSAT-OSCAR 19 CW are shown in Table 7.4.6.

Table 7.4.6 LUSAT-OSCAR 19 CW Telemetry Decoding Equations

CH# 1 = N1 +5 Reg Volts :	$636/N1$	(Volts)
CH# 2 = N2 +10 Volts Battery	$0.064*N2$	(Volts)

CH# 3 = N3 CW TX Temperature 0.354(134.7-N3) (Deg. C)
 CH# 4 = N4 CW TX Power Output (10.9+N)^2/40.1 (Watts)
 CH# 5 = N5 Temp. BOX No. 4 0.356(136-N5) (Deg. C)
 CH# 6 = N6 +10 V Current 0.7*N6 (mAmps.)
 CH# 7 = N7 Panel +Z Volts 0.15*N7 (Volts)
 CH# 8 = N8 Reg. +8.5 Volts 0.056*N8 (Volts)

A typical example of a CW telemetry frame is shown below.

E LUSAT HI HI 10 128 167 042 162 040 148 045 156

decoding it, We have: E LUSAT HI HI

NL = 10 : N=1 (first version) ; L=0 (Memory 6805 RAM "OK")

N1=128: 636/128 = + 4.97 V. REG.
 N2=167: 0.064*167 = +10.69 V. BATTERY
 N3=042: 0.354(134.7-042) = 32.81 Deg. C
 N4=162: (10.9+162)^2/40.1= 745.5 mW.
 N5=040: 0.356(136-040) = 34.17 Deg. C
 N6=148: 0.7*148 = 103.6 mA. (over 10 V)
 N7=045: 0.15*045 = + 6.75 V. +Z
 N8=156: 0.056*156 = + 8.736 V. REG.

NOTE: the reduced cw code is USED ONLY for the numeric data, and AFTER the "HI HI" as in the following example.

L	U	S	A	T	H	I	H	I	1	0
.--	--	---

1: .-	(A)	6: -....	(6)
2: ..-	(U)	7: -...	(B)
3: ...-	(V)	8: -..	(D)
4:-	(4)	9: -.	(N)
5: .	(E)	0: -	(T)

7.5 Fuji-OSCAR 20

Fuji-OSCAR 20 which was launched on February 7, 1990 is a communications satellite in low earth orbit providing simultaneous analog and digital communications capability. Fuji-OSCAR 20 was built in Japan for Japanese radio amateurs and is the second Japanese built OSCAR.

On February 7 1990, the National Space Development Agency of Japan (NASDA) put the Marine Observation Satellite (MOS) 1b into orbit. The launch vehicle also carried two secondary payloads, Fuji-OSCAR 20 and the Deployable Boom and Umbrella Test (DEBUT) spacecraft which is similar in shape and weight to Fuji-OSCAR 20.

MOS-1b was placed into a circular polar orbit, then DEBUT and Fuji-OSCAR 20 separated from the launch vehicle at 0233, above Santiago, Chile. First signals from the spacecraft were received in Tokyo around 0309 UTC.

Fuji-OSCAR 20 is similar in construction to Fuji-OSCAR 12. In fact, much of it was originally constructed as a backup to Fuji-OSCAR 12 and designated as JAS-1B. It has since been modified and improved as a result of the lessons learned during the flight of Fuji-OSCAR 12. Fuji-OSCAR 12 was known as Fuji-1 in Japan, so this spacecraft is known by the Japanese as Fuji-2 and as Fuji-OSCAR 20 by the rest of the world.

Fuji-OSCAR 20's planned service life is 5 years. It is in a sunsynchronous elliptical polar orbit, having a perigee of about 900 km and an apogee of about 1740 at an inclination of 99 degrees. The Period of the orbit is about 105 minutes. This orbit is optimal for MOS-1b which is to study oceanographic resources and observe agricultural environmental conditions. In this orbit, the spacecraft passes over a given line of latitude at approximately the same time each day. In this orbit, the spacecraft is shielded from the sun by the earth for about 33% of the time. This eclipse means that the solar cells can only provide power for about 70 minutes in each orbit and that the on-board nickel cadmium storage batteries have to power the spacecraft for the remaining 35 minutes.

Fuji-OSCAR 20 weighs about 50 kg. and is a polyhedron shaped spacecraft 440mm in diameter and 470mm in height covered by approximately 1500 gallium arsenide solar cells which provide about 11 Watts of power to keep the 11 series-connected NiCad cells (rectangular) with a capacity of 6 AH charged. There are 26 sides to the polyhedron which almost makes it spherical for all practical purposes other than sticking solar cells to it. Fuji-OSCAR 12 was the same shape but only carried about 600 cells. This larger number of cells means that Fuji-OSCAR 20 has a positive power budget and should not need to be switched off to recharge.

The Power supply converts the raw bus voltage of +11 to +18 V (+14 V average) to the three regulated voltages (+10 V, +5 V, -5 V) used by the rest of the satellite with an efficiency greater than 70%.

The attitude of the satellite is maintained by using the torque generated by the interaction of two permanent magnets with the earth's magnetic field. This is a fairly conventional technique used in the OSCAR series. Temperature stability is achieved by using thermal insulation.

Fuji-OSCAR 20 carries two Mode J transponders, both of which may be operational at the same time. One transponder is analog (Mode JA), the other is digital (Mode JD).

The frequencies and capabilities of the analog transponder are similar to those of Fuji-OSCAR 12. It consists of an inverted heterodyne linear translator with a passband 100 kHz wide, operating with a mode J Uplink passband of 145.9 to 146.00

MHz, and a corresponding Downlink Passband of 435.9 to 435.8 MHz. The spacecraft has a Transmitter Output of approximately 1 watt. A ground station needs an Uplink EIRP of about 100 W to communicate through the transponder. The JA telemetry beacon is on the nominal frequency of 435.795 MHz with a power output of about 100 mW and can use CW or PSK modulation. Fuji-OSCAR 20 is using the callsign 8J1JBS and the beacons transmit telemetry in the same manner as Fuji-OSCAR 12.

The digital transponder provides store-and-forward packet communication using AX.25 link level protocol, version 2. Stations who used Fuji-OSCAR 12 are able to use Fuji-OSCAR 20 without making any modifications to their equipment. The uplink requires Bi-phased Manchester code on an FM signal, at a bit rate of 1200 bps. There are four Uplink Frequencies: 145.85 MHz, 145.87 MHz, 145.89 MHz, 145.91 MHz. The necessary ground station Uplink EIRP is also about 100 W. The transponder has an output power of about 1 W on a downlink frequency of 435.91 MHz and uses NRZI PSK at 1200 bps. The same PSK modem used to copy Fuji-OSCAR 12 or the Microsats is needed to copy Fuji-OSCAR 20. The downlink channel also carries packet telemetry.

The 144 MHz receiving antenna is a ring turnstile mounted at the bottom of the side panels. The 435 MHz transmitting antenna is a turnstile antenna mounted at the top of satellite. Both antennas are circularly polarized. Ground tests have shown that the transmitting antenna is more omnidirectional than that of Fuji-OSCAR 12, however due to the structure of the hybrid circuitry which allow both transponders to share the same antenna, the sense of the circular polarization on the downlink is different for each mode. As the apparent polarization is different depending on the geometry between the spacecraft and the groundstation, you will probably have to change between left hand and right hand circular polarization during a pass. The spacecraft is designed so that you can usually keep the uplink and downlink polarization the same.

Mode JA has provided strong transatlantic signals and many CW and SSB QSOs. Mode-JD was switched on for the first time during Orbit #95. To Digipeat via Fuji-OSCAR 20 you don't need to use a digipeater call. With the present version of the software, all AX.25 frames with a valid CRC heard by the spacecraft will be digipeated.

The spacecraft also carries a BBS which is accessed by means of the same commands used to access a terrestrial WA7MBL/W0RLI/AA4RE type of BBS. You access the BBS by connecting to 8J1JBS on any of the four uplink channels. When you do connect to it, make sure that you disconnect before LOS because Fuji-OSCAR 20 only allows 16 simultaneous connections. Stations that hang in there after the satellite drops below their local horizon block access by other stations and have been christened 'Zombies'. The BBS program is a modified version of the BBS program written for Fuji-OSCAR 12 and allows the use of 4 banks (1Mbyte) of memory. A

typical list of messages copied by KI6QE is shown in Figure 7.5-1.

Figure 7.5-1 Typical Message Listing from the BBS
(copied by KI6QE)

```
Fuji-OSCAR 20/JAS1b Mailbox ver. 2.00
commands [B/F/H/M/R/U/W]
Use H command for Help
JAS>JAS>NO.  DATE    UTC      FROM      TO        SUBJECT
0086 04/13 05:15   WB6GFJ    W6SHP     Welcome
0085 04/13 05:14   WB6LLO    KI6QE     SOFTWARE
0084 04/13 05:14   WB6GFJ    W9FMW     Our Chat
0082 04/13 03:38   W9FMW     WA4EJR    MESSAGE ON CIS
0080 04/13 03:36   KG6EX     N1GCR     From Ashley
0078 04/13 03:32   KG6EX     KD8SI     From Ashley
0077 04/13 03:31   KG6EX     N8AM      From Ashley
0076 04/13 03:30   KG6EX     DD4YR     From Ashley
0075 04/13 03:27   KG6EX     DL1CR     From Ashley
0074 04/13 03:25   KG6EX     G3RUH     From Ashley
-----
```

The spacecraft telemetry is transmitted either as CW or as PSK. The CW telemetry monitors 12 analog data points and 33 status points, the PSK telemetry monitors 29 analog data points and 33 status points. Telemetry data from Fuji-OSCAR 20 is transmitted on both the mode JA and JD beacons. Mode JA sends data by Morse code on the beacon signal of 435.795 MHz, repeating one frame every one minute. Mode JD sends a telemetry packet every 2 seconds on the digital downlink channel of 435.91 MHz when the telemetry mode is operating, otherwise, one frame is downlinked every one minute. The spacecraft can downlink up to 30 items of data and 31 items of status in the telemetry. The Mode JA beacon however only carries 12 data elements and most of status bytes.

Mode JA Telemetry Data

The Mode JA beacon transmits the telemetry data in the format shown below. These data are sent by Morse code with a "HI HI" at the beginning of each frame, with a speed of about 100 characters every minute, and always in this format repeatedly.

```
HI  HI  1A  1B  1C  1D
      2A  2B  2C  2D
      3A  3B  3C  3D
      4A  4B  4C  4D
      5A  5B  5C  5D
```

The number identifies the group, the letters A through D are decimal values expressed in two digits. Let this two-digit be N, for each item, true value or engineering value is obtained by decoding N as shown below. For example, a value of 123 for 1A means group 1 and 23 is the measured value of the solar array

current. Groups 4 and 5 contain status information about the bird, where A, B, C and D represent octal two-digit combinations of 00 through 37. This corresponds to a combination of five binary digits. Each bit shows status of each designated item in the order from MSB (Most Significant Bit) to LSB (Least Significant Bit). The decoding equations for the CW Mode JA telemetry are shown in Figure 7.5.2.

