

What did COST 238 really achieve?

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ABSTRACT

COST238 was a four-year research project of the European Commission to develop improved European ionospheric maps and models. Summaries of the objectives and principal technical results obtained have been published (*Bradley, 1990, 1993*) and a full description of the work carried out together with adopted formulations appear in the Final Report (*Bradley and Vernon, 1999*). The present account examines the background to the creation of the project, considers its impact on the various groups in the different countries that took part in the work, and shows how, along with successor COST Actions, it has served as a kernel in stimulating and fostering co-ordinated ionospheric research among workers in both Member States and the wider international community.

Key words: Ionosphere Modelling, European Union Research Project

1. INTRODUCTION - HOW WE CAME INTO BEING

I (PAB) was sitting in my bedroom in a small motel in Concord, Massachusetts. It was about 9.30 on a Tuesday evening in the Spring of 1988 and after a meal in a downtown restaurant with the rest of our team I was reading papers distributed that day, in preparation for the next morning session. Suddenly the telephone rang. It was my friend Bodo Reinisch. Would I be able to come over to his house in Bedford on Thursday for dinner? - he would like to discuss some proposals for a new project. I knew Bodo's wife Gerda as an excellent cook, and I readily accepted.

As a then staff member of the Radiocommunications Research Unit of the UK Rutherford Appleton Laboratory (RAL) I had been taking part in a research project in conjunction with Ramsey Shearman of the University of Birmingham to use an HF over-the-horizon radar to monitor sea state. RAL's role was to provide propagation support to UK universities and other national organisa-

tions. Ramsey had the idea that the returns from a high-power transmitter coupled to a steerable narrow-beam antenna could be used to deduce wind patterns as an aid to meteorological monitoring and forecasting. Bragg scattering of the radio waves from the ocean waves leads to a pair of Doppler-shifted spectral lines, the amplitude ratio of which, according to a certain theory, can indicate the bearing of the associated driving wind waves relative to the radar boresight. So, by range gating and successive antenna beam slewing to define a series of separate sea cells, it should in principle be possible to map out all the wind-circulation patterns over much of the North Atlantic from just a single westwards-looking radar located in Southern England. We would use existing government facilities and operate the radar in synoptic trials to assess the viability of the technique. Sadly though, after about a year of data collection, we all reluctantly concluded that the associated operational problems were insuperable. Even with transmitter frequency agility, ionospheric support to all sea cells could not be assured, ionospheric Doppler shifting and spreading corrupted the received spectra, and left-right ambiguities combined to prevent adequate discrimination of the wind patterns. Nevertheless, having established our role in over-the-horizon radar studies, this early work led to our being invited to take part in other HF radar trials from the same site to examine the feasibility of detecting and tracking ships and aircraft. Our sponsors wanted particularly to determine, this time for a northwards-pointing radar, whether auroral clutter and sporadic-E ionisation would limit long-distance target detectability, and what accuracy could be achieved in target positioning. US colleagues were also involved in these trials, and that was why we were present at a planning meeting in Massachusetts at this time.

A couple of days later, following Bodo's instructions, I turned my hire car into his drive. There I found two other of Bodo's colleagues joining us for dinner: Gary Sales and Leo McNamara. Bodo is Head of the Center for Atmospheric Research at the University of Massachusetts in Lowell (UMLCAR), some 10 miles to the north of Bedford. The fortés of his group are the development, manufacture and exploitation of digital ionospheric sounders (Digisondes™) for the monitoring of the state of the overhead ionosphere. After an excellent meal we went to his basement 'second office' and Bodo brought out various papers. He explained that the US Army Signal Corps at Fort Monmouth, New Jersey, wanted to carry out communications trials in the western sector of Germany, with synoptic ionospheric sounding being used to up-date long-term prediction information to optimise frequency selection of operational links and so improve HF communications availability. An invitation to tender (ITT) had been issued and UMLCAR wanted to respond. Their proposals were to have seven Digisondes distributed within the various European countries, all making a vertical sounding every hour. Between the hours on a co-ordinated time schedule the sounders would also radiate among one-another, so that each sounder received the signals from every other one in turn. With synchronised sweeps the resulting oblique-incidence records would be 'inverted' to

equivalent mid-path vertical-incidence data. In this way, with just these few equipments the ionosphere would be sampled at 28 separate positions. All results would be forwarded to a control centre, to be located at Darmstadt, Germany, where operational predictions would be produced. What did I think? I agreed this was a very interesting and worthwhile investigation. My only comment was that in days before the Internet it did seem a lot of expense was going to be associated with getting all the data to Darmstadt, and I couldn't really see why the feasibility studies could not be conducted off-line using past-epoch measurements. The answer was that what was proposed in this respect was what the sponsor requested!

