OPEX PROPAGATION MEASUREMENTS AND STUDIES

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Abstract -- With the launch of the OLYMPUS satellite a new area began for the OPEX group. The years of preparations are now paying off- the experiments are underway and the co-operative effort is now turning its attention to the processing and analysis of data and to the interpretation of results. The aim of this paper is to give a short review of the accomplishments made since NAPEX 13 and the work planned for the future.

1. Introduction

When ESA's telecommunications satellite OLYMPUS was launched in summer of 1989 it carried a payload producing three unmodulated beacons at 12.5, 19.8 and 29.7 GHz. The main purpose of these beacons is to enable scientists to carry out long term slant path propagation experiments at these frequencies. The Olympus Propagation Experimenters group, OPEX, which was set up under ESA auspices in 1980, had been preparing for this event very carefully. The specifications for the equipment to be used and the elaboration of standard procedures for data processing and analysis have been worked out jointly. Today the OPEX community includes approximately 30 groups of experimenters.

2. In-Orbit Performance of the Propagation Payload

Immediately after achieving platform stability at the orbital location at 341 degrees east, ESA performed the In-Orbit Tests. Most measurements were carried out at the IOT station of Redu in Belgium using terminals specially developed for this purpose. Table 1 gives a summary of the test results.

It shall be noted that the EIRP variations quoted in Table 1 are including propagation variations. The real variations occurring on the satellite are much smaller. The redundancy for B1 was lost because of a failure between multiplier and tube and the redundant B2 tube displayed a fault immediately after the first in-orbit switch-on.

For the B1/B2 signals further tests are planned with the new TMS-7 test station. After the measurements are completed in Europe, it is planned to ship the TMS-7 station to Ottawa, Canada and to Blacksburg (VA), USA, for measurements of co-and crosspolar signal power.

3. Geographical Distribution of Experiments

In virtually all member-countries of ESA and in a couple of other countries OLYMPUS propagation experiments are being planned. In 12 sites the experiments have already started. At the majority of sites more than one beacon is received and radiometers are co-located to facilitate bias removal at clear sky conditions.

Table 2 gives an overview of the locations of these experiments. In addition to the experiments listed in table 2, there are measurements planned in Raleigh, NC (USA), Madrid (Spain), about 20 more sites in Italy, in two sites in Yugoslavia, in Spitzbergen (Norway) and a number of other places. In a special effort supported by the Italian government plans are made for experiments in tropical regions of Africa ("TROPEX").

In most places the experimenters are carrying out the bulk of the data analysis in house; in England a group of Universities have agreed to jointly analyze the data coming from the Rutherford-Appleton Laboratory in Chilton.

4. Working Groups

For some time a small group of experimenters have been supporting the Agency in the definition of preprocessing and analysis routines, data formats and the like. This support also included participation in the progress meetings with the software house writing the code. A high level of both expertise and motivation have provided the basis for the success of this group. At the last OPEX meeting (OPEX XIII, held in Noordwijk in March 1990) the formation of new working groups has been proposed and accepted. The work of these groups will be focused on data analysis but also special measurement questions will be addressed.

The following groups have been established:

- Data Processing Software ("Dapper") Evaluation
  This is an extension of the activities of the "Small User Group" which will give advice on questions of software revision and maintenance.

- Radiometry
  The proper processing of data from single- and multi-frequency radiometers to provide bias removal for the beacon data and questions of set-up, calibration and operation of the radiometers are being treated.

- Attenuation
  All aspects of the analysis of attenuation data such as annual and worst month cumulative statistics, diurnal distribution, fade duration, fade slope, scintillations, site diversity, frequency scaling are being investigated. An area of special interest for 20/30 GHz systems is the cloud attenuation.

- XPD
  Rain- and ice-induced crosspolarization effects are analyzed as functions of attenuation and rainrate. Also the dynamic behaviour of the XPD is of interest.

- Polarimetric 20 GHz measurements
  A special feature of the Olympus 19.8 GHz beacon is the continuous switching of the polarization plane. This allows to make co-and crosspolar measurements in two orthogonal planes to investigate the anisotropy of the propagation medium. The working group will focus on the analysis of these data.

- Radar measurements
  Some Experimenters have access to specialized meteorological radars in the vicinity of the Olympus receiver station. In particular, radars with dual polarization which are capable of scanning the beacon receiver's antenna beam can provide special insights into the fine scale characteristics of precipitation. Rain can be clearly distinguished from ice and the drop size distribution can be established. The Radar-Opex ("ROPEX") working group will co-ordinate the observation and analysis procedures.

In addition to the above mentioned working groups a steering group has been set up which will deal with the overall co-ordination, with the organization of meetings and with the setting up of agreements for use of software and exchange of data.

5. Software

The standardized data-preprocessing software has been completed in its pre-release version for 80386 machines. Distribution to a limited number of experimenters who have volunteered to beta-test the package will follow. The analysis part of the software is also coming along well. The development fell behind schedule when the XENIX development system did not appear on the market and a decision had to be made to switch to UNIX instead. As a result of this the minimum requirements for the computer hardware have increased. A hard-disk of 150 Mbyte capacity and 8 Mbyte of RAM are now required.

The single parameter standard analysis results are listed in Table 3 and the Joint statistics are listed in Table 4. User defined channels can also be analyzed and class sizes can be altered for special purposes.

6. Plans for the coming year

When the 80386-users will have received the software, the porting to other target machines will start. On 15 October 90 the next OPEX meeting will be held which will present the first outputs from the new working groups. For April 1991 a workshop is scheduled at ESTEC to compare the results from the first year's data.

