New service module for the MASER sounding rocket

Gunnar Andersson  
Swedish Space Corporation,  
PO Box 4207, S17104 Solna, Sweden  
Tel: +46-86276286  
Fax: +46-8987069  
Email: GAN@SSC.SE

ABSTRACT

In order to reduce refurbishing costs and mass and to increase service systems performance, a new service module for MASER is under development. It will be flown on the next MASER mission in April 1998.

The main refurbishment cost saving features in the service module are:

- The rate control system is included in the service module, thus sharing common functions as power system and ground support equipment.
- The mechanical rate gyros are replaced by rugged optical gyros with no moving parts.
- The payload cable harness is standardised and greatly simplified, leading to lower engineering costs.
- The physical accessibility of subsystems is greatly improved, so that any subsystem can be removed or integrated separately.

The major performance enhancements in the new service module are:

- The maximum telemetry down link speed is increased to 10 Mbit/s.
- An optional second S-band transmitter can be added, either for TV-transmission or for a second high speed telemetry down link
- The telecommand up link uses error correction coding
- The rate control system has several low thrust levels for rate corrections during the microgravity phase, leading to lower acceleration disturbances during rate correction.
- Payload time is synchronous to range time and distributed to the experiment modules so that all events can be referred to a common time reference.

- A GPS sensor is giving very accurate position information for quick recovery
- The total weight is below 30 kg. The length is about 260 mm

The new service module is backward compatible with old experiment module telemetry and telecommand interfaces.

The new service module is developed jointly by SSC and DLR.

A test flight of the new service module will take place in November -97 on a Nike-Orion rocket together with one microgravity experiment. The microgravity time will be about 3 minutes.

INTRODUCTION

The present MASER service module and RCS (Rate Control System) module have been flown on MASER4, MAXUS test, MASER5, MASER6 and MASER7. It has become more and more obvious that an update and integration SM/RCS is needed, since new functions have been included as add on:s, and the service module has become difficult to handle both in terms of refurbishment and operation.

Building on the experience from the present MASER service module built and flown by SSC and the miniTEXUS service module (which includes a rate control system) built and flown by DLR the best parts of both designs are incorporated into a new service module design.

An increased demand on telemetry down link speed because of new digital data sources, such as digital video cameras, has been taken into account in the design.
MECHANICAL SYSTEM

The module length is 260 mm and the estimated weight is about 28 kg.

The mechanical design of the service module has resulted in a layout that is particularly convenient for assembly and disassembly, servicing, calibration and testing.

The basic concept comprises a deck on which the rate sensor packages, accelerometer block, box for the TM/TC and RCS electronics, telemetry transmitters, telecommand receiver and accumulators are mounted. This deck is mounted in a 260 mm long skin section which supports the complete cold gas system at the aft end, the umbilical block and the antennae, couplers and cables for the telemetry and telecommand systems.

Disassembly of the deck from the skin requires only the removal of the deck screws, separation of two antenna cables, umbilical, cold gas system electrical interface, aft interface and skin temperature sensor connectors.

The accelerometer package is attached to the deck and isolated from the thermal environment of the skin and the telemetry transmitter utilises the deck as a heat sink.

Covered ports in the skin provide direct access to a TM/TC and RCS flight and test plugs on the electronics box and the fill and drain valves for the cold gas system.

The interface of the deck and skin also provides a convenient and logical separation point for the initial refurbishment by SSC (TM/TC and power) and DLR (cold gas system, RCS electronics boards and RF systems), whereby the RCS electronics boards, telemetry transmitters and telecommand receiver may be easily removed from the deck.
TELEMETRY

The telemetry main encoder is a development based on the Odin and Astrid satellite telemetry system. The high speed circuitry for the slave interfaces and the down link is implemented using FPLD (Field Programmable Logic Device) technology.

The main encoder can interface up to 14 TM/TC slaves. The communication speed with the slaves is 1.25 Mbit/s (duplex). The main encoder processor can reconfigure 2 of the slave interfaces to carry higher speed data, 5 Mbit/s, but only in the slave to master direction. The return channel from master to slave is then only used to supply the transmit clock for slave data.

The down link coding is selectable according to the following:

- NRZ-L biphase coded, bandwidth 0.5f to f
- NRZ-M biphase coded, bandwidth 0.5f to f
- NRZ-M scrambled, bandwidth 0 to 0.5f
- NRZ-M scrambled and with convolutional code, bandwidth 0 to f

The bandwidth f = 1/T where T is the time for one data bit in NRZ-L coding.

NRZ-L: A logic “1” is represented by one signal level and logic “0” by another signal level.

NRZ-M: A logic “1” is represented by a shift in the signal level and a logic “0” by no shift.

Biphase-L: A logic “1” is represented by a high to low signal transition and a logic “0” by a low to high signal transition.

