Proposal for the Delivery
of a

GPS Receiver for Space Applications

For

IIT, Mumbai
India

Submitted by
Accord Software and Systems Private Limited
37 K R Colony, Domlur Layout
Bangalore, INDIA

Revision History

Issue No.	**Description of Amendment**	Change Request No.	**Release Date**
Draft 1.1	Preliminary Draft	None	11 March 2009

WRITTEN BY: G VYASARAJ
PROJECT MANAGER

SIGNATURE & DATE: _____

APPROVED BY: G S VARADARAJ / J K RAY
GROUP MANAGER

SIGNATURE & DATE: _____

ISSUE AUTHORIZED BY: S PURUSHOTHAM
EXECUTIVE DIRECTOR

SIGNATURE & DATE: _____

About The Document

This document describes a proposal for the delivery of GPS Receiver for Space applications to IIT, MUMBAI, Bangalore

The document is broadly divided into four parts.

Part I contains general information about the proposal.

Part II has technical information about the receiver to be delivered.

Part III has business terms and conditions, product roadmaps, IP rights etc.

Part IV includes the company's credentials, track records and the past projects related to this development.

Table of Contents

Executive Summary

This proposal describes Accord's GPS Receiver for Space applications for IIT, MUMBAI. The following is the summary of milestones and schedule:

SL. No.	Delivery Schedule	Item
Milestone 1	T0	Project initiation
Milestone 2	T0 + 4 months	GPS Receiver for acceptance testing

Part I – General

Introduction

This document describes a proposal for the development of GPS Receiver for Space applications as per the relevant specifications. This development shall be carried out by Accord Software and Systems Private Limited, Bangalore, India based on their proprietary GPS receiver technology.

Project Title

Proposal for GPS Receiver for Space applications (GPSSPACE)

Project Mnemonic

GPSSPACE

Contact Name and Address

Contact Person: G S Varadaraj, Group Manager - Marketing
Authorized Signatory: S Purushotham, Executive Director
Accord Software and Systems Pvt. Ltd.
37 Krishna Reddy Colony, Domlur Layout
Bangalore: 560 071, INDIA
Phone: +91-80-2535 0105, +91-80-2535 0136, +91-80-2535 0138 Ext : 503
Fax: +91-80-2535 2723
Email: varadaraj@accord-soft.com

Scope of this document

This document addresses the technical overview, technical description, interfaces, business terms and condition for the development and delivery of the GPS Receiver for Space applications for IIT, MUMBAI.

References

In Response to telephone conversation held on 09/03/2009

Acronym

DSP	Digital Signal Processing
GPS	Global Positioning System
GLONASS	GLobal Navigation Satellite System
ICD	Interface Control Document
PVT	Position Velocity Time
RF	Radio Frequency

Part II – Technical

About this section

This section gives a technical description of the GPSSPACE

Receiver Overview

GPSSPACE is a high dynamics 12-channel C/A code Global Positioning system receiver based on FPGA correlator. This receiver is custom designed for small satellite applications and it has a small form factor. The outputs of GPSSPACE can be used for precise positioning of the spacecraft and satellite orbit determination.

GPSSPACE interfaces to a standard GPS antenna through SMA connector for receiving RF signal. Receiver has a standard 9-pin DB connector for power and signal interface. Receiver is powered from single 3.3V supply with power consumption of less than 2W. Receiver computes navigation data such as position, velocity and time and this data is transmitted serially through RS232 interface. GPSSPACE provides 1 PPS pulse output, which is synchronized with GPS time. Receiver also has provision to accept external reset.

Figure 1 shows a simple interface diagram of GPSSPACE:

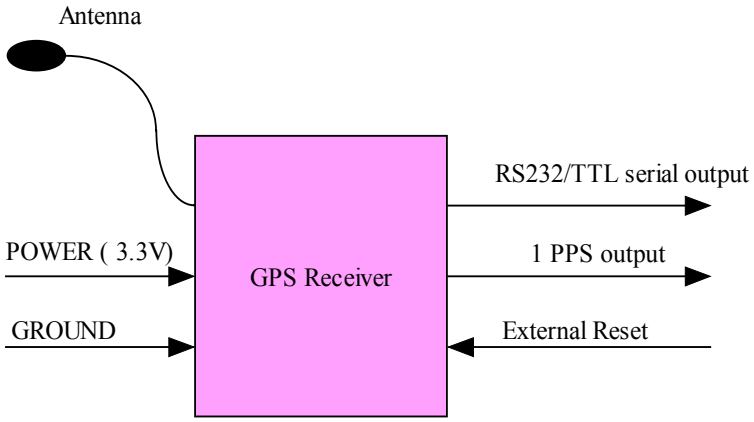

Figure 1: GPSSPACE Interface diagram

Block Diagram

The receiver mainly comprises of an RF down converter, Field Programmable Gate Array (FPGA) based GPS correlator core, DSP based navigation processor and RS232 drivers

The L1 GPS signal, received through an active antenna, gets down converted to a low... in the RF front end - designed around a VLSI down converter. High performance FPGA performs correlation on the digitized IF signal. Carrier & code tracking loops and computation of user's position, velocity and time as well as the communication interface to a host are all implemented in software running on the DSP.

