BIRDS BUS Open-Source Webinar

APRS Mission in BIRDS Satellites

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14/09/2022

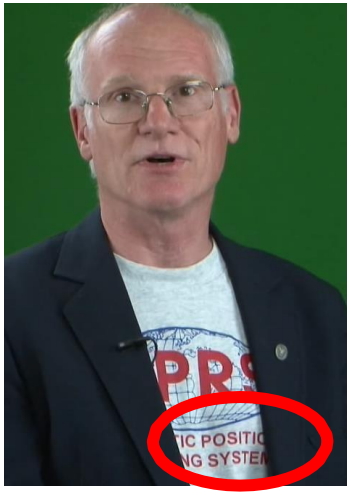
Background…

What is APRS?

- Automatic Packet Reporting System (Technical term)
- Automatic Position Reporting System (Deprecated)

A tactical, real-time information sharing system using standard protocols over packet radio

- Developed by Bob Bruninga around 1992.
- Supported by several major radio manufacturers(Kenwood, Yaesu, Alinco etc)
- Useful for both emergency operations and standard day to day operations.



Bob

Background

❑ Common terms in APRS

Trackers

- APRS stations with GPS receivers that move around

Digipeaters

- APRS Stations with good antennas/radios which can repeat your packet for more range

I-gate(Internet Gateway)

- A listening post connected to the internet to forward traffic to (and from) the APRS-IS

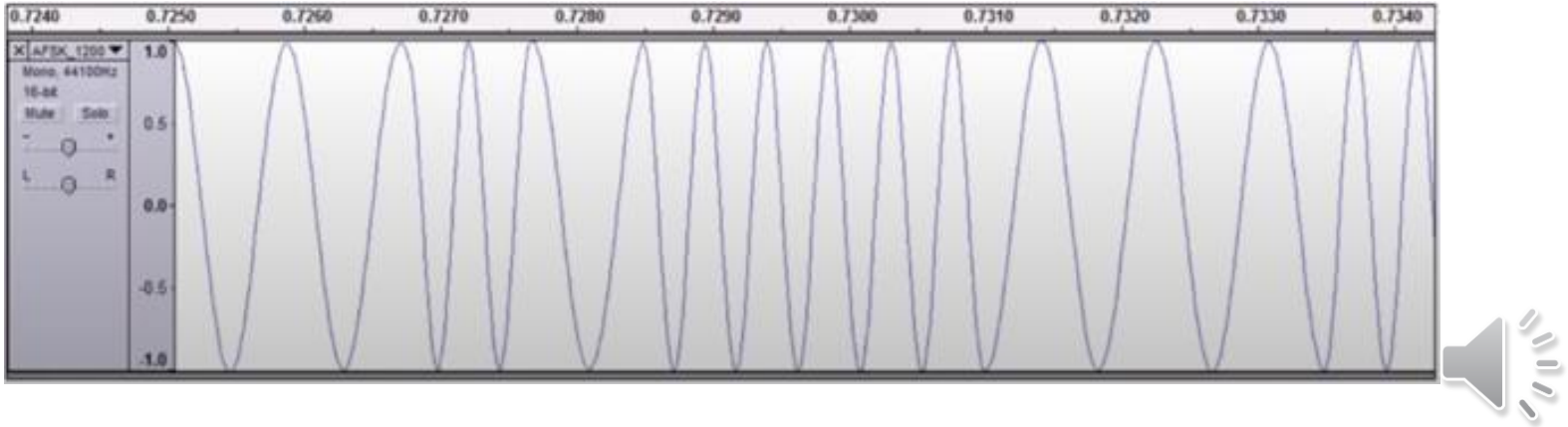
Terminal Node Controller

- A packet modem that handles audio modulation/ demodulation

Background

How does it work?

- Passes packets on a normal FM channel
- Uses AX.25 Protocol, based on AFSK (Audio Frequency Shift Keying) modulation
- Speeds of up to 1200bps on a single channel



Background

What's in APRS packet?

TNC Description	Source Address	Routing Path (Optional)	Control (0x03)	PID (0xF0)	Information Field
7 octets	7 octets	N x 7 octets	2 octets		1-256 octets

Example

W6TDM-2>APOT30,WIDE1-1,qAR,W6IA:!3719.14N/12201.72Wo 12.1V 76F cupertinoares.org

N2UFM-1>APWW10,PSAT*,ARISS::ALL :Hello de N2UFM via PSAT

Source TNC Description Path Destination Information

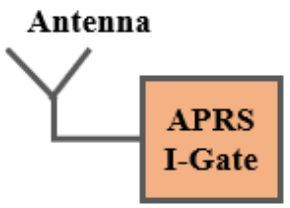
Background

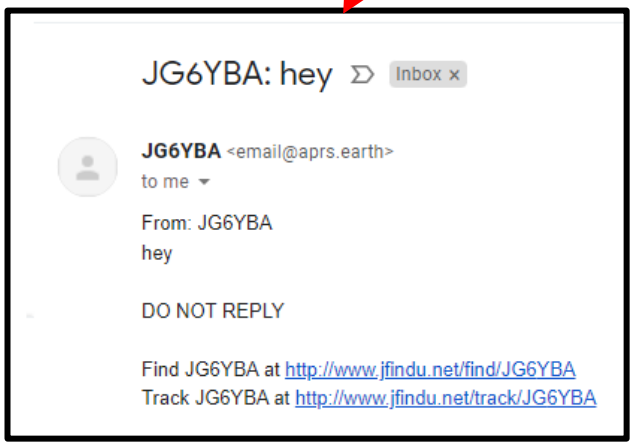
What can you do with APRS?

- Send and receive global APRS messages/announcements
- Lookup names/Locations based on callsign
- Location of a station (Cars, Moto-cycles, Fire trucks)
- Telemetry (Weather stations, battery levels, plant health, etc)

What can you do with APRS?

- Send APRS EMAIL





Text Message to APRSMAIL
Format: <email Address> <Message>

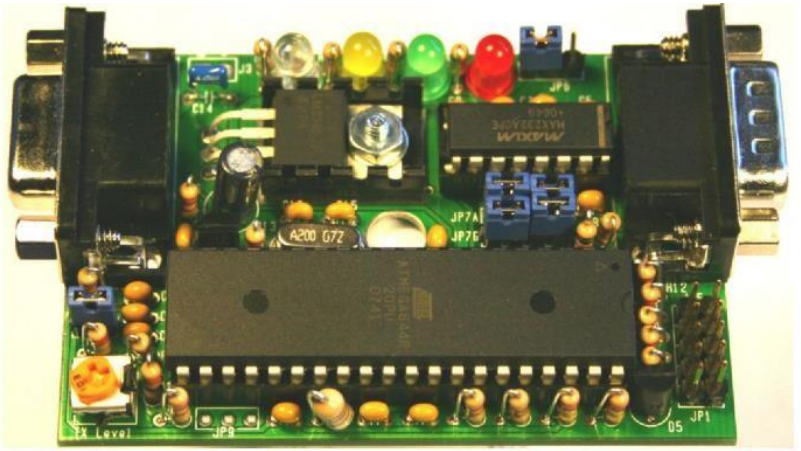
APRS Trackers Available today

Byonics Tiny Trak4

- Costs about $70 ready to go package
- Does 300, 1200, 9600 baud packets
- User upgradable firmware, updated regularly

http://www.byonics.com

Purchase Module



Build kit

APRS Radios Available today

- APRS Radios make a full APRS communication system by combining User Interface, TNC and Transceiver in one unit

Kenwood TMD-710

Yaesu FTM-100DR

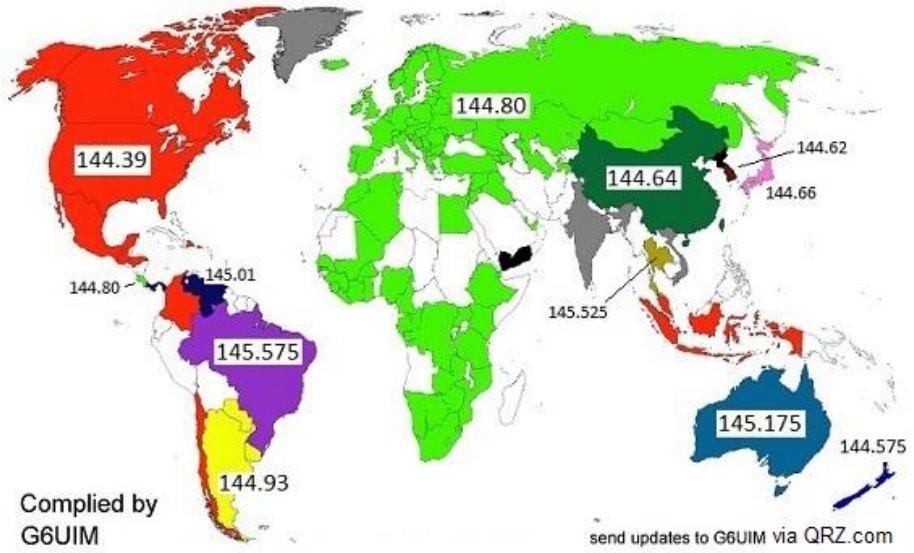
Yaesu FT2D

Kenwood TH-D72

Anytone AT-D878

❑ APRS VHF Frequencies

- 144.390 MHz North America
- 144.660 MHz Japan
- 144.800 MHz South Africa, Europe, Russia
- 144.930 MHz Argentina, Uruguay
- 145.175 MHz Australia
- 145.570 MHz Brazil
- 145.525 MHz Thailand
- 145.825 MHz ISS



Source: *https://www.sigidwiki.com/wiki/Automatic_Packet_Reporting_System_(APRS)*

Ham Radio on ISS (APRS & Voice)

ARISS – Amateur Radio on International Space Station offers APRS messages and Voice on frequencies of 145.825MHz and 145.99MHz

https://www.ariss.org

ISS APRS Call-Signs

- Russian: **RS0ISS**
- USA: **NA1SS**
- European: **DP0ISS, OR4ISS, IR0ISS**

- ARISS contacts afford education audiences the opportunity to learn firsthand from astronauts

- Students also get an opportunity to learn about satellite communication, wireless technology, and radio science.

