9.6 Antennas

In the early years of the laboratory, aerial research was carried out by the communications and radar teams and closely allied to systems studies in which they were involved. However, when the new (B Block) building was opened in 1958 the opportunity was taken to group the experts, together with people with microwave background from the vacuum physics section, into a microwave physics group. In 1962 the aerial work had expanded to the stage where it was decided to constitute a specialist aerial research group, under the direction of F.A. Dutton, other activities remaining with the microwave physics group led by M.J.B. Scanlan.

In 1969 a team based on the Baddow site, and led by S. Nolan, which was involved in the design of R.F. communications antennas on behalf of the Communications Division of Marconi, joined the aerial research group which was then renamed the Antenna Department in recognition of its dual role in research and development. Thereafter, in addition to carrying out centrally funded research work it did virtually the whole of the electrical design of antenna systems on behalf of the Marconi Product companies until the early 1980's when some degree of decentralisation was re-introduced.

In this period the Department engaged in a spectrum of activities ranging from H.F. into the millimetric bands. At the lower end of the spectrum much of the work was concerned with development and installation of new antenna designs as called for by Marconi Communication Systems. However, some research work was carried out with the specific intention of replacing existing design methods for wire antennas, which demanded considerable skill and experience from the designer, with computer based analytical techniques which could be used by people less experienced.

At the microwave end of the spectrum much thought was given to the design of wideband systems for both radar and communication purposes. Many radar antennas developed during the 1939-45 war and in the two decades which followed it used linear arrays, i.e. waveguides with radiating slots at intervals along their length from which a beam was formed at an angle a few degrees off the normal which varied with the frequency of operation. They were therefore unsuitable for use in wideband systems where, for example, frequency of operation might be changed in a random manner in order to counter jamming, since the apparent position of targets displayed would change with the frequency. Designs were evolved for "squintless" arrays, i.e. arrays of radiating elements from which the beam emerged at the same angle (usually normal to the array) independently of the frequency of operation, and were widely used in systems sold by Marconi Radar. For some systems circular polarisation was desirable and research programmes covering the design of radiating systems producing circular polarisation but with similar beam patterns in orthogonal planes were carried out. Systems with a high factor of isolation between orthogonal polarisations were designed so that they might be used independently for satellite communication and thereby double the capacity available from a particular frequency allocation. Also satellite communication systems were designed in which there was effectively a free space path between the antenna and the receiver system (so called beam waveguides) so that the receiver could be mounted in a fixed cabin below the antenna, rather than on the movable structure, without the penalty of a connecting loss.

Throughout the 1970's the laboratories were involved in electrical design of all antennas sold by the Communications and Radar Companies and in many cases were also responsible for mechanical design and installation. Research work enabled both electrical and mechanical design techniques to be improved. For example, with the aid of the digital computing facilities then available on site it was possible to design antenna configurations of higher efficiency and better sidelobe performance than those previously available, and to predict the effect on both these parameters of environmental changes. Improved measurement techniques on site, including the extrapolation (again with the aid of the computer) of near field measurements to far field performance, and in anechoic chambers enabled the refinements in design techniques to be evaluated.

9.7 Microwave Components

The new radar and communications systems which emerged during this decade also called for improved microwave couplers, switches, rotating joints and filters. The laboratories maintained a unit carrying out research and development on such devices, covering all regions of the microwave spectrum up to frequencies approaching 100 GHz. Most of the work was concerned with earth-based systems but in the middle 1970's the unit undertook design of a number of devices, notably microwave switches, for use in satellites and became approved as a supplier of space approved components. Most of the devices designed and manufactured were incorporated in equipment sold by Marconi Companies, although much of the development work was done under the auspices of authorities such as Ministry of Defence, British Telecom or European Space Agency and some designs were sold to other companies supplying equipment to them.

9.8 Satellite Sub-Systems

As was mentioned earlier the Marconi Company decided in the 1960's not to operate as a prime contractor for supply of satellite-borne equipment. However, as a supplier of ground stations it was concerned with overall system performance and with the analogue and digital methods being employed. Research at Baddow was concentrated on those topics and continued to grow throughout the late 1960's and 1970's, with much of the work being supported by contracts placed by the European Space Agency. By 1969 the English Electric/GEC merger had brought into the Marconi group of companies the GEC unit based at Stanmore (re-named Marconi Space and Defence Systems) within which was a satellite design and manufacturing division. This increased the importance of the systems research activities. Three of them justify special mention.

One was a new technique for analysis of system performance, using specially developed software, prominent in which was a program called MODSIM, established in the early 1970's by J.K. Skwirzynski and colleagues, and further developed by them under a contract from ESA.

