ION Operations Handbook

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ION Ground-Station & Communications Teams

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Contents

Chapter 1

Introduction

The goal of this handbook is to help orient people with the ground station. The intent was for all members of the team to submit topic from their areas of expertise.

1.1 Assumptions

This handbook works under the assumption that one has a basic understanding of amateur radio operations and has at least a technician class license. If one of these prerequisites are not met, one should contact an amateur radio operator for more information. Information on getting licensed can be gotten from the ARRL - the Amateur Radio Relay League. Their URL is in the appendix of this handbook.

1.2 Revision History

Initial Revision - December 05 - David Stipp

Chapter 2

Equipment

Station equipment - from antennas to radios.

2.1 Ground Station

The ground station consists of three primary areas: the computer interfaces, the radios, and the TNC.

Current configuration of ground station equipment can be seen in figure 2.1.2 as diagrammed by Alex Rein in the Fall of 2005.

2.1.1 Radio Equipment

Radio communications is provided by the ICOM IC-910 satellite radio. Operations manuals can be found on ICOM's website and physically in the ground station.

2.1.2 Terminal Node Controller - TNC

Uplink and downlink data from ION and any other packet satellite is provided by a Kantronics TNC. This handles converting the AFSK data to ASCII that is fed to the computer via serial. It can then be accessed directly, or parsed using the ION control software.
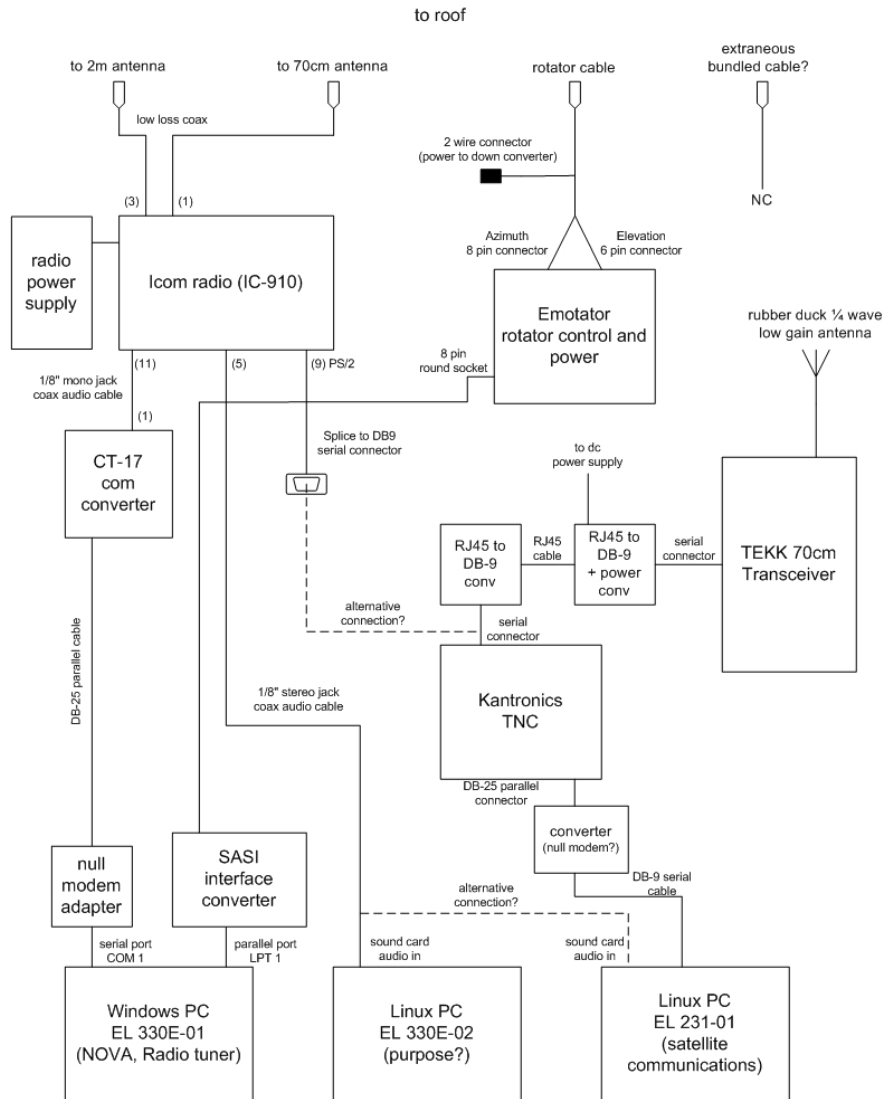
to roof

to 2m antenna   to 70cm antenna   rotator cable   extraneous
                                                                        bundled cable?