I returned to England and the months passed. For some time RAL had been operating a Digisonde at Slough and there were also existing Digisondes in Dourbes, Belgium and at Roquetes, Spain. The UMLCAR proposals called for the use of these, with additional Digisondes to be procured and deployed at further sites; agreement to make use of the present sounders was readily given by their respective owners. Then we heard that the Signal Corps, who by this time had already placed orders for two more Digisondes for Germany, were having second thoughts about project costs. Next we were approached by a second organisation, the Aluminium Company of America (ALCOA). They too were now responding to the ITT, but with a more modest submission. With just two initial oblique paths between Dourbes and Slough (very short range high-angle) and between Dourbes and Roquetes, use would also be made of near-midpath vertical sounding data from Poitiers, France. Perhaps a German path would follow later. I had to tell the ALCOA representatives who visited us that I could not really see how these very western path data would help communications towards eastern Germany, but that we would be willing to collaborate with whichever organisation obtained the Signal Corps contract. The other ionosonde groups provided similar undertakings.

Time moved on. We learned that two Digisondes had been procured and shipped to Germany, but that no contract decisions had been taken. In October 1988 Bruno Zolesi and Tony Meloni from the Istituto Nazionale di Geofisica, Rome jointly convened a Workshop at which attendees were invited to present and discuss the various investigations under way at their respective organisations within the fields of ionosphere and geomagnetism. Those present working on ionospheric topics included Lili Cander (Geomagnetic Institute, Grocka, Yugoslavia), Rudi Hanbaba (CNET, now France Telecom), Jean-Claude Jodogne (Royal Belgian Meteorological Institute) and Stamatis Kouris (Aristotelian University of Thessalonika, Greece). Inevitably at some stage in the discussions attention turned to the question of the US sounding project. How much longer must we wait to find out if this was going ahead? Bruno was keen to see if it might be possible to have one of the Digisondes just sitting in a packing case in Germany moved to Rome, so that then a second Italian sounder could be transferred to their field station in Gibilmanna, Sicily. (This in fact did later happen). I suggested if we were all keen to undertake a European vertical and oblique-in-



The PRIME group in Greece in April 1990, before we became a proper COST project. The meeting was hosted by the National Observatory in Athens, and the picture shows Professor E T Sarris, Observatory Director (second row, second from left), together with several other of his staff. Founder COST members include (same row, counting from the left): (1) Stamatis Kouris, University of Thessalonika, Greece, (4) Rudi Hanbaba, France Telecom, (5) Lili Cander, Geomagnetic Institute, Belgrade and Rutherford Appleton Laboratory, (6) Benito de la Morena, INTA, El Arenosillo, (7) Luis Alberca, Ebre and (8) Bruno Zolesi, Istituto Nazionale di Geofisica, Rome.

vidence ionospheric sounding experiment somewhat along the lines proposed using best real-time regional information to update global prediction maps and models, and if we already had several working Digisondes among us, why not go ahead with a project the way we wanted it to be conducted. If later the US came along with ideas, equipment and money!, we could listen to what they said, and concur or not in the light of what we were by then doing. They all readily agreed to this idea, and as usually happens when one makes a suggestion, I was asked to go ahead and arrange things. But there was keenness on everyones' part to help. We would call ourselves PRIME, standing for 'Prediction and Retrospective Ionospheric Modelling over Europe'. Rudi suggested we should all go away and think about things, and he would see if it was possible to hold a planning meeting in a few months time at his organisation in Paris. It was a good job we decided to proceed in this way, because eventually the ITT was withdrawn without being acted upon.

