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HET GENOOTSCHAP

De vereniging stelt zich ten doel het wetenschappelijk onderzoek op het gebied van de elektronica en de informatietransmissie en -verwerking te bevorderen en de verbreiding en toepassing van de verworven kennis te stimuleren.
Het genootschap is lid van de Convention of National Societies of Electrical Engineers of Western Europe (Eurel).

BESTUUR

LIDMAATSCHAP

Voor lidmaatschap wende men zich via het correspondentie-adres tot de secretaris. Het lidmaatschap staat open voor academisch gegradueerden en hen, wier kennis of ervaring naar het oordeel van het bestuur een vruchtbaar lidmaatschap mogelijk maakt. De contributie bedraagt *f* 60,- per jaar.
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De contributie is inclusief abonnement op het Tijdschrift van het NERG en deelname aan de werkvergaderingen.

HET TIJDSCHRIFT

Het tijdschrift verschijnt gemiddeld vijfmaal per jaar. Opgenomen worden artikelen op het gebied van de elektronica en de telecommunicatie. Auteurs, die publicatie van hun onderzoek in het tijdschrift overwegen, wordt verzocht vroegtijdig contact op te nemen met de voorzitter of een lid van de redactiecommissie.

De abonnementsprijs van het tijdschrift bedraagt *f* 60,-.

REDACTIECOMMISSIE

'IDaSS':the InteractiveDesign and Simulation System for Digital Circuits - Introduction and Use in Education

dr.ir. A.C. Verschueren
Eindhoven University of Technology,
Section of Digital Information Systems

Summary

The 'Interactive Design and Simulation System' (IDaSS) is a CAD toolbox which allows the definition, design and simulation of digital circuits at an abstraction level between structured programming and register transfer languages. IDaSS uses a mix of concise graphical and textual languages, combined with immediate simulation of the design while it is being constructed. It facilitates exploratory design methods while catching design errors before they are hidden by many changes and additions to the design. IDaSS is used to teach students the basics of hardware design at the level of communicating datapaths and controllers. This is done by using the graphical simulation capabilities in the classroom to show the operation of different design structures as well as with hands-on work. Tools are available which convert IDaSS designs into ASIC layouts and UPL program files, so students are able to design actually working devices during practical working- or graduation periods. IDaSS is suitable for tele-learning because it can run on relatively low-end PC's.

1 Introduction

Designing information processing and communication systems has become a task of ever-increasing complexity during the last decade:

- The specifications of the systems are often incomplete and contain internal inconsistencies - not surprising given the complexity of these systems.
- The optimal mapping of functionality on hardware and software (and the choice of hardware to run the software) has become very difficult - there are a lot of choices to make, each with their own implications.
- The requirement to build first-time-right hardware implementations (using Application Specific Integrated Circuits) poses stringent requirements regarding correctness of specifications.

The section of Digital Information Systems at the Eindhoven University of Technology has started several projects to find design methodologies which must solve these problems. The *'Object-Oriented design of (hardware) systems'* project divides the design path of complex systems into the following three phases:

1) *Specification analysis* uses Object-Oriented system analysis techniques to convert the (informal) system specification into a (executable) system specification consisting out of parallel communicating objects.
2) *System synthesis* transforms the Object-Oriented system specification into a network of communicating processing nodes and chooses implementation methods for all these nodes and communication channels.
3) *Module implementation* implements the nodes and channels according to the chosen methods. For the nodes, any combination of hardware and/ or software is possible. The implementation phase of hardware nodes can be subdivided as follows:

   3a) The Object-Oriented model of the module is refined to specify the hardware interface and choose implementable algorithms for the specified behaviour.

   3b) For these algorithms, suitable datapaths and accompanying control structures are designed at the Register Transfer Level (RTL).

   3c)A converter tool transforms the this RTL description into a synthesizable hardware description. This description can be used by a silicon compiler to create an ASIC layout or User-Programmable Logic (UPL) program file.

The *Interactive Design and Simulation System ('IDaSS')* is under development as a part of the 'Object-Oriented design of (hardware) systems' project. The current IDaSS toolbox contains the RTL level design and simulation tools only. The tools for specification analysis and system synthesis will be added to the IDaSS design environment in the future (prototypes of these already exist). In it's final state, it will support all three design phases with description and simulation tools.

The next two sections will focus at the RTL-level IDaSS tools and their use in edùcation.

2 Introduction to the IDaSS tool

In this section, we will take a look at the components which are used by RTL-level IDaSS to model hardware designs, the overall method of designing and simulating with IDaSS and the system requirements for running IDaSS.

2.1 Available modelling components at RTL level

This part of IDaSS allows describing hardware at the Register Transfer Level and uses highly parametrisable components to do so. These components can be grouped together according to their function in a design:

Providing a system hierarchy

IDaSS uses graphical methods to describe the structure of a design. As usual in graphical environments, a hierarchy of (sub-)***schematics*** is used to group system elements together.

Data transfer and (combinatorial) data handling

Data transfers take place using ***busses***, with a width between 1 and 64 bits. IDaSS uses ***three-state buffers*** to handle bi-directional communication. Busses can break through the hierarchy layers in the system.

Combinatorial operations on data are performed in ALU-like ***operators***. Each of them can be given multiple functions to execute. Functions are defined as a set of expressions, using more than 60 hardware-implementable basic operators.

Data storage

Data storage is done in ***registers***, ***RAM***'s, ***ROM***'s, ***FIFO***'s (First-In-First-Out memories), ***LIFO***'s (Last-In-First-Out or 'stack' memories) and ***CAM***'s (Content Addressable Memories). Writing into storage structures is always synchronous to a simulated system clock, forcing the design of synchronous systems. Reading RAM's and ROM's can be asynchronous or synchronous.

System control

System control is done by ***state controllers*** (which can represent finite state machines or micro programmed controllers). Test and control lines are defined textually. Given commands are denoted by abstract names, the designer does not need to specify bit encodings for them. Local control of a single system element can be performed by ***control connectors*** (which translate a bus value into local commands).

2.2 Interactive design and simulation

IDaSS uses a mix of graphical (for the system structure) and textual (for the detailed behaviour) descriptions in a multi-windowing environment.

The IDaSS environment behaves like an electronic breadboard with live insertion and removal of components (without the risk of destroying them). There are always enough components in stock and these are easy to parametrise to the correct size and behaviour. An unlimited supply of virtual test probes makes it possible to inspect the system state in great detail. Unlike a real breadboard, it is very simple to manipulate the system state in preparation for test sequences.

2.3 System requirements

Several versions of RTL-IDaSS exist, with varying system requirements:

Mini-IDaSS is purely intended for small designs like simple 8 or 16 bit mi-

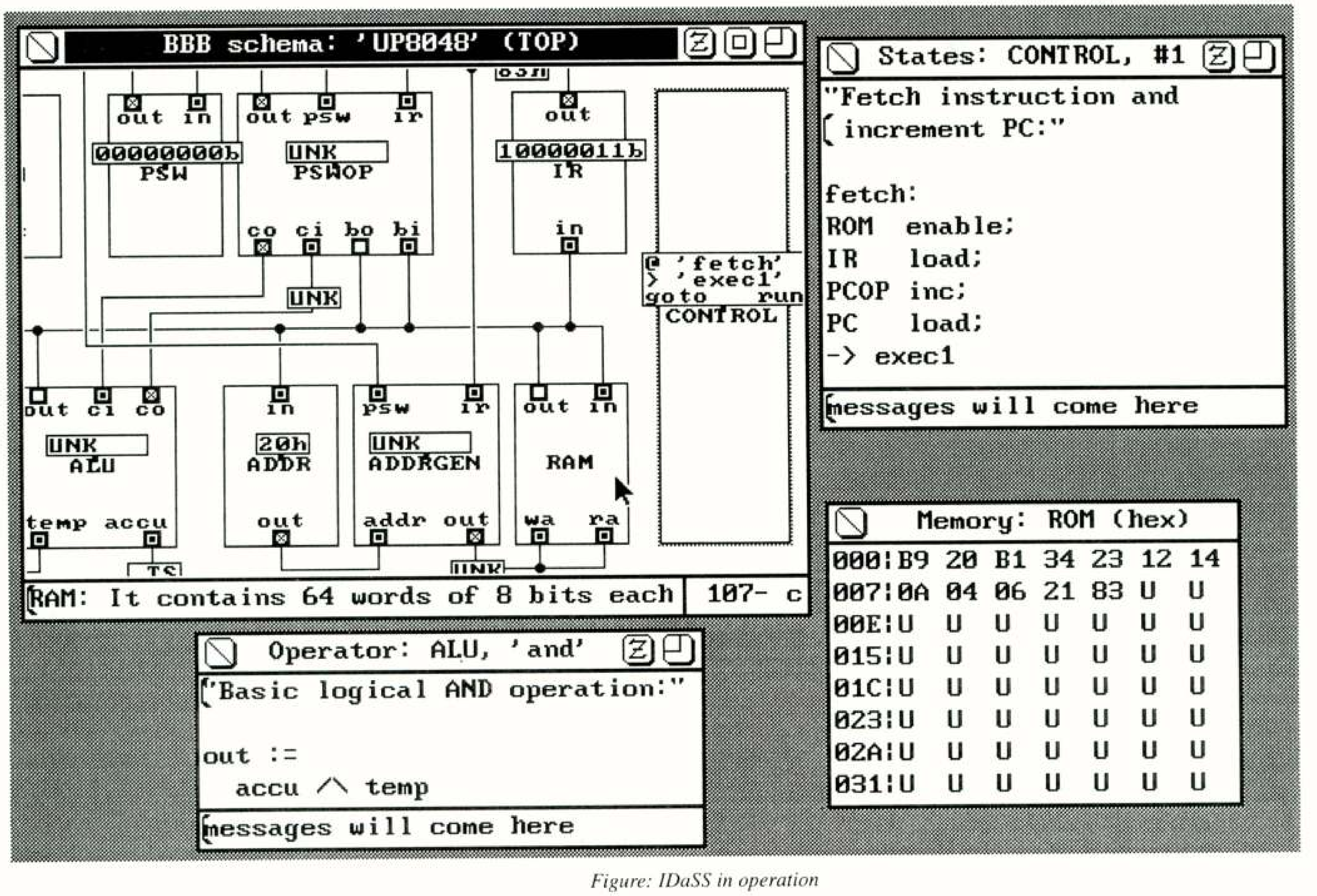

Figure: IDaSS in operation

We wanted to create a design environment which allows us to 'play around' with architectures. The main stumbling block in most design environments is the fact that design entry and simulation are completely separated activities. An edit-compile-simulate-analyse cycle can easily take from several minutes up to hours. This does not encourage trying different solutions to a certain problem and also promotes entering large parts of the system before debugging them. To overcome these problems, we started with the following overall requirement for the IDaSS environment:

We want to design interactively with continuous simulation.

Using IDaSS, simulation never ceases to run. A schematic change immediately recalculates system state, as does saving a textual behaviour description (which compiles the text into behaviour 'on the fly'). The enter-simulate-analyse cycle shrinks to only a few seconds, giving a very strong feedback to the designer. The design can be expanded and debugged in small steps, allowing a new (and much faster) working style. By allowing 'Cut and Paste' operations on system parts just as with a word processor, re-use of system parts, the building of a design library and separate design and debugging is greatly simplified.

crocomputers. It has slightly reduced modelling capabilities when compared to standard IDaSS. Mini-IDaSS requires a PC-XT (or up) with 640 kilobyte RAM, 2 megabyte hard disk space, graphics card and a mouse.

Standard IDaSS allows very complex designs to be made, depending on the amount of memory present in the computer. It requires a PC-AT (or up) with 640 kilobyte of base RAM, 2..16 megabytes of extended memory, 3 megabyte hard disk space, graphics card and a mouse.

In the near future, standard IDaSS will be extended to handle the Object-Oriented system and architecture model (increasing the minimum extended RAM size and hard disk space). It will also be ported to a new base system which allows it to be run on high-end workstations.

3 Use of IDaSS in education

IDaSS is used for educational purposes in different ways.

Lecture demonstrations:

With video projection, IDaSS can be used to let schematics come alive and show the actual flow of data in a design. It is possible to build a design in small pieces, thereby introducing the actual design method by demonstration.

This can be done in interaction with the students - let them decide what to do next.

Remote education and practical training:

The Dutch Open University uses IDaSS routinely in a first year digital circuit design course. Students run the program on their own PC at home after a few afternoons of classroom training. They are asked to build designs of increasing complexity, during which they learn to use the basic parts and how to trade off different architectures.

Examinations:

We give students the option to (re-)design an existing component in IDaSS as examination for second year digital circuit design courses. The complexity is chosen such that it takes them roughly 100 hours to complete the design (8 bit microprocessors and I/O devices). This is somewhat longer than it would take them to study for the normal written examination, but they themselves indicated that it is well worth the trouble.

Practical working periods and (post-) graduation work:

Given enough time, very complex designs can be built by students:

- A 50 mm^2 telephone exchange switching network ASIC for 10.000 subscribers was designed during a graduation period of approximately 600 hours.
- A 15 mm^2 25 megabyte per second data encryption/decryption ASIC was designed during a practical working period of 150 hours.

Numerous other designs have been made, ranging from highly pipelined re-designs of existing processors to compete neural networks, data flow processors, local area network controllers and even super scalar processors. Some of these designs are so complex that synthesising them is currently impossible. Our experience has shown that it takes students less than one week to learn to use IDaSS without specific training. After that, they take the tool for granted and only require guidance regarding the design decisions in the project they are working on.

4 Conclusion

The 'Interactive Design and Simulation System' (IDaSS) is a CAD tool which is powerful enough to handle very complex Register Transfer Level designs. The completely interactive way of operation with simulation while designing has attracted interest from industry because it allows design time to be cut considerably. IDaSS is very easy to use and allows much more concise descriptions of hardware behaviour than for instance VHDL, which makes it attractive as 'front end' for other CAD tools.

For educational purposes, IDaSS has proven to be very useful in teaching students the principles of digital circuit design:

- The graphical nature makes it easy to visualise the operation of a design, much better than a static picture in a book or on an overhead sheet.
- Teaching first year students the operation of digital circuit elements and how they can be created with IDaSS can be done in a matter of days. This can then be used as basis for studying more advanced system architectures.

IDaSS can also be used to let students show their actual knowledge by letting them design fairly complex digital circuits:

- The interactive method of designing prevents a lot of errors and gives them enough time to try different architectures.
- Designing 10.000+ gate equivalent circuits down to ASIC layout level in a practical working period of 150 hours is possible.

Future expansions of IDaSS will allow much more complex systems to be designed. Describing and analysing systems at the abstract behaviour level will allow much better trade-offs between hardware and software to be made. It will also remove ambiguities in the specifications of the different system parts to be implemented, easing final system integration. Teaching students to work this way will be an interesting challenge, as this is currently almost unexplored territory.

5 References

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Voordracht gehouden tijdens de 427e werkvergadering

NEDERLANDS ELEKTRONICA- EN RADIOGENOOTSCHAP
427e werkvergadering

UITNODIGING voor de werkvergadering van het NERG op donderdag 3 november 1994 in collegezaal EH van de faculteit Elektrotechniek van de Technische Universiteit Eindhoven, Den Dolech 2, Eindhoven.

THEMA: GEBRUIK VAN SOFTWARE PAKKETTEN IN HET HOGER ONDERWIJS VOOR ELEKTROTECHNIEK

De opzet van dit onderwerp is om docenten in het HBO- en universitair onderwijs in de Elektrotechniek nader kennis te laten maken met software pakketten die de onderwijstaken kunnen ondersteunen. Er worden pakketten besproken en deels ook gedemonstreerd, die zowel de didaktiek ondersteunen als ook bij het doceren van ontwerp- en analysemethoden kunnen worden ingezet. Meestal kunnen deze pakketten ook leiden tot een concreet fysisch product.

PROGRAMMA:

13.45 - 14.00 uur	Ontvangst en koffie
14.00 - 14.45 uur	Leren met computersimulaties: het vormgeven van instructieondersteuning **DR. W.R. VAN JOOLINGEN,** TUE faculteit Wijsbegeerte en Maatschappijwetenschappen, UT faculteit Toegepaste Wetenschappen
14.45 - 15.30 uur	IDaSS: het Interactieve Design and Simulation System voor digitale circuits **DR.IR. A.C. VERSCHUEREN,** TUE faculteit Elektrotechniek
15.30 - 15.45 uur	Theepauze
15.45 - 16.30 uur	Hoogniveau DSP-ontwerp m.b.v. Hypersignal for Windows **ING. E NIJEBOER EN IR. R. STROOT,** TRANSFER EDS BV
16.30 - 17.15 uur	Computer ondersteund ontwerpen met het COMPASS systeem **DR.IR. J.F.M. THEEUWEN,** TUE faculteit Elektrotechniek
17.15 - 17.45 uur	Demonstraties van alle pakketten

Aanmelding voor deze middag dient te geschieden vóór 27 oktober aanstaande door middel van de aangehechte kaart, gefrankeerd met een postzegel van 70 cent.
Leden van het NERG en studenten hebben gratis toegang. De kosten van deelname voor niet-leden bedragen *f* 15,00.
Betalingen dienen vóór 27 oktober te zijn ontvangen op girorekening 94746 t.n.v. Penningmeester NERG, Postbus 39, 2260 AA Leidschendam.

