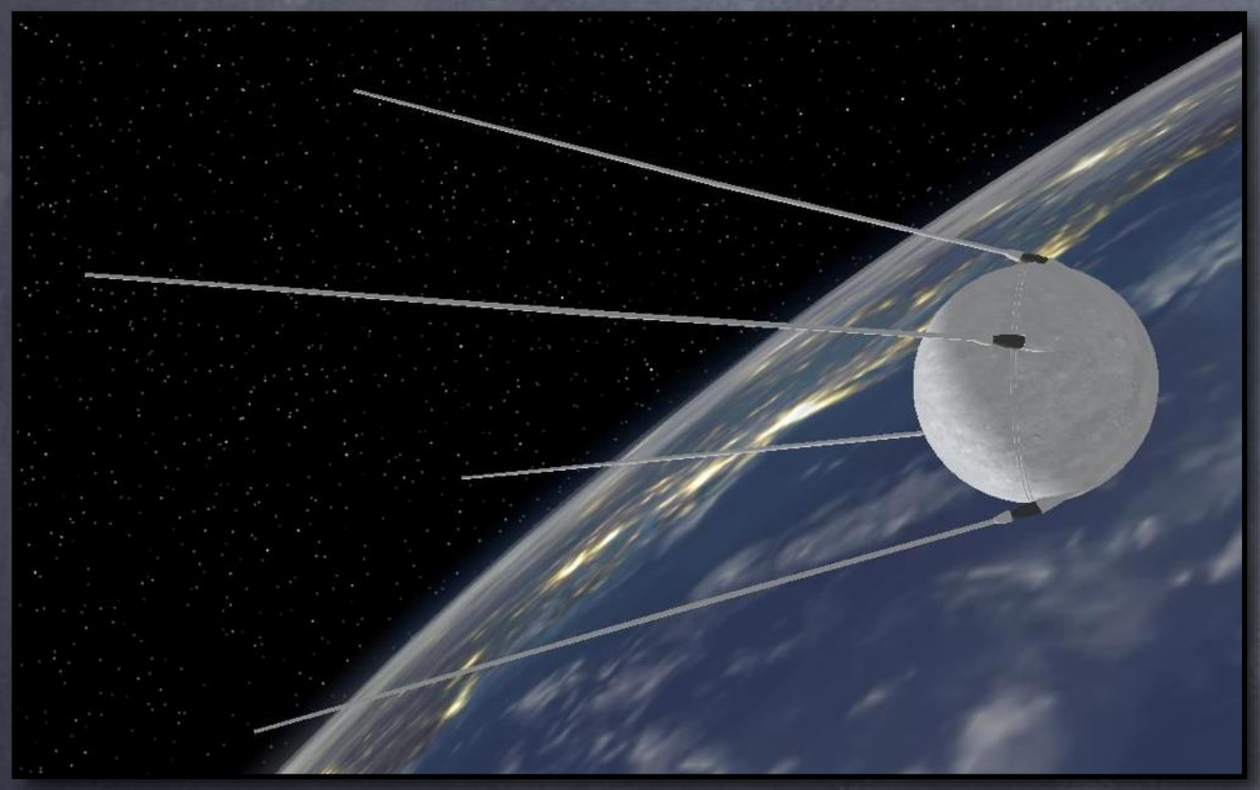
Ham Satellites

A Brief History
and a How To....

by Ed Poccia,
KC2LM

Satellites Through the Decades

1957: Russia launches the first satellite



Sputnik I

* 23 inches in diameter
* 184 pounds
* no sensors onboard
* detectable radio pulses
* lasted 21 days

* Propagation of its radio signals increased our understanding of the ionosphere
* Its orbit helped determine density of upper atmosphere

Hams Get Started in the 60s

Only 4 years after Sputnik,
hams built Oscar 1

* 10 pounds
* 140 mw beacon
* Launched “piggy-back” with Discovery 36 spacecraft
* Built in basements and garages
* Ground stations used signals to measure propagation through the ionosphere
* 570 hams in 28 countries sent observations
* Lasted 22 days in low Earth orbit

The Early Birds

Oscar 2: June 1962

* internal temperature measuring sensor
* external coating to provide cooler internal temperature

Oscar 3: March 1965

* carried a linear transponder
* operated for 18 days
* 1000 hams in 22 countries made contacts
* 50 kHz wide band of uplink signals near 146 MHz with downlink near 144 MHz

The 70s:

Oscar 5: Jan, 1970

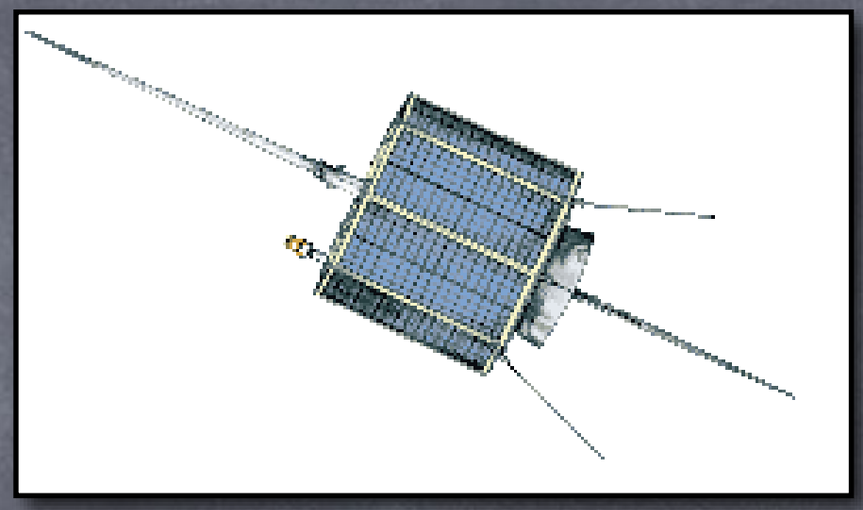
* telemetry beacons on 29 MHz & 144 MHz
* had an magnetic attitude stabilization system

Oscar 6: Oct. 1972

* Improved telemetry:
  internal temps., battery current & voltage
* Codestone;
  an early store & repeat messaging system
* operated for 4 1/2 years