Figure 7.5-2 Fuji-OSCAR 20 Mode JA Telemetry Conversion Equations

CH	DESCRIPTION	CALIBRATION	UNITS
1A	total solar array current	$19 \times (N+0.4)$	mA
1B	battery charge/discharge current	$-38 \times (N-50)$	mA
1C	battery voltage	$(N+4) \times 0.22$	V
1D	center tap voltage of battery	$(N+4) \times 0.1$	V
2A	bus voltage	$(N+4) \times 0.2$	V
2B	+5 V regulator voltage	$(N+4) \times 0.062$	V
2C	JTA output power	$2.0 \times (N+4)^{1.618}$	mW
2D	calibration voltage	$(N+4)/50$	V
3A	battery temperature	$1.4 \times (67-N)$	deg. C
3B	baseplate temperature #1	$1.4 \times (67-N)$	deg. C
3C	baseplate temperature #2	$1.4 \times (67-N)$	deg. C
3D	baseplate temperature #3	$1.4 \times (67-N)$	deg. C

The status byte conversions are shown in Figure 7.5-3. This method is used because all items whose status is represented in this manner only have two possible situations, either ON or OFF, or binary values 0 or 1. For example, if the first item of status 4A were 423, the 4 identifies group 4, and the 23 should be thought of as its equivalent binary code (10011). This shows the status in the order of MSB to LSB, or bit 4 to bit 0. Using the decoding data 423 can be decoded as follows.

```

1: Beacon is PSK,
0: Engineering data #2 is blank,
0: Engineering data #1 is blank,
1: JTD power is ON,
1: JTA power is ON.
```

Figure 7.5-3 Fuji-OSCAR 20 Mode JA System Status Bytes

CH	BIT	DESCRIPTION	STATE	
			1	0
4A	0	JTA power	ON	OFF
4A	1	JTD power	ON	OFF
4A	2	Eng. data #1	---	---
4A	3	Eng. data #3	---	---
4A	4	Beacon	PSK	CW
4B	0	UVC	ON	OFF
4B	1	UVC level	1	2

4B	2	Battery	tric	full
4B	3	Battery logic	tric	full
4B	4	Main relay	ON	OFF
4C	0	PCU	bit 1 (LSB)	
4C	1	PCU	bit 2 (LSB)	
4C	2	PCU	manual	auto
4C	3	Eng. data #3	---	---
4C	4	Eng. data #4	---	---
4D	0	Memory bank #0	ON	OFF
4D	1	Memory bank #1	ON	OFF
4D	2	Memory bank #2	ON	OFF
4D	3	Memory bank #3	ON	OFF
4D	4	Computer power	ON	OFF
5A	0	Memory select	bit 1 (LSB)	
5A	1	Memory select	bit 2 (MSB)	
5A	2	Eng. data #5	---	---
5A	3	Eng. data #6	---	---
5A	4	Eng. data #7	---	---
5B	0	Solar panel #1	lit	dark
5B	1	Solar panel #2	lit	dark
5B	2	Solar panel #3	lit	dark
5B	3	Solar panel #4	lit	dark
5B	4	Solar panel #5	lit	dark
5C	0	JTA CW beacon	CPU	TLM
5C	1	Eng. data #8	---	---
5C	2	Eng. data #9	---	---
5C	3	Eng. data #10	---	---
5C	4	Eng. data #11	---	---
5D	0	Eng. data #12	---	---
5D	1	Eng. data #13	---	---
5D	2	Eng. data #14	---	---
5D	3	Eng. data #15	---	---
5D	4	Eng. data #16	---	---

Telemetry data are downlinked on Mode JD by means of packets. These data are transmitted the ASCII format shown in Figure 7.5-4. In the ASCII telemetry (RA and RB) XXX is a 3 digit decimal number with a range between 000 to 999. This number represents the value of N in Table 5 for channels denoted #00 - #26.

Figure 7.5-5 contains the equations for converting the received data into engineering values. The YYY bytes are three hexadecimal bytes of system status data, denoted #27a - #29c and can be decoded as shown in Figure 7.5-6. The SSS byte in the last row are binary status data, denoted #30a - #39c. Figure 7.5-7 provides the information needed to decode them in a manner similar to the Mode JA status points shown in Figure 7.5-3.

Figure 7.5-4. Fuji-OSCAR 20 Mode JD PSK telemetry data format

```
JAS-1b FF YY/MM/DD HH:MM:SS
XXX XXX XXX XXX XXX XXX XXX XXX XXX
XXX XXX XXX XXX XXX XXX XXX XXX XXX
XXX XXX XXX XXX XXX XXX XXX YYY YYY YYY
SSS SSS SSS SSS SSS SSS SSS SSS SSS
```

where, FF is the Frame Identifier, which may contain the following types:

```
RA: Realtime telemetry, - ASCII
RB: Realtime telemetry, - Binary
SA: Stored telemetry, - ASCII
SB: Stored telemetry, - Binary
M0: Message #0
M1: Message #1
.....
M9: Message #9
```

YY/MM/DD is year/month/day, and HH:MM:SS is hour/minute/second, all in UTC.

Figure 7.5-5. Fuji-OSCAR 20 Mode JD Telemetry Decoding Equations

CH	DESCRIPTION	CALIBRATION/UNITS
#00	total solar array current	$1.91 \times (N-4) \text{ mA}$
#01	battery charge/discharge	$-3.81 \times (N-508) \text{ mA}$
#02	battery voltage	$N \times 0.022 \text{ V}$
#03	battery center voltage	$N \times 0.009961 \text{ V}$
#04	bus voltage	$N \times 0.02021 \text{ V}$
#05	+5 V regulator voltage	$N \times 0.00620 \text{ V}$
#06	-5 V regulator voltage	$-N \times 0.00620 \text{ V}$
#07	+ 10 V regulator voltage	$N \times 0.0126 \text{ V}$
#08	JTA output power	$5.1 \times (N-158) \text{ mW}$
#09	JTD output power	$5.4 \times (N-116) \text{ mW}$
#10	calibration voltage #2	$N/500 \text{ V}$
#11	offset voltage #1	$N/500 \text{ V}$
#12	battery temperature	$0.139 \times (669-N) \text{ deg. C}$
#13	JTD temperature	$0.139 \times (669-N) \text{ deg. C}$
#14	Baseplate Temperature #1	$0.139 \times (669-N) \text{ deg. C}$
#15	Baseplate Temperature #2	$0.139 \times (669-N) \text{ deg. C}$
#16	Baseplate Temperature #3	$0.139 \times (669-N) \text{ deg. C}$
#17	Baseplate Temperature #4	$0.139 \times (669-N) \text{ deg. C}$
#18	temperature calibration #1	$N/500 \text{ V}$
#19	offset voltage #2	$N/500 \text{ V}$
#20	Solar Cell Panel Temp #1	$0.38 \times (N-685) \text{ deg. C}$
#21	Solar Cell Panel Temp #2	$0.38 \times (N-643)$
#22	Solar Cell Panel Temp #3	$0.38 \times (N-646)$
#23	Solar Cell Panel Temp #4	$0.38 \times (N-647)$
#24	-----	
#25	temperature calibration #2	$N/500 \text{ V}$
#26	temperature calibration #3	$N/500 \text{ V}$

Figure 7.5-6. Fuji-OSCAR 20 Mode JD HEX System Status Bytes

CH	DESCRIPTION
#27a	Spare (TBD)
#27b	Spare (TBD)
#27c	Spare (TBD)
#28a	Spare (TBD)
#28b	Spare (TBD)
#28c	error count of memory unit #0
#29a	error count of memory unit #1
#29b	error count of memory unit #2
#29c	error count of memory unit #3

Figure 7.5-7. Fuji-OSCAR 20 Mode JD BINARY System Status Bytes.

CH	DESCRIPTION	STATE	
		1	0
#30a	JTA power	on	off
#30b	JTD power	on	off
#30c	JTA beacon	PSK	CW
#31a	UVC status	on	off
#31b	UVC level	1	2
#31c	main relay	on	off
#32a	engineering data #1	-----	
#32b	battery status	tric	full
#32c	battery logic	tric	full
#33a	engineering data #2	-----	
#33b	PCU status	bit 1 (LSB)	
#33c	PCU status	bit 2 (MSB)	
#34a	memory unit #0	on	off
#34b	memory unit #1	on	off
#34c	memory unit #2	on	off
#35a	memory unit	on	off
#35b	memory select	bit 1 (LSB)	
#35c	memory select	bit 2 (MSB)	
#36a	engineering data #3	-----	
#36b	engineering data #4	-----	
#36c	computer power	on	off
#37a	engineering data #5	-----	
#37b	solar panel #1	lit	dark
#37c	solar panel #2	lit	dark
#38a	solar panel #3	lit	dark
#38b	solar panel #4	lit	dark
#38c	solar panel #5	lit	dark
#39a	engineering data #6	-----	
#39b	CW beacon source	CPU	TLM
#39c	engineering data #7	-----	

A typical set of raw PSK telemetry packets are those captured by

KI6QE and shown in Figure 7.5-8. A typical decoded and display page from WHATS-UP is shown in Figure 7.5-9 for a different set of raw data.

Figure 7.5-8 Fuji-OSCAR 20 PSK telemetry (as copied by KI6QE)

```

03-Apr-90 17:40:32 8J1JBS*>BEACON:
JAS1b RA 90/04/03 17:45:18
554 433 700 686 757 837 841 823 398 666
617 001 503 516 526 523 526 523 654 000
683 675 685 684 999 643 875 316 002 000
110 111 000 000 100 000 001 011 111 000

03-Apr-90 17:40:34 8J1JBS*>BEACON:
JAS1b RA 90/04/03 17:45:20
566 427 699 705 746 837 841 824 541 659
617 001 503 516 526 523 526 523 654 000
683 675 686 683 999 642 874 316 002 000
110 111 000 000 100 000 001 011 111 000

```

Figure 7.5-9 Sample Decoded Display (General Housekeeping) Page from Fuji-OSCAR 20.

```

JAS1b RA 91/01/13 00:40:58

Solar Panel Temp #1: 15.20 Deg.C Total Array Current:1105.89 mA
Solar Panel Temp #2: 31.92 Deg.C Battery Charge      : 102.87 mA
Solar Panel Temp #3: 32.68 Deg.C Battery Voltage     : 14.806 V
Solar Panel Temp #4: 29.64 Deg.C Battery Center      : 6.744 V
Baseplate Temp. #1 : 40.73 Deg.C Bus Voltage         : 17.259 V
Baseplate Temp. #2 : 41.42 Deg.C +5 V Regulator      : 5.214 V
Baseplate Temp. #3 : 40.87 Deg.C -5 V Regulator      : 0.000 V
Baseplate Temp. #4 : 41.14 Deg.C +10 V Regulator     : 10.471 V
Temperature Cal. #1: 1.30 V Offset Voltage #1       : 0.000 V
Temperature Cal. #2: 1.29 V Offset Voltage #2       : 0.000 V
Temperature Cal. #3: 1.75 V Calibration Volt #2: 1.230 V
Battery Temp.      : 45.04 Deg.C JTA TX Output Power: 0.46 W
JTD Temperature    : 42.12 Deg.C JTD TX Output Power: 3.52 W

```

7.6 AMSAT-OSCAR 21 (RM-1)

AMSAT-OSCAR 21 (AO-21) was launched in February January 1991 from the North Cosmodrome at Plesetsk. The orbit is a slightly elliptical polar orbit with an apogee of 1000 km at an inclination of 83 degrees. The period of the orbit will be 105 minutes.

AMSAT-OSCAR 21 is the first international OSCAR in which radio amateurs from the Soviet Union took part. RM1 stands for "RADIO M-1", which is the official prelaunch name of AMSAT-OSCAR 21, emphasizes that the spacecraft was built by, and for, Radio Amateurs around the world.

The idea of a joint effort between the two groups, one in the USSR and the second, in Germany first appeared in the spring 1989. The discussions about what and how things had to be done lasted till the meeting of the representatives of the two groups in Surrey in July 1989 when the preliminary agreement about the cooperation was signed. The final version of the cooperation agreement was later signed in the autumn of 1989 after much of the work had been completed.

According to the mutual agreement, Amsat-U-Orbita developed and made the linear transponder, command radio link, telemetry system, power supply system and decided all the problems with the official and other government organizations about the location of the equipment and launching.

The RUDAK group of AMSAT-DL developed and built the digital part, called RUDAK-2 which contains a digipeater and an AX.25 mailbox. It also provides other possibilities for experiments in transmitting of information using modern digital methods. It also contains its own RF input and output circuits.

The ground command station was developed by the Amsat-U-Orbita and Amsat-U-Sputnik groups. The Rudak group however provided some special digital part for it.

During the launch and orbital test period ground, the command stations will be UC1CWA situated in Molodechno and RK3KP in Moscow. The ground command stations for Rudak-2 only will be situated near Munich at DK1YQ and near Hanover, at DB2OS. The final agreement was signed on behalf of Amsat-U-Orbita by the technical director of project "RADIO-M1" - V.Chepyzhenko, RC2CA; and on behalf of AMSAT-DL, by their president, K. Meinzer, DJ4ZC. The Project Manager for the RUDAK-2 is Hanspeter Kuhlen, DK1YQ. The coordinators for the project are P. Guelzow, DB2OS and L. Labutin, UA3CR.

AMSAT-OSCAR 21 is an attached secondary payload (Piggy-back) aboard a USSR geological research satellite which provides a Mode B communications transponder in low earth orbit as well as an orbiting experimental digital communications capacity.

The AMSAT-OSCAR 21 Specifications are as listed below.

Dimension and shape: Cylinder of height about 4 meters and diameter 1.8 meters

System configuration: Professional geological research equipment, telemetry system, command link equipment, transponders and power supply, thermal control. Amateur linear and digital transponders, telemetry system, command link equipment, power supply.

Attitude control: Satellite attitude will be maintained using a gravity gradient approach in the form of a rod 9

meters long pointing away from the earth.

Planned service life: 3 years.

Two sets of the equipment are installed aboard the satellite: Linear transponder #1 is Mode B and contains the RUDAK-2 and other subsystems, while Linear transponder #2 mode B with subsystems. The Primary transponder is Linear Transponder #1, the second one is a spare which can be put into operation in the event of a failure of the primary system. Mode B in low earth orbit provides a very good communications link as anyone who worked AMSAT-OSCAR 7 Mode B will testify.

