INTERNATIONAL TWO-WAY SATELLITE TIME TRANSFERS USING INTELSAT SPACE SEGMENT AND SMALL EARTH STATIONS

L. B. Veenstra
International Telecommunications Satellite Organization
3400 International Drive, N.W.
Washington, D.C. 20008–3098

Abstract

The satellite system operated by the International Telecommunications Satellite Organization (INTELSAT) provides new and unique capabilities for the coordination of international time scales on a world wide basis using the two-way technique. A network of coordinated clocks using small satellite earth stations collocated with the time scales is possible. Antennas as small as 1.8 m at K-band and 3 m at C-band transmitting powers of less than 1 W will provide signals with timing jitters of less than 1 ns using existing spread spectrum modems.

One way time broadcasting is also possible, under the INTELSAT INTELNET system, possibly using existing international data distribution (press and financial) systems that are already operating spread spectrum systems.

The technical details of the satellite and requirements on satellite earth stations are given. The resources required for a regular operational international time transfer service is analyzed with respect to the existing international digital service offerings of the INTELSAT Business Service (IBS) and INTELNET. Coverage areas, typical link budgets, and a summary of previous domestic and international work using this technique are provided. Administrative procedures for gaining access to the space segment are outlined. Contact information for local INTELSAT signatories is listed.

The microwave time and ranging experiments (MITREX) modem is an efficient device for time transfer via satellite using spread spectrum techniques. International time transfer using satellite spread spectrum techniques regularly will probably require the use of an INTELSAT space segment. There are no substantial technical problems in such use. However, it is necessary to identify the operational issues of using this system in the INTELSAT environment. This paper describes the INTELSAT service compatible with spread spectrum time transfer and suggests how such a service could be implemented.

INTELSAT

INTELSAT, the International Telecommunications Satellite Organization, with headquarters in Washington, D.C., is an international cooperative of 119 member nations that owns and operates the global commercial communications satellite system used by over 178 countries around the world for international communications and by 35 countries for domestic communications. A fundamental characteristic
**International Two-Way Satellite Time Transfers Using Intelsat Space Segment and Small Earth Stations**

**Performing Organization:**
International Telecommunications Satellite Organization, 3400 International Drive, N.W., Washington, DC, 20008-3098

**DISTRIBUTION/AVAILABILITY STATEMENT:**
Approved for public release; distribution unlimited

**SUPPLEMENTARY NOTES:**
See also ADA239372. 22nd Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting, Vienna, VA, 4-6 Dec 1990

**ABSTRACT:**
see report

**SUBJECT TERMS:**

<table>
<thead>
<tr>
<th>Security Classification of:</th>
<th>Report</th>
<th>Abstract</th>
<th>This Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. REPORT</td>
<td>unclassified</td>
<td>unclassified</td>
<td>unclassified</td>
</tr>
<tr>
<td>16. LIMITATION OF ABSTRACT</td>
<td>Same as Report (SAR)</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>17. NUMBER OF PAGES</td>
<td>17</td>
<td>19a. NAME OF RESPONSIBLE PERSON</td>
<td></td>
</tr>
</tbody>
</table>
of the system, from the point of view of time transfer is that access to the INTELSAT space segment is controlled by various national entities, usually the members of INTELSAT. These entities are responsible for the operation of earth stations accessing INTELSAT space segment. In many cases, these entities, the posts, telephones and telegraphs (PT&T), are part of their national government or are chartered by their governments to provide access to INTELSAT. The earth stations may be owned directly by the entities, by common carriers or by the end users, depending on national policy. INTELSAT operates only the space segment and has no direct role in the operation of the ground segment. Thus, time transfer users will need to arrange with their national entities for earth station operation and for the right to use INTELSAT space segment. Appendix 1 of this paper contains contact points for these entities in countries of interest to the PTTI community.

Services

Two specialized INTELSAT services, IB$ and INTELNET, are intended for digital links to small earth stations. INTELNET in particular, has enough flexibility in its technical description to allow the operation of a spread spectrum time transfer link.