In June 1989, just eight of us gathered in a small meeting room at the CNET Headquarters in the Paris suburb of Issy-les-Moulineaux to consider



Attendees at the 1st Management Committee Meeting, RAL Cosener's House, Abingdon, UK, November 1991.

what to do next. After the dates for our get-together had been arranged, I learned to my surprise that Martin Hall, a RAL colleague concerned with tropospheric studies, was holding a meeting of COST210 of which he was Chairman also in the same Institute and at the same time. I had then only a very vague idea what COST was, and had not given this any further thought. I was staying in one of the several small hotels dotted around Issy and I had noticed a couple of mornings one gentleman sitting alone at the breakfast tables. He too had walked ahead of me the first morning into the CNET. Next day we got into conversation over breakfast. He introduced himself as Manuel Monteiro, originally from Portugal, but now working for the European Commission in Brussels. He was a member of the COST Secretariat and was acting as Secretary and representing the Commission at Martin's meeting. We talked about COST and in turn I told him what our meeting was about. 'Why don't you turn your group into a COST project?' he asked. 'Oh I don't know', I replied, 'It seems like a lot of extra complications, with no evident advantages'. 'Well, I'll tell you what' he said, 'Would you like me to come for a few minutes to talk to your people about COST, so they can see what they think?'. Of course I thanked him for this offer and readily accepted.

Manuel addressed our group. He explained that COST stands for *Co-operation in Scientific and Technical Research*. It is an initiative of the Commis-

sion aimed at bringing together governmental, university and industrial teams in the different Member States to work on common problems that have been identified as in the interest of the Community at large. The aim is to develop a technological base that will serve to make the Community more effective in the world arena. There are a whole series of different COST projects (or 'Actions' as they are called in 'Eurospeak' language). Every Action has clearly defined objectives and time-scales, with States taking part on an a-la-carte basis in only those where there is a national interest to contribute. Actions are structured within various principal disciplines such as transport, food technology, meteorology and environment. Our work would fall within the '200 series' under the heading of telecommunications. Actions are administered on a day-to-day basis by a Management Committee who determine the detailed work programme and areas of responsibility. All participating groups have to find their own funding, but the Commission supports and provides a Secretarial service to each Action.

I thanked Manuel for his information, and after he had left we had quite a full and frank discussion centred on what he had said. Did we want to become a COST Action? What were the advantages, and what the disadvantages? There were several aspects. Firstly, if we were recognised by the Commission as doing a worthwhile job and if this was for a defined time period, that helped guaranteed support from within our own organisations, both to carry out the work and to attend the necessary planning meetings and Workshops. Secondly, it enabled small teams to benefit from the experiences of larger group long-established workers in the field in recommending what investigations were worthwhile and necessary. It would probably too bring additional groups into the project, which must be an advantage. On the negative side though were the real concerns that being an official European Union (EU) project would carry with it added bureaucracy, the extent of which at that point we could only hazard to guess! I proposed we should take these thoughts away with us. I undertook to circulate a questionnaire outlining what I saw as the salient points, leaving everyone then to vote 'yes', or 'no'. Later, COST financial arrangements were changed, such that we all benefited in ways to be explained below. Had we known that then, there would surely have been no doubts of peoples' wishes. Nevertheless, as things stood, the outcome was still a resounding 'yes'. And so I had the job of starting the ball rolling! I knew this would be a long business, hence in the mean time we arranged another combined planning meeting cum-Workshop at the National Observatory, Athens in April 1990. By this time we were familiar with the sort of management structures that COST would require and so we set up an ad-hoc organising committee with me as Chairman and Rudi as Deputy, with parallel Working Groups each with their own leaders addressing specific subject areas. My memory of that meeting is that everybody wanted to take part in everything and there was considerable opposition to my proposals to have separate parallel working sessions, with people rushing from one room to another to see what had been agreed in their absence. At later me-

etings though they became more realistic and withdrew from some of the investigations when they found they were over-committed and unable to deliver on their promises. We held a third PRIME business and Workshop meeting in Rome in January 1991.

2. GETTING APPROVAL FOR A COST ACTION

Armed with much paperwork, I soon learned that COST Actions are very formal affairs, and that there are strict procedures that must be followed. Firstly, a written proposal in standard form must be prepared and submitted to a meeting of the COST Telecommunications Technical Committee (TCT). Besides outlining the studies to be carried out and confirming the teams willing and supported to do the work, the benefits to the Community of the Action had to be clearly expounded. The lifetime, chosen as four years in our case, and summed expenses of all participants, including proposed meetings, had to be specified and quantified. In due course I was summoned to one of the periodic meetings of the TCT, which turned out also to be in Athens and just a couple of weeks before our planned Athens PRIME meeting, to present my proposals. On the whole I think they were fairly kind in their questioning, even if quite searching: Wasn't all this sort of thing already being done via the International Radio Consultative Committee (CCIR) of the International Telecommunication Union (ITU)? Why do we want regional ionospheric maps and models when HF radio waves know no national boundaries? Why were all the proposed participating groups from middle and southern Europe, with no Scandinavian involvement? I explained that Europe already had the densest network of ionospheric sounders in the world and that techniques could be developed using such data to produce more accurate maps than are possible elsewhere. Several of us were already serving on Working Groups of the CCIR and I confirmed there was no duplication or conflict of interest. I stressed that we enjoyed very good working relationships with ionospheric scientists in Norway, Sweden and Finland, but that we were restricting our geographical area of concern at this stage to an upper latitude of 55° , not because there was no interest in the higher latitudes, but because the increased importance of particle precipitation, leading also to greater spatial and temporal variability in such regions, made mapping there more difficult, and possibly the subject of a follow-on project. In due course I was advised that the TCT accepted our proposals, and that if approved, the Action would be known as COST238.