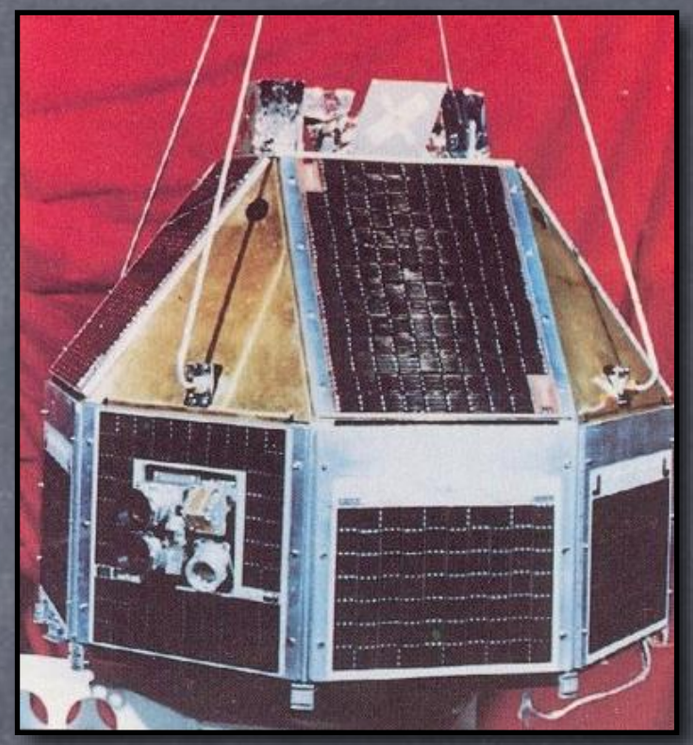
Oscar 7:

known as AO-7, Nov. 1974



* Two Transponders
  - uplink 146 MHz, downlink 29 MHz
  - uplink 432 MHz, downlink 146 MHz
* First satellite to satellite radio link-up
* Operated for 6 1/2 years
* Declared dead in 1981 due to battery failure
* Back to Life in 2002 and supports contacts during sunlight hours
* Build by teams from Australia, Canada & U.S.

Russia's Ham Radio Sputniks



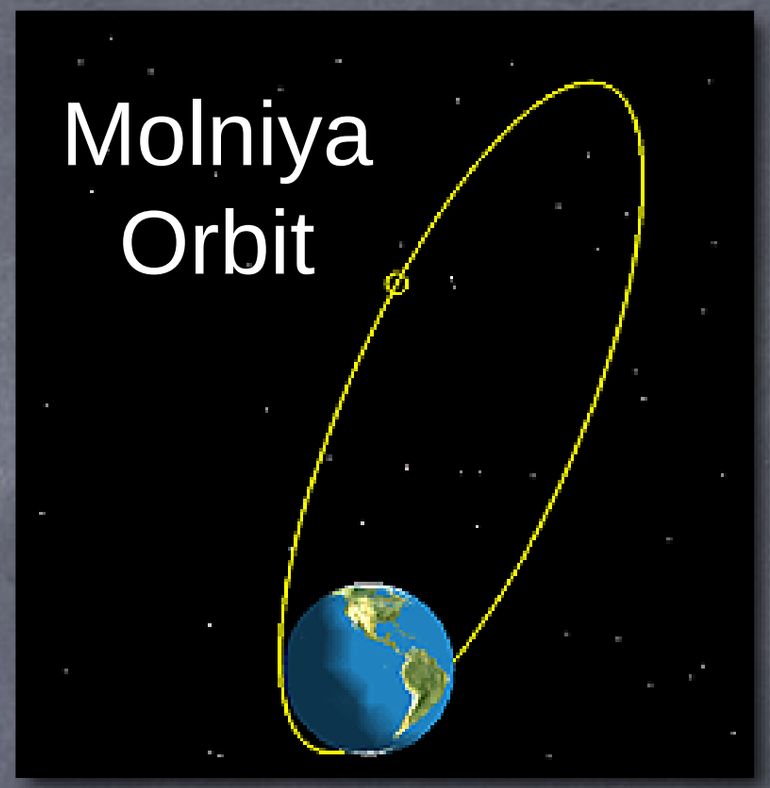
RS-1 and RS-2: July 1980

* Transmitted telemetry beacons in CW
* Receivers had overload breakers
* Hams transmitting hundreds of watts would cause the "birds" to shut down. Western hams kept shutting off the transponders.
* 145 MHz to 29 MHz transponder
* Codestone store and forward mailbox
* Lasted until 1981

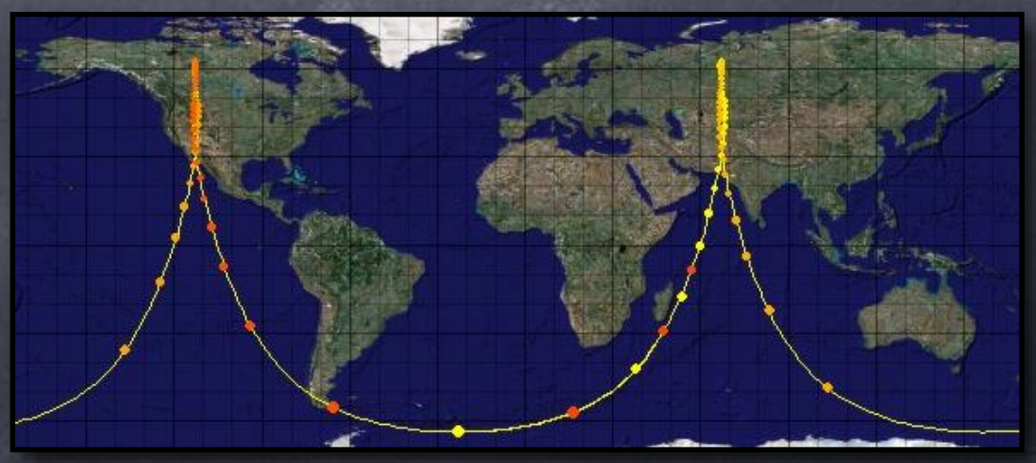
The 80s

Oscar 13: Jun. 1988

"The DX Satellite"



* High elliptical, Molniya Orbit
* Apogee of 22,000 miles
* Perigee of 1500 miles
* Four transponders; packet, slow scan TV, SSB (voice), RTTY, facsimile & morse code
* Transponders received at 435 and 1296 MHz
* Retransmitted at 145, 435, and 2400 MHz
* Onboard computer managed transponder activation
* Satellite appears to "hang" in space



K6LIE's DXCC Contacts via Oscar 13

Germany
Italy
Austria
Corsica
Saudi Arabia
England
Crete
Hong Kong
Sweden
Santa Maria Island
Howland Island
Hawaii
Costa Rica
Wales
Japan
Plus, Plus, Plus

Impressive, and something to look forward too.