low loss coax

2 wire connector
(power to down converter)

NC

(3)   (1)

Azimuth   Elevation
8 pin connector   6 pin connector

radio
power
supply

Icom radio (IC-910)

Emotator
rotator control and
power

rubber duck ¼ wave
low gain antenna

(11)   (5)   (9) PS/2   8 pin
                                   round socket

1/8" mono jack
coax audio cable

(1)

Splice to DB9
serial connector

to dc
power supply

CT-17
com
converter

RJ45 to
DB-9
conv

RJ45   RJ45 to
cable   DB-9   serial   TEKK 70cm
              + power   connector   Transceiver
              conv

alternative
connection?

serial
connector

Kantronics
TNC

1/8" stereo jack
coax audio cable

DB-25 parallel
connector

converter
(null modem?)

null
modem
adapter

SASI
interface
converter

alternative
connection?

DB-9 serial
cable

serial port   parallel port   sound card   sound card
COM 1   LPT 1   audio in   audio in

Windows PC   Linux PC   Linux PC
EL 330E-01   EL 330E-02   EL 231-01
(NOVA, Radio tuner) (purpose?)   (satellite
                                       communications)

Figure 2.1: Station Diagram - Alex Rein

2.2   Roof

All of the antennas that the ground station use are currently on a single tower on the roof. The electronics shop provides assistance to the ground station team whenever maintenance needs to be done on the tower. A minimum of two people are needed to complete this operation safely. When lowering the tower, remember to position the antennas in a position that will allow safe lowering of the tower. This position is roughly 270 degrees azimuth and 90 degrees elevation.

Current configuration of external ground station equipment can be seen in figure 2.2 as diagrammed by Alex Rein in the Fall of 2005.
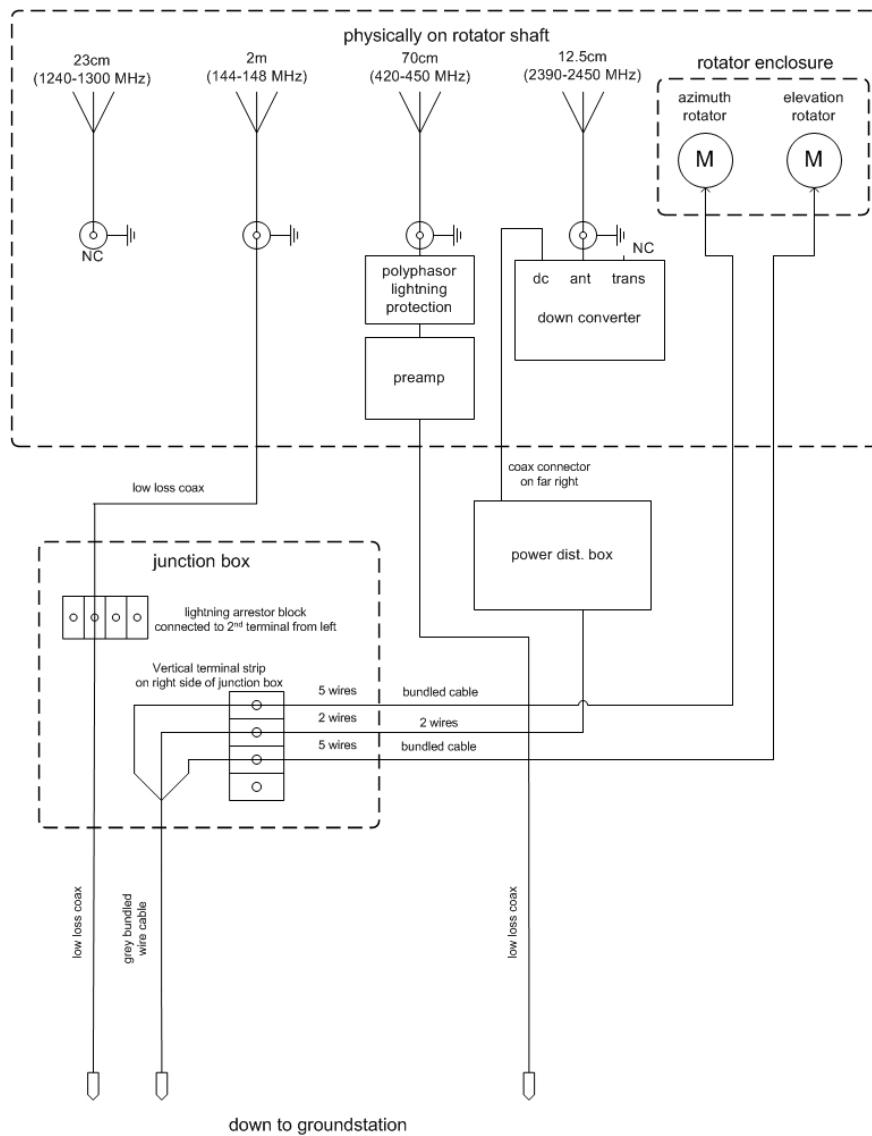
Figure 2.2: Roof Diagram - Alex Rein

