Ground Terminal Development for GEO (Phase 4B)

By Michelle Thompson, AMSAT and W5NYV

Michelle's video reports:
https://www.youtube.com/playlist?list=PLavdGnjBLuiX97DAKk32NJ1bCF1a0cv01

We live in a golden age. We have numerous options for innovative and inexpensive software-defined radio, a myriad of embedded processors, a variety of powerful development environments, and plentiful and cheap general-purpose processors. Data ubiquity has revolutionized personal and professional communications. Everyone has a cell phone and digital communications have triumphed over all. Communications is a solved problem!

Well, hold the phone. While many frequency bands have plenty of hardware, software, and firmware choices, there are many exceptions. Amateur microwave is still dominated by bespoke rigs producing narrowband analog voice and CW. Activity is mainly during contests, with beacons holding down the spectral fort for the long months between events. We are working very hard to change this situation in a fundamentally positive way.

AMSAT's next generation of digital microwave satellites is moving firmly into the 5GHz/10GHz bands. This is where the bandwidth is at, this is where the current professional interest lies, and this is where we must become competent designers and more plentiful operators.

In order to operate, radios must exist. Buying inexpensive off-the-shelf equipment to work these new digital satellites is not an option for the microwave bands. We believe that we must provide solutions for radios for the satellite service, otherwise these satellites will simply not be used. These solutions must include instructions on how to build rigs from scratch, instructions on how to build up rigs from existing components and radio gear, and a quality manufactured solution that can also be used for emergency communications services.

The amateur satellite service alone may not justify the expense and effort required to design and build a new radio system. But, this is the age of software-defined radio. Since the selected waveforms for AMSAT digital satellites and the waveforms for terrestrial digital television are from the same family of standards, we have a wonderful opportunity to make a radio that will do both space and ground. This opens up both amateur terrestrial and amateur space markets.

But we're not done yet. If intelligently designed, this radio is also microwave band test equipment, providing yet another market. Phase 4 Ground exists to make this radio a reality.

What have we done so far?

We have attracted 70 volunteers for the ground terminal. AMSAT has provided a mailing list for this international community in order to communicate and plan. Active volunteers meet with each other at events and conferences throughout the year. Many of us are building things and writing code and figuring things out. As an open source and open process project, we are committed to documentation and have excellent support here from github. As a ground terminal project, we separate ourselves from payload development, and are therefore not controlled under ITAR/EAR. We communicate with the payload teams through common air interface documents. This separation allows us to operate in public and accept non-US persons as volunteers.

https://github.com/phase4ground

We've decided on a communications protocol. Namely, DVB. Space projects use DVB-S2 or DVB-S2X, depending on their mission. Geosynchronous, high-earth-orbit, extra-planetary like the Cube Quest Challenge, and many other orbits are possible to support. Terrestrial "groundsats" that provide powerful and fun digital microwave communications systems will use DVB-T2. S stands for space, T stands for terrestrial. The primary difference between the two is the need for terrestrial systems to be resilient against multi-path propagation. Therefore, the waveform design differs. There's another difference. Terrestrial and satellite communications have different frequency assignments in these microwave bands. Auspiciously, those sub-bands are located close enough together that one radio really can do it all without onerous frequency agility requirements.

Using DVB, a widely accepted and highly-regarded communications standard, provides enormous educational experience for anyone that builds their own rig, puts together a kit, or that looks under the hood of their manufactured radio. Technical education in digital systems is a core motivation for this project. This commitment extends past the completion of the engineering and design in order to support the use of this radio in schools and wherever communications theory and practice is taught or appreciated.

We've transmitted and received both space and terrestrial standards in the lab, and have solutions for very inexpensive terrestrial receivers.

We've begun work on creating the required GNU radio flow graphs to implement all the radio functions we require. There will be a lot of programming involved in this area, especially in the area of fully utilizing the large FPGAs that are in the sort of software-defined radios that GNU radio targets. Writing GNU radio blocks that can fully utilize the FPGAs is a very advanced area of the radio art and an area of active current research. Our project is fully committed to supporting and assisting this effort in any way we can.

We've begun to build the RF chains. The 5GHz uplink has prototypes and results, and the power produced is promising. 10GHz receiver strategies have been prototyped and several methodologies to use DSP techniques to allow the use of very inexpensive LNBs are being evaluated.

We've designed an improved dual-band feed to enable single-dish communications. Using one dish enables improved portable communications for emergency operations. It also enables more compact permanent deployments. This is a challenging problem due to the mathematical relationship between the two bands. The second harmonic of the 5GHz transmitter must not be allowed to desense the 10GHz receiver. Simulations of the dual band feed show 10dB improvement in isolation over the current commercial design. Prototypes for range tests are being manufactured now.

We've evaluated three of the most commonly available microwave-capable SDRs and found them to be compelling candidates for inclusions in a kit approach to the radio. The growing list of recommendations and recipes will be documented and shared as part of the public document repository.

We need more volunteers that are willing to build things and do code. This is a permanent condition for a volunteer-based technical open source project. Recruitment will continue indefinitely. We welcome anyone willing to commit time and energy. We will meet anyone where they are and use whatever expertise they have.

We need enough money to pay for development boards that Flex Radio has indicated they are willing to build for us. Having hardware as close as possible to the manufactured solution would provide substantial forward momentum. Our ambition is to continue to work with Flex as our manufacturer. This is not an exclusive arrangement, but they are a supportive and interested partner very closely aligned with the Phase 4 Ground market. We need money to integrate the lessons learned from the development boards into the final product. We will need money to support customer service and technical support.

As these radios are reconfigurable, we anticipate enabling advanced features moving forward. Some costs are going to be associated with as-yet unthought-of innovations and applications. These costs, while minimal, are non-zero.