RS232 drivers provide serial interface for the navigation data output. Hardware watchdog timer provides recovery mechanism for processor hang ups induced by radiation.

The block diagram of the GPSSPACE receiver is as shown below:

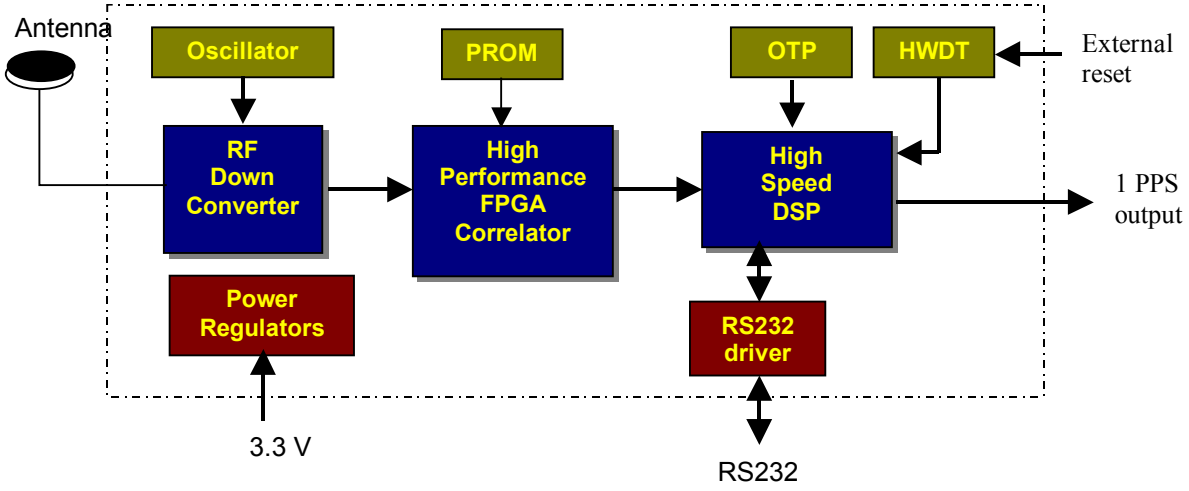

Figure 2: GPSSPACE Block Diagram

Receiver Specification

Characteristics		Specification	Compliance
No of Channels		12	Yes
Update Rate		1 Hz	Yes
TTFF		75 seconds (Cold Start, Typical), Warm start and Hot Start feature not available	Yes
Accuracy	Position	10 m (95%)	Yes
	Velocity	0.12 m/s (95%)	Yes
	Time	500 ns	
Signal Dynamics		+/- 12 Km / s	Yes
Altitude Limit		No Limit	Yes
Data Interface		RS232 levels	Yes
Baud Rate		9600 bps for UART	Yes
Voltage Input		3.3 V DC	Yes
Power Consumption		2 W (Typical)	Yes
Vibration Specifications		15 g (rms)	Yes
Temperature Specifications		-25˚ to +65˚ C	Yes
Radiation Levels		Better than 10K Rads	Yes
Provision for external reset		Available	Yes
RF Input		SMA Connector	YES
Signal / Power Input		9-pin D type connector (male)	Yes
Mechanical Dimension of the box		85 (L) x 55 (W) x 40 (H) mm (approximate)	Yes
Weight of the box		500g (Approximate)	Yes

Antenna Specification

Characteristics	Specification	Compliance
Polarization	RHCP	YES
Power input to active antenna	+3.3V	YES

Connector Interface

The GPSSPACE has a 9 pin male connector.