The Transponder RF Frequency Assignments and Beacon Data for the Primary Payloads are shown in Table 7-6.1, and those for the Backup payload in Table 7.6-2. The 1100 bps is not a misprint, it is real. Apparently this data rate is used by a popular PC tape cassette interface in the Soviet Union. Because this PC is simple and cheap for the Hams in the USSR, the AMSAT-U-Orbita team decided to use it on this spacecraft, much in a similar manner to the use of reversed AFSK tones in UoSAT-OSCAR 11 due to the wide availability of a popular interface for those tones in the United Kingdom. It is unclear as of the time of writing this, if the telemetry is HDLC or some proprietary synchronous PSK such as the 400 baud AMSAT-OSCAR 13 downlink. As such you may not be able to copy this telemetry.

Table 7.6-1 Primary Payload

Beacons and telemetry #1

CW telemetry 8 channels	145.822 MHz 0.2 Watts
Digital telemetry	30 channels 145.952 MHz 0.4 Watts
	1100 bps, BPSK/FM, deviation 2kHz
Digital telemetry	
Rudak-2	145.983 MHz 3.0 Watts
	BPSK 1200 bps AX.25 (like F-O 20)

Transponders #1

Linear transponder:	inversely heterodyned translator
Uplink passband	435.102 to 435.022 MHz
Downlink passband	145.852 to 145.932 MHz
Transmitter output max.	10 Watts
Bandwidth (3db)	80 kHz
Uplink EIRP required	about 100 Watts

Digital transponder Rudak-2: digipeater and store&forward packet communication (AX.25), telecommunications experiment with digital signal processing up to nearly 20 kHz, 1 MByte RAM disc, four separate uplink channels.

Uplink frequencies:

RX-1 435.016 MHz 1200bps, FSK, NRZIC/Biphase-M

RX-2 435.155 MHz (AFC) 2400 bps,BPSK, Biphase-S
RX-3a 435.193 MHz (AFC) 4800 bps,RSM
RX-3b 435.193 MHz (AFC) 9600 bps,RSM
RX-4 435.041 MHz (digital AFC) RX for RTX-DSP

Downlink frequency: 145.983 MHz 3 Watts

The downlink can be switched to the following operating modes:

Mode 1: 1200 bps, BPSK, NRZI, (NRZ-S) (like FO-20)
Mode 2: 400 bps, BPSK, Biphase-S (Like AO-13 beacon)
Mode 3: 2400 bps, BPSK, Biphase-S
Mode 4: 4800 bps, RSM, NRZIC (Biphase-M) (like 4800 bps uplink)
Mode 5: 9600 bps, RSM, NRZI (NRZ-S) +Scrambler (like 9600 bps uplink)
Mode 6: CW keying (only for special events)
Mode 7: FSK (F1 or F2B),e.g. RTTY, SSTV, FAX, etc.(for special events)
Mode 8: FM modulated by D/A signals from DSP-RISC processor (speech)

Table 7.6-2 Secondary Payload

Beacons and Telemetry #2

CW telemetry 8 channels	145.948 MHz 0.2 Watts
Digital telemetry 30 channels	145.838 MHz 0.4 Watts 1100 bps,
BPSK/FM, deviation 2kHz	
Digital telemetry 30 channels	145.800 MHz 2.0 Watts 1100 bps
BPSK/FM, deviation 2kHz	

Transponder #2

Linear transponder: inversely heterodyned translator
Uplink passband 435.123 to 435.043 MHz
Downlink frequencies 145.866 to 145.946 MHz
Transmitter output max. 10 Watt max.
Bandwidth (3db) 80 kHz
Uplink EIRP required about 100 Watts

The spacecraft uses two antennas. The 435 MHz receiving antenna which is shared by the analog and digital modes is a Helix with up to +3 db gain using Right Hand circular Polarization. The 145 MHz transmitting antenna is a Half wave dipole. AMSAT-OSCAR 21 draws up to 100 Watts from the main spacecraft's power supply system. The Primary RM-1 payload including the RUDAK draw up to 47 Watts, the secondary payload draws up to 40 Watts. The Primary AMSAT-OSCAR 21 payload including the RUDAK weighs approximately 28 kg, the secondary payload weighs approximately 22 kg. Both payloads are about 480x400x300 mm³.

The CW telemetry started up as soon as the combined spacecraft separated from the launch vehicle and was powered by main satellite power system. A CW Morse-Code telemetry frame consists

of the call RS14 and 8 channels of four digits in the following format:

RS14 S0AB=S1AB=S2AB=S3AB=S4AB=S5AB=S6AB=S7AB

Channels 0 to 6 contain analog telemetry data. Channel 7 contains engineering calibration parameters.

The first digit (S) identifies which system the telemetry is from. A prefix of 7 identifies a general status, a prefix of 5 identifies a command status. The second digit (0 to 7) are the numbers of the line (channel). The remaining digits (A and B) are the analog telemetry data which can be decoded according to the equations shown in Table 7.6-3.

Table 7.6-3 AMSAT-OSCAR 21 CW Telemetry decoding parameters

Channel	Parameter	Formula	Unit
0	Transponder power output	$0.05 * N$	Watts
1	Transponder PA Temperature	N	Deg. C
2	+24 V Regulated	N	Volt
3	+16 V Regulated	N	Volt
4	+9 V Regulated	N	Volt
5	+24 V Regulated	N	Volt
6	Inside Temperature	N	Deg. C
7	Engineering Value	N	*

A typical frame such as

"RS14=7080=7137=7224=7316=7409=5524=5032=57PPRS14" may be decoded as shown below.

```

RS14
7080 - 4 Watts    - general
7137 - 37 Deg. C - general
7224 - 24 Volts   - general
7316 - 16 Volts   - general
7409 - 9 Volts    - general
5524 - 24 Volts   - command
5032 - 32 Deg. C  - command
57PP                - command (transponder #1)
    
```

Examples of other frames copied and edited by G3ZCZ/W3 are

```

28-Feb-91 01:40 RS14=7032=7121=7224=7316=7410=7500=7600=77PP
01-Mar-91 02:19 RS14=7028=7121=7224=7316=7410=7500=7600=77PP
    
```

The "PP" at the end of the frame identifies the telemetry as having come from transponder #1. Transponder #2 identifies its telemetry with the "PPPP" sequence.

The AMSAT-OSCAR 21 Digital telemetry consists of 30 parameters

monitoring on-board conditions and 2 calibration verification points. If you intend to receive, decode and display the digital telemetry you will need an FM receiver, a TNC, a PSK modem, and a computer or terminal. Even then you may not be able to decode the data since it may not be downlinked in HDLC format. The decoding equations for the digital telemetry are shown in Table 7.6-4. The raw digital telemetry is expected to show up on your screen in the format shown in Table 7.6-5.

Table 7.6-4 Decoding Equations for AMSAT-OSCAR 21 Digital Telemetry (Version 26-Dec-90)

Line	Parameter	Formula	Unit	Hex-Format-Line
1	"Zero" of the comparator	0C	N/A	0000
2	Reference voltage	6D	N/A	0010
3	Transponder #1 HF output pwr	$0.2N^2$	Watt	0020
4	Transponder #1 PA temperature	$0.8*N$	Deg. C	0030
5	DC/DC converter temperature	$0.8*N$	Deg. C	0040
6	+14 V Regulated	$10*N$	Volt	0050
7	+24 V Regulated	$10*N$	Volt	0060
8	+16 V Regulated	$10*N$	Volt	0070
9	+12 V Regulated	$10*N$	Volt	0080
10	+9 V Regulated	$10*N$	Volt	0090
11	+7.5 V Regulated	$10*N$	Volt	00A0
12	+5 V Regulated	$10*N$	Volt	00B0
13	+9 V Regulated (linear)	$10*N$	Volt	00C0
14	+9 V Regulated (digital)	$10*N$	Volt	00D0
15	Service	N	*	00E0
16	Service	N	*	00F0
17	Transponder #2 HF output pwr	$0.2*N^2$	Watt	0100
18	Transponder #2 PA temperature	$0.8*N$	Deg. C	0110
19	+24 V Regulated	$10*N$	Volt	0120
20	+16 V Regulated	$10*N$	Volt	0130
21	+10 V Regulated	$10*N$	Volt	0140
22	+9 V Regulated	$10*N$	Volt	0150
23	+7.5 V Regulated	$10*N$	Volt	0160
24	Status command link	1	*	0170
25	Status command link	2	*	0180
26	Status command link		*	0190
27	Status command link		*	01A0
28	RPC +5V for Rudak-1	$2.47*N$	Volt	01B0
29	RPC +5V for Rudak-RTX	$2.47*N$	Volt	01C0
30	RPC +5V for Ramdisk	$2.47*N$	Volt	01D0
31	RPC +14V total supply current	$627-289*N$	mA	01E0
32	RPC module temperature	$56.7*N-49.5$	Deg. C	01F0

Note: RPC - Rudak Power Conditioner. The Service and command link channels are reserved for use by the ground control team.

Table 7.6-5 Expected Format of Raw AMSAT-OSCAR 21 PSK Telemetry

0000 0C E6 0C E6 0C E6 0C E6 0C E6 0C E6 0C E6 0C E6

```

0010 6D E6 6D E6 6D E6 6D E6 6D E6 6D E6 6D E6 6D E6
0020 i E6 i E6 i E6 i E6 i E6 i E6 i E6 i E6
.....
01F0 j E6 j E6 j E6 j E6 j E6 j E6 j E6 j E6

```

i...j - the value of the parameter in the hex format, repeated 8 times
E6 - separation

The RUDAK system is a message store-and-forward package. Its downlink is not expected to contain any telemetry. An example of some RUDAK signals copied by W3/G3ZCZ a few days after launch is shown in Table 7.6-6.

Table 7.6-6 Example of AMSAT-OSCAR 21 RUDAK Signals.

```

26-Feb-91 02:31:36 RUDAK*>BEACON:
* RUDAK-II / AMSAT OSCAR 21/RM1
* Up: 435.016MHz (1200)
* 435.155MHz (2400)
* Mailbox=RUDAK Mheard=RUDAK-1
26-Feb-91 02:32:37 RUDAK*>BEACON:
RUDAK-Telemetry (91-02-25 23:03:00):
Used stack entries: 0
Uplink Carrier Detect (during last minute): 0%
26-Feb-91 02:33:36 RUDAK*>BEACON:
* RUDAK-II / AMSAT OSCAR 21/RM1
* Up: 435.016MHz (1200)
* 435.155MHz (2400)
* Mailbox=RUDAK Mheard=RUDAK-1
26-Feb-91 02:34:37 RUDAK*>BEACON:
RUDAK-Telemetry (91-02-25 23:05:00):
Used stack entries: 0
Uplink Carrier Detect (during last minute): 0%
26-Feb-91 02:35:09 RUDAK,*>WB5BZE (UA)
26-Feb-91 02:35:11 RUDAK*>WB5BZE:
+-----+
+ Welcome to the RUDAK II Bulletin Board System V0.04 +
+-----+
26-Feb-91 02:35:13 RUDAK*>WB5BZE:
-----+
Logged in at 91-02-25 23:05:33, 1 User
This is a preliminary release.
Please rep
26-Feb-91 02:35:15 RUDAK*>WB5BZE:
ort deficiencies to DL2MDL.
73 de AMSAT-UA/AMSAT-DL/RUDAK-Group.
Enter H for help.
WB5BZE de RUDAK>
26-Feb-91 02:35:36 RUDAK*>BEACON:
* RUDAK-II / AMSAT OSCAR 21/RM1
* Up: 435.016MHz (1200)
* 435.155MHz (2400)
* Mailbox=RUDAK Mheard=RUDAK-1
26-Feb-91 02:35:51 RUDAK*>WB5BZE [D]

```



```
26-Feb-91 02:35:56 RUDAK*>WB5BZE [D]
26-Feb-91 02:36:32 KF4WQ>RUDAK*>KF4WQ [C]
26-Feb-91 02:36:37 RUDAK*>BEACON:
RUDAK-Telemetry (91-02-25 23:07:00):
Used stack entries: 0
Uplink Carrier Detect (during last minute): 0%
26-Feb-91 02:37:35 RUDAK*>WB5BZE (UA)
```

7.7 SARA-OSCAR 23

On 17 July 1991, the attention of AMSAT and the rest of world's amateur radio satellite communicators was focused on UoSAT-F. UoSAT-F became UoSAT 5 when it separated from the launcher and another OSCAR carrying a packet amateur communications payload was in ORBIT. The University of Surrey calls the spacecraft UO-5, AMSAT and radio amateurs call it OSCAR 22 or UO-22. UO-5/UO-22 is a scientific satellite similar to UO-4, launched in 1990.