INTELNET

INTELNET was designed to facilitate the operation of very small earth stations in one-way data broadcasting and two-way low speed data transfers. Spread spectrum operation is allowed, along with conventional BPSK or QPSK modulation. Operation under the INTELNET service description is specifically authorized for very small antennas.

Space segment is leased in "bulk" under the INTELNET service. This offering is defined in terms of specific transponder bandwidths with a corresponding allocation of power. Any required bandwidth may be used, with the resources scaled from the defined allocation. For example, at K-band, a lease of 100 Khz capacity would provide 8.6 dBW of transponder power. A lease of 2.25 MHz would provide 22.1 dBW. In general, the ratio of power to bandwidth is higher (excess power) than is needed for a single spread spectrum time transfer link. Both full time and occasional use service, with a minimum of 30 minutes per period, is available. Listed below are the basic lease powers, referenced to a 100 Khz bandwidth, available on the INTELSAT V series spacecraft.

<table>
<thead>
<tr>
<th>Service</th>
<th>Band</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>C-Band</td>
<td>-6.5 dBW</td>
</tr>
<tr>
<td>Iiemi</td>
<td>C-Band</td>
<td>-5.5 dBW</td>
</tr>
<tr>
<td>Zone</td>
<td>C-Band</td>
<td>-5.5 dBW</td>
</tr>
<tr>
<td>Spot</td>
<td>K-Band</td>
<td>+8.6 dBW</td>
</tr>
</tbody>
</table>

INTELNET DATA BROADCAST FOR ONE WAY TIME TRANSFER

There are a variety of commercial services operating spread spectrum one way data broadcasting systems on INTELSAT. Many of these are operated in C-band on Global transponders, typically with a chip rate (spreading code rate) of 2.4576 MHz. Most are press news services, operating multiple time division multiplexed channels or low data rates, having an aggregate rate of either 9.6 or 19.2 kbit/s.
These broadcasts could be used for one way time dissemination if the transmitting stations chip rate was synchronized to a standard, and a low speed data subchannel was used to carry ephemeris and other correction information.

**INTELSAT Business Service**

Space segment for digital communications links can also be obtained under the INTELSAT Business Service (IBS) tariff. In this service the power and bandwidth supplied for a channel are defined in terms of reference links between standard sized earth stations. The reference link assumes conventional QPSK data transmission with either rate 3/4 or rate 1/2 forward error correction (F.E.C.). Sufficient power is available to provide better than $10^{-8}$ bit error rate performance under clear sky conditions. It is available under a full-time, part-time (scheduled at least 1 hour per day, 7 days per week), or occasional-use tariff. While the spread spectrum nature of the MITREX modem is outside the IBS technical description, the IBS service should be considered when it is necessary to provide communication links between standards sites. On most transponders where IBS is used, INTELSAT has reserved occasional use capacity. This bandwidth could be used to accommodate the MITREX modem operating under the INTELSAT service as described below.

**Operational Matters**

**Satellite Locations**

INTELSAT operates 15 satellites, serving the three ocean regions, Atlantic, Indian, and Pacific. These locations in degrees East are:

<table>
<thead>
<tr>
<th>AOR</th>
<th>IOR</th>
<th>POR</th>
</tr>
</thead>
<tbody>
<tr>
<td>307.0</td>
<td>57.0</td>
<td>174.0</td>
</tr>
<tr>
<td>325.5</td>
<td>60.0</td>
<td>177.0</td>
</tr>
<tr>
<td>332.5</td>
<td>63.0</td>
<td>180.0</td>
</tr>
<tr>
<td>335.5</td>
<td>66.0</td>
<td>183.0</td>
</tr>
<tr>
<td>338.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>341.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>359.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Frequency Bands**

At C-Band, INTELSAT satellites operate with both left and right circular polarization in the following frequency bands:

- **Ground Transmit**: 5854 - 6423 MHz
- **Ground Receive**: 3629 - 4198 MHz

At K-Band, INTELSAT satellites operate with horizontal and vertical polarization in the following frequency bands:
Ground Transmit: 14,004 – 14,494 MHz
Ground Receive: 10,954 – 11,694 MHz
Ground Receive: 11,709 – 11,946 MHz (307 Deg. West only)
Ground Receive: 12,501 – 12,746 MHz (307 Deg. East only)

Transponder Configurations

Most of the Europe-North American IBS traffic is carried on the INTELSAT VA(F-13) located at 307° East. The following configurations of transponders are currently available:

- East K-band spot to West K-band spot
- West K-band spot to East K-band spot
- East K-band spot to West C-band hemi
- West C-band hemi to East K-band spot
- West K-band spot to East C-band hemi
- East C-band hemi to West K-band spot
- East K-band spot to West C-band hemi
- West C-band hemi to East K-band spot
- West C-band zone to East C-band zone
- East C-band zone to West C-band zone
- West C-band hemi to West C-band hemi
- East C-band zone to East C-band zone

The full-connectivity transponder configuration provides the most flexible environment for time transfer links. This consists of a set of four transponders, interconnected at the satellite so that a signal received on any of the four uplink beams is retransmitted on all four downlink beams simultaneously. Two of the beams operate at C-band. These are the West Hemi and the East Hemi. The K-band West spot covers the United States and southern Canada, and the East K-band beam covers western European be seen Figure 1 and 2. Figures 3 through 7 show the global coverage areas for all the C and K satellite antennas from the 307, 341.5 (typical AOR), 359, 63 (typical IOR) and 174 (typical POR). In addition to showing the coverage areas for the Spot, Hemi, and Zone antennas, the usable area is delimited by plots of the locations having 10, 5 and zero degree elevation look angles toward the satellite.

Full-connectivity operation can be used with spread spectrum code division multiple access (CDMA) to allow several time transfer links to be established simultaneously on the same frequency, with all
carriers visible to each user. This means that in a two-station, two-way transfer, it is possible for each site to monitor its own signal while receiving from the remote site.

Additional capacity in the form of East spot–West spot K-band capacity is available at the 325.50 East and 335.50 East locations. C-band capacity is assigned on the 325.5, 335.5 and 341.50 East locations serving the Atlantic Ocean region.

The Indian Ocean Region is served by satellites at 60 and 630 East with Global transponders and east/west zone capacity at C band. A cross strap connection WS/EZ provides a link a K–band in Europe to C–band to the Far East.

In the Pacific region at 174 and 180 degrees East, K–band capacity is available in the Pacific Ocean region between Korea or Japan and the West coast of the United States.

In all three ocean regions there are satellites with capacity reserved for occasional use. The reserved bandwidth is 3.173 MHz wide, sufficient for a 2.048 Mbits/s IBS carrier. These occasional use channels clearly would accommodate a spread spectrum link if the transmit spectrum were restricted by additional filtering. In the full–connectivity transponders, described above, the reserved capacity is in the form of two adjacent occasional–use channels, providing a bandwidth of 6.345 MHz. The operating frequencies for the occasional use channels are listed in Appendix 2.

**Link Budgets for MITREX**

The link budgets below show the required power for a time transfer link operating in the full–connectivity transponder. The transmitted power has been set to produce at least 54 dB–Hz to a small K–band (1.8 m) station. This same power will also be sufficient for use with a C–band 4.5 m antenna.