The 90s: Age of the Microsats

Oscar 14, AO-14: Jan. 1992

* spent 18 months as a packet store & forward “bird”
* later used to send & receive email in Africa
* In March 2000, returned to Hams use as FM repeater

Oscar 16:

* A dedicated store and forward file server @ 1200 baud
* Files & emails could be “broadcast” to stations under the Satellites footprint

Oscar 25: Sept. 1993

* took pictures for transmission back to Earth
* measured radiation
* useful receive & forward message system

The Future

* It's difficult for AMSAT to build & launch a complex bird relying solely on member dues, volunteer workers & donations.

* The German AMSAT organization is building a Phase III, high altitude DX satellite.

* An Phase IV geosynchronous amateur radio multi-transponder module to be included on Intelsat
  - reside inside the Intel spacecraft
  - use a common power source
  - promises continuous 24/7 hemisphere-wide communications

AMSAT

For Hams interested in the exploration of space

* Formed in 1969
* Participates in majority of ham Sat projects
* Responsible for Breakthroughs:
  - first voice transponders
  - first with “store & forward” messaging
  - first satellite to satellite link
* A true Volunteer Operation
* Offers: news, satellite status, pass predictions
* Operating revenue comes from membership dues
* Offers satellite tracking software &
  has links to decode satellite telemetry

Awards: VUCC (100 Grids),
AMSAT Achievement (20 States)

Ham Radio & the ISS

Uplink	Downlink	Mode
144.490	145.800	Crew Contact FM Region NA
*145.99	145.800	Packet BBS
*145.825	145.825	APRS Digipeater
	145.490	SSTV
437.800	145.800	FM Repeater

ARISS: Connecting Schools with Astronauts

Access amsat.org for pass predictions

* Temporary Change Currently in Place

The Two Meter ARISS Packet System is Currently Inoperative

The 70cm ISS Packet is Now Functioning on 437.550 MHz. +/- for Doppler

Memory Channel #	Receive Freq.	Trans. Freq.
1	437.560	437.540
2	437.555	437.545
3	437.550	437.550
4	437.545	437.555
5	437.540	437.560

* Change Memory Channels as the Pass Progresses
* The 2 mtr. repeater is scheduled to be replaced in late 2017

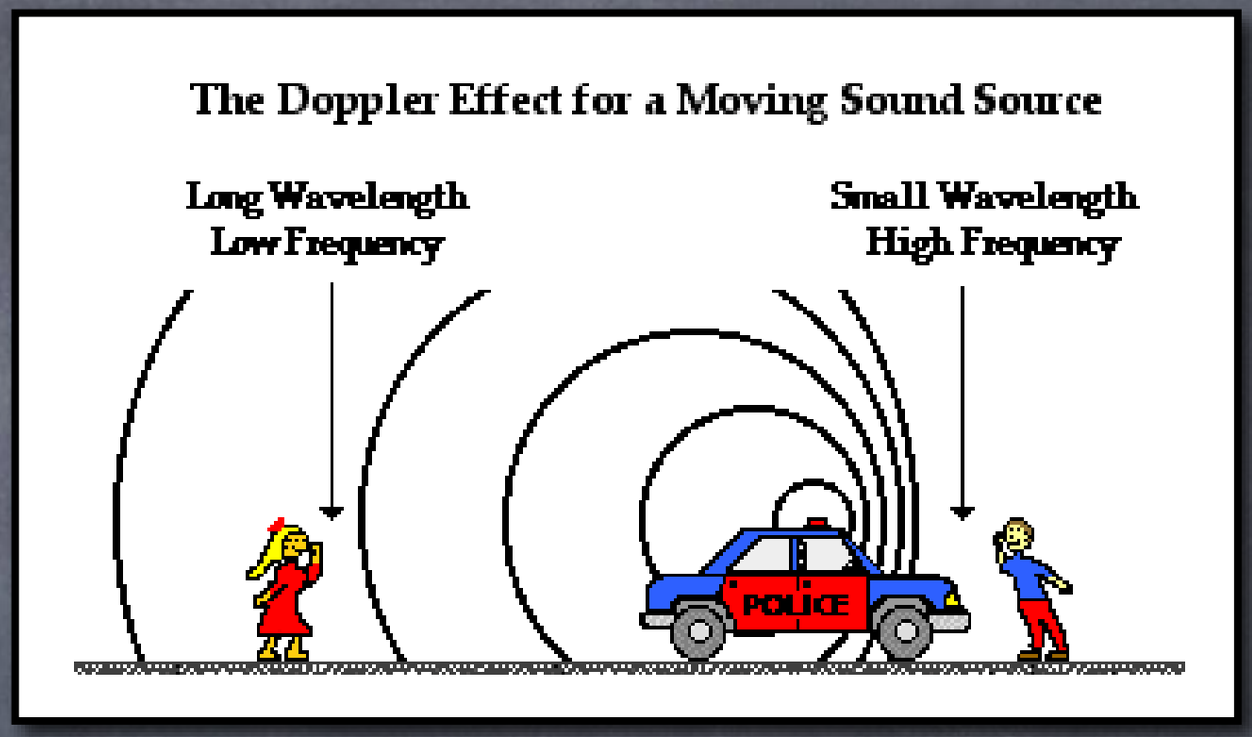
Active Satellites amsat.org/status

Satellite	Uplink	Downlink	Mode
Oscar 85 AO-85	435.172 w/67 Hz tone	145.980	FM Repeater Use 20+ watts
Oscar 50 SO-50	145.850 w/67 Hz tone	436.795	FM Repeater Dual Band Hts
AO-73 Educational SAT		145.935	BPSK Beacon & Telemetry

* These Ham Sats are a good place to start. They can be accessed easily using minimal equipment and have frequent passes over the American SW.
* The listed frequencies are “central frequencies” and adjustments need to be made to allow for doppler shift.

Doppler Shift

The **doppler effect** is observed whenever the source of waves is moving with respect to an observer.



SO-50

The 2 mtr FM pass band is large enough that adjusting for doppler on 2 meters transmit frequencies is not needed.

Ch #	*Name*	*TX Freq*	*CTCSS*	*RX Freq*	*CTCSS*
501	50 +4	145.850	67.0	436.815	None
502	50 +3	145.850	67.0	436.810	None
503	50 +2	145.850	67.0	436.805	None
504	50 +1	145.850	67.0	436.800	None
505	*50 74*	*145.850*	*74.4*	*436.795*	None
506	**SO-50**	**145.850**	**67.0**	**436.795**	**None**
507	50 -1	145.850	67.0	436.790	None
508	50 -2	145.850	67.0	436.785	None
509	50 -3	145.850	67.0	436.780	None

In Practice: The frequency memory set here works better for low angle passes. Adjust Tx frequencies for Doppler for passes with high elevations. (+/- .005 MHz)

Hams Satellites & S.T.E.M.