The pin outs of the above connector are as per the following table:

Table 1: Connector Interface

Pin Number	Signal	Description
1	DT1	Main GPS Data
2	Reset	250 ms active low input
3	3.3V	Supply main
4	DT2	Redundant GPS Data
5	GND	Ground
6	1 PPS	TTL 3.3V, Buffered output
7	DGND	Ground
8	3.3V	Supply redundant
9	GND	Ground

Message Structure

Interface:	RS232 compatible
Baud rate:	9600 baud
Message formats:	Accord's proprietary binary
Start bits:	1
Data bits	8
Stop bits:	2
Parity check:	No
Flow control:	None

Output Messages:

Binary

User's present position in terms of Latitude, Longitude, Altitude, ECEF/Geodetic coordinates, Time, DOP, Receiver status, Signal to noise ratio, Solution time.

List of Accord's custom Binary Messages

Message ID	Message Name	Units	Message Attributes	Size (Bytes)
AC04	**Position in ECEF**	Mm	T, P	22
AC05	**Velocity in ECEF**	Mm/s	T, P	22
AC06	**Solution Time**	Sec	T, P	18
AC08	**Receiver Status**		T, P	24
AC0A	**SNR**	dB /Hz	T, P	18
AC0B	**DOP**		T, P	14
AC0E	**Geodetic Position**		T, P	22
AC0F	**Time date**		T, P	13

T – Transmit; P – Periodic

Note:
The periodicity of these messages is 1 seconds. Accord's custom binary message will have the following format:

Field	Meaning	Size in bytes
'??'	Indicates beginning of a binary message	2
Message ID	Message identification	2

Body of the message	Body of the message	Variable length
Checksum	Checksum for all bytes in the message up to the end of the body of the message	1
Line Feed	Indicates the end of the message	1

Checksum Computation

Checksum is computed by logically XOR-ing all bytes till the end of the body of the message.

Message Details:

Position in ECEF co-ordinates:

??AC041234CL

1 X Position in ECEF co-ordinates – Long

2 Y Position in ECEF co-ordinates – Long

3 Z Position in ECEF co-ordinates – Long

4 GPS time in seconds – unsigned Long

C Checksum

L Line feed

Byte number	Message Field Name	Description	Status
1	?	Message Type	1 Byte
2	?	Message Type	1 Byte
3	04	Message ID	LSB
4	AC	Message ID	MSB
5	1-A	X-position in ECEF	LSB
6	1-B	X-position in ECEF	2 nd Byte
7	1-C	X-position in ECEF	3 rd Byte
8	1-D	X-position in ECEF	MSB
9	2-A	Y-position in ECEF	LSB
10	2-B	Y-position in ECEF	2 nd Byte

11	2-C	Y-position in ECEF	3 rd Byte
12	2-D	Y-position in ECEF	MSB
13	3-A	Z-position in ECEF	LSB
14	3-B	Z-position in ECEF	2 nd Byte
15	3-C	Z-position in ECEF	3 rd Byte
16	3-D	Z-position in ECEF	MSB
17	4-A	GPS time in seconds	LSB
18	4-B	GPS time in seconds	2 nd Byte
19	4-C	GPS time in seconds	3 rd Byte
20	4-D	GPS time in seconds	MSB
21	C	Checksum	1 Byte
22	L	Linefeed	1 Byte

Data Type:

Long (4 bytes), has been chosen. The limits of position is between -7500Km to 7500Km. The unit in which position is represented is cm. The range of long, which is, 2^31 = 2147483648 mm/s, is adequate to accommodate the required range of position values.

Velocity in ECEF:

??AC051234CL

1 X Velocity in ECEF co-ordinates- Long

2 Y Velocity in ECEF co-ordinates – Long

3 Z Velocity in ECEF co-ordinates – Long

4 GPS time in seconds – Un-singed Long

C Checksum

L Line feed

Byte number	Message Field Name	Description	Status
1	?	Message Type	1 Byte
2	?	Message Type	1 Byte
3	05	Message ID	LSB

4	AC	Message ID	MSB
5	1-A	X-Velocity in ECEF	LSB
6	1-B	X-Velocity in ECEF	2 nd Byte
7	1-C	X-Velocity in ECEF	3 rd Byte
8	1-D	X-Velocity in ECEF	MSB
9	2-A	Y-Velocity in ECEF	LSB
10	2-B	Y- Velocity in ECEF	2 nd Byte
11	2-C	Y- Velocity in ECEF	3 rd Byte
12	2-D	Y- Velocity in ECEF	MSB
13	3-A	Z- Velocity in ECEF	LSB
14	3-B	Z- Velocity in ECEF	2 nd Byte
15	3-C	Z- Velocity in ECEF	3 rd Byte
16	3-D	Z- Velocity in ECEF	MSB
17	4-A	GPS time in seconds	LSB
18	4-B	GPS time in seconds	2 nd Byte
19	4-C	GPS time in seconds	3 rd Byte
20	4-D	GPS time in seconds	MSB
21	C	Checksum	1 Byte
22	L	Linefeed	1 Byte

Data Type:

Long (4 bytes), has been chosen. The limits of velocity is between -12,000 m/s to 12000 m/s. The unit in which velocity is represented is mm/s. The range of long, which is, 2^31 = 2147483648 mm/s, is adequate to accommodate the required range of velocity values.