It was extensively used within Marconi units and was also sold under licence to other satellite system designers working on behalf of the Agency.

The second was a hardware-based system for evaluation of performance of a projected satellite system by experiments carried out on earth. The European Space Agency set up an experimental system using two mountain sites between which there was an uninterrupted line-of-sight path, and a contract was placed with the communications group at Baddow to design and supply the 180 Mbit/sec digital equipment used in assessment of system performance. This was installed in 1975 and on-site support was provided for about 2 years thereafter.

The third was the setting-up on the Company's Rivenhall site, a facility for measurement of the polar diagrams and sidelobe performance of a satellite antenna, to an accuracy not hitherto achievable. This was done in close association with the Satellite Division of Marconi Space and Defence Systems which, with partners from Europe, was involved in the design and manufacture of the MAROTS experimental satellite for ESA. (It is interesting to note that not only was the team entrusted by ESA to set up this unique facility, but the engineers concerned were regarded so highly that some of them were recruited by the Agency, in mid-programme, to join its own staff!) The contract for this work was placed in 1975 and the site completed to ESA's full specification in 1977, although practical measurements on antennas had been made before the completion date.

Work for the Post Office (later British Telecom.) included a 60 Mbit/sec modem for use in trials of the Intelsat System (1973-1978) and 120 Mbit/sec equipment for the "OTS/MAROTS" system at Goonhilly (1976-79). The same team developed an 60 Mbit/sec modem for the Independent Broadcasting Authority in 1979.

9.9 Synthetic Aperture Radar

Synthetic Aperture Radar as a means of getting high resolution from airborne systems, was not studied seriously in the laboratories before 1970. However, between 1966 and 1970, work had been done under a contract from RSRE in digital signal processing, which was becoming practical as a result of the developments in semi-conductor based processors. The work was completed successfully and led to a further contract in 1970 to build a processor specifically designed for synthetic aperture radar studies at the Government research establishment. This was the first equipment of its type and showed that the technique of digital processing had now advanced sufficiently to become the basis of practical SAR systems.

By the mid 1970's it had became apparent that similar techniques might be used in satellites for studies of earth resources, the behaviour of the sea surface and weather patterns. In addition to continuing work on airborne radar, research was therefore devoted to processing of satellite derived data, some financial support being provided by the Department of Industry and the European Space Agency, with both RSRE and the Royal Aircraft Establishment having an interest in the outcome. By the end of the decade the laboratories had established a leading position in this field and were working closely with the Satellite Division of Marconi Space and Defence Systems (which became Marconi Space Systems Limited in 1984) in proposals to the European Space Agency for work on operational satellites.

9.10 Special Materials

After the merger of GEC and English Electric in 1968 the Marconi Companies had access to the work on semi-conductor physics in GEC's Hirst Research Centre and the need for a solid-state physics unit in Baddow was correspondingly reduced. Some work on gallium arsenide and other III-V compounds was continued in order to enable devices such as light emitting diodes and varactor diodes to be made as necessary to meet system needs, and support was obtained from Ministry of Defence for research work on components for specialised military applications. (A small manufacturing unit within the laboratories was accepted by MOD as an approved source for these components.)

In the early 1970's it was decided that the unit should devote attention to other materials which might be of strategic importance to the Product Companies, one of which was polyvinylidene fluoride, a plastic material made in sheet form which could be made both pyrolectric and piezoelectric by applying an electric field at an elevated temperature. The properties were retained permanently on cooling to normal room temperature. With minimal effort and using film imported from Japan but processed in the laboratory, prototype heat sensors, microphones and loudspeakers were assembled. (Some of these were demonstrated on a BBC Tomorrow's World programme in 1974). However, although the material could be used as an alternative to those already in use for such purposes it became clear that its main advantage lay in specialised applications, particularly those in which the sensor had to be configured into an unusual shape. One such device was supplied to the National Physical Laboratory for measurement of energy distribution across a laser beam but the principal use of the material proved to be in acoustic transducers for use underwater. Some devices for this purpose were supplied to the Admiralty Underwater Establishment and others were exploited through the Naval Unit of Marconi Space and Defence Systems. By the early 1980's demand had grown to a scale such that it again justified a small manufacturing unit within the laboratories.

9.11 Video Recording

Plastic films also seemed to be a promising alternative to magnetic tape for video recording providing that a practical means of writing on the tape could be devised. The research laboratories were therefore encouraged by the Broadcasting Division of Marconi Communication Systems to undertake research on writing techniques. Two alternative methods were studied; they were (a) producing a charge pattern on the film by electron beam and then fixing it by raising the temperature of the film and allowing it to deform under the electric field so induced and (b) deforming the film directly by a laser beam modulated by the video signal. In both cases the video signal was assumed to be digitised initially, as the trend in the television authorities was to move towards digitisation of signals wherever practicable. Also in both cases the tape reader had to be capable of detecting indentation patterns on the tape, although this was not regarded as a major difficulty.

