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NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia
August 26, 1987

To: VLBA Scientific Advisory Group
From: A. R. Thompson
Subject: Navstar Receivers for Timing and Ionospheric Calibration

In VLBA Memorandum No. 380, Irwin Shapiro suggested the use of signals from the Navstar Satellites at 1227 and 1575 MHz for ionospheric calibration. Since a decision has been made to use Navstar rather than Loran receivers for any new timing units to be purchased for the VLBA, it is logical to consider the use of a single system for both timing and ionospheric calibration.

In July of this year a request for quotations on Navstar timing receivers was issued to a number of companies. The request gave a specification for a basic timing system with accuracy ± 200 ns, and two additional options: increased timing accuracy, and two-frequency operation for ionospheric calibration. Seven companies gave quotations on the basic timing system, but only one, ISTAC, offered a two-frequency system. The prices for a basic timing system are mostly in the range \$13,500 to \$20,000, and the price of ISTAC's two-frequency system for timing and ionospheric calibration is \$60,000. A copy of ISTAC's quotation is attached. The timing accuracy of the ISTAC two-frequency system is 20 ns. Similar accuracy can be obtained with the single-frequency receivers using a calibration service available from the National Bureau of Standards, Boulder.

The ISTAC system will provide simultaneous measurements of the columnar content for as many of the Navstar satellites as are above an elevation of about 15 deg. With 18 satellites in the final configuration, the number of directions measured will be nine or less. If one can use data taken over several hours in deriving ionospheric model parameters, the motion of the satellites will provide increased directional coverage. The accuracy in the measured columnar content quoted by ISTAC is 10^{16} electrons m^{-2} . A description of Navstar ionospheric measurements and a comparison with those obtained from Faraday rotation is given by Royden, et.al., Radio Science, 19, pp. 798-804, 1984. Would Navstar data be adequate for the calibration of astrometric and geodetic data, and is it worth the extra cost of about \$45,000 per antenna?

At the present time we need to start procurement on a timing system for the Kitt Peak antenna, and I believe that funding restraints will limit us to a basic single-frequency system. We may be able to buy two-frequency systems for later antennas, if they are worth the additional cost when considered in competition with other optional items. Some guidance from the Scientific Advisory Committee would be useful.

ISTAC, Inc.

444 North Altadena Drive, Suite 101, Pasadena, California 91107, USA
(818) 793-6130 • FAX: (818) 440-9224

27 July 1987

RECEIVED

Karen M. Thach
National Radio Astronomy Observatory
2015 Ivy Road
Charlottesville, VA 22903

JUL 30 1987
PURCHASING-CV

Dear Ms. Thach:

Thank you for your July 14, 1987 Request For Quotation "Navstar Timing Receivers". ISTAC responds in offering three options that address your specifications:

- i) ISTAC 2002CAT -- C/A Timing Receiver
- ii) ISTAC 2002DFI -- Dual Frequency GPS Ionospheric Calibration Receiver
- iii) ISTAC 2002DFT -- Dual Frequency Timing Receiver
[An integration of items i) and ii).]

The functional performance of the 2002CAT is in conformance with NRAO Specification No. A53311N001, dated April 9, 1987.

Included in this packet are descriptive Price Sheets which represent ISTAC's quote on each system.

Quantity orders of more than one system effectively receive a discount equal to the software package price for the second and all subsequent systems ordered at one time. For example, the sales price of one ISTAC 2002CAT compared with two 2002CAT's is:

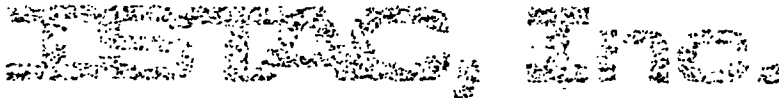
	1 2002CAT	2 2002CAT's
Hardware: Antenna/LNA	\$1,455	\$2,910
C/A Receiver	9,950	19,900
Cables	295	590
Software: Package	2,495	2,495
Maintenance/Service	995	995
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Total	\$15,190	\$26,890

When we can be of further service, please let me know.