Chapter 3

Tracking

How do we track things?

3.1 Nova

(From NLSA) Nova for Windows has become the most popular Windows-based satellite tracking program in the world. In use by NASA, the U.S. Air Force, industry, and thousands of amateur radio operators, Nova sets the standard for excellence.

Nova includes realistic maps that are shaded to show vegetation, topography, and ocean bathymetry. Satellite positions are shown with accompanying ground tracks, orbital paths, and star background.

3.2 Predict

PREDICT, released in 1999, is an open-source satellite tracking and orbital prediction program written for the Linux OS. It currently runs on Unix systems and derivatives, such as Linux and Mac OS X. Additionally, a DOS version exists with limited functionality. Satellite tracking is implemented mainly through a plugin called "Fodtrack", but can be accessed through an API in PREDICT. Radio control is also possible using the gsat tool, a graphical frontend to PREDICT.

The current version of the software is version 2.2.2 for Unix, released on June 24, 2004. A recent compilation package called "Portable PREDICT Plus" was released in Feburary of 2005. It is a stand-alone version that boots from floppy disks "that includes PREDICT, MoonTracker, Fodtrack, PB/PG, AX.25 Utils, Minicom, PacsatTools, and a host of related utilities." The program is in a mature phase of developement, hence the slow release cycle.

Currently, the ION ground-station consists of a Unix (Linux) and a Windows based machine. All tracking activities are handled by Nova on the Windows machine. The ION communications software runs on the Unix machine. One of the main advantages of moving to PREDICT is platform consolidation. This would allow for a single point of control for

ION ground-station activities. Another major benefit is the the access to the program source code. This would allow special customizations or safety checks to be written into the rotor control module, to prevent another incident pertaining to damaging the rotor.

These benefits are not without cost. As compared to Nova and it's companion programs, PREDICT and its add-ons are much harder to use. There is a significant learning curve to PREDICT's main interface. In addition, the issue of actually controlling the rotor and radio come up. Radio control appears to already be implemented for ICOM receivers. Since all ICOM equipment uses the same interface, it should work for our transceiver. At this time, the major roadblock seems to be the rotor control interface. At this time, it is unknown if the "fodtrack" controlling software will work with our existing setup. Testing will be required once the rotor is operational again.
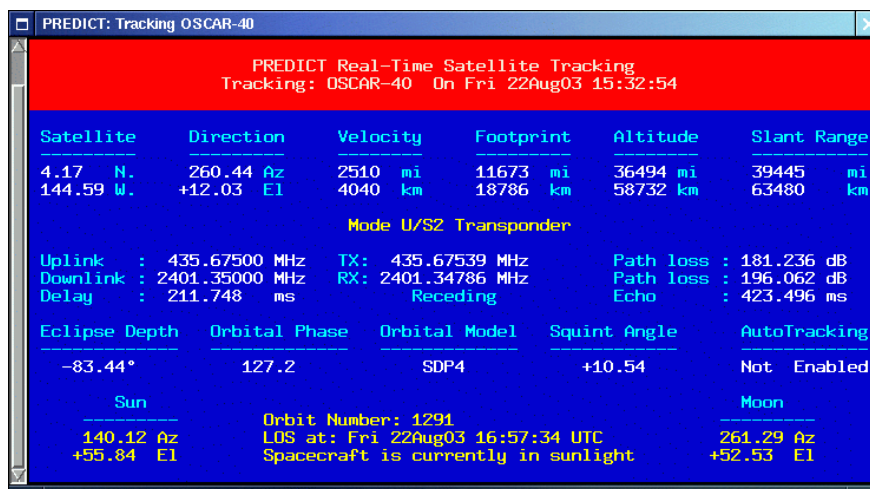

Figure 3.1: Predict - Single Satellite Tracking

The ION ground-station can easily use the existing Nova package, or can be converted to the PREDICT package. The Nova package will be much easier for people to use and debug, and has the added bonus of auto-update of the Keplerian elements. There is, however, no access to the Nova code for any type of customizations. If PREDICT was chosen, ground-station operations could be consolidated onto a single computer machine. Since the source code is available, customizations could be added to any aspect of it. This choice requires much more initial setup work, such as training people to use it, writing code to update Keplerian elements, and possibly having to write code to interface PREDICT with the rotor controller and radio interface box.