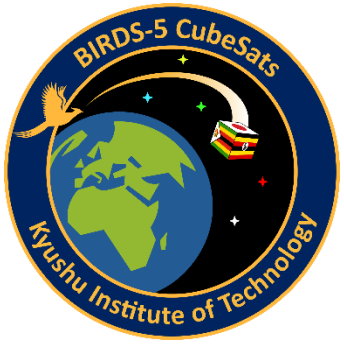
❑ Ham Radio on ISS – Talk to Astronauts

Source: *YouTube*

APRS in BIRDS Satellites

BIRDS-2

BIRDS-4

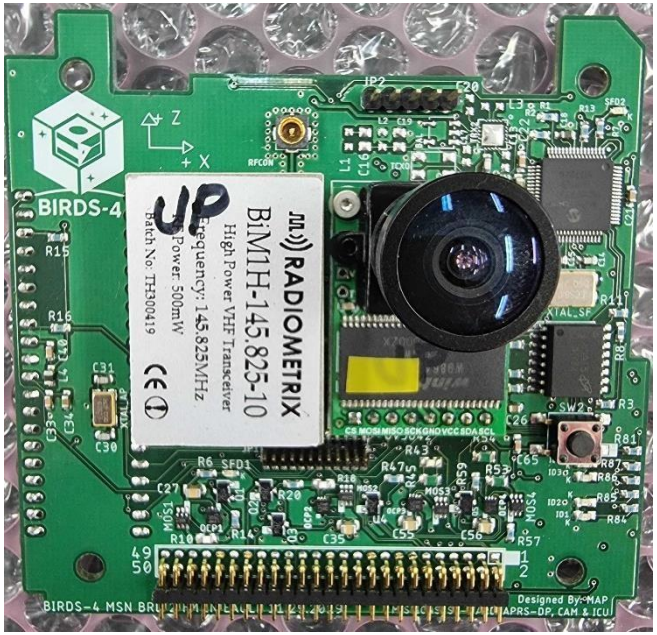


BIRDS-5

APRS in BIRDS Project

BIRDS satellites utilize APRS;

- In Store & Forward Mission data collection from GSTs in remote areas.
- To serve armature Radio community through APRS Digi-peating.



Birds-4 APRS/SF-ward Mission Board

Birds-5 APRS/SF-ward Mission Board

APRS-DP/ SF-WARD Mission Main Components

VHF Transceiver

BiM1H 145.825MHz

- Data rates: up to 10kbps(APRS)
- Good Heritage
- Sensitivity:
  - Manufacturer: -120dBm
  - FM: -96dBm
  - EM cable test: -118dBm

APRS Module(TNC)

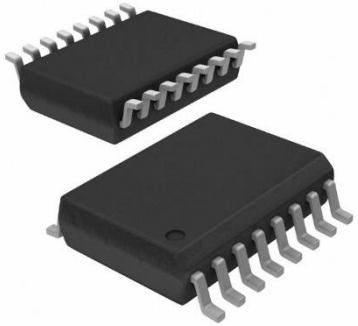
ATMEGA644-20PU

- Widely used in TT4 APRS digipeaters
- Good Heritage

SF-Ward MCU

PIC18F67J94

- Low power requirements
- Low cost
- Good Heritage



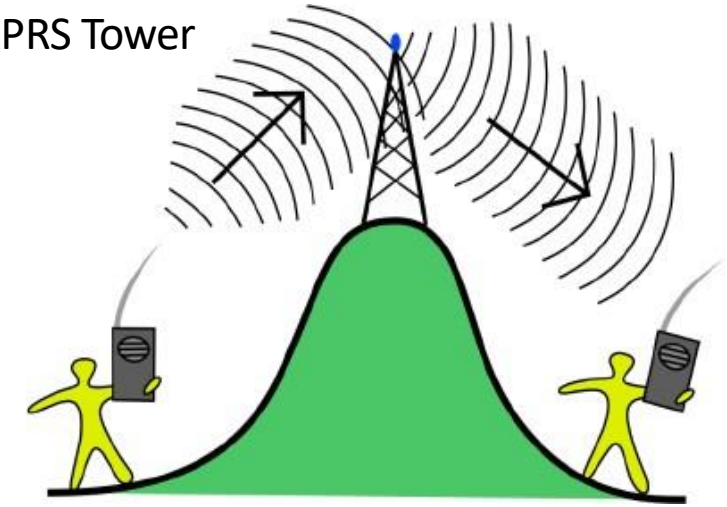
SF-Ward Flash Memory

MT25QL01GBBB8ES

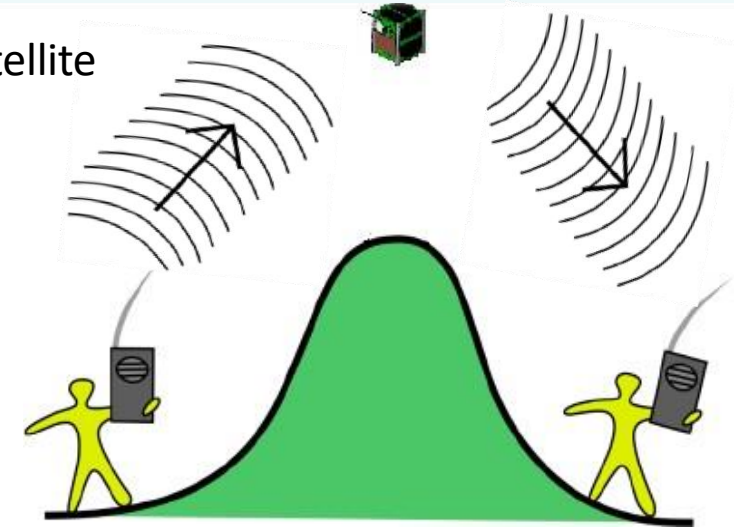
- Low power requirements
- Low cost
- Good Heritage

APRS Digi-Peating…

APRS Tower

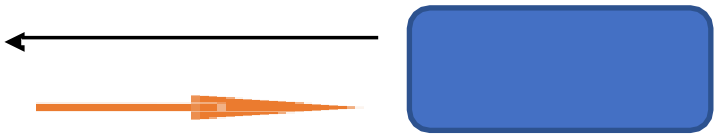


APRS Satellite



Satellite Digi-peating Demo

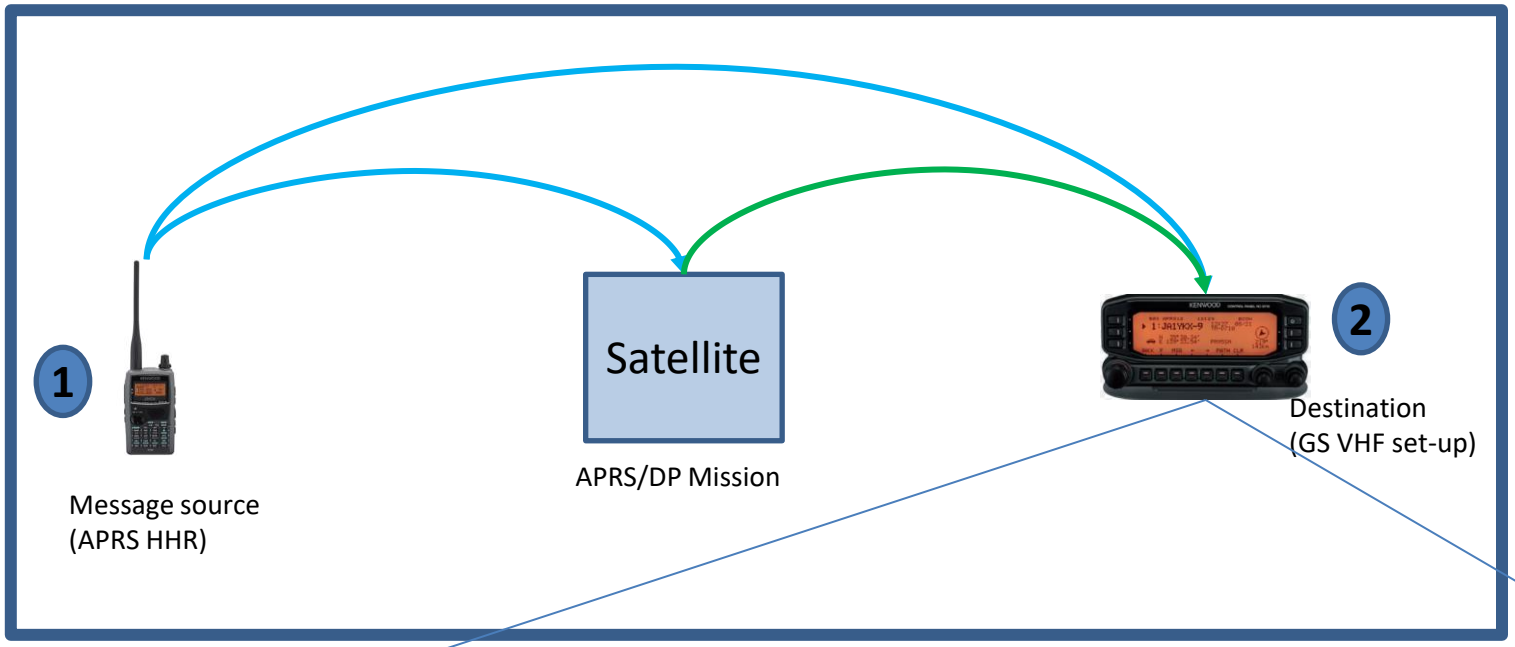
Attenuated signal



Satellite

Attenuated signal

APRS Digi-Peating (On Ground)




```
Fm JG6YBA To APK003 Via WIDE1-1 <UI pid=F0 Len=23 >[19:57:45]
:JK1ASJ   :digipeat{45

Fm JG6YBA To APK003 Via BIRDS5*,WIDE1* <UI pid=F0 Len=23 >[19:57:46]
:JK1ASJ   :digipeat{45
```