The next stage was to get the approval of the Committee of Senior Officials (CSO). This group of individuals tends to be composed of Civil Servants from the Member States concerned with ensuring that national interests are preserved. They also have the job of making sure that an appropriate balance is maintained in providing support within the different COST disciplines and in defining priority areas. I supposed that with no recent flow of applications for

new Telecommunications Actions, approval of ours would cause no difficulties and would be near-automatic. But I was wrong. The objection was raised that the information we were seeking to produce might have military significance. We had to do quite a bit of collective lobbying to remove these doubts, first finding the source of concern, and then briefing at national level in the State involved, to convince that related information already lay in the public domain.



2nd Management Committee Meeting and Workshop on 'Data validation of ionospheric models and maps (VIM)', convened jointly with the Ionospheric Informatics Working Group of the International Union of Radio Science (URSI), Observatori de l'Ebre, Roquetes, Catalonia, Spain, May 1992.

With the ultimate acceptance by the CSO, notification that an associated Memorandum of Understanding (MOU) for the Action was available for Signature appeared in the Official Journal of the Union. Signature is the prerogative of the Ambassador to the EU from each Member State, which makes its own arrangements for instructing him what to do. (In the early days of COST in some countries participation in each Action was debated in National Parliament). Our role at this stage was to ensure that all our group took steps through appropriate national channels to make his or her Ambassador aware of the interest and support within their organisation for the particular Action. Indeed we were rather surprised to learn at one point that the Ambassador of a smaller country had signed the MOU, although we had no contact with any active io-



Work continues over lunch during the Roquetes meeting. In the picture are Father Luis Alberca, Director of the Observatory (standing) and Professor Sandro Radicella, International Centre for Theoretical Physics, Trieste, Italy (camera in hand) talking to Chairman Peter Bradley.

nospheric group in that country; it later transpired that he had signed the wrong piece of paper! No matter. We awaited anxiously for there to be signatories from four Member States, so that the Action could formally begin. A period of six months is allowed for the initial signature process, with the option of later entries at any time to an ongoing Action. Nowadays with the enlarged Union a minimum of five signatures is initially needed. But having done our homework, we were all right. A Brussels inaugural meeting in May 1991 with 18 participants was convened by the COST Secretariat, who took the Chair until adoption of pre-drafted near-standard Rules of Procedure and the formal appointment of my Chairmanship. We each were instructed to introduce ourselves to one-another, despite the fact that by this time we had all been happily working together regularly for two years, and we were finally off.

3. MEETINGS

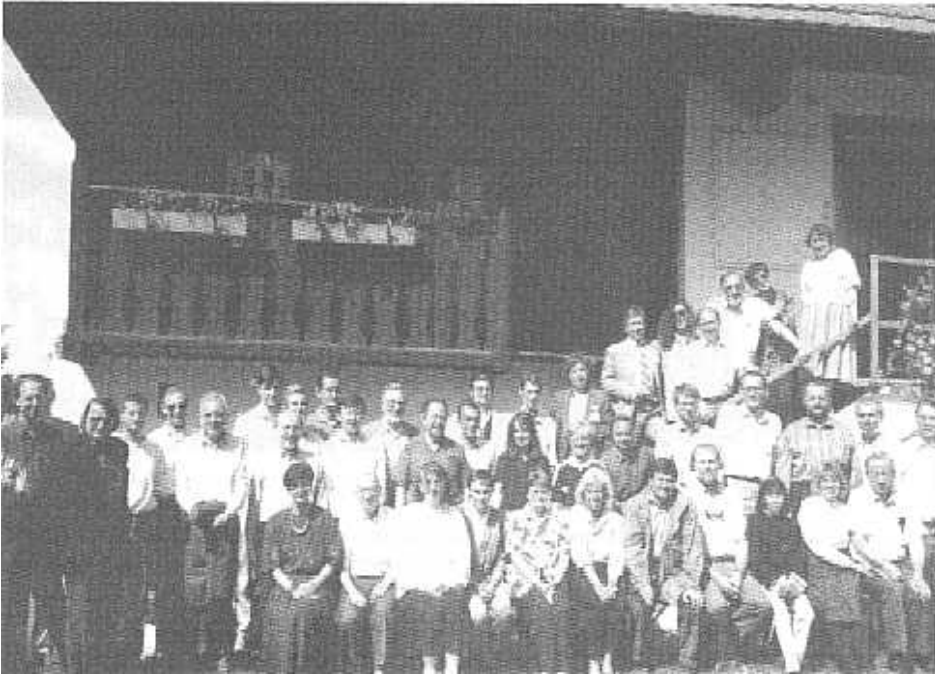
COST work is conducted in a variety of ways, with much achieved through one-to-one correspondence, now greatly facilitated via email. The Working Group Leaders took overall responsibility for detailed organisation of the stu-