If the decision is made to not use PREDICT for primary tracking, the solar illumination calendar that PREDICT provides may provide power budgeting information for mission decisions. This may be worth further investigation.

Date	Mins/Day	Sun%	Date	Mins/Day	Sun%
Fri 22Aug03	925	64.24%	Tue 09Sep03	896	62.22%
Sat 23Aug03	924	64.17%	Wed 10Sep03	916	63.61%
Sun 24Aug03	898	62.36%	Thu 11Sep03	905	62.85%
Mon 25Aug03	925	64.24%	Fri 12Sep03	938	65.14%
Tue 26Aug03	889	61.74%	Sat 13Sep03	936	65.00%
Wed 27Aug03	894	62.08%	Sun 14Sep03	943	65.49%
Thu 28Aug03	899	62.43%	Mon 15Sep03	983	68.26%
Fri 29Aug03	873	60.62%	Tue 16Sep03	968	67.22%
Sat 30Aug03	895	62.15%	Wed 17Sep03	994	69.03%
Sun 31Aug03	875	60.76%	Thu 18Sep03	993	68.96%
Mon 01Sep03	870	60.42%	Fri 19Sep03	981	68.12%
Tue 02Sep03	892	61.94%	Sat 20Sep03	1003	69.65%
Wed 03Sep03	864	60.00%	Sun 21Sep03	962	66.81%
Thu 04Sep03	883	61.32%	Mon 22Sep03	963	66.88%
Fri 05Sep03	883	61.32%	Tue 23Sep03	950	65.97%
Sat 06Sep03	869	60.35%	Wed 24Sep03	921	63.96%
Sun 07Sep03	905	62.85%	Thu 25Sep03	939	65.21%
Mon 08Sep03	881	61.18%	Fri 26Sep03	900	62.50%

Figure 3.2: Predict - Solar Illumination Calendar

Chapter 4

ION Control Software

Operations on ION are controlled by event / time based control files. These are written and then uploaded via a control software running on a GTK based program on a *NIX machine.

This section needs work. Leon says: "There isn't any formal documentation on the ground station software, but there should be a fair amount of documentation on the hardware used and how communications with ION works in general in the final reports from past semesters."

Despite repeated requests, no information has been submitted from Leon. This section will be updated after documentation is received.

Chapter 5

Operations

5.1 Tracking

How do I track something? Under Nova, the process is quite simple.

Step one is to ensure that the keplarian elements are up-to-date. (Figure 5.1) Nova automatically downloads new elements from "Space Track" when a valid username and password are entered in the configuration panel. (Figure 5.1)

The next step is to select the active satellite. To select the satellite to track, goto the "Views" menu and select "Configure current view." Under the "Satellites" tab, you can select the satellite that you want to track, and drag it from the left column to the box to the right of the red arrows. To ensure maximum reliability, make sure that there is only one satellite being tracked. Select "Ok."