<table>
<thead>
<tr>
<th>Uplink beam</th>
<th>WS</th>
<th>ES</th>
<th>EH</th>
<th>WII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antenna size</td>
<td>1.8</td>
<td>1.8</td>
<td>4.5</td>
<td>4.5 meters</td>
</tr>
<tr>
<td>Hpa power</td>
<td>7.7</td>
<td>0.9</td>
<td>1.0</td>
<td>1.0 Watts</td>
</tr>
<tr>
<td>Hpa power</td>
<td>8.9</td>
<td>-0.4</td>
<td>0.0</td>
<td>-0.1 dBW</td>
</tr>
<tr>
<td>Antenna gain</td>
<td>46.0</td>
<td>46.0</td>
<td>47.7</td>
<td>47.7 dBi</td>
</tr>
<tr>
<td>E.I.R.P.</td>
<td>54.9</td>
<td>45.6</td>
<td>47.7</td>
<td>47.6 dBW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Downlink beam</th>
<th>WS</th>
<th>ES</th>
<th>EH</th>
<th>WH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam edge power</td>
<td>11.7</td>
<td>9.8</td>
<td>-4.1</td>
<td>-3.5 dBW</td>
</tr>
<tr>
<td>2.25 MHz lease</td>
<td>22.1</td>
<td>22.1</td>
<td>8.0</td>
<td>8.0 dBW</td>
</tr>
</tbody>
</table>

**MITREX Modem Use**

The simplest way to use the MITREX modem on INTELSAT would be to identify a tariffed INTELSAT service that provides at least the necessary power and bandwidth. For regular PSK transmissions, the signal bandwidth at the -18 dB points is required to be within the allocated bandwidth. As can be seen in the attached spectrum analyzer plot. Figure 8 shows, the bandwidth of the MITREX modem is 3.5 MHz at the -18 dB point. The 6 dB bandwidth of the MITREX modem output is 2 MHz. It
is possible to apply additional filtering to the spread spectrum transmitted signal reducing its -18 dB bandwidth, and thus the nominal tariff. However with the spread spectrum operation at such low levels, the -18 dB bandwidth may not be appropriate for tariffing.

Earth Stations

The earth station requirements to operate a time transfer link are quite modest. The presented link budgets assume the use of 1.8 m K-band stations as a minimum size. This certainly is not the absolute minimum, but it does represent a useful compromise of physical size, link power requirements, and sidelobe performance. Therefore a station equipped with a solid state amplifier would clearly be suitable. Links involving larger stations will need even less transmitting power. At C-Band earth stations in the range of 2.5 to 3 meter diameter are practical.

Any earth station classed as a standard INTELSAT antenna must satisfy the sidelobe gain limit described by the expression:

\[ G = 32 - 25 \log i, \]

where G is the gain of the sidelobe envelope relative to an isotropic antenna in the direction of the geostationary orbit and is expressed in dBi, and i is the angle in degrees from the axis of the main lobe.

In addition antennas operating at C-band must use circular polarization with a voltage axial ratio that does not exceed 1.09. However C-band antennas with a diameter of 2.5 m or less are only required to have a voltage axial ratio of 1.3. To operate in the IBS service a K-band antenna must have a minimum G/T ratio of 25 dB/K, qualifying as a standard E1. At C-Band the G/T requirement is 22.7 dB/K and a minimum transmitting gain of 47.7 dBi to qualify as an F1 (nominal 4.5m diameter) standard antenna. To operate under the INTELENET service, there is no minimum G/T requirement.

Implementation

INTELSAT has always been willing to support innovative uses of satellite technology by granting free use of space segment for tests and demonstrations. A request for free use must be submitted through the national signatory for each station involved. The technical approval process for a test or demonstration has two parts:

1. Initially, the earth stations involved must be approved. Small stations not having the minimum G/T values (25 dB/K at K-band, 22.7 dB/K at C-Band) for IBS stations, would have to qualify under the standard G specification.

2. A transmission plan for the proposed experiment will have to be examined to see whether what is proposed will work with the resources requested and, finally, whether the proposed transmissions may cause harm to other users of the space segment.

After approval, the carrier powers are set up in accordance with a test plan issued by INTELSAT and the experiment will then proceed. At the conclusion of the experiment, the participating Signatories
are obligated to submit to INTELSAT a test report on the results. This report will be made available to any interested INTELSAT members.

One objective of such an experiment should be an evaluation of the compatibility of such a service with normal INTELSAT operations, with the view to proposing a tarifed technical description of spread spectrum time transfer. This could then be submitted to the INTELSAT Board of Governors for formal approval as a regular international service with the resources allocated and the consequent tariffs appropriate to the unique demands of spread spectrum time transfer.