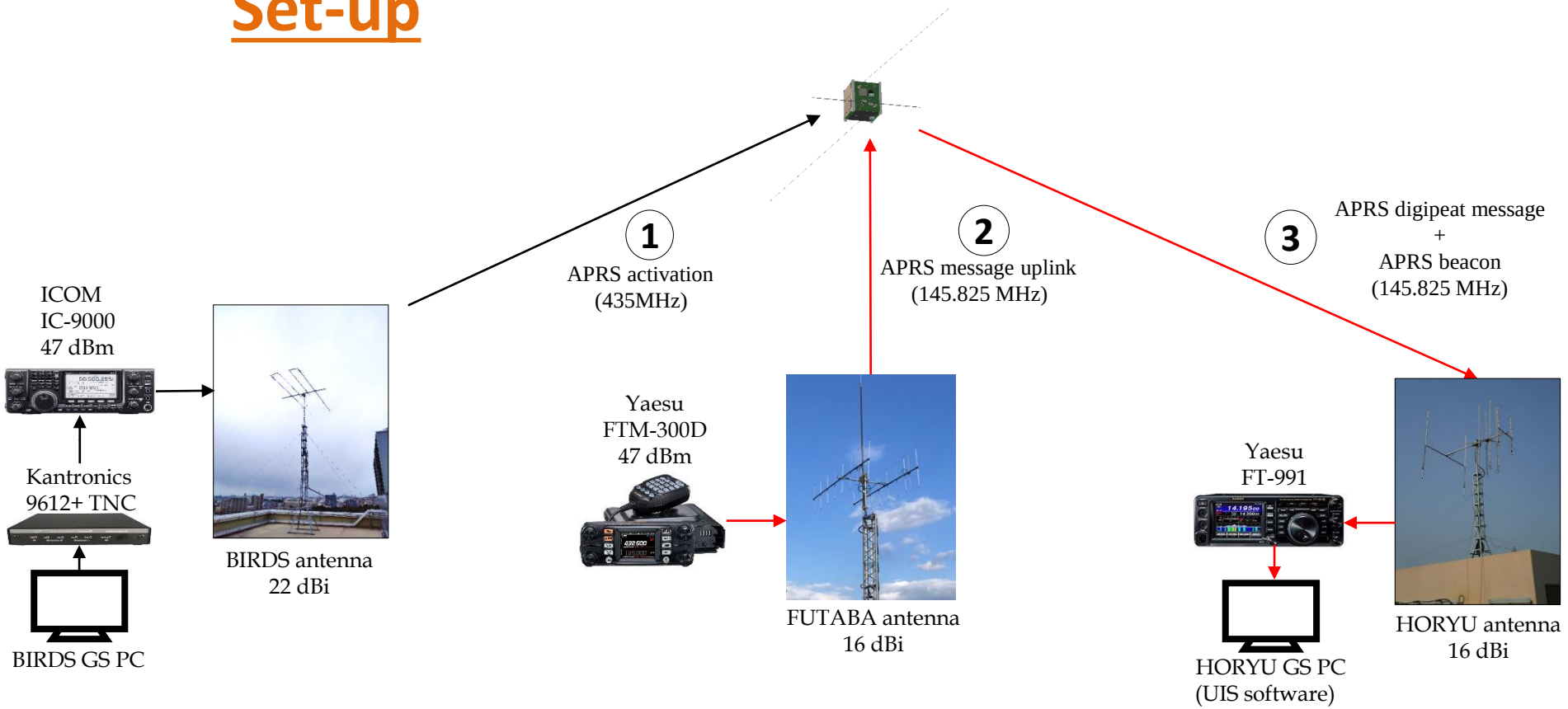
Direct message

Digipeated message

Digipeater

APRS Digi-Peating (In Orbit)

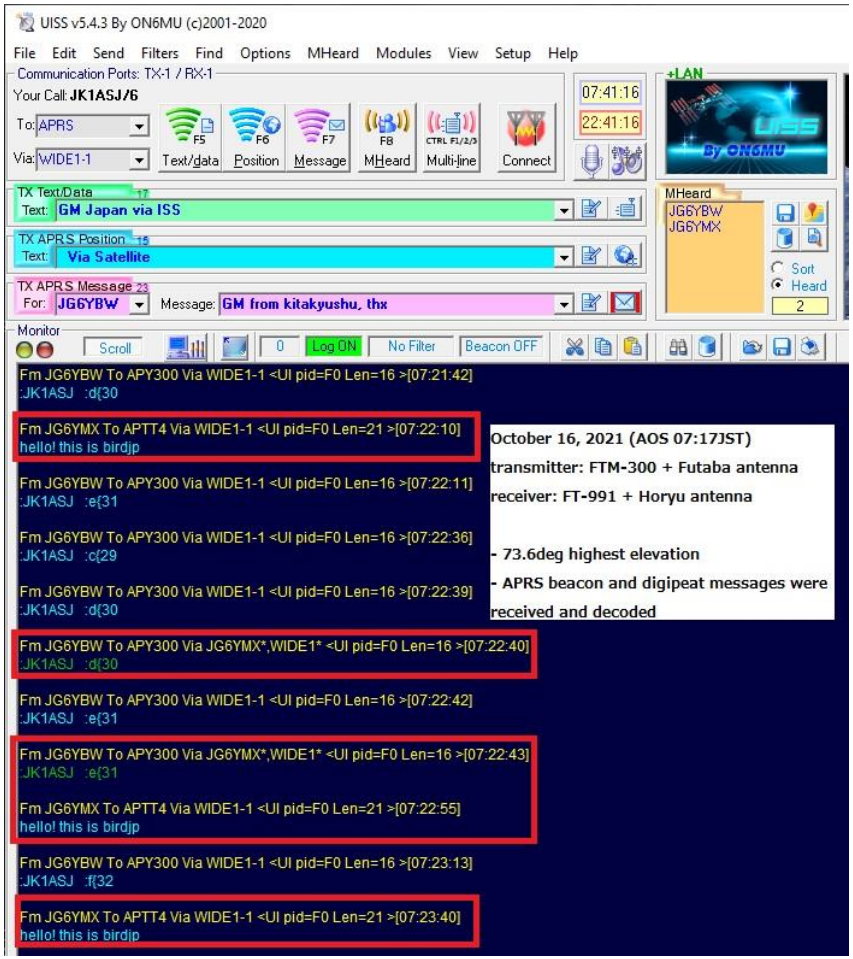
Set-up

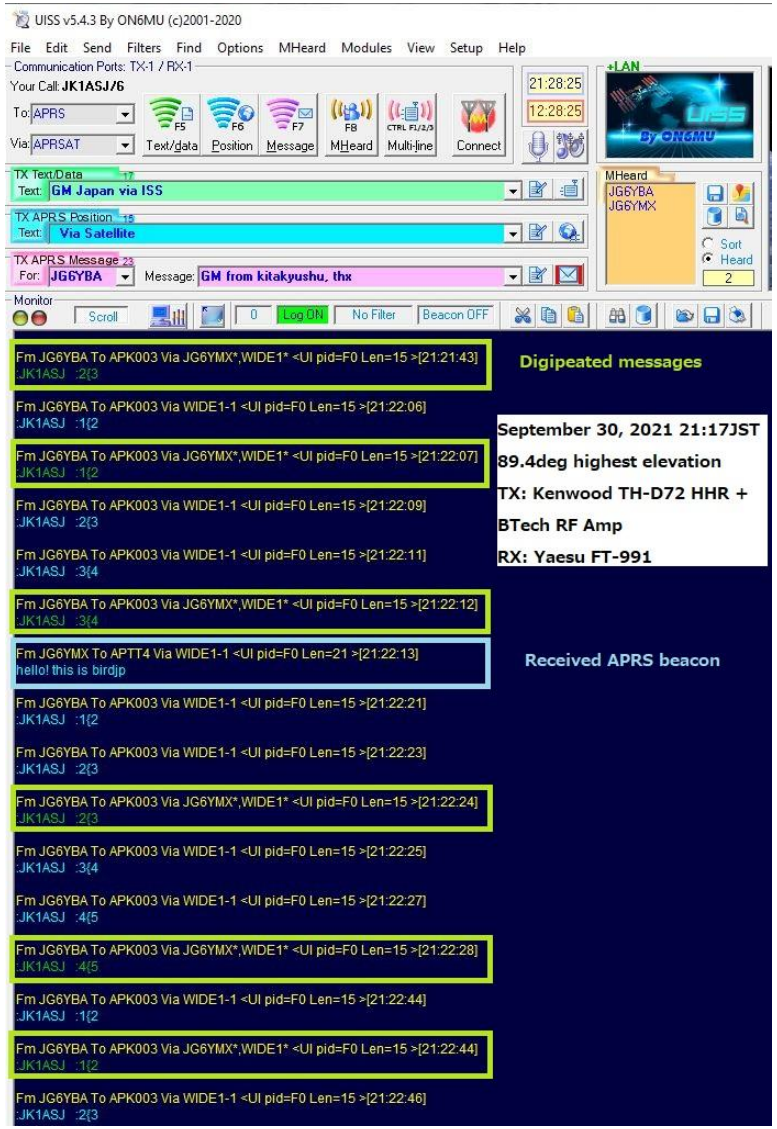


By: Marloun (BIRDS-4)

APRS Digi-Peating (In Orbit)

Results





By: Marloun (BIRDS-4)

APRS Contact with Satellites

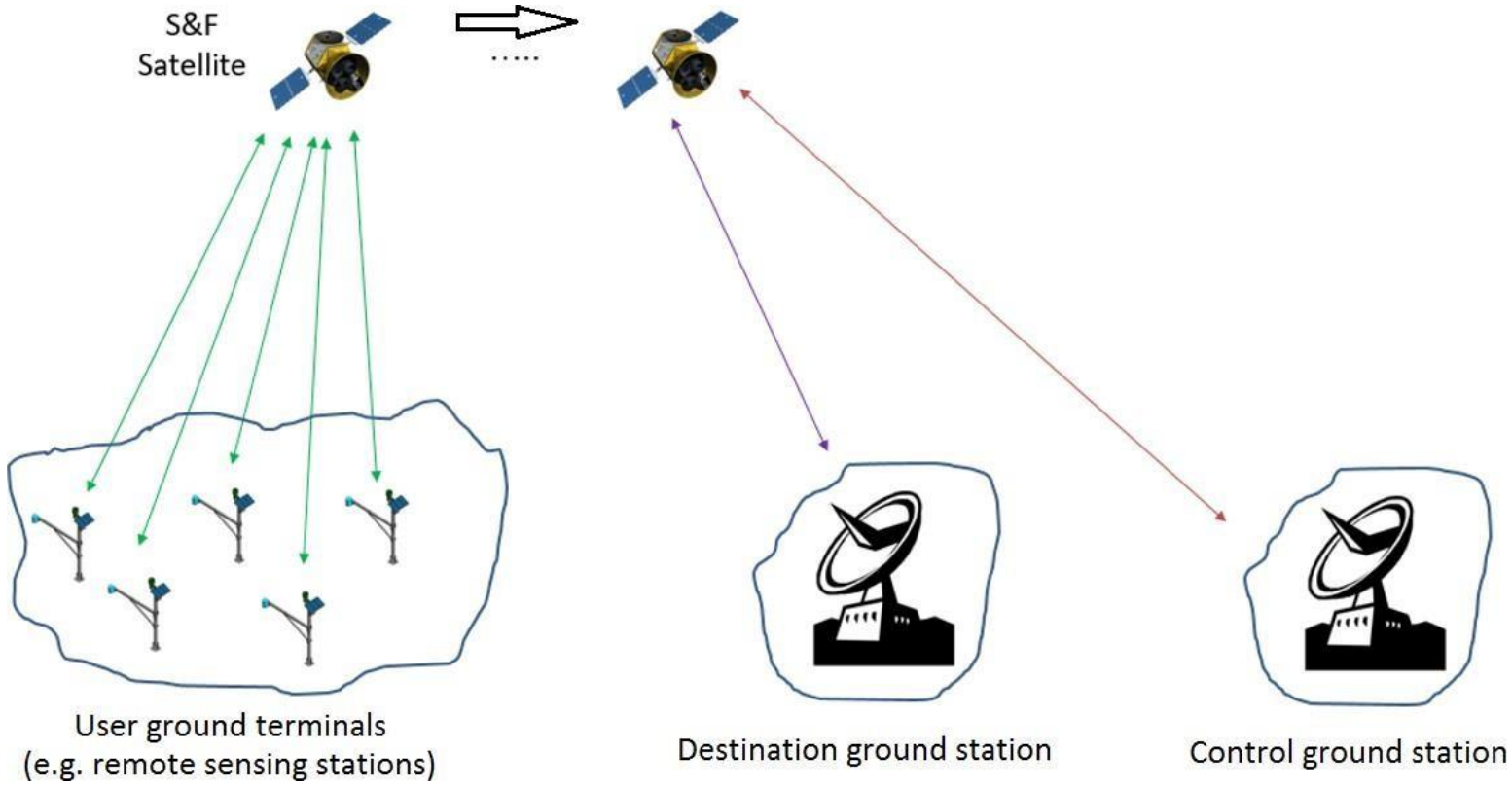
APRS Contact with BIRDS-4 Satellite in Orbit using HHR

