FAST Electrical Systems Engineering Development Plan

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Prepared by: Matt Tooley Date: 1-6-92
Matt Tooley/743.1 FAST Lead Electrical Systems Engineer

Approved by: Mark S. Steiner Date: 1/6/92
Mark Steiner/743.1 Head, Payload Design Section

Approved by: Robert W. Stone Date: 1-6-92
Robert W. Stone/743 Head, Instrumentation Branch

Approved by: Tim Gehringer Date: 1/24/92
Tim Gehringer/740.4 FAST Mission Manager

1 Introduction

This document describes the plan for the FAST Electrical System Engineering. The FAST electrical system is made up of six subsystems: Mission Unique Electronics (MUE), Transponder, Antenna, Harness, Power, and Instrument Data Processing Unit (IDPU). The Instrumentation Branch, Code 743, has the responsibility for the contents and implementation of this document. This document will cover the elements, manpower, funding, schedule, and verification testing required for providing a flight qualified electrical system.

The electrical system is made up of integrated electrical subsystems. The design and building of the electrical system is achieved by making system level technical trades and decisions; designing the command and telemetry system from end-to-end; identifying, defining, and refining requirements for each subsystem; making sure all interfaces are understood and agreed to by affected parties; and supporting the scheduling of integration and testing. The job of ensuring that they work as a unit is the job of the Electrical System Engineer.

2 Applicable Documents

3 Requirements

The FAST electrical system as a whole will meet all applicable requirements in the FAST Mission Requirements Document. Most of the derived electrical system requirements can be found in the MUE Requirements Document.

4 System Description

The electrical system performs the following functions: communications (command and telemetry), attitude control electronics, power generation and conditioning, pyrotechnics, and instrument control and data collection. Each of these functions is performed by one of the electrical subsystems.

4.1 MUE

The MUE is the heart of the electrical system. It performs the attitude control, data management, housekeeping, telemetry, and commanding for the FAST spacecraft. The power system electronics are also housed in the MUE. The MUE is headed up by code 745 with support from code 743.

4.2 Transponder

The transponder provides the RF uplink and downlink. The transponder is provided by code 727.

4.3 Antenna

The antenna is a four patch micro-strip antenna provided by code 727.

4.4 Harness

The harness is an all metal conductor wiring harness to provide the interconnection of all the electrical subsystems. The harness does not contain a fiber optic portion like SAMPEX. The harness is provided by code 743.

4.5 Power

The power subsystem is broken down into two parts, electronics and power generation. The electronics are housed in the MUE and are based on the SAMPEX PSE. Code 745 is providing the power electronics. The power generation is the solar array and battery. They are being provided by Code 711. Code 711 is the lead on the power system.

4.6 Instrument Data Processing Unit (IDPU)

The IDPU is the microprocessor and mass memory for the instruments. It contains 128 Mbytes of memory. UCB is providing the IDPU.

5 Trade Studies

No known trade studies are seen to be done at this time.

6 Costing

The costing of each subsystem can be found in their respective development plans. Therefore I will show only the costing for the electrical system itself here.

6.1 Make/Buy

There are no make buy items.

6.2 Manpower

Civil Service

Position/Skill	FY92	FY93	FY94
Lead Electrical Systems Engineer	1.0	1.0	0.8
Communications Engineer	0.1	0.1	0.1
Totals	1.1	1.1	1.1

6.3 Costing

Item Description	Total	FY92	FY93	FY94
System Development and Testing Tools	$15K	$5K	$5K	$5K

These cost should be included in the MUE Budget TC

7 Schedule/Activity Flow

The following is a description of the activities to be performed, coordinated, and reviewed by the electrical system engineer. In parenthesis is shown the organization primarily responsible. The items highlighted with an asterisk are the items that the electrical system engineer will be directly responsible.

7.1 Documentation

7.1.1 SMEX/FAST Telemetry and Command Data Formatting Requirements (743) *

This document defines how the telemetry and commands are to be formatted to meet the CCSDS standards. It identifies the options being used by FAST. The document covers the formatting of the telemetry and command from the physical layer (RF signal) through the application layer (STOL). It primarily covers the data structures of the telemetry and commands.