Those present at the 3rd Management Committee Meeting, CNET France Telecom, Lannion, France, October 1992.

dies within their domains, and it is a great credit to all of them that the separate investigations slotted together in complementary and timely fashions. Management Meetings were held approximately every six months throughout the four years lifetime of COST238 (RAL Abingdon UK, November 1991; Roquetes Spain, May 1992; Lannion, France, October 1992; Graz, Austria, May 1993; Trieste, Italy, October 1993; Eindhoven, Netherlands, May 1994; El Arenosillo, Spain, September 1994 and Rome, February 1995). We also tried to arrange a Workshop every six months too, usually associated with a Management Meeting. At our meetings we had to approve our annual expenditure and agree the written versions of Annual Progress Reports that were submitted to the TCT to complement the oral accounts I gave at the yearly Chairmens' TCT June get-togethers (Stockholm, 1991; Rome, 1992; Budapest, 1993; Leidschendam, Netherlands, 1994; Warsaw, 1995).

Some seven Specialist Group meetings were held at the most appropriate times, hosted by the various participating Institutes, and each attended by typically half a dozen people. These meetings covered such subjects as measure-



A welcome break and delightful mid-week afternoon excursion from the city during the May 1993 4th Management Committee Meeting and Workshop on 'PRIME studies with emphasis on TEC and topside modelling', held at the Technical University of Graz, Austria, when we headed by coach to a buffet meal at the summer home of our host, Reinhart Leitinger, in the Styrian mountain foothills.

ment data bases, map generation and testing, electron-density true-height profile modelling and the production of the Action computer program incorporating all the developed and agreed models. There were also various opportunities for informal get-togethers of COST attendees at international conferences, and full use was made of these opportunities to further the work.

Important changes in the way COST was administered within the Commission were introduced during the lifetime of COST238. Various 'hick-ups' and highs in the funding occurred from time to time, some to our definite advantages. It was agreed from 1995 on that each Action would provide its own External Secretary, and AV, who already had been doing much of the secretarial tasks and attending meetings in an unofficial capacity anyway, was appointed by acclaim to this role; a contract was awarded from the Commission to RAL for this purpose. Also it was agreed there would be additional support from the Commission to each Action for future meetings. Specifically from then on two attendees from each Member State could be funded to participate in Management Meetings, but not Workshops. Furthermore, the organisers of



Participants at the 7th Management Committee Meeting and Workshop on 'Development and testing of an electron density height profile model for PRIME'. Atmospheric Sounding Station, «El Arenosillo», INTA, Huelva, Spain, September 1994.



Light relief from the hectic INTA sessions – dinner cruise and exhibition of flamenco dancing aboard a steamer on the river Guadalquivir in Seville. Afterwards the chairs were removed and everyone joined in the dancing, as we steamed along viewing the floodlit buildings. It was very late home to bed in the 'small hours', but needless to say, we were all ready for the following morning sessions of the Workshop.

one Workshop a year were allowed to be reimbursed up to half the costs involved, including the expenses of attendance of one International Expert. All these changes were naturally much welcomed, though their implementation was not without administrative complication. There were definite advantages in having present the most knowledgeable outsiders to comment and advise on what we were doing, and we gained in this way particularly from the experiences of US and Australian scientists. The Workshop in Roquetes, held jointly with the *Ionospheric Informatics Working Group of the International Union of Radio Science (URSI)* that Bodo Reinisch chaired, had present attendees from several other countries, including India. It is a credit to all the organisations hosting Workshops and Specialist Group meetings that, not only did they support half the costs, but too they found additional sources of funding to permit others to attend who otherwise could not have been present. Russian colleagues benefited much in this way.

