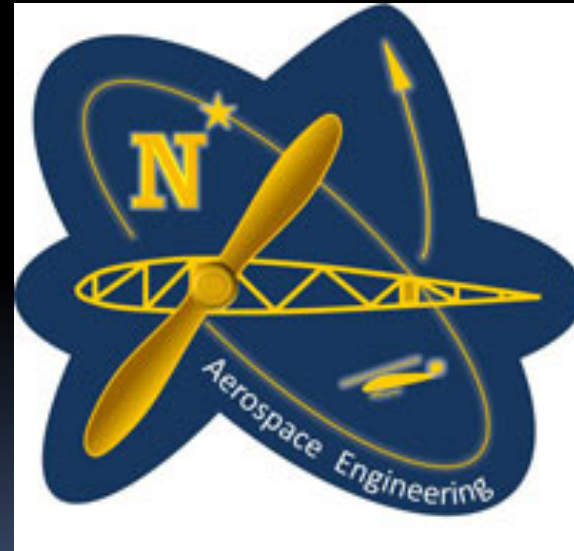


QIKCOM 1 & 2 RE-CONFIGURABLE TRANSPONDER MODULES

Nestord Diaz-Ordaz, Bryan Hunt
Michael Segalla, & Cole Skinker
Advisor: Bob Bruninga

March 8, 2015



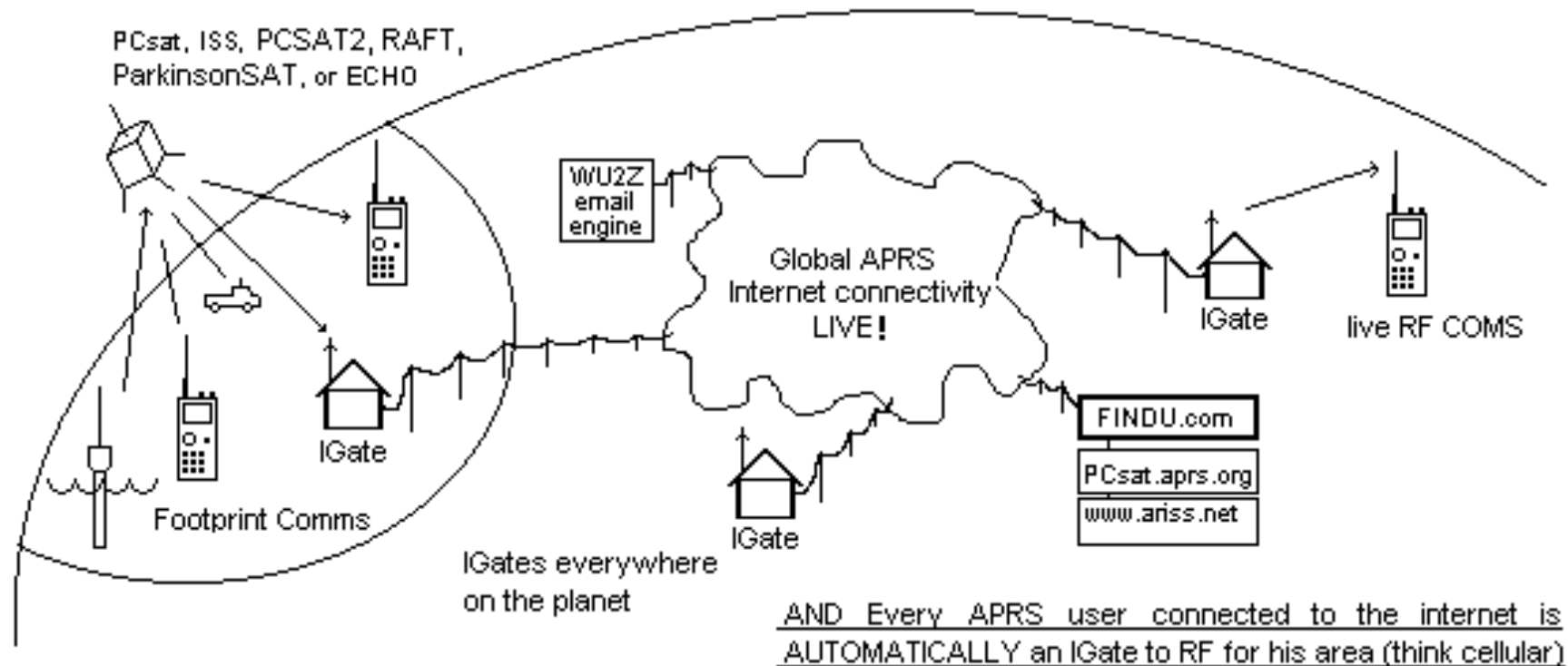
QIKcom Team



Automatic Packet Reporting System (APRS)

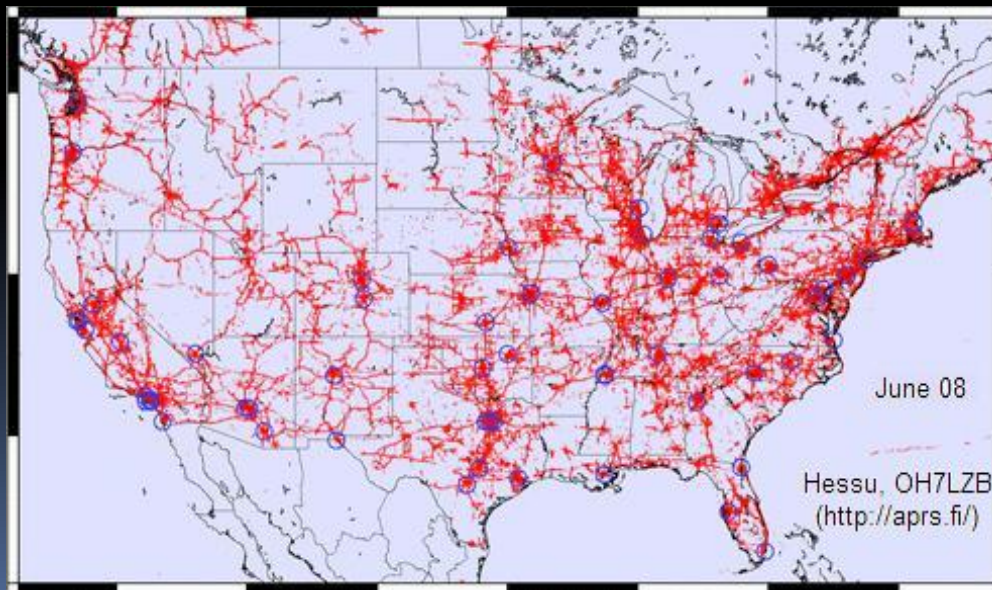
Global APRS Real-Time Connectivity

(End-to-End Everywhere)