Work on the first method was discontinued early in the programme, primarily because writing by electron beam demanded a vacuum system, which was not likely to be acceptable if an alternative technique at atmospheric pressure could be devised. The second method was pursued to the stage of demonstration of a working system but was then discontinued on the advice of Broadcasting Division who decided that advances in magnetic recording had removed the need for an alternative in their area of the market.

9.12 Process Instrumentation

In 1975 a number of companies in the process instrumentation field became part of GEC Marconi Electronics Limited under the direction of Sir Robert Telford and GEC Marconi Process Control was formed to co-ordinate their activities. T.W. Straker as Managing Director of that Company asked the laboratories to set up a small team to carry out research specifically related to that field and work began on a range of sensors for flow, temperature, pressure level and load measurement. Direct support for the work was provided by the Product Company until 1980 when the Process Control activities passed to the Fisher Company (USA) with GEC receiving a share in the equity of that Company in exchange. Thereafter the unit continued to carry out some research under specific contracts from Fisher, but most of its activities were devoted to the interests of other GEC Companies.

Amongst the many topics studied was the use of vibrational sensors, the prime charateristic being that the frequency of oscillation was dependent on the magnitude of the variable (pressure, flow, depth) being measured. As frequency variations are easily translated into digital signals, such devices were wholly compatible with the digital control techniques being applied in both military and civil systems. Another speciality of the laboratory was encoding of rotational movement by means of precision discs on which were inscribed digital codes and from which data was taken by interception of an optical beam. This work which started in the Mechanical Laboratory in the 1960's continued throughout the 1970's with gradual but consistent improvement in the accuracy available.

A number of the sensors, including the optical encoders, were embodied in products sold by Marconi Companies, either as they emerged from the research laboratories or after further development in the company concerned.

9.13 Theoretical Work

Almost all of the work described in previous sections had a strong theoretical content, sometimes the direct responsibility of the laboratory concerned and sometimes carried out in a central theoretical facility. However, for some research topics the initial stimulus came from the theoretical areas. Propagation studies featured continuously in the programme, with major contributions being made to the work of international bodies such as CCIR as well as general support to the Marconi Companies in prediction of system performance. In 1976 S. Rotheram from the Propagation Team was awarded a GEC Fellowship which enabled him to study for a Ph.D at Cambridge University.

Following his work there he carried out further theoretical studies at Baddow which resulted in a much better understanding of how electromagnetic waves propagate over the surface of the sea. Prediction of the performance of radar or communication systems propagating close to the sea surface became thereby a much more precise science.

Amongst the more prosaic duties still being carried out into the 1980's was the provision of long range forecasts of H.F. system performance to be used by operators who wished to know the optimum frequencies for use at specific times. This service, financed by the Ministry of Defence, was available to both military and civil users via publications available from HM Stationery Office.

Propagation loss is an important parameter in prediction of system performance but there are other variables involved in the design of the electronic equipment itself, such as the noise factor of the receiver and the degradation of components and sub-systems in operation. The theoretical teams in the laboratory produced very sophisticated computer programs for simulation of system performance, and for estimate of operational parameters such as mean time between failures and whole life cost assessment.

Other important theoretical studies in the 1970's included prediction of the likely damage to equipment caused by the electro-magnetic pulse induced by a nuclear explosion and of the reliability of an equipment over its lifetime. The effect on an antenna's polar diagram of the platform, such as an aircraft, on which it is mounted was also assessed by means of theoretical models and recommendations made on methods of achieving an optimised configuration.

9.14 Ground Radar

The impetus for most research in ground radar during the 1970's came from the needs of the military or of combined military/civil systems. Much of the work in Baddow came from the Ministry of Defence via one of its Research Establishments.

The prime emphasis throughout was to improve the operational performance of a radar system in the presence of natural "clutter" and of man-made jamming. Work on transmitters covered the use of solid-state devices in new forms of modulator and in inverters, and on the phase and amplitude characteristics of high power amplifiers. One substantial project known as FRME (Frequency Response Measuring Equipment), completed in 1972 under contract from the Royal Radar Establishment, involved measurement of amplitude to ± ¼ dB and phase to ± 1° in a high power tube under operational conditions. Measurements could be made at microwave frequencies ranging from 2.7 to 10 GHz on a pulse-to-pulse basis and over a wide range of pulse recurrence frequencies. They were also valid in amplifiers, such as those used for pulse compression systems, in which the radio frequency was varied during the pulse duration. The FRME equipment was probably the most sophisticated system of its type existing in the early 1970's.