4. WIDENING PARTICIPATION AFTER THE WALL CAME DOWN

The Berlin wall was demolished in 1989 and following moves towards re-unification in Germany, the European Union recognised the needs to widen its membership and to provide economic assistance to scientists in the newly developing nations of the former Soviet Union. Participation in COST is not restricted to EU Member States and in November 1991 a special gathering attended by Foreign Ministers was convened in Vienna to welcome the membership of the then *Czechoslovakia, Hungary, Iceland and Poland*. Associated with this meeting, a mini-conference provided a forum for COST Chairmen to appraise delegates of the collaborative opportunities available within their Actions. Further initiatives were taken, including the release of specific additional funding to permit participation of other eastern European groups in existing COST Actions. In October 1992 Chairmen of Telecoms Actions were invited to a special TCT session in Rome entitled 'New Frontiers in Telecommunications' at which representatives from Bulgaria, the Czech Republic, Hungary, Poland and Russia presented surveys of relevant work in progress in their respective countries. The idea was to have a two-way information exchange, so that the most relevant links might be forged. This was followed by similar sessions in Budapest in June 1993, though some of us felt that speakers were not unbiased or even knowledgeable in every case of all that was going on in their own respective countries. By this time too, our radar work had ceased with the removal of the requirement, and at RAL we were able to devote ourselves more fully to the COST studies.

It became clear that we ionospheric people were in a particularly favoured position in that we were well aware, through membership of long-established international organisations such as the CCIR and URSI, and via the International Council of Scientific Unions (ICSU) and the associated World Data

Centre network, which were the most relevant groups to collaborate in COST238. Indeed we already knew many of the people concerned at the personal level and when the invitation was received in mid-1992 to make proposals for support to particular groups under an initiative referred to by the acronym PECO (Pays European Centrale et Orientale) for Cooperation in Science and Technology with Central and Eastern European countries, we were all ready with the necessary names. We established a small working group to prepare justifying documentation and this group was unanimous in selecting the Institutes to support. Moneys were to be spent primarily on the procurement of equipment such as computing facilities and ionospheric sounders, but small amounts could also be used for travel and subsistence costs to permit participation in meetings. We tried hard to be realistic in our bids, and indeed all the groups we identified were accepted for support. Evidently bids exceeded available funding, and we got precisely 90% of what we asked for our Czech and Polish colleagues. Our Bulgarian friends though benefited from an allotment of 50% more money than we sought; we have good reason to believe this was because many other COST Actions had been unable at that time to identify the most relevant groups in that country. We much regretted that PECO arrangements did not extend to Russian scientists, for which a separate initiative INTAS was established. But INTAS required there to be specific links with western Institutes that would control collaborative work programmes and associated funding. INTAS was not linked to COST and was therefore understandably heavily over-subscribed. Despite gallant efforts, none of the Russian groups we had identified were able to make use of INTAS arrangements during the lifetime of COST238. Unfortunately too the EU was most probably unrealistic in supposing that just a couple of years support would be sufficient to enable all PECO groups to become self sustaining. The state of the economies in these countries in recent years is well known, and whilst some of the groups that had joined our Action became able to fund themselves to the various later meetings, this was not the case for all of these. Particularly it should be recorded that the Action was enhanced significantly by their presence, and that without exception everyone searched isolated sources of funding to permit their continued involvement.

5. SHORT-TERM MISSIONS

In the summer of 1994 the COST Secretariat announced the likely availability of additional special funding for what were to be known as Short-term Missions. These were described as visits of one or two weeks of named individuals identified by the Action Management Committee to other participating Institutes to work on common problems lying within the agreed work programme. The attitudes of the different Actions to this initiative were varied. Some, composed mainly of industrial participants, wanted to



Annual review by the TCT – Joe Dwyer (TCT Chairman, on the right) and Jan Ekberg (Vice-chairman, middle of picture) enjoy a discussion with Swedish hosts on an evening dinner cruise round the Stockholm harbour islands, June 1991.

have nothing to do with it. Their reasoning was understandable, for how were those people to be supported to be identified? How would a balance between numbers to support and level of support for each be reached? Much time would be wasted at the Management Meetings in discussing such matters. Furthermore, delays in a definitive announcement of the release of these resources to near year-end left some to feel that this was just a guise to ensure the overall COST budget would be spent by 31 December at the completion of the accounting year.