Problem Background

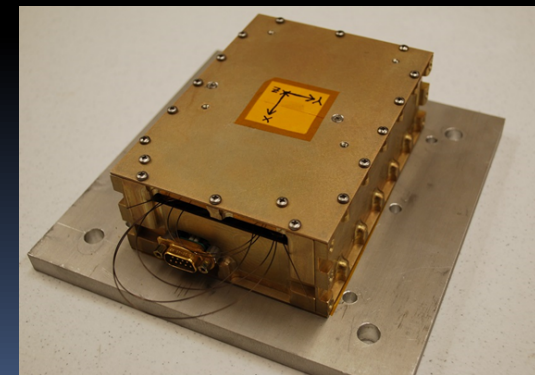
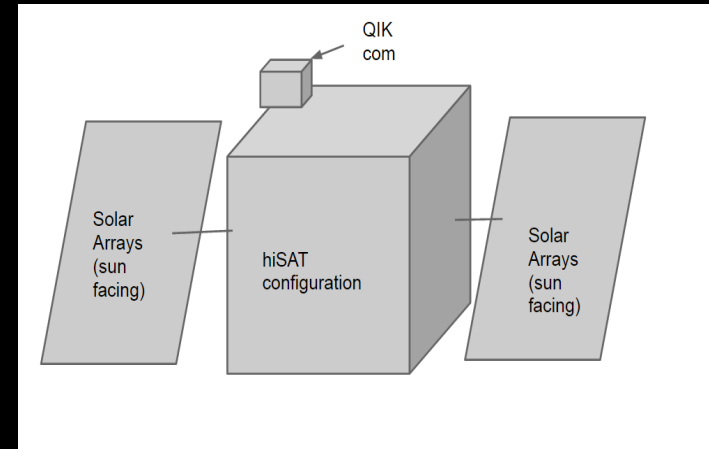
- Automatic Packet Reporting System Protocol (APRS) is the primary communications protocol used by USNA satellites
- With long development time, the response time for short-fuse launch opportunities is limited
- Lack of APRS satellites -> users remain on terrestrial frequency, rarely monitor space frequency



APRS Digipeaters in US as of 2008

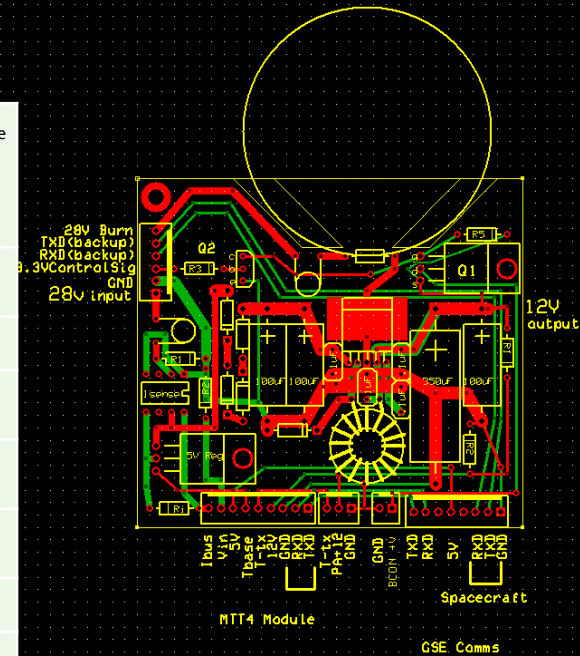
Host Satellite Opportunity: QIKcom1

- NovaWurks to host QIKcom1
 - HiSAT Provides:
 - Power
 - Thermal Control
 - Attitude determination system
- USNA provides capabilities:
 - Transponder to actively notify users
 - Power regulation
 - Antenna release mechanism



QIKcom1 Components: Electrical Power System

Load	Operating Voltage	I_{pk} (mA)	Duty Cycle	I_{avg} (mA)	28V I_{pk} (mA)	28V I_{ave} (mA)
Beacon (Standby)	12	15	98.3%	14.75	7.14	7.02
Beacon (TX)	12	600	1.70%	10.2	260	4.86
MTT4 (TX-users)	5	280	1.7%	4.8	55.6	0.95
MTT4 (TX-Telemetry)	5	280	4%	11.2	55.6	2.2
MTT4 (RX)	5	45	100%	45	8.93	8.93
Power Amp (TX)	12	600	10%	60	260	28.6
Total					647.3	52.6
28 V - Peak Power (W)				18		
28 V - Average Power (W)				1.5		

