

Summary Proposal – Open Research Institute Phase 1 P4XT

Introduction

P4XT is an open source project with hardware, firmware, software, and documentation components. The goal is to create an amateur radio communication system using Digital Multiplexed Transponders (P4XDMTs) in geosynchronous orbit. The P4XT project is expected to extend over a total period of two to three years. It will include construction of a small number of transponders, including development articles and eventually flight hardware. In addition, the project will create ground station modem designs, including a cost-optimized modem intended for volume production. The overall project and its motivations are described in some detail in a separate document. This summary focuses on Phase 1 development of the transponder.

Leverage

The P4XT project invests in components, test equipment, tools, and Internet resources. These investments enable dozens of engineers in the global amateur radio community who are willing to provide their valuable time at no cost. All of the work product of the project is open source and available for use by the community. Everything is available through the project's git repositories. The project team will continue to provide tens of staff years of volunteer engineering talent. This would easily cost many millions of dollars in a traditional commercial or government project settings of similar complexity.

P4XDMT Phase 1

In complex electronic projects, there are numerous advantages to producing early hardware articles. Many lessons can be learned through an agile development process that produces some early working hardware that can demonstrate key well-defined capabilities while also demonstrating the viability of the development approach. Accordingly, we are proposing a Phase 1 for the DMT project that will produce a few articles of DMT hardware that will initially demonstrate a DVB-S2 Downlink from the open source P4XDMT codebase. These articles will not be the final design and will not be based on fully validated FPGA code. They will nevertheless serve as an intermediate reference from which the final design can be evolved. These "engineering articles" will run all of the code base (FPGA code and General-Purpose processor code) on hardware very similar to the target. This will allow real world test and evaluation, particular with respect to hardware matters, e.g. Size Weight, and Power (SWAP) and environmental tolerance. This is far preferable to the use of off-the-shelf evaluation boards that have few of the severe hardware design constraints associated with equipment ultimately destined for space.

Phase 1 Milestones

Phase 1 will produce a small number of Engineering articles for the DMT. Each article will be a two board (90mm x 90mm) set consisting of a Baseband Processor Board and a Radio Board. The two boards will communicate via JESD204B SERDES links. The BBP will be based on a Xilinx Zynq Ultrascale+ device with 2 ARM A53 64-bit cores and 2 ARM R5 32-bit lockstep cores. The boards will have 200K - 500K logic elements in the FPGA fabric depending on the particular FPGA that is fitted. The Radio Board will be based on an AD9371 device with low power RF output in a suitable amateur UHF/Microwave band (23cm). The Phase 1 Software/Firmware load for the milestone will provide a complete DVB-S2 transmitter with a relatively low-level RF power. The data input to the transmitter will be a combination of fixed demonstration data and external data from a host. DVB-S2 QPSK AND FEC rates from $\frac{1}{4}$ to 8/9 will be supported at symbol rates from 80kHz to 8MHz (RF output of 100kHz to 10MHz). The output can be received by any compliant DVB-S2 GSE receiver.

It should be noted that the engineering articles will include receive as well as transmit hardware. However, the Milestones will be limited to the DVB-S2 Transmitter.

Phase 1 Funding

Achieving the Phase 1 milestones requires a funding grant of \$50,000. This will be allocated approximately to the following expense categories:

- \$25,000 for component hardware and fabrication related services.
- \$10,000 for off the shelf evaluation boards.
- \$ 5,000 for Cloud Resources (e.g. EC2-F1, Google Cloud, etc.)
- \$ 5,000 for Tool Licensing
- \$ 5,000 for overhead travel and other direct overhead expense.

Amounts may be shifted somewhat between categories depending on need. Note that there are no labor costs associated with the Phase 1 project.

Principal Investigator

Wally Ritchie (WU1Y) will serve in the role of principal investigator responsible for the technical success of Phase I.