7.1.2 FAST Spacecraft EMI/EMC Requirements (743) *

This document will fully define, as best understood from the PI, the EMI/EMC requirements as they pertain to the electrical system. This will be accomplished by red lining the ISTP Polar and Wind EMI/EMC guidelines and requirements and removing any that don't apply to the FAST mission. The project and PI will sign off on the final EMI/EMC requirements. This document shall be included in the MUE Requirements document as an appendix.

7.1.3 FAST Spacecraft Grounding Requirements (743) *

This document will contain the grounding requirements and guidelines for the FAST electrical system. These requirements will be derived from the EMI/EMC requirements and *Noise Reduction Techniques in Electronic Systems*, by Henry Ott.

7.1.4 MUE CCSDS Implementation Document portion of MUE Users Guide (745/743)

This document will be a supplement to the SMEX/FAST T&C Formatting Requirements. This document will be a Users Guide that explains how the Command and Telemetry System works on the FAST spacecraft. Topics to be included are: S/C Packet Generation, Instrument Packet Generation, Telemetry Modes, Low Rate Transfer Frame Generation, High Rate Mode Transfer Frame Generation, Command Ingest, Telemetry Recording, and Stored Command Processing.

7.2 MUE Command and Telemetry System Testing (743)

7.2.1 Testing of D/L Breadboard (743/Settles)

The testing of downlink breadboard will determine that the breadboard design meets the functional requirements imposed upon it by the Telemetry System. These functions include: high rate telemetry interfacing from IDPU, low rate telemetry interfacing from the MUE, and telemetry channel coding.

7.2.2 Testing of U/L Breadboard (743/Settles)

The testing of the uplink breadboard will determine that the breadboard design meets the functional requirements imposed upon it by the Command system. These functions include: data sense (inverted or normal), byte synchronization, parity checking, and time correlation.

7.3 Transponder (727)

7.3.1 Sign off Interface for Transponder to MUE (727/743)

The interface of the MUE to the transponder needs to be accepted to by Code 727 (Motorola) and Code 743. This will be the interface that both parties are designing their subsystems to meet. This interface should be agreed to before Motorola's CDR.

7.3.2 Characterize the Telemetry Input Channel (727)

The telemetry input channel of the SAMPEX transponder needs to be characterized. A plot or a series of plots will be generated for showing the mod. index for different frequency voltage combinations. The same will need be done to the FAST transponder. This data will be used to select the values for the MUE downlink interface so that the desired (1.1 rads) can be achieved.

7.3.3 Define Allowable Mod. Index Range (743/727)

The allowable range for the Mod. Index needs to be defined so that Motorola can know what is the acceptable range if they can't guarantee 1.1 across the bandwidth. The mod index of the receivers at WFF, TGS, and DSN needs to be determined. This needs to be done before CDR.

7.3.4 Motorola CDR (727)

I will support code 727 at the Motorola CDR to ensure Motorola is incorporating the necessary changes to the transponder to meet the FAST requirements. Also need to make sure that the problems from SAMPEX are corrected.

7.3.5 Motorola Testing (727)

I will support code 727 to ensure Motorola is testing the transponder to meet all the GSFC specs. before shipping to Goddard.

7.3.6 GSFC Delivery and Acceptance Testing (727)

Code 743 will support 727 as needed to perform an acceptance test of the transponder to ensure that it meets the functional requirements and specifications.

7.4 Harness (743)

7.4.1 ICD Definitions (743/745/UCB)

Support B. Settles in the definition of all harness connectors. These include all connections to the MUE, IDPU, instruments, and other spacecraft subsystems. The harness connectors will broken down into spacecraft bus and instrument bus.

7.4.2 Wiring Diagram (743)

Support Settles with the generation of the wiring diagram for the harness. This diagram will use the connector definitions to generate a diagram for the harness to be fabricated.

7.4.3 Harness Fabrication (743)

Support Settles with getting the harness fabricated using the wiring diagram and the mockup.

7.5 Project Data Base (743.2)

It is planned that the project data base for FAST will be hosted on a Code 740 Sun work station. The lead for the development of the FAST PDB will performed by the FAST I&T GSE Lead Engineer (K. Keadle-Calvert).

7.5.1 Define Requirements (743.2)

Support the requirements definition phase by identify new requirements needed by the FAST T&C system. Lessons learned from the SAMPEX experience will also be incorporated.

