Memorandum of Understanding

For the implementation of a European Concerted Action Research Action designated as

COST Action 280

"Propagation Impairment Mitigation for Millimetre Wave Radio Systems "

The Signatories of this Memorandum of Understanding, declaring their common intention to participate in the Concerted Action referred to above and described in the Technical Annex to the Memorandum, have reached the following understanding:

1. The Actions will be carried out in accordance with the provisions of the document COST/400/94 "Rules and Procedures for Implementing COST Actions", the contents of which the Signatories are fully aware of.

2. The main objective of the Action is to improve the design and planning of present and future millimetre wave broadband telecommunications systems (including broadcast) and services (especially multimedia) through the development of knowledge and tools for a refined evaluation of their performance.

3. The overall cost of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at roughly 7 Million • in 2001 prices.

4. The Memorandum of Understanding will take effect on being signed by at least five Signatories.

5. The Memorandum of Understanding will remain in force for a period of four years, unless the duration of the Action is modified according to the provisions of Chapter 6 of the document referred to in Point 1 above.

TECHNICAL ANNEX
COST Action 280

" Propagation Impairment Mitigation for Millimetre Wave Radio Systems "

A. Background

Nowadays, fixed telecommunication and broadcasting services are in a phase of rapid expansion due to the increased demand from users to be provided with more and more multimedia services such as digital TV or audio broadcasting, high speed Internet, video-conference, tele-education, tele-medecine, video-on-demand and so on. Trunking systems may also be of interest for transporting high volumes of information. This demand has been driven recently in a large part by the possibility to be connected to the Internet both for professional and private purposes. This anticipated growth of multimedia services can be actually possible only if new fixed-services systems could be able to supply a sufficient data rate with acceptable transit delay, which leads to the need of broadband communication systems and to the use of the bands above 20 GHz.
Some broadband fixed-service terrestrial systems are already operational mainly to provide broadcasting services (initially called MVDS for Microwave Video Distribution Services), at 42 GHz in Europe. But there is also a great interest in the more recent development of LMDS (Local Multipoint Distribution Services) at millimetre wave (eg 28 GHz or/and 42 GHz). LMDS is a more general concept well suited for broadband wireless multimedia services. Systems that aim to provide broadband services have already been tested (for example in the European Commission 4th Framework AC215 CRABS project). Indeed quite a few countries are given licenses for operational systems, but standardisation work is still going on. It is believed that the deployment of such systems will increase considerably in the near future. Not only in Europe, but also in the USA and in Japan, R&D activities are underway in this field.
As far as satellite systems are concerned, large bandwidths are available mainly at higher frequency bands such as Ka-band (20 GHz - 30 GHz) or V-band (40 GHz - 50 GHz). For some years, innovative multimedia satellite systems have been proposed for multimedia applications (Astra ARCS, Astrolink, Cyberstar, Euroskyway, Eutelsat Skyplex, Skybridge 2, Spaceway, Teledesic, West, Domino …), but the realisation of some of these systems is still very challenging.

One of the problems laid down by these millimetre wavelengths (either for terrestrial or satellite telecommunication systems for fixed services) is to quantify precisely the influence of the atmosphere on the propagation of electromagnetic waves. As the operating frequency is increased, the attenuation and scintillation effects of atmospheric gas, clouds, rain and the melting layer become more. Fading thus becomes the dominant propagation impairment; but owing to technology limitations, system margin can no longer be considered as the sole mean to compensate propagation disturbances at any percentage of time. From a practical point of view, margins are designed in order to insure minimum outage duration of the service for a given availability.

As it is not cost efficient to design a large power margin, link signal fading must be compensated by other means in order to increase system availability. Fade Mitigation Techniques (FMT) are thus employed as an important class of Propagation Impairment Mitigation Techniques (PIMT) to overcome fading in real time without the use of large fixed margins. With such techniques, it will be possible for instance to design fixed-services systems with a fixed margin corresponding to the worst case of fading achievable in clear-sky conditions, the implementation of FMT allowing to counteract in real time rain attenuation, scintillation, and depolarization events (if polarisation re-use is needed). Other PIMT have to counteract multipath effects which are particularly important in terrestrial broadband access systems.
Furthermore, interference issues and frequency management aspects have to be considered very carefully, first of all because of the increasing problems caused by the saturation of the spectrum, secondly because some FMT can augment the interference problems, and finally because some systems (especially terrestrial ones) will be more interference limited rather than power limited. Frequency management and interference issues also need a refined information on propagation characteristics, as well as specific adaptive techniques.