However, within COST238, composed mainly of governmental and university participants, there was a strong feeling that we should avail ourselves of this offer. A special group from within the Management Committee was established to review applications from all who considered there was a case for their support under the initiative. That group had a hard time in reconciling the conflicting demands, but it is to everyone's credit that their findings were accepted without criticism. The group, working within a defined budget, did not give full-costs support to all successful applicants, expecting each to augment awards from their own resources. Short-term Missions were arranged at times consistent with Action milestones and indeed some such missions took place before the funding was assured. In all, 12 missions were held, with some of the-

se linked to the Specialist Group meetings already mentioned. Despite the several difficulties, there is no doubt that Short-term Missions were a great help in furthering the work of COST238.

6. PRODUCING AGREED SOLUTIONS

Some of the groups that joined COST238 understandably had already been working previously within their own Institutes on ionospheric mapping and modelling studies. So naturally they wanted to pursue their ideas, hopefully to get these adopted as the COST solutions. This is certainly what their sponsors would want. Particularly in the areas of long-term and instantaneous mapping of ionospheric characteristics, including total electron content, and in the specification of height profiles of electron density, there were already several possibilities. In every case it was clear we had to select best average empirical formulations fitted to observational data, but how to choose what is 'best', when there are an infinite number of possibilities balancing accuracy of fit to specific observational data sets, with degree of numerical complexity? Whilst Action work led in a number of cases to the formulation of composite models, in several areas there remained multiple candidate approaches.

Fortunately, various participants already had experiences of how to handle such situations through the work of the CCIR, where in the area of HF oblique-path signal-strength estimation separate teams had fitted formulae to different observational data sets, made comparisons with other formulations and concluded that their own expressions were the most accurate in each case. What were needed for COST238 it was accepted were the same agreed measurement data sets against which each of the candidate models could be compared. Moreover, the measurements used for testing should not also be applied in model development, a hard restriction to accept in data-sparse scenarios. Furthermore, a single figure-of-merit must be composed, whereby the 'goodness' of different models could be ranked. But these conditions raised all sorts of complications. How was the testing data set to be selected? Must it include results for a series of different geographical locations, times-of-day, months of the year and solar epochs? In our case, not all models used the same index of solar epoch. How should we effect the comparisons when the relationship between indices is not unique and the separate indices are predicted with varying accuracies? Sets of reference index values had to be agreed. Some models may be best under certain conditions and others best for different conditions. For example, one model might be best in southern Europe and another in the northern part of the COST238 region. One might be best at solar maximum and another at solar minimum. A height profile might be best at heights around 200km and another best around 300km. In reality, it all depends what one wants to use the model for, whereas a single figure-of-merit, albeit incorporating some form of weighting factors for the different conditions, must involve subjective judgement of the perceived 'average' needs.

We set up a testing team, firstly to specify the test measurement data sets, and then to formulate the figure-of-merit algorithms. With the adoption of their proposals by the full Management Committee, they then interacted with the different map and model developers to implement the computer programs associated with their respective formulations, and to carry out the actual testing. It has to be commented how readily all concerned accepted the results of the testing, despite the obvious disappointments of some teams at their outcome, and the incentive to go away, make a few adjustments and ask for a re-trial. Recognising though that under different conditions and needs other than the adopted maps and models might be preferable, a decision was made to describe each of these fully in the Final Report.

7. PERSPECTIVE AND THE FOLLOW-ON

In total, COST238 involved the registered and active participation of 72 scientists and engineers from 31 organisations within 13 European countries. It brought together all the principal ionospheric groups throughout the EU. But project success should be judged not by such numbers, but by what was actually achieved. The five Working Groups had well-defined goals and interacted with one-another in timely fashion. Group 1 co-ordinated synoptic vertical-incidence ionospheric soundings to create a data base for the long-term ionospheric maps produced by Group 5, and organised periodic limited-duration rapid-sequence soundings for the instantaneous mapping by Group 3. The Group 2 were responsible for oblique sounding, with results available to Group 5, also concerned with height-profile specification and map testing. Group 4 addressed various studies concerned with short-term variability as an aid to ionospheric forecasting. The list of publications by all these groups is impressive, and the international interest in what we were doing was tangibly demonstrated by the keenness of the principal individuals to join our meetings. The various maps and models produced were forwarded to the CCIR for international use when the requirement is to have regional solutions.

