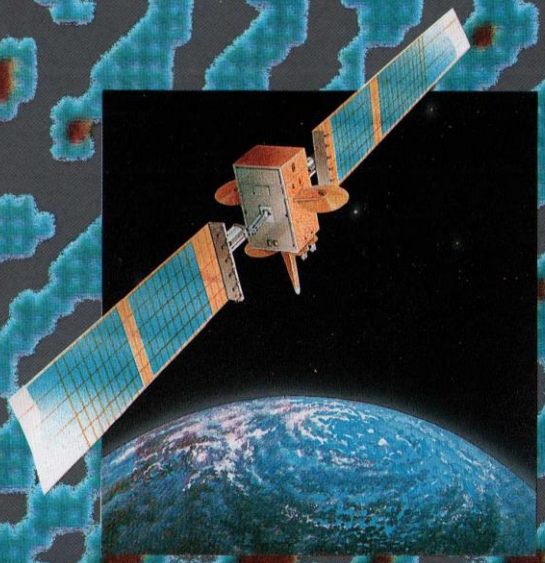
RADIO COMMUNICATIONS RESEARCH UNIT (RCRU)



RUTHERFORD APPLETON LABORATORY
SCIENCE AND ENGINEERING RESEARCH COUNCIL

Radio Communications Research Unit (RCRU)

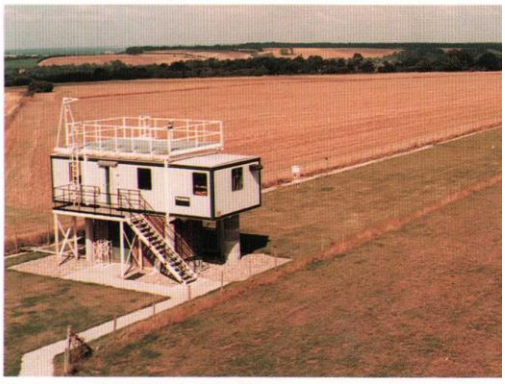
Radio communication systems play an important role in the global telecommunications network. Until recently all the high capacity telephony circuits between continents were provided by satellite. Radio also provides the vital link for mobile and personal communication systems, where other methods are not available.

The Radio Communications Research Unit (RCRU) at Rutherford Appleton Laboratory (RAL) concentrates the majority of its research activities on studying the propagation element of current and future radio systems through the Radiocommunications Agency's (RA) National Radio Propagation Programme (NRPP). In addition, a number of individual contract studies are funded by such organisations as MoD, NERC, Met Office and ESTEC. Other research includes studies of future satellite mobile systems and novel coding and modulation schemes.
Much of the experimental work of the RCRU is conducted at Chilbolton near Andover, where facilities include a 25m steerable antenna and an experimental millimetre-wave range. The more analytical studies, which are undertaken at the main location of the Rutherford Appleton Laboratory, Chilton, Oxfordshire, lead to the development of improved propagation models and novel communications concepts, essential for efficient radio communications planning and spectrum management.

The Chilbolton 25m Antenna.

The current programme ranges from high frequencies (HF) to millimetric wavelengths and includes:

- *Development of high frequency (3-30 MHz) prediction methods.*
- *Forecasting propagation conditions from ionospheric soundings.*
- *Measurement of HF fading on medium length paths.*
- *Studies of terrestrial and satellite-based mobile systems.*
- *Experimental European studies of transhorizon interference.*
- *Anomalous propagation and diffraction modelling using the parabolic equation method.*
- *Development of a novel dual-polarization radar with cross-polar and Doppler capabilities.*



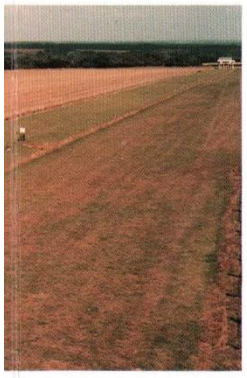
The Experimental Millimetre-Wave Range.

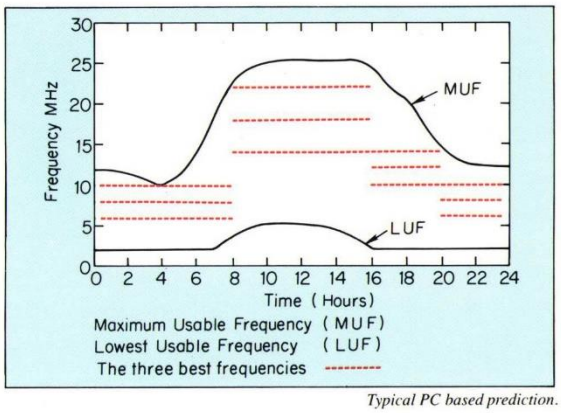
- *Evaluation of the performance of satellite and terrestrial systems using information collected by this radar.*
- *Development of propagation models for satellite systems.*
- *Experimental studies of millimetre-wave propagation and development of prediction techniques.*
- *Development of modulation and coding schemes for communications systems.*

PROPAGATION STUDIES

Predictions are required for the planning of both high frequency (HF) broadcast and communication systems. RCRU has headed an international team in the development of these techniques and has produced a PC based program which is widely used for both research and operational HF systems. Interest in forecasting propagation conditions in Europe from measurements obtained from a network of ionosondes has been stimulated through the PRIME project, which involves nine groups in seven European nations.

