Radio Communications for the Future

by Dr Chris Gibbins

Overcrowding of the radio spectrum is severely restricting the reliability and information-carrying capacity of existing communications systems. But moving to higher frequencies, where there is more room, brings a different set of problems to do with the atmosphere and weather.

A massive expansion in radio communications over recent years has generated an ever-increasing demand for more channels, and those channels are having to carry more and more information, be it voice, television or other kinds of data. The net result is that the radio spectrum, a restricted resource, is fast becoming overcrowded. This creates problems of interference between adjacent channels (as anyone who listens to short-wave radio, especially at night, will know well) with reduced reliability. There is an additional side-effect of such overcrowding: the bandwidth available to each channel, which determines the amount of information that can be transmitted, is severely limited. That in itself restricts both the capacity and the reliability of communications systems.

Millimetre Waves

A remedy for these problems is to be found in exploiting higher and higher frequencies, made possible through the development and availability of new technologies. Communications now extend well into the microwave region of the electromagnetic spectrum (frequencies up to 30 GHz) and even beyond into the millimetre-wavelength region (frequencies from 30 to 300 GHz). This regions of the spectrum are still relatively uncrowded, particularly at the higher frequencies, and the bandwidths available are so large that they open up the possibility of new communications channels with a capacity for carrying huge amounts of information.

But use of the microwave and millimetre wave regions of the spectrum for communication brings an additional set of problems not met with at lower frequencies. The Earth's atmosphere starts to interact with the radio waves, resulting in attenuation of the signals which must be taken into account in the design of systems.

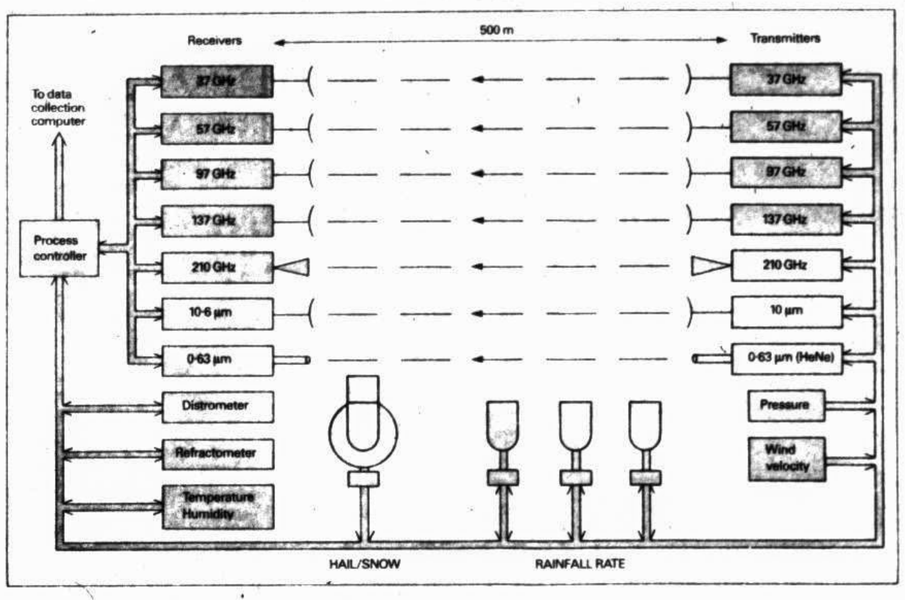
There are two distinct and quite different effects, which are shown in the first diagram. First, the molecules of oxygen and water vapour in the atmosphere absorb rediowaves at certain characteristic frequencies. This is known as resonant absorption. They radiate them isotopically, that is, equally in all directions, a fraction of a second later; this means that the signal is attenuated through the loss of directivity and coherency. The second effect is that raindrops, hail and snow scatter the signals, thereby attenuating it still more. This effect is non-resonant and increases with increasing frequency, as the wavelength decreases and becomes comparable with the sizes of raindrops; at that point the scattering process is most efficient and signal attenuation is greatest. The first effect, molecular absorption, is present all the time, and changes only slowly with varying temperature, pressure and humidity. A great deal of research has been undertaken into this phenomenon and the effects of molecular absorption can now be predicted fairly accurately. So the designer of communications systems can take reasonably accurate account of attenuation by oxygen and water vapour when assessing the overall performance of microwave and millimetre-wave links.

Fade Margin

Signal attenuation by rain and other forms of precipitation, however, presents a quite different problem. Precipitation is a highly variable phenomenon, changing both in time, space (that is, geographic location) and intensity. This makes it much more difficult to take account of rain attenuation in designing systems. The problem is generally treated statistically instead of by the short of exact calculation that can the used for molecular attenuation. The systems designer specifies a level of reliability for a particular communications link : for example, the link might be required to provide acceptable voice communication for 99.9 per cent of the time, or acceptable television transmission for 95 per cent.