Hardly anyone noticed that the same Ariane launch vehicle carried the SARA spacecraft, which became OSCAR 23 a few seconds after UoSAT-F became UoSAT-5. SARA-OSCAR 23 (SO-23) was built at ESIEESPACE, an aerospace club at the Ecole Supérieure d'Ingenieurs en Electrotechnique et Electronique (ESIEE), in France. SARA is the culmination of six years of development work which included building payloads for balloon and sub orbital rocket launches.

SARA is not an amateur radio communications satellite. Although not as complex, it is also an educational and experimental satellite similar to the spacecraft built at the University of Surrey in England, (UO-1, UO-2, UO-3, UO-4 and UO-5). It holds (and identifies using) the call sign FX0SAT. SARA stands for "Satellite for Amateur Radio Astronomy".

Radio astronomy was born in 1932 with the discovery by Karl Jansky at the Bell Telephone Laboratories in New Jersey that radio waves were coming from a source in the sky. SARA is not amateur radio's first connection with radio astronomy. In 1937, Grote Reber, W9GFZ, designed and built the world's the first radio telescope, a 31ft. (9.4m) dish antenna, in his own backyard in Wheaton, IL. Using this antenna, he discovered the first discrete radio sources in the sky and mapped the distribution of radio emissions in the Milky Way. Grote Reber was the only person doing research in Radio Astronomy before World War II and single-handedly brought radio astronomy to the attention of professional astronomers. Like Grote Reber, SARA is also a pioneer, albeit with a twofold mission.

7.7.1 The Primary Mission: - a Radio Astronomy Experiment

SARA's primary mission is a Radio Astronomy Experiment to listen for hf radio signals from Jupiter's radio-electric activities in the decametric wavelengths. Jupiter is known to be emitting radio noise in the hf frequency bands. This Jovian DX cannot be

investigated by a terrestrial station because for much of the time, either the Earth or its atmosphere blocks the signals. In the past, a few other satellites have measured the Jovian emissions, but not for a long enough period of time to achieve meaningful results.

Jupiter's radio emissions in the decametric band is powerful enough to wipe out all other natural extra terrestrial signal sources under normal conditions. In the vicinity of the earth, the flux received from Jupiter ranges from $10.E-20$ to $5.10.E-19$ $W.m^{-2}.Hz^{-1}$ which is much stronger than the galactic background noise. During the Sun's calm period, the flux received from the sun is about $10.E-24$ $W.m^{-2}.Hz^{-1}$. During periods of high solar activity it increases to $10.E-17$ $W.m^{-2}.Hz^{-1}$. The solar eruptions can be distinguished from the Jovian signals by their signal strength, length of time, and by correlation with signals received on other wavelengths. Jupiter's radio activity in the decametric band is partially known: above 15 MHz the ionosphere sometimes becomes transparent and makes it possible to do some measurements, which can then be extrapolated to the 2 to 15 MHz band.

The Jovian decametric emission is irregular. It occurs mostly during storms that last from periods ranging from one minute to an hour. Depending on the type of storm, radio-electrical energy is concentrated into peaks of 1 to 50 mS or 1 to 10 S, in frequency bands about 50 KHz wide sweeping across the spectrum. These storms are closely related to the rotation of Jupiter's satellite Io and to Jupiter's own rotation. Solar eruptions may also influence them.

Voyager 1 carried out reception tests in the vicinity of Jupiter, but because of electromagnetic interference from its own instruments in the decametric band, it could only detect the strongest peaks of the Jovian emissions. To date, no measurements have yet been made in the 2 to 15 MHz band during a period of high solar activity. SARA is a pioneer following a voyager.

The radio-electrical waves are received by means of three pairs of aerials placed perpendicularly to each other. This configuration allows computation of the intensity of the field regardless of its direction and polarization.

As the received electromagnetic field is quite strong, three pairs of short aerials, five meters long are used. One of the pairs is also used to downlink telemetry data to earth in the 2 m band. The aerials are made of 100 mm wide steel tape. They were rolled up for the launch and unrolled themselves as soon as they were freed in orbit.

The Jovian emissions between 2 and 15 MHz are measured on eight channels, each of them 100 KHz wide. The on board equipment averages their amplitude over a time interval of 150 S. The average amplitude produces the envelope of the storms but hides

the peaks, which represent the internal structure of the storms. A single receiver is switched between the channels and between the three pairs of aeri^{als}. The receiver thus gets in succession the three polarizations of each of the eight channels. This cycle is executed several times during the 150 S to prevent the measurements on the different channels from being separated in time.

The receiver has a 40 dB dynamic range in order to detect the Jovian peaks as well as certain solar ones without saturating the receiver. This allows for enough sensitivity to detect the galactic background noise which is constant at a known level, and which will serve as a reference standard when Jupiter and the sun are silent.

7.7.2 The Secondary Mission: - a Reliability Experiment.

Consider the reliability of the electronic components in a spacecraft. SARA uses consumer-made components, rather than military or space qualified parts, for reasons of cost and availability. Why do professional satellites use the most expensive components, and why did SARA do otherwise? The launch causes vibrations amounting to 10 g. Once the payload gets into orbit, outer space is a favorable environment for electronic equipment. As a result, SARA is made from components that have been tested and burnt in.

Commercial mass produced components are just as reliable as conventional space qualified parts. For instance, a TV set that can work for 10 years or more without needing repairs has to be built out of very reliable components. While SARA doesn't use hardened components, it doesn't use risky components either. Chemical capacitors are banished, the Power Amplifier transistors are oversized and well cooled, the PROMs are debugged after programming, as advised by the manufacturer. SARA's equipment is simple and conservatively designed and that is why, statistically, a long operational life can be anticipated for the satellite.

7.7.3 The Downlink

The satellite circles the earth in 100 minutes on its low, sun synchronous, quasi-polar orbit at an altitude of about 770 km downlinking its data continuously. One telemetry transfer frame cycle takes 2 minutes 48 seconds. An uplink command capability can shut the beacon down if it causes QRM.

The downlink transmitter power of the satellite is about 1 W at 145.955 MHz. The carrier wave is modulated in amplitude with a ± 3400 Hz spectrum using AFSK coding at frequencies of 1200 and 2200 Hz at a speed of 300 bits/s. The aerial polarization is linear.

7.7.4 The Onboard Electronics

The electronics are controlled by a sequencer because data acquisition and transmission are made at different rates and times. All the logic state machines required for the experiment are built on a single printed circuit card, the remaining cards being analog or combinational logic. This approach simplified the design of the equipment and testing.

The sequencing card manages the measurements: it specifies the frequency and the pair of aeriels to be used by the receiver, digitizes and stores the data, interprets received commands, and prepares the telemetry. Data stored during a 24 hour time period is time-tagged and downlinked in telemetry cycles lasting a few minutes.

The functions described above are performed by a microcontroller. As the program must operate over a period of years in spite of errors that could occur due to interference or ionizing particles, it will be reset regularly.

7.7.5 The Power System

The power system supplies power to the electronics equipment, and also started the satellite up after the launch, having detected the separation from the launcher. After a proper time delay, the energy system freed the aeriels and started supplying power to the equipment. The equipment needs about 3 W and uses a non-regulated voltage bus that is locally regulated to 5 V.

During certain times of the year, the satellite is eclipsed by the earth for up to a third of each orbit. A storage battery is thus used as a permanent power supply. The battery is charged when sun shines on the photovoltaic cells. The battery is protected against overloading.

Because the satellite does not have an attitude control system, sunlight can hit it from any direction. Solar cells were placed on each side of the space craft, which is in the form of a cube. Its size was calculated so that each side is able to supply power for the whole experiment. This means 60% of the surface of the 470 mm cube was covered with high quality cells.

Separation from the launcher was detected by a push button that directly controlled the power supply for the on-board experiment and the cutter to free the aeriels. In addition, the power supply is controlled by a security circuit.

7.7.6 Mechanical integration

Integration is based on a single plate 400 mm by 400 mm, on which everything else is mounted; the electronic equipment, the aeriels, the solar cells, the interface with the launcher and the manual controls.

The solar cells are placed on two half shells made of aluminum sheets that constitute the case when they are brought together. The integration plate is easily accessible when they are removed. Each piece of equipment is a box. The cables are directly connected to the pieces they connect. The whole mechanical structure is made of aluminium pieces. The junctions that carry strains are soldered. The spacecraft when assembled is a cube measuring about 470 mm each side.

7.7.7 Thermal Control

To accomplish their mission, the electronic equipment and the batteries need moderate temperatures. These temperatures can be achieved using passive controls. The internal temperature only depend on exterior conditions (Sun and Earth) and on the satellite's characteristics.

The target temperature is an average of + 20 C, which can be achieved by choosing appropriate coatings for the external surfaces of the satellite. About 40% of the surface was not covered with solar cells and was thermally coated. The shape of the box was chosen so as to have a quasi-constant section in all directions, temperature being then independent from the orientation of the satellite relative to the sun. The equipment dissipates 3 W and does not modify the thermal balance of the structure.

The heat must be able to pass easily from the lighted sides to the dark ones so that temperatures remain close to the average. The problem is simplified by the small size of the satellite, and by the use of aluminium shells 2 mm thick which are enough to limit the thermal gap to 30 degrees. The satellite then does not need to be spun to maintain thermal control.

7.7.8 Educational Opportunities

SARA provides a unique educational opportunity in orbital dynamics. The radio signals SARA are monitoring are generated by the interaction between Jupiter and one of its moons (Io) as a beam of radio energy. Why? How? The signals are synchronized to sidereal time and appear roughly four minutes earlier successive day. Why? It takes about two hours for the beam to swing across the earth. Why?

Ideally SARA should have been placed in an orbit in which the earth never gets between the spacecraft and Jupiter. SARA however took the orbit the Ariane rocket gave it, an orbit optimized for the primary payload, the Earth Resources Satellite (ERA-1). When the earth gets between SARA and Jupiter there will be breaks in reception of Jovian signals for up to 40 minutes each orbit.

Plot the current positions of Jupiter and the Earth in the solar system. Look at the angles between Jupiter and the orbital plane of SARA around the Earth. Does the Earth eclipse SARA? If so, how

long before the geometry is such that SARA will get uninterrupted viewing of Jupiter? If SARA has uninterrupted viewing, how long will this condition last? If SARA receives signals when it is eclipsed by the earth, what are they and where are they coming from?

Educators, just answering these questions can provide material for a semester or more. Additionally why not bring space into the classroom. Set up a receiving station to acquire and capture the telemetry. Send in a reception report for a QSL? Write to NASA for some pictures of Jupiter.

8.0 Spacecraft No Longer Active

This section is provided for post mission analysis of digital data from spacecraft that are no longer active in case you have access to data from those satellites and wish to the tools in WHATS-UP to view and analyze the data.

8.1 Fuji-OSCAR 12

The Fuji-OSCAR 12 PSK Telemetry Data Format. It is practically identical to the Fuji-OSCAR 20 format. The format is shown in Table 8.1-1, the decoding equations are presented in Table 8.1-2.