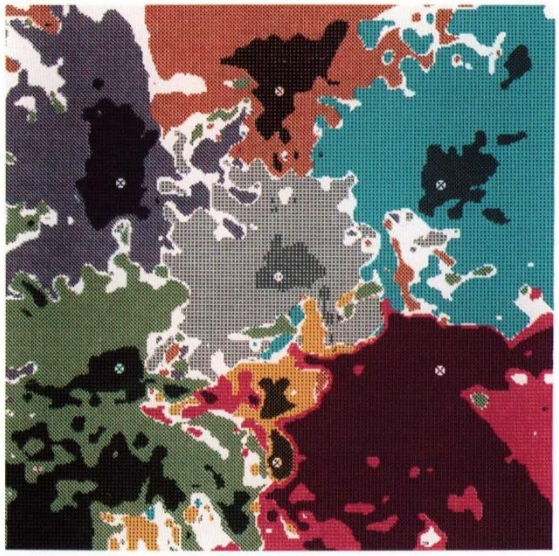
RCRU is also involved in an experimental programme in which the short term correlation of HF fading, as a function of frequency and spatial separation, is being monitored on medium length paths.



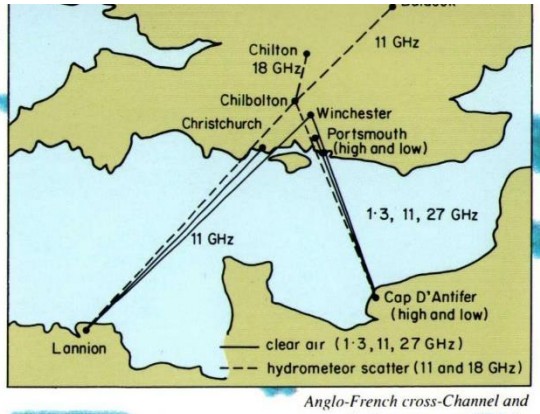


Typical PC based prediction.

Mobile systems are increasingly in evidence in the guise of cellular radio, cordless telephones and personal communication networks. RCRU has analysed the relative merits of several methods of predicting coverage and interference for such systems and has developed its own PC based methods. These methods have been tested against data at 150, 450 and 900 MHz and will be validated with 1.7 GHz measurements when available.

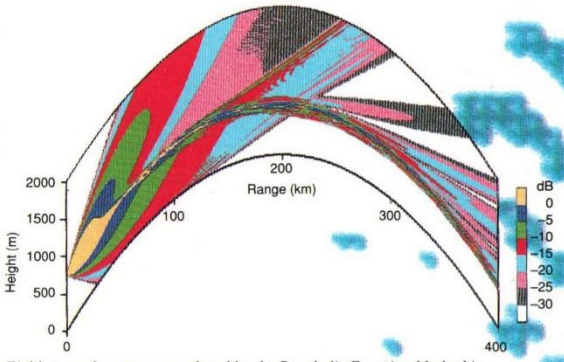


Contour plots of Carrier to Interference ratios (C/I) for a seven cell system.
C/I colour code – Dark shades > 15 dB
Light shades 0 to 15dB
White<0dB



Anglo-French cross-Channel and hydrometeor scatter paths.

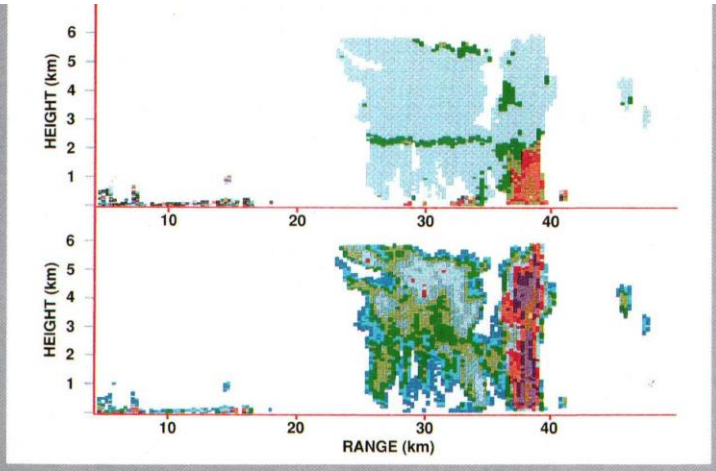
Although the radio spectrum is a finite resource, the same frequency band can be reused at different locations, provided interference levels are kept within limits. Interference can occur from anomalous propagation in anticyclonic weather and from rain scatter. RCRU has played the leading role in establishing a European collaborative experiment (COST 210) where more than 40 paths with transmissions from 1 to 30 GHz have been established in ten European countries. The UK contribution to this project involves British Telecom Research Laboratories, IBA, RA, Portsmouth Polytechnic and the Polytechnic of Wales, together with RAL.