That means the users can tolerate the service being unavailable for 0.1 per cent or 5 per cent of the time respectively. The designer then needs to know what level of signal attenuation will be exceeded on the link for these small percentages of time. This is known as the 'fade margin' which the link must be able to overcome when providing an acceptable signal-to-noise ratio, to achieve the specified level of reliability. This turn, has an impact on the transmitter power, receiver sensitivity and the size of the antennas, which in the end affects the overall cost of the system. It is therefore of paramount importance that the systems designer should have available the most accurate information from which to derive the necessary fade margins, to achieve the most reliable and cost-effective design.

Fade margins are not easily calculable and in general tend to be empirically derived from transmission measurements carried out over long periods. A great deal of work has already been done at frequencies up to about 40 GHz, and there are extensive data banks from which the necessary statistical information and service predictions can be derived. For example, the International Radio Consultative Committee (CCIR) at Geneva collates, distils and publishes information of this kind. At higher frequencies, however, there is a marked paucity of data.



Schematic diagram of the 500 m experimental range at Chilbolton.

Foundation for Systems

To provide the necessary information on terrestrial radiowave propagation, the Rutherford Appleton Laboratory has set up an experimental transmission range at its Chilbolton Observatory near and over, in southern England. This facility, represented schematically in the second diagram, works on a number of links transmitting over distance of 0.5 km at frequencies of 37, 57, 97, 137 and 210 GHz in the millimetre-wavelength region of the electromagnetic spectrum and at wavelengths of 10.6 km in the infra-red and 0.63 km in the visible region. Frequencies of 37, 97, 137 and 210 GHz were chosen as representative of those parts of the spectrum where atmospheric attenuations due to oxygen and water vapour are low; such parts are know as atmospheric 'windows' and hold out the opportunity for cost-effective, wide-bandwidth communications.

— *Spectrum*

PROBING THE SECRETS OF THE EARTH'S CRUST

GEOLOGISTS all over the world are eagerly following the progress of the research bore with which German geoscientists have initiated a milestone project: the exploration of the mysterious depths of the earth's continental crust and the upper mantle of our planet. It is the Kontinentales Tiefbohrprogramm der Bundesrepublik Deutschland (Continental Deep Drilling Program of the ,Federal Republic of Germany) of KTB, three kilometers west of the town of Windischeschenbach in the "Oberpfalz" region of Bavaria.

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The project is being carried out by the Niedersachsisches Landesamt fur Bodenforschung (Lower Saxony State Office for Geological Research) in Hanover; the project management team, consisting of a chairperson and four scientific directors, belong to this office. The Deutsche Forschungsgemeinschaft (German Research Association) is responsible for the scientific supervision of the project, and has established a concentrated program for this purpose. The operating costs are being financed from a special fund of the Bundesministerium fur Forschung and Technologie (Federal Ministry for Research and Technology).

Upon completion of the bore to a depth of precisely 4,000.1 meters in April 1989, this first German large-scale project in the area of basic geoscientific research entered a decisive phase: the main bore, begun in September, 1990, is the giant step into the depths. How far down it is to go will be decided sometime in 1993.

At that point scientists must determine whether they can drill beyond the depth of 10,000 to 12,000 meters which they expect to reach by then, and whether the required means "will be in a reasonable relation to the expected gain in scientific knowledge". That, at least, is how Professor Rolf Emmermann of the Institute for Geosciences and Lithosphere Research at the University of Giessen puts it. Professor Emmermann is also Chief Coordinator of KTB and Director for Geosciences in the KTB project management.

The temperature measured as the depth increases will play an important role in this decision. According to the geoscientist from Giessen, the aim of the project is not to set an "absolute depth record", which, in any event , is held by the Soviet Union in a bore over 12 kilometers deep on the Kola Peninsula, which has a much different type of basement. The goal here is to penetrate a temperature range of about 300 degrees Celsius at as great a depth as possible. There, according to the results of laboratory experiments, the behavior of the rock in response to forces acting on it should change from brittle-fracture to plastic-flow type. This boundary region is very important for geoscientists, as it is also believed to be the lower limit of earthquake activity.

However, this temperature region is also of interest for petrology and geochemistry. Here, processes are initiated which provide an opportunity for observing the interactions between rocks and the aqueous solutions and gases, or fluids, trapped in them. Fluids affect the chemical reactions and transport of matter and heat in the earth's crust, and, in particular, the shaping behavior of the rocks which occurs at these pressures and temperatures.