Solution Time:

??AC06123CL

1 Nanosecond

2 Seconds

3 Week Number

C Checksum

L Line feed

Byte number	Message Field Name	Description	Status
1	?	Message Type	1 Byte
2	?	Message Type	1 Byte
3	06	Message ID	LSB
4	AC	Message ID	MSB
5	1-A	Nanosecond	LSB
6	1-B	Nanosecond	2 nd Byte
7	1-C	Nanosecond	3 rd Byte
8	1-D	Nanosecond	MSB
9	2-A	Second	LSB
10	2-B	Second	2 nd Byte
11	2-C	Second	3 rd Byte
12	2-D	Second	MSB
13	3-A	Week Number	LSB
14	3-B	Week Number	2 nd Byte
15	3-C	Week Number	3 rd Byte
16	3-D	Week Number	MSB
17	C	Checksum	1 Byte
18	L	Linefeed	1 Byte

Data Type:

The data type that is used for the solution time is unsigned long.

Receiver Status:

??AC081234CL

1 8-bit SV ID for channel 1 to 4

2 8-bit SV ID for channel 5 to 8

3 8-bit SV ID for channel 9 to 12

3 2 bit Channel Status for channels 1 to 12,
1 bit constel for channels 1 to 12,
1 bit ephemeris for channels 1 to 12

4 1 bit GPS_mon flag,
2 bit Pos Mode,
1 bit Time Sync flag,
2 bit Almanac avail flag,
1 bit Pos avail flag,
1 bit GPS avail flag,
1 bit Almanac flag for channels 1 to 12,

8 bit Version number

C Checksum

L Line feed

Byte number	Message Field Name	Description	Status
1	?	Message Type	1 Byte
2	?	Message Type	1 Byte
3	08	Message ID	LSB
4	AC	Message ID	MSB
5	1-A	SV ID1	LSB
6	1-B	SV ID2	2nd Byte
7	1-C	SV ID3	3rd Byte
8	1-D	SV ID4	MSB
9	2-A	SV ID5	LSB
10	2-B	SV ID6	2nd Byte
11	2-C	SV ID7	3rd Byte
12	2-D	SV ID8	MSB
13	3-A	SV ID9	LSB
14	3-B	SV ID10	2nd Byte
15	3-C	SV ID11	3rd Byte
16	3-D	SV ID12	MSB
17	4-A	2 bits of status for channels 1 to 4	LSB
18	4-B	2 bits of status for channels 5 to 8	2nd Byte
19	4-C	2 bits of status for channels 9 to 12	3rd Byte

20	4-D	1 bit Constel flag for channels 1 to 8	MSB
21	5-A	1 bit Constel flag for channels 9 to 12 / 1 bit Ephemeris flag for channels 1 to 4	LSB
22	5-B	1 bit Ephemeris flag for channels 4 to 12	2nd Byte
23	5-C	1 bit GPS_mon flag, 2 bit Pos Mode + 1 bit Time Sync flag + 2 bit Almanac avail flag + 1 bit Pos avail flag + 1 bit GPS avail flag	3rd Byte
24	5-D	1 bit Almanac flag for channels 1 to 8	MSB
25	6-A	1 bit Almanac flag for channels 9 to 12/ Dummy (4-bits)	LSB
26	6-B	Version	MSB
27	6-C	Checksum	1 Byte
28	6-D	Linefeed	1 Byte

Note:

GPS_mon flag can be taken out to say that the receiver is working fine. This bit toggles continuously, reflecting that the receiver health is okay.