Table 8.1-1 Fuji-OSCAR 12 PSK Telemetry Frame Format

```
JAS-1 FF YY/MM/DD HH:MM:SS
xxx xxx xxx xxx xxx xxx xxx xxx xxx xxx
xxx xxx xxx xxx xxx xxx xxx xxx xxx xxx xxx
xxx xxx xxx xxx xxx xxx xxx xxx xxx yyy yyy
sss sss sss sss sss sss sss sss sss sss
```

```
FF := Frame Identifier    RA: Realtime Telemetry - ASCII
                           RB: Realtime Telemetry - Binary
                           SA: Stored Telemetry - ASCII
                           SB: Stored Telemetry - Binary
                           M0: Message #0
                           M1: Message #1
                           .....
                           M9: Message #9
```

YY/MM/DD = Date

HH:MM:SS = Time (The command station attempts to keep the clock as close as possible to UTC)

[Following is valid only for RA and SA frames]

xxx = 000 - 999 Format: 3 digit decimal (Analog Data) 28 samples in row 0 column 0 through row 2 column 7 (denoted #00 - #27 below)

y = 0 - F one byte Hex (System Status Data)

9 samples in row 2 column 8 through row 2 column 9
(denoted #28a - #29c below)

s = 0 or 1 Binary Status Data
30 samples in row 3 through row 3 column 9
(denoted #30a - #39c below)

Table 8.1-2 Fuji-OSCAR 12 Telemetry Calibration Equations

Ch.	Item	Equation	Units
#00	Total Solar Array Current	$1.91 * (N - 4)$	mA
#01	Battery Charge/Discharge	$3.81 * (N - 528)$	mA
#02	Battery Voltage	$N * 0.0210$	V
#03	Half-Battery Voltage	$N * 0.00937$	V
#04	Bus Voltage	$N * 0.0192$	V
#05	+ 5 V. Regulator Voltage	$N * 0.00572$	V
#06	- 5 V. Regulator Voltage	$N * -0.00572$	V
#07	+10 V. Regulator Voltage	$N * 0.0116$	V
#08	JTA Power Output	$5.1 * (N - 158)$	mW
#09	JTD Power Output	$5.4 * (N - 116)$	mW
#10	Calibration Voltage #2	$N / 500$	V
#11	Offset Voltage #1	$N / 500$	V
#12	Battery Temperature	$0.139 * (689 - N)$	Deg. C
#13	JTD Temperature	$0.139 * (689 - N)$	Deg. C
#14	Baseplate Temperature #1	$0.139 * (689 - N)$	Deg. C
#15	Baseplate Temperature #2	$0.139 * (689 - N)$	Deg. C
#16	Baseplate Temperature #3	$0.139 * (689 - N)$	Deg. C
#17	Baseplate Temperature #4	$0.139 * (689 - N)$	Deg. C
#18	Temperature Calibration #1	$N / 500$	V
#19	Offset Voltage #2	$N / 500$	V
#20	Facet Temperature #1	$0.38 * (N - 684)$	Deg. C
#21	Facet Temperature #2	$0.38 * (N - 684)$	Deg. C
#22	Facet Temperature #3	$0.38 * (N - 690)$	Deg. C
#23	Facet Temperature #4	$0.38 * (N - 683)$	Deg. C
#24	Facet Temperature #5	$0.38 * (N - 689)$	Deg. C
#25	Temperature Calibration #2	$N / 500$	V
#26	Temperature Calibration #3	$N / 500$	V
#27	Depth of Battery discharge	$(N - 500) / 189$	AH

Fuji-OSCAR 12 System Status Telemetry Bytes

Ch.	Item
#28a	Spare (TBD)
#28b	Spare (TBD)
#28c	Memory Unit #0 error count
#29a	Memory Unit #1 error count
#29b	Memory Unit #2 error count
#29c	Memory Unit #3 error count

Fuji-OSCAR 12 Binary Status Data Points

Ch.	Item	1	0
#30a	JTA Power	On	Off
#30b	JTD Power	On	Off
#30c	JTA Beacon	PSK	CW
#31a	UVC Status	On	Off
#31b	UVC Level	1	2
#31c	Main Relay	On	Off
#32a	Engineering Data #1	----	----
#32b	Battery Status	Tric	Full
#32c	Battery Logic	Tric	Full
#33a	Engineering Data #2	----	----
#33b	PCU Status	Bit 1 (LSB)	
#33c	PCU Status	Bit 2 (MSB)	
#34a	Memory Unit #0	On	Off
#34b	Memory Unit #1	On	Off
#34c	Memory Unit #2	On	Off
#35a	Memory Unit #3	On	Off
#35b	Memory Select	Bit 1 (LSB)	
#35c	Memory Select	Bit 2 (MSB)	
#36a	Engineering Data #3	----	----
#36b	Engineering Data #4	----	----
#36c	Computer Power	On	Off
#37a	Engineering Data #5	----	----
#37b	Solar panel #1	Lit	Dark
#37c	Solar panel #2	Lit	Dark
#38a	Solar panel #3	Lit	Dark
#38b	Solar panel #4	Lit	Dark
#38c	Solar panel #5	Lit	Dark
#39a	Engineering Data #6	----	----
#39b	CW beacon source	CPU	TLM
#39c	Engineering Data #7	----	----

9.0 File formats

This section contains details of the contents of the different files used by WHATS-UP.

9.1 Configuration File

The contents of the Configuration file (WHATS-UP.SYS) are as follows:


```

1   Your callsign (e.g. G3ZCZ)
2   Default spacecraft configuration file (e.g. Dove)
3   station latitude (e.g. 35.00)
4   station longitude (e.g. 74.00)
5   station altitude (e.g. 100)
6   station minimum antenna elevation for acquisition (e.g.
    0)
7   station minimum usable pass time (e.g. 5)
8   early warning time (e.g. 5)
9   default Kepler file (e.g. whats-up.2ln)
10  UTC offset (e.g. EST = 5)
11  default directory path (e.g. C:)
12  default extracted data file (e.g. whats-up.txt)
13  default file name with list of telemetry parameters to
    extract file (e.g. ARRAYS)
14  TNC Type (e.g. PK-232)
15  PC serial port to TNC (e.g. 1)
16  PC serial TNC port baud rate (e.g. 1200)
17  PC Serial TNC port data bits (e.g. 8)
18  PC Serial TNC port Stop bits (e.g. 1)
19  PC Serial TNC port parity (e.g. N)
20  PC serial port to Radio (e.g. 2)
21  PC serial Radio port baud rate (e.g. 1200)
22  PC Serial Radio port data bits (e.g. 8)
23  PC Serial Radio port Stop bits (e.g. 1)
24  PC Serial Radio port parity (e.g. N)
25  Post pass delay (e.g. 2)
26  status (top) window color (e.g. 79)
27  Incoming window color (e.g. 14)
28  outgoing window color (e.g. 30)
29  prompt window color (e.g. 15)
30  alarm window color (e.g. 15)
31  bottom window color (e.g. 79)
32  Emphasis color (e.g. 14)
33  option color (e.g. 78)
34  parameter changed color (e.g. 95)
35  parameter limit exceeded color (e.g. 14)
36  Orbit element window color
37  Orbit element window Orbit element window In range
    color
38  Orbit element window early warning color
39  Orbit element window next one up color
40  Orbit alert dit time
41  Orbit alert note
42  Flag Sound
43  Doppler display Flag
44  The next few lines link the spacecraft configuration
    files and contain:- SC ID, Spacecraft configuration
    file name, autotune parameter.

```

The * that follows denotes the last line of SC ID data.

You must configure WHATS-UP before you try any Real Time activity.

The items in the configuration file are described below.

9.1.1 Your callsign

This item is the callsign displayed at the top of the screen and appended to the capture files when capture-to-disk is turned on.

9.1.2 Default spacecraft Name

This item is the default spacecraft name (e.g. Dove). WHATS-UP adds the ".SYS" to the end of the name (e.g. DOVE.SYS) and loads that configuration file at start up.

9.1.3 Station Latitude

This item is your station latitude (e.g. 35.00). In the southern hemisphere, enter a negative number.

9.1.4 Station longitude

This item is your station longitude in degrees WEST of Greenwich. (e.g. 74.00)

9.1.5 Station Altitude

This item is the altitude of your station antenna above sea level in Meters. (e.g. 100)

9.1.6 Station minimum antenna elevation for acquisition

This item is the minimum angle of elevation of your antennas at which you can acquire a signal. If you are on top of a hill or tall building the angle may be less than 0, if you are in a valley, it may be greater, such as 5 degrees.

9.1.7 Station minimum usable pass time

This item is the minimum time in minutes for a usable pass for collecting data (e.g. 5).

9.1.8 Early warning time

This item is the early warning time in minutes you want for notice that a spacecraft is about to come up above your local horizon (e.g. 5).

9.1.9 Default Kepler file

This item is the default file name that contains the orbit element data used when the program is first turned on (e.g. whats-up.2ln).

9.1.10 UTC offset

This item is the time difference (in hours) between the local time in your PC and GMT or Universal Coordinated Time (UTC). WHATS-UP always displays UTC time. (e.g. EST = 5)

9.1.11 Default directory path (e.g. C:)

This item is the directory path for the spacecraft capture-to-disk (YYMMDD.S/C), spacecraft configuration (*.SYS) and spacecraft operations schedule files (*.OPS).

9.1.12 Default extracted data file

This item is the name of the file to which data which is extracted from a playback file will be written to in a comma delimited format so that the data can be imported into a spreadsheet package for further analysis (e.g. whats-up.txt).

9.1.13 Default file name with list of telemetry parameters to extract file

This item is the name of the file containing the channel numbers to extract from a playback file for further analysis (e.g. ARRAYS)

9.1.14 TNC Type

This item is the type of TNC or Multi-mode controller you are using. WHATS-UP currently supports the PK-232.

9.1.15 Serial port to TNC

This item is the Communications port number between the TNC and the PC (e.g. 1). If you set it to 0, WHATS-UP will never try to access the TNC.

9.1.16 PC TNC Serial baud rate

This item is the baud rate used between the TNC and the PC (e.g. 1200).

9.1.17 PC TNC port data bits

This item is the number of data bits used between the TNC and the PC (e.g. 8).

9.1.18 PC TNC port Stop bits

This item is the number of stop bits used between the TNC and the PC (e.g. 1).

9.1.19 PC TNC Port parity bits

This item is the parity setting used between the TNC and the PC. The letters to use are defined as

- N No parity,
- O Odd,
- E Even,
- M Mark,
- S Space.

9.1.20 PC serial port to Radio

This item is the Communications port number between the PC and the Radio (e.g. 2). If you set it to 0, WHATS-UP will never try to access the radio.

9.1.21 PC Radio port Serial baud rate

This item is the baud rate used between the PC and the Radio (e.g. 4800).

9.1.22 PC Radio port data bits

This item is the number of data bits used between the Radio and the PC (e.g. 8).

9.1.23 PC TNC port Stop bits

This item is the number of stop bits used between the Radio and the PC (e.g. 2).

9.1.24 PC Radio Port parity bits

This item is the parity setting used between the Radio and the PC. The letters to use are defined as

- N No parity,
- O Odd,
- E Even,
- M Mark,
- S Space.

9.1.25 Post pass delay

This item is the time (in minutes) that WHATS-UP after the computed LOS time before returning the radio to the default frequency (e.g. 2). This delay is to be used in the event that the elements do not quite predict the exact times for your system.

The following items are the color values used for different windows or messages.

9.1.26 status (top) window color (e.g. 79)

9.1.27 incoming window color (e.g. 14)
9.1.28 outgoing window color (e.g. 30)
9.1.29 prompt window color (e.g. 15)
9.1.30 Alarm window color (e.g. 15)
9.1.31 Bottom window color (e.g. 79)
9.1.32 Emphasis color (e.g. 14)
9.1.33 Option color (e.g. 78)
9.1.34 Parameter changed color (e.g. 95)
9.1.35 Parameter limit exceeded color (e.g. 14)
9.1.36 Orbit element window color
9.1.37 Orbit element window In range color
9.1.38 Orbit element window early warning color
9.1.39 Orbit element window next one up color

9.1.39 Orbit alert dit time

This item is the speed of the morse code annunciator used to alert you of satellite AOS, EWT and LOS.

9.1.40 Orbit alert note

This item is the tone of the morse code annunciator used to alert you of satellite AOS, EWT and LOS.

9.1.41 Flag Sound

This item controls the sounds coming from the PC. A 1 is on, 0 is off.

9.1.42 Doppler display Flag

This item determines the type of Doppler display as follows:-

0 display beacon frequency,
1 display Doppler shift.

9.1.43 Spacecraft Configuration File Linkages

The next few lines contain the information which WHATS-UP uses to link the spacecraft configuration files to the Keplerian elements for orbit determination and automatic selection of spacecraft at AOS time. There should be NO SPACE characters before or between the commas, in the first two data elements. The lines contain data as shown below.

```
UO-11,UOSAT11.SYS, 0
AO-13,OSCAR13Z.SYS,0
AO-16,PACSAT.SYS, 0
DO-17,DOVE.SYS,   1
WO-18,WEBER.SYS,  0
LO-19,LUSAT.SYS,  2
FO-20,FUJI.SYS,   0
```

The first item is the Keplerian element identifier for the spacecraft as used in the orbit element files.

The second item is the FULL configuration file name for the spacecraft.

The third item is the automatic AOS selection flag as itemized below.

'0', automatic selection is inhibited.

'1', WHATS-UP selects that spacecraft configuration file at EWT time (if it is not selected at that time), and tunes the radio to the beacon frequency + offset defined in that file.

'2', WHATS-UP selects that spacecraft configuration file at AOS time (if it is not selected at that time), and tunes the radio to the beacon frequency + offset defined in that file.

9.1.44 * Comment line

This line must be present and signals WHATS-UP that the default parameters have been read and that the following lines contain commands to be sent to the TNC on starting up the program.

9.1.45 The remaining lines are commands sent to the PK232 when you configure the TNC. Note to avoid lock ups FLOW and XFLOW MUST be OFF. Typical commands are as follows:-

```
HEAD ON
ECHO OFF
DAYSTAMP ON
MONITOR 6
MSTAMP ON
FLOW OFF
XFLOW OFF
MFILTER None
```

9.2 Spacecraft Parameter Files

You need a Different spacecraft parameter file for each spacecraft. Spacecraft parameter files are named by the spacecraft and given the extension '.SYS'. Examples are 'DOVE.SYS' and 'Fuji20.SYS'. These files determine how the individual channels are decoded, and where, in which screen page, and in which color the decoded data are displayed. Some of the items are unique to WHATS-UP and some to the particular spacecraft.