That is why geoscientists all over the world regard this project as a unique experiment for gathering first-hand knowledge of conditions and processes in the continental crust, and to view the lower crust and upper mantle as if through a telescope.

More than 300 scientists from Germany and abroad are already working on the over 140 individual projects which comprise the research topics.

The spectrum ranges from geophysics and tectonics to earthquake research, utilization of the earth's heat and the study of geological deposits, and even includes problems of precision engineering and underground mining.

— *Franziska Becher.*

The Space Research and Remote Sensing Organisation (SPARRSO) building at Agargaon,Sher-e-Bangla Nagar,

'Knops' See Action In Gulf Oil Spill

The first trial shipment was airfreighted to Saudi Arabia when the war was entering its final stages.
by Ian Mc Crone

CHRISTCHURCH (New Zealand) : Little balls of wool intended for filling pillows and lightweight bed coverlets may have a big future in mopping up oil spills.

The first major testing ground is the Persian Gulf,into which millions of barrels of heavy crude oil were spilled during the recent brief war.

The small fluffy spheres of wool are called knops. They are made from crossbred wools, by a patented process New Zealand scientists discovered five years ago.

Their secret is that in their raw state, wool knops are able to absorb up to 40 times their own weight in crude oil. And they can be wrung out and used again.

The fingernail-size are created by holding lower-grade and second-shear (short) sheep's fleece in a series of machine rollers to break up and curl the fibres.

It all began in the early 1980s, when the Wool Research Organisation of New Zealand (WRONZ) was casting around for a new fill for bedding. For many years about one-fifth of the New Zealand crossbred wool clip went into blankets, rugs and other coverings.

Then in the 1960s, lightweight synthetics with improved heat-retaining properties appeared on the scene and began taking over markets which were once the prerogative of wool.

The WRONZ research centre at Lincoln, near the South Island city of Christchurch, has a name for doing practical work and coming up with a string of useful inventions.

As a nonprofit-making institution funded by government and the wool industry, it aims for better processes and products, assistance for New Zealand wool through new technology and collaboration with research laboratories overseas.

But it does not develop its discoveries commercially. It may patent them and then turn them over under licence to companies in the wool trade for manufacturing or more research.

In the case of knops, the small firm Woolfill Corporation, owned mainly by the New Zealand Wool Board and a private investor, was granted rights to the WRONZ process to make bedding.

The absorbency of wool and its affinity for grease are well known. The possibility of using wool knops to blot up oil spilled on the sea was recognised. It took the Gulf war to bring the possibility into focus.

Another South Island company, Donaghys, which has long experience in cordage and rope-making, had its textiles division working on fine-mesh netting bags to hold the wool knops.

The idea was to link up a series of three-metre segments to construct flexible booms strong enough to contain floating oil slicks.

The first trial shipment was airfreighted to Saudi Arabia in February, while the war was entering its final stages. It went "with complements" to Olayan Trading, the company coordinating the Gulf clean-up plans.

A delighted spokesman for Donaghys said his firm was getting what amounted to a "display stand" for product. A total consignment of about 150 booms had been landed in Bahrain by early March.

The firm announced that production was being increased to meet expected market growth at home and overseas. Obvious target countries are much of Europe and the United States which are big users of other organic absorbents, like sawdust and cork granules.

Oil producing nations in the Middle East are expected to show particular interest in how the new product performs in protecting Saudi Arabian desalination plants and cleaning up the outflow from the wells in Kuwait.

One claim for the wool knops is that they work best on heavier oils, the cause of the worst pollution when released on the ocean. Unlike most synthetics, wool products are biodegradable and will decompose when buried.

The new opportunities could not have come at a better time for the New Zealand Wool Board, a grower-funded organisation which contributes heavily to the WRONZ research budget.

For the last two years, it has been subsidising auction prices to ensure New Zealand woolgrowers got a guaranteed minimum return — from a fund they themselves built up by a board levy on their sales in better times.

With China, Japan and the Soviet Union slashing their purchases in the last two seasons, the wool board has had to buy in huge amounts of wool to the point where it now has a stockpile of 650,000 bales.

— DEPTHNEWS

Soviet Space Programmes: An Update

THE first months of this year saw the downfall of the salyut space station. The event received extensive press coverage in the USSR and abroad. If it fell on a densely populated area, the 40-ton monster could have caused much trouble.

The flight control centre could not precisely say where the orbiter would hit the earth. People in any endangered region could only be warned one round-the-earth circuit or 1.5 hours before the fragments began to pour down. Luckily, all passed well. Early in the morning of February 7, the salyut-7 safely flopped down in the Argentinian mountains. In world manned-flight history, it was the second such flop after the American skylab creators of bulky space structures should give more thought to safety and their disposal, not only launch and operation.