Regards,



Peter F. MacDoran
President



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ISTAC 2002CAT

ISTAC C/A TIMING RECEIVER,
2002CAT

P R I C E S H E E T

HARDWARE:

- L1 Antenna and LNA (low noise amplifier) \$1,455
- L1 C/A code correlation GPS receiver,
single channel 9,950
- Cables 295
- Computer PC XT Model NOT INCLUDED
Customer Provides.
Operating System required: CP/M-86 or MS/DOS
One serial RS232 port required.

SOFTWARE:

- 2002CAT Software Package 2,495
- Software Maintenance &
Software Service Annual Fee 995

TOTAL \$15,190

PERFORMANCE: 100 nanosecond accuracy, 5 min averaging.

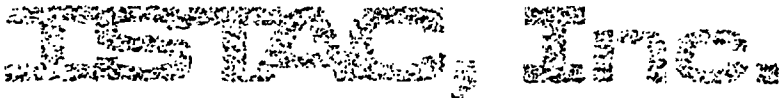
Performs time interval count with 5 n sec accuracy, 1 n sec stability and 0.1 n sec resolution between the input one pulse per second (1 PPS) from the user clock to the 1 PPS event as derived from the software user selected GPS satellite translated to the Universal Time Coordinated scale.

Sampling intervals and statistical combinations are user selected.

Delivery: 45 Days
Warranty: 12 Months

Prices effective July 1987

Printed in USA



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ISTAC 2002DFI

ISTAC DUAL FREQUENCY GPS IONOSPHERIC RECEIVER,
2002DFI

P R I C E S H E E T

HARDWARE:

Dual Frequency L1/L2 Antenna	\$1,995
Dual Frequency L1/L2 Codeless P-channel Receiver	29,495
Cables	745
Computer PC XT Model	NOT INCLUDED
Customer Provides. A to D Converter Board and CP/M86 Operating System Required.	

SOFTWARE:

Ionospheric Software Package	15,495
Includes:	
GPS Signal Detection	
Ionospheric Columnar Content Calibration	
Ephemeris Almanac Acquisition Modem	
GPSView, Observational Planning Software	
Software Maintenance & Software Service Annual Fee	2,995

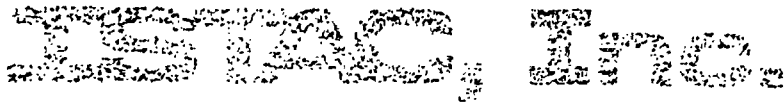
TOTAL \$ 50,725

Ionospheric calibration accuracy: 10^{16} electrons per square meter,
5 minute averaging.

Delivery: 45 Days
Warranty: 12 Months
Personnel Training in Pasadena

Prices effective May 1987

Printed in USA



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(818) 793-6130 • FAX: (818) 440-9224

ISTAC 2002DFT

ISTAC DUAL FREQUENCY TIMING RECEIVER,
2002DFT

P R I C E S H E E T

HARDWARE: Integrated GPS Time Transfer
with Ionospheric Calibration

Dual Frequency L1/L2 Antenna with LNA's \$1,995

Dual Frequency, codeless P channel
ionospheric calibration L1/L2 Receiver
with C/A code correlation subsystem
for time signal acquisition 37,495

Cables 745

Computer PC XT Model NOT INCLUDED
Customer Provides.
A to D Converter Board and
CP/M86 Operating System Required.

SOFTWARE:

Ionospheric / Timing Package 17,495
Includes:
Codeless GPS Signal Detection
Ionospheric Columnar Content Calibration
Ephemeris Almanac Acquisition Modem
GPSView, Observational Planning Software

Software Maintenance &
Software Service Annual Fee 2,995

TOTAL \$ 60,725

Performance: 20 nanoseconds or better limited by broadcast
ephemeris. 5 min. averaging.

Ionospheric calibrations available as a separate data-type with
accuracy of ten to the 16 electrons per square meter, given 5
minutes averaging.

→ 10¹⁶ electrons

Delivery: 60 Days
Warranty: 12 Months