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OPEX - Olympus Propagation EXperiment

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The Olympus propagation mission

The Olympus-1 satellite carries four distinct payloads for experimental utilisation and research in the field of satellite communications:

- the Direct Broadcasting Service (DBS) Payload
- the Specialised Services Payload
- the 20/30 GHz Advanced Communications Payload
- the Propagation Payload.

Experimental utilisation of the first three payloads involves ground transmissions to the satellite and hence sharing of available satellite time among experimenters. This is coordinated through the Olympus Utilisation Programme.

The Beacon Payload consists of three microwave transmitters that produce three unmodulated CW (Continuous-Wave) signals through three individual horn antennas. The beacon signals are designated B0, B1 and B2, respectively. B0 is at 12.5 GHz and provides 10 dBW of radiated power (EIRP) over the entire visible earth . The horn antennas for B1 and B2 are designed to cover W. Europe with an EIRP of 24 dBW. High EIRP, and hence high flux density on the ground allow the use of relatively small earth stations, with antenna diameters ranging from 1 to 6 meters. The beacon frequencies are all derived from a common oscillator through multiplication chains. This allows coherent detection of all three beacons, providing possibilities for special experiments and several alternatives for earth station design. An interesting feature of the coverage of the 20 and 30 GHz (B1 and B2) beacons is that reception from the U.S. and Canadian East coast is not excluded, albeit with reduced signal power and stability (see Proceedings of NAPEX XI).

The Propagation Payload allows reception on ground by all participants simultaneously and is available continuously. Its utilisation therefore is not a matter of scheduling. Instead, the high level of interest in utilising this payload shown by many research institutes has led to a programme of intensive cooperation in preparing for the propagation experiments with Olympus. This voluntary cooperation project is coordinated by ESA/ESTEC under the acronym OPEX (Olympus Propagation EXperiment).

rate inter-satellite communication technology and the second is to investigate personal satellite communication systems. The onboard system has 40 cm dish antenna and is installed on a gimbal platform of ETS-VI. A solid state power amplifier of 0.5 w output power is under development for the transponder. A possible user spacecraft for inter-satellite link is Japanese Experimental Module of the Space Station. Personal communication terminals with 30 cm-class antennas can communicate each other at the data rate of about 16 kbps. Ground stations with antenns of various sizes will also be prepared for experiments to demonstrate a personal communications concept.

(3) Optical inter-satellite communications

CRL develops experimental optical communication system with telescope of 75 mm diameter which has gimbal mirror beam pointing/tracking mechanism. The onboard system has fundamental optical communication functions with laser diode transmitter of wavelength 0.83 micron, laser beam point-ahead mechanism, receiver of wavelength 0.51 micron, modulation/demodulation subsystem, and so on. Various basic experiments simulating inter-satellite link are planned. In the experiments two optical ground staions are used, one is a fixed station with 1.5 m telescope and the other is a transportable station.

History of European cooperation

In the period July 1976 - October 1977 the NASA satellite ATS-6 was placed at 35 deg E longitude and the European scientific community was given the opportunity to carry out propagation experiments using the beacon facilities of the satellite. These included the so-called millimeter-wave (MMW) experiment using stable on-board beacons at 20 and 30 GHz and the COMSAT experiment using a transponder arrangement allowing 13 and 18 GHz uplink measurements. Unfortunately, these experiments could only be carried out during certain hours of the day (or rather, the night). The rather complicated arrangements that were necessary for participation included dissemination of schedules, loan of transmit equipment and centralised processing of the uplink measurements. ESA was asked to coordinate the European participation in the experiments and represent experimenters vis a vis NASA and COMSAT. This led to the establishment of a European experimenters group which met regularly during the project and published its collective results in an ESA Special Publication (ref. 1).

Another activity of European cooperation in propagation research was initiated in the framework of the COST (COoperation Scientifique et Technique) project of the European Commission. From 1972 to 1977, in "Action COST 25/4" results of propagation experiments above 10 GHz obtained in 13 different countries were collectively analysed in order to obtain better understanding of the variations of propagation effects with climate (ref. 2). In this project mainly analysed results of individual experiments were put together and compared. It was realised that a higher level of collective analysis would be possible, if statistics obtained from measurements were put into a common data base and made available for collective analysis. This was carried out in the subsequent action COST 205 (1978-1984), where 11/14/18 GHz propagation data obtained with the ESA satellite OTS and the Italian satellite SIRIO were collated and analysed (ref. 3). This required a higher level of cooperation, including agreements on standard formats for presenting the various statistics obtained.