The Soviet Topaz space reactors also made headlines. The hard-up Russia sells Star wars weapons. Western newspapers wrote on the Soviet-US Topaz negotiations. Academician Nikolai Ponomarev-Stepnoi, co-author of shipborne nuclear power plants, explained that the Topaz-2 reactor was only five-kilowatt and no military use could be found for it.

Late in February, focus was on the operational Mir orbiter, which marked its fifth year in space on February 20. Unlike the salyut, Mir has in-flight buildup and updating capability. Now the cluster includes four 20-ton sections — the station proper and three joined modules — Kvant, Kvant-2 and Kristal. Before the year end, it will receive Spektr and in 1992, the last unit — the Priroda.

Over five years, the Mir has hosted eight Soviet and five international crews. Another two foreign cosmonauts, British and Austrian, will visit it this year. French and German researchers are in the 1992 flight plans. Each international mission involves serious research. On the agenda now are advertising and commercial flights, such as the one with a Japanese newsman late last year.

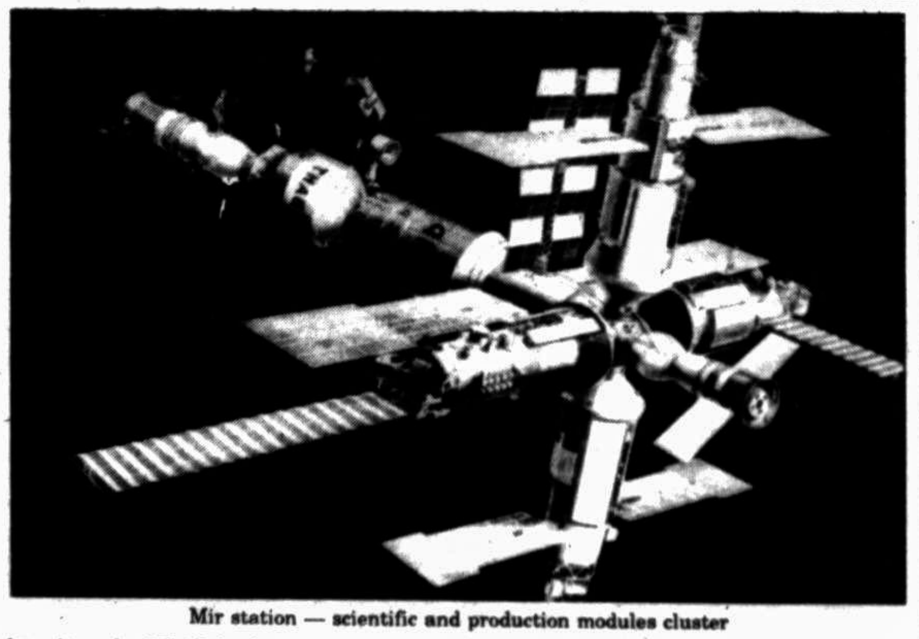
Work aboard the Mir continues. The eighth crew of Victor Afanasyev and Musa Manarov handle, alongside research, what's called "cost-accounting work". The Mir is commercialising both international and domestic-research programmes. The rule now is "each flight must pay its way".

But how? Above all, through sharp increase in semiconductor and biotechnology products from the Mir. Until now, they could only be brought to earth in crew reliefs in the Soyuz ferries. The new automatic recoverable progress ferry brings food, water and fuel to and takes 150-kg payloads from the Mir.

The upcoming docking with the Buran shuttle will be a watershed . It will be on auto and the date has not yet been fixed. Next year the Buran will go on a manned mission.

Last February the Soviet space agency, Glavcosmos, and the Indian space research organisation signed two commercial agreements. One is on launching the IRS-1C landsat by a Soviet booster and is the third such contract. The first landsat, IRS-1A, was put into orbit in 1988 and is still in operation, reporting on forests, plantations and water resources. The second satellite, IRS-1B, will go up in June from the Baikonur space centre, where the preparations are under way. Under the new contract, the IRS-1C will be orbited in 1994.

The second commercial agreement involves putting into geostationary orbit an Indian "village satellite" for educational specialists will help designing the rocket stage to shift satellites from low-earth into geostationary orbit 36,000 kilometres above the earth surface.



Mir station — scientific and production modules cluster

Technology Briefs

FLEXIBLE DIAMOND COATING

A researcher at Northwestern University is perfecting a flexible diamond coating — something that will bend under stress rather than crack and that could be the most damage-resistant protective coating yet, reports the journal Futuretech.