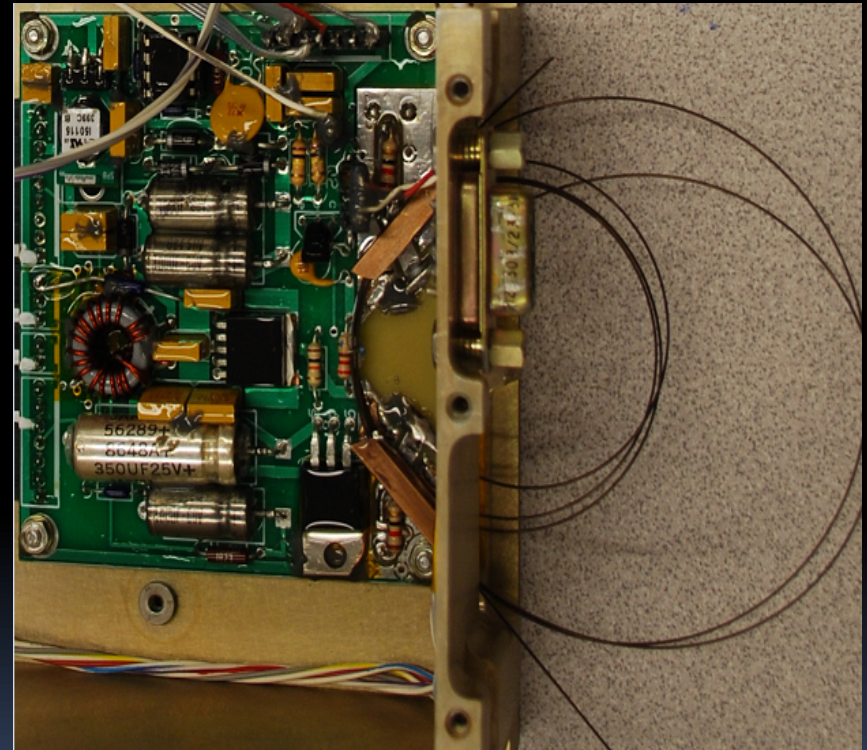


PCB Board Design

Power provided by host bus. P_{avg} of 1.5W consistent with 1U CubeSats, however all is dedicated to comms rather than other subsystems

QIKcom1 Components: Antenna Deployment Mechanism

- Attached to EPS Board
- 28 V burn signal sent by host spacecraft
- $\frac{1}{4}$ Watt 220 Ohm resistor
- Approximately 3 Watts power
- Burns through fishing line constraining the antennas in about 5 seconds
- 20 tests conducted with 100% reliability of release



QIKcom1 Components: Beacon and Transponder

- Beacon notifies users when satellite is overhead
- "145.825MHz QSY 4 OPS"

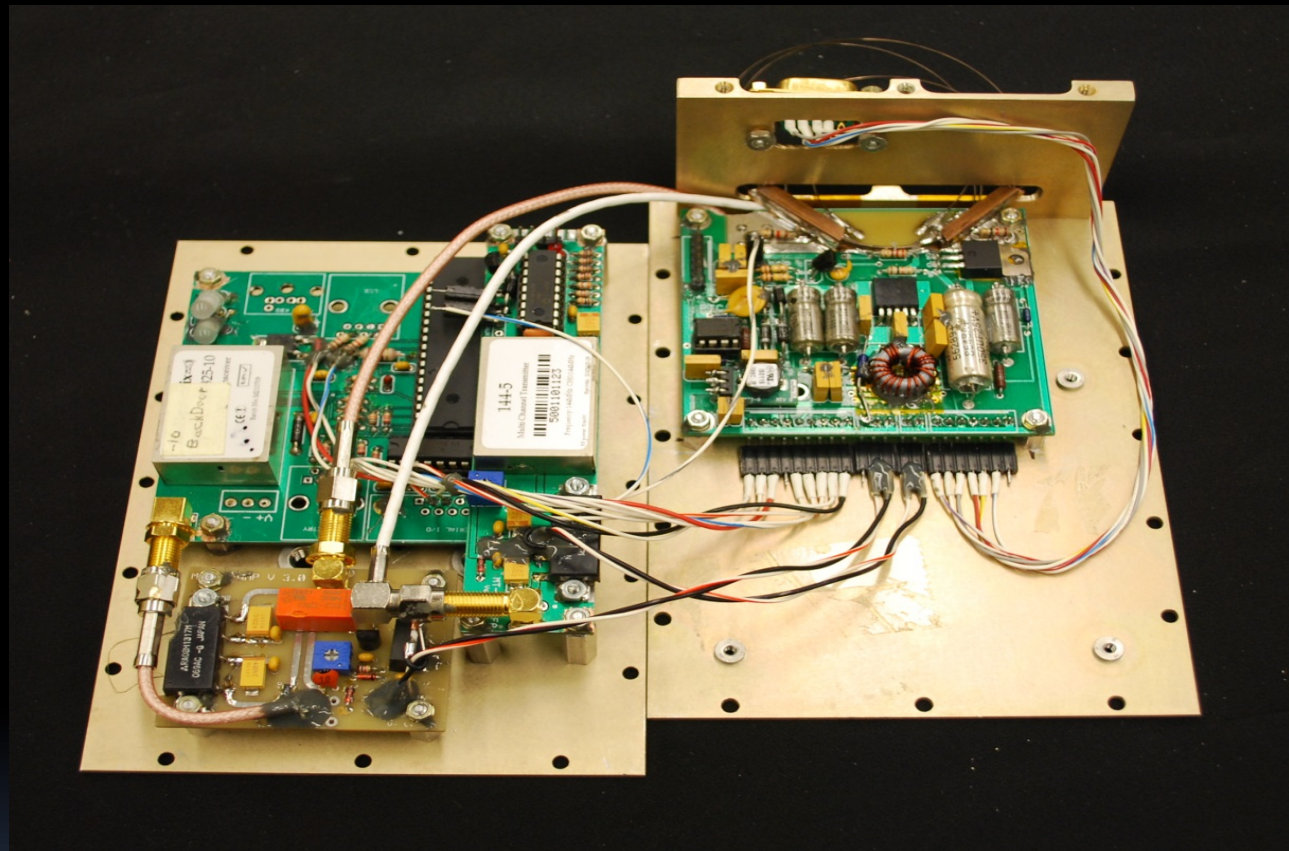


Telemetry Format:

QIKCOM-1>APTT₄,ARISS:T#001,28V, lbus,12V,Base_Temp,Trans_Temp,0000011



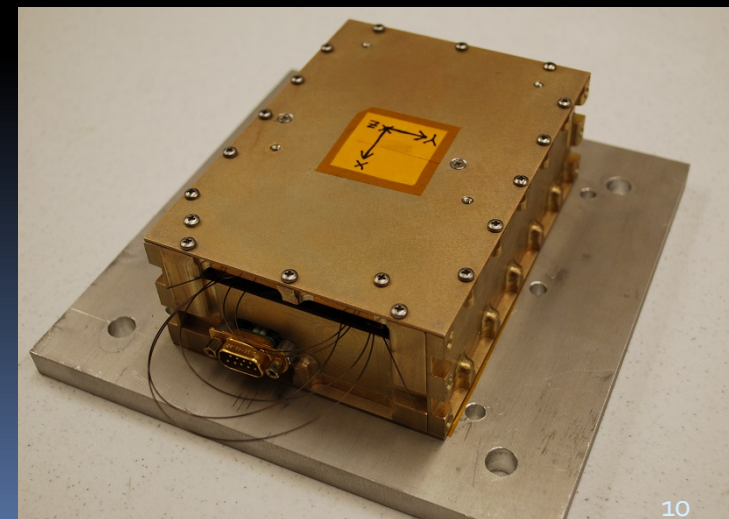
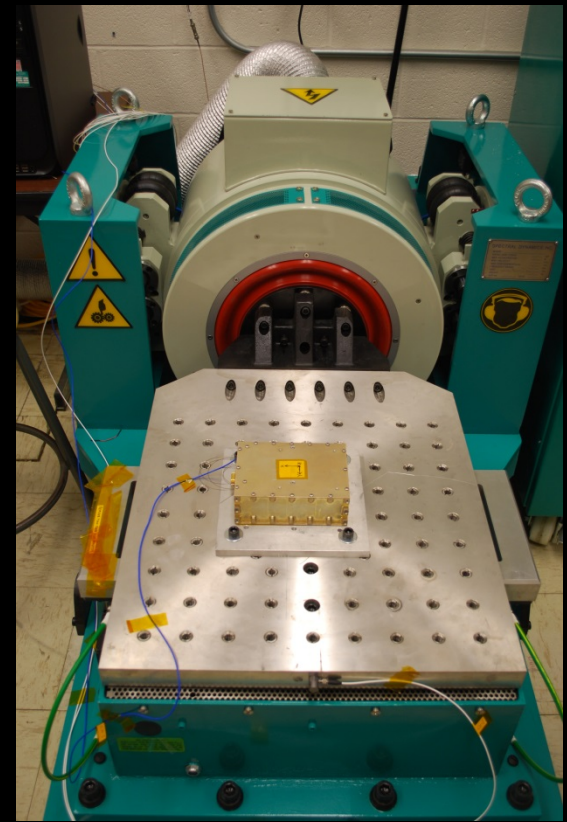
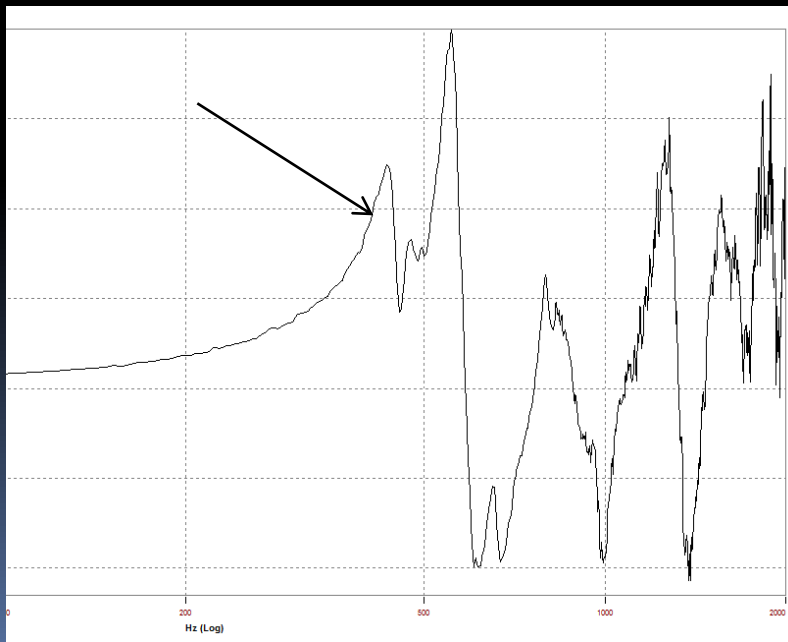
QIKcom1: Assembled Structure



- Baseplate with comms on left, Lid with EPS on right
- Irridite Aluminum, Emissivity: 0.11
- Flathead screws with countersunk holes for smooth attachment to NovaWurks host

QIKcom1: Vibe Test

- Conducted 24 Feb 2015
- Shaken in X and Y axes
 - Random vibe to Acceptance Levels of 10 G RMS
 - Both axes lowest resonance in both directions above 400 Hz
 - Satisfied launch provider requirements
 - Pre/post-test sine tests conducted at 0.5G to identify any anomalies; none detected



QIKcom1: Problems

- APRS radios are expensive; 10% users have a radio that can use it
 - Cheap radios cannot send or receive APRS messages or text messages of any sort
- No processing capabilities
 - No reconfiguration possible once launched

QIKcom2: Solution

- Dual-Tone Multi Frequency (DTMF)
- Text to speech + voice synthesizer
- Basic Stamp CPU
- MTT₄B APRS Transponder