7.5.2 Design (743.2)

The PDB will be designed using either civil service or contractor support. The design effort will be lead by the FAST I&T GSE Lead. I will support the design as needed to ensure that it is meeting the requirements.

7.5.3 Test (743.2)

The new PDB should be backward compatible with the old. Therefore the new PDB should be able to be tested in parallel with the old. I will support the testing as needed by making sure that the resources are available.

7.5.4 Populate

The new PDB needs to be populated with the FAST command and telemetry mnemonics, limits, etc.

7.5.5 Generate First Release of T&C Handbook

The first release of the T&C handbook generated by the PDB should be ready for distribution.

7.6 S/C End to End Testing of the C&DH System (743) *

The electrical systems engineer will lead the end-to-end testing and verification of the S/C C&DH system. The end-to-end testing and verification of the FAST C&DH system will be performed by defining and pulling together teams of engineers to perform tests of each link in the system. These tests are listed below. These tests are important to ensure compatibility with the ground in both data and RF. Also the interface between the IDPU and MUE is critical because of the integrated approach taken. The tests listed below will lead by myself or the communications system engineer (D. Everett).

7.6.1 Signal Format Test (743)
This is to test the NRZ-L/Convolutional signal format of the telemetry channel. It is to test the bit density and inter-symbol inteference of the 5 Mhz channel.

7.6.2 MUE-->IDPU (745)
This test is to test the Port A interface between the IDPU and MUE. This test will include sending commands and high rate telemetry through the IDPU. This test will be broken down into a series of small tests starting at sending a small string bytes, interface protocol, and working up to sending commands and telemetry simultaneously.

7.6.3 IDPU-->MUE (743/745/UCB)
This test will be to see that Port B interface is functioning properly. This test will see if the high rate telemetry from the IDPU comes out the other end of the D/L card.

7.6.4 D/L-->Xpndr (743/727)
This test will see if the transponder to MUE interface is working correctly. The parameters to be checked are the mod index, bandwidth used, data in equals data out.

7.6.5 U/L-->Xpndr (743/727)
This test will check the CDU of the transponder, the status and control lines, and the command channel of the transponder. The data in to the transponder should equal the data out. This test will be through the auxiliary input first followed by the going the antenna input port.

7.7 Box Level Integration
Integration is done at different levels. The integration starts at the subsystem level and works its way up to the spacecraft level. The integration processes include: MUE box level integration, MUE box to IDPU box level integration, and spacecraft integration. The MUE box integration and MUE to IDPU integration is lead by the MUE lead engineer, T. Gruner. The spacecraft integration will be lead by Gary Cooper/743 and the FAST I&T Manager.

7.7.1 I&T GSE to MUE GSE Interface Testing (743/745)
I will coordinate the interface between these two systems needs to be tested before I&T begins.

7.7.2 MUE to IDPU Wire Wrap (745/743)
Support the preliminary integration of the MUE's wire wrap boards with the IDPU processor boards to allow interface and functional testing. This integration is planned to occur at UCB. The WW boards will be left at UCB for them to use during their development cycle.

7.7.3 MUE ETU boards (745/743)
Support the ETU board integration.

7.7.4 MUE ETU to IDPU (745)
Support the MUE ETU to IDPU integration.

7.8 Spacecraft Integration and Test
I will support the scheduling of I&T activities with the FAST I&T manager, particulary the spacecraft level functional tests.

7.8.1 RF Compatibility (515/727)
Support the RF compatibility testing of FAST with code 515.

7.8.2 POCC Compatibility (5xx/74x)

Support the tests with the POCC to ensure data compatibility.

7.8.3 Pegasus Interface (74x/OSC)

Support the testing of the interface of the FAST Payload avionics with the Pegasus rocket.

8 Deliverables

The deliverables listed are those that are the direct responsibility of the electrical systems engineer. There are many other deliverables that are the responsibility of other individuals.

8.1 Documentation

8.1.1 SMEX/FAST Telemetry and Commands Data Formatting Requirements
8.1.2 EMI/EMC Requirements
8.1.3 Grounding Requirements
8.1.4 Inputs to the MUE User's Guide
8.1.5 Spacecraft System Test Procedures
8.1.6 FAST T&C Handbook

8.2 Flight Qualified Electrical System Integrated with Spacecraft Ready for Launch