Namens het NERG,
Prof.dr.ir. W.M.G. van Bokhoven
Ir. P.R.J.M. Smits, programmamanager
Tel. 070 - 332 51 12 (administratie NERG)

DSP DEVELOPMENT TAKES A VISUAL ROUTE

David Crowell
Hyperception, Dallas, USA.

For an engineer designing a DSP chip, sketching a block diagram on the back of an envelope is as good a place as any to begin. It could be said that a block diagram is the highest-level language for DSP design, and any automated tool should offer the same ease of visualisation as pen on paper. Today's engineers are using high-end PC's in DSP development and implementation, and the most successful PC-based tools like the visual route while also solving other problems intrinsic to DSP design. Such tools, including those from Hyperception, run on Windows. The operating system's visual interface can keep up with the designer's train of thought, and the closer a simulation tool resemles the thought flow of the engineer, the faster the work will go. Since most engineers begin with a drawing, the perfect design tool allows development in a blockdiagram environment and then implements the results in code. Typically, beginning a DSP design means conceptualising the algorithm, then manipulating it. If a program needs to be compiled each time the algorithm is adjusted, progress will be slow. But the best tools let you change structure or adjust parameters and run the new algorithm with no delays. They also make it easy to arrange and reconnect function blocks, and adjust the parameters of each.

A major difficulty in DSP simulation is the varied nature of the algorithms involved. In most, their very essence is a unique mathematical relationship or property implemented in such a way that it can be called "digital signal processing". Every new development in DSP calls for a new transfer function, perhaps unrelated to previous ones. For this reason, an effective DSP development platform must allow for user customisation.

With a package such as Hypersignal for Windows Block Generator (which creates all the Windows code needed for a new function), from Hyperception, the user automatically creates new blocks representing processing functions, date inputs, data outputs or displays. While 90 to 100 percent of typical algorithms can be programmed visually using the block functions in the existing library, the user must add some proprietary functions may not be adequate to build the latest algorithms.

Then too, the package must be flexible enough to handle a variety of problems that are difficult to fit into a standard structure. One is multidimensional data algorithms like those in image processing, a field that will use DSP much more in the coming years. Another tough nut is multirate problems. A simulation tool that handles these and other types of problems will remain useful as DSP continues its rapid evolution.

In terms of programming languages, the clear leader for DSP development is C. Many libraries exist for signal processing in this powerful, widely used, industry standard language, and all DSP chip makers have support tools for compiling C code. The optimal way to add a new function to a DSP tool, therefore, is to describe the function in C and automatically generate a block on a compiler. When used with Block Generator, Microsoft's Visual C++ cuts deveolpment time for new function blocks to 15 minutes or less. All the user needs to write in C is the actual transfer function.

This code is inserted where Block Generator leaves stubs; the resulting block can then be used in the visual environment, or even during code generation. Another property a DSP simulator must have is a structure of hierchy to make complicated designs easier to manage. DSP algorithms get very complex, and many levels of hierarchy are needed to deal with them, from the overall scheme to the smallest details. Entire screen of processing blocks must be shrunk to single blocks that can be duplicated.

A good hierarchical structure helps fix bugs, too. Sometimes, early versions of simulation software miss a function that users quickly say they need. If a high-level function block is then upgraded, it must in turn update every copy of itself; in doing so it will fix a bug throughout the system without repetition. The more a simulation package is used, the more a user appreciates a good hierarchical structure.

Yet another key feature for an algorithm development platform is the ability to bring in signals from the real world and send out result. Lab instruments help analyse those signals, and a comprehensive development package would include a spectrum analyser, oscilloscope and data recorder, all in the same computing environment as the simulation tools.

One way to use the instruments - and the method taken in the Hypersignal AMPS (for aquisition, measurement, processing and storage) package - is via a DSP/aquisition board plus software. To ease the transition from traditional instruments to virtual ones, the software relies on the easy-to-use interface provided by Windows. For its part, the DSP chip performs FFT's for the spectrum analyser and digitally filters data as it goes into or out of the computer. The board can also verify and debug DSP code. Using the same board as an algorithm test bed and a set of instruments trims cost and complexity.

DSP development boards are available for all the popular general-purpose DSP chips, and the Hypersignal software supports a variety of them. The other key ingredient is development software, assembler, linker, simulator, C compiler, from the chip maker, which can be bundled into a system if the user needs it.

With all of the hardware and software for DSP code development provided, some attention should be given to the task of documenting the work. Many DSP algorithms, once conceptualised, must be presented to managers or contracting companies. The quality of the presentations is sometimes as important as the content.

The traditional approach is to take the simulation results and put them into a more attractive form using presentation software. But this forces an engineer to spend more time on a problem he has already solved. A better idea is an algorithm development package with presentation-quality graphics built in, and such is now possible thanks to Windows. Graphically sophisticated, Windows also lets users import screen captures from their wordprocessing programs. And its broad printer support ensures that reports will be easy to produce.

Producing code

Now that the algorithm is fully defined and fine-tuned, it must be converted to DSP assembly-language code to run quickly. That's no easy job. DSP is a relatively new field, so few engineers are experienced in it and development tools have not had long to mature. Designers, especially neophytes, want to generaye code the easiest way possible from C or, even better, from a visually programmed flow chart.

To fulfill the need for C-based code, DSP chip makers have released compilers that turn C code into assembly language for their DSP's. Harder to find, until recently, were affordable visual systems. Where once only a few high-end, workstation-based systems could do it, now PC-based software is available for the task. Such programs can tie into the algorithm-development environment to produce C code based on the simulation that has been created.

This is compiled with the chip maker's tools to produce DSP assembly language code.
At this point, the code is not as optimised as it could be. Most designs require that sections of the code in time-critical areas be rewritten and optimised, a task that is usually much more attractive than creating the entire program in assembly language. Ideally, the best route would be to go from a block diagram to assembly language whenever possible, and the new PC based tools make this option affordable at last.
Certain commonly used operations, particularly filter design, can be addressed in optimised assembly language. The Hypersignal software contains programs that design digital filters and implement them in DSP assembly language. The libraries offered by DSP board makers are another source of optimised DSP assembly language functions. Where these functions are present in the algorithm, the optimised DSP code can replace the C code produced by Block Diagram. The resulting program has an organised, maintainable structure, as well as optimisation.
Once the DSP code is written, it needs to run on a chip to find all the problems, and a number of DSP development boards make this possible (the same boards that function as real-time instrument front ends). The advantage of plugging them into the computer is obvious: No custom hardware needs to be designed, thus saving development cost. The typical development board contains the general-purpose circuitry to cover most DSP designs, such as static RAM, A/D, D/A, and other types of memory. These boards vary in how they handle the A/D and D/A conversion, depending on the application. To assist in DSP code development, many boards include debugger monitor software.

Another level of software support now available is a set of real-time function blocks that run in common simulation environments. These blocks perform input, output or processing like their counterparts in C, but they run on the DSP board in assembly langage. This ties the real-time DSP code into the design package and lets the developer test it from the visually programmed environment.
The short-term advantages of a visually programmed DSP development environment under Windows are fairly obvious. Generating the majority of the code automatically cuts design time by possibly 80 percent. That translates into engineering man-hours that can go into design iterations for quality improvement or cost reduction, or into new projects. Even more important is time-to-market. Since a product's success often hinges on whether it gets released ahead of the pack, the impact of speedy design is considerable.

Finally, the PC platform is cheap and available to virtually all design engineers, and it promises to be around for a while. When investing in a development environment, the buyer wants to know that the hardware and software will be useful or at least easily upgradable for years to come. Current trends indicate that powerful new platforms based on the Pentium Alpha and R4000 chips will run Windows and the Windows NT, thus keeping visually programmable DSP development programs viable.

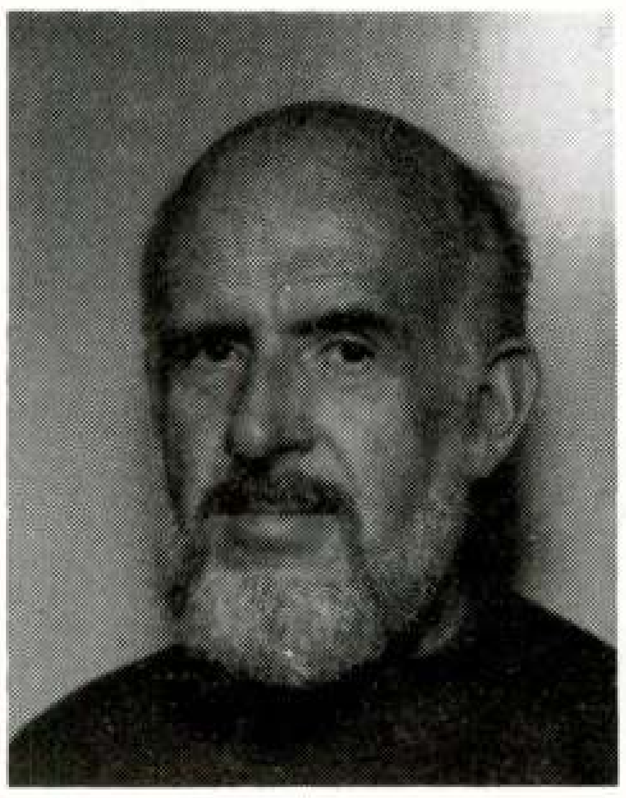
Tijdens de 427e werkvergadering met het thema:" Gebruik van software pakketten in het hoger onderwijs voor elektrotechniek" werd door ing. E. Nijeboer en ir. R. Stroot van Transfer EDS BV. een voordracht met demonstratie gegeven onder de titel: Hoogniveau DSP-ontwerp met behulp van Hypersignal for Windows. In dit artikel worden de mogelijkheden van dit softwarepakket beschreven.

HET RADIOPROPAGATIE-ONDERZOEK AAN DE TECHNISCHE UNIVERSITEIT EINDHOVEN

Prof.dr.ir. G. Brussaard
Technische Universiteit Eindhoven, Vakgroep Telecommunicatie

Summary

The paper is an introduction to the papers presented on at the 428th meeting of the NERG and published in this issue of the NERG Journal. Since its establishment in the early '60s, the Eindhoven University of Technology has been carrying out a programme of research in radiopropagation. A brief summary of the development of this programme is given. The three papers presented are introduced and put in the broader context of this programme. Past and current developments are discussed, after which the prospects for future work are outlined. In the near future much emphasis will be placed on the development of mobile personal communications, with corresponding demand for propagation models for urban and in-door communication systems. An integral part of such models is the proper representation of the transmission channel. At the same time, the demand for additional transmission capacity will generate a requirement for propagation models for 40-50 and possibly 90 GHz systems.



Inleiding

Het onderzoek op het gebied van radiopropagatie ten behoeve van toepassing in telecommunicatiesystemen is te verdelen in twee hoofdgebieden, n.l. het onderzoek van de atmosferisch propagatie en de modellering van de invloed (diffractie en reflectie) van aardoppervlak, vegetatie en bebouwing. Dit onderzoek is steeds gedreven geweest door de behoefte aan basisinformatie voor de ontwikkeling van nieuwe radiosystemen. Men ziet daarom in de ontwikkeling van het propagatie-onderzoek de weerspiegeling van de ontwikkeling van de radiocommunicatie. In dit artikel wordt een beeld geschetst van de ontwikkeling van dit onderzoek en van het kader waarin het huidige onderzoek ten behoeve van mobiele radiocommunicatie, zoals beschreven in de hierna volgende artikelen, wordt uitgevoerd.

Atmosferische propagatie

In de ontwikkeling van het atmosferische propagatie-onderzoek kan men een aantal periodes van ongeveer tien jaar onderscheiden:

In de eerste tien jaar na W.O. II werd veel en intensief onderzoek gedaan naar de eigenschappen van de ionosfeer ten behoeve van verdere ontwikkeling van de HF radio.

Tot het midden van de zestiger jaren werd veel aandacht besteed aan VHF en UHF verbindingen. Met name de onderlinge storing van systemen door superrefractie (over-de-horizon propagatie) werd onderzocht. Het onderzoek van HF radiopropagatie werd in die periode geleidelijk afgebouwd.

In de periode tot 1975 werd, ten behoeve van de ontwikkeling van een steeds dichter net van (C-band) straalverbindingen, behalve storing door superrefractie ook distorsie en signaalverlies door meerwegpropagatie een belangrijk aandachtsgebied.

In de daarop volgende periode kreeg de 11/14 GHz satellietcommunicatie veel aandacht, vooral door de experimenten met de Europese "Orbital Test Satellite" (OTS). Hierin heeft Nederland een belangrijke rol gespeeld, niet in de laatste plaats omdat dit onderzoek landelijk werd afgestemd binnen een samenwerkingsverband van het Dr. Neherlaboratorium van PTT, T.U. Delft en T.U. Eindhoven, mede gesteund door de Stichting voor de Technische Wetenschappen (STW) en de "European Space Agency" (ESA). In internationaal verband werden in verschillende projectgroepen en organisaties (COST, SIRIO, CCIR, EUTELSAT) de resultaten vergeleken, verwerkt en gerapporteerd.

In de laatste tien jaar verschoof de aandacht van de Ku-band naar de Ka-band (20/30 GHz). De ontwikkeling van de OLYMPUS satelliet, met een speciaal voor propagatie-onderzoek ontwikkeld pakket van bakenzenders, het z.g. "propagation package", bood een unieke gelegenheid tot gedetailleerd onderzoek van de karakteristieken van atmosferische propagatie in de 20/30 GHz band. In Nederland werd de nationale samenwerking geïntensiveerd; met steun van STW, PTT Research en ESA/ESTEC werden door T.U. Eindhoven en T.U. Delft complementaire onderzoeken uitgevoerd binnen het Europese samewerkingsverband OPEX (Olympus Propagation EXperiment),

Figuur 1 Het OLYMPUS grondstation van TUE

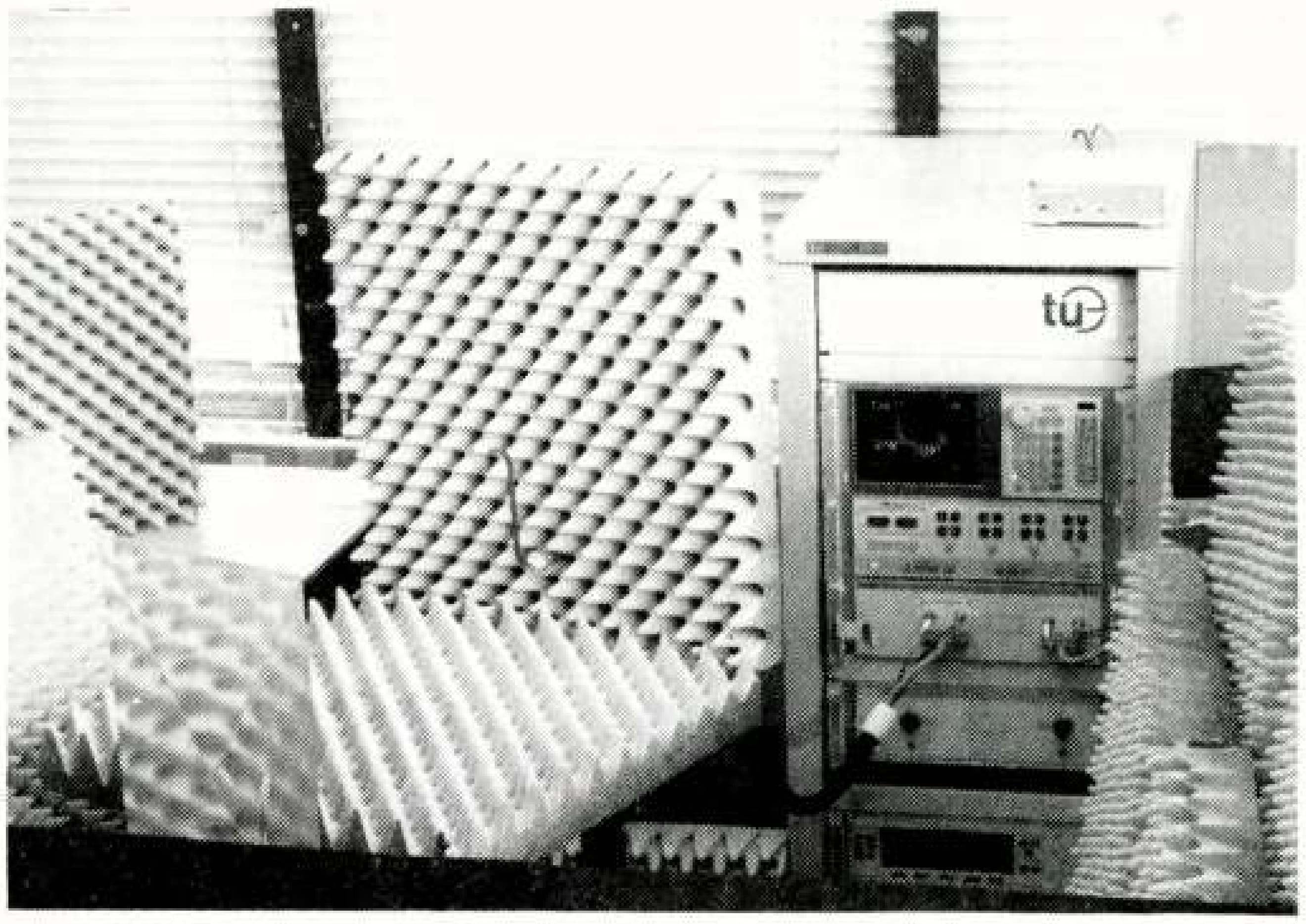
gecoördineerd door ESTEC en onder voorzitterschap van Brussaard (ref. 1). Het door T.U. Eindhoven ontwikkelde grondstation (Figuur 1) was één van de twee stations in Europa met een geheel complete uitrusting voor alle baken-experimenten met OLYMPUS. Op dit moment zijn de experimenten met de OLYMPUS satelliet afgerond; de algemene resultaten werden in november 1994 gepresenteerd op de Tweede OPEX Workshop (ref. 2).