The use of wideband antenna arrays and frequency changing as a means of avoiding jamming have been mentioned earlier. The ability to scan a beam electronically in three dimensions by computer control is also potentially important as it permits energy to be switched at high speed into areas where targets are most likely to be located.

Some theoretical and experimental work on techniques for scanning of the beam had been made in the 1960's and during the following decade this was extended with the specific objective of devising systems which could be manufactured at an acceptable cost. The problem was a formidable one, in that scanning systems involve large numbers of separately addressed radiating or receiving elements, of which both phase and amplitude components must be capable of variations in a controlled manner and in which the requisite amplitude/phase variations are maintained with time, i.e. do not vary as a result of uncontrolled variations in the performance of receivers, amplifiers or other system elements.

A prototype system in which receiving beams were scanned in one plane over a sector of approximately 70° by phase variations at the individual elements, and where built-in monitoring and feedback arrangements ensured maintenance of this correct amplitude/phase relationship, was assembled and its performance measured. In a parallel programme networks were constructed in which energy from a number of receiving elements was channelled to a number of different outputs to produce the equivalent of beams originating from different directions in space (beam-forming networks).

By the end of the 1970's knowledge gained from this research was being used by Marconi Radar Systems in design of their new Martello radar which offered a surveillance and height finding capability from the same antenna but did not yet offer the facility of fully computer controlled scanning. Scanning in the horizontal plane was by antenna rotation but in the vertical plane separation of targets, or of jamming signals, was achieved by means of a beam former. The first models of beam formers were analogue and used resistive networks operating at i.f. and using discrete components. Using techniques developed in the Microcircuit Assembly Techniques Facility these were superseded by thick film networks, i.e. networks in which the required resistors and interconnections were printed on a single substrate using inks with the requisite electrical properties.

By the early 1980's analogue techniques were being largely replaced by digital processors. The incoming signals were digitised and clutter suppression (MTI), sidelobe cancellation for reduction of the effect of jamming and beam forming were all being carried out digitally. The demand for increased processing speed and data storage capability was insatiable and research teams were highly dependent on advances made in the computing industry in many countries. A good illustration of the scale of the requirement was in "over-the-horizon" radar.

In the late 1970's the Research Laboratories were invited by the Royal Radar and Signals Establishment to undertake a study into the use of H.F. radar for the detection and tracking of targets beyond the optical horizon as an alternative or complementary approach to the use of airborne surveillance radar. Assistance was sought from Marconi

Communications Limited who contributed expertise in the transmitter field, arising from their work on H.F. communications, and from Marconi Radar Systems, particularly in signal and data processing. The theoretical studies were backed by practical experiments carried out in Essex and on board a Royal Navy ship and the practicability of an operational system demonstrated in 1981. In such a system the bandwidth available is severly restricted by the need to avoid interference with communication channels in the same band. Antenna beams are wide because of the long wavelength and limited horizontal aperture. Resolution in both range and azimuth is therefore relatively low. Sea clutter, including that from the regular "Bragg waves" which are characteristic of the ocean surface is considerable but its effect can be reduced by Doppler processing, i.e. target discrimination by velocity measurement. All these factors lead to a requirement for a high speed parallel processor in order that targets can be identified in the short time available for interception to be initiated. Much of the research was therefore concerned with the software techniques necessary for effective employment of the processors then becoming available.

A futher topic of research in the same period was the application of bi-static radar techniques, i.e. the use of transmitters and receivers on widely separated sites. Such systems would be less vulnerable than those with common transmitter/receiver facilities but involved new problems, particularly in signal processing and plot extraction, which were the subject of research in the first half of the 1980's decade.

9.15 Avionic Applications of Holography

Reference was made earlier to the work on infra-red techniques at Essex University and to that on lasers in the Baddow Laboratories. In 1968 the team was joined by Dr. K. Firth who had been working at the BTH Laboratories at Rugby on lasers and a programme was initiated on potential uses of holography in Marconi Companies. Initial work was devoted to the production of 3-dimensional pictures and many demonstration samples were produced but did not lead directly to new products. However, following the absorption by English Electric in 1968 of Marconi Elliott Avionics the opportunity for application of holographic techniques in the avionics field arose.