Some preliminary studies have been carried out in the frame of COST 235 regarding PIMT that could be implemented in next generation fixed-services terrestrial telecommunication systems. The possible implementation of Adaptive Transmitter Power Control (ATPC) and Adaptive TDMA for point to multipoint systems has been studied in this framework. ATDMA can make more efficient use of the available power and bandwidth ; ATPC provides the excess resource when required, hence reducing the potential for interference. During the CRABS project, modelling and measurements of rain attenuation taking area effects into account have resulted in new information about the improvement achievable by deploying route diversity. Angular diversity has also been considered in urban environment. Other PIMT include Adaptive Cross Polarisation restoration (ACPR) and Channel Equalisation (CE) techniques. The latter are particularly important in radio-based terrestrial broadband access systems.
In COST 255, FMT have been considered as a key concept with the possibility to offer acceptable availability for new satellite telecommunication system operating at Ka-band and above. A state-of-the art review in the FMT domain has been carried out (power control, adaptive signal processing, diversity FMT), and the performance of some simple FMT have been evaluated in terms of air interface performance of some generic SatCom systems through the use of propagation time series.

Some European Earth-Space propagation experiments have been carried out in the recent past : the OPEX campaign (with ESA's OLYMPUS satellite) and the CEPIT campaign (with the Italian ITALSAT satellite). Millimetre wave propagation properties have also been studied on several terrestrial experiments, for example in UK, Norway or France. Ground radar measurements of rain spatial properties, currently achieved by meteorological radars, are also of great interest for some aspects of PIMT implementation or coverage prediction, either for terrestrial or satellite systems. All these data allow for the development and validation of new models to describe the radio-channel for Ku-, Ka- and V- frequency bands. The measured data should also form the basis of realistic simulated time-series data to test the dynamic behaviour of communication systems subjected to real propagation conditions.

Other ongoing COST activities have been considered to ensure that best use is being made of existing knowledge and to avoid overlap. In particular, close links between COST 280 and others (for example COST 262 or 264) concerning next-generation communication systems have to be established, for example through the organisation of a joint annual workshop.

This Action is best carried out within the COST framework for the following reasons :

- Channel Modelling and PIMT studies require a long-term multi-disciplinary effort involving: system issues, network and access aspects, communication techniques, propagation modelling, antenna aspects, radio-climatology database, simulation techniques as well as interference issues and frequency management aspects.

- The COST framework provides the best means of harmonising national research activities in the field of many countries, including central and eastern Europe, as well as allowing the involving of other non-COST countries such as Russia, Canada, …

- By focusing on a four-year COST activity, timely completion of the work is expected. (Note that the actual work is to be completed within 3 years, the Final Report should be published within 3.5 years and the MoU should remain in force for 4 years).

B. Objectives and Benefits

The main objective of the Action is to improve the design and planning of present and future millimetre wave broadband telecommunications systems (including broadcast) and services (especially multimedia) through the development of knowledge and tools for a refined evaluation of their performance.

To achieve this goal it will be necessary to co-ordinate European research activity in the following areas:

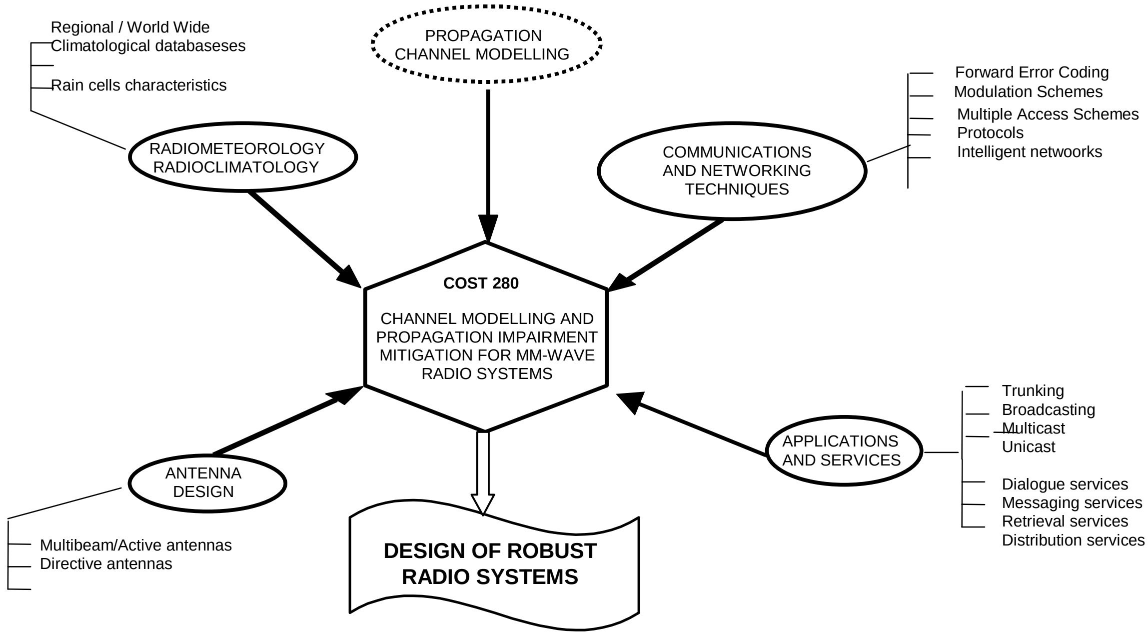
1. Designing and planning of millimetre-wave broadband telecommunications systems (including broadcast, and especially for multimedia services)
2. Development and implementation of propagation impairment mitigation techniques
3. Channel modelling for Earth-satellite and terrestrial paths above about 20 GHz

The Action will address the interest of European Industry to introduce terrestrial and satellite-based broadband telecommunication systems, which are making optimal use of the limited frequency spectrum. The work will build on the results of earlier successful COST Actions such as COST Action 255.

C. Scientific Programme

The initial philosophy of the Action is based on a close co-operation and interaction between scientists and engineers from Telecom industry, Telecom operators and Agencies working in the different fields of expertise necessary to design a telecommunication system, i.e. radio-propagation, antennas, communications techniques, communication networks and applications. As it is not possible in the framework of a COST Action to achieve a real coherent activity between all these fields, the rationale for the Action will be to concentrate on channel modelling and propagation impairment mitigation techniques, but with a clear and stable link with the other related fields.

The context of the Action can be illustrated by the following figure :



This figure illustrates the need for interdisciplinary work in various related fields (radiometeorology, antenna design, communications techniques, communications network, applications and services) in order to make significant improvements in the design and concrete implementation of PIMT for future multimedia broadband telecommunications systems. This also means that the design and implementation of PIMT have to be entirely inter-connected to these fields, especially communications techniques, communications network, applications and services.

It would be unrealistic to think that each of these fields could be well covered by a working group inside a single COST Action, since all of these topics could generate separate COST actions. But, for each field not covered by a working group, it will be necessary to appoint a focal point to make the necessary link with outside the Action (other COST Actions, ITU-R groups, ETSI groups, ...).

Another important point for the Action will be the emphasis on demonstrating the effectiveness of the new achievements by working on particular generic systems. Such systems will have to be defined in a first phase of the Action, which should last no more than six months. Of course, the inputs from Telecom industry, Telecom operators and multimedia services providers will be of paramount importance in this phase.

Most of the work for studying the efficiency of PIMT on any particular system will be based on simulations. In the framework of the Action, simulation tools will thus be the focal point for making progress. Hence, it would be very valuable to establish, at the beginning of the Action, a specific group for thinking about the best way to use and exchange existing tools, and eventually to design new tools. In addition, the necessary input data for the simulations (especially real propagation time series have been demonstrated very useful in some FMT studies) will need to be gathered at an early stage.