The contents of the SPACECRAFT.SYS file are as described below.

9.2.1 Spacecraft ID.

This is the call sign of the spacecraft. For example,

Spacecraft	ID
DOVE-OSCAR 17	DOVE-1
Fuji-OSCAR 12	8J1JAS
Fuji-OSCAR 20	8J1JBS

In the case of the Microsats and Fuji-OSCAR 12/20, and any other using packet telemetry, WHATS-UP searches the packet headers to detect the spacecraft by this callsign.

9.2.2 Spacecraft Suffix

This becomes the filetype for the capture-to-disk files. The default suggestions are as shown below.

Spacecraft	Suffix
UoSAT-OSCAR 11	U11
Fuji-OSCAR 12	F12
AMSAT-OSCAR 13	O13
AMSAT-OSCAR 16	O16
DOVE-OSCAR 17	D17
WEBER-OSCAR 18	W18
LUSAT-OSCAR 19	L19
Fuji-OSCAR 20	F20
AMSAT-OSCAR 21	O21

9.2.3 Beacon Frequency

This is the frequency of the spacecraft beacon (in MHz) that you are monitoring. It will be displayed in the status window.

9.2.4 Doppler Measurement File

This is the default name of the file used to store the Doppler frequency measurements.

9.2.5 Spacecraft Identification in Keplerian Element File, examples are as follows.

UO-11	AO-13	AO-16	DO-17
WO-18	LO-19	FO-20	

9.2.6 Doppler Measurement Sample Interval

This is the default sample interval (in seconds) used between Doppler frequency measurements.

9.2.7 Initial Frequency Offset

This is the default value (in kHz) added to the beacon frequency, and output to the Radio Receiver when a particular spacecraft is selected. The default value is 5 to tune the radio 5 kHz above the beacon. This will allow the signal to slide into lock, whereby the TAPR PSK Modem will lock on and follow the frequency for the rest of the pass.

9.2.8 Autotrack flag

This item tells WHATS-UP if it should allow another AOS to interrupt data collection from this spacecraft.

- 0 Don't let another AOS to interrupt collection.
- 1 Allow another spacecraft AOS to interrupt collection, namely, tune to that spacecraft at its AOS.

9.2.9 Modulation

This is the type of modulation to set the Radio to copy data from the spacecraft. Current options are :-

- C CW
- F FM
- L LSB
- P PSK
- U USB.

9.2.10 Data Type

This is the type of data downlinked by the spacecraft.

- A ASCII as used by UoSAT-OSCAR 11.
- B BAUDOT as used by AMSAT-OSCAR 13.
- C CW as used by AMSAT-OSCAR 21.
- P Packet as used by DOVE-OSCAR 17, Fuji-OSCAR 20 and the Microsats.

9.2.11 Receiver Type

This is the manufacturer of the radio receiver you are using. This version of WHATS-UP only supports the Kenwood series.

9.2.12 Receiver Address

This is a spare for use with future radios such as Icom.

9.2.13 Selected or default display page number

This is the default display page for the Real-time and Playback modes, when WHATS-UP is first loaded.

9.2.14 Page Definitions

These are the page definitions, with two items on the line. The format is PAGE_TITLE, Page_Color, as in the example below.

SPACECRAFT HOUSEKEEPING, 30

9.2.15 Telemetry Parameter Configuration

The next set of items are the Telemetry parameter configurations (maximum = 99). You must have at least one of these lines in the file. If you want a value to show up in more than one page (other than the wild card [0]) you must enter it twice (once per page). Typically each row contains 17 items in the format shown below.

TLM_Channel, TLM_Segment_ID, TLM_Description, TLM_Eqn_Type, TLM_Ceof_C, TLM_Ceof_B, TLM_Ceof_A, TLM_Units, TLM_Page, TLM_Row, TLM_Col, TLM_Width, TLM_Dec, TLM_Limit_Check, TLM_Limit_Low, TLM_Limit_High, TLM_Negative_Blank.

Each item is described in the following sections.

9.2.15.1 TLM_Channel

This is the channel number of the telemetry data in the frame. The DOVE channel number is hexadecimal (e.g. '0F'), Fuji is decimal. Each entry must be two digits.

A special identifying TLM_Channel is defined in WHATS-UP. If the value is '99' then the segment identifier and position of the segment identifier is defined in two positions in the line. This special channel identifies the type of telemetry frame.

9.2.15.2 TLM_Segment_ID

This is the segment identifier as described in Section 9.2.15.99 below.

9.2.15.3 TLM_Description

This item is the text string or description of the telemetry channel that will be displayed on the screen page. (e.g. '+Z Array Temp.')

9.2.15.4 TLM_Eqn_Type

This item tells WHATS-UP the type of equation to use to decode the telemetry.

Type 1 is the general purpose equation used by AMSAT-NA

in the Microsats.

Fuji uses two other types of equations (2 and 3). They are in the formats of

$Y = D*(N+E)$, and $Y = F*(G-N)$. If you know some algebra you can convert both of Fuji's equations to the Format used by AMSAT, but since a computer is involved, why not let it do the job. You do however have to convert an equation of the form $Y=(N+a)/b$.

AMSAT-OSCAR 13 also needs three more types (4 5 and 6) of equations to decode the RTTY Z blocks.

A type 1 equation in WHATS-UP is a quadratic of the form

$Y = A*N^2 + B*N + C$,
 where: N = raw telemetry data value
 A, B, C = Equation Coefficients; Y, N are decimal values.

A type 2 equation in WHATS-UP has the format in the form of

$Y = B*(A+N) + C$
 where C, B, A are coefficients; Y, N are decimal values.

A type 3 equation in WHATS-UP has the format in the form of

$Y = B*(A-N) + C$
 where C, B, A are coefficients; Y, N are decimal values.

A type 4 equation in WHATS-UP has the format in the form of

$Y = B*(N+A)^2 + C$
 where C,B, A are coefficients; Y, N are decimal values.

A type 5 equation in WHATS-UP has the format in the form of

$Y = B*(A-N)^2 + C$
 where C, B, A are coefficients; Y, N are decimal values.

A type 6 equation in WHATS-UP is a special case. It is the AMSAT-OSCAR 13 (Channel 1C) Spin Rate equation as specified below.

```
if N > 131
then Y := 479/(N - 109) - 2
else Y := (131 - N) * 0.85 + 20;
```

where N is the raw decimal number in Channel 1C and Y

is the spin rate.

9.2.15.5 TLM_Ceof_C

This item is the equation Coefficient C.

9.2.15.6 TLM_Ceof_B

This item is the equation Coefficient B.

9.2.15.7 TLM_Ceof_A

This item is the equation Coefficient A.

9.2.15.8 TLM_Units

This item is the Units text string (e.g. '.C') in the screen display. However if the Tlm_Channel is '99' then this item is the segment identifier string.

9.2.15.9 TLM_Page

This item is the Display page number. A 0 is a 'wild card' which will be displayed on every page.

9.2.15.10 TLM_Row

This item is the Display page row. It identifies which row in the screen the data element will be displayed.

9.2.15.11 TLM_Col

This item is the Display page column. It identifies which column in the screen the data item will be displayed.

9.2.15.12 TLM_Width

This item is the Display width for Engineering Units. It tells WHATS-UP how many characters wide the display is to be. You can set it to any value you want. For example, you can display a voltage as '1.3' or '1.28567'. Before you widen the display too much, remember the sampling accuracy of the analog-to-digital converter in the spacecraft.

9.2.15.13 TLM_Dec

This item defines the number of digits after the decimal point in the display.

9.2.15.14 TLM_Limit_Check

This item tells WHATS-UP to perform limit checking on

the telemetry channel. It may have several values as described below.

- 0 = do nothing,
- 1 = check below low limit,
- 2 = check above high limit,
- 3 = check for EITHER [below low limit] or [above high limit]).

9.2.15.15 TLM_Limit_Low

This item is the Low limit value (e.g. -4.00).

9.2.15.17 TLM_Limit_High

This item is the High limit value (e.g. +10.6).

9.2.15.18 TLM_Negative_Blank

This item is a 1 if you want computed negative values to be displayed as a zero. Use this for example, in Solar Cell Voltage computations, when negative values are produced by the equation supplied even though the negative values are not real. The negative values are produced because the equation used to convert the data is not valid at low or zero values of light.

A line with an '*' as the first character terminates this section.

9.2.15.99 The Telemetry Identifier Line

The Telemetry identifier line has the same format as a regular line, but contains different parameters as follows:

9.2.15.99.1 The Line Identifier

This item has to be '99' to identify the telemetry identifier line.

9.2.15.99.2 The Segment Identifier

This is used when the spacecraft transmits telemetry in more than one segment. It contains the segment identifier showing which segment the channel is down-linked in.

9.2.15.99.3 Spare/Not Used

9.2.15.99.4 Location of Segment Identifier in Line

This item contains the location of the segment identifier in the first line of the telemetry data.

9.2.15.99.5 Spare/Not Used

9.2.15.99.6 Spare/Not Used

9.2.15.99.7 Spare/Not Used

9.2.15.99.8 Segment Identifier String

This item is the segment identifier string as follows.

9.2.15.99.82.1 Fuji

The Fuji frame contains one real time segment (Segment 1) in a frame addressed as 8J1JBS>BEACON. A typical frame is shown below.

```
19-Apr-90 17:14:34 8J1JBS*>BEACON:
JAS1b RA 90/04/19 17:13:58
609 430 687 676 744 837 845 829 498 681
617 001 505 516 526 524 526 523 654 000
683 675 686 695 999 643 875 471 099 000
110 111 000 000 111 100 001 111 111 000
```

The segment identifier is in the seventh and eighth characters of the first line of the data. A segment identifier of that position identifies the second segment. The segment identifier is the 'RA' located on the first line of the data just after the JAS1b where the 'R' in 'RA' is the seventh character in the line.

Any telemetry frame addressed to BEACON received without that segment identifier is assumed by WHATS-UP to be Segment 2.

9.2.15.99.8.2 DOVE

DOVE transmits telemetry in two frames each addressed as DOVE-1>TLM. The Microsat ASCII frame thus contains two segments. Two typical segments of DOVE telemetry are shown below.

```
DOVE-1>TLM [01/29/90 22:08:46]:
00:59 01:59 02:86 03:30 04:58 05:58 06:6D 07:45 08:6C 09:66 0A:A1
0B:D9 0C:E8 0D:D8 0E:01 0F:23 10:CC 11:A8 12:00 13:01 14:A8 15:94
16:96 17:94 18:95 19:96 1A:93 1B:90 1C:9A 1D:98 1E:23 1F:5E 20:BC
```

```
DOVE-1>TLM [01/29/90 22:08:47]:
21:98 22:7B 23:24 24:21 25:2E 26:00 27:00 28:00 29:00 2A:00 2B:00
2C:00 2D:29 2E:00 2F:9B 30:C8 31:9C 32:11 33:DA 34:C0 35:95 36:A4
37:A4 38:B2 39:96 3A:00
```

The default segment identifier used by WHATS-UP is in the first and second characters of the first line of the data. A segment identifier of '00' identifies the first segment, and anything else in that position identifies the second segment.

AMSAT-OSCAR 13 RTTY Telemetry is transmitted in the form of Z blocks shown below (several blank lines have been deleted to save space in this document).

```
Z  HI. THIS IS AMSAT OSCAR 13
    05.02.44  4661
    .0086    .0000    .07B9

64  6    0    1    16  218 1

193 170 158 143 181 144 147 140 200 7
147 7   7   7   165 29  100 7   149 7
10  7   145 115 34  7   153 129 122 180

152 73  7   145 137 55  7   183 136 151
7   154 137 169 211 142 127 100 9   140
161 7   173 149 150 154 14  131 127 210
HI THIS IS AMSAT OSCAR 13 08SEP90
NEW AO13  SCHEDULE FROM 17OCT90 AFTER MOVE TO  LON
    180  LAT 0
MODE B  MA 000 TO 095
MODE JL MA 095 TO 125
MODE LS MA 125 TO 130
MODE S  MA 130 TO 135
MODE BS MA 135 TO MA 140
MODE B  MA 140 TO 256
```

Note the non telemetry information at the end of the block. UoSAT-OSCAR 11's ASCII telemetry looks different, so WHATS-UP is told where to look for the telemetry by the following items.

9.2.15.99.9 Spare

9.2.15.99.10 Number of Lines

This item is used in non packet telemetry to tell WHATS-UP how many lines of data are in a frame.

