

PART 1

CHAPTER 1.1

Executive Summary

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1.1 Executive Summary

1.1.1 Introduction

COST 255 has:

- Made an examination of the existing propagation prediction models for fixed satellite communications at Ku- and Ka-band. These models included cumulative statistics of attenuation or XPD as well as dynamic effects. Particular emphasis was put on the combination of effects, which is considered important for low-margin systems.
- Developed new models for scintillation, depolarisation, cloud attenuation and the combination of these effects.
- Undertaken careful tests (applying the ITU-R criteria) to verify the performance of these new models. (At higher frequencies these models show promising results).
- Expanded the traditional maps of radiometeorological parameters to include the fine-scale information of the medium-term weather forecasting grid. Some of this work has already found its way into the recommendations of ITU-R; other elements are due to be submitted. In the field of refractivity mapping the previous work of COST 235 has been continued.
- Carried out studies of the shadowing and multipath effects on satellite mobile links.
- Analysed existing and proposed new statistical and deterministic modelling approaches and compiled a set of validation data.
- Elaborated the impact of propagation impairments on the design of satellite communication systems and outlined the use of adaptive impairment mitigation techniques.
- Defined a set of four fixed and two mobile test cases, which served to demonstrate the use of the models and procedures recommended in Parts 2, 3 and 4 of the report.

In total, about 150 technical papers have been produced and presented, many of which have formed the basis of this report.

The key results have been presented at the Final Workshop in Bech (Luxembourg). Some of the salient findings have been or will be transformed into input documents to ITU-R Study Group 3 and the work in the area of impairment mitigation techniques establishes the basis for a new COST Action.

1.1.2 Activity report

1.1.2.1 *Background*

When, in 1993, the OLYMPUS propagation experiments came to an end, the well-organised group of experimenters proposed to launch a COST Activity to exploit the collected statistics for development and validation of new prediction methods. At the same time, a very successful COST Activity (COST 235) was nearing completion and one of its areas of interest, namely radiometeorology, was found to have potential to be expanded in the frame of a new collaborative venture.

Several of the participants of the early planning meetings were also actively involved in the work of ITU-R Study Group 3 (responsible for recommendations on radiowave propagation) and were therefore keenly aware of the need for improved prediction methods.

Lastly, it was considered important to link the knowledge of propagation specialists with the requirements of system planners. It was noted that in many cases system planning was done with only a limited understanding of propagation aspects while at the same time, propagation specialists were not aware of the needs and constraints of communication systems.

So, when in 1995 a Memorandum of Understanding was drafted, the objective was to improve the design and planning of present and future telecommunication systems and services through the development of tools for the evaluation of their performance.

To achieve this goal, the work was organised around the following core topics:

- Modelling of propagation effects affecting satellite communications (fixed, broadcasting and mobile services).
- Mapping climatological and morpho-topographical parameters pertinent to radiowave propagation
- Designing and planning of telecom systems of which the satellite system is a segment.

After the MoU was approved by the Committee of Senior Officials (CSO) in December 1995, it was opened for signature by COST member states. The Action was declared officially opened on 15 February 1996, after the first five countries had signed the MoU.

In total 19 COST countries signed – see the table below (signatories listed in alphabetical order):

Austria	1996-12-10	Belgium	1996-02-15	Czech Rep.	1996-04-23
Finland	1996-03-14	France	1996-02-15	Germany	1996-04-25
Greece	1996-02-21	Hungary	1996-04-15	Ireland	1996-02-15
Italy	1996-03-07	Luxembourg	1997-06-12	Netherlands	1998-11-12
Norway	1996-04-23	Portugal	1996-05-15	Romania	1997-07-11
Slovakia	1996-02-15	Spain	1996-02-15	United Kingdom	1996-03-14
ESA	1997-01-27				

In addition, two institutes of non-COST countries joined: CRC Canada (Ottawa) and the Radio R&D Institute (NIIR - Moscow) of Russia. Two organisations, namely EUTELSAT and the Wroclaw University of Technology joined as observers.