The first phase of the Action will be to review present-day and expected future telecom systems in the light of their requirements regarding system characterisation and its relation to channel modelling and Propagation Impairment Mitigation Techniques. This activity will be led by system engineering specialists in an Advisory group (AG 1) and will be used by the Action to identify available models, data, tools, software and procedures that may be used to satisfy the requirements, as well as those areas where research and development work will need to be concentrated. This activity will also result in the selection of two or three generic systems, on which the main achievements of the Action could be demonstrated.
At the same time, a second Advisory group (AG 2) will collect all relevant information on readily available simulation tools and on propagation data suitable for creating time series.
This phase is expected to last 6 months (see Section D).

Part 1 : Channel Modelling for satellite and terrestrial systems

Improvement in channel modelling is a required step for improving the implementation of PIMT in any telecommunication system (both satellite and terrestrial). Channel modelling can be understood as the whole knowledge necessary to describe the propagation channel in all its dimensions, this means the temporal properties of the channel (or dynamic characteristics), the frequency properties of the channel (for broadband systems) and the spatial properties of the channel (for short scale as well as large scale areas). The basic knowledge and studies for channel modelling are related to propagation research, but signal processing theory is also of concern. Finally, the output of this activity should be channel models to be used in computer simulations, that is to say transfer functions (or impulse responses) representing the propagation channel, ideally as a function of time, frequency and location.

In practice, the Channel Modelling working group could be split into two sub-groups, the first one devoted to more basic propagation activity, and the second one devoted to the development of channel models.

Propagation research :

In order to build the best channel models for future millimetre-wave broadband systems, it is still necessary to improve and to increase the knowledge and the characterisation of the propagation effects that influence the performance of such systems. Here the emphasis should not be on the statistical long term characteristics of the channel, but on the second order statistical characteristics with reference to: the time variability and dynamic properties (scintillation intensity, fade slope, fade duration, …); the frequency dependence (frequency selective effects if any, coherence bandwidth, frequency scaling aspects, ...); the spatial properties (coverage prediction, fade correlation distance, rain cells distribution and characteristics over large areas, ...). The main part of this activity will be of interest both for satellite and terrestrial systems ; specific issues could also be considered for one application only.

Of course, the huge amount of data acquired in previous propagation experiments (i.e. OLYMPUS, ITALSAT, CRABS, …) and the outputs of previous COST Actions in the propagation domain (especially COST 235, COST 255) will be of great value for this activity.

Channel models :

The objective of this activity would be to develop different models or algorithms for each of the different influences on the propagation channel, such as free space loss, rain fading (as well as other sources of atmospheric fading for millimetre-wave systems, i.e. clouds for example), in addition to scintillation effects and multipath effects (especially for terrestrial systems).
These channel models should be parameterised. For example, the channel model for rain fading should be such that its parameters can be adapted to different climatic zones (i.e. different types of rain), elevation angles and frequencies.
These channel models may be based on stochastic processes of various kinds: usual laws (Gauss, Rayleigh, Rice, …), ARMA schemes, Markov chains or similar patterns.
The output of the propagation channel may be either a transfer function or directly synthetic time series representative of the behaviour of the channel, in order to feed computer simulation tools.

Part 2 : Propagation Impairment Mitigation Techniques

As already mentioned in the introduction, PIMT are of key importance for future millimetre-wave radio systems. This is especially true for satellite systems for which fade mitigation is the key issue for ensuring both availability and quality of services at Ka band and above. For terrestrial broadband wireless systems, some propagation impairment aspects have also to be considered. Interference issues are also of concern in this context.

(i) PIMT concepts for fixed terrestrial and satellite systems

The objective of this activity would be to work on possible concepts that could lead to PIMT design for new millimetre-wave fixed-services telecommunication systems, both terrestrial and satellite. These concepts would have to be closely linked with propagation characteristics, network issues (mainly multiple access and protocols), communication techniques (coding, modulation, signal processing) as well as antenna design (active or multibeam antennas, directive or less directive antennas).
PIMT to be considered will include : power control techniques (ULPC, ATPC, …), adaptive signal processing, diversity techniques (site diversity for SatCom systems, time diversity, route diversity, angular diversity for terrestrial systems, …), Adaptive Resource Sharing (adaptive FDMA, TDMA or CDMA, On-board Beam Shaping for SatCom systems), higher level FMT, …. This work has already been considered in recent framework (COST 255, CRABS, …), but deeper studies are still needed.