Set-up

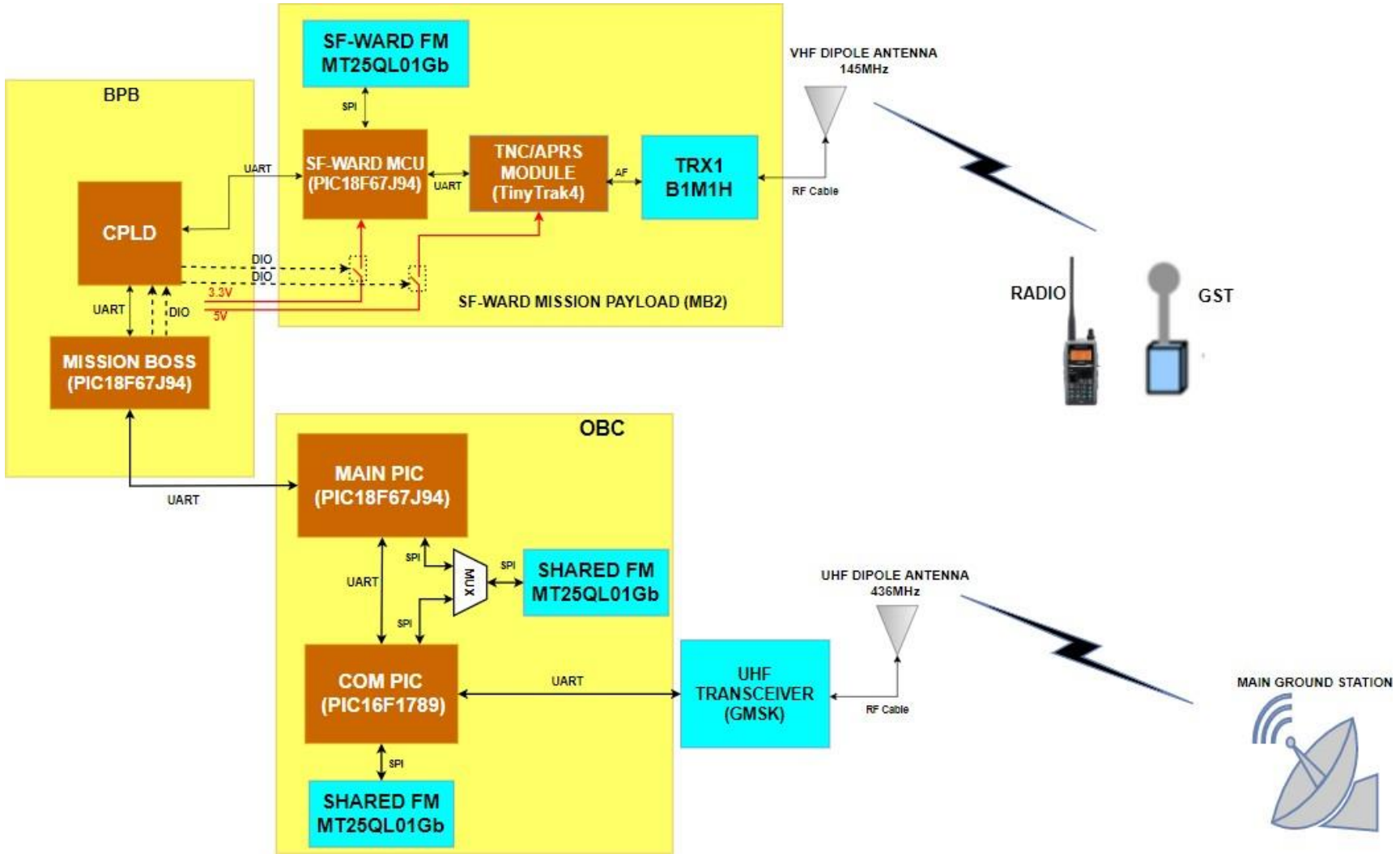
- Kenwood TH-D72+ BTech RF Amp(40W) + Yagi Antenna(6dBi)

Satellite Store &Forward System

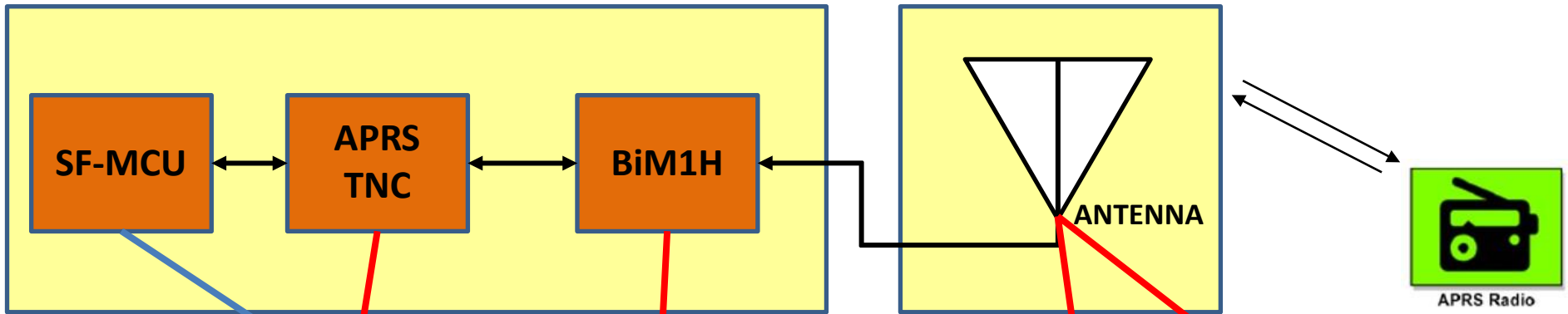
- A spacecraft that “receives and stores messages while over one part of the earth and downloads them later over another part of the globe.”

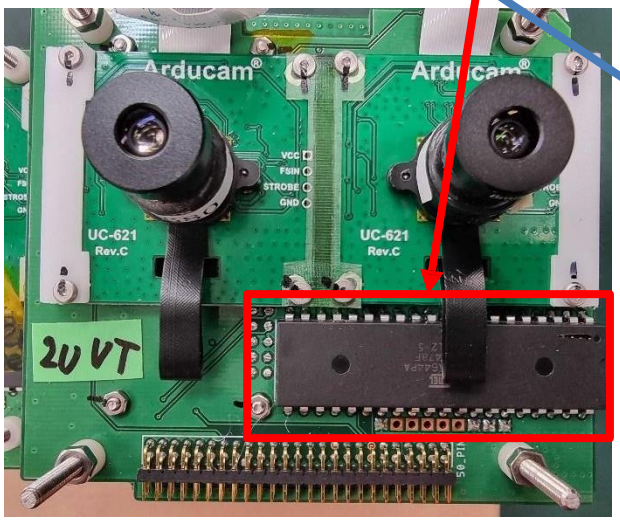


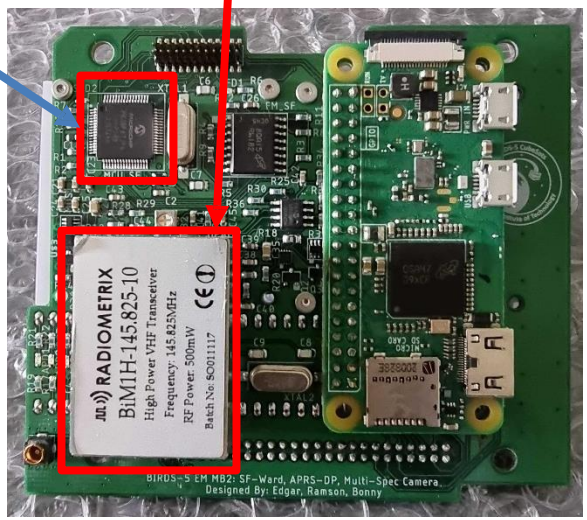
APRS/SF-ward Block Diagram (BIRDS-5)



