

## Specification for Upperstage Ground Command, Telemetry, and Ranging System (GCTRS)

### 1.0 Background:

As part of the Upperstage Program, NRL and the Blossom Point Ground Station would like to migrate to next generation of Ground Support equipment to support the Upperstage Spacecraft RF Communications Requirements as well as support future advanced Command, Telemetry, and Ranging requirements. The Upperstage Ground Command, Telemetry, and Ranging System (GCTRS) will be used at the Blossom Point Ground Station and NRL Spacecraft Integration and Test Facility to provide a complete baseband signal processing capability, which supports the RF Communications Link for The Upperstage Spacecraft. The RF communication system on the Upperstage is SGLS (Space Ground Link System) compatible per AFSCN SIS -000502D. The GCTRS provides the complete Uplink command formatting, encoding, and modulation at 70 MHz IF Frequency. It also provides the complete receive, demodulation, and baseband telemetry processing capability for the downlink. Finally the GCTRS creates a Pseudo Random Numeric (PRN) Code which is modulated on the Uplink and received on the downlink, processed, and computes the range and range rate calculation. The GCTRS is the primary part of the Transponder Ground Test Equipment Suite as shown in Figure 1.

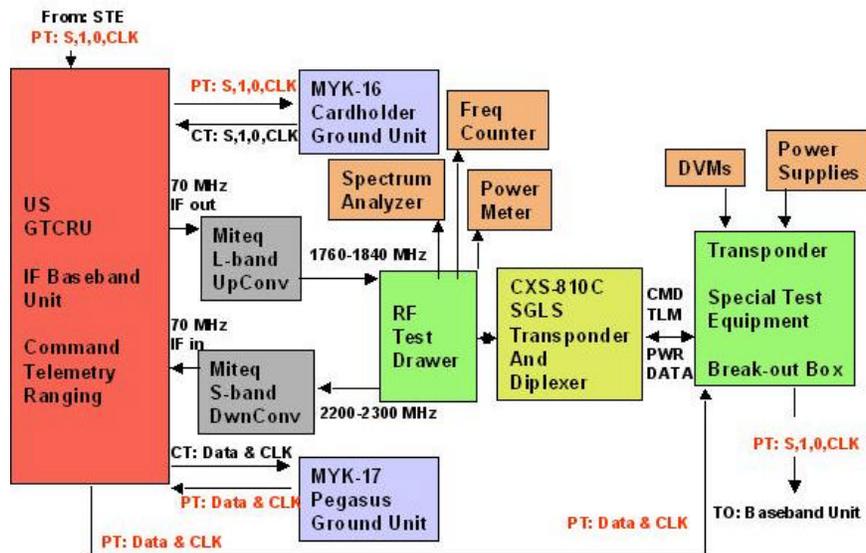


Figure 1. Upperstage RF Ground Support Test Equipment Block Diagram

## **2.0 Scope:**

The contractor shall provide complete ground systems which support telemetry, command, and ranging functions (RF through baseband) in a compact 4U chassis. Telemetry signal processing functions include RF downconversion, 70MHz IF Receiver, (PM, PSK, FM Demodulation), subcarrier demodulation (BPSK/QPSK), bit synchronization, decoding (Viterbi/Reed-Solomon), and frame synchronization. The systems must also accept command data inputs from network packets and discrete ternary or di-bit interfaces. The systems shall generate the appropriate tone frequencies for the command bits and performs command modulation (SGLS, STDN, USB, Tone) to baseband, IF and RF frequencies. Range tone generation (PRN, multi-tone) and processing of the returned ranging signal must be supported for SGLS, STDN, and multi-tone schemes. The systems must also include a Command and Telemetry Bit Error Test Capability for Transponder Level testing as shown in Fig 1.

## **3.0 Upperstage GCTRS Requirements:**

3.1 The contractor shall provide an Upperstage Ground Command, Telemetry, and Ranging System that meets or exceeds the following specifications.

### **3.2 Outputs**

- PCM Clock and Data
- Various Test Points — Baseband, Digital

### **3.3 Command Generation/Modulation**

- SGLS, STDN, Tone
- Output Frequency — 65 MHz to 75 MHz
- IF Output Power Level — -55 dBm to 0 dBm

### **3.4 Carrier Modulation**

- PM, PSK, FM — up to 5 Msps

### **3.5 Subcarrier Modulation**

- Up to Two PSK subcarriers
- FM — up to 750 kHz deviation

### **3.6 Physical Dimensions**

- 4 U 19" Rack Mountable Unit
- Physical Dimensions
  - Height = 177 mm (4U)
  - Width = 483 mm (19 inches)
  - Depth = 550 mm
  - Weight = 35 kg

**3.7 Environmental**

- Operating Temperature: 10 to 30 deg. C
- Non-Operating Temp: -20 to 60 deg. C

**3.8 Power**

- 110/240 VAC
- 50/60 Cycle

**3.9 IF Receiver**

- IF Signal Level: 0 to -90dBm
- 3 dB Bandwidth: 35MHz
- Max Doppler: 200 KHz
- Maximum Doppler Rate: 10 kHz/sec
- IF Center Frequency: 66 MHz to 74 MHz 1Hz Res.
- Acquisition Time 1000 bits for EB/No  $\geq$  6dB; 100 bits for EB/No  $\geq$  15 dB
- Up to 2 Simultaneous IF Receiver Channels (2 TLM, 1 Ranging and Command Echo)