Mission: Develop QIKcom-2 for under \$1000

QIKcom2: DTMF/Voice CONOPS

TX



Audio tones



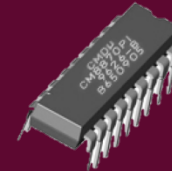
VHF RX



Audio tones

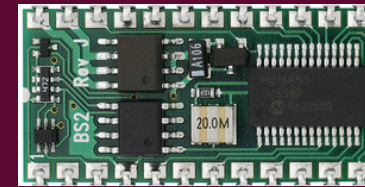


DTMF



16 Character Language

CPU



APRS packet



Text content



Text-to-Speech



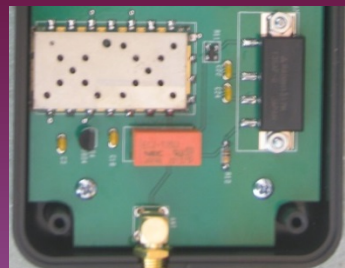
Voice Synthesizer



Audio Voice



VHF TX

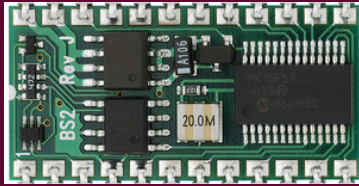


RX



QIKcom2: APRS Packet CONOPS

DTMF Decoding
CPU



APRS packet

MTT4-B



Ground Stations



APRS Radio



APRS packet

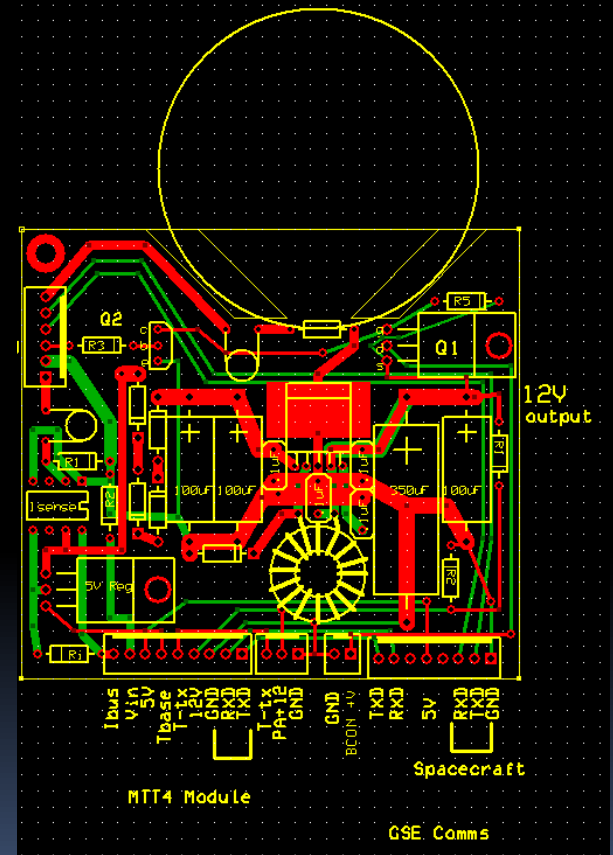
Global APRS
Internet
connectivity LIVE



QIKcom-2 Components

QIKcom-2 Components: Electrical Power System

Load	Operating Voltage (V)	I_{pk} (mA)	Duty * Cycle	I_{avg} (mA)	28V I_{pk} (mA)	28V I_{ave} (mA)
DTMF and Receiver	12	30	100%	30	14.29	14.29
MTT ₄ (TX-users)	5	600	4%	4.8	119.05	0.95
MTT ₄ (TX-Telemetry)	5	600	1.70%	11.2	119.05	2.22
MTT ₄ RX	12	60	100%	11.2	28.57	5.33
Text-To-Speech Module (active)	5	220	5%	11	43.65	2.18
Text-To-Speech Module (idle)	5	30	95%	28.5	5.95	5.65
SpeakJet (active)	5	5	5%	0.25	0.99	0.05
SpeakJet (idle)	5	5	95%	4.75	0.99	0.94
Paralax BS2 CPU (active)	5	8	10%	0.8	1.59	0.16
Paralax BS2 CPU (sleep)	5	100	90%	90	19.84	17.86
Total					353.97	49.64
28V - Peak Power (W)	10					
28V - Average Power (W)	1.4					



QIKcom-1 EPS with added DTMF and Voice modules

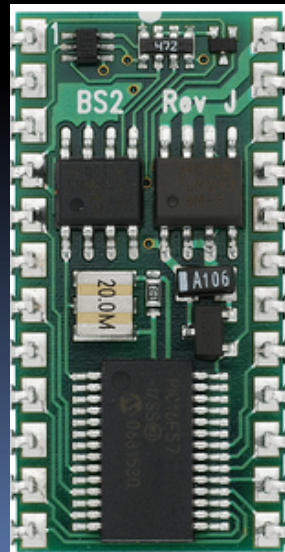
Dual-Tone Multifrequency Decoder & CPU

- Receives audio tones from amateur radios
- Translates DTMF tones into 16 key codes (4 bits)
- \$160

DTMF



CPU: Basic Stamp 2pe



- Parses DTMF key codes into APRS text packet
- Can alter APRS and Voice formats based upon channel load
- \$75

MTT4-B APRS Transponder

- Transceiver
- Flexible frequency range at 145 MHz
- Integrated 10W power amp
- Designed for automobiles
- \$250



Text-to-Speech & Voice Synthesizer

- Text-to-Speech chip receives DTMF data from CPU; converts to audio-phoneme codes
- Voice Synthesizer takes audio-phoneme codes and converts it to audio waves, then transmits them down on VHF