Once this is done, the satellite will have a footprint displayed on the tracking display. (Figure 5.1)
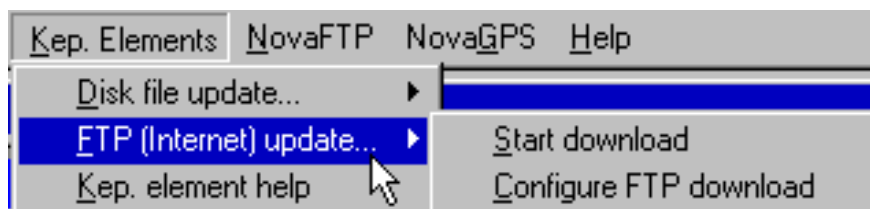
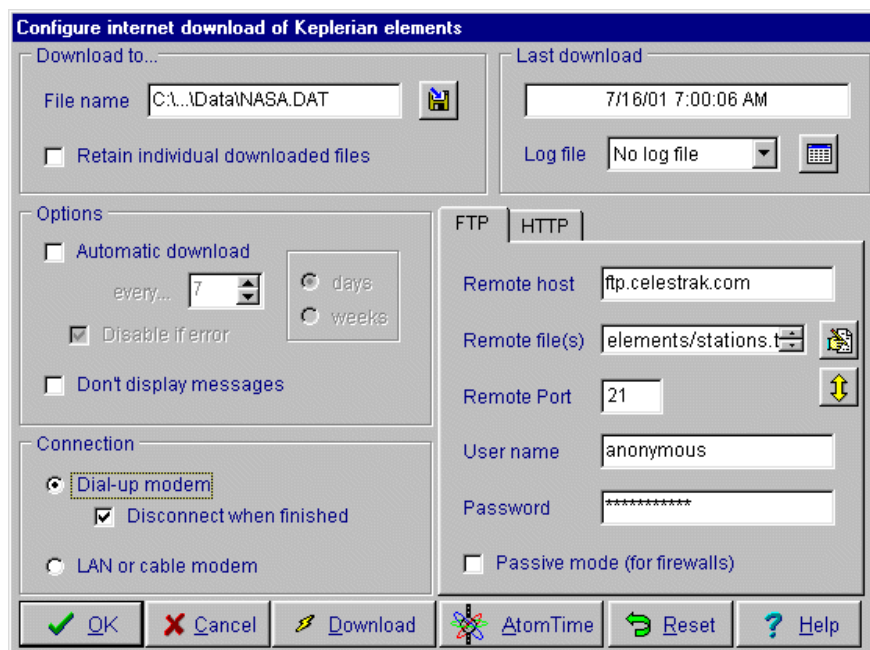Figure 5.1: Tracking - Updating Keplerian Elements

Figure 5.2: Tracking - Keplerian element update configuration

In addition to basic tracking, you can enable automatic rotator control. This is done in the "AutoTracking" menu. Select the "Start AutoTracking" option to have Nova use the rotator to point the antennas in the proper direction.
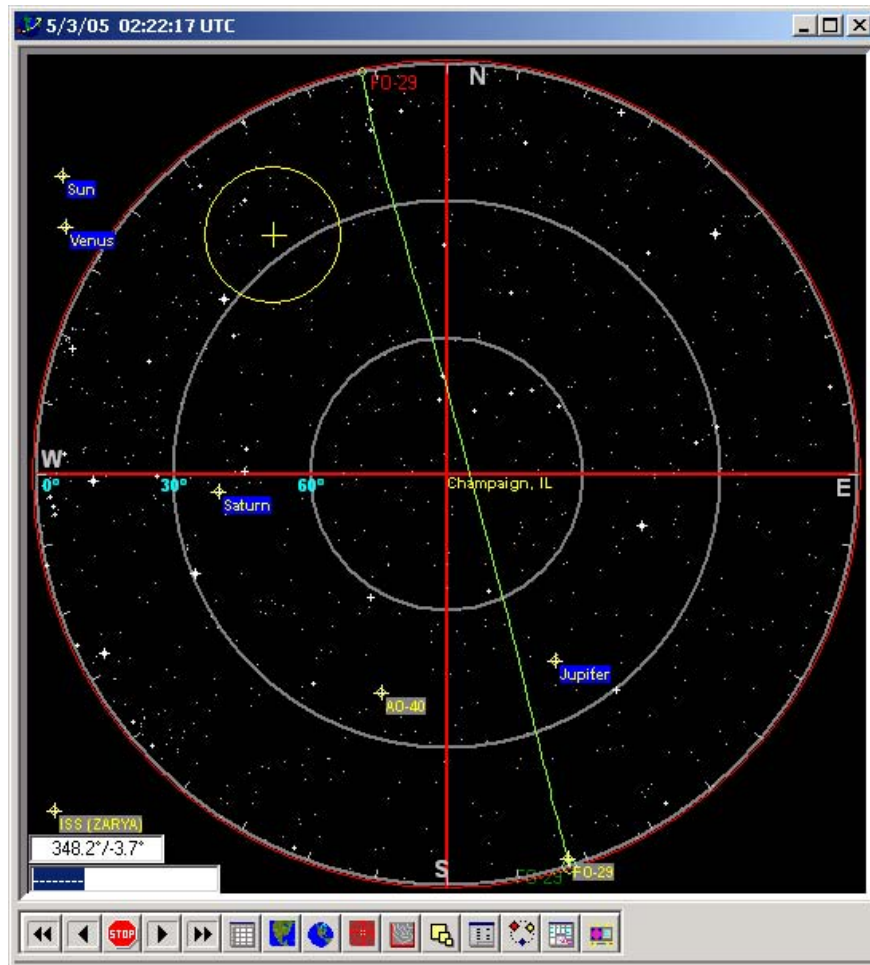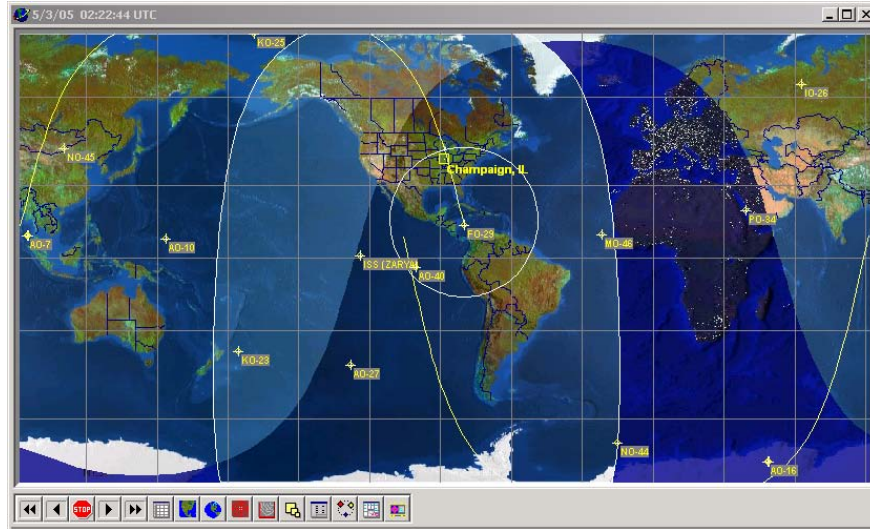