Sinds enige tijd is er binnen Europa een mogelijkheid geboden voor propagatiemetingen in de 40/50 GHz band door middel van de Italiaanse ITALSAT satelliet. Deze heeft een tweetal bakenzenders voor propagatiemetingen aan boord, waarvan de specificaties zijn afgeleid van de OLYMPUS bakens. De internationale deelname aan het ITALSAT experiment is bescheidener dan de OPEX deelname, allereerst omdat de prijs voor de benodigde apparatuur zeer hoog is, maar tevens omdat ten tijde van de voorbereidingen van dit experiment de belangstelling voor toepassingen van de 40/50 GHz band gering was; een trend die de laatste tijd weer omgebogen wordt door de toenemende belangstelling voor universele "Personal Communication Networks" (PCN) waarbinnen zowel cellulaire systemen ("outdoor" en "indoor") als satellietsystemen die gebruik maken van millimetergolven (40/50 en 90 GHz) een belangrijke rol kunnen gaan spelen.
De ITALSAT bakenzenders zullen voorlopig wel de laatste mogelijkheid zijn voor geavanceerd propagatie-onderzoek op een satellietpad. De Radiogroep van TUE voert reeds een bescheiden ITALSAT experiment uit op 40 GHz. Een 50 GHz ontvanger, geheel in eigen beheer ontwikkeld, is bijna gereed.

Het gebruik van millimetergolven beperkt zich niet tot telecommunicatietoepassingen. Met name voor tele-observatie van de atmosfeer is de belangstelling voor het frequentiegebied 20-300 Ghz sterk toegenomen. Een project van wolkenobservaties vanaf de grond met millimetergolf radiometers (20,30,45 en mogelijk 90 GHz) is in opbouw bij de Radiogroep.

Modellering van diffractie en reflectie

Reeds omstreeks 1985 werd in het kader van het onderzoek naar storing op en door straalverbindingen, aansluitend aan de over-de-horizon metingen, een onderzoek gestart naar de mogelijkheden om grote grondstationantennes af te schermen voor storingsbronnen. Voor deze z.g. "site shielding" kan in Nederland geen gebruik gemaakt worden van natuurlijke afscherming in geaccidenteerd terrein; reden waarom de mogelijkheden van kunstmatige "site shielding" door schermen beschouwd werden. Voor de modellering werd gebruik gemaakt van de "Geometric Theory of Diffraction" (GTD). Scheeren (ref. 3) beschouwde de afscherming van een eenvoudige paraboolantenne door een oneindig breed scherm. Dit onderzoek werd voortgezet door van Dooren (ref. 4) met de modellering van een scherm van eindige breedte in combinatie met een Cassegrain-antenne. Hierbij werd gebruik gemaakt van de "Uniform Theory of Diffraction" (UTD).
De door van Dooren ontwikkelde computermodellen gebaseerd op UTD kunnen ook toegepast worden voor het modelleren van de invloed van bouwconstructies op de eigenschappen van z.g. VSAT (Very Small Aperture Terminal) antennes, die toegepast worden in kleine grondstations voor satellietcommunicatie.
De UTD diffractiemodellen zijn nauwkeurig experimenteel getoetst met behulp van modelmetingen op 60 GHz in het laboratorium van de Radiogroep van TUE (Figuur 2).
Inmiddels is de belangstelling voor de toepassing van diffractiemodellen voor mobiele communicatie in een stedelijke omgeving sterk toegenomen. Voor de toepassing van steeds kleinere cellen in mobiele communicatiesystemen is



Figuur 2 Diffractiemeting op 60 GHz aan een eindig breed scherm

de lokale omgeving van zowel het mobiele station als van het basisstation bepalend voor de kanaalkarakteristieken. Daarom zijn op statistische modellen gebaseerde planningsmethoden veelal niet toereikend voor de planning van z.g. microcellen. In deze gevallen kunnen deterministische modellen die gebruik maken van diffractietheorie gekoppeld met terrein-data een alternatief bieden. Datzelfde geldt voor de modellering van mobiele satellietverbindingen alsmede voor in-huis systemen die van zeer kleine "picocellen" gebruik maken.

Op dit moment is het propagatie-onderzoek voor mobiele communicatie aan TUE gericht op een drietal toepassingen. In samenwerking met PTT Research wordt de modellering van het transmissiekanaal in cellulaire systemen in een stedelijke omgeving beschouwd, zowel theoretisch als experimenteel. Met ESA/ESTEC en een Italiaans researchinstituut wordt samengewerkt bij de verdere ontwikkeling van modellen voor mobiele satellietcommunicatie. Op het gebied van in-huis communicatie zijn uitgebreide experimenten uitgevoerd met behulp van een "60-GHz channel sounder" waarmee nauwkeurige metingen van de impulsresponsie van verbindingen binnen gebouwen zijn bepaald. In al deze projecten wordt in internationaal verband (COST) samengewerkt. De in dit Tijdschrift opgenomen artikelen van van Dooren, Buonomo, Smulders en Mawira (refs. 5,6,7) gaan nader in op deze projecten.

Vooruitzichten en conclusies

Het klassieke onderzoek van atmosferische radiopropagatie aan TUE is een vruchtbaar arbeidsveld gebleken voor toepassing bij de planning en modellering van microgolf- enmillimetergolf- radiosystemen. Binnen Europa, en in het algemeen binnen de geïndustrialiseerde landen van het Noordelijk halfrond zijn op grote schaal statistische propagatiegegevens verzameld voor de planning van satelliet- en straalverbindingen. Dit is nog niet het geval voor ontwikkelingslanden die veelal sterk afwijkende klimaten hebben. Het onderzoek van het gebruik van klimaatfactoren voor de ontwikkeling van op mondiale schaal te gebruiken planningsmethoden is op dit moment nog een belangrijk aandachtsgebied. De Radiogroep van TUE heeft grote ervaring in samenwerkingsprojecten met ontwikkelingslanden; projecten zijn uitgevoerd in Indonesia en in Tanzania. Op dit moment wordt gewerkt aan het realiseren van een nieuw project in een aantal Afrikaanse landen, gericht op het onderzoek van propagatiemodellen voor tropische klimaatgebieden.

Het 60 GHz in-huis project, dat reeds vijf jaar geleden gestart werd, staat nu volop in de belangstelling in verband met de ontwikkeling van breedbandige in-huis "Local Area Networks" (LANs) op 60 GHz. Een internationaal samenwerkingsproject op dit gebied is in ontwikkeling.

Moderne ontwikkelingen op het gebied van mobiele digitale radiosystemen hebben de aandacht gericht op het modelleren van radiotransmissie binnen steeds kleiner wordende cellen. Hier liggen nog vele vragen met betrekking tot het efficiënt modelleren van zowel natuurlijke structuren (vegetatie, terrein) als kunstmatige obstakels (gebouwen, verkeer). Daarbij dienen zowel vorm als materiaaleigenschappen beschouwd te worden. Datzelfde geldt voor in-huis communicatie en voor het grensgebied tussen "outdoor" en "indoor" systemen en tussen cellulaire systemen en satellietsystemen in een geïntegreerd netwerk voor persoonlijke communicatie. Het ontwikkelen van efficiënte "interworking" tussen verschillende transmissiesystemen en netwerken zal hoge eisen stellen aan de modellering van het kanaal. Het valt te verwachten dat de binnen de Radiogroep aanwezige combinatie van kennis op het gebied van millimetergolfpropagatie en van diffractiemodellen een goed uitgangspunt zullen vormen voor verder onderzoek in het zich zo dynamisch ontwikkelende gebied van de mobiele communicatie.

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Voordracht gehouden tijdens de 428e werkvergadering

NEDERLANDS ELEKTRONICA- EN RADIOGENOOTSCHAP
428e werkvergadering

UITNODIGING voor de werkvergadering van het NERG op donderdag 24 november 1994 in Dorgelo/Posthumus-zaal in het Bestuursgebouw van de Technische Universiteit Eindhoven, Den Dolech 2, Eindhoven.

THEMA: RADIO WAVE PROPAGATION RESEARCH FOR THE DESIGN OF MOBILE COMMUNICATIONS SYSTEMS

Propagatieonderzoek staat aan de basis van elke vorm van radiocommunicatie. Deze middag zal propagatieonderzoek in drie verschillende mobiele omgevingen worden besproken.

PROGRAMMA:

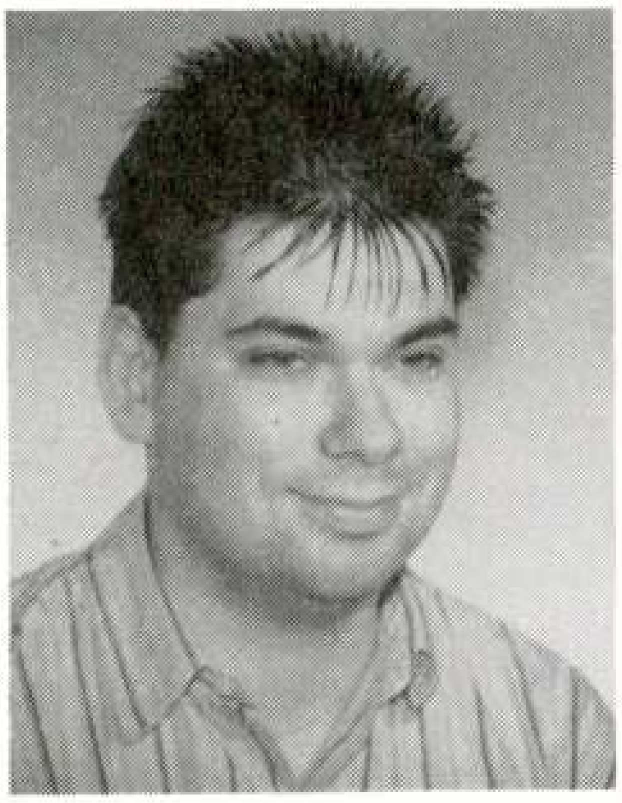
14.00 - 14.15 uur	Ontvangst en koffie
14.15 - 14.40 uur	Introduction **PROF.DR.IR. G. BRUSSAARD,** TUE , dagvoorzitter
14.40 - 15.20 uur	Land-mobile satellite communications **DR.IR. G.A.J. VAN DOOREN,** ESA/ESTEC
15.20 - 15.40 uur	Theepauze
15.40 - 16.20 uur	Terrestrial land-mobile communications **IR. A. MAWIRA,** PTT Research
16.20 - 17.00 uur	Millimeter-wave in-house radio communications **IR. P.F.M. SMULDERS,** TUE
17.00 - 17.30 uur	Borrel en sluiting

Aanmelding voor deze middag dient te geschieden vóór 17 november aanstaande door middel van de aangehechte kaart, gefrankeerd met een postzegel van 70 cent.
Leden van het NERG en studenten hebben gratis toegang. De kosten van deelname voor niet-leden bedragen *f* 15,00.
Betalingen dienen vóór 27 oktober te zijn ontvangen op girorekening 94746 t.n.v. Penningmeester NERG, Postbus 39, 2260 AA Leidschendam.

Namens het NERG,
Dr.ir. M.H.A.J. Herben
Ir. P.R.J.M. Smits, programmamanager
Tel. 070 - 332 51 12 (administratie NERG)

FIELD STRENGTH PREDICTION IN LAND MOBILE SATELLITE COMMUNICATION SYSTEMS USING ANALYTICAL MODELS

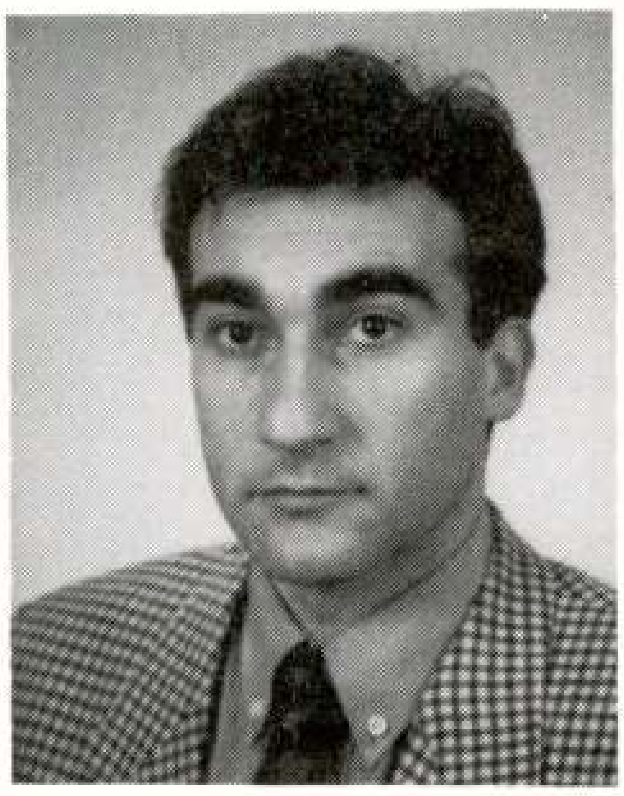
dr. G. van Dooren and dr. S. Buonomo
XE Division, ESA/ESTEC, PO Box 299, 2200 AG Noordwijk



dr. G. van Dooren

Abstract

In this paper a ray model for field strength prediction in an urban environment is presented. The model is based on the Uniform Geometrical Theory of Diffraction (UTD/GTD), extended to include effects of non-perfect conductivity and surface roughness of the objects. Through the use of simple object shapes the user is able to build up the model of the urban area to be analysed. The deterministic prediction and planning tools discussed can be used by system engineers in the design of a mobile or fixed communication service in built-up areas; it delivers accurate information on signal amplitude and phase, time delay and delay spread profiles, delay-Doppler spectra and so forth. As an example, the results of an analysis carried out with the software on a scaled model of the Eindhoven University of Technology campus are presented. Furthermore, a comparison is made between the predicted and measured field strength behind a rectangular block at a frequency of 50 GHz.



dr. S. Buonomo

Introduction

The conventional way for field strength prediction in Land Mobile Satellite (LMS) communication systems has, in the past, used empirical models that were derived from measurement campaigns. An inherent drawback from these statistical models is the fact that they are suitable for one specific geometry only. For this reason a number of statistical models to be used for urban, suburban, and other environments have been developed and compared to existing data in the literature [1, 2, 3, 4, 5, 6, 7]. Furthermore, the main characteristics of the signal obstruction and specular reflections are not accurately modelled. For these and other reasons there is a need for a prediction tool not related to a specific urban scenario, but based upon canonical and well-known electromagnetic laws. Some examples of environments are shown in figures 1and 2.