The OTS experiments themselves were coordinated by ESA and Eutelsat together. The habit of convening the coordination meetings of experimenters at the different participating institutes across Europe, which was established in the COST 25/4 project and since then followed by many other COST projects, has led to an intensive exchange of information which has proven to be indispensible for cooperation "at working level". Collective European results of the satellite propagation experiments have been made available to the International Telecommunications Union (ITU) and form a major part of the data bank of CCIR Study Group 5 on Earth-Satellite propagation statistics.

Organisation of OPEX

Thus in the previous 15 years an active European community of researchers in the field of radio propagation was established. When in the late seventies plans for a large satellite carrying a number of experimental telecommunications payloads were taking shape, this community was called upon to input their requirements for a propagation experiment. ESA specifications were drawn up in consultation with prospective experimenters. Soon it became clear that there was wide interest in such experiments and a need existed for regular information exchange in the preparatory stages. Starting as early as 1980 regular meetings of interested parties (researchers and industry) were held. Based on the experience from the COST projects the general opininon was that collective development of specifications for earth station hardware as well as procedures for data acquisition, preprocessing and analysis would be very beneficial for experimenters and greatly enhance the results to be obtained. In 1984 this work was started by the establishments of three working groups:

W.G. 1 - Earth station requirements.
Chairman: Mr. S.K. Barton (UK)

W.G. 2 - Data acquisition and preprocessing
Chairman: Mr. F. Zelders (NL)

W.G. 3 - Data analysis
Chairman: Prof. A. Paraboni (I)

The overall objective of the preparatory stage of the OPEX project thus established was to arrive at a level of standardization that allows direct comparison of results of experiments without the usual uncertainties regarding equipment quality and compatibility of data analysis procedures. Detailed discussions were held in the working groups of all aspects of the experiments and the results envisaged. The work of these groups resulted in the issuing of three handbooks, specifying quality objectives and defining interfaces for data acquisition, preprocessing and analysis, respectively.

Participation in the OPEX meetings has been very encouraging and a good measure of the high level of interest. Attendance to the meeting is at a constant level of some 40 people from all ESA member states. The possibility to carry out experiments from the N. American continent has generated interest also from U.S. experimenters and resulted in regular contact with the NAPEX group. The table on next page lists the organisations that are actively involved in the OPEX work.

Table of participants in OPEX

Organisation	Location
Technical University Graz	Graz, Austria
ASSA	Vienna, Austria
BTMC	Antwerpen, Belgium
Newtech	Antwerpen, Belgium
E.B.U.	Brussels, Belgium
U.C.L./Lab. de Telecomm.	Louvain-la-Neuve, Belgium
C.R.C./Radio Prop. Lab.	Ottawa, Canada
FTZ	Darmstadt, W.Germany
Dornier System	Friedrichshafen, W.Germany
Inst. Fuer Rundfunktechnik	Muenchen, W.Germany
DFVLR	Oberpfaffenhofen, W.German
P. and T./Radio Comms.	Copenhagen, Denmark
ElektronikCentralen	Copenhagen, Denmark
T.U.D./Electromagn. Inst.	Copenhagen, Denmark
ETSI Telecomunicacion	Barcelona, Spain
ETSI Telecomunicacion	Madrid, Spain
CNET	Paris, France
I.R.A.M.	Grenoble, France
Eutelsat	Paris, France
March Microwave	Braintree, U.K.
Univ. Bradford	Bradford, U.K.
Signal Processors	Cambridge, U.K.
Rutherford Appleton Lab.	Chilton, U.K.
Univ. Essex	Colchester, U.K.
CSR	Ilkley, U.K.
BTRL	Martlesham, u.k.
Portsmouth Polyt.	Portsmouth, U.K.
BAe	Stevenage, U.K.
Politecnico di Milano	Milano, Italy
CNR / PSN	Roma, Italy
Fond. Ugo Bordoni	Roma, Italy
SeleniaSpazio	Roma, Italy
Telespazio	Roma, Italy
CSELT	Torino, Italy
Telecomm. Research Est.	Kjeller, Norway
ELAB	Trondheim, Norway
NIVR	Delft, Netherlands
Technical Univ. Delft	Delft, Netherlands
Technical Univ. Eindhoven	Eindhoven, Netherlands
APT	Huizen, Netherlands
Dr, Neherlab. PTT	Leidschendam, Netherlands
Universidade Aveiro	Aveiro, Portugal
Swedish Telecom Radio	Farsta, Sweden
Helsinki Univ. of Technol.	Espoo, Finland
Virginia Tech	Blacksburg, U.S.A.
JPL	Pasadena, U.S.A.
NASA	Washington, U.S.A.