DTMF Text Encoding

Radio memories constrained to 16 digit memories

QIKcom-2 Keypad Format



DTMF Grid/Callsign Encoding

***GGGGCCCCC>NNN#**

G – 4 Digit Position Code

C - 6 Digit Callsign

N – 4 Digit Binary callsign decoder

DTMF Text to Speech Messaging

CTMMCCCCC>NNN#

C – C Key to indicate message

T – Test byte, “g” indicates emergency

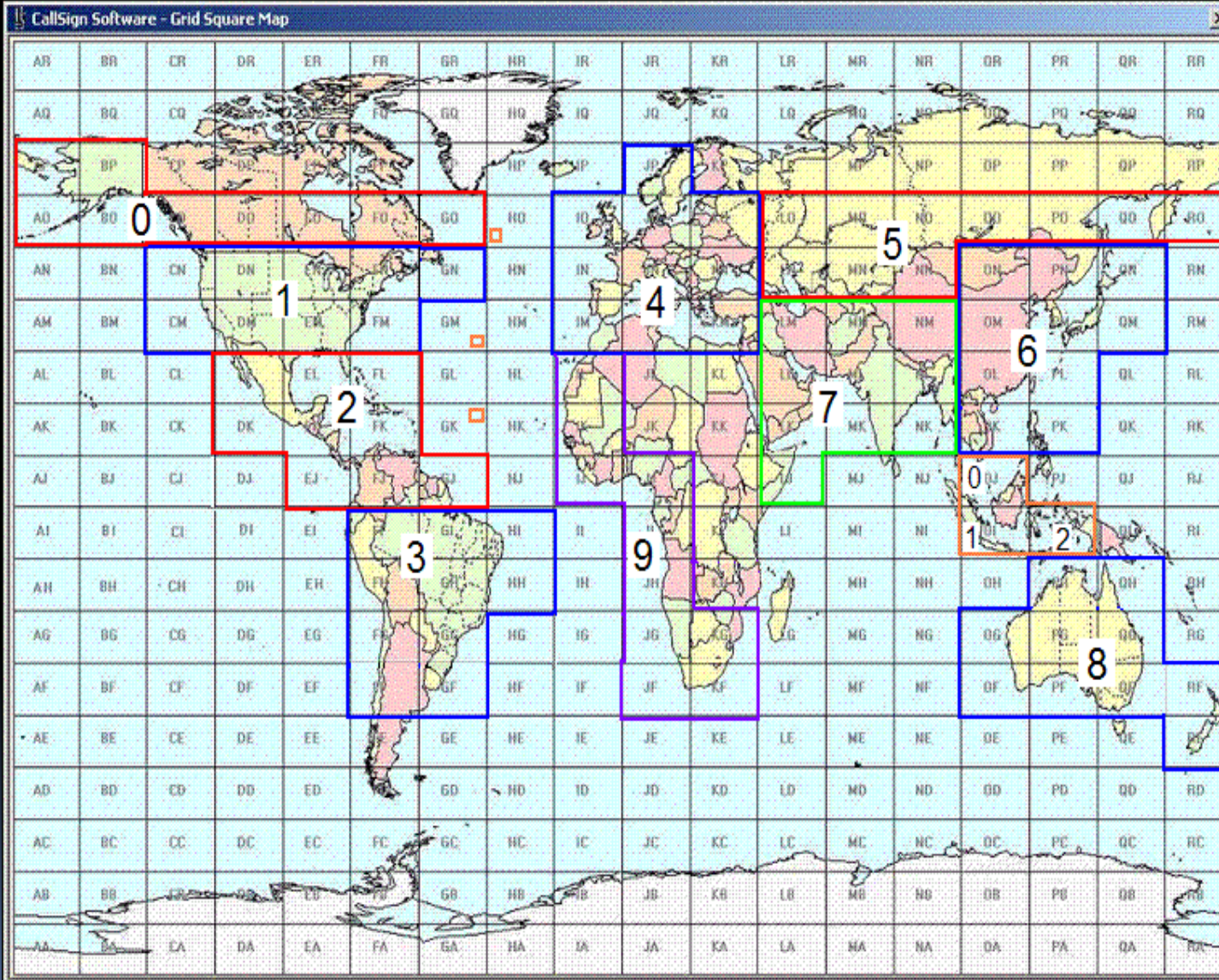
M – 2 Digit ARL radiogram

C – 6 Digit Callsign

N – 4 Digit binary callsign decoder

QIKcom-2 Gridsquare Position Reporting

Maidenhead Grid Square System



- 0 - Canada
AP, BP, AO, BO, CO
DO, EO, FO, GO, JO
- 1 - USA
CN, DN, EN, FN, GN
CM, DM, EM, FM, OM
- 2 - C America
DL, EL, FL, DK, EK
FK, EJ, FJ, GJ, OJ
- 3 - S. America
FI, GI, HI, FH, GH
HH, FG, GG, FF, GF
- 4 - Europe
JP, IO, JO, KO, IN
JN, KN, IM, JM, KM
- 5 - Russia
LO, MO, NO, OO, PO
QO, RO, LN, MN, NN
- 6 - Japan, China
ON, PN, QN, OM, PM
QM, OL, PL, OK, PK
- 7 - India
LM, MM, NM, LL, ML
NL, LK, MK, NK, LJ
- 8 - Aus/NZ
PH, QH, OG, PG, QG
OF, PF, QF, RF, RE
- 9 - Africa
IL, IK, IJ, JJ, JI,
JH, JG, KG, JF, KF

The table at right begins at 00 thru 99 to give worldwide 4 digit Grids for the next APRStt DTMF satellite using DTMF only.

DTMF Message Encoding Example

*1819 924277 1558#

DTMF Callsign Encoding

Callsign	W	B	4	A	P	R	
Letter Key	9	2	4	2	7	7	
Letter positions	1	2	0	1	1	2	
Weight	1024	256	64	16	4	1	
Sum	1024	512	0	16	4	2	1558