The Marconi team at Rochester had been successful in selling to the U.S. Air Force "Head-up" displays i.e. displays in which data from the cockpit instrument panel was presented to the aircraft pilot via an optical system which superposed it on his view of the external scene. In order to meet increasing competition from US suppliers the Avionics team were seeking to improve the system by increasing the pilot's angle of view and reducing the loss of intensity of light from the instrument panel during its transmission through optical system. An engineer from Rochester (S. Ellis) devised a new optical system with the required characteristics but which entailed the deposition of layers of optically transmitting material with periodic variation of refractive index on the glass surfaces. (The layers acted as a very narrow band filter which reflected the monochromatic light from the instrument panel but transmitted virtually the whole of the broadband spectrum from the external scene.) The research group at Baddow was able to show that layers of gelatine with the required refractive index profiles could be produced by holographic techniques and prototype optical systems were fabricated and demonstrated. This led to the receipt of a further order from the US Air Force and to a decision by Marconi Avionics to set up their own factory at Rochester to make production systems.

Research continued in the 1980's on improvement of holographic techniques and in particular on the generation of holograms (i.e the patterns contained a layer of film which when illuminated by monochromatic light would generate a specified wavefront) by computer assisted printing techniques.

9.16 Bragg Cells and Spectral Analysis

An interesting merging of two techniques, quartz delay cells and lasers, explored in the early 1970's led to the Bragg cell spectral analyser. In this the signal to be analysed was launched into a quartz or lithium niobate cell via an electric/acoustic transducer and the laser beam was passed through the cell in an orthogonal direction. The acoustic wave induced changes in refractive index in the cell which became thereby a diffraction grating travelling through the cell and having a periodicity depending on the frequency of the applied electrical signal and its velocity in the quartz. The laser light therefore emerged from the cell as a diffraction pattern with a first order maximum at an angle dependent on the frequency of the applied signal - or at a series of different angles each one corresponding to one frequency in the applied waveform.

Two types of analyser were studied. In one the acoustic wave was launched by transducers mounted on the cell ends and travelled as a longitudinal wave through the bulk of the material; in the other interdigital structures, similar in type to those used earlier for pulse compression delay lines but in this case having a uniform spacing, were used to launch a shear wave through the cells. By using optimised design techniques bandwidths exceeding 1 GHz, centred on a frequency of about 2½ GHz were achieved. Data for both types of cell were passed to Marconi Space and Defence Systems at Stanmore for embodiment in analysers which they were designing for systems use.

10. THE EARLY 1980's

10.1 Project Universe

In 1980 the laboratories were approached by staff of Rutherford and Appleton Laboratory who were discussing with several universities a project to be carried out under the auspices of the Science and Engineering Research Council, in which local networks in each of the participating organisations were to be linked via satellite. In order to bring some applications experience to the project, industrial participation was invited. Cambridge University had been involved in design of a network "the Cambridge Ring" and other forms of network existed or were commissioned within the laboratories of Marconi, Loughborough College of Technology and University College, London, the British Telecom Research Laboratories and Rutherford and Appleton. Work on the collaborative project began in January 1981 and all the partners were linked via the European Space Agency's OTS satellite during that and the following year, using ground stations supplied by Marconi Communications Systems Limited. Many successful experiments were carried out until the satellite was switched off in December 1983 and under a parallel contract from the Department of Industry the Marconi Laboratories investigated and reported on potential applications of linked networks, using the results of the Universe studies.

10.2 Robotics

In 1981 a programme of research aimed primarily at improving the productivity of GEC factories was initiated in the research laboratories. Mass production was rarely a feature of GEC units, many of which were concerned with relatively small production runs often of very complex equipment. It was necessary therefore that manufacturing processes should be capable of modification at short notice and in minimum time, i.e. should be compatible with batch rather than continuous manufacture. In principle these requirements should be compatible with a suitably programmed (and reprogrammable) robot and work was therefore initiated to study the characteristics of a commercially available robot and particularly its relevance to operations typical of a Marconi manufacturing unit, such as the placing of components in a printed board. It soon became apparent that the robot purchased was not capable of achieving simultaneously the speed of operation required and the accuracy of component placement necessary for this type of work and alternative designs, capable of giving the required performance, were studied. From this work emerged a prototype (called Gadfly) in which movement of the workpiece was via six independently mounted motors on a circular frame, thus avoiding the necessity of moving large masses at the end of supporting arms as was the case in most of the robots of the period. This device excited considerable interest and a number of them were made for evaluation in GEC Laboratories.

In parallel with this work designs were evolved for a number of manipulators ("hands") which might be used in the placing of components or the assembly of devices and the necessary software for control of the robot and manipulators was developed.