Figure 5.3: Tracking - Sky Radar Map
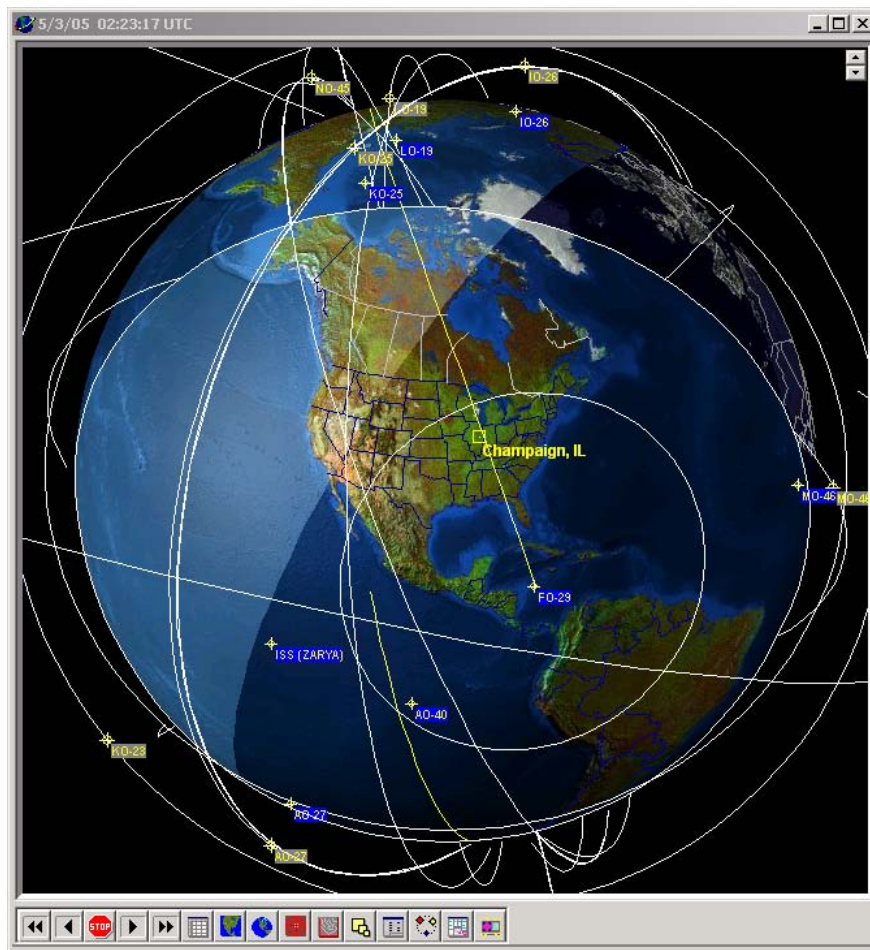
Figure 5.4: Tracking - Rectangular Map