Decoding Satellite Telemetry

- Graphing internal satellite temperature over time
- Graphing battery voltage & current over time

Communicating Through Satellites

- Reading & Graphing Pass Predictions (reading data charts)
- Azimuth and Elevation (reading compass & protractor)
- Operating TX & Rec. , Antenna Alignment & Tuning

Building Satellite Antennas

(use of formulas & measuring devices)

- Simple Fixed Antennas: Helix, Turnstile,

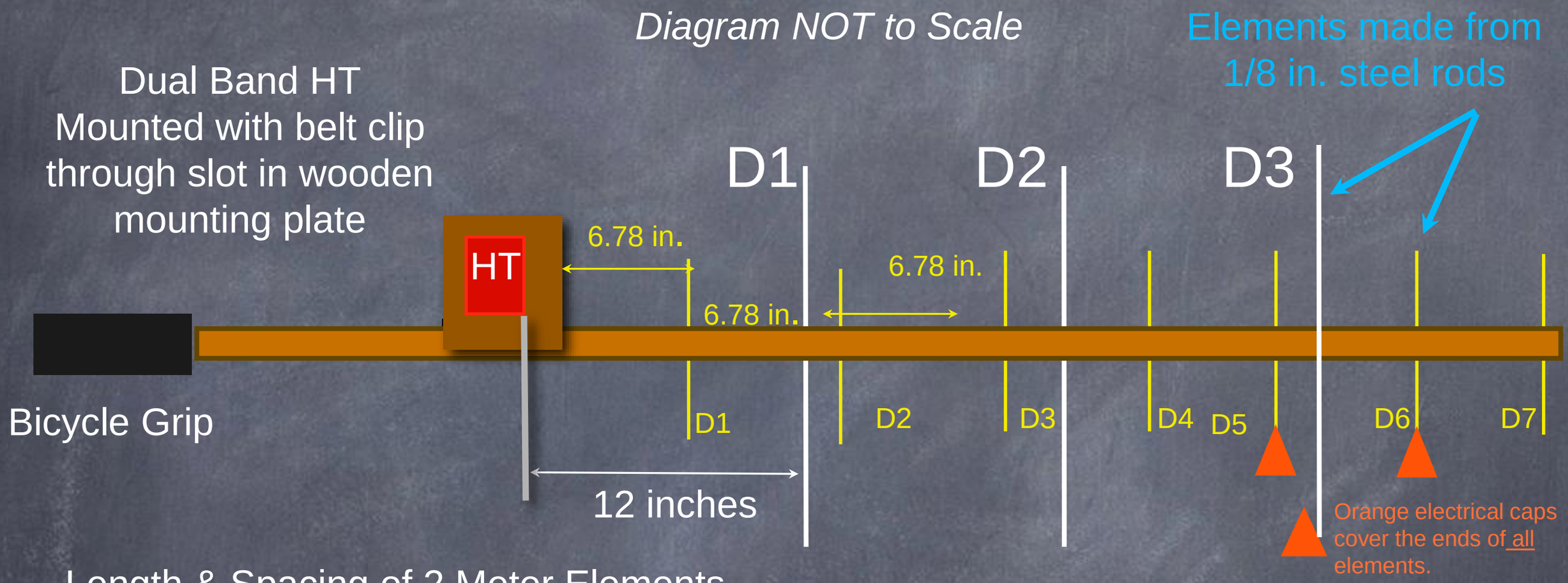
  (ARRL Satellite Handbook)
- Hand Held Yagi
- Building models of satellite stabilization systems

Moxon Rectangle

Simple Yagi for the SO-50 Satellite

(without Driven Element, Reflector, Matching Network or Feed Line)

Diagram NOT to Scale



Length & Spacing of 2 Meter Elements

Dimensions in Inches

Director	D1	D2	D3
Length	37.5	36.375	36
Ele. Spacing	D1 to D2	D1 to D2	D2 to D3
Spacing	12”	12”	12”