Figure 1: Sub-urban environment

In this paper we will describe the methodology used in two of these models, viz. FiPre and ARAMIS, both currently in use at ESTEC. Both models have been designed and developed under contract for the European Space Agency (ESA) by research groups at the University of Technology in Eindhoven, and Space Engineering/IDS in Italy, respectively. Some of the requirements of the model are that it should enhance the insight into the wave propagation process in mobile environments, it should have a good theoretical background, and that it should calculate the field strength at the mobile in amplitude, phase and polarisation as function of the position of the mobile. Because it is throughout assumed that the dimensions of the obstacle are large compared to the wavelength, the use of high-frequency techniques is clearly justified. These requirements have led to the choice of Geometrical Optics (GO) complemented with the Uniform Theory of Diffraction (UTD) for the calculation of the aforementioned properties of the electromagnetic (EM) wave.

Figure 2: Urban environment

2. Description of prediction model

The wave propagation model uses Geometrical Optics (GO) complemented with the UTD to account for the bending of EM waves around (sharp) edges. In these theories, the EM wave is assumed to travel along lines in space (rays). In this high-frequency description of EM wave propagation several classes of waves are distinguished, that corresponds to the physical propagation mechanism of the waves encountering obstacles while propagating from a source S to an observation point *Obs*. The following classes of EM waves are defined:

1. The direct wave;
2. The reflected wave, where the reflection may either take place at the ground or at an obstacle in the urban environment;
3. The edge diffracted wave, where the diffraction takes place at a sharp edge of the obstacle;
4. The double diffracted wave (both diffractions take place at the same obstacle);
5. The corner diffracted wave;
6. Waves that encounter combinations of the mechanisms in the previous points;
7. Waves that are subject to EM scattering at objects in the vicinity of the observation point.

The wave contributions discussed are shown in Figure 3.

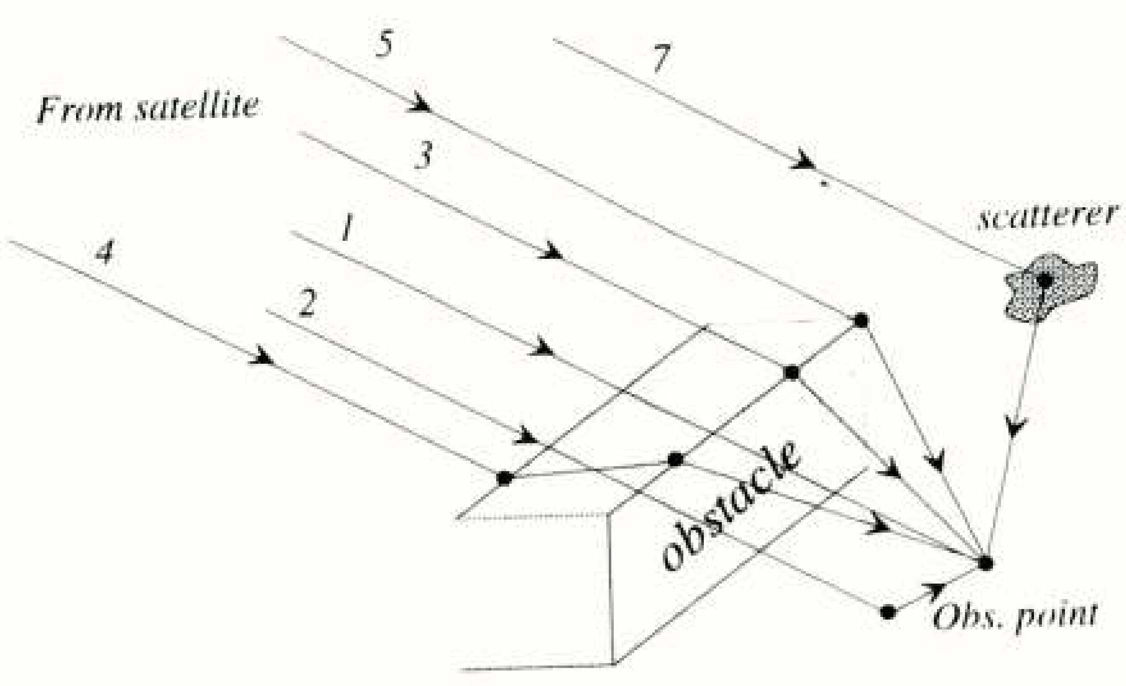


Figure3: An obstacle and various wave contributions

The frequency range for which the model was primarily developed goes from 1 to 60 GHz. Within this range numerous results have been reported in the literature dealing with the application of the UTD with regard to scattering problems. We will come back to this in section 5.

In GO, an EM wave is fully described by its polarisation, the amplitude and phase at some reference point, the divergence factor $A(s)$ accounting for attenuation as the wave is propagating and the direction of propagation $\hat{k}$. For waves emanating from a point source propagating in a direction $\vec{k}$ we have

$$\vec{E}^{Obs} = \vec{E}^{S} \cdot A(s) \cdot e^{-jks} = \vec{E}^{S} \cdot \frac{e^{-jks}}{s}, \qquad (1)$$

with s the distance from S to Obs, $\vec{E}^{Obs}$ the electric field in the observation point, $\vec{E}^{S}$ the electric field in the source point, and k is the wavenumber for free space. Also the edge diffracted field can be written in a format similar to that used in equation (1), however, another divergence factor $A(s)$ should be used, and a *diffraction coefficient* should be incorporated in the analysis.

Obviously, all of the mentioned wave parameters such as polarisation, divergence factor and phase, change as the wave interacts with the objects in the environment. A ray-tracer routine keeps track of these changes in the wave parameters. Furthermore, the same routine determines the location of the reflection and diffraction points using the principle of stationary optical path length, i.e. the reflection and diffraction points can be found using variational methods [8, 9, 10].

Since it is assumed that the medium in the urban environment is homogeneous, the rays are straight lines in space. This enables the ray-tracer to quickly find reflection and diffraction points using schemes and procedures originally developed for computer graphics [11]. In this way also the complex problem of ray blocking by polygonal obstacles can exactly be solved, and these procedures are very time efficient from the computational point of view.

Because GO and the UTD are deterministic methods, S and *Obs* are well-defined points in space. The wave launched at S interacts with the environment before it reaches *Obs* and this results in multipath propagation. At the point *Obs* the total electric field $\vec{E}^{Obs}$ can be written as

$$\vec{E}^{Obs} \propto \sum_{l} \vec{E}_{l}, \qquad (2)$$

where $\vec{E}_l$ is a wave arriving at *Obs* through one of the propagation phenomena mentioned. At *Obs*, each component $\vec{E}_l$ is weighted in amplitude and polarisation to yield co- and cross-polarised signals at the antenna terminals

$$E^{Obs} = \sum_{l} G(\vartheta)\vec{E}_{l} \cdot \hat{e}_{pol}(\vartheta) = \sum_{l} U_{l}, \qquad (3)$$

where $\hat{e}_{pol,l}$ is the polarisation weighting vector corresponding to the co- or cross-polarised signal for the direction of arrival $\hat{k}_l$. The function G is introduced for spatial weighting of the waves and the angle υ is the direction 'cosine' between the boresight direction of the antenna and the direction of arrival $\hat{k}_l$. If *Obs* is assigned a vectorial velocity, $\hat{k}_l$ is also used to calculate the Doppler-signal of magnitude $| U_l |$. Because the waves do not travel along the same propagation path, differences in path length are automatically introduced. Each wave will therefore have its own path length s_l, that, related to the path length of the reference ray s_{ref}, is easily converted to time delays using the speed of light.

To model the objects in the urban lay-out a standardised obstacle has been

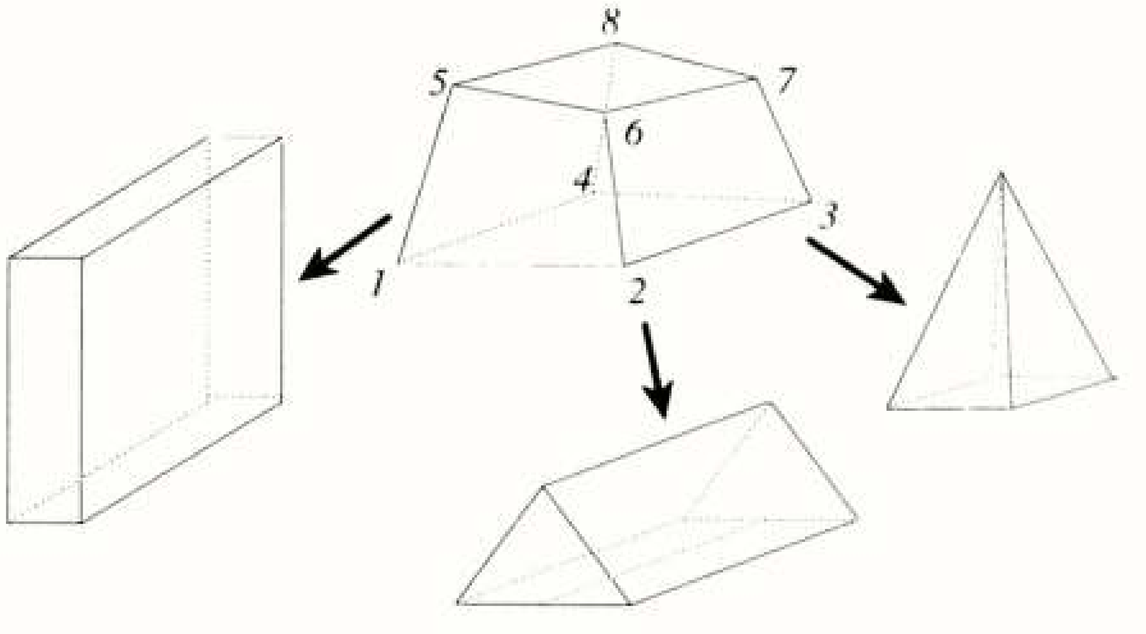


Figure 4: The block-shaped obstacle in this various geometries.

used, referred to as the block-shaped obstacle [12]. This obstacle is depicted in Figure 4 and is specified numerically by its eight corner points, its permittivity and its surface roughness.

Note that the edges of the obstacle are straight, and its faces are plane; this considerably simplifies the ray-tracing procedure. No further restrictions apply to the obstacle as to the position of its corner points. Further it is permitted to make logical combinations of the objects, and in this way fairly complex geometries can be assembled. The objects are defined in an Cartesian coordinate system, of which the xy-plane is assumed to be the ground plane onto which the objects are placed. The number of objects to be analysed is mainly restricted by the CPU time, the number of observation points, and the types of contributions included. An in-built CAD tool can additionally simplify the locations and orientations of the objects into the defined scenario.

Before the ray-tracer can actually be invoked some input data has to be defined:

1. The source position;
2. The trajectory of the observation point *Obs* and the number of sample points;
3. The frequency;
4. The source polarisation;
5. The types of contributions to be included in the ray-tracer analysis.

The ray-tracer produces a (large) datafile where for each sample point the type of ray (direct, reflected, diffracted,..), $\vec{E}_l$, $\hat{k}_l$ and s_l are specified. Using this datafile the data postprocessing can be carried out.

3. Data postprocessing

The types of contributions included in the ray-tracer can be individually selected to be included in the data postprocessing. The spatial antenna weighting functions G depend obviously on the angle ϑ that the direction of propagation makes with the boresight direction. The latter is also defined by the user. In this paper we will present data using the hemi-spherical antenna weighting function because this antenna type closely resembles the radiation pattern used in mobile communications. The amplitude weighting function of this type of antenna is modelled as

$$G(\vartheta) = \begin{cases} \sqrt{22}\cos^5(\vartheta) & , 0 \le \vartheta \le \pi/2 \\ 0 & , \pi/2 \le \vartheta \le \pi \end{cases}, \tag{4}$$

where ϑ is defined as

$$\cos(\vartheta) = -\hat{k}_l \cdot \hat{e}_z, \tag{5}$$

where $\hat{e}_z$ is the boresight direction of the antenna. Since the antenna weighting functions are defined analytically within the software, it is very easy to include other functions G if necessary.

A. Field strength analysis

By using equation (3) the received field at the feed position is readily calculated. An advantage of **FiPre** is that the same ray-tracer output file can be used more than once, for example, to analyse the impact of excluding some wave contributions in the postprocessing, or to use different antenna weighting functions G. Using this postprocessor blockage effects can be clearly visualised because individual results are still available. Co- and cross-polarised signals are available for all polarisation states defined, and for all types of waves. Note that in the field strength calculation no attention is paid to the speed of the vehicle and the relative arrival time of the individual waves.

B. Time delay analysis

In addition to the direction of propagation $\hat{k}_l$, in the time delay analysis attention is also paid to the excess path length $\Delta s_l = s_l - s_{ref}$, which yields an excess time delay $\Delta t_l = \Delta s_l / c$, c being the speed of light. At an observation point *Obs* the time delay response $h(t)$ is given by

$$h(t) = U_0 g(t - \Delta t_0) + \sum_l U_l g(t - \Delta t_l), \tag{6}$$

where the subscript 0 indicates the LOS wave and the function $g(t)$ is the channel impulse response. For a CW analysis the function $g(t)=\delta(t)$, and for the arrival of the EM signal discrete pulses in the time domain are found. The average excess time delay $\overline{\sigma}$ and the time delay spread $\overline{\Delta\sigma}$ can be calculated by using the first and second central moment of $h(t)$. Within the software, these parameters are separately calculated for LOS and optical shadow (OS) regions.

C. Delay-Doppler analysis

In the delay-Doppler analysis attention is paid to the time delay as well as to the direction of arrival and the vectorial speed $\vec{\upsilon}$ of the mobile. The Doppler shift $\Delta\omega_l$ is defined by

$$\Delta\omega_l = -\omega \frac{\vec{\upsilon} \cdot \hat{k}_l}{c}. \tag{7}$$

The amplitude of the spectral line at frequency $\omega + \Delta\omega_l$ obviously is $|U_l|$. The Doppler spectrum $D(\omega)$ is simply the summation of all spectral lines arriving at *Obs*

$$D(\omega) = U_0 \delta(\omega - \Delta\omega_0) + \sum_l U_l \delta(\omega - \Delta\omega_l). \tag{8}$$

The relative movement of the satellite can be introduced in the Doppler-spectrum calculation for a complete analysis of the Doppler phenomena.

The delay-Doppler spectrogram is calculated by a two-dimensional mapping of the amplitude terms U_l with respect to the excess time-delay Δt_l and the Doppler shift $\Delta\omega_l$. Using this spectrogram the time response and Doppler spectrum can be found by projections of the delay-Doppler spectrum along the time and frequency axes, respectively.

4. Analyses of testcase

An illustration of the potential and capability of a deterministic model a realistic testcase is analysed. A ray tracing analysis for a trajectory on the EUT campus has been performed. The trajectory will treat a specific case frequently encountered in mobile communications, namely strong shadowing. The analysis is carried out at L- and S-band (1.5 and 2.3 GHz) and the signal is assumed to be transmitted from a geostationary satellite at 19*W* seen from the EUT campus at an elevation of 27^0.

The EUT campus as seen from the satellite is shown in Figure 5, while a top-view of the campus is shown in Figure 6.