Figure 5.5: Tracking - View From Space

5.2 Radio Communications

Another feature of Nova is automatic frequency control and Doppler shift adjustments. This feature is enabled by starting up the external program "W6IHG Radio Tuner." Once this program is started, select the "Connect to Nova" and "Connect to Radio" options. This will gather the appropriate information and set the radio to the proper modes.
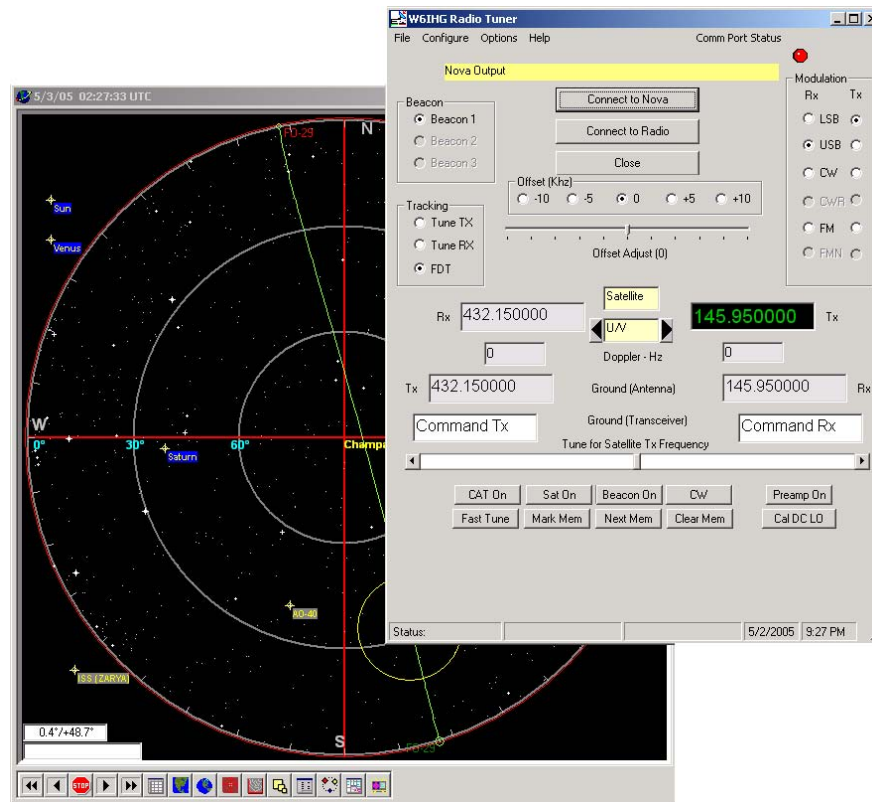

Figure 5.6: Tracking

Once this is done, all that is necessary is to wait for the satellite to enter communications range. When the satellite is above the horizon, communication can commence.

Yes, it really is that simple.

5.3 Downlink Recording

In order to prevent a situation where the audio from the satellite cannot be decoded at present time, the audio can be recorded from the radio's audio output jack. The output audio from the radio can be stored on the computer for further post-processing, applying filters in MATLAB or a similar program.

In order to facilitate this, use the perl script "downlinkrecorder.pl" written by David Stipp

to automatically record audio output from the radio, input into the computer's microphone input.

This script has two major requirements.

First, The Active Audio Recorder plug-in must be downloaded and purchased from http://www.guangmingsoft.net/audiorecord/. Upon purchase, a registration code will be received. This code must be inserted into the perl script in place of the "SetCode" routine.

Second, ActivePerl must be installed. This can be acquired at http://www.activestate.com. Second, the "Net::Telnet" module must be installed. This can be done using the 'ppm' command as shown in figure 5.3.

```
D:\projects\downlinkrecorder>ppm
PPM interactive shell (2.2.0) - type 'help' for available commands.
PPM> install net::telnet
Install package 'net-telnet?' (y/N): y
Installing package 'net-telnet'...
Downloading
http://ppm.activestate.com/PPMPackages/5.6/MSWin32-x86-multi-thread/
Net-Telnet-3.03.tar.gz ...
Installing D:\Perl\html\site\lib\Net\Telnet.html
Installing D:\Perl\site\lib\Net\Telnet.pm
PPM> quit
Quit!
```

Figure 5.7: Net::Telnet installation with "ppm" in ActivePerl

Third, the TCP server must be enabled in Nova. This is done by going to the setup menu, and then to the selecting the TCP option. In the new dialog, select the "Active" option, as shown in figure 5.3.