10.3 1982 Re-organisation

At the end of 1981 some re-organisation of the GEC-Marconi Group of Companies took place. Sir Robert Telford, until that time Managing Director of the Group, became its Chairman and Mr Arthur Walsh became Managing Director of the Marconi Company with responsibility for overall management of all the companies in the GEC-Marconi grouping other than Marconi Avionics, of which Mr J. Pateman was Managing Director with Sir Robert again as Chairman. The organisation of the Baddow Laboratories was reviewed in the light of these changes and two major modifications were agreed. The first was that the laboratories should become part of the GEC central research organisation, responsible to D.H. Roberts as GEC Director of Research, instead of being a unit of the Marconi Company as had been the case since their inception. The second was that a precedent set at Hirst Research Centre, whereby specific laboratories were associated with particular product companies, should be followed at Baddow; thus the Communications Research Laboratory was directly associated with Marconi Communications Company, whereas it had previously been a unit devoted to communications research with its output directed to any product company able to make use of it. Avionics and Radar Laboratories were also set up and in all three cases the Laboratory Manager was transferred to the staff of the associated company, while his team remained on the strength of the research laboratories but with objectives closely aligned to the needs of his company. (At that time Marconi Space and Defence Systems had an associated research team within the Hirst Research Centre and elected not to have one at Baddow, but that decision was changed some two years later when a laboratory devoted to their needs was set up. At about the same time the microwave group, which was involved in research and development for a wide range of passive microwave components was formally associated with Marconi Electronic Devices Ltd., which become thereby its prime marketting outlet although it still continued to give a direct service to local Marconi Units.

In May 1982 Dr. J.C. Williams moved from Hirst Research Centre to Baddow as Deputy Director and in September of that year he took over as Director, replacing G.D. Speake who became Deputy Director of Research for GEC, reporting to D.H. Roberts.

Coincident with this re-organisation it was decided that while the laboratories would continue to assist the product companies, particularly those in the Chelmsford area, on more advanced projects, greater emphasis would be placed in longer term research and less on support to development in product companies than had been the case hitherto. In addition to the units associated directly with product companies there were therefore some laboratories on more general topics, mainly in the longer term research area. The opportunity was also taken to integrate the research programmes and the administrative structure more closely with those of the Hirst Research Centre, with accounting and commercial functions being common to the two units.

The procedure whereby a proportion of the funding of the laboratories (about 20%) had been collected from product companies as a research contribution not related to any specific project was terminated and companies were invited to sponsor individual projects as agreed between their managements and their representative (Laboratory

Manager) within the centre. Longer term work and projects not immediately identifiable with a particular product company were supported from GEC Central Funds but over 80% of the work continued to be financed either by product companies or by contracts obtained from customers such as Ministry of Defence, Department of Industry or European Space Agency.

In order to establish a "customer/contractor" relationship for the centrally funded research, arrangements were set up for 6-monthly technical audits of projects, the audit team being selected from people with interests and expertise in the topic, and usually containing members from product companies and/or Hirst Research Centre. They were expected to comment on the effectiveness of the work and to offer suggestions for improvement where appropriate.

10.4 Software Engineering and Artificial Intelligence

The 1970's had been a period of increasing demands for software with virtually all projects within Marconi Systems Companies making extensive use of computers and using teams of qualified staff to produce the necessary software. Software writing became not only one of the most costly items on production of a new system but also the most hazardous. In general the work could only be entrusted to people who were highly skilled both in the subject, e.g. radar or communication, and in software production. Such people were in short supply and tended to move around within the industry and because the disciplines for software design and recording were less established than for hardware the effect of staff turnover was more serious. By 1980 research was therefore being devoted to software engineering, i.e. to the design of tools and procedures whereby software could be developed by people with lower skills (or more effectively by the higher skilled people) and documented in ways which made it possible for responsibility for its creation to be handed from one designer to another.

In 1981 this work was extended to embrace "artificial intelligence" which had been conceived and abandoned many years previously but was beginning to attract new attention from researchers because of the much wider possibilities which had been opened up by increases in storage capability and processing speed of digital computers.

During the next three or four years a team was built up to study techniques for the development of "expert systems" in which the computer would store, process and utilise data in such a way that someone of lower skills could, with its aid, carry out a task as effectively as an expert in the particular field. A typical application to which the research was applied was the "programmer's assistant", a system in which the computer utilised acquired knowledge to assist a software writer in producing programs more easily and more reliably. Many other applications could be foreseen, some of which became the subject of studies carried out as collaborative exercises with other companies.