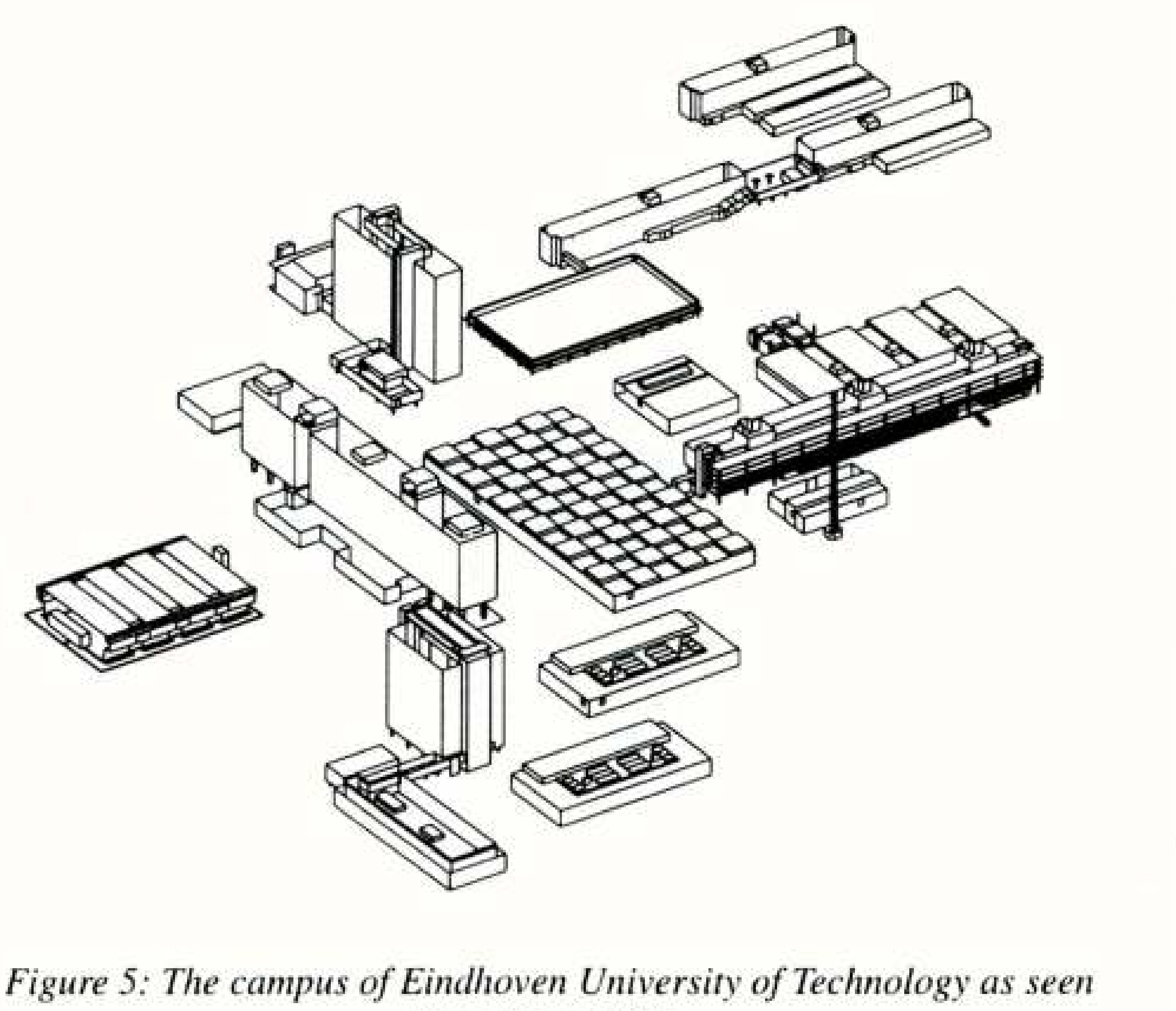


Figure 5: The campus of Eindhoven University of Technology as seen from the satellite.

In the latter also the two trajectories are depicted. For the trajectory from point 3 to 4 twenty-two objects have been selected. The trajectory has a length of 200*m*, and at both frequencies 3 sample points per wavelength have been used, resulting in 3000 sample points for the analysis at 1.5 GHz,

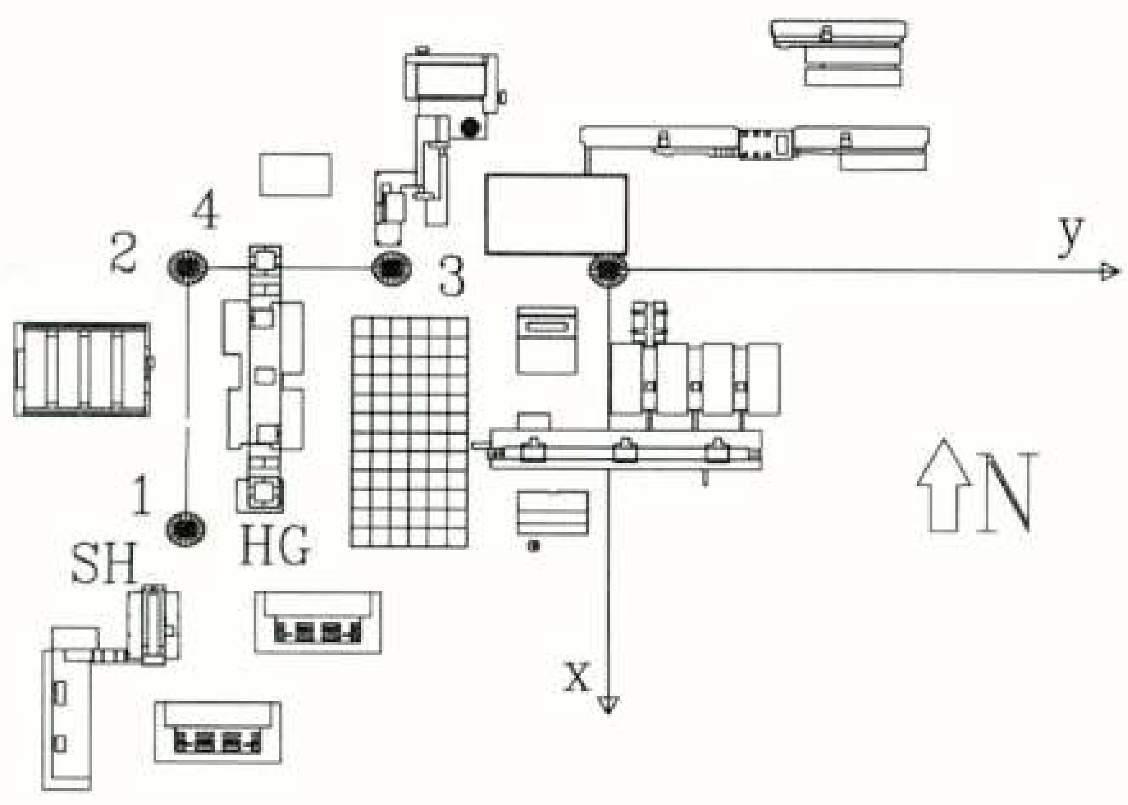


Figure 6: Schematic top-view from the EUT campus and trajectory.

and 4600 for the one at 2.3 GHz. It is assumed that all the buildings are made of brick with a relative humidity of 5%. This results in a (complex) relative permittivity ε_r of 5.3-1.25i at 1.5 GHz, and ε_r= 5.3-4.1i at 2.3 GHz [13].

A. CPU effort

Obviously, considerable time is needed to perform the analysis. The calculations have been performed on an 486 PC running at a clock speed of 66 MHz. For simplicity only the direct, reflected and singly diffracted types of contributions were included. The time needed to complete the ray tracing at 1.5 GHz is 4h27 and for 2.3 GHz it is 6h50.

In Figure 7 the received signal along trajectory 3 $\rightarrow$ 4 for both frequencies is given. In this case strong shadowing from building HG occurs between $y = -210m$ and $y = -120m$. It is found that for the higher frequency the level in the deep shadow is lower, while the slope of the received signal near the shadow boundaries, viz. $y = -220$ and $y = -120m$, is higher. This is expected from the theory [9] in view of the dependence of the diffraction coefficient on the wavelength. For the results presented in Figure 7, $\overline{\sigma}$, $\overline{\Delta\sigma}$ and σ_{max} have been calculated and these values are reported in Table 1.

	LOS region		OS region		
	$\overline{\sigma}$	$\overline{\Delta\sigma}$	$\overline{\sigma}$	$\overline{\Delta\sigma}$	σ_{max}
1.5 GHz	113	8	19	17	683
2.3 GHz	113	8	19	17	683

Table 1: Excess delay $\overline{\sigma}$, delay spread $\overline{\Delta\sigma}$ and maximum excess delay σ_{max} in LOS and OS regions, in nanoseconds.

Because σ_{max} is a function of the urban environment, it is found that for a fixed geometry the values found are not dependent on the frequency, while $\overline{\sigma}$ and $\overline{\Delta\sigma}$ are also dependent on $|U_t|$ and Δt_r.

For trajectory 3 $\rightarrow$ 4 we have also calculated the PDF and CDF of the relative received field, which are reported in Figure 8 and 9, respectively.

The large peaks at a power level of -15 dB are caused by diffraction, while the peaks around 0 dB are caused by reflection and the direct contribution.

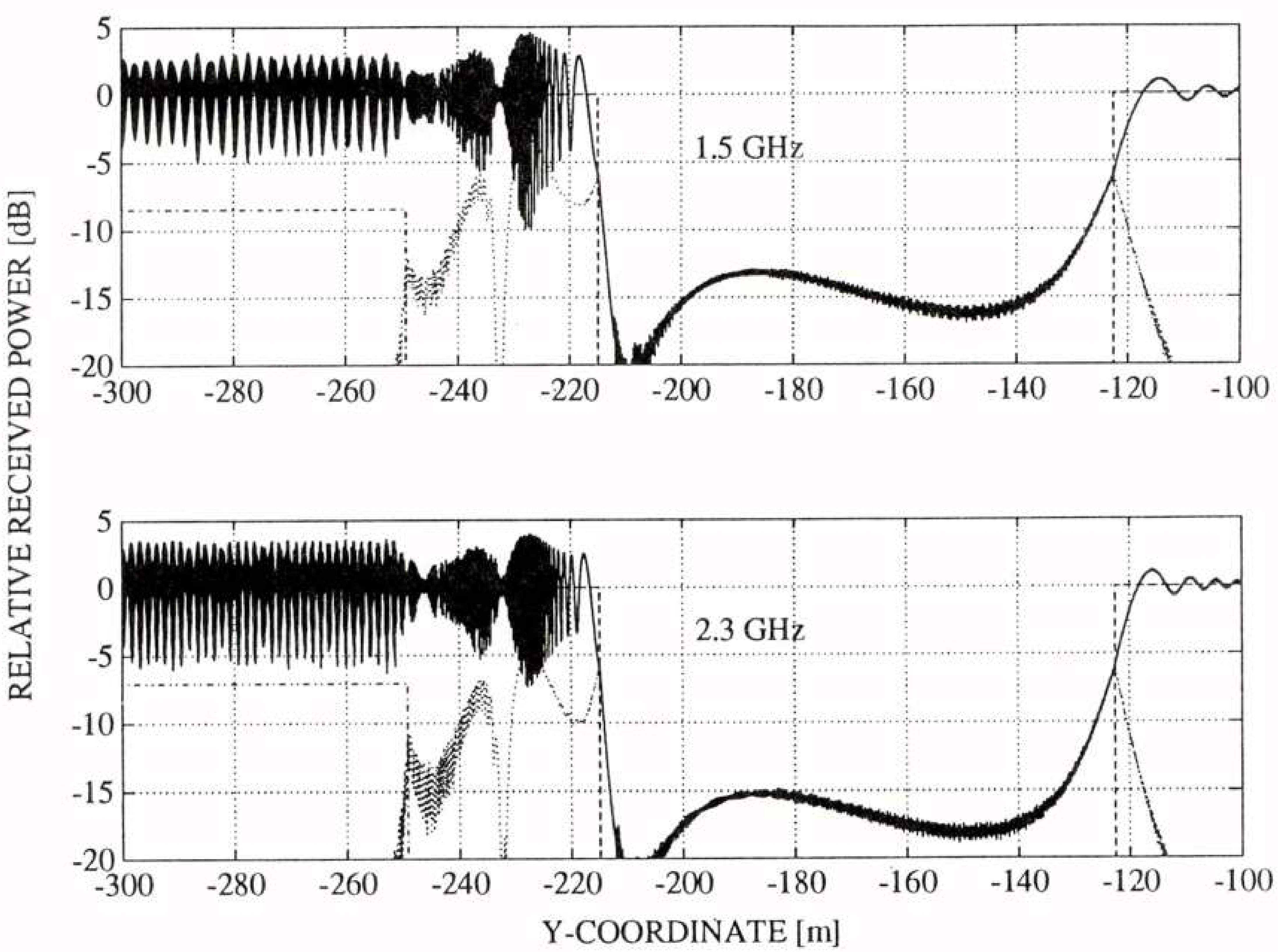


Figure 7: Relative received power for both frequencies. The total field (———), the direct (---------), reflected (-.-.-.-) and diffracted field (......) are indicated.

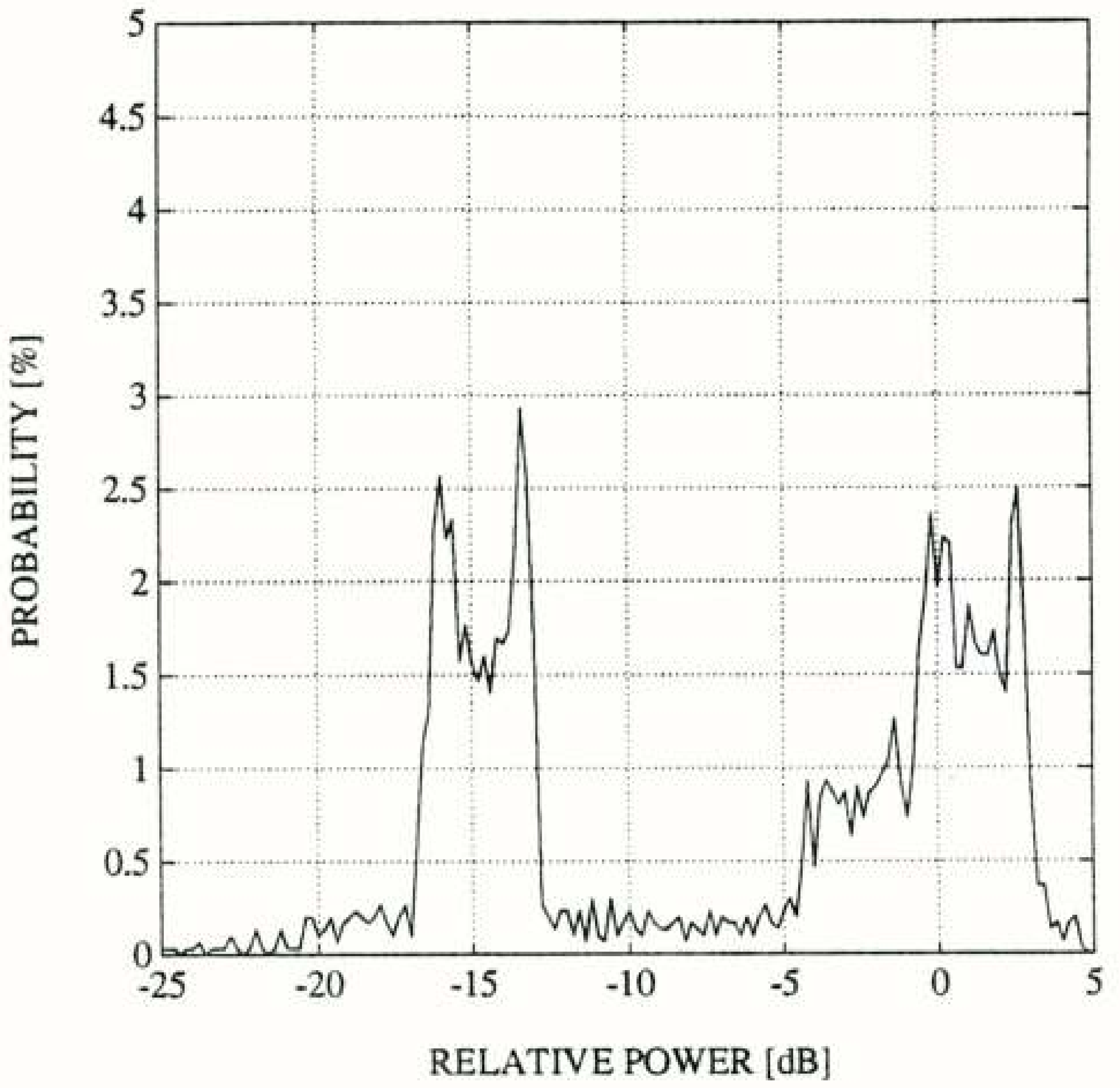


Figure 8: Probability density function of relative received power at 1.5 GHz.