9.2.15.99.11 First Line

This item is used in non packet telemetry to tell WHATS-UP which line in the frame contains the first line of data.

9.2.15.99.12 Last Line

This item is used in non packet telemetry to tell WHATS-UP which line in the frame contains the last line of data.

9.2.15.99.13 Header Lines

This item is used in non packet telemetry to tell WHATS-UP how many lines there are in the header.

9.2.15.99.14 Character Count

In non packet telemetry this item tells WHATS-UP the maximum number of characters on a line. Use it in BAUDOT, ASCII and CW telemetry to stop the display overrunning the page and to force recognition of the identifier and turn the automatic capture-to-disk on.

9.2.16 Digital Telemetry Status Channels

The next set of lines instruct WHATS-UP how to display digital telemetry status in the Fuji-OSCAR 20 frame. Digital status channels contain a number of status points. Fuji-OSCAR 12 and 20 have three data elements in each digital status channel. Typically, each line in the WHATS-UP.SYS file contains ten items in the following format.

```
Status_Channel,      Status_Display_Page,      Status_Text,
Status_Bit_Mask,  Status_Row,  Status_Col,  Status_ON_Text,
Status_OFF_Text,  Status_ON_Color,  Status_OFF_Color.
```

Each item is described in the following sections.

9.2.16.1 Status_Channel

This is the channel number of the digital status telemetry data in the frame. Each entry must be two digits.

9.2.16.2 Status_Display_Page

This item is the Display page number. A 0 is a 'wild card' which will be displayed on every page.

9.2.16.3 Status_Text

This is the text that is displayed in the page.

9.2.16.4 Status_Bit_Mask

This is the bit mask to mask out the position of the

desired bit. The masks are in decimal. i.e. 1, 10 and 100.

9.2.16.5 Status_Row

This item is the Display page row. It identifies which row in the screen the data element will be displayed.

9.2.16.6 Status_Col

This item is the Display page column. It identifies which column in the screen the data item will be displayed.

9.2.16.7 Status_ON_Text

This item is the text that is displayed when the spacecraft telemetry contains a 1 value.

9.2.16.8 Status_OFF_Text

This item is the text that is displayed when the spacecraft telemetry contains a 1 value.

9.2.16.9 Status_ON_Color

This item is the color the text is displayed in when the spacecraft telemetry contains a 1 value.

9.2.16.10 Status_OFF_Color

This item is the color the text is displayed in when the spacecraft telemetry contains a 0 value.

These lines also terminate with an '*' character. A few typical lines from a Fuji.SYS file are shown below.

```
30,3,JTA Power      :,100, 4, 1, ON  , OFF ,11,10
30,3,JTD Power      :, 10, 4,25, ON  , OFF ,11,10
30,3,JTA Beacon     :,  1, 4,45, PSK  , CW  ,11,10
38,3,Solar Panel 3 :,100,12, 1, LIT  , DARK,11,10
38,3,Solar Panel 4 :, 10,12,25, LIT  , DARK,11,10
38,3,Solar Panel 5 :,  1,12,45, LIT  , DARK,11,10
```

Note the blanks in the Text ON and OFF positions. The blanks are used to ensure that a word such as "LIT" which contains three letters fully overwrites a word which contains four characters such as "DARK".

9.2.17 Packet/Link Parameters

The next set of items are the Packet/Link Parameters configurations (maximum = 16). If you want a value to show up in more than one page (other than the wild card [0]) you

must enter it twice (once per page). Typically each row contains 10 items in the sequence shown below.

Packet_title, Packet_Type, Packet_Lines,
Packet_Page, Packet_Color, Packet_Row,
Packet_Col, Link_Page, Link_Row,
Link_Col, Binary_Byte_Count.

Each item is described in the following sections.

9.2.17.1 Packet_title

This item is the name of UNP address (e.g. TLM,WASH, BCXRT).

9.2.17.2 Packet_Type

This item is used by WHATS-UP to define the type of telemetry. The following assignments have been allocated but are not necessarily used in this release of WHATS-UP.

- 0 AMSAT-OSCAR 13 Non Packet Decimal telemetry.
- 1 AMSAT Microsat Packet Telemetry (TLM) with the format CC:DD where CC is the hexadecimal channel number and DD the hexadecimal data.
- 2 AMSAT Microsat Packet Telemetry, hexadecimal ASCII STATUS telemetry.
- 3 Fuji Packet Telemetry format of decimal data in which the line and the position on the line identify the channel. WHATS-UP allows for up to 60 channels.
- 4 AMSAT Microsat Packet Telemetry hexadecimal Binary STATUS telemetry.
- 5 AMSAT Microsat Binary TLM Packet Telemetry.
- 6 UoSAT-OSCAR 9/11 ASCII Telemetry.

9.2.17.3 Packet_Lines

This item is the number of lines of text in the packet. for example, the AMSAT TLM packets contain three lines, the WASH packets contain only one.

9.2.17.4 Packet_Page

This item is the page that the raw contents of the packet will be displayed on. A '0' is a wild card which will make WHATS-UP display it on every page. By careful

use of this item, you can display both raw and decoded packet data on the same page.

9.2.17.5 Packet_Color

This item is the color that the raw packet data will be displayed in.

9.2.17.6 Packet_Row

This item is the row position that the raw packet will be displayed in, on the selected page.

9.2.17.7 Packet_Col

This item is the column position that the raw packet will be displayed in, on the selected page.

9.2.17.8 Link_Page

This item is the Display page for the cumulative count of the packet type. The wild card '0' applies.

9.2.17.9 Link_Row

This item is the row position that the packet header will be displayed in, on the selected page.

9.2.17.10 Link_Col

This item is the column position that the packet header will be displayed in, on the selected page.

9.2.17.11 Binary_Byte_Count

This item is the number of bytes in a binary packet. As no standard currently exists, we have to tell the computer how many bytes to expect.

These lines also terminate with an '*' character.

9.3 Telemetry Channel Extraction File

The contents of this file are the defaults for extracting data from the playback file. A typical set are shown below. WHATS-UP does a string match, and looks for the first time that a particular string occurs. You may thus use the contents of a time packet, or the time mark in a header.

```
ZCZC (default start time string) {start of file}
NNNN (default stop time string) {end of file}
2F
35
38
```

The first line contains the start string. 'ZCZC' tells WHATS-UP to start extracting at the beginning of the file. The second line contains the stop string. 'NNNN' tells WHATS-UP to stop extracting at the end of the file. The remaining lines are the individual channels (uppercase letters), one channel per line.

9.4 Extracted Telemetry Data File

This an ASCII string, comma delimited file which can be imported into your spreadsheet. The format of the file is such that each line starts with a date code or packet header. Then each channel and the datum associated with that channel follow for all channels in the packet segment or non packet frame for each and every channel displayed in the selected page on the screen. If the data from that channel is not displayed on the screen in the extract mode, the data will not be extracted.

A typical example of three lines from this file is shown below.

```
"01-Mar-91 03:39:46 DOVE-1*>TLM:", "35", 6.7, "38", -9.7
"01-Mar-91 03:39:56 DOVE-1*>TLM:", "35", 6.7, "38", -10.3
"01-Mar-91 03:40:06 DOVE-1*>TLM:", "35", 6.7, "38", -10.3
```

9.5 Doppler File

Doppler data are stored in this file. If the file does not exist, it is created when needed. IF it does exist, data are appended to the file. The first line of data identifies the time, place and spacecraft as shown below.

```
"*** 22-Feb-91 02:57 Doppler Track STARTED for WEBER @ G3ZCZ"
```

The next line provides the headings for the five columns as follows.

```
"Time", "Doppler Mark", "Frequency", "Doppler Shift", "Measured Shift"
```

9.5.1 The Time

The Time is obtained from the PC clock.

9.5.2 The Doppler Mark

The Doppler Mark is a sequential count incrementing at each sample. It can be used to provide an 'X' axis in a graph. Elapsed time will be the Doppler mark multiplied by the Doppler sampling interval in seconds.

9.5.3 The Frequency

The Frequency is the measured radio frequency.

9.5.4 The Doppler Shift

The Doppler Shift is the calculated/predicted Doppler Shift in kHz.

9.5.5 The Measured Shift

The Measured Shift is the difference (in kHz) between the measured radio frequency and the beacon frequency in the configuration file.

These parameters should allow you to plot Doppler curves and determine orbit parameters using the time of closest approach technique.

Typical entries in the file are shown in the following lines.

```
"02:57:32", 2, 437110740, 8.1494,10.740
"02:57:37", 3, 437110740, 8.1354,10.740
"02:57:42", 4, 437110740, 8.1202,10.740
"02:57:47", 5, 437109860, 8.1045,9.860
"02:57:52", 6, 437110670, 8.0880,10.670
"02:57:57", 7, 437110620, 8.0709,10.620
"02:58:13", 8, 437110620, 8.0525,10.620
"02:58:18", 9, 437109780, 7.9868,9.780
.
.
"03:07:17", 115, 437092570, -7.7884,-7.430
"03:07:22", 116, 437092570, -7.8204,-7.430
"03:07:27", 117, 437092570, -7.8511,-7.430
"03:07:32", 118, 437092570, -7.8802,-7.430
"*** 22-Feb-91 03:07 Auto End"
```

The lines of data end with a termination statement.

All text items are enclosed in double quotation marks ("). All elements are delimited by comma characters (,).

If you plan to do Doppler measurements on the Microsats, then you may be interested in the following information.

The following frequencies were taken after the completion and final tuning of the completed transmitter assemblies. The measurements were made at a temperature of 23 deg. C. As the frequency does change with temperature the current frequency will be slightly different.

PACSAT:	Normal PSK TX:	437.02625 MHz
	Raised Cosine TX:	437.05130 MHz
	S-Band TX:	2401.14280 MHz
DOVE:	FM TX No. 1:	145.82516 MHz
	FM TX No. 2:	145.82438 MHz
	S-Band TX:	2401.22050 MHz

WEBERSAT:	Normal PSK TX:	437.07510 MHz
	Raised Cosine TX:	437.10200 MHz
LUSAT:	Normal PSK TX:	437.15355 MHz
	Raised Cosine TX:	437.12580 MHz

9.6 Kepler Element Files (*.2LN)

The following outlines the "NASA Two-Line" Keplerian data format. Data for each satellite consists of three lines in the following format:

Example:

```
Mir
1 16609U          91 36.87776287 0.00038608          39705-3 0 2481
2 16609  51.6077 232.9299 0024950 205.6681 154.3223 15.64092124284608
```

Line 1 contains an eleven-character name.

Lines 2 and 3 are the standard Two-Line Orbital Element Set used by NASA and NORAD. The format description is:

Line 2		Description
Column		
01-01		Line Number of Element Data
03-07		Satellite Number
10-11		International Designator (Last two digits of launch year)
12-14		International Designator (Launch number of the year)
15-17		International Designator (Piece of launch)
19-20		Epoch Year (Last two digits of year)
21-32		Epoch (Julian Day and fractional portion of the day)
34-43		First Time Derivative of the Mean Motion or Ballistic Coefficient (Depending on ephemeris type)
45-52		Second Time Derivative of Mean Motion (decimal point assumed; blank if N/A)
54-61		Radiation pressure coefficient. (Decimal point assumed)
63-63		Ephemeris type
65-68		Element number
69-69		Check Sum (Modulo 10)
		(Letters, blanks, periods = 0; minus sign = 1; plus sign = 2)

Line 3		Description
Column		
01-01		Line Number of Element Data
03-07		Satellite Number
09-16		Inclination (Degrees)

18-25	Right Ascension of the Ascending Node (Degrees)
27-33	Eccentricity (decimal point assumed)
35-42	Argument of Perigee (Degrees)
44-51	Mean Anomaly (Degrees)
53-63	Mean Motion (Revs per day)
64-68	Revolution number at epoch (Revs)
69-69	Check Sum (Modulo 10)

All other columns are blank or fixed.

9.7 AMSAT Format Element File (*.AMS)

The AMSAT format file is the AMSAT file as received by means of packet radio. WHATS-UP scans the text for the word "Satellite:". When it finds it, it assumes that the next few lines carry the data in the fixed order. You thus, do not need to edit the file, just capture it to disk, and save with a filetype of 'AMS'. For example the following file could be saved as ORBS-19.AMS.