1.1.2.2 *Participants*

The following organisations have been actively participating in the work of COST 255:

Country	Participating Institution
Austria	TU Graz INW (Communications & Wave Propagation)
	Joanneum Research - IAS Institute of Applied Systems Techn.
Belgium	Université Catholique de Louvain (UCL) Microwave Laboratory
	KU Leuven
Canada	Communications Research Centre (CRC)
Czech Rep.	TESTCOM, Telecommunications Experts Dpt.
	Czech Technical University, Dept Electromagnetic Fields
	Inst. of Atmospheric Physics (IAP)
Finland	Helsinki University of Technology, Radio Laboratory
	University of Oulu, Telecommunication Lab
France	France Telecom - CNET
	CERT-ONERA DERMO
Germany	Inst. of Mobile & Sat. Comm. Techniques (IMST)
	Aachen University of Technology, Communication Networks Dept.
	Deutsche Telekom AG, Technologiezentrum Darmstadt
	German Aerospace Research DLR, NE-NT-S, Inst. f. Telecoms
	Univ. Karlsruhe, Lehrstuhl f. Nachrichtensysteme
Greece	National Technical University of Athens, Mobile Communications Lab.
	Nat. Observatory of Athens, Institute of Ionospheric & Space Research
	Aristotelion University of Thessaloniki, Electrical Eng. Dept
Hungary	Technical University of Budapest, Dept. of Microwave Telecomm
Ireland	Univ. of Dublin - Trinity College, Dept. of Electronic & Electrical Eng ^g
Italy	Università dell'Aquila, Dip. di Ingegneria Elettrica
	Politecnico di Milano, CSTS-CNR
	CSELT, Mobile Services and Radio Propagation
	Fondazione Ugo Bordoni, Radiocommunications Dept
Luxembourg	UF Data Analysis
	Société Européenne des Satellites (SES/ASTRA)
Netherlands	Eindhoven University of Technology
Norway	Telenor , Research and Development
Poland	Wroclaw University of Technology (Observer)

Portugal	Inst. Sup. Tecnico de Lisboa, Dep. Engenharia Electronica e de Comp.
	Universidade de Aveiro, Instituto de Telecomunicacoes
Romania	Technical University of Cluj-Napoca, Faculty of Electronics & Telecoms
Russia	Radio R&D Institute (NIIR)
Slovakia	Slovak Technical University, Faculty of Electrical Engineering
Spain	USC Vigo, E.T.S.I. Telecomunication
	Universidad Politecnica de Madrid (UPM), ETSI Telecomunication.
United Kingdom	ERA Technology Ltd., Electronic & Software Engineering Div.
	CCLRC-Rutherford Appleton Lab., Radio Communications Research
	University of Surrey, Centre for Communication Systems Research
	Coventry University, School of Engineering
	University of Portsmouth, Dept. of E&E Engineering
	University of Glamorgan, Dept. of Electronics & Information Technology
	University of York, Dept of Electronics
	University of Bath, Dept of Electronic and Electrical Engineering
	Radiocommunications Agency
ESA	ESTEC, Electromagnetics Division
EUTELSAT	Systems Engineering Division (Observer)

1.1.2.3 Management Committee

COUNTRY	MC MEMBER(s)
Austria	Mr. Erwin Kubista, Joanneum Research - IAS
Belgium	Prof. Andre Vander Vorst, Universite Catholique de Louvain
	Prof. Danielle Vanhoenacker, Universite Catholique de Louvain
Czech Rep.	Dr. Ondrej Fiser, Inst. of Atmospheric Physics
	Dr. Vaclav Kvicera, TESTCOM
Finland	Prof. Erkki Salonen, University of Oulu
	Dr. Jouni Tervonen, Helsinki University of Technology
France	Mr. Laurent Castanet, ONERA-CERT
	Dr. Joel G. Lemorton, ONERA-CERT
Germany	Mr. Joerg Habetha, Aachen University, Comnets
	Dr. Gerd Ortgies, Deutsche Telekom AG
Greece	Prof. Philip Constantinou, National Technical University of Athens
	Prof. Stamatis S. Kouris, Aristotelion University of Thessaloniki
Hungary	Prof. Istvan Frigves. Technical University of Budapest