During the later stages of the Action lifetime, significant consideration was paid to possible follow-on activities. Nobody wanted the teams that had been established to be dispersed. We were aware of other EU supported research via the so-called Framework Programmes, but in these blocks of funding are released periodically and applications considered within specific priority areas, none of which at that time related to telecommunications. The EU also supports Networks whereby resources can be made available for joint investigations between established teams carrying out like studies. We felt though that one of the COST advantages was to bring together groups that alone had insufficient resources and were not viable, or were under threat. But the problem with COST is that each Action has a finite life-time, whereas what is needed as far as propagation goes is for a permanent body of experts available to apply

their knowledge in timely fashion to whatever operational problems arise. We discussed at length the possibility of setting up a European Propagation Laboratory, arguing that the EU needs just one such facility. Because ionospheric interests are known to be dwindling in all countries, it is hard for each country to justify maintaining its own knowledgeable groups. Yet without these, when problems arise, there would be nowhere to turn. Our thoughts, put to the TCT, were that a small group could be established in one location within the EU as a permanent nucleus. Others would serve there for sabbatical periods and training. Besides the group carrying out specific in-house studies, it would also undertake paid operational contract work related to its areas of expertise, the income from which would help to sustain the resident team. Although in principle sympathetic to this proposal, the TCT were not able to advance the ideas expressed because these did not fall within the ambit of COST.

Our aim had to be to determine how to exploit practically the COST238 results. We were aware of another EU organisation, somewhat akin to COST, known as EUREKA. Like COST, EUREKA brings together workers in the different Member States, but it is specifically concerned with the development and marketing of established products. We rightly felt we had not yet reached the point where we could show how useful our results were. So the idea of seeking to establish a follow-on COST project was born. Proposals were generated to have a new Action that would bring in additional operational people, would test the value of the COST238 models, and would refine these in the light of the findings obtained. At the same time the geographical area of interest would be extended both northwards and eastwards. I was fortunate to secure the approval of



Farewell to COST 238. Final Review Meeting and 1st Management Committee Meeting of follow-on new Action COST 251, Cosener's House, October 1995.

the TCT for this follow-on project, arguing that it would be foolish not to exploit what had already been produced at considerable expense, and so COST251 was born. The work associated with this successor Action is described elsewhere in this present issue of *Física de la Tierra*.

8. CONCLUSIONS

COST238 came into being as a result of a number of chance events. Its timing was extremely fortunate in bringing together the various European research groups at a period when interest in ionospheric investigations was waning and certain individual teams were threatened and alone had insufficient personnel and financial resources to be viable. COST provides minimal funding for the holding of meetings, but with 'top-up' from host institutes this was just sufficient to sustain the work. Recognition that the project had community-wide interest helped in some cases to maintain national funding.

Specific tasks were agreed by consensus consistent with broad project objectives, and team members were formed according to individual interests. Typically the different teams and associated publications were of a multi-national nature. The informal working arrangements with periodic Workshops and business sessions provided a stimulus for young scientists to be recruited and have their efforts channelled along worthwhile lines of study. Specialist Group meetings and funded Short-term Missions allowed individuals to visit member groups in other overseas institutes to further joint investigations. Established contacts with scientific colleagues in eastern Europe were rapidly strengthened to permit full project participation of relevant institutes when special funding became available. The procedures that were formulated and agreed to compare the merits of different candidate models developed within the project in order to select those recommended for use provided valuable lessons for all, 'winners' and 'losers' alike; all models, not just those adopted, were documented for potential possible future use. More than 400 articles describing the separate investigations were produced and published in Workshop Proceedings and various international scientific journals.

Most scientific studies are never ending, with completed results leading naturally to new topics to pursue. There was a near-unanimous wish of all COST238 participants to take part in follow-on investigations, and with additional membership and extended objectives, it is indeed very satisfactory that smooth transitions were possible to COST251 over the years 1995-1999 and COST271 from 2000 onwards.

We count it a privilege to have served respectively as Chairman and External Secretary of COST238. Besides a lot of hard work, all who took part without exception had many fun times in each other's company, also with lots of opportunities for European travel. The bringing together of people with different backgrounds, experiences and resources has led to a number of bilateral

sabbatical sojourns that otherwise would not have arisen or been possible. In many cases real friendships have been forged that have already extended outside the technical level, and that will certainly be sustained beyond COST lifetimes. Learning of the interests and ideals of people from different countries must too serve as a focus towards improved world understanding in the 21st Century.

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