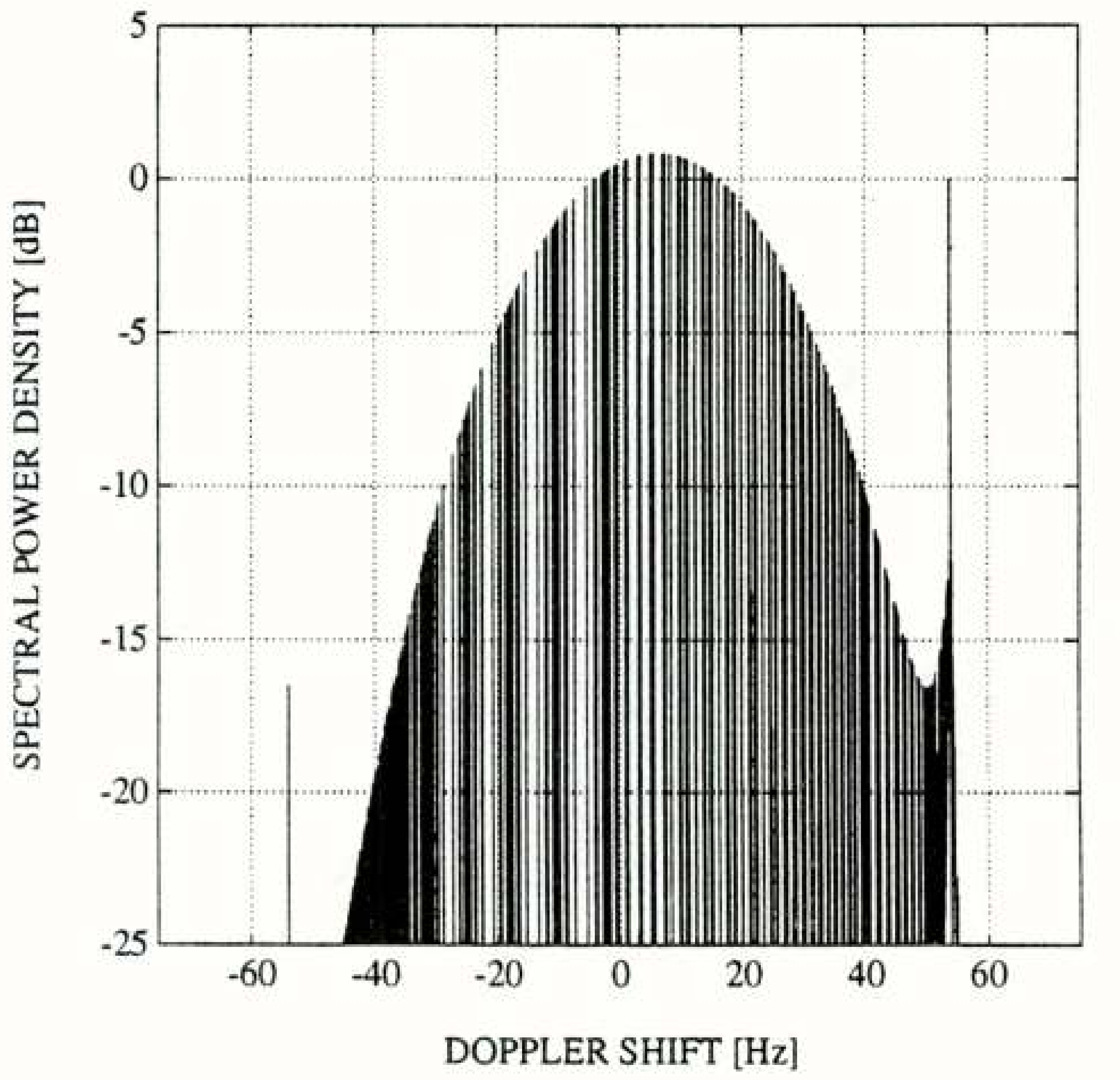


Figure 10: Doppler spectrum at 1.5 GHz for a mobile at a speed of 50 km/h.

From this Figure it can for example be seen that for 20 % of the time the signal level exhibits an attenuation of 15 dB or more, and that for 30 % of the time it is higher than the LOS level.

The Doppler spectrum for a mobile travelling at a speed of 50 km/h along trajectory 3 $\rightarrow$ 4 at 1.5 GHz is given in Figure 10.

For this case the maximum Doppler shift is ± 55Hz. Because the mobile is moving towards the source, the maximum of the Doppler spectrum occurs at a positive Doppler shift. The delay-Doppler spectrogram is shown in Figure 11. The time response and the Doppler spectrum can be found using the delay-Doppler spectrogram by projections of the data onto the both side planes.

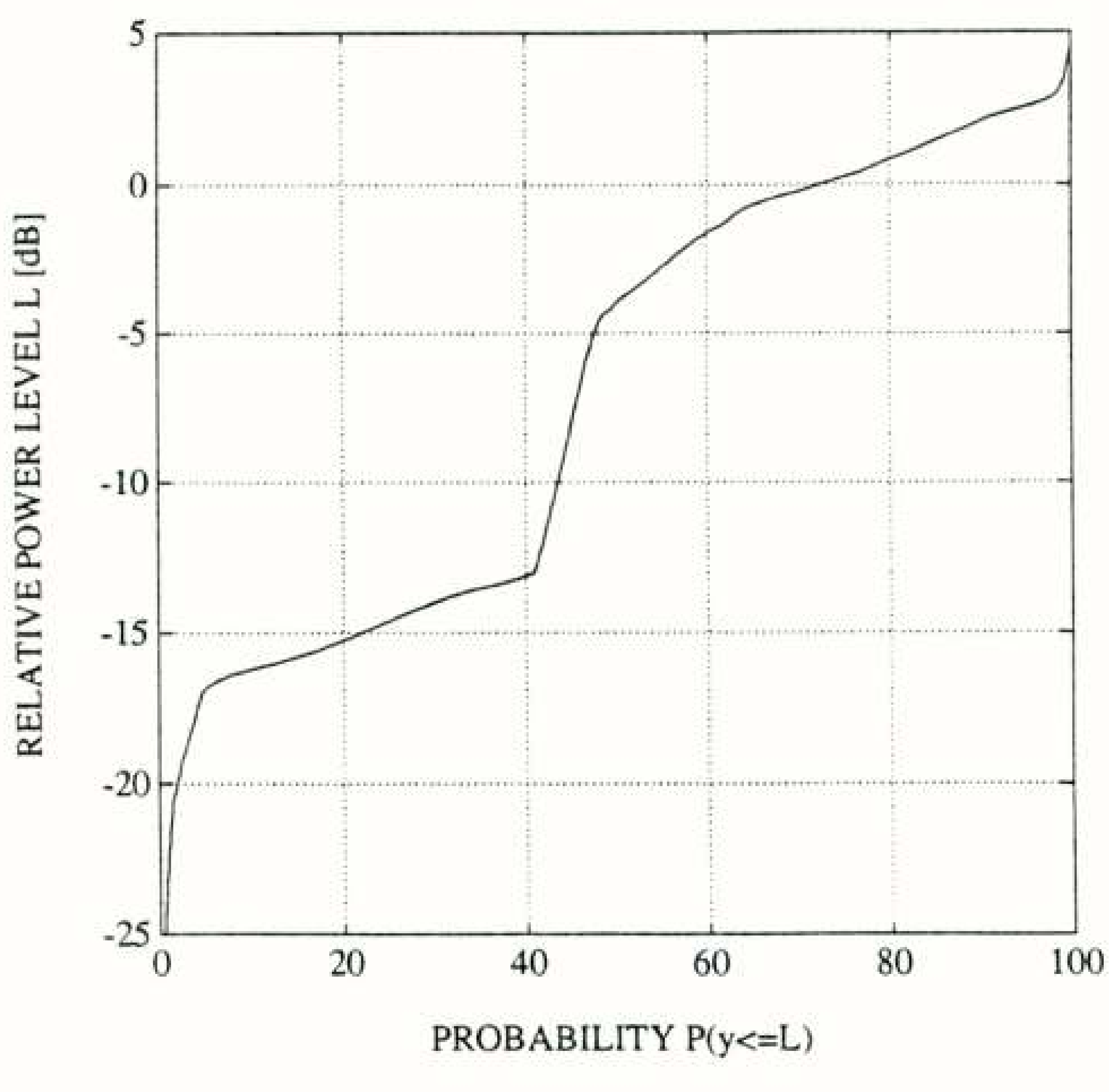


Figure 9: Cumulative density function of relative received power at 1.5 GHz.

5. Practical verification

The methodology used here to formulate the deterministic model has been extensively verified using a measurement setup incorporating a vector network analyser [10]. In these measurements the emphasis was on the correct modelling of the deterministic model, and so only one obstacle was used. These measurements were carried out at 50 GHz using isolated obstacles with various shaped and types of material. In Figure 12 a comparison of simulated and measured results is shown for the field strength behind a rectangular block made of commercially available absorbing material [10]. For this kind of material the theory found in [9] was modified in order to include effects of non-perfect conductivity.

As can'be seen from Figure 12 excellent agreement occurs between measured and predicted results, confirming the validity of the model discussed. More measurement results can be found in [10, 13].

Recently, a measurement campaign 'in the field' has been carried out. A mobile van with a K_a-band terminal driven at a speed of 30 km/h receiving a signal from a geostationary satellite. The measured data are presently compared with the predicted results.

6. Future improvements

The deterministic prediction tools are still under development and future improvements will include obstacle transmittivity and improved ray-racing procedures. Also scattering from vegetation is intended to be included and other types of contributions (multiply reflected and diffracted) will be implemented.

7. Conclusions

In this paper the major features of a prediction tool originally developed for the simulation of the most significant parameters of an LMS communication channel have been presented and discussed. This simulation package is particularly suited for the study of the narrow and wideband channel characteristics of any LMS system serving built-up areas. Significant results of some of the postprocessor available functions have been given showing the potential of such LMS prediction tool. Due to its inherent capabilities and to the large use of UTD/GTD routines, our simulation tool is also very effective for the planning of fixed communication systems in urban environ-

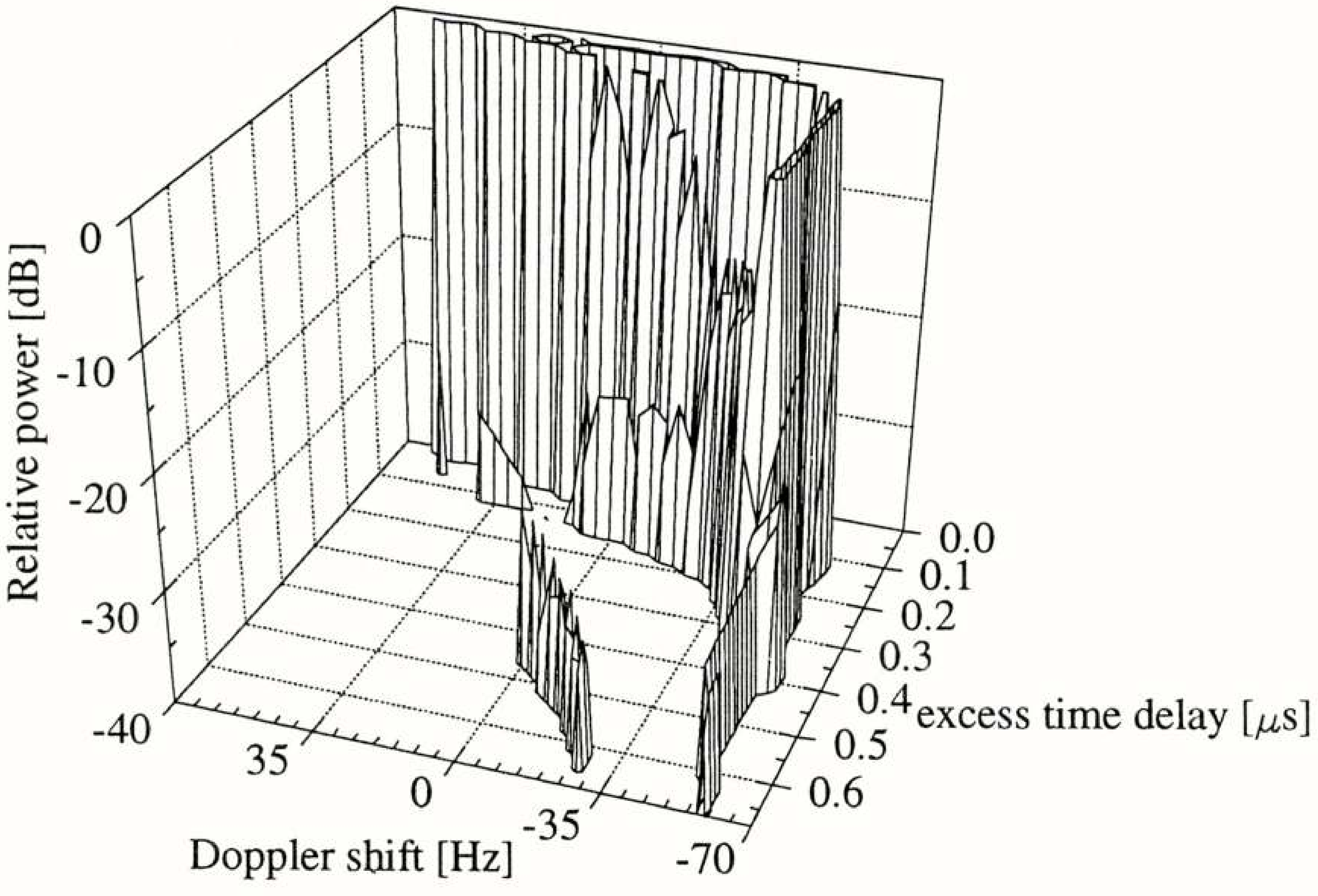


Figure 11: Delay-Doppler spectogram at 1.5 GHz.

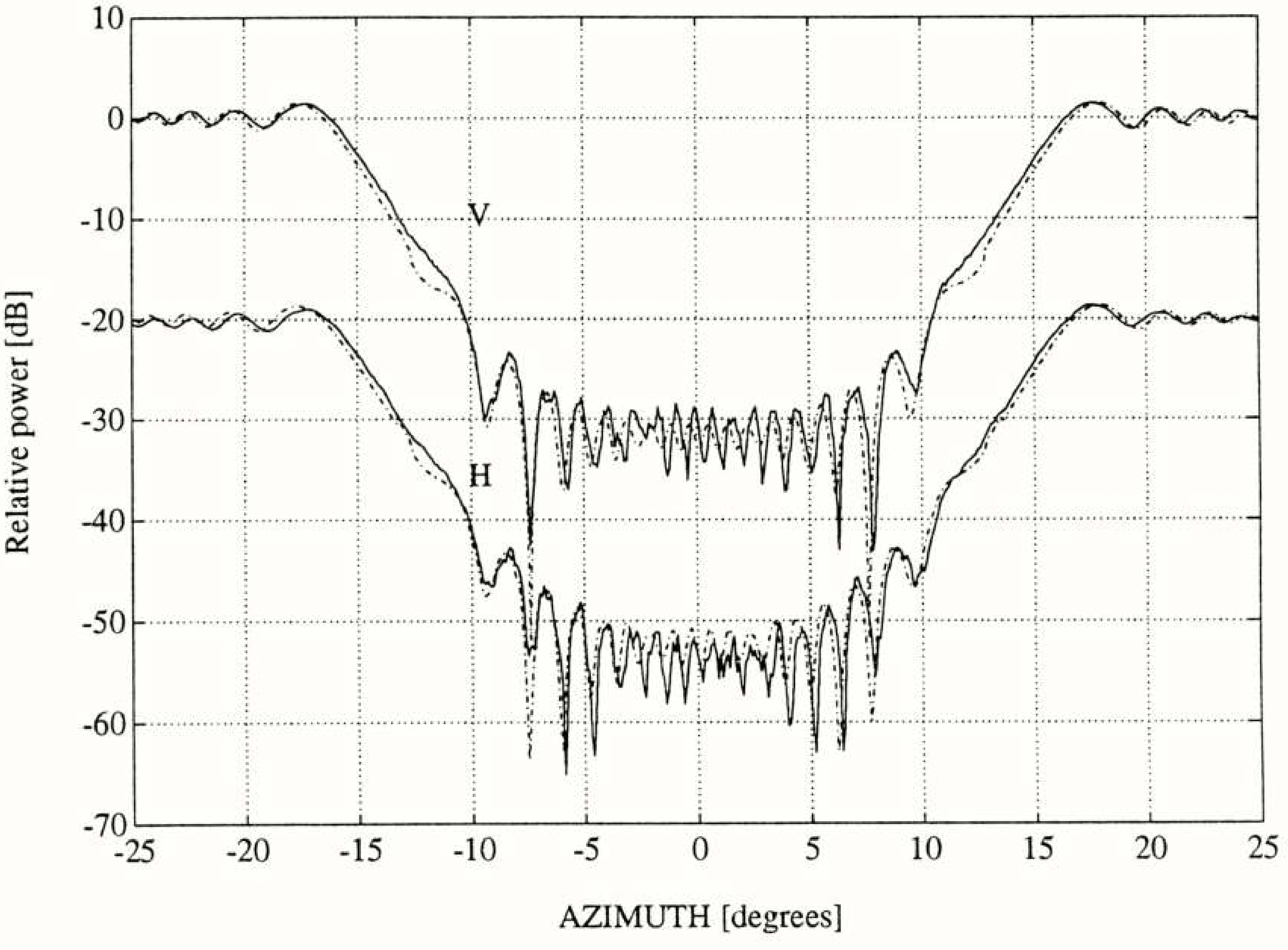


Figure 12: Field strength behind a rectangular block; measured (———) and calculated (-.-.-.-) for vertical (V) and horizontal (H) polarisation. The H-curves have been lowered by 20 dB for legibility.

ments such as broadcasting services and site shielding for VSAT networks.