Length of 70 cm Elements

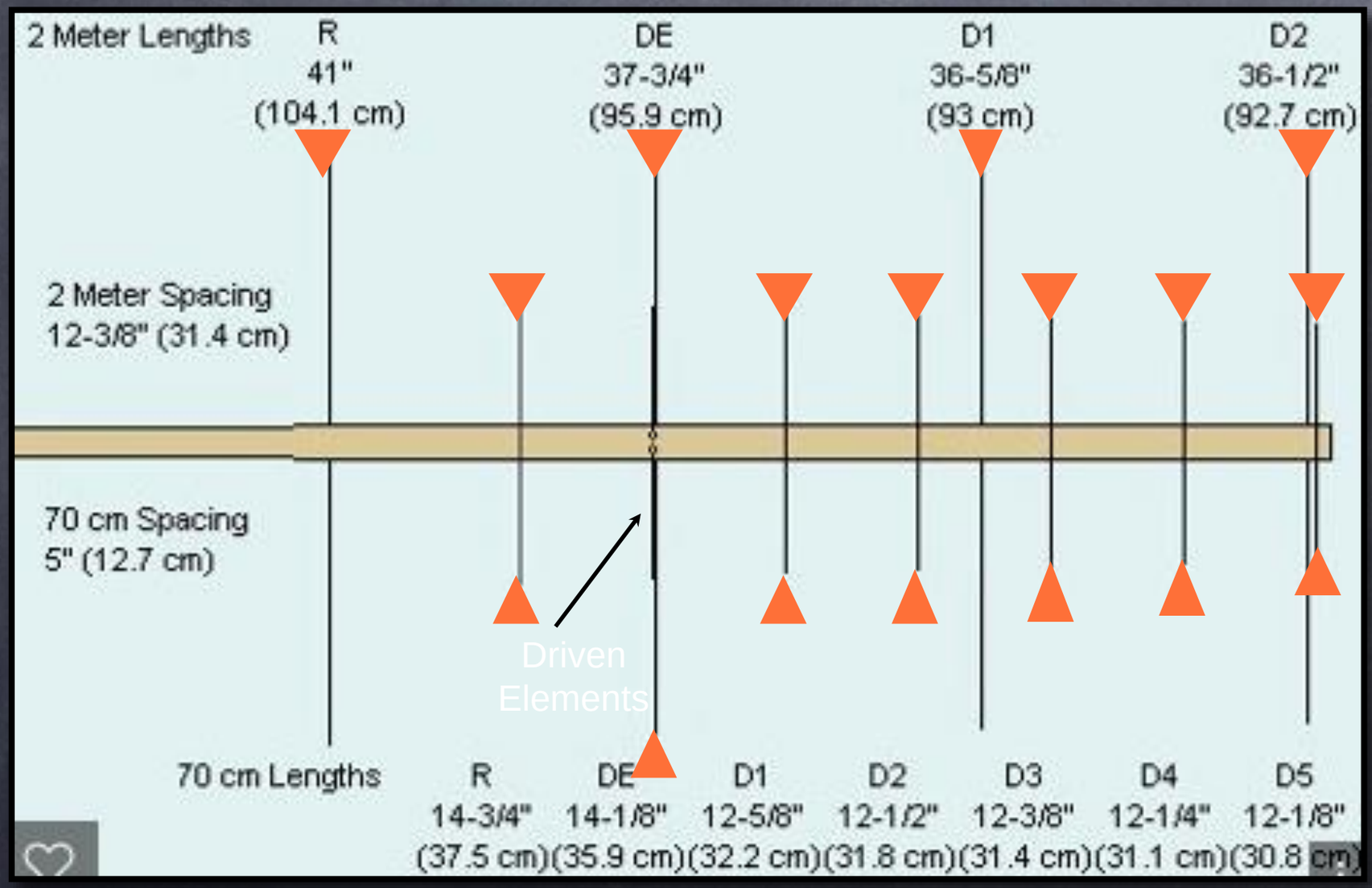
Dimensions in Inches

D1	D2	D3	D4	D5	D6	D7
11.750	11.688	11.625	11.563	11.500	11.438	11.375

All 70 cm Element Spacing = 6.78 in.

Dual Band Yagi for HTs

* A 1”x2” pine board acts as the boom.
* 1/8 inch steel rods function as elements.
* Feed Line: RG8X, w/four loops of 4” as balun



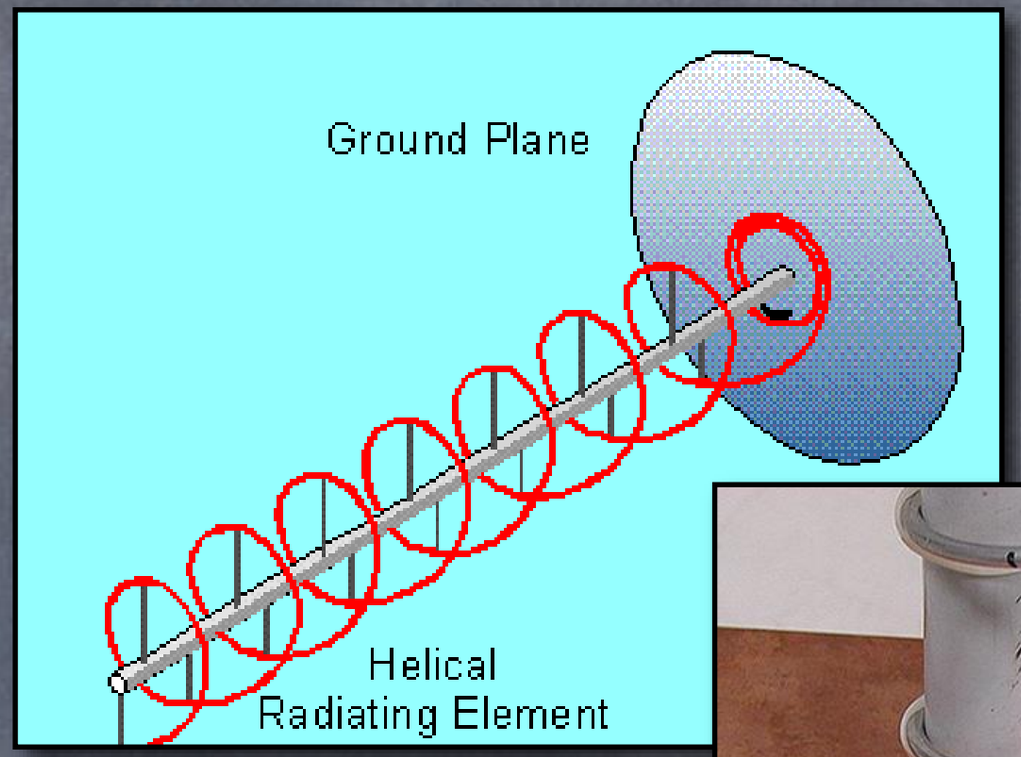
The driven elements, 2 mtr on one side, 70 cm on the other are mounted to the boom with a bolt connecting the two. Ground lugs hold the elements and have coax leads attached.

Screw electrical caps ( ) into the end of each element for safety.

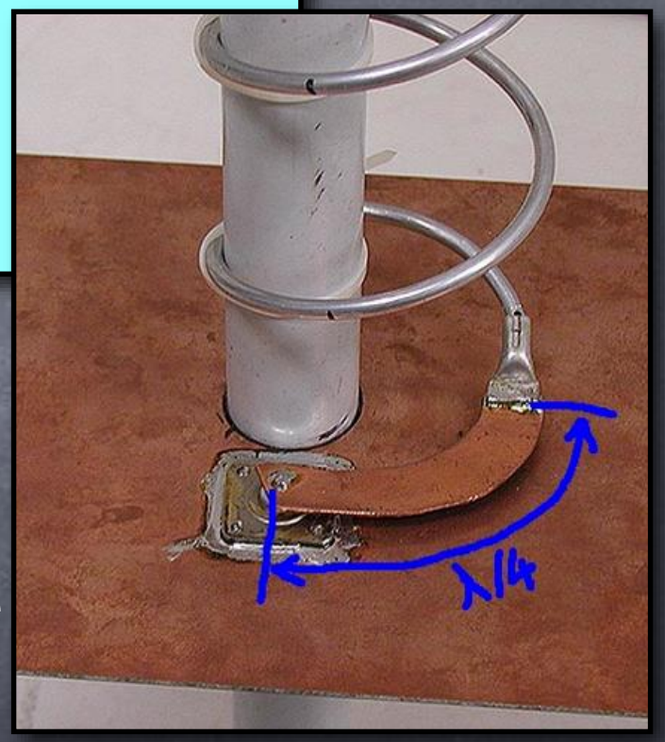
Turnstile Antenna

An axial-mode turnstile antenna consisting of a pair of driven crossed dipoles above a pair passive crossed dipoles serving as a reflector.