Ireland	Dr. Peter J. Cullen, University of Dublin, Trinity College
Italy	Dr. Francesco Barbaliscia, Fondazione Ugo Bordoni
	Prof. Aldo Paraboni, Politecnico di Milano
Luxembourg	Mr. John Raabo Larsen, Societe Europeenne des Satellites (SES/ASTRA)
	Mr. Marcel Pettinger, Societe Europeenne des Satellites , (SES/ASTRA)
Netherlands	Mr. Max Van de Kamp, Eindhoven University of Technology
Norway	Mr. A. Nordbotten, Telenor Research
	Dr. Terje Tjelta, Telenor
Portugal	Prof. Francisco Cercas, Instituto Superior Tecnico de Lisboa
	Prof. Armando C. D. Rocha, Universidade de Aveiro
Romania	Dr. Tudor Palade, Technical University of Cluj-Napoca
Slovakia	No active member. (Prof. Chytil, deceased, Slovak Univ.of Technology)
Spain	Prof. Leandro de Haro Ariet, Universidad Politecnica de Madrid
	Dr. Fernando Perez Fontan, E.T.S.I. Telecommunication, U. Vigo
United Kingdom	Dr. Misha Filip, University of Portsmouth
	Dr. John W.F. Goddard, CCLRC-Rutherford Appleton Laboratory
ESA	Mr. J.P.V. Poiaras Baptista, ESA/ESTEC
	Mr. Bertram Arbesser-Rastburg, ESA/ESTEC

1.1.2.4 Working method

The Action was officially kicked off at the first Management Committee meeting in May 1996. It was then decided, to hold an average of two meetings per year, in which each meeting would be a combination of management committee meeting and technical meeting. All material to be presented at a meeting would be available to all participants well ahead of the meeting. The documents would be downloadable in PDF format on a password-protected WEB site. No paper copies were mailed to the participants, with the exception of the official minutes of the meeting. This method was used very successfully – more than 150 technical papers were produced within 3 years – forming the basis of this Final Report.

The work was, from the beginning, divided among four working groups, with the following titles and chairmen:

WG1A - 'Fixed Propagation Modelling': Aldo Paraboni

WG1B - 'Mobile Propagation': Fernando Perez-Fontan

WG2 - 'Climatic Parameters and Mapping': Pedro Baptista

WG3 - 'Systems and Simulation Issues': Paul Thompson, later Marcel Pettinger

The Working Group chairmen organised working sessions as part of each bi-annual MC meeting. Usually two days out of three were devoted to Working Groups meeting in parallel sessions. At the early meetings this enabled each group to concentrate fully on its own area of work. Technical contributions were formally presented and discussed, and recommendations made for further work to be completed by the next meeting. However it became clear that the parallel sessions made it

realise test cases. Peter Watson was assigned the task of overall co-ordinator of the two Project Groups;

PG-A - 'Fixed Link Test Cases': Misha Filip

PG-B - 'Test Cases with a Mobile Link': Simon Saunders

Plenary sessions were arranged to hear of the progress made in the other groups, but the limited time available made these rather short and ineffective. The minutes of each meeting were as full as possible, and sent to each participant in paper form, but it was still difficult to gain an overview of the complete project before the Final Meeting. At this meeting a draft version of the Final Report was on the table, thanks to enormous effort on behalf of the chapter editors and the secretariat. This would not have been possible without electronic mail and the use of the ESTEC FTP server. The COST 255 web page is located on the ESTEC server: <http://www.estec.esa.nl/xewww/cost255/>

It should be mentioned, that a major contribution to the smooth and effective operation of this COST Action was the continuous effort of the Action Secretary and Grant Holder, Sue Upton. She prepared all the necessary correspondence and annual reports for the COST Secretariat, prepared information on meetings and workshops and ensured that the financial aspects of the Action were managed in line with the overall rules of COST.