Acknowledgment

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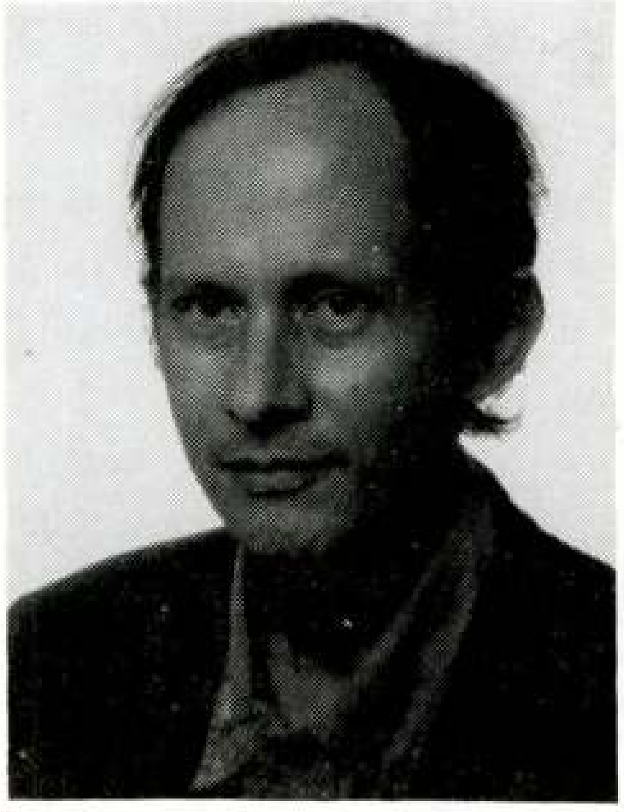
TERRESTRIAL LAND-MOBILE COMMUNICATIONS

A. Mawira
Signal Transmission Systems
PTT Research
PO Box 421,2264 XZ Leidschendam



Summary: The paper explains the role of propagation data and models in cellular communication systems (in particular in the planning of cellular networks and design of radio systems). The development of propagation models in the Netherlands is discussed.

1. Introduction

All over the world the market for terrestrial land-mobile communications (eg. GSM handhelds and car-phones in Europe) is rapidly growing. It is estimated that by the end of this century in the Netherlands alone more than a million people will be using this type of services. The radio-bands available for such communications are however very limited, in most countries less than a thousand channels have been allocated by the regulating agencies. This limited allocation is caused by the fact that the VHF/UHF frequency-band, which from the propagation point of view is attractive for providing such services, is also used for other purposes (e.g. broadcast, satellite-services, military).

In order to obtain the needed high capacity of the network, cellular techniques are applied [1]. Here the service area is covered by many cells. The communication within each cell is served by a base station located in the centre of this cell. Each of these base stations is linked by way of cable or microwave links with the fixed network which provides for the connectivity. With this method a frequency channel can be (re) used by many base stations, provided that the distances between them are large enough to ensure a minimum of interference. Figure 1 illustrates this principle using hypothetical hexagonal cell structures. In this example the available frequency channels are divided into 3 separate sets. Each base station is assigned the usage of only one of the 3 sets (in this figure indicated by the symbols: o, + and x). The base stations using a same frequency set are placed such that interference between them is minimised. This method of frequency/channel assigment is called Fixed Channel Assignment (FCA).

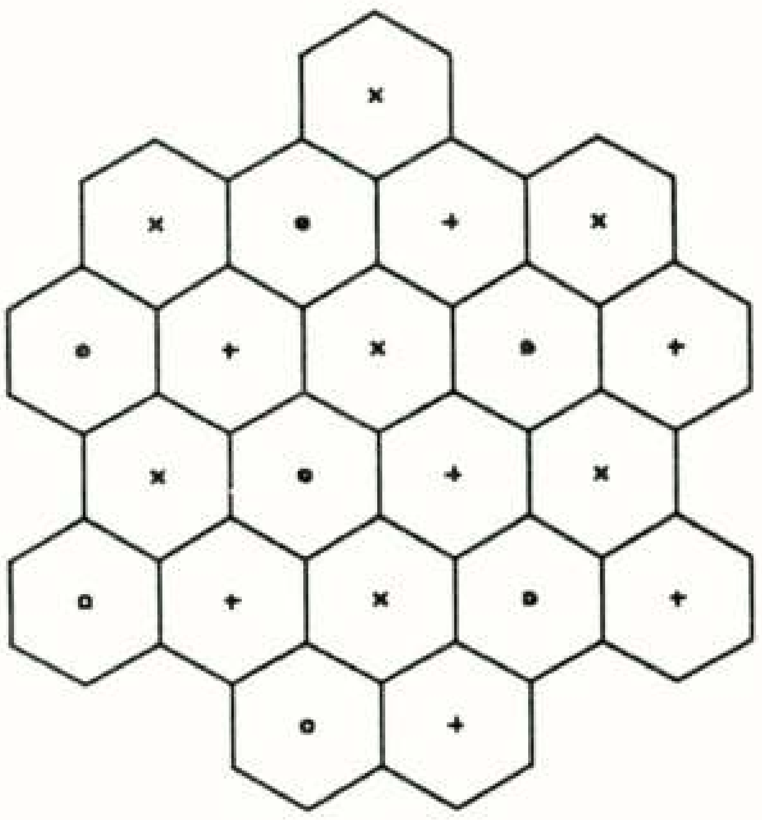


Figure 1. Celluar service areas.

The size of the cells is dictated by the capacity requirements. Higher capacity is obtained by using smaller cells in order to obtain higher number of channels per area. Currently cell sizes of 1 to 2km diameter are used in urban areas, while larger cells are used to cover rural areas. In the future the cell sizes, used in urban areas, may become much smaller, about 200 meters, in this case the cells are called micro-cells.
An alternative method to generate higher capacity is to split the cells in several sectors by equipping each bases station with several narrow beam antennas. In this way a larger frequency re-use can be obtained. At the moment sectors of 120 degrees are already employed. In the future antennas employing much smaller sectors will be employed with furthermore capabilities of dynamically reconfiguring themselves according to traffic need ('smart antennas'). Channel/frequency will be assigned dynamically according to the traffic need (DCA = Dynamic Channel Allocation), see [2].

Service areas with hexagonal structures as shown in Figure 1 can only occur in a hypothetical world with uniform propagation properties, such as the case of a spherical earth made of a homogeneous matter with no mountains and objects on it. The reality is of course much more complex, leading to a large variation of the strength of signals as it propagates outward from the transmitters.

For the designer of radio-systems and for the planner of cellular-networks knowledge of the propagation of radiowaves is of paramount importance. The designer of radio-systems must know the nature of the propagation channel, especially its dispersive characteristics, in order to be able to develop suitable modulation schemes. The planner of cellular networks must be able to predict the field strengths in order to evaluate the coverage and interference situation of various network scenarios before buying and implementing the very costly network hardware. In this paper we discuss this role of propagation data and models.

2. General propagation characteristics

The propagation in terrestrial land-mobile environments is generally very complicated. This is due to the fact that the mobile stations are located close to the ground so that a line of sight (LOS) situation, in urban areas, is very rare. The transportation of power happens here by way of many different paths, with the radiowaves undergoing attenuation, diffraction and reflections.

Many investigations have shown that two very different propagation effects may in general be discerned. The first effect represents the micro-structure characteristics (eg. channel distortion) of the propagation channel and is usually called the *multipath component*. The second effect represents the transmission loss: the *loss component*. These two effects can be introduced by way of the following 'link-budget' equation:

$$p_r = p_t \, g_B \, g_M \, \chi \, l \qquad \textbf{(1)}$$

p_r is the received power, p_t is the power fed to the transmit antenna, both in linear units (eg. milliWatt). g_B and g_M are the gains of the base and the mobile antennas, respectively. χ is the multipath component, and l is the slowly varying component. The multipath component is normalised to its mean value $<\chi> = 1$.
Note: in engineering practice it is usual to represent l by its deci-Bell representation L_b
(the *basic transmission loss*):

$$L_b = -10 \log_{10}(l) \qquad dB \qquad \textbf{(2)}$$

2.1 The multipath component χ

This component arises due to the fact that the received signal is the sum of many ray components, each ray having traversed a different path from transmitter to receiver (and having therefore a different phase). It represents the temporal, spatial and frequency 'distortion' of the signal. The resulting behaviour of the received signal depends strongly on the modulation system used.
In a narrowband *analogue* system the effect of multipath manifests itself in the occurence of 'fades' as the mobile unit moves along the road, see upper half of Figure 2. The interval of the deep fades is in the order of a wavelength (30 centimeter at 900 MHz). These fades are caused by the changing of the (relative) phases of the rays-components as the mobile moves along the road. As a result the way the ray-components combine with each other also changes, leading to other values of the received power. This effect is also known as Rayleigh fading.

In a *digital* system this multipath may result in intersymbol interference of the transmitted pulses. Each transmitted pulse will result in the reception of many pulses ('echoes') which reach the receiver by way of many different paths (each with a different path-length and subsequently a different delay time). The lower half of Figure 2 illustrates the reception of many such 'echoes' produced by transmission of a single pulse. Because of this phenomenon a transmitted sequence of pulses may result in the reception of very complex pattern of distorted pulses.

2.2 The loss component l

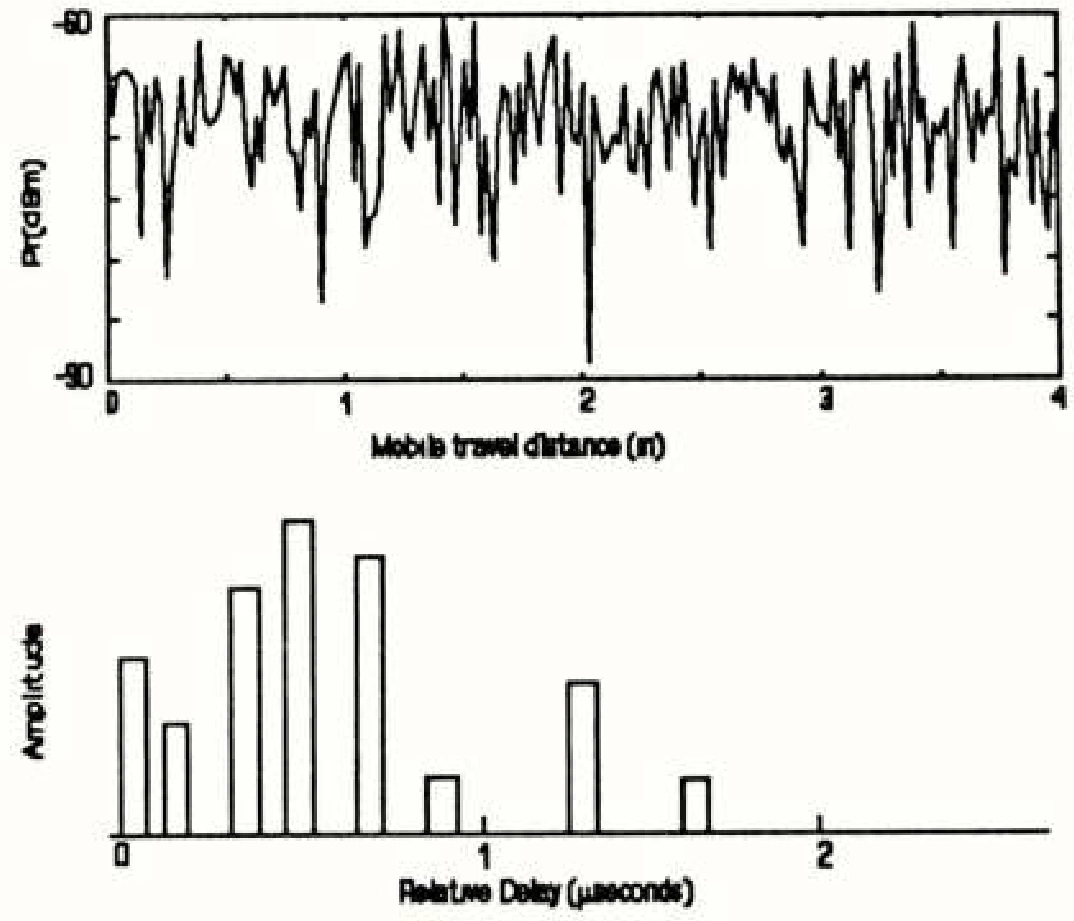


Figure 2. Illustration of "multipath" effects

l represents the true loss of power as the signal propagates from transmitter to receiver. In narrowband propagation experiments l is usually extracted from measured data through filtering or averaging over 10 meters (which effectively removes χ). Although the behaviour of l is very complex some general characteristics in non hilly terrain have been observed [3],[4]. These characteristics are illustrated by Figure 3.

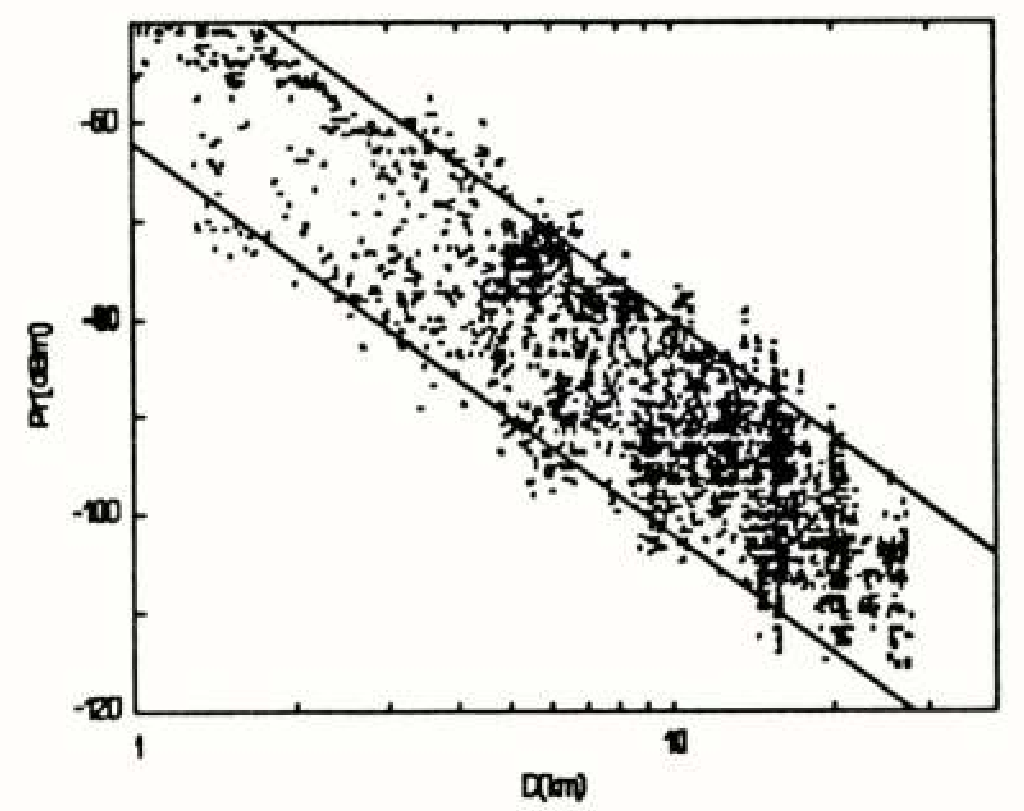


Figure 3. Example of influence of l

This figure gives data which were obtained from an experiment carried out at 900MHz nearby Utrecht. In this figure the received signal power, expressed in deciBell unit (dBm), is plotted against the distance, D(km), from base to mobile station. The received signal has been averaged over each 50m displament of the mobile station, so that the influence of χ has been removed. The area where this data was measured consists of open areas and areas with some houses and areas with some trees.
As can be seen from this figure p_r (resp. l), on average, decreases with distancce according a *power-law*:

$$l \sim D^{-\nu} \qquad \textbf{(3)}$$

There is however a large spread of the data points. The upper envelope of the data points corresponds to open regions, while the lower envelope corresponds to areas with some houses and trees. Such a behaviour has also be observed in other types of areas. In general the power law is found to be valid for many situations with the slope parameter having values in the range $3 < \upsilon < 4.5$. At very short distances with LOS conditions $\upsilon = 2$ (corresponding to free space conditions).