Helix Antenna



A helical antenna is an antenna consisting of a conducting wire wound in the form of a helix. In most cases, helical antennas are mounted over a ground plane. The feed line is connected between the bottom of the helix and the ground plane.



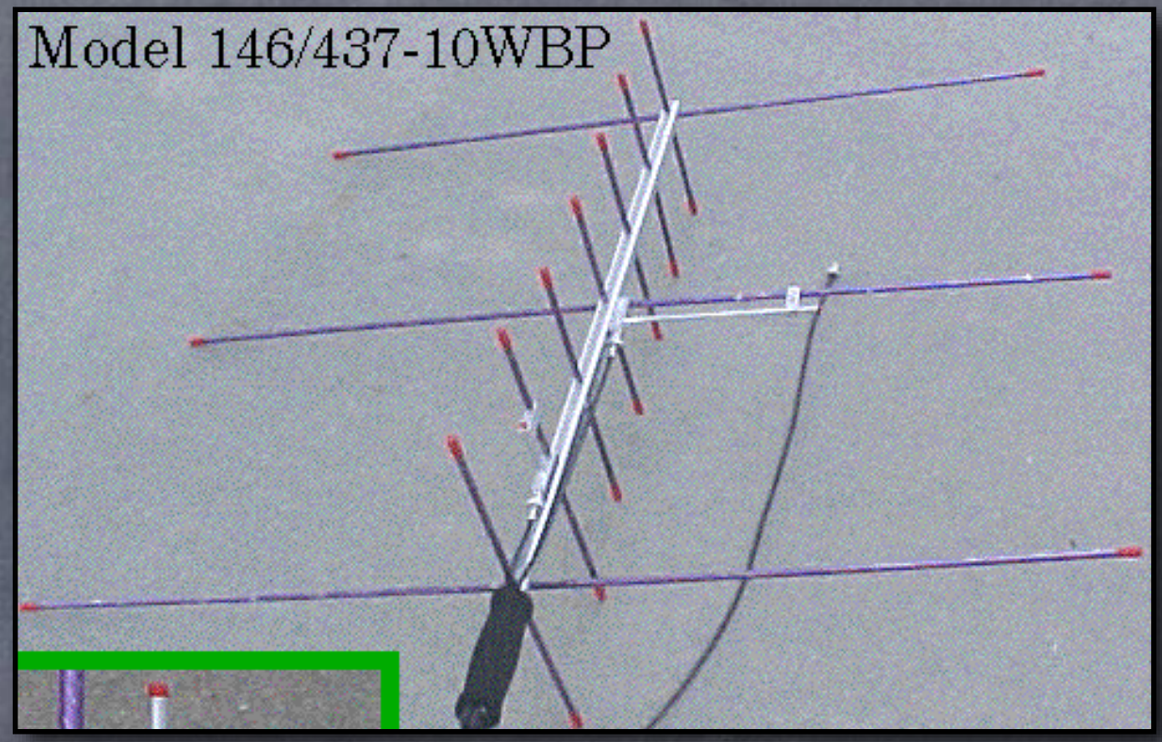
Commercial Satellite Antennas

Elk Log Periodic

elkantennas.com

* Breaks down to a convenient size in minutes
* Fits into backpack for Mtn. topping
* $120

Arrow Antenna



arrowantenna.com

* popular antenna for Satellite work
* $85 to $140 depending on features

To Work a “Bird”

The SO-50 satellite is a FM Repeater, EZ to work with a HT and a simple home made yagi antenna with at least one good pass per day.

1. Access amsat.org
2. Click on Satellite Info
3. Select Pass Predictions from the pull-down menu

To Work a "Bird" (con't)

4. Select the SO-50 Satellite from the pull-down menu

5. Input your location data

(The Grid for Abq is DM65)
(Abq.'s Elevation is 1500 meters)