Results

Major results of discussions of beacon receiver design have been in the area of standardization of output specifications of receivers and a thorough discussion of calibration principles. For the output interface of the receiver hardware a digital output has been recommended presenting 100 samples/second of I and Q channels of the receiver. Principles of oversampling of signals in the presence of noise have been discussed and resulted in some novel design ideas for digital beacon receivers. A digital receiver has been developed by Signal Processors Ltd in Cambridge, U.K., based on frequency feed-forward control, using digital signal processing techniques in software.

In the areas of preprocessing and analysis of data the OPEX Handbooks produced by the Working Groups have been the basis for the specification of a software system, the development of which is now taking place under contract to ESA by Siemens Austria (Vienna) and CSR Ltd. (Ilkley, U.K.). This processing system is intended to become the European reference system for the treatment of propagation data. CSR have already delivered a complete Olympus propagation station, including a data acquisition and processing system, to the German Post Office Research Centre FTZ.

It has been emphasized as a result of the studies by the OPEX group, that for an accurate measurement of fading an independent measurement of total attenuation under conditions of clear sky or light rain by means of radiometers is indispensable. The development of a low-cost 20/30 GHz dual-frequency radiometer for this purpose is being pursued under contract to ESA by Farran Ltd (Ireland). The instrument which has been named Atmospheric Water Radiometer (AWR) will have a variety of other applications (remote sensing, meteorology) by virtue of its capability to measure total atmospheric water vapour content and liquid water content separately through a well-proven inversion process.

In the area of scientific analysis a major decision facilitating a comparison of results among experimenters concerned the treatment of crosspolar data. As the polarisation orientation at the groundstation is dependent on its location, crosspolarisation results cannot be compared directly. The common analysis specified as a standard is in terms of the tilt angle of the principal axes of the medium itself and the differential attenuation along these axes.

To facilitate an exchange of calibrated time-series data on a bilateral basis, a specification of a standard file format for the storage of "events" has been made. This "standard event tape" (which, physically, most likely will be an optical disk) at the same time serves as the "reference" interface between the data acquisition and preprocessing system and the data analysis system.

Anticipating a large amount of statistical information to result from propagation research in the nineties, ESA also started, in collaboration with Intelsat, the development of an intelligent data base management system for the production of propagation predictions and the evaluation of prediction methods that use large-scale statistics of propagation and meteorological data. A contract to study the feasibility of a DBMS using modern software techniques is carried out by Bradford University under contract with ESA and Intelsat.

Propagation measurements using millimeter waves will be possible in a few years in Europe with the Italsat satellite (40/50 GHz). Looking ever further ahead, ESA has now started the development of a small, light-weight 45/90/135 GHz beacon payload by letting a contract to assess feasibility and critical technology for such an instrument to Contraves Italiana (Rome).

Conclusion

The OPEX project was started as a voluntary coordination activity under ESA guidance. Its success is marked by industrial activities now taking place in Europe to implement the recommendations of the European experimenters. As a result there exists now a very positive outlook for an unprecedented level of cooperation and exchange of information in the area of propagation research. Large-scale pooling of results appears to be the only way to make progress in the development of global prediction methods that can be used effectively in the planning of new satellite communication systems.

Marking the conclusion of the preparatory phase of the OPEX project will be the 11th OPEX meeting mid June in Copenhagen, where status of user preparations and current research are reviewed, as well as progress in the software development contract on data processing.

A symposium on the utilisation of Olympus, covering all planned experiments with the four payloads, will be organised by ESA in collaboration with the Austrian Solar and Space Agency (ASSA) next year April in Vienna, hopefully marking the sucessful launch of the satellite.

References

1. G. Brussaard and B. Battrick (editors), "ATS-6 propagation experiments in Europe", ESA SP-131, October 1977

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3. F. Fedi (editor), "Special Issue on the COST 205 project on Earth-Satellite radio propagation above 10 GHz", Alta Frequenza, May/June 1985