10.5 ESPRIT and ALVEY

In 1981 a group of 12 of the largest European companies involved in storage, processing, transmission and utilisation of data met under the auspices of Viscount Davignon, Commissioner for Industry in the European Community, to consider the desirability and practicability of a collaborative programme of pre-competitive research in information technology. (The 12 companies were GEC, ICL and Plessey from U.K., CII Honeywell-Bull, CGE and Thomson-CSF from France, AEG Telefunken, Nixdorf and Siemens from Germany, Philips from Holland and STET and Olivetti from Italy.) Senior executives of the companies and of the Commission formed a "Round Table" which agreed that such a programme should be initiated and a Steering Committee from the same companies was set up to propose areas for research and devise a 5-year workplan. Five specialist panels covering the areas selected, which were microelectronics, software engineering, advanced information processing, office automation and computer integrated manufacturing, were set up. Both Hirst Research Centre and Marconi Research Centre contributed to the specialist panels, with MRC being primarily concerned in those concerned with software engineering and office automation (but taking over from HRC in computer integrated manufacturing work at a later stage).

In order to gain experience in the application of collaborative programmes a number of pilot projects were initiated in 1983, with 50% support from Community Funds, the remainder of the cost being borne by the companies concerned.

Baddow was involved in three projects. They were in the following categories: Software Engineering (A Basis for a Portable Tool Environment), Office Automation (Standarisation of Integrated LAN Services and Service Access Protocols), Computer Integrated Manufacturing (Integrated Electronic Sub-Systems for Plant Automation).

In 1984 proposals from industry and universities were invited via the Commission's Official Journal. As with the pilot projects, participation from at least two Community Countries was a condition of acceptance and both Marconi and Hirst Research Centre formed associations with companies from the Round Table and with others not previously involved as well as with universities. However, although a number of proposals involving the two centres were accepted, work did not begin until well into 1985, primarily because the Commission was unable to formulate conditions of contract acceptable to all the participating nations.

In 1984 the workplan was revised to take account of progress made in the pilot phase, and of contracts expected to be placed, and a further set of proposals was invited in announcements made at the end of that year. Again both centres submitted proposals in April 1985 and at that stage some GEC operating companies also began to become involved.

While ESPRIT was being conceived as a Community Project, the UK Government decided to set up a committee chaired by John Alvey of British Telecom to advise on national policy in information technology.

The committee recommended a similar programme of pre-competitive research work in four areas; very large scale integration (VLSI) of semi-conductor circuits, software engineering, man-machine interface (MMI) and intelligent knowledge based systems (IKBS). The recommendations were accepted by Government and a Directorate (The Alvey Directorate) was set up in the Department of Trade and Industry to implement them. In 1983 proposals were invited from UK industry, research associations and universities and again there was a response from both main GEC Research Centres.

10.6 Other Collaborative Schemes

Collaboration was the order of the day during this period. The Department of Industry had several other schemes in operation including two (CADCAM and CADMAT) to encourage computer aided design in the mechanical and electrical/electronics industries respectively. A scheme called JOERS (Joint Opto Electronics Research Scheme) involved both Marconi and Hirst Research Centres, with partners from other Companies and Universities. The European Commission also took a lead in a major exercise in telecommunications, aimed at standardization of systems and equipment across Europe and increased competitiveness for European industry in the world at large. Industrial support for the studies carried out came principally from the twelve Companies who had helped to form the strategy for ESPRIT. The main GEC input was from GEC Telecommunications, Coventry and Hirst Research Centre, with assistance from Marconi Communications Systems and Marconi Research Centre. The PTT authorities collaborated, together with the European standardization authorities CEN/CENELEC and CEPT. From the activities of the groups so formed a programme called RACE (Research in Advanced Communications for Europe) was devised and expressions of interest from organisations who wished to participate were invited in May 1985. Proposals were put forward by both Baddow and Wembley.

Yet another activity promoted by the European Commission was BRITE (Basic Research in Technology for Europe). Expressions of interest for work under this label, which covered a number of areas regarded as strategically important for Europe, were invited in 1983 and ideas were put forward from HRC, MRC and the Whetstone and Stafford laboratories. There was then a long delay while the agreement of the political and financing bodies across Europe were obtained. However in the Spring of 1985 formal proposals were requested and responses were submitted from HRC, MRC and Whetstone.

10.7 GEC Research Limited

In 1985 the association between the Hirst and Marconi Laboratories; which had existed since the GEC and English Electric mergers in 1968, was strengthened by the inclusion of both in a newly-created GEC Research Limited, with D.H. Roberts, the GEC Technical Director, as Chairman and Dr. J.C. Williams, Director of Baddow, as Managing Director. The Whetstone and Stafford laboratories of GEC Power Engineering were also transferred into GEC Research Limited, which thereby had three Research Centres -Hirst (Wembley), Marconi (Baddow) and Engineering (Stafford and Whetstone).