Alternatively, commercial service could start immediately under the INTELSNET service definition and tariffs. The occasional-use option would probably satisfy the requirements for periodic coordination links between various national standard labs.
Appendix 1.

INTELSAT Correspondent Representatives

Australia  Mr. Alan Ward
            Intelsat Access Center
            GPO Box 7000
            Sydney NSW 2001, Australia
            Tel. 2–287–5612
            Tlx. 10162 OTCNA

Austria  Dipl. Ing. Wolfgang Schladofsky
            Generaldirektion fur die Post–
            und Telegraphenverwaltung
            Abt. 21
            Postgasse 8
            A–1011 Vienna, Austria
            Tel. 1–5125234
            Tlx. 112300 GENT A

Canada  Mr. M. Stephens
            Teleglobe Canada
            680 Sherbrooke St West
            Montreal, Quebec, H3A 2S4
            CANADA
            Tel. 514–289–7584
            Tlx. 9224
            Ms. G. Pazos 514–289–7771

China  Mr. Yang Xueming
            Directorate General of Telecom
            Ministry of the P&T
            13 West Changan Ave.
            100804 Beijing
            Peoples Republic of China
            Tel. 661390
            Tlx. 222185 DGTEL

France  Mr. J. Meunier
            France Telecom – D.T.R.E.
            246 rue de Bercy
            75584 Paris, FRANCE
            Tel. 1–43426275
            Tlx. 670372
Germany  
Mr. A. Binzer  
Referat S15  
FTZ Darmstadt, GERMANY  
Tel. 6151-833459  
Tlx. 419201  
Mr. G. Rudolf 6151-83-3383

Greece  
Mr. S. Kontoleon  
Hellenic Telecom. Org. (OTE)  
International Comm. Dept  
15 Stadiou Street  
Athens 124, GREECE  
Tel. 322-0899  
Tlx. 219797

India  
Mr. M.K.G. Nayar  
Videsh Sanchar Nigam, Ltd.  
Videsh Sanchar Bhavan  
Matatma Gandhi Road, Fort  
Bombay – 400 001 India  
Tel. 22-271819x307  
Tlx. 11 2429 VSHN IN HQ BY

Italy  
Dr. Luigi Ruspantini  
Telespazio  
Via Alberto Bergamini 50  
00159 Rome, ITALY  
Tel. 498-2355  
Tlx. 610654

Japan  
Mr. Naohiko Hattori, Director  
Network Engineering Department  
KDD Tokyo Network Headquarters  
3-2 Nishi Shinjuku  
2-Chome Shinjuku-ku  
Tokyo 163, Japan  
Tel. 3-347-6600  
Tlx. 22500 KDD TOKYO
<table>
<thead>
<tr>
<th>Country</th>
<th>Name</th>
<th>Company/Position</th>
<th>Address</th>
<th>Telephone</th>
<th>Telex</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Netherlands</td>
<td>Mr. Peter Essers</td>
<td>PTT Telecommunicatie Directorate for Infrastructure (DIS)</td>
<td>Prinses Beatrixlaan 9, P.O. Box 30000, 2500 GA The Hague, The Netherlands</td>
<td>70434725</td>
<td>32482 DIS NL</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Mr. L. A. Watt</td>
<td>International Relations</td>
<td>Telecom Networks and Int'l. Ltd., Telecom Corp. of New Zealand Ltd., P.O. Box 1092, Wellington, New Zealand</td>
<td>4-738-4448061</td>
<td>31688 TELINT NZ</td>
</tr>
<tr>
<td>Norway</td>
<td>Mr. Claus Svendsen</td>
<td>Norwegian Telecommunications Admin</td>
<td>PO Box 6701, St. Olavs Plass, N-0130 Oslo 1, NORWAY</td>
<td>70434725</td>
<td>71203 Gentel N</td>
</tr>
<tr>
<td>Spain</td>
<td>Mr. J. Lorente</td>
<td>TELEFONICA</td>
<td>Plaza de Espana 4, Pta. 3 - 7th Floor, Madrid 28008, Spain</td>
<td>1241 9380</td>
<td>47793</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mr. A. Martin 1-522-2936</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>Barbro Svensson</td>
<td>Televerket</td>
<td>S-123 86 Farsta, SWEDEN</td>
<td>8-713-1568</td>
<td>14970 GENTEL S</td>
</tr>
</tbody>
</table>
Switzerland
Mr. P. Breu
General Directorate PTT
Radio and Television Main Division
Satellite Communications Branch
Speichergasse 6
CH-3030 Berne, Switzerland
Tel. 31-623756
Tlx. 911025
Mr. P. Chablais 31-622533