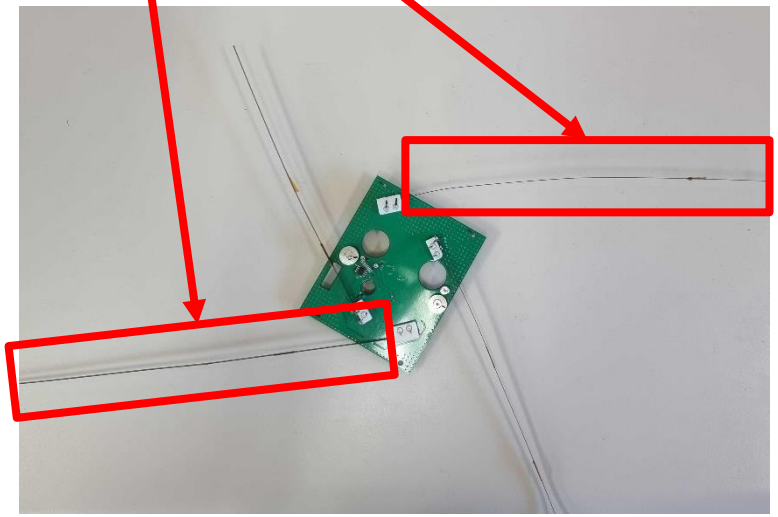
APRS/SF-ward Block Diagram







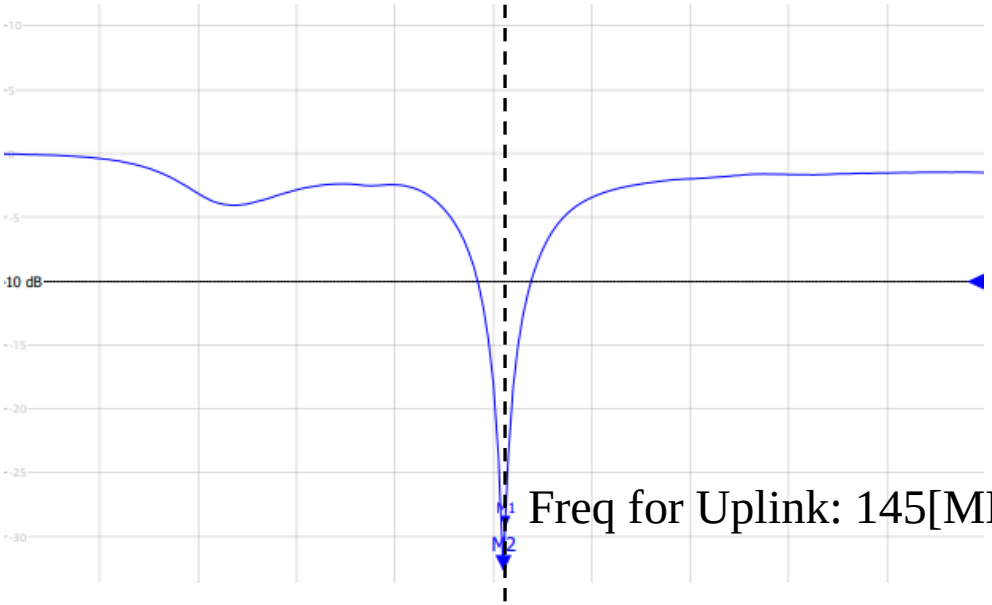
BIRDS-5 Mission Board 2



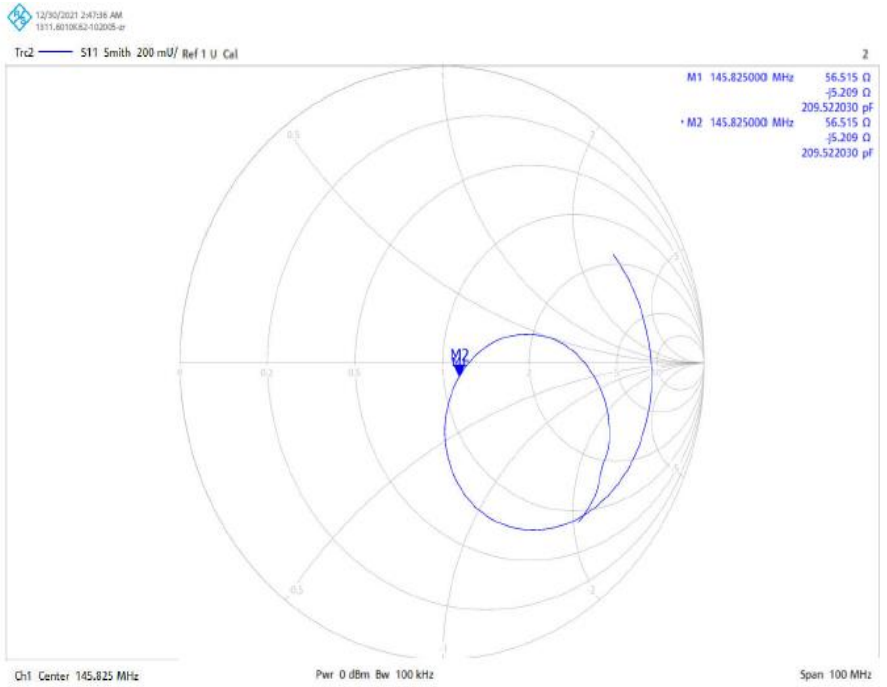
VHF Antenna

APRS (VHF Antenna Tunning)

Reflection Coefficient (S11) of VHF Dipole



Freq for Uplink: 145[MHz]



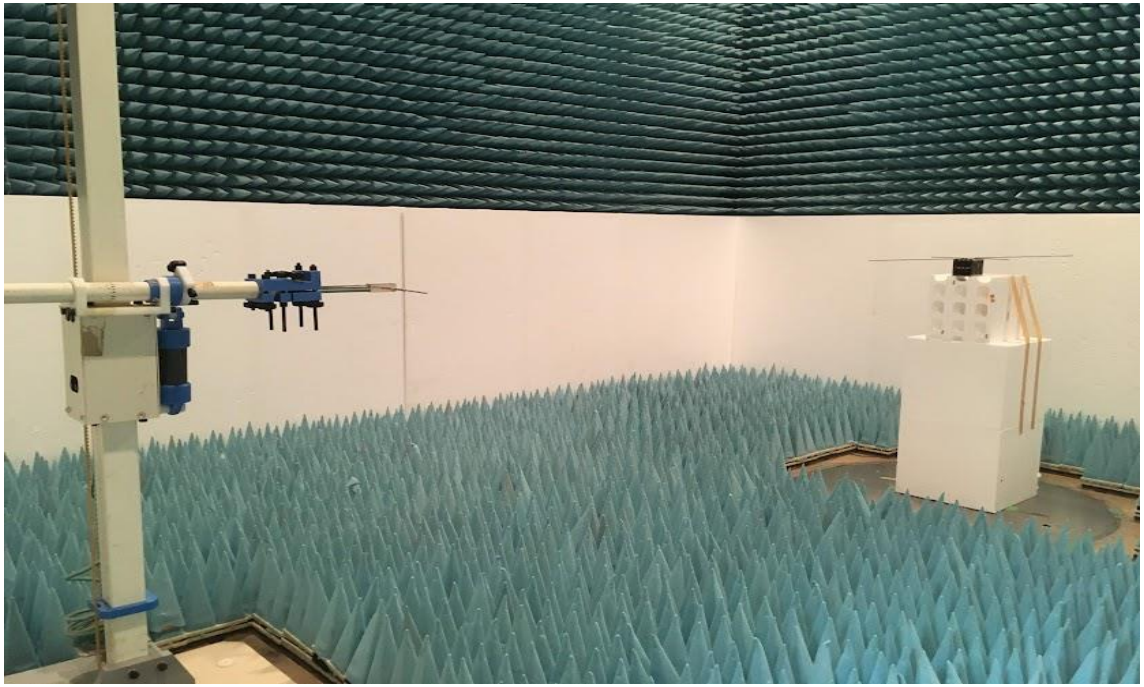
Element Length: 510 [mm]

S11: -29.09 [dB]

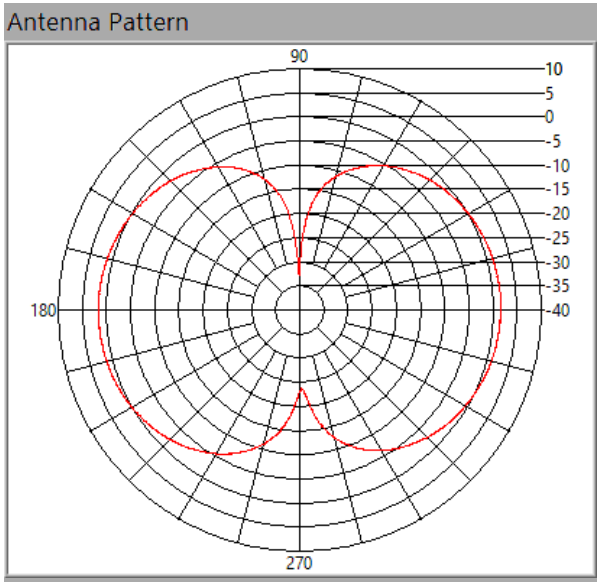
Frequency: 145 [MHz]

M1 145.825000 MHz 56.515 Ω -j5.209 Ω 209.522030 pF
M2 145.825000 MHz 56.515 Ω -j5.209 Ω 209.522030 pF