If you need to enter data in by hand, edit an AMSAT format file.

```

4116] B   BID: ORBS-019.D
Date: 20 Jan 91 02:58:24 Z
From: N4QQ@N4QQ
To: ALL@AMSAT
Subject: Orbital Elements    019.MICROS

R:910120/0258z 18616@N4QQ.MD.USA [Silver Spring,Md]  Z:20901
From: N4QQ@N4QQ.MD.USA
To: ALL@AMSAT

```

```

HR AMSAT ORBITAL ELEMENTS FOR THE MICROSATS
FROM N3FKV HEWITT, TX      JANUARY 19, 1991
TO ALL RADIO AMATEURS BT

```

```

Satellite: AO-16
Catalog number: 20439
Epoch time:      91014.08680572
Element set:      188
Inclination:      98.6853 deg
RA of node:       94.6412 deg
Eccentricity:     0.0010690
Arg of perigee:   259.0593 deg
Mean anomaly:     100.9381 deg
Mean motion:     14.28942714 rev/day
Decay rate:       3.95e-06 rev/day^2
Epoch rev:       5098

```

```

Satellite: DO-17
Catalog number: 20440
Epoch time:      91014.07510019
Element set:      187

```

```
Inclination:      98.6867 deg
RA of node:       94.6574 deg
Eccentricity:     0.0010787
Arg of perigee:   258.7019 deg
Mean anomaly:     101.2949 deg
Mean motion:      14.29004143 rev/day
Decay rate:       4.60e-06 rev/day^2
Epoch rev:       5098
```

9.8 Spacecraft Operations File

This is a text file which can usually be obtained from a packet radio bulletin. You may create one with the editor, if you can't find one on a packet radio BBS. A Typical file is shown below.

AO-13 TRANSPONDER SCHEDULE

```
Mode-B : MA 060 to MA 165 :
Mode-JL: MA 165 to MA 190 :
Mode-LS: MA 190 to MA 195 :
Mode-S : MA 195 to MA 200 : <= Mode B is Off - no swishing!
Mode-BS: MA 200 to MA 205 : <= QRP on BS please.
Mode-B : MA 205 to MA 256 :
Omnis  : MA 240 to MA 060 :
```

This schedule is expected to continue through 27 March 91

10.0 Glossary

AMSAT	The Radio Amateur Satellite Corporation
AO	AMSAT-OSCAR
AOS	Acquisition of Signals
ARRL	American Radio Relay League
CCD	Charge Coupled Device
DO	DOVE-OSCAR
DOVE	Digital Orbiting Voice Encoder, also used interchangeably with DOVE-OSCAR or DO
EWT	Early Warning Time
FM	Frequency Modulation
FO	Fuji-OSCAR
FSK	Frequency Shift Keying
LO	LUSAT-OSCAR
LOS	Loss of Signals
OSCAR	Orbiting Satellite Carrying Amateur Radio
AO	AMSAT-OSCAR
PSK	Phase Shift Keying
RTTY	Radio Teletypewriter
SSB	Single Side Band
TNC	Terminal Node Controller
TU	Terminal Unit (Radio Modem)
UO	UoSAT-OSCAR
WO	WEBER-OSCAR

11.0 References and Further Reading

The best book is "The Space Radio Handbook" by John Branegan, GM4IHJ. It is published by the Radio Society of Great Britain. The book is available from the RSGB, Lambda House, Cranborne Rd, Potters Bar, Herts., England EN6 3JE. The price is 13.34 pounds sterling. John has also written several booklets on MIR, DOVE and UOSAT-OSCAR 14 specifically for the educator and beginner. He can be reached at 8 Whitehills, Saline, Fife, Scotland KY12 9UJ.

Other books and articles of interest are listed below.

Space Radio Handbook, John Branegan, GM4IHJ, Radio Society of Great Britain.

Satellite Experimenter's Handbook, Martin Davidoff, K2UBC, ARRL 1990, 2nd Edition.

A Turnstile Antenna for Two Meters, Joe Kasser, G3ZCZ, 73 Magazine, June 1978.

Antennas for Microsat Ground Stations, Dick Jansson, WD4FAB, The AMSAT Journal, Volume 13, Number 1, March 1990.

Satellite Antennas from Recycled Junk, Howard Sodja, W6SHP, Proceedings of the OSCAR Seminar, September 29 & 30, 1990. Available from Project OSCAR Inc.

Microcomputer Processing of UoSat-OSCAR 9 Telemetry, Robert J. Diersing, N5AHD, The Satellite Anthology, Pages 46-51, ARRL, 1988.

The First Flock of Microsats, Tom Clark, W3IWI, Jan King, W3GEY, Bob McGwier, N4HY and the AMSAT team, The AMSAT Journal, Volume 12 Number 1, May 1989.

Ariane Launch Vehicle Malfunctions - Phase 3A Spacecraft Lost!, Tom Clark, W3IWI, Joe Kasser, G3ZCZ, Orbit Magazine, Volume 1 Number 2, June/July 1980.

12.0 Change History

1.00 (4/01/91) Initial Release.

1.10 (7/15/91) Converted to TP 6.0. Break procedure added on TNC port. Radio port parameters added to WHATS-UP.SYS. Autotrack added. Default radio freq/mode added. TNC and Radio Serial Port values 0 added to allow WHATS-UP to run in a multi-tasking environment without interfering with the serial ports. Directory path changed to apply only to capture-to-disk files. Debug Menu added. Radio Menu changed. CW telemetry automatic capture-to-disk added (for A-O 21).

1.20 (11/08/91) SARA, TNC1, TNC2, PK-88, KAM and MFJ-1278 added.

APPENDIX 1 Obtaining Further Information Page #

For further information about any of the spacecraft and the Radio Amateur Satellite program, photocopy and mail the following form together with a self addressed stamped envelope (SASE) to :-

To:

[] Project OSCAR Inc. POB 1136, Los Altos, CA. 94023-1136.

[] AMSAT-UK, 94 Herongate Road, Wanstead Park, London E12 5EQ. Telephone (081) 989 6741.

I read about the Radio Amateur Satellite program in WHATS-UP and am interested in it. Please send me further information about the program, and details of membership in your organization.

CALL _____ TODAY'S DATE _____

NAME _____

ADDRESS _____

CITY _____

STATE _____ POSTCODE _____

Comments and questions ...

APPENDIX 2 Amateur Radio Software by Joe Kasser G3ZCZ

PC-HAM 3.52

PC-HAM contains a number of programs some of which are described below.

LOGBOOK

Full blown logging package. With automatic check of logs for awards such as DXCC. Allows you to recall any entry by call sign within seconds. Indexed displays, QSLing, Contest mode QSLing (prints the lot) and lots more written in dBASE3, but a compiled LOGBOOK.EXE file is supplied together with the source code.

CONTEST

Keeps Dupes in memory, logs QSO's to disk in format which can be processed by the LOGBOOK package.

CQSS

Sweepstakes game. Work the ARRL Sweepstakes contest on your computer. You are located just outside Washington DC. A propagation model is built in to the program. This program is REQUIRED training for all sweepstakes operators. Program is based on the one described in detail in 'Software for Amateur Radio' by Joe Kasser G3ZCZ, published by TAB Books, Blue Ridge Summit, PA. 17214.

WHATSON

Predict HF Propagation. Contest mode with printout to whole world at hourly intervals. Needs BASIC

LAN-LINK 1.59

LAN-LINK will capture AMSAT related bulletins from packet radio BBSs automatically. Amongst its many features are :-

Zmodem binary file transfer capability.

Function key and Menu driven.

Automatic logbook entries for Packet and Mailbox/Beacon Mode AMTOR Connects, semiautomatic logbook entries for other modes. Log file can be processed by the Logbook Package of PC-HAM. Contest operation, sends standard message and automatically increments QSO count. Automatic optimized configuration of the TNC for each communications mode.

All mode Function key 'OVER' feature (End). There are 10 files with fixed names (LAN-LINK.001 through LAN-LINK.010)

which may be viewed and transmitted by means of function keys. They may also be edited from the Edit Menu.

Time display and event scheduler. ASCII Text Editor. Customizable Colors. Access to the TNC Command Mode is provided in case the user wishes to override any defaults.

Automatic capture to disk of all packet radio connects. Automatic indication of the number of Packet connects. Local Area Network (LAN) message store and Forward capability. Capable of automatic connect attempts to download a QTC from another station in the LAN. Capable of automatic connect attempts to a packet BBS to download your incoming messages, when your callsign appears on the BBS mail beacon annunciator.

Capable of automatically requesting Bulletins on subjects that interest you from your local packet BBS. Digipeat monitoring and capture. Alert signal to let you know when a predetermined call shows up in a packet header on frequency.

Conference Mode in multiconnect situations. Bridge Mode in multiconnect situations. Path determination to DX station via :QMH:. Indicator that a specific station designated as the 'target' call connected in Packet Mode, or linked to AMTOR Beacon/Mailbox while you were away. Automatic NET/ROM and KA Node path set up from LAN-LINK.DIR call/path directory file.

Selective answering machine and MAILBOX using NC/L command dialogue. Screen indication of connect by desired station (target call).

Automatic Beacon Mode CQ caller. Will call CQ repetitively and either work the connect and keep going after disconnect or signal you when a reply is received. SAREX special features. :QRA: trigger to determine who else is on channel. Automatic AMTOR SELCAL determination.

Function key change from monitoring AMTOR FEC CQ's to QSO's in progress (chirpcopy). NAVY MARS RTTY file transmitting protocols for the PK-232. Log files in dBASE 3 format. AND MORE !!!!!

WHATS-UP APPENDIX 3 SHAREWARE Page #

The Association of Shareware Professionals (ASP) has established standards for its members and for any organization which has "ASP Approved" status. The ASP wants to make sure that the shareware principle works for you. If you are unable to resolve a problem with an ASP member or organization (other than technical support), the ASP may be able to help. Please write to

The ASP Ombudsman, 545 Grover Rd, Muskegon, MI. 49442, U.S.A.

You are encouraged to copy the floppy disk and share it freely with others. You have the luxury of trying out the product at your own pace and in the comfort of your own home or workplace.

After you have used the material for a reasonable evaluation period (90 days), you should either discontinue use of the material or register your copy. Your support is important and greatly appreciated. With it, Shareware authors are encouraged to design and distribute new products. Without it, a great deal of high quality, low cost software will cease to be available.

Why pay at all?

- * You receive support from the author.
- * You receive a CURRENT copy of the program.
- * Your input and ideas help shape future products.
- * A sense of pride and ownership in having honestly participated in the Shareware revolution.
- * You help to keep software prices down by supporting a distribution method which doesn't depend on expensive advertising campaigns.

Be aware of the following restrictions, designed to protect the community of Shareware users and to prevent greedy people from taking unfair advantage of the trust, hard work and good will of Shareware authors.

1. No price or consideration may be charged for the material. However, a distribution cost may be charged for the cost of the diskettes, shipping and handling, not to exceed \$6.
2. The files and programs on the disks may not be modified or deleted.
3. The material cannot be sold as part of some other more inclusive package.
4. The material cannot be "rented" or "leased" to others.
5. The end user must be told clearly in writing on the outside of the package and in all advertising that the diskette(s) are "Shareware."

6. The package must contain a written explanation that the disk is for evaluation purposes, and that an additional "registration fee" is expected by the author, if the material is used beyond an initial evaluation period.
7. In the case of distribution via any telecommunications link, the following must be done:

An error checking protocol must be used.

The individual files must be combined into, and transferred in a library or archive format.
8. Shareware distribution is permitted only in the United States, Canada, England, and Australia.

WHATS-UP 1.20 Registration form

WHATS-UP 1.20 Registration Fee \$35.00
LAN-LINK 1.59 Registration Fee \$35.00
PC-HAM 3.52 Registration Fee \$36.50
Register them all for \$95.00.

Evaluation Copies free, you pay only for the disk/postage. For an evaluation copy (unregistered full blown version) of each software send a formatted disk and SASE to Joe Kasser. Overseas users, send \$5.00 (\$10.00 covers all three) instead. Try the software first, and only register your copy if you make use of it.

To: Joe Kasser G3ZCZ, P O BOX 3419, SILVER SPRING, MD 20918.

CALL _____ TODAY'S DATE _____

NAME _____

ADDRESS _____

CITY _____

STATE _____ POSTCODE _____

TNC TYPE _____ Home BBS _____

I enclose a check for _____. Please send me the latest version of _____, and register me as a user.

I enclose a disk/sase or \$5.00. Please send me the latest version of _____ to evaluate. If I like it and use it, I plan to become a registered user.

Disk Size 5.25 _____(360k) 5.25 _____(1.2Mb) 3.5 _____(730k)

I AM NOT/AM currently using Shareware Version _____ which I obtained from _____.

Signature _____

Classroom Registration 6 to 10 copies \$195.00.
Radio Club Registrations 10 or more copies, 10% discount.
50 or more copies, 25% discount.

Clubs; designate one contact person to receive classroom or club registered updates, and supply a list of names and call signs of club members who will be using the Registered Club Copy.