Meetings of the Management Committee

MEETING	DATE	LOCATION	HOST ORGANISATION
1 st Preparatory Mtg	1995 Dec 12	Brussels	EC
2 nd Preparatory Mtg	1996 Feb 14/15	Brussels	EC
1 st MC Meeting	1996 May 21/22	Brussels	EC
2 nd MC Meeting	1996 Nov 25/26	Athens	National Technical Univ. of Athens
3 rd MC Meeting	1997 May 12/14	Trest/Prague	Institute of Atmospheric Physics
4 th MC Meeting	1997 Oct 27/29	Brussels	EC
5 th MC Meeting	1998 May 27/29	Vigo	University of Vigo
6 th MC Mtg & Workshop	1998 Oct 28/30	Noordwijk	ESA-ESTEC
7 th MC Mtg & Workshop	1999 May 18/21	Toulouse	CERT-ONERA and SUPAERO
8 th MC Mtg & Workshop	1999 Oct 25/27	Bech, Lux.	SES-ASTRA

Management Committee Meetings were attended by an average of 50 delegates.

About 100 delegates attended the Workshops. The Workshop held in Toulouse was organised jointly with COST Actions 252 and 253.

Short-term scientific missions

Eleven Short Term Scientific Missions (STSM) have been funded in the framework of COST Actions 255. The purpose of these missions was twofold:

- To allow direct collaboration and exchange of information between researchers at different institutes
- To allow the participants to establish good personal relations between host and guest thereby opening the door to future collaboration.

The missions carried out in COST 255 can be termed successful in both respects. In the beginning, the mission were use to get acquainted with procedures and data, whereas towards the end the missions were oriented towards the joint production of this report.

The Table below shows the organisations involved in the STSM scheme:

Visitor (one person from...)	Host organisation	Duration
UCL, Louvain, BE	University of Surrey, UK	1 month
FUB, Rome, IT	IAP, Prague, CZ	1 week
IMST, Kamp Lintfort, DE	University of Vigo, ES	5 days
U. Vigo, Vigo, ES	IAP, Prague, CZ	2 weeks
ONERA-CERT, Toulouse, FR	UCL, Louvain, BE	5 days
Univ. Karlsruhe, DE	University of Surrey, UK	2 weeks
IAP, Prague, CZ	FUB, Rome, IT	2 weeks
Bath Univ., UK	ONERA, Toulouse, FR	4 days.
Univ. Cluj-Napoca, RO	Politecnico di Milano, IT	2 weeks.
Univ. Eindhoven, NL	Politecnico di Milano, IT	4 days
FUB, Rome, IT	Bath University, UK	5 days

1.1.3 Dissemination of Results

1.1.3.1 *Conferences and Workshops*

- COST 255 First International Workshop on Radiowave Propagation modelling for SatCom services at Ku-band and Above, held at ESTEC, Noordwijk, Netherlands. 28-29 Oct. 1998. ESA publication WPP-146 ISSN 1022-6656, Feb. 1999.
- Joint Workshop with COST252 and COST 253, held at ONERA, Toulouse, France, 19-20 May 1999.
- Final Workshop to present the draft Final Report, Luxembourg, 25-27 Oct. 1999.
- Special Session on COST 255 at the AP-2000 Conference, held in Davos, Switzerland, 10-14 April 2000.

1.1.3.2 *Web site*

The COST 255 website is on the ESTEC server at

<http://www.estec.esa.nl/xewww/cost255/>

The site is maintained by ESA, as a service to COST.

There are links to the parent COST sites, information on MC meetings past and future, links to the websites of associated research organisations.

Of major importance is the password protected private area, where *bona fide* COST members have been able to access all the technical documents, reports on Short Term Scientific Missions and names and addresses of members. As far as possible all papers presented at meetings have been available on the web in advance, which has contributed greatly to the overall success of the project.