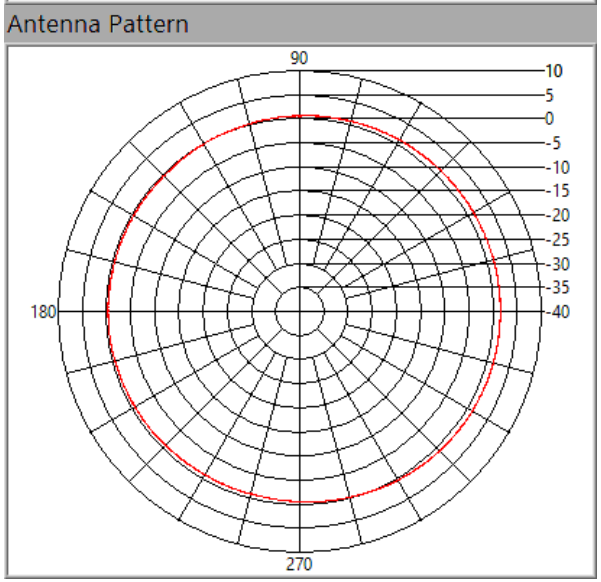
VHF Antenna Radiation Pattern



E-plane

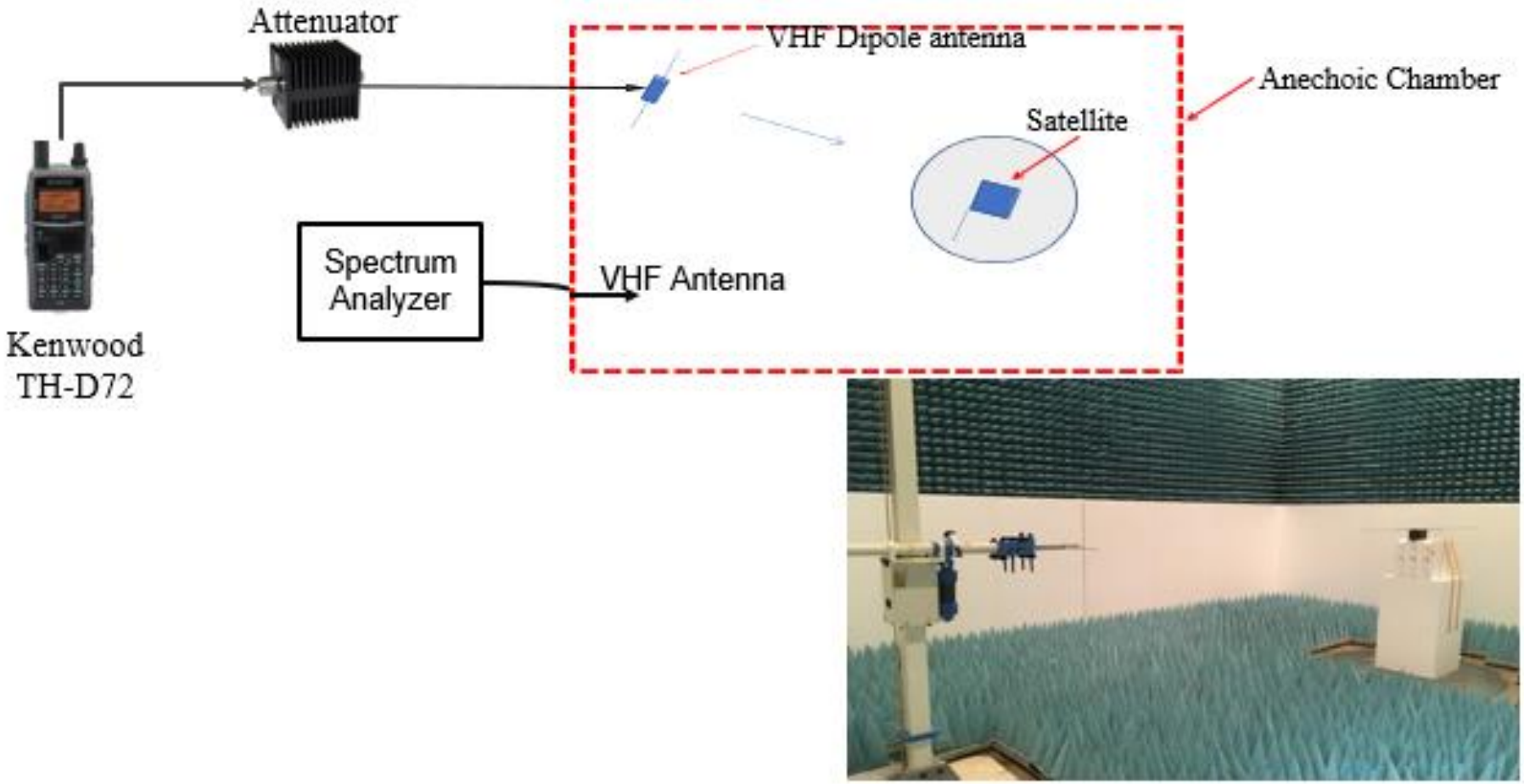


H-plane



G_{max} – 1.7dBi

VHF Transceiver Sensitivity Measurement



APRS GS Link Budget

ELEVATION		30°	60°	80°
GROUND STATION				
Transmit Output Power	[W]	50	50	50
Transmit Output Power	[dBm]	47	47	47
Antenna Gain	[dB]	16	16	16
Transmission Line Loss	[dB]	3	3	3
EIRP	[dBm]	60	60	60
UPLINK PATH				
GS Antenna Pointing Loss	[dB]	3	3	3
Polarization Loss	[dB]	3	3	3
Atmospheric + Ionospheric Losses	[dB]	1.4	1.4	1.4
Path Loss	[dB]	133.1	128.9	127.9
Antenna Pointing Loss	[dB]	3	3	3
Effective Attenuation	[dB]	130.5	126.3	125.3
Power at the satellite	[dBm]	-83.5	-79.3	-78.3
SATELLITE				
Antenna Gain + Cable Loss	[dB]	0.5	0.5	0.5
Transceiver Received Power	[dBm]	-83	-78.8	-77.8
Minimum Received Power	[dBm]	-95	-95	-95
Link Margin	[dB]	12	16.2	17.2

Uplink

ELEVATION		30°	60°	80°
SATELLITE				
Transmit Output Power	[W]	0.5	0.5	0.5
Transmit Output Power	[dBm]	27	27	27
Antenna Gain + Cable Loss	[dB]	0.5	0.5	0.5
EIRP	[dBm]	27.5	27.5	27.5
DOWNLINK PATH				
Satellite Antenna Pointing Loss	[dB]	3	3	3
Polarization Loss	[dB]	3	3	3
Atmospheric + Ionospheric Losses	[dB]	1.4	1.4	1.4
Path Loss	[dB]	133.1	128.9	127.9
Antenna Pointing Loss	[dB]	3	3	3
Effective Attenuation	[dB]	143	138.8	137.8
Power at the ground station	[dBm]	-116	-111.8	-110.8
GROUND STATION				
Antenna Gain	[dB]	16	16	16
Transmission Line Loss	[dB]	3	3	3
Transceiver Received Power	[dBm]	-103	-98.8	-97.8
Minimum Received Power	[dBm]	-125	-125	-125
Link Margin	[dB]	22	26.2	27.2

Downlink

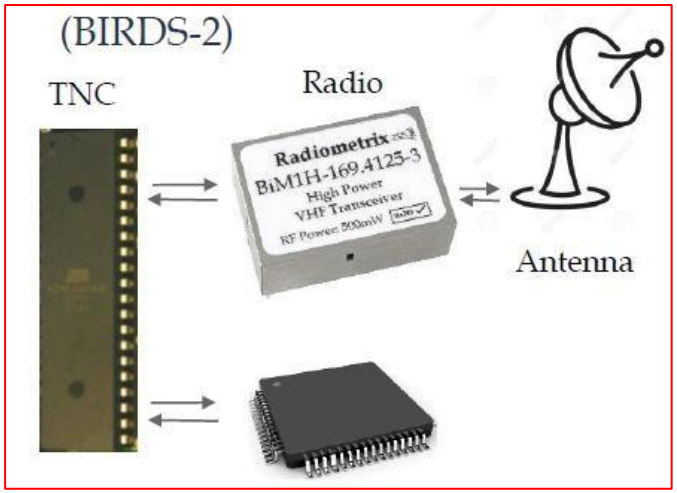
Ground Sensor Terminals

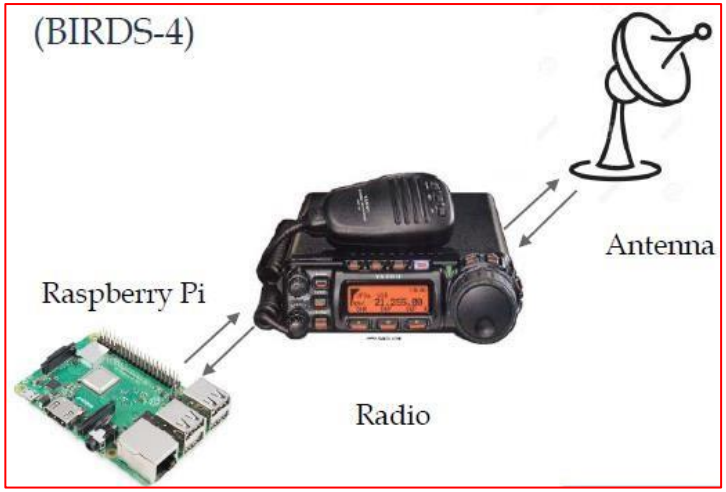
- GSTs can either be interfaced to an existing host station (with sensors) or stand-alone.

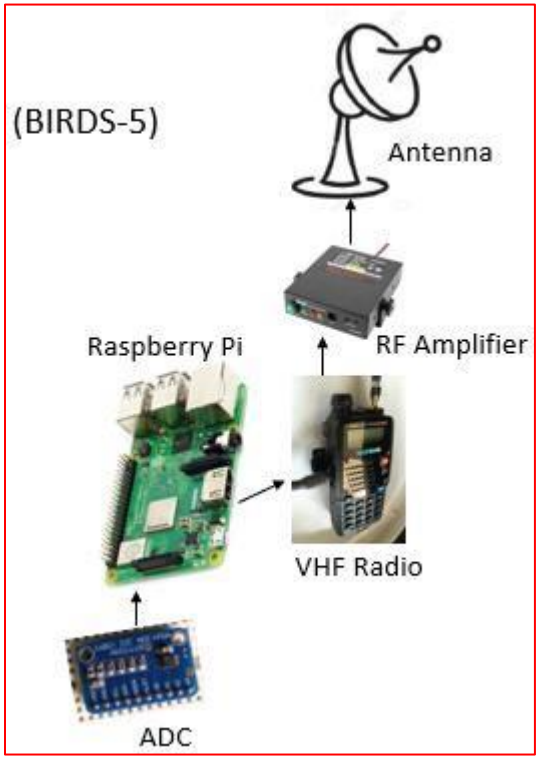
Courtesy of Joven Javier, DOSTASTI

APRS GST Development

- Proposed Configurations of BIRDS APRS GSTs…







Software TNC on Raspberry Pi…

What is Dire Wolf?

Decoded **I**nformation from **R**adio **E**missions for **W**indows **O**r **L**inux **F**ans

- Open-source software replacement for the traditional TNC

Platforms

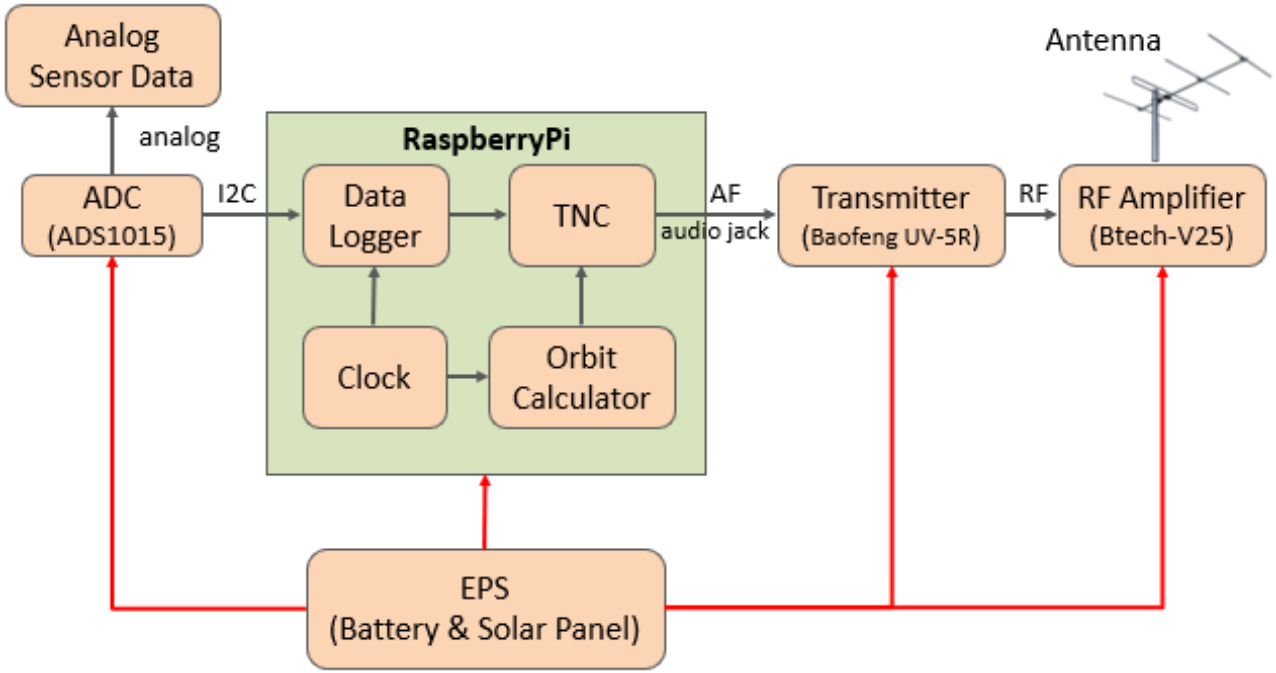
- Windows.
- Linux – x86, x86_64PC, Raspberry Pi.
- Mac OSX.