Once all this is done, the automatic downlink recorder can be run. Ensure that the desired satellite is currently being autotracked by Nova for rotator control, and the Radio Tuner Controller is controlling the radio (IC-910). Then, launch the script. It will connect to Nova, and initiate recording when a satellite is above the horizon. Recordings will be saved in .wav format into the current directory, named with the satellite name and the Unix time. An example of the program output is shown in figure 5.3.

After each of these passes, a .wav file containing a recording of the pass will be left behind.

5.4   ION communications

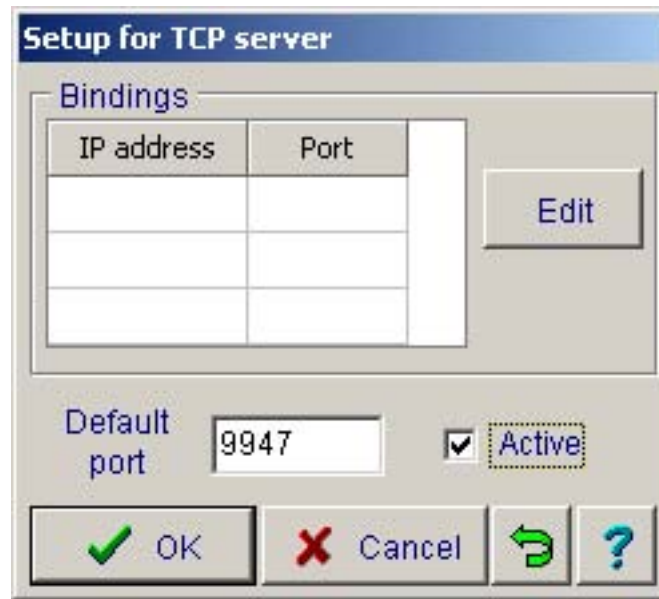See the section on ION Control Software for more information.

Figure 5.8: TCP Server configuration

Leon indicated that most of the major control files have already been written, and are checked into the CVS repository. He promised to write directions on how-to check these files out and upload them to ION using the control software. More forthcoming once he sends them to me.

```
D:\projects\downlinkrecorder>downlinkrecorder.pl
Downlink Recorder v1.0
David Stipp <dstipp@coolhack.net>

ISS (ZARYA) UP: Sat Dec 3 11:04:05 CST 2005
ISS (ZARYA) DOWN: Sat Dec 3 11:14:02 CST 2005
ISS (ZARYA) UP: Sat Dec 3 12:39:53 CST 2005
ISS (ZARYA) DOWN: Sat Dec 3 12:48:57 CST 2005
```

Figure 5.9: Downlink Recorder output

Chapter 6

Additional References

The following contains links to additional references, sources of equipment, operation procedures, and other useful material.

6.1 Amateur Radio

- ARRL - The national association for Amateur Radio
  http://www.arrl.org/

6.2 Cube-Sat Projects

- CubeSat
  http://littonlab.atl.calpoly.edu/

- Cornell CubeSat
  http://www.mae.cornell.edu/cubesat/

- CubeSat Kit
  http://www.cubesatkit.com/

- USNA CUBESAT Notes
  http://web.usna.navy.mil/~bruninga/cubesat.html

6.3 Equipment

- Icom America
  http://icomamerica.com/

- IC-910H - All Mode VHF/UHF/1.2 GHz Satellite Radio
  http://icomamerica.com/products/amateur/910h/

- KD2BD articles on TNCs, Digital Communications
  http://www.amsat.org/amsat/articles/kd2bd/

- PolyPhaser Corporation
  http://www.polyphaser.com/

6.4   Research Papers

- Design of a Distributed Ground Support System for Small Satellites
  http://esl.ee.sun.ac.za/papers/SSC01-VIIIa-3.pdf

6.5   Tracking

- ActiveState Perl
  http://www.activestate.com

- Active Audio Record
  http://www.guangmingsoft.net/audiorecord/

- NLSA - Nova for Windows
  http://www.nlsa.com/

- PREDICT - A Satellite Tracking / Orbital Prediction Program
  http://www.qsl.net/kd2bd/predict.html

- Space Track - The Source for Space Surveillance Data
  http://www.space-track.org/