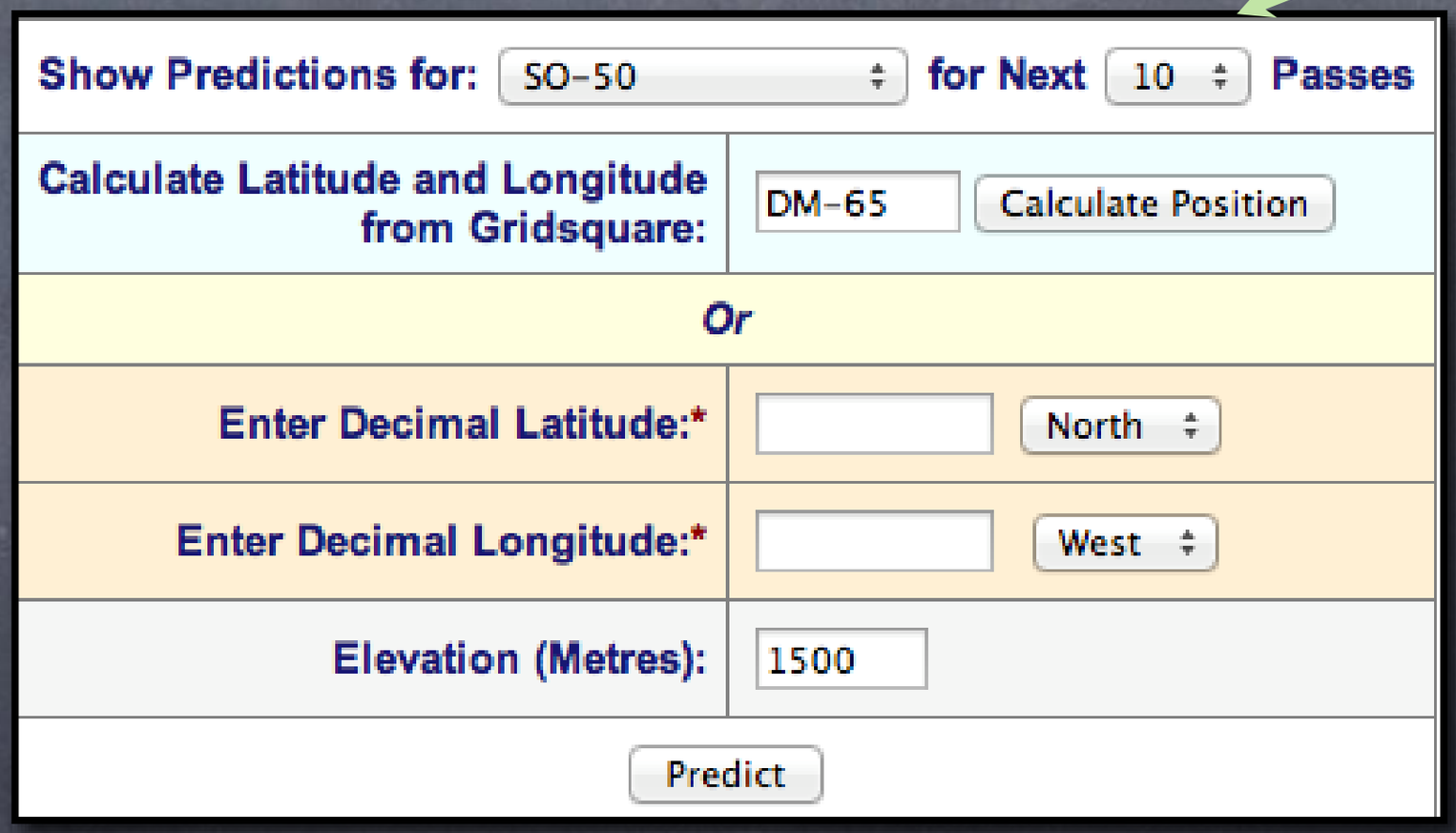
6. Click on Calculate Position

(The software will post the Lat./Long.)

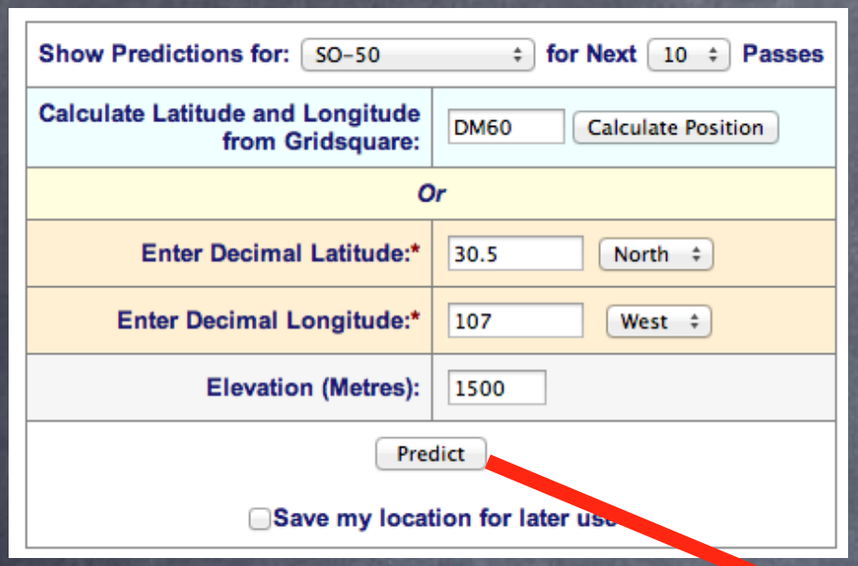
7. Click on Predict

The software will generate a list of details needed to work the listed, in this case, SO-50 satellite.

Adjust the number of Satellite passes to 25 to get a list for the next few days.



To Work a “Bird” (con’t)



Two Good Passes

“Good” passes are those whose maximum elevation is >40 degrees. This would mean operators would have a clear view of the “bird” and a greatly increased chance of a successful contact(s).

AMSAT Online Satellite Pass Predictions - SO-50

View the current location of SO-50

Date (UTC)	AOS (UTC)	Duration	AOS Azimuth	Maximum Elevation	Max El Azimuth	LOS Azimuth	LOS (UTC)
05 Nov 16	19:15:29	00:10:23	357	10	37	100	19:25:52
05 Nov 16	20:54:53	00:13:24	330	71	265	159	21:08:17
05 Nov 16	22:38:11	00:06:04	284	3	258	229	22:44:15
06 Nov 16	09:24:44	00:10:54	158	11	119	56	09:35:38
06 Nov 16	11:03:02	00:14:08	215	59	289	23	11:17:10
06 Nov 16	12:47:03	00:08:58	276	6	316	356	12:56:01
06 Nov 16	19:40:09	00:12:31	346	24	40	125	19:52:40
06 Nov 16	21:20:39	00:12:17	316	23	260	182	21:32:56
07 Nov 16	09:48:31	00:13:27	183	31	100	40	10:01:58
07 Nov 16	11:29:10	00:13:06	238	22	293	13	11:42:16

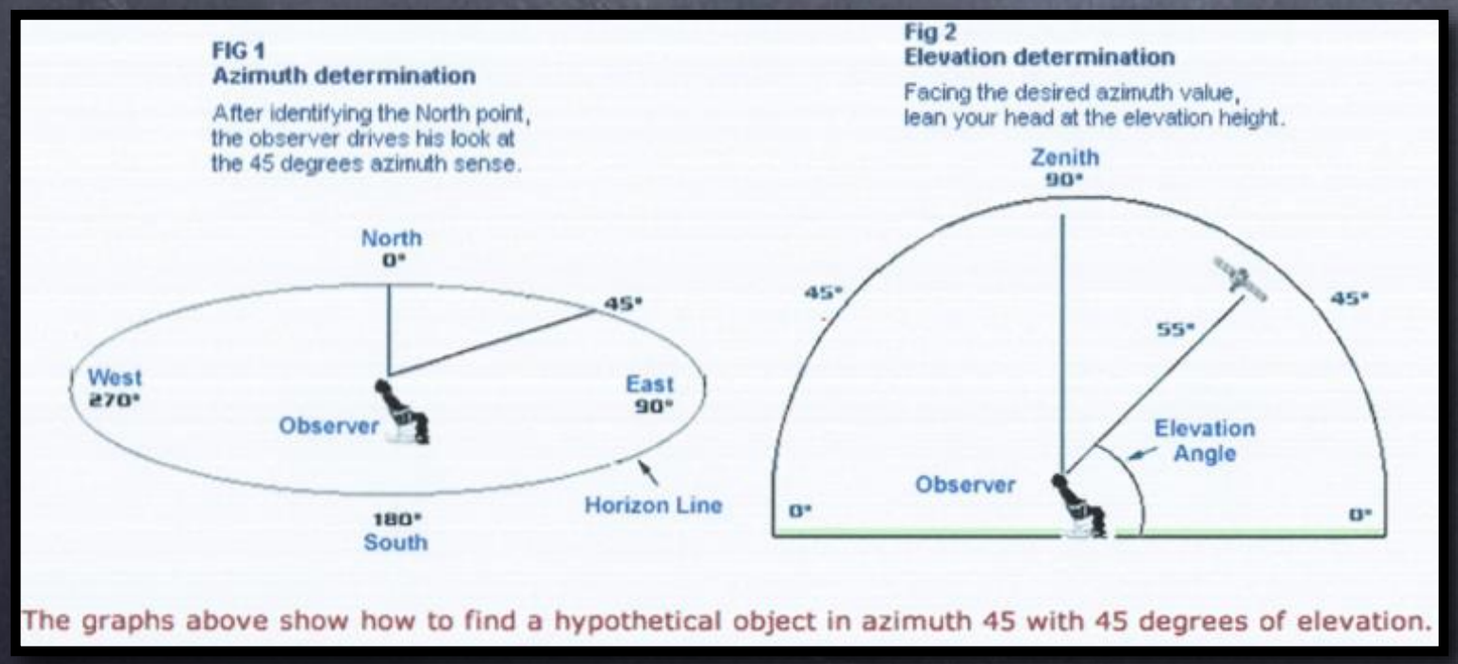
To Work a “Bird” (con’t)