SNR:

??AC0A12CL

1 SNR for channels 1 to 4

2 SNR for channels 5 to 8

C Checksum

L Line feed

Byte number	Message Field Name	Description	Status

1	?	Message Type	1 Byte
2	?	Message Type	1 Byte
3	0A	Message ID	LSB
4	AC	Message ID	MSB
5	1-A	SNR for channel 1	LSB
6	1-B	SNR for channel 2	2 nd Byte
7	1-C	SNR for channel 3	3 rd Byte
8	1-D	SNR for channel 4	MSB
9	2-A	SNR for channel 5	LSB
10	2-B	SNR for channel 6	2 nd Byte
11	2-C	SNR for channel 7	3 rd Byte
12	2-D	SNR for channel 8	MSB
13	3-A	SNR for channel 9	LSB
14	3-B	SNR for channel 10	2 nd Byte
15	3-C	SNR for channel 11	3 rd Byte
16	3-D	SNR for channel 12	MSB
13	C	Checksum	1 Byte
14	L	Linefeed	1 Byte

DOP:

??AC0B1CL

1 2 bytes of HDOP and 2 bytes of PDOP

C Checksum

L Line feed

Byte number	Message Field Name	Description	Status
1	?	Message Type	1 Byte
2	?	Message Type	1 Byte
3	0B	Message ID	LSB
4	AC	Message ID	MSB

5	1-A	HDOP	LSB
6	1-B	HDOP	MSB
7	1-C	PDOP	LSB
8	1-D	PDOP	MSB
9	2-A	Gps second	LSB
10	2-B	Gps second	2ND Byte
11	2-C	Gps second	3rd Byte
12	2-D	Gps second	MSB
13	C	Checksum	1 Byte
14	L	Linefeed	1 Byte

Geodetic Position:

??AC0E1234CL

Byte number	Message Field Name	Description	Status
1	?	Message Type	1 Byte
2	?	Message Type	1 Byte
3	0E	Message ID	LSB
4	AC	Message ID	MSB
5	1-A	GPS time of week (SECOND)	LSB
6	1-B	GPS time of week (SECOND)	2nd Byte
7	1-C	GPS time of week (SECOND)	3rd Byte
8	1-D	GPS time of week (SECOND)	MSB
9	2-A	Latitude	LSB
10	2-B	Latitude	2nd Byte
11	2-C	Latitude	3rd Byte
12	2-D	Latitude	MSB
13	3-A	Longitude	LSB
14	3-B	Longitude	2nd Byte

15	3-C	Longitude	3rd Byte
16	3-D	Longitude	MSB
17	4-A	Altitude	LSB
18	4-B	Altitude	2nd Byte
19	4-C	Altitude	3rd Byte
20	4-D	Altitude	MSB
21	C	Checksum	1 Byte
22	L	Linefeed	1 Byte

Data Type:

The data types for latitude, longitude and altitude is long and for GPS time of week (second) it is unsigned long. Latitude and longitude, the units is degrees and altitude is meters. Latitude and longitude is scaled by 1e7. Altitude is scaled by 1e2 and it's units is meters.

Time and Date Message:

??AC0F1234567CL

Byte number	Message Field Name	Description	Status
1	?	Message Type	1 Byte
2	?	Message Type	1 Byte
3	0F	Message ID	LSB
4	AC	Message ID	MSB
5	1	Hours	LSB
6	2	Minutes	2nd Byte
7	3	Seconds	3rd Byte
8	4	Date	MSB
9	5	Month	LSB
10	6	Year (LSB)	2nd Byte
11	7	Year (MSB)	3rd Byte
12	C	Checksum	1 Byte
13	L	Linefeed	1 Byte

Part III –Commercial Business Terms and Conditions

About this Section

In this section, the commercial business terms and conditions are described. This includes roles and responsibilities, commercial terms, intellectual rights etc.

Accord's Responsibilities

1) Accord shall deliver GPS Receiver for Space applications Card to IIT, Mumbai as per business terms and condition

2) Accord shall deliver the Technical documentation

3) Accord shall identify a technical and a business point of contact for all communications

4) Accord shall give a warranty for manufacturing defects for a period of 12 Months from the date of supply

IIT, Mumbai's Responsibilities

1) IIT, MUMBAI shall promptly respond to Accord's technical and business related queries

2) IIT, MUMBAI shall make payments as per the payment terms and conditions

3) IIT, MUMBAI shall identify technical and business points of contact for all communications

4) IIT, MUMBAI to conduct the performance specification test on the GPS Receiver for Space applications

Intellectual Property Rights

The rights for the intellectual property used to create this GPS Receiver for Space applications Card shall remain with Accord.

Warranty

Accord warrants that the products delivered will be free of defects in materials and workmanship and will conform to the applicable requirements. If within twelve (12) months from the date of delivery, any product fails to comply with the applicable requirements, and providing that the product has been installed, used and/or serviced in conformity with applicable service manuals, bulletins or instructions, Accord shall at its expense and at its election, either 1) repair, modify or correct the defective product, or 2) replace the defective product. During the warranty period, Accord shall provide email or telephonic support for any software related issues and problems.

Acceptance

Acceptance of GPSSPACE would be based on the Acceptance Test Plan mutually agreed upon.