With all their outstanding advantage — hardness, heat conductivly, electrical resistance and transperency — artificial diamond coatings are stiff and brittle. This limits their value when applied to more flexible surfaces. A diamond coating sheet would crack when the metal bends, exposing the metal to rust and corrosion.

The researcher R P H Chang, professor of materials science and engineering, has created a composit oif diamond pairticles in a matrix of amorphous films and has successfully applied this composite to sheet metal surfaces, the journal said in its TechTips section.

The composite film contains diamond crystallites in a plastic like base, a hydrogenated amorphous carbon polymer and/or a fluorocarbon polymar. With the diamond crystela resting in a pliable substance the coating can bend.

The crystals are packed densely enough for the film to retain all the properties of the stiffer coatings. Chang's film is capable of bending about 10 degrees. The film is applied as a vapor and can be grown in thicknesses ranging from less than 100 micrometres to one millimetre thick. Researchers hope to have quality flexible diamond films within two years, the journal said.

TECHNOLOGY FOR CHEAPER CLEANER COAL

Ultra clean coal with potential for far wider use than the present product is being processed at an Australian pilot plant near Mudgee, New South Wales, Australia, reports the Australian Science and Technology Newsletter.

The plant, the first of its kind in Australia, takes research from the laboratory to the mine site as the first step in commercialising locally developed coal-processing technology.

Using a relatively simple cleaning technique, the basic ash levels of a typical black coals can be reduced to as little as 0.2 to 0.6 per cent, the newsletter said.

Once processed, the clan coal is available as a prime energy source, in powdered form for power stations, or in a slurry form as an alternative to heavy fuel oil. It also has potential as a feedstock for carbon anodes used in the aluminum smelting industry.

The technology was developed by the Commonwealth Scientific and Industrial Research Organisation's division of coal technology and is being used in a plant operated by White Mining limited.

After initial washing, the coal is treated with aqueous alkali at moderate temperatures and pressures, followed by acid extraction and thorough washing.

The alkali treatment dissolves silica from the coal and converts aluminium and silicon, present in the coal as clay or shale, into hydroxysodalite when then can be dissolved in acid. The process can produce coal with an ash content of between one and 0.2 per cent.

There is also a strong environmental benefit in the end product. With an ash yield of less than one per cent compared with conventionally cleaned Australian coals' 10 to 20 per cent yield. Less ash emission equates with reduced collection and disposal problems. The combustion of ultra clean coal is more efficient than the conventional variety because energy is not wasted heating unwanted ash. Transport and fuel costs are also lowered because the coal's mineral content is not being carried.

All these factors lead to lower emissions of carbon dioxide, a greenhouse gas. Cost estimates indicate that chemically demineralised coal would be less than half the cost of heavy fuel oil, on an energy basis, providing an economic source of low ash pseudoliquid fuels of the coal-oil and coal watermixtures. Suchmixtures have attracted much interest as fluid fuels specially when the coal component is cleaned by physical methods down to about 3 per cent ash.

Chemically cleaned coals with typically 0.3 per cent ash provide additional scope for the development of a new class of fuels, making it possible to contemplate applications in gasturbines and perhaps slow speed diesel engines as well as a widen range of industrial combustion equipment.

In a parallel development, a research group has been formed to produce carbon anodes from ultra clean coal for use in the production of aluminum in Australia and overseas.

NOVEL AIRCRAFT RESTORATION METHOD

Boron patching, a unique, fast and cheap Australian method of restoring stressed aircraft fuselages and parts, is soon to go on to the world market, reports the Australian Science and Technology Newsletter.

Helitech Industries Pty Ltd. a wholy owned Australian company specialising in aircraft repair has been awarded a 10-year agreement by the Australian government to market the technology. The company has facilities in four overseas countries and is a contractor to the US department of defence.

Conceptual repair proposals have been submitted to the air forces of Singapore and Norway while technology teams have visited the Boeing company in Seattle in the US to apply boron patches to new 747-400 series test aircraft.

The technology was developed over two decades at Australia's Aeronautical Research Laboratory in a programme directed by Dr. Alan Baker, the newsletter said.

Dr. Baker's early studies 15 year ago, led to a system of repairing stress and corrosion cracks in the wing skins of Hercules aircraft. The system is still used today by the Royal Australian Air Force. By 1989, it was estimated to have reduced maintenance costs by 66 million dollars.

Requests from the RAAF for more complex repairs followed. These included the wheels on Macchi jet trainers, the wind skins of Mirage jet fighters and the cockpit frames and wing pivot fittings of F 1 1 strike and reconnaissance aircraft.