DTMF Grid Position Code 1819

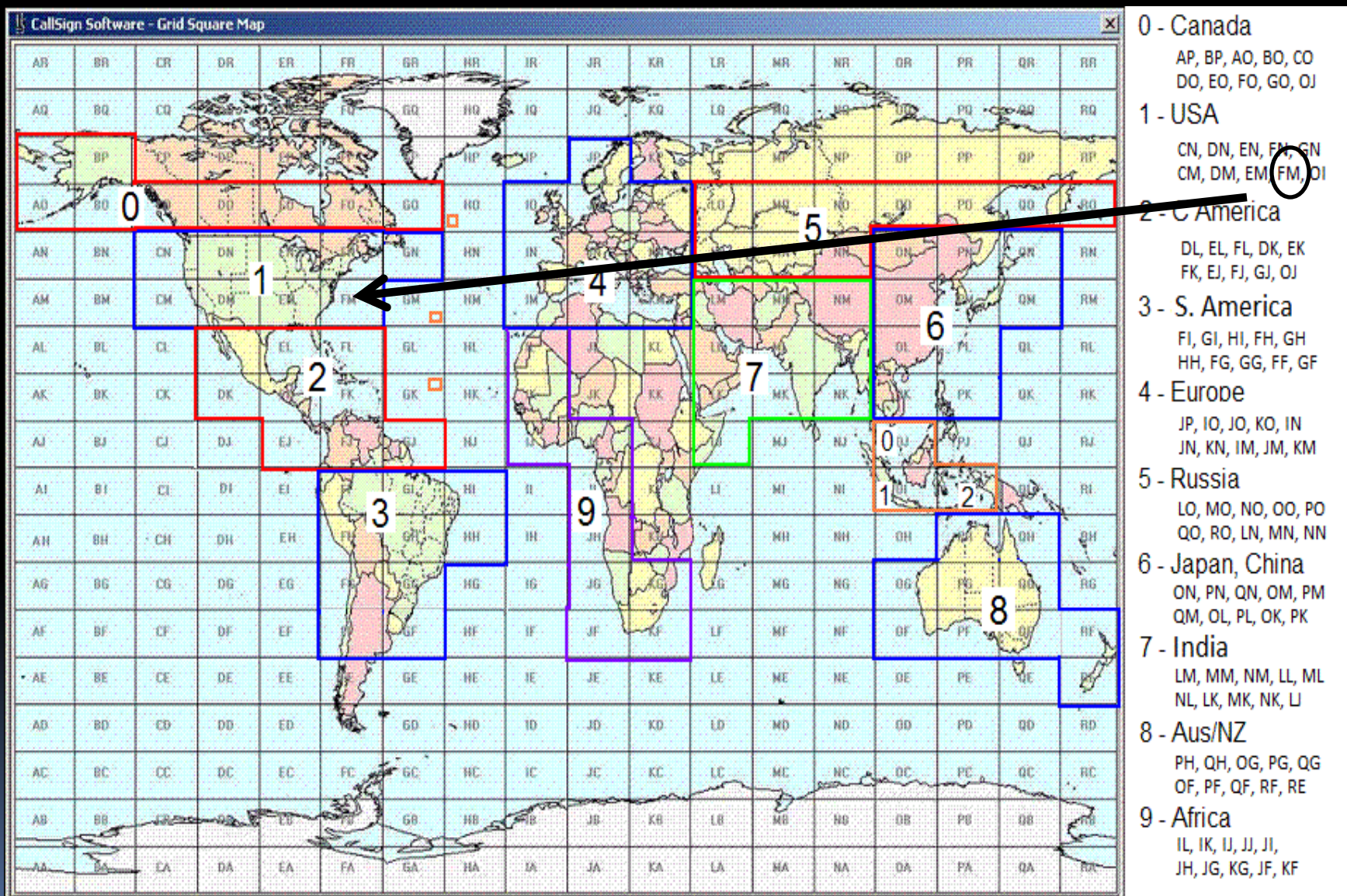
DTMF Position Reporting

1819



18 = "FM"

19 = Inner square coordinates



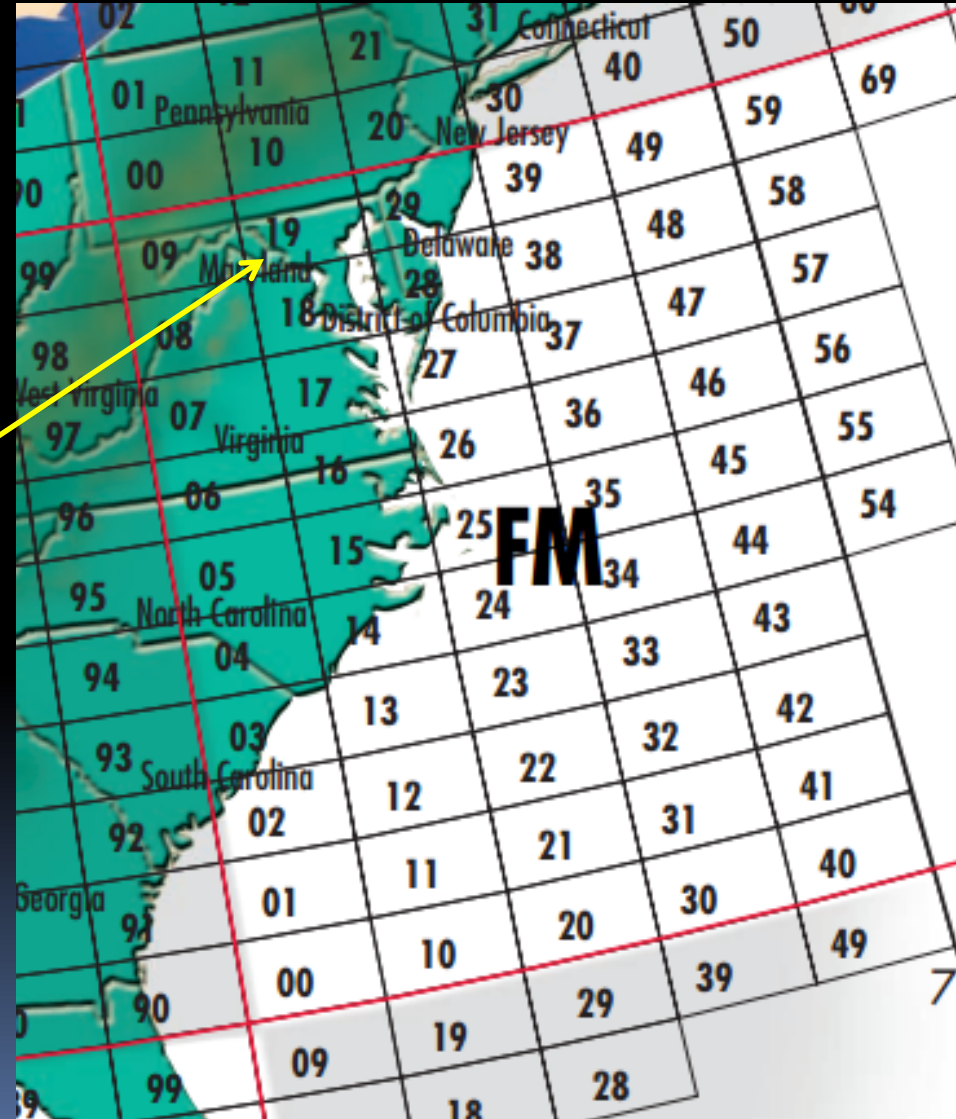
The table at right begins at 00 thru 99 to give worldwide 4 digit Grids for the next APRStt DTMF satellite using DTMF only.