USSR
Mr. G. Korolev, Director
U.S.S.R. Satellite Communications Company
Ministry Of Posts and Telecommunications
7 Gorky Street
103375 Moscow, U.S.S.R.
Tel. 95-9255108
Tlx. 411120

United Kingdom
Mr. M. Seymour
British Telecom, PLC
Landsec House Room 407
23 New Fetter Lane
London EC4A 1AE, England
Tel. 1-492-3166
Tlx. 883739
Mr. Mike Perry 1-492-2263

United States
Mr. Calvin Harriott
Communications Satellite Corp.
950 L. Enfant Plaza S.W.
Washington D.C. 20024
Tel. 202-863-6427
Tlx. 892688

INTELSAT
Mr. Lester Veenstra
INTELSAT
3400 International Drive, N.W.
Washington, D.C. 20008
Tel. 202-944-7090
Tlx. 64290
Appendix 2.

Typical Occasional-Use Frequencies

<table>
<thead>
<tr>
<th>Transponder Configuration</th>
<th>Uplink</th>
<th>Downlink</th>
<th>Satellite</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/71 WH/ES</td>
<td>5938.7425</td>
<td>10963.7425</td>
<td>(335)</td>
</tr>
<tr>
<td>71/11 ES/WH</td>
<td>14044.9975</td>
<td>3744.9975</td>
<td>(335)</td>
</tr>
<tr>
<td>11/11 WH/WH</td>
<td>5933.7700</td>
<td>3708.7700</td>
<td>(307)</td>
</tr>
<tr>
<td>41/41 WZ/WZ</td>
<td>5930.5975</td>
<td>3705.5975</td>
<td>(307)</td>
</tr>
<tr>
<td>41/41 WZ/WZ</td>
<td>5933.7700</td>
<td>3708.7700</td>
<td>(307)</td>
</tr>
<tr>
<td>41/51 WZ/EZ</td>
<td>5939.9625</td>
<td>3714.9625</td>
<td>(332)</td>
</tr>
<tr>
<td>51/41 EZ/WZ</td>
<td>5939.9625</td>
<td>3714.9625</td>
<td>(332)</td>
</tr>
<tr>
<td>62/72 WS/ES</td>
<td>4123.4025</td>
<td>11073.4025</td>
<td>(335)</td>
</tr>
<tr>
<td>72/62 ES/WS</td>
<td>4123.4025</td>
<td>11073.4025</td>
<td>(335)</td>
</tr>
<tr>
<td>43/53 WZ/EZ</td>
<td>6095.5975</td>
<td>3870.5975</td>
<td>(307)</td>
</tr>
<tr>
<td>53/43 EZ/WZ</td>
<td>6095.5975</td>
<td>3870.5975</td>
<td>(307)</td>
</tr>
<tr>
<td>13/373 WH/ES</td>
<td>6106.9825</td>
<td>12686.9825</td>
<td>(307)</td>
</tr>
<tr>
<td>73/13 ES/WH</td>
<td>14176.0425</td>
<td>3876.0425</td>
<td>(307)</td>
</tr>
<tr>
<td>23/163 EH/WS</td>
<td>6095.5975</td>
<td>11875.5975</td>
<td>(307)</td>
</tr>
<tr>
<td>63/23 WS/EH</td>
<td>14170.0000</td>
<td>3870.0000</td>
<td>(307)</td>
</tr>
<tr>
<td>14/24 WH/EH</td>
<td>6216.4225</td>
<td>3991.4225</td>
<td>(174)</td>
</tr>
<tr>
<td>24/14 EH/WH</td>
<td>6216.4225</td>
<td>3991.4225</td>
<td>(174)</td>
</tr>
<tr>
<td>64/54 WS/EZ</td>
<td>14296.2150</td>
<td>3996.2150</td>
<td>(174)</td>
</tr>
<tr>
<td>54/64 EZ/WS</td>
<td>6221.1925</td>
<td>11496.1925</td>
<td>(174)</td>
</tr>
<tr>
<td>64/54 WS/EZ</td>
<td>14264.2200</td>
<td>3964.2200</td>
<td>(63)</td>
</tr>
<tr>
<td>54/64 EZ/WS</td>
<td>6189.1975</td>
<td>11464.1975</td>
<td>(63)</td>
</tr>
<tr>
<td>61/171 WS/ES</td>
<td>14058.0000</td>
<td>12563.0000</td>
<td>(307)</td>
</tr>
<tr>
<td>71/161 ES/WS</td>
<td>14058.0000</td>
<td>11763.0000</td>
<td>(307)</td>
</tr>
<tr>
<td>69/79 WS/ES</td>
<td>14459.4075</td>
<td>11659.4075</td>
<td>(325)</td>
</tr>
<tr>
<td>69/79 ES/WS</td>
<td>14459.4075</td>
<td>11659.4075</td>
<td>(325)</td>
</tr>
<tr>
<td>38/38 GA/GA</td>
<td>6388.5925</td>
<td>4163.5925</td>
<td>(332)</td>
</tr>
<tr>
<td>86/86 GB/GB</td>
<td>6303.5975</td>
<td>4078.5975</td>
<td>(60)</td>
</tr>
</tbody>
</table>