(ii) PIMT algorithms and simulation

To implement PIMT, a real problem is to detect and predict in real time the dynamic behaviour of a propagation impairment. It is then necessary to discuss the way to detect and quantify a possible fade, and the method to distribute the information to the equipment that is going to implement the compensation (transmitting Earth station, satellite, network control station, …). Differently from the previous activity, here the objective will not be to consider PIMT concepts, but really to think about the practical issues linked to PIMT (whatever the type of PIMT considered). This activity could include :

- Detection of the channel behaviour : what possible schemes could be implemented (open-loop, closed-loop, hybrid schemes ?) and comparative studies.

- Control of the PIMT loop : definition of PIMT thresholds and evaluation of the response delay of the system => detection and hysteresis margins : fixed, variable, adaptive.

- Short-term prediction of the channel behaviour : filtering of low/fast components of the signal, frequency scaling (for open-loop), prediction taking into account system response and filtering delays.

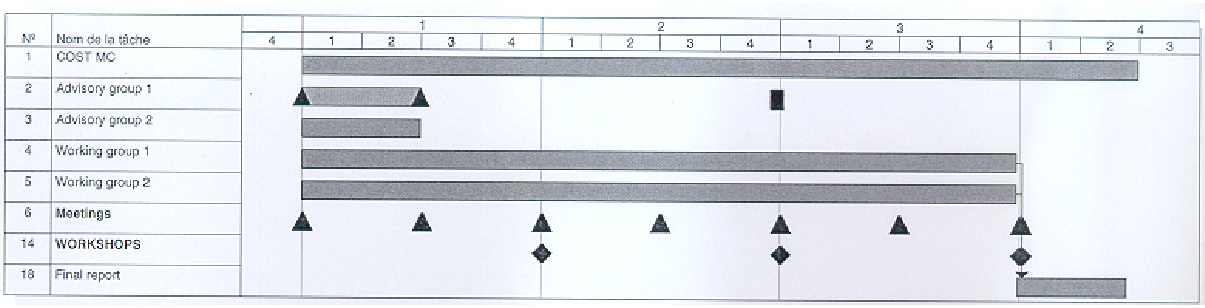
The influence of the implementation of PIMT on other part of the system has also to be considered here. In fact, some PIMT (adaptive resource) have to be thought directly at the system level (which is different from PIMT on a single link).

D. Organisation and Timetable

Due to the multi-disciplinary nature of the Action, annual workshops will be organised. This form of meeting favours extensive exchange of information between the different groups of specialists and will impose strict deadlines that will favour a timely completion of the Action.
At the end of each annual workshop, the requirements defined in the first phase of the Action will be reviewed and updated so that the targets of the Action are clear at each stage of the work. These requirements, together with other relevant documentation discussed and presented at each workshop will be electronically published in the form of an Annual Report.
Adopting electronic publishing and an extensive annual review process will minimise the time necessary to produce the Final Report.

In principle, two annual meetings of the Management Committee are planned, with one of them occurring in the same period as the annual workshop. All documents submitted will be electronically published unless otherwise requested by any of the signatories.