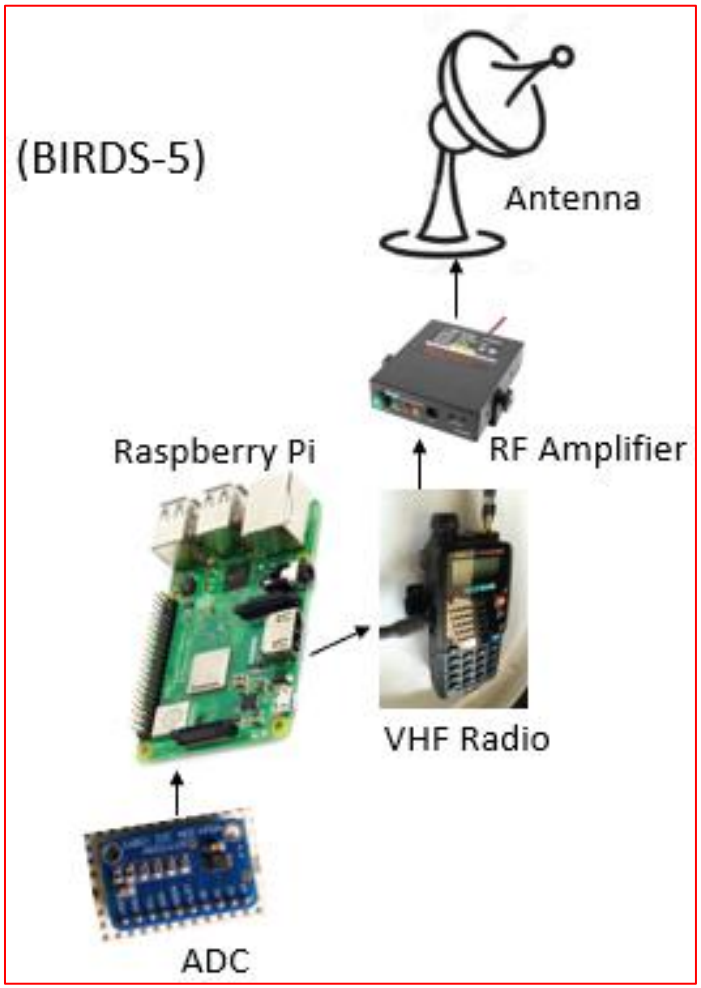
Services supported

- GPS Tracker.
- Digipeater.
- Internet Gateway (IGate)
- Virtual TNC for Applications such as APRSIS32, Xastir, SARTrack, UISS, Linux AX25, Winlink Express

BIRDS-5 GST Development

GST Block Diagram

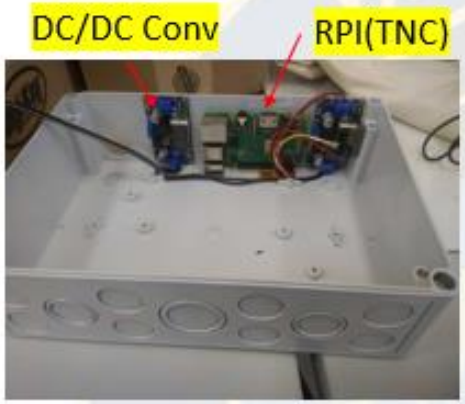


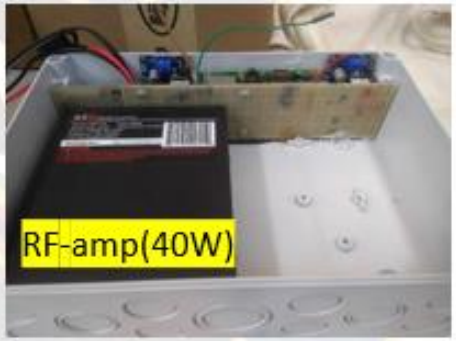


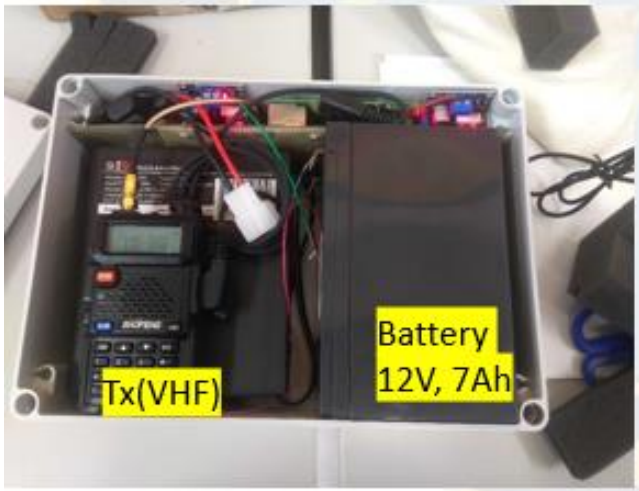
GST uplink Sample

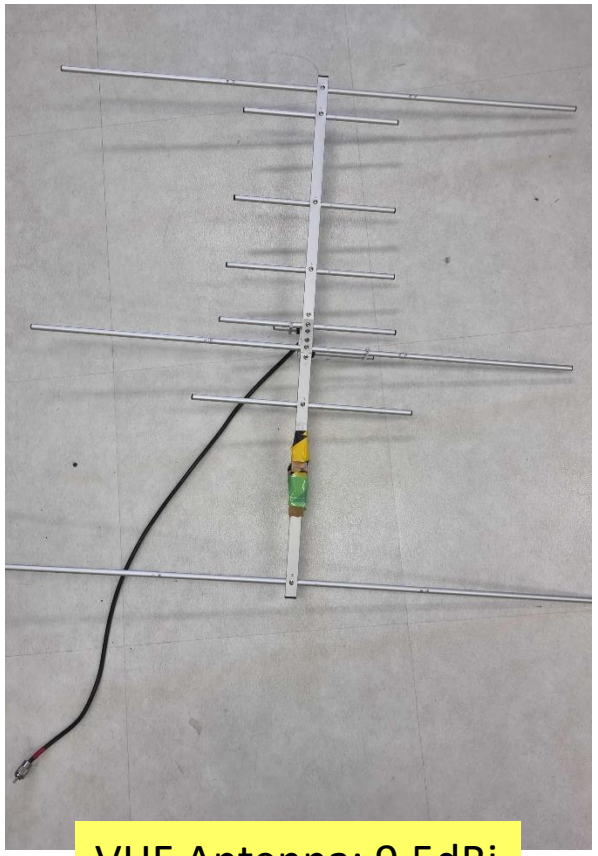
```
JG6YBA>APDW17::BIRDS5 GST1 - 260721 214548  0.57  0.57
JG6YBA>APDW17::BIRDS5 GST1 - 260721 214618  0.57  0.57
JG6YBA>APDW17::BIRDS5 GST1 - 260721 214648  0.57  0.56
```

BIRDS-5 GST Components









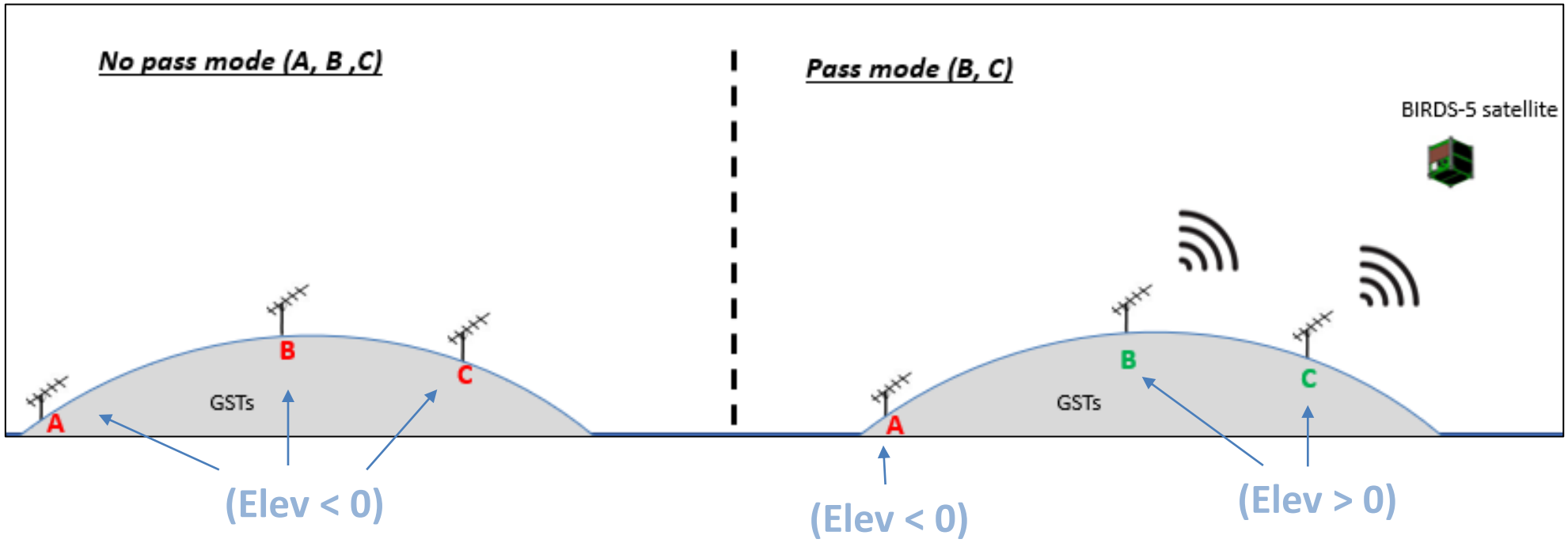
VHF Antenna: 9.5dBi

Link Margin: ≈8dB(at 30°)
≈13dB(at 80°)

APRS GST Orbit Calculator

Advantage:

- Power Saving
- Efficient use of communication channel

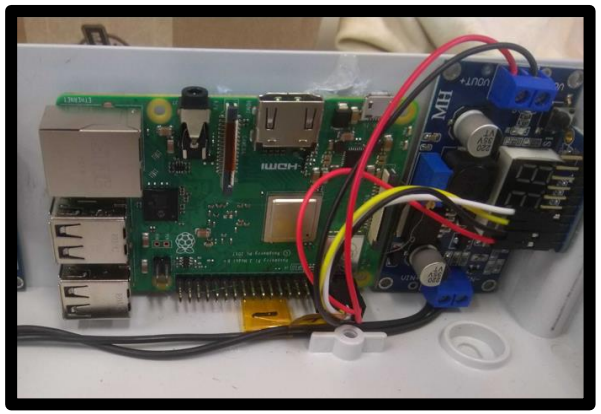


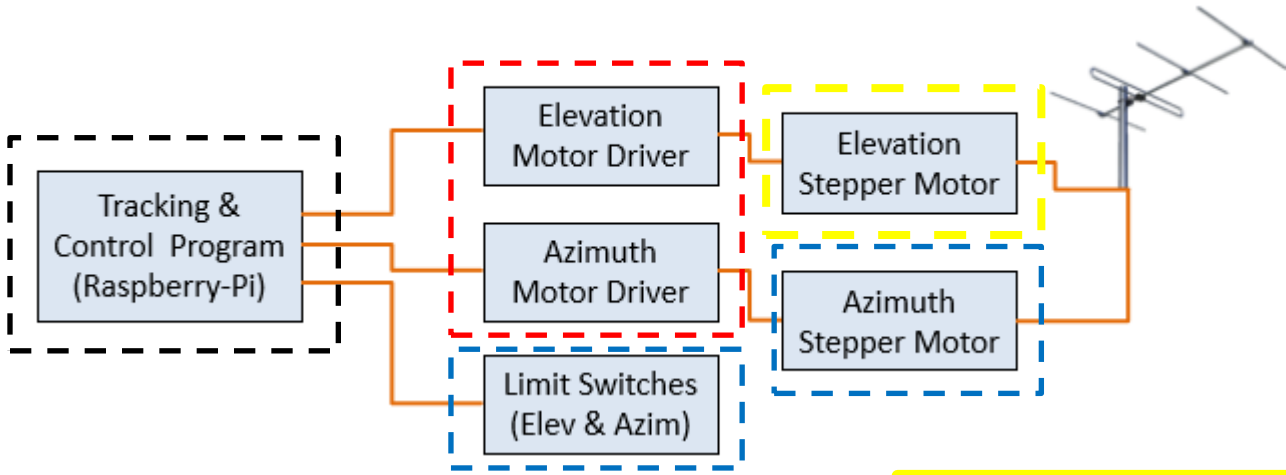
Inputs:

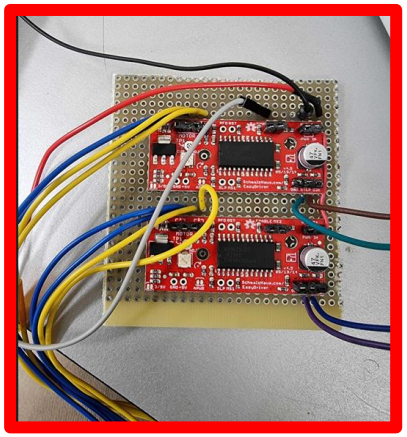
- GST Location
- Satellite TLE

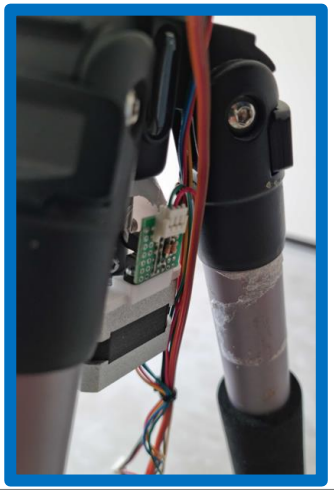
How to improve GST Uplink Success rate…

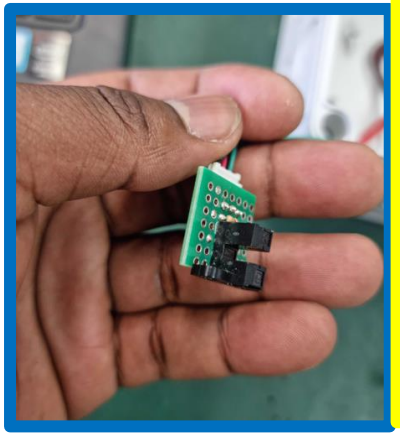
1. Use of High gain Antenna
2. Antenna pointing
   - Use Stepper Motors for Elev & Azim Control





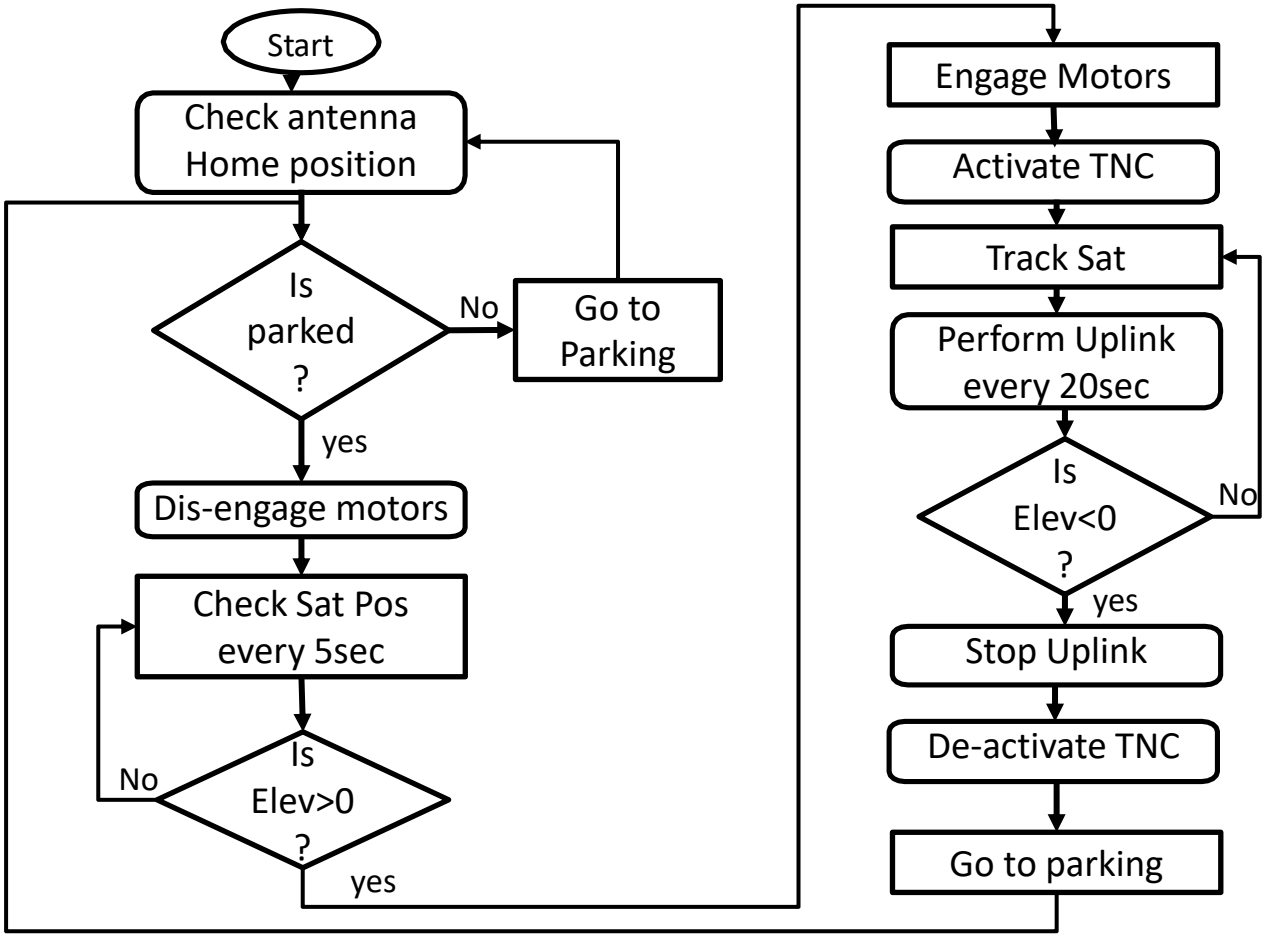






BIRDS-5 GST Development

Antenna Tracking program flow chart



Technical Challenges Associated….

- Limited satellite visibility and moving coverage
- Low data rate
- High Transmission Power Required

“Internet of Things (IoT)”: The Next Industrial Revolution

“Smart objects”

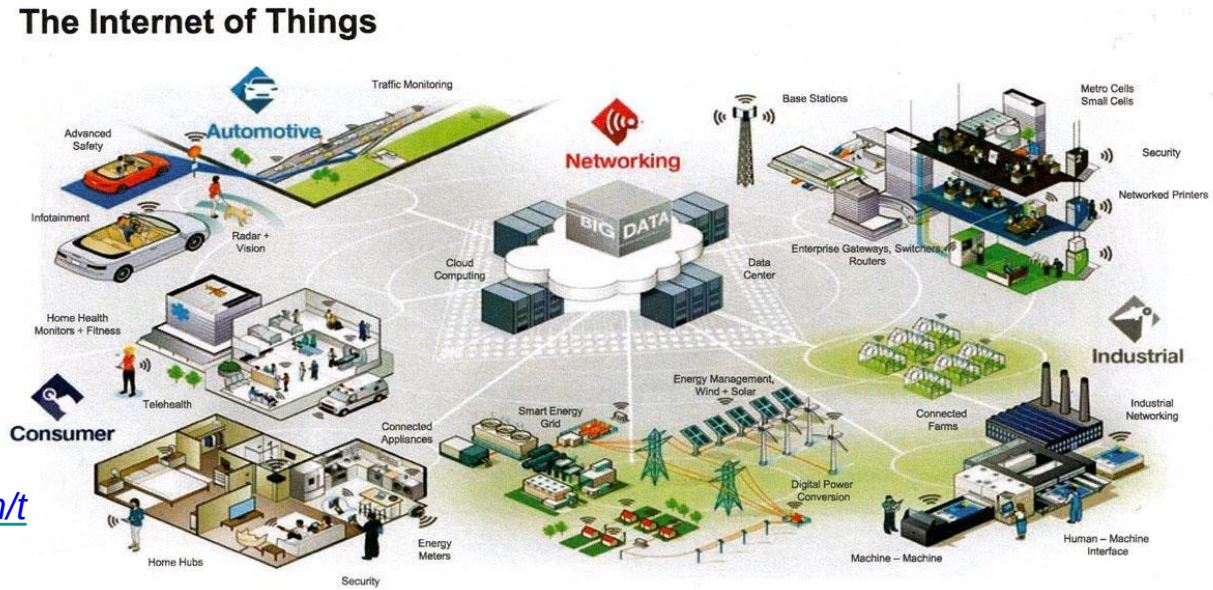
“Smart homes and cities”

“Technologies deeply embedded in environment and space”

“Ability to monitor and control distant objects [X]”

“Everything is connected to the cloud.”

Source: http://www.huffingtonpost.com/sam-cohen/internet-of-things-as-the_b_10937956.html



Source: https://opentechdiary.wordpress.com/tag/internet-of-things/

The End

Thank You!