AMSAT Online Satellite Pass Predictions - SO-50

View the current location of SO-50

Date (UTC)	AOS (UTC)	Duration	AOS Azimuth	Maximum Elevation	Max El Azimuth	LOS Azimuth	LOS (UTC)
5 Nov	20:54	13 min.	330 deg.	71 deg.	254 deg	159 deg.	21:08

Translation: On Nov. 5, at 20:54z (2:54PM MDT) use a compass to find 330 deg. & point the antenna in that direction. Listen on memory freq. #1 until you capture the satellite. Continue in an arc to 71 deg. and then down to 159, where you will lose the satellite’s signal, 13 min. later.



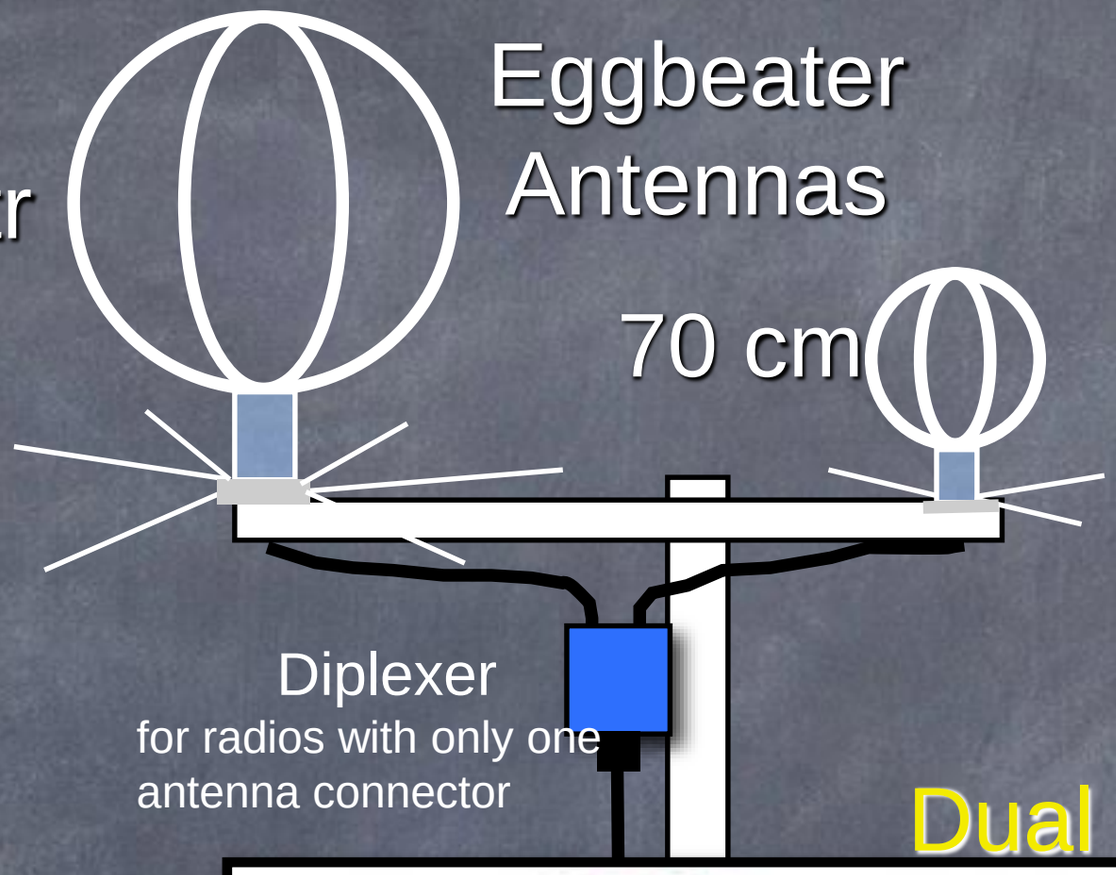
Memory #	Tx. Freq. w/PL 67	Rev. Freq.
#1	145.840	436.805
#2	145.845	436.800
#3	145.850	436.795
#4	145.855	436.790
#5	145.860	436.785

Fixed Station Layout

2 mtr

Eggbeater Antennas

70 cm



Diplexer

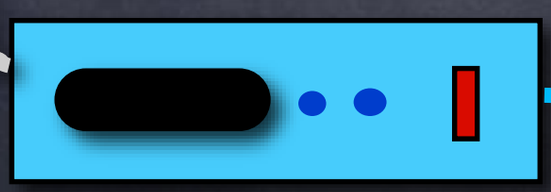
for radios with only one antenna connector

Hints:

* Run 20-40 watts to reach A0-85
* “Birds” need to be >30 deg. Ele. for these antennas
* Access FM Repeaters
* Copy Telemetry

Computer

Packet TNC



Dual Band FM Mobile Transceiver

In Conclusion

* Hams & Sats Have a Long History & an Exciting Future
* Ham Satellites Offer a Great Opportunity for S.T.E.M.
* Working the “Birds” is Easy, even with Just an HT
* The Home-Made Sat Antennas Shown Here, Work Well
* “Elk” Antennas are Good for Portable Operation
* The Dual Band “Arrow” Antenna is Popular
* The AMSAT Website is a Useful Resource (amsat.org)
* Awards for SAT contacts are Worthwhile Goals

This Slide Show is available on the HDARC website.

http://www.nm5hd.com

Resources:

ARRL Satellite Handbook (Sat. History), AMSAT.org (Antenna Design & Pass Data,) KG0ZZ Antenna Design (https://www.youtube.com/watch?v=Hy_XwvMmIro),