**3.10 Demodulation**

- Up to 2 Carrier Demods/DSP
- Carrier Demodulation Modes: PM, FM, BPSK, QPSK, SQPSK, AQPSK, PCM/PM (PSK)
- Up to 2 Simultaneous Sub-Carrier Demods/DSP
- Sub-Carrier Demodulation Types: BPSK, PCM/FM
- Subcarrier Frequency — up to 20 MHz
- FM — up to 250 kHz Deviation

**3.11 Bit Synchronization**

- 2 Telemetry Bit Synchronizers/DSP
- 100 bps to 20 Mbps Bit Synchronization
- PCM Code Processing: Re-Interleaving, Viterbi Decode (Rate  $\frac{1}{2}$ ,  $\frac{1}{3}$ ), QPSK/SQPSK ambiguity resolution, Reed Solomon
- PCM Codes Supported: NRZ-L, NRZ-M, NRZ-S, Bi-F L, Bi-F M, Bi-F S, DBi-F M, DBi-F S, DM-M (Miller M), DM-S (Miller S)
- BER Performance: 1.5 dB from Theory Worst Case

**3.12 Uplink IF**

- One 70 MHz IF/DSP
- IF Signal Level: 0 to -40dBm
- Output Level Accuracy: 1dB
- In-band Spurious: < -55 dBc
- Out-of-band Spurious: < -40 dBc
- Phase Noise: 0.5 deg. RMS from 50 Hz to 1 MHz
- IF Center Frequencies: 66MHz to 74 MHz 1Hz Res.
- Carrier Modulation: Direct PSK types, FM, PM

**3.13 Uplink Modulation**

- SGLS Commanding (FSK AM)
- USB Commanding
- Echo Processing For SGLS and USB Commands
- Alternative Commanding

**3.14 SGLS Commanding**

- 3-Tone FSK With AM Modulation
- Tone Frequencies: 1kHz to 1.1 MHz with 1 Hz Resolution
- AM Sync Delay: 53% to 67% of bit period with 1% Resolution.
- AM Mod Index: 0 to 100%
- Uplink BER: < 5 out of 10<sup>9</sup> Bits
- Carrier Mod Index: 0.1 to 2.0 radians with 0.01 radian Resolution.
- Symbol Rates: 1ksps, 2ksps, 10ksps

**3.15 USB Commanding PSK Frequencies: 1kHz to 2MHz**

- Bit Rates: 100 bps to 2 Mbps
- Modulation Type: BPSK, Direct PSK (> 4kbps)
- Sub-Carrier Mod Index: 0.1 to 2.0 radians with 0.01 radian Resolution.
- Sub-Carrier Frequencies: 8kHz or 16 kHz

**3.16 Alternative Commanding**

- PSK Frequencies: 1kHz to 2MHz
- Bit Rates: 1kbps to 2 Mbps
- Direct Carrier Modulations: PSK, QPSK, BPSK, SQPSK, AQPSK, PM, FM
- Sub-Carrier Frequencies: 1.0 to 1.7 MHz
- Sub-Carrier Mod Index: 0.1 to 2.0 radian with 0.01 radian Resolution

**3.17 SGLS Ranging Ranging Coherency Modes: Coherent and Non-Coherent Transponders**

- PRN Ranging Method
- Ranging Distances: 148 km to 186000 km
- Bias Error: < 6m RMS with a 30 dB.Hz Sr/No
- Noise Error: < 1.5m RMS with a 30 dB.Hz Sr/No
- Measurement Time: < 10 s for Sr/No  $\geq$  50 dB.Hz; < 100 s for ranges Sr/No  $\geq$  30 dB.Hz
- Maximum Doppler: 200 kHz
- Maximum Doppler Rate: 10 kHz/sec
- Ranging Resolution: 1ns (LSB)

**4.0 Preliminary Design Review (PDR)**

The contractor shall support a one-day PDR at their facility 30 days after contract award. The PDR shall include but not be limited to the following items Electrical Description, Mechanical Description, Interfaces, Test Program, & Schedule.

**5.0 Installation and Integration**

The contractor is responsible for installing and integrating a fully functional system 7 (seven) days after delivery of the system, 150 days to the laboratory.

## **6.0 Technical Support**

The contractor shall provide telephone/fax/e-mail support for a period starting with delivery of the completed systems and extending for 12 months after the installation and training is completed.

## **7.0 Training**

The contractor shall provide training for the GCTRS. The training will take place at NRL for (6) six personnel fro a period of 2 days (8 hrs each). The operator's manuals shall be used in the training session.

## **8.0 Acceptance Test Procedures**

The contractor must submit 90 days after contract award a system performance verification procedure for the overall system and subsystems, which will be used to verify the system performance specifications

## **9.0 Manufacturers Data and Specifications**

All hardware subsystems delivered under this contract and the manufacturers published specifications on each subsystem must be submitted 30 days after contract award for Government review and delivered with the systems.

## **10.0 System Verification and Acceptance**

The contractor shall provide test data verifying that all system performance parameters are met for the GCTRS with the delivery of system.

## **11.0 Warranties**

The contractor must provide a standard commercial warranty for the GCTRS