The master clock for the telemetry system is a highly stable oven controlled crystal oscillator that enables payload position acquisition using a slant range system on ground.

The down link data rate is selectable 312.5 625 1250 2500 5000 or 10000 kBit/s

The telemetry down link is using an S-band transmitter with an output power of 5 W.

There is room to mount a second S-band transmitter that shares the same antenna system. This transmitter can be used either for a second telemetry link or for video transmission, in which case the power must be increased to 10W.

The telemetry main encoder is mounted in an electronic cabinet with 7 slots for circuit boards. It occupies 1 or 2 slots depending of the number of slave interfaces. Thus a second main encoder with 8 slave interfaces can be fitted in the spare slot.

The main encoder software can be loaded via the module umbilical.

Telemetry slaves

The new telemetry/telecommand system is compatible with the old SSC TM/TC subunits.

An enhanced TM/TC slave that makes full use of the new features in the telemetry system is under development at SSC. This slave also works as a high performance experiment controller and is a direct upgrade replacement for the previous experiment controller board in the SSC microgravity module standard electronic system.

TELECOMMAND

Telecommands are collected on ground using the SSC telecommand multiplexer.

Two different command types exist:

- Bit commands that set or reset individual bits in a 64 bit long stream, that is included in every up link telegram.
- Extended commands, where each command contains user address (4 bits) and 24 bits of data that is transferred to the addressed user.

An up link telegram is assembled, convolution coded and sent to the payload using GMSK modulation. The transmission speed is 19200 bit/s. The command update rate is about 65 times/s.

An L-band receiver receives the telecommands.

The telecommand decoder and the distribution to the TM/TC slaves is integrated into the main encoder board. The telecommands are distributed over the same lines as the telemetry polls.

One message from the main unit to the slaves contains the following information:

- Request for a telemetry packet from the slave
- Payload time
- Payload status
  - liftoff
  - microgravity quality
  - telecommand link status
- Acceleration level
- Telecommand
RATE CONTROL

The RCS (Rate Control System) provides the payload with rate control after motor separation and coarse despin. Rate control is necessary for providing microgravity conditions in the payload.

The rate sensors will be fibre optic sensors with a maximum drift better than $10^{-7}$/h.

Payload control torque is provided by a cold gas system comprising three sets of solenoid valve thrusters mounted in the service module skin. A new feature of this cold gas system will be a continuously variable pressure control system, providing the facility for fine adaptive control.

The RCS controller processes the sensor data and produces the regulator and solenoid thruster control signals. The RCS will acquire, compress and pack data from all sensors in a serial data stream that will be sent via the umbilical to the EGSE and also to the telemetry encoder for insertion in the PCM telemetry frame. Firmware, control parameters and test commands may be loaded from the EGSE via the umbilical, and in-flight commands will be accepted from the TM/TC system. Additional serial interfaces will be provided for optional supplementary sensors. A major design aim is to maintain the flexibility and simple assembly and test features of the MINI-TEXUS Service Module.

The cold gas system comprises a high-pressure tank, a variable pressure regulator and a set of thrusters to provide control torques about each of the three orthogonal payload axes.

Static Simulator for the RCS

The Static Simulator provides the facility for simulation of the motion of the payload under the influence of thrust and torque control signals generated by the controller and generation of the appropriate sensor signals. The connection of such a simulator between the controller output and the sensor input interfaces provides closed loop simulation whereby the controller hard and software may be comprehensively tested under a wide range of possible conditions. The simulator is connected through a skin access port during tests and is replaced by a flight plug for operations. A feature of the simulator is the provision of a slot for insertion of the RCS processor alone to provide software test and qualification in the absence of the service module.

ACCELEROMETERS

There are two sets of accelerometers, one for levels between 1g and 50g and another with a range from 4 µg to 1g. The accelerometers are sampled about 1000 times per second in order to allow for post flight vibration analysis.

TEMPERATURE SENSORS

There are 12 temperature sensors distributed every 30° around the circumference of the module skin.

BLOCKING OF RF TRANSMISSION

For safety reasons the transmission of RF energy from the payload can be blocked by a signal from the MASM EGSE. The blocking function is active for the MASM TM transmitters and the TV transmitters located in the TV modules.

After detection of landing, the TM transmitters are turned off. One transmitter is turned on shortly every 15 seconds to transmit GPS position data to the recovery helicopter. The service module can be switched off by inserting a switch off unit in the umbilical connector, or by removing the flight plug, which will disconnect battery power from all module circuitry.
PAYLOAD INTERFACE HARNESS

The payload harness is designed to be the same for all MASER missions. Each experiment can change place with any other experiment module in the payload without any modification to the harness. This is a benefit for payload testing when an experiment module is missing.

Every slave is connected with four lines, two for transmission and two for reception.

These lines are only connected in the slave that uses them.

All other lines are passing through to the next module.

All master / slave communication lines are optically isolated at the receiving end.

Payload interface harness