Later in the same year, Roberts was appointed to the position of Deputy Managing Director (Technical) of GEC and nominated Dr. C. Hilsum, FRS, who had joined the Hirst Research Centre from RSRE in 1982, as the group's Director of Research, to work alongside Dr. Williams in the formulation and implementation of programmes in all the laboratories of GEC Research Limited.

11. CONCLUDING NOTE

Research is essentially a speculative activity. In most companies it becomes development as soon as the emergence of a marketable product can be predicted with reasonable confidence and, although the Great Baddow Laboratories have at times in their history made major contributions to development, particularly in the radar field, a substantial part of the work has been exploratory in nature. It is not surprising therefore that this account contains examples of ideas which have led to successful products, manufactured and marketed by Systems Companies; of others which have been technically successful in the research phase but were not pursued into development because the commercial benefits forecast were not thought to be commensurate with the investment in money and manpower required; and of some which have been abandoned in the research phase because they proved to have less promise or to be more difficult to exploit than had been anticipated initially.

Most research workers, as well as the organisations providing the money for the activity, would prefer all their ideas to be in the first category, but if that were so they would in effect be development staff under another name. (There are indeed many examples of straightforward development which have ended in commercial disaster!) Nevertheless there is an obligation on researchers, as much as on their colleagues in other parts of the company, to seek to give value for money, and this involves financial control as well as technical judgement on a consistent basis. The Centre has had a small commercial unit since 1965, when it was set up to negotiate and monitor its own external contracts - a service which had previously been provided via one of the Marconi Trading Divisions (usually Radar Division). From the same date it has also had its own accounting staff and personnel department although until 1981 some services in both these categories were provided from the Marconi Company headquarters in Chelmsford. From the early 1970's it has had a Quality Manager and a small supporting unit to ensure that in all areas, but most importantly those which are engaged in work for Government Departments or other external customers, the necessary standards of equipment and software reliability are maintained.

For many of the activities described the services of high grade mechanical designers and draughting staff and of a precision model shop have been essential. Until 1965 the Drawing Office and Model Shop were under the control of Marconi Company headquarters staff. When this arrangement ended the Model Shop was administered by Marconi Radar Systems, whose development team shared the site with Research, but from 1981 (when they left to join their radar colleagues on the Writtle Road site) control was assumed by the Centre Director, and allocated to the manager of the Engineering Laboratory (L.W. Gill), together with the Design Office, Library and Quality Department.

Two other important services, the maintenance of the site and the management and operation of the canteen were also administered from the Marconi Company headquarters for many years. In the early 1970's maintenance became a local responsibility and the process was completed with transfer of the canteen in 1983. Thereafter, the site became self-sufficient within the overall GEC central research organisation.

Thus in its first four decades the research centre has grown from a hundred or so staff, many of whom were highly inventive and well skilled in practical matters but not necessarily academically qualified and whose main tools were a soldering iron and a multi-meter, to a self-sufficient unit of over 1000 people of whom nearly half are qualified to university degree standard, and who operate in an environment of sophisticated electronic instrumentation. The ways in which an individual can express his or her creativity have changed dramatically but the need to do so is at least as vital in the highly technological competitive world of the 1980's as it was when the idea of a new laboratory in the green field site at Great Baddow was conceived.

12. ACKNOWLEDGEMENTS

My personal knowledge of the Great Baddow Laboratories dates from December 1950 when I joined as a radar systems engineer and thereby renewed acquaintance with Eric Eastwood, with whom I had served as an RAF officer during the 1939-1945 war, and several other wartime colleagues. For all the information prior to that date, and for much of it since, I have depended on conversations with, or letters from, former members of the laboratories, and on a limited amount of research into such documentary records as are readily available. I would like to thank everyone concerned.

I am particularly indebted to George Grisdale, Mervyn Morgan, Roger Shipway and Roy Simons who read an early draft and offered many helpful suggestions, and to Roy Rodwell who has fed me from time to time with material from the Marconi Company archives.

I am conscious that, even with their help, I have omitted many important subjects. I also accept that those in which I was personally involved are likely to have received more consideration than others with which I was less familiar. To those people who feel that I have done their work less than justice I offer my apologies. Others, who have been involved in projects on which security restrictions still apply, will appreciate why they do not appear in the report.

Finally, some of the dates quoted have been recalled from my own or someone else's memory. I have tried to check them by reference to another source but if there are errors I apologise again.

REFERENCE

Details of many of the topics covered in this history are given in issues of Marconi Review for the relevant period.