1.1.3.3 *Transfer of results*

The primary vehicle for the transfer of results is this Final Report, see Section 1.1.3.4

The new global maps of meteorological parameters are available on the ESTEC FTP server and those of water vapour, the 0° C isotherm and topography have been submitted to the ITU-R.

The work carried out under WG2 regarding the precipitation maps for propagation models has been adopted by the ITU-R to replace the recommendation ITU-R P837 (characteristics of precipitation for propagation modelling). Also adopted by the ITU is the map of cloud columnar water content (in Rec. P-840).

Early in the project an active attempt was made to contact operators and manufacturers by sending out a questionnaire on future satellite systems to 200 organisations, but it elicited very little response (8%).

There has been active participation in COST255 from EUTELSAT and from SES (ASTRA), who have been very helpful in identifying future satellite systems. As active members they have also had the opportunity to influence the direction of the research and benefit directly from the results.

1.1.3.4 *The Final Report*

The key result of the work of COST Action 255 is this Final Report. The Final Report has been divided in 7 Parts, coordinated by Part editors. In the following, the Parts (2 to 7) are briefly introduced and the responsible Part Editors are mentioned:

Part 2: Fixed propagation models (Part Editor: Antonio Martellucci)

Summarizes the results of the WG1A on propagation modeling for fixed satellite systems, including model description and testing.

Part 3: Climatic Parameters (Part Editors: J.P.V. Poiares Baptista and T. Tjelta)

Based on the results of WG2, it contains a description of the climatic parameters relevant to satellite propagation modelling and illustrates the available databases to be used as input to propagation models.

Part 4: Terrain and Clutter Effects, Mobile Modelling (Part Editor: F. Perez-Fontan)

This part illustrates current models, techniques and databases for the propagation in satellite-mobile systems as analysed in the activities of WG1B.

Part 5: Systems and simulation Issues (Part Editor: M. Pettinger)

This part contains an overview of trends in satellite communication systems and the impact of propagation modelling. It also presents techniques for fade mitigation needed for the design of new satellite communication systems. The material represents the results of the work of WG3.

Part 6: Test Cases Involving Fixed Satellite Links: Part Editor M. Filip

Part 7: Test Cases Involving Mobile Links: Part Editor S. Saunders

Those two parts summarize the results of the test case analysis performed by Projects Groups A and B. Using the results and the indications of WG1A, 1B, 2 and 3, the propagation prediction methods and data have been applied to currently envisaged satellite communications systems. These test cases demonstrate the possibilities, limitations and future needs of propagation models for satellite communication systems.

This paper copy will be complemented by a CD-ROM containing propagation models, databases and documentation.

The completion of the final version of this Report was made possible by the efforts of the following individuals:

- The Part editors listed above and the Chapter editors listed on the title page of every chapter who had been instrumental in creating a coherent report from many individual contributions.
- Peter Gallois who kindly accepted to be Report Editor after the Final Workshop in Bech. He performed a thorough review leading to a substantial improvement of the consistency, presentation and language. Pedro Baptista and Sue Upton who, besides correcting and refining the text, communicated with the editors of the different parts on the necessary modifications.
- Prof. W. Riedler and Prof. M. Tomlinson, who had been appointed reviewers of the Action, carefully evaluated the Final Report in March 2001. Their suggestions have contributed to a number of clarifications and improvements.
- Bob Harris of the ESA Publications Division, who spent many long hours getting all chapter and section headings, equation numbers and figure captions right. Richard Magri, who helped in fixing automatic numberings and references.
- Antonio Martellucci, who has performed the final editing and review of this report.

1.1.4 Concluding remarks

Successes of COST Action 255 have been:

- Excellent co-operation between countries
- Good use of previously measured propagation data
- Two successful workshops
- Validation of new propagation models
- Establishment of communication between propagation experts and operators
- Encouragement of young scientists through the Short Term Scientific Mission opportunities
- Use of the world wide web as a means of disseminating results

It is felt that COST 255 has made a useful contribution towards improved planning of spectrum efficient telecommunication systems.

*Bertram Arbesser-Rastburg,
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