DTMF Position Reporting

1819

Maidenhead Grid Square

19 = Baltimore area



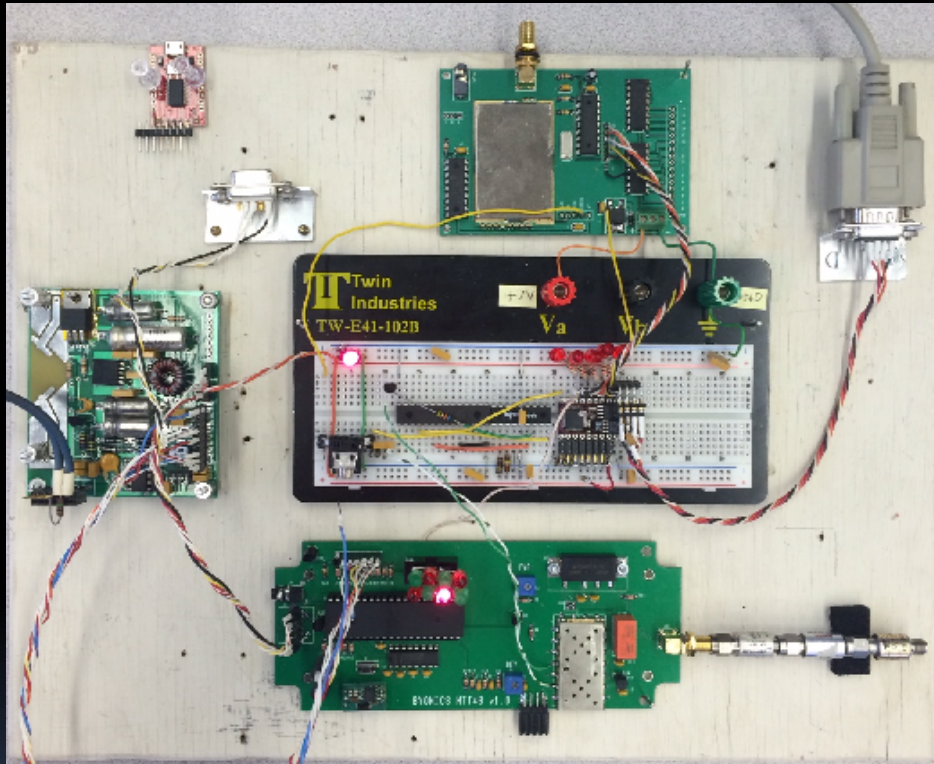
DTMF ARL Standard Radiograms

- Located at www.arrl.net
- Have been used for past 60 years for abbreviated radio communications
- Help DTMF users communicate given their limited capability
- Examples
 - **15** Please advise your condition and what help is needed.
 - **70** Go Navy, Beat Army!

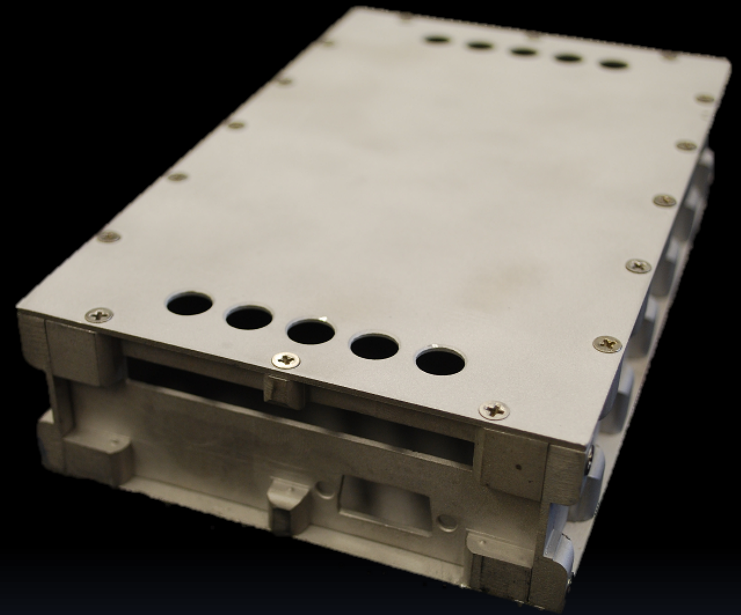
Power/Congestion Management

- Depending on system popularity, handling DTMF and APRS can overwhelm QIKcom-2
- Solution:
 - 2 Banks on MTT₄B, one includes APRS relay functions and one excludes them
 - Ground Control of multiple speech options (simple, verbose)

Current Work



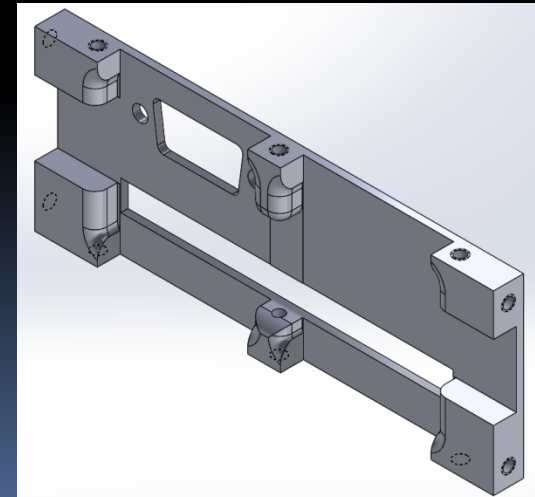
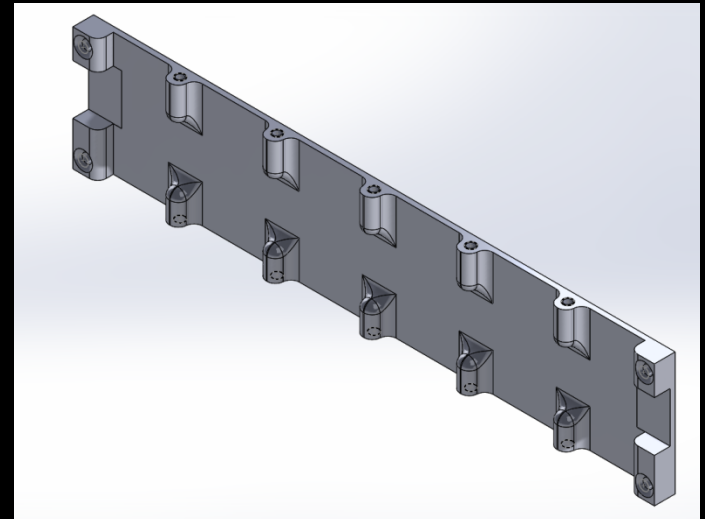
Breadboard Model



Flight Box

Future Work

- Assembly
 - Structure
 - Text-to-speech board assembly
 - Irridite the structure
 - Circuit Board Stacking
- Vibe Testing
- Acceptance Testing
- Delivery Date of May 15th





Acknowledgements

CDR Bob Bruninga, USN (ret.)

Assistant Professor Jin Kang

Technician Dante Marasco



Questions?

Extra: QIKcom-2 Schematic