Action duration 4 years



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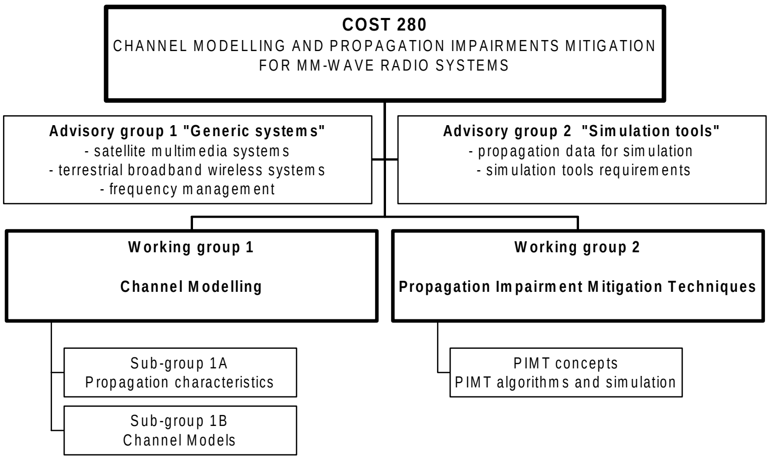
Organisation

The work in the present Action will be organised in two Working Groups (see organigram below).



The flow of information and interaction will be very high between Working Groups (I) and (II) while the driving requirements will flow mainly from systems experts in the Advisory Group 1 to the other groups.
Advisory Group 1 will express the needs in propagation and channel modelling, and in frequency management issues ; it will also give information on systems that needs PIMT and on simulation tools to be used for their analysis. This group could be partly formed by people external to the Action.
Advisory Group 2 on simulation tools will define the common requirements for these tools and will gather the necessary propagation data already available to the participants of COST 280.

It is expected that each Working Group will elect a Chairperson to coordinate the work within the group and represent it within the Management Committee.

The Management Committee will elect a Chair- and Vice-Chairperson, and will be responsible for interfacing with other projects (European or international) to make use of already available material and to avoid any overlap or duplication. It is expected that this process will create a close liaison with the following programmes or organisations: EU 5th

Framework Programme (in particular IST projects such as EMBRACE and other COST Actions such as COST 262 or 264), ITU, ETSI, and also national programmes such as DAVID in Italy. Furthermore, it is expected that some of the results of the Action could be provided to the ITU-R.

The Management Committee will usually have two annual meetings and associated technical meetings. For exchange of information with other COST groups, joint workshops will be arranged. In addition, laboratory visits and staff exchanges (short-term scientific missions), inter-comparison of results between different laboratories or organisations, etc., to achieve a rapid and smooth exchange of information.

Delegates representing Signatories in the Management Committee are expected to:

- attend and contribute to meetings of the Management Committee (two meetings per year are expected)
- be actively involved in a research programme in line with the objectives and time scale of the Action
- take responsibility for specific items of the Action
- seek at least annually the advice of the Technical Committee for Telecommunications, Information Science and Technology (TC-TIST) to achieve a working liaison between the Action and other related COST Actions
- set up national working groups for specific items and be responsible for liaising between the Management Committee and national research groups in the participating countries.

E. Economic Dimension

Based on the interest shown in preparing this MoU, the number of signatories is estimated to be 14. The following countries and International Organisations have actively participated in the preparation of the Action:
Austria, Belgium, Czech Republic, Finland, France, Germany, Italy, Luxembourg, Netherlands, Norway, Romania, Spain, United Kingdom, ESA.

Estimated number of signatories : 14

Cost per signatory per year:
It is assumed that each signatory will have the equivalent of two people (one Researcher, one Student) involved full-time in work contributing to the programme.

1 person/year: Engineer, Researcher	70.000 •
1 person/year: PhD, Student	60.000 •
Total per signatory per year	130.000 •

Economic dimension:

Total over four years for 14 signatories	
4 x 14 x 130000	
Economic Dimension:	Appr. 7 Million •

The estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

F. Dissemination

The target audience for dissemination are the following entities:

- Other researchers working in the field
- Other research projects and undertakings
- Standards Bodies (i.e. ITU, ETSI)
- Industry represented by equipment manufacturers and service operators.

The dissemination of information will be implemented through:
- posting of general information such as objectives, dates of meeting, workshop announcements etc., on a set of dedicated public WEB pages.
- posting of all working documents on a password protected WEB or FTP site
- contributions to national and international conferences and symposia
- exchange and discussion of scientific findings in specialised workshops organised by the Management Committee (with appropriate proceedings)
- publication of papers in scientific and technical Journals
- publication of annual reports
- publication of a Final Report

The communication between the participating groups will be done by e-mail.