PARAMETER \ Beacon:	**B0**	**B1**	**B2**
Frequency [GHz]	12.501866	19.770393	29.655589
Frequency offset [kHz] over 24 hours	-1.77	-2.80	-4.20
Freq. variation [kHz] over 24 hours	0.31	0.49	0.74
EIRP [dBW]	13.1	31.7	27.7
EIRP Variations [dB] peak-to-peak over 24 h	0.25	0.4	0.86
XPI [dB]	35	>43	-
Polarisation (X or Y)	Y	X/Y	Y
Pol. sw. frequency [Hz]	-	933.000525	-
Redundancy	Full	No	No

Table 1: Results of OLYMPUS propagation package in-orbit test.

LOCATION		LAT	LON	ALT	EL
City	Country	[deg] N	[deg] E	[m]	[deg]
Blacksburg, VA	USA	37.220	-80.450	300	13.4
Ottawa	CAN	45.000	-76.000	50	13.5
Coventry	UK	52.417	-1.517	100	27.8
Chilton	UK	51.567	-1.283	100	28.6
Martlesham	UK	52.060	1.286	25	27.5
Gometz La Ville	F	48.671	2.121	168	30.3
La Folie Bessin	F	48.653	2.196	160	30.3
Delft	NL	52.000	4.372	60	26.6
Leidschendam	NL	52.092	4.389	8	26.6
Louvain	B	50.667	4.617	160	27.6
Lessive	B	50.130	5.150	162	27.9
Eindhoven	NL	51.448	5.487	30	26.8
Torino	I	45.067	7.667	238	32.0
Darmstadt	D	49.869	8.625	180	26.9
Milano	I	45.413	9.495	84	30.4
Kjeller	N	59.983	11.033	20	17.4
Oberpfaffenhofen	D	48.050	11.160	580	26.9
Munich	D	48.189	11.629	514	26.6
Albertslund	DK	55.680	12.360	30	20.6
Rome	I	41.830	12.470	50	32.0
Graz	A	47.068	15.495	489	25.7
Metsahovi	SF	60.218	24.394	300	12.3

Table 2: List of OPEX Propagation experiments reported active or near completion in March 1990. Listing sorted by longitude.

Parameter	Class size
Co-polar Att 12 GHz (CPA)	0.2 dB
Copolar Att.20 and 30 GHz (CPA)	0.5 dB
Ratio CPA 30/12 GHz (RCPA)	.2
Ratio CPA 30/20 GHz and 20v/12 GHz	.1
Radiometer Att. 12 GHz (CPARM)	0.2 dB
Radiometer Att. 20 and 30 GHz	0.3 dB
CPA hor-vert 20 GHz	0.1 dB
XPD 12, 20v, 20h, 30 GHz	1 dB
Fade Duration 12, 20 & 30 GHz (τ)	1 or $32*2^n$s
CPA-Rate of Change (S), 12,20&30 GHz	0.05 dB/s
Std Dev of log Ampl.scint. (σx)	0.1 dB
Real & Imag Part of anisotropy	3 deg
Canting angle	1 deg
Circ Pol copol unbalance	0.1 dB
Copolar phase (CPH) at 12,20 &30 GHz	1 deg
Crosspolar phase (XPH) 12,20 &30 GHz	1 deg
Std Dev cop. phase (σph) 12,20&30GHz	1 deg
Rain rate (R)	2 mm/h
Water vapour density (ρ_w)	0.58g/m^3
Ground temperature (Tgnd)	1 K
Pressure (P)	1 mBar
Wind Velocity (Vw)	0.5 m/s
Transversal Wind speed (Vwt)	0.5 m/s
Wind direction (Dw)	1 deg
Cloud-cover (CC)	octals
Radar Reflectivity (Z)	1 dB
Diff Reflectivity (ZDR)	0.1 dBz
Bit error rate (BER)	

Table 3: Cumulative distributions produced by DAPPER.

Parameter Y / Parameter X	Class sizes
CPA vs CPA (30/12,30/20,20/12 GHz)	0.2 /0.2 dB
RCPA (20/12) / CPA(12)	0.2 /0.5 dB
RCPA(30/20)/CPA20;RCPA(20,12)/CPA12	0.1 /0.5 dB
CPA / CPARM at 12,20 & 30 GHz	0.5 /0.5 dB
CPA / Z	1.0 /1.0 dB
CPA / τ at 12, 20 & 30 GHz	0.5 dB/1s
CPA / S at 12, 20 & 30 GHz	.5dB/.05dB/s
CPA / XPD at 12, 20 & 30 GHz	0.5 /1.0 dB
XPD / XPH at 12, 20 & 30 GHz *	2 dB/ 3 deg
CPAh-CPAv/CPHv-CPHh (20 GHz) *	.1dB/ 3 deg
XPD / CPAh-CPAv (20 GHz)	3 dB /.1 dB
XPH / CPAh-CPAv (20 GHz)	3 dB /.1 dB
XPD / XPD (30/20,30/12,20/12 GHz) *	2.0/ 2.0 dB
σ_x^2 / ρ_w	.01dB^2/.5g/m^3
σ_x^2 / Tgnd	.01dB^2 / 1K
CPHv-CPHh / XPH (20 GHz) *	3.0/3.0 deg
Z / ZDR	1 dB/.2 dBz
BER / CPA	
BER / XPD	
BER / σ_x^2	

Table 4: Joint Statistics provided for by the DAPPER software. For the entries marked with "*" multiple curves are being produced with CPA as parameter in 2 dB steps.