Finally, studies done by [5] have shown that the variations, expressed in dB, of l around its power-law predicted values can be modelled as the sum of two Normal processes, with correlation distances of about 100m and 1km, respectively (corresponding to street-to-street changes and changes in city macro structures).

3. Relevance of the propagation to cellular systems

3.1 Multipath

Propagation data are used in the design of various modulation systems. It is especially relevant to the design of digital modulation systems. In a digital Time Division Multiple Access (TDMA) this multipath may result in intersymbol interference of the transmitted pulses and subsequently loss of information unless special measures are taken.

In GSM, which uses TDMA, this multipath effect is combatted by regularly determining the channel response and subsequently reconstructing the original puls-train from the received distorted pulse-train by using the obtained channel information and sophisticated algorithms. In order to develop optimal algorithms it was necessary for the designer of radio equipment to know the specific nature of this multipath effect (eg. the relative delay-times & amplitudes of the 'echoes').

In 1986, during the specification phase of GSM, PTT Research has performed many such 'echo' measurements at 900 MHz. The results of these measurements, together with results from mainly Germany and Italy, were used by the GSM specification committee to define standard multipath channel characteristics with which equipment manufacturers can design their systems.

Note: A Code Division Multiple Access (CDMA) system is impervious to the multipath effects, provided that the spreading bandwidth is much larger than the coherent bandwidth of the channel (typically 1MHz in urban areas).

3.2 The loss component l

Information on the loss component, l, is mainly of interest to the planners of the cellular radio networks. It is vital to the optimisation of the cellular networks with regard to the cost, capacity and quality. We illustrate this by considering a simple scenario as given in Figure 4.

Here a base station is placed at position $X = 0$. A question that the designer has to answer is whether sufficient coverage can be achieved, e.g. is the signal reception within the envisaged cell strong enough. As can be seen from Equation (2) information on l is here needed as well as equipment specifications. The equipment specifications are given by the supplier (the information on multipath is usually also given by the supplier in the form of the sensitivity margin of the system).

While the above analysis is necessary when designing any type of radio link another complicated analysis has to be performed in the case of designing cellular radio networks. Namely: at which minimum distance, $X = D_u$, can another base station use the same set of frequency-channels as the base station at $X = 0$? The constraint here is that the interference within the two cells

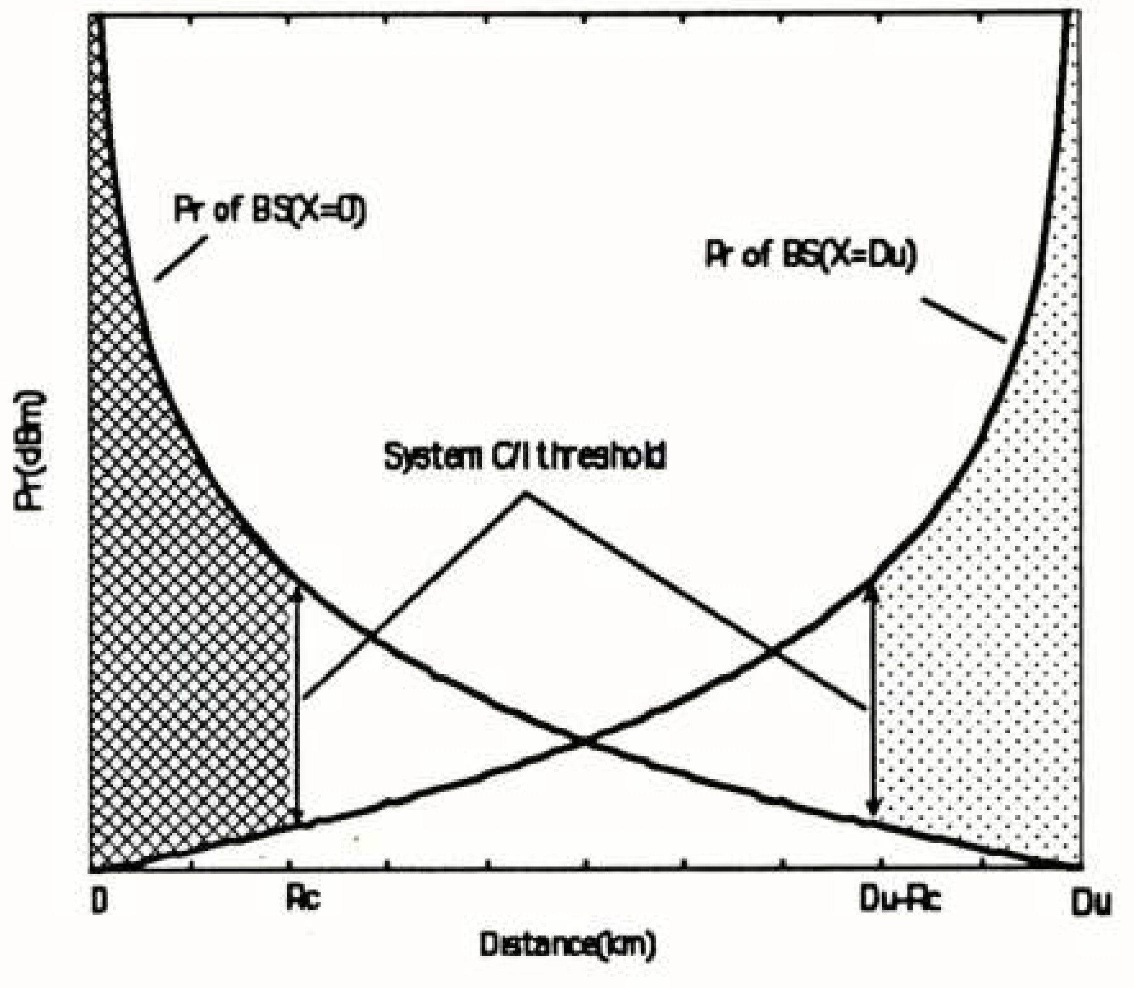


Figure 4. Interference between 2 BS.

must be kept to an acceptable level. In the simplified situation shown in Figure 4 we can see that at distances between 0 and R_c the signal transmitted from the base station located at $X = 0$ is much stronger than the signal transmitted from the base station located at $X = D_u$; the reverse situation applies at distances between D_u-R_c and D_u. At distances between R_c and D_u-R_c the ratio of the two signal strengths is not sufficient to allow interference free communication. When assuming that both base stations use the same values for the EIRP and assuming further that the simple power law model holds for the propagation, the ratio between the *reuse-distance* D_u and the cell radius r_c is given by:

$$D_u/r_c = 1 + (t_{C/I})^{1/\upsilon} \tag{4}$$

where $t_{C/I}$ is the *system Carrier to Interferer sensitivity margin*. For GSM $t_{C/I}$ is approximately 10 (or 10 dB) leading to D_u/r_c values of 2.8 to 3.2 (for $\upsilon = 4$ or 3). This means that with GSM two cells using the same frequency/channel sets need only to be separated by another cell using a different frequency/channel set. A more realistic two dimensional analysis produces the cell structure shown in Figure 1 (a 3-Cluster structure). An analogue system, e.g. NMT, has a $t_{C/I}$ value of around 300 (or 25 dB) leading to D_u/r_c values of some 5.2 to 7.7. In the NMT system each two bases station using the same frequency/channel must be separated by 3 cells with non-interfering frequency/channel sets. This leads to a 7-Cluster structure: each base station can use at most 1/7 of the available frequency channels. This simple analysis shows why the GSM system has an inherently higher capacity than the NMT system. Future GSM system, using half-rate codecs, will reduce the needed bandwidth per channel by half, leading to an even much more efficient system than NMT.

The above analysis is based on the assumption of a very simple behaviour of the propagation. In reality, as can be seen from Figure 3, the propagation shows a very complex behaviour. Large variations from the power law behaviour can occur, furthermore the variations of the signals associated with different base stations may or may not be correlated depending on the geometrical configurations [5]. *A planner which is not able to predict accurately the propagation will either produce a much too expensive network (e.g. by taking the worst case scenario) or just as likely produce a network of bad quality.*

4. Propagation models

Traditionally, propagation models for cellular radio has always been *empirically* based. That is to say the models were derived from a huge number of measurement data, by fitting simple equations to the radio and topographic data. Recently, more and more effort has been put to the development on models which is based on more exact theories regarding interaction of the radiowaves with generically shaped objects. This so called *fundamental* model has only recently become feasible with the advent of fast computers, accurate building data-bases and new developments in Electromagnetic Theory, see [6].

4.1 Empirical models

The traditional empirical models (e.g. models for large cell planning) are based on the observed fact the the behaviour of L_b (the deciBell representation of l), in non hilly areas, can be described by the following general form:

$$L_b = L_{ref}(D,h_B,h_M,f) + A_M + S \qquad \textbf{(5)}$$

L_{ref} is a simple mathematical function of the distance D, the heights h_B and h_M above ground of the base and mobile station antennas, and f the frequency. A_M is a propagation factor which depends mainly on the topographic characteristics of the area around the mobile station, eg. the value of A_M for open regions is some 30 dB smaller than that for an urban region. Finally, S represents a normally distributed stochastic variate with standard deviation varying from 5 to 10 dB depending on the region and resolution with which the prediction is carried out.

Usually the formula given by Ref.[4] is used for L_{ref}. Information on A_M must be found by the planners themselves through extensive calibration using measured radio data and their own topographic data. The accuracy that have been obtained with this model depends on the quality of the topographic data and the resolution; however an RMS error much better than 6dB, at 900MHz for 10m resolution, does not seem to be obtainable. In hilly terrain usually additional attenuation components are added to account for losses due to shadowing by hills.

For microcell applications this model is unsuitable. The reason for this is that in microcells the basestation is placed at a low height to ensure rapid decay of the signal with distance. This means that buildings nearby the bases station will have a large influence on the propagation. Without further modification the above model leads to large errors (RMS error > 10 dB) in microcell surroundings. At PTT Research we have investigated empirical methods to account for the influence of large buildings nearby the base station [7]. With such a modification a reasonably accurate model (RMS error = 7 dB) is obtained for *large microcell* applications (cell diameter not smaller than 500m). *Nevertheless the consensus now is that for true microcell applications the empirical model must be replaced by fundamental models such as that discussed in Section 4.2.*

Finally, for the multipath component the empirical approach that until now has been followed consists strictly speaking in no more than giving useful summaries of measured data (e.g. the average impulse-response delay pattern for GSM). Such data are only usefull for very restricted application, it is practically impossible to extend its application domain (e.g. to another frequency). The fundamental model given in Section 4.2 gives for the future a much more general method for studying the multipath effects.

4.2 Fundamental models

An alternative to the empirical approach is to actually model the true physical processes involved in propagation such as diffraction, scattering, absorption etc.. The most popular approach currently taken is to start from the high frequency approximation of the interaction of radio waves with objects of standard shapes (eg. a limited planar surface). Previous theoretical studies have shown that when the object is much larger than the wavelength the propagation can be accurately approximated as the sum of geometrical optical terms and diffraction terms. The geometrical optical terms represent the asymptotic high frequency limit (e.g. producing sharp boundaries between 'lit' and 'shadow' regions). The diffraction terms produces the more realistic transitions between 'lit' and 'shadow' region. An interesting aspect of this model is that the diffraction terms behaves as waves generated from simple sources (eg. point or line sources). This implies that the same method as mentioned above can be applied to estimate the results of the interaction of the diffracted waves with other objects. This leads to a recursive scheme, a parent wave generating secondary waves which in turn generates third order waves etc., which can be efficiently implemented in software, see [6] for review of fundamental models.

In 1993 Eindhoven University of Technology has developed such a fundamental model and implemented it in a software tool called FIPRE [8]. This tool has been developed for ESA for application to Land-Mobile-Satellite-Systems. In a cooperative venture between Eindhoven University of Technology and PTT Research this tool was subsequently modified for application to the more complex propagation surrounding of cellular radio and tested against measured data in 1994. The results of these tests have been reported elsewhere, [9], in this paper we summarise the results:

(1) At short distances (shorter than 200m) the model performs well, RMS errors between 5 to 7 dB were obtained.

(2) At larger distances the RMS errors increase markedly (up to 10 dB). The errors may be due to the high value assumed for the reflection coefficient of building surfaces. Furthermore, the roughness of the surface of many buildings suggests that diffuse reflection models must be developed and used.

(3) The computation time is high. On a 486DX2 66 MHz PC each point requires up to several minutes of computation time (which is several orders of magnitude slower than the speed required for usage in network planning). One of the reason for this is that the current software does not have the intelligence to quickly identify significant and insignificant propagation paths. As a consequence the current software wastes much valuable time in calculating insignificant propagation contributions.

(4) Unique measurements were performed which allowed the observation of the (azimuthal) angles and amplitudes of the incoming rays. The measurements show that in many cases, in a microcell configuration, the power is transferred by way of scattering by tall buildings, after that the strongly scattered waves are coupled into the streets, while within the streets an efficient propagation along the street takes place ('guided waveguide' mode). This result shows that attempts by some researchers to reduce computation time by restricting the calculation to a 2-dimensional situations cannot lead to a good result.

These initial results were obtained with a model which comes directly 'from the drawing board', without any empirical matching to measured data. It is therefore reasonable to expect a much better performance when the model is developed further by e.g. improving the model for the reflection process, using 'intelligent' algorithms and inclusion of models for propagation effects due to vegetation. We conjecture that within a few years an RMS error between 4 to 5 dB may be obtainable.

Now, we give here a result which demonstrates the strength of the FIPRE model as compared to the empirical model. Figure 5 shows the configuration of an experiment performed in The Hague. A 900MHz transmitter is placed at 23m height at the East side of building AB (which is some 30m high). Surrounding the AB building are some very tall buildings (taller than 40m), in this figure indicated by the 'filled' structures), such as the DC2 building.

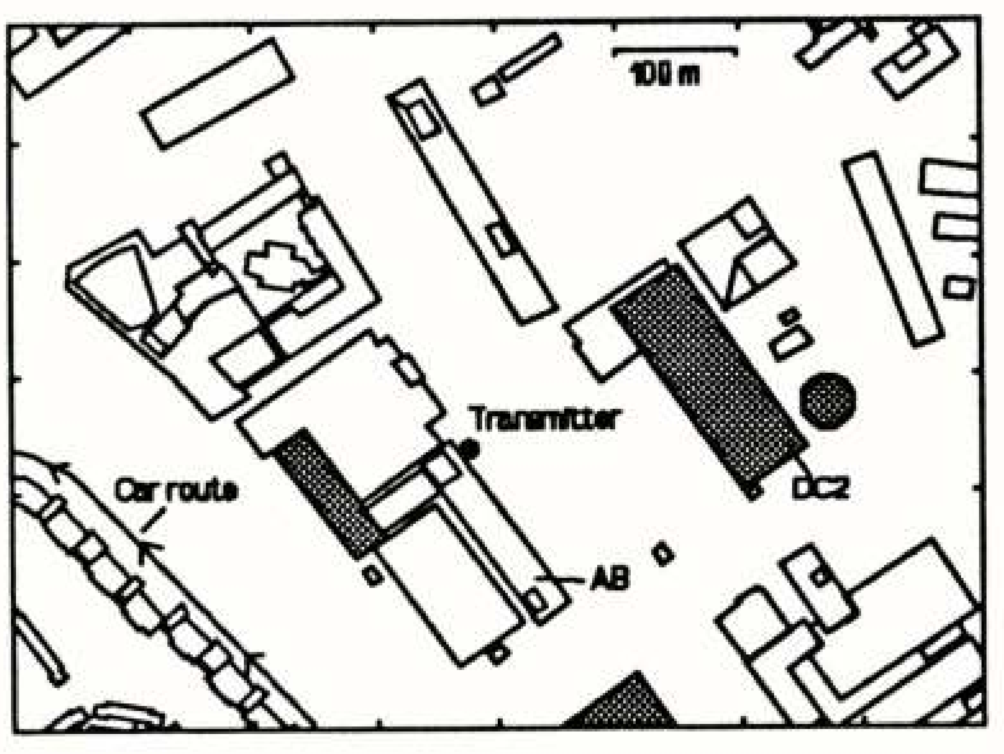


Figure 5. Experimental configuration.

At Valentijnstreet, located to the West of building AB, fieldstrength measurements were performed using a mobile unit.

According to the empirical model hardly any signal should be observed on this street. The signal in the direction of Valentijnstreet should have been totally suppressed by building AB (and the very low gain in that direction of the sector antenna used by the transmitter).

A glance at Figure 6 shows that markedly high signal levels were observed