Field strength contours produced by the Parabolic Equation Method in ducting conditions on an over-sea path.

Atmospheric measurements of the variability of the radio refractive index have been made using an aircraft instrumented by RCRU and with the Meteorological Office's Hercules aircraft. Field strength patterns have been produced by the parabolic equation method with data from both aircraft and balloon-based measurements.

A refractometer mounted on the nose of an aircraft.



Vertical section of an intense rainstorm indicating both conventional and differential reflectivities. The upper differential reflectivity diagram shows the melting layer in green at about 2.5 km height and the intense rain in reds and yellows. The lower conventional reflectivity plot makes no distinction between the ice and rain phases in the central part of the storm (reds and purples).

RCRU has developed a unique dual-polarization rain radar which uses the 25m diameter antenna at Chilbolton. The interpretation of transmissions on satellite paths are greatly assisted by this radar which can probe the detailed structure of precipitation. The data base has facilitated the investigation of rain scatter, space diversity and elevation angle effects on satellite systems and is currently being used to estimate ground truth measurements of rainfall to validate satellite observations.
The radar has recently been upgraded to provide both a dual and cross-polar capability. A Doppler measurement system is also being developed.

The Olympus satellite is now providing, for the first time, beacon transmissions at 12.5, 20 and 30 GHz over Europe. RCRU is constructing receiving systems to monitor these transmissions.
The data will be used to develop prediction methods, particularly for the 20 and 30 GHz bands, as part of a European project coordinated through ESTEC. The RCRU dual-polarization radar will function as a diagnostic tool to assist in these model developments. The Universities of Bradford, Essex and Surrey, together with Coventry Polytechnic, will also be involved in the analysis programme associated with Olympus.

RCRU also has interests in developing prediction methods for satellite-based land mobile systems. Collaborative experimental studies with the University of Bradford are being performed at a variety of elevation angles and over a range of frequencies to provide information on vegetation and building effects.

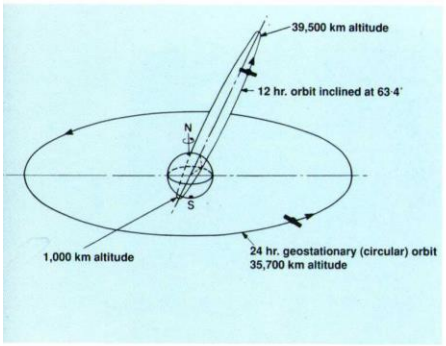
Theoretical models based on the geometric theory of diffraction are also under investigation.

The millimetric wavebands could provide a significant increase in the spectrum available for future radio systems. RCRU has collected a three year database on the climatic effects at frequencies ranging from 37 to 210 GHz from a 500m experimental range at Chilbolton. Parallel measurements at infra-red and optical wavelengths were also performed. This comprehensive database is now being used to develop prediction methods, which will be tested against measurements being obtained on longer paths.

Installing the 12.5 GHz dish for the Olympus receiving system.

Contract Studies

The expertise generated in this comprehensive programme is also used to address a number of specific contract studies. These have included MoD sponsored studies on air-to-ground propagation at both microwave and millimetric wavelengths on land and sea paths. Other contract studies have investigated propagation effects at HF on very long paths and the variations in spectral occupancy in the HF bands. Support from other organizations such as ESTEC, NERC and the Met. Office has played a significant role in the development of the dual-polarization radar.



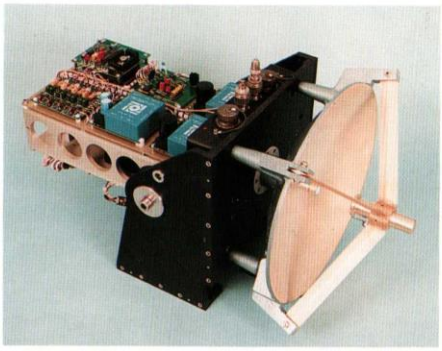
Relationship between highly inclined Molniya and geostationary orbits.

Communications Research

Communications research has generally been supported through SERC funds. A large collaborative project which involved the study of mobile satellite systems, in inclined orbits, using on-board processing techniques, has recently been concluded. The Universities of Bradford, Loughborough, Manchester, Surrey, Kings College and Queen Mary College, London and Portsmouth Polytechnic were all involved in various aspects of this project. The current research topics include the development of demodulation techniques using combinations of digital signal processing and transputer chips in collaboration with Loughborough University. Modulation, coding and access techniques for very small pocket-size satellite terminals are being investigated with the University of Bradford.

Expertise and Facilities

The RCRU consists of some thirty scientists and engineers engaged on a wide ranging interdisciplinary programme of radio communications research. The expertise of the Unit covers basic electromagnetic theory, communication systems, microwave system design, meteorology and geophysics. The programme is supported by a number of unique experimental facilities which include the 25m antenna and 500m range at Chilbolton, a dual-polarization radar, a three frequency satellite receiver for the Olympus project, an extensive number of radio links, an instrumented aircraft, a transportable HF receiving system, an ionosonde network and a geophysical database.



A 94 Ghz radiometer used for air to ground measurements.

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