12/22/62/72/162/172 Full Connectivity

<table>
<thead>
<tr>
<th></th>
<th>Uplink</th>
<th>Downlink</th>
<th>Satellite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Connectivity</td>
<td>6017.1600</td>
<td>3792.1600</td>
<td>(307)(Hemi)</td>
</tr>
<tr>
<td></td>
<td>14092.1600</td>
<td>11797.1600</td>
<td>(307) (WS)</td>
</tr>
<tr>
<td></td>
<td>12597.1600</td>
<td></td>
<td>(307) (ES)</td>
</tr>
</tbody>
</table>

394
FIGURE 1
INTELSAT V-A(F-13) at 307 Degrees East West Spot

307.0E IS V8 WEST SPOT BEAM

FIGURE 2
INTELSAT V-A(F-13) at 307 Degrees East East Spot

307.0E IS V8 EAST SPOT BEAM
FIGURE 3
INTELSAT V-A(F-13) at 307 Degrees East

INTELSAT V(F-6) at 341.5 Degrees East
FIGURE 5
INTELSAT V-A(F-12) at 359.0 Degrees East

FIGURE 6
INTELSAT V(F-5) at 63 Degrees East
Dr. Gernot Winkler, U. S. Naval Observatory: If you used one of these occasional offerings of, say, a half an hour per week, and a bandwidth of 3.5 MHz, is there any restriction regarding the information other than just the time code. In other words, would there be a problem sending teletype messages also?

Mr. Veenstra: If we approach this as a time transfer service, it would be wise to say that the data channel which is being proposed on the newer spread spectrum modems is an order wire. Intelsat never charges for order wires. We know that earth stations need to talk to each other for coordination purposes. Unofficially and off the record to this minor group, I would suggest that you do not emphasize the fact that this is a data channel. I would suggest that you mention the fact that it is an order wire, a low data rate channel, that is used to coordinate at either end. That makes it easier for us to say that we will give this is a free channel because there is really no information being sent, they are transferring phase information. That is zero information so the bureaucrats do not think that you are transferring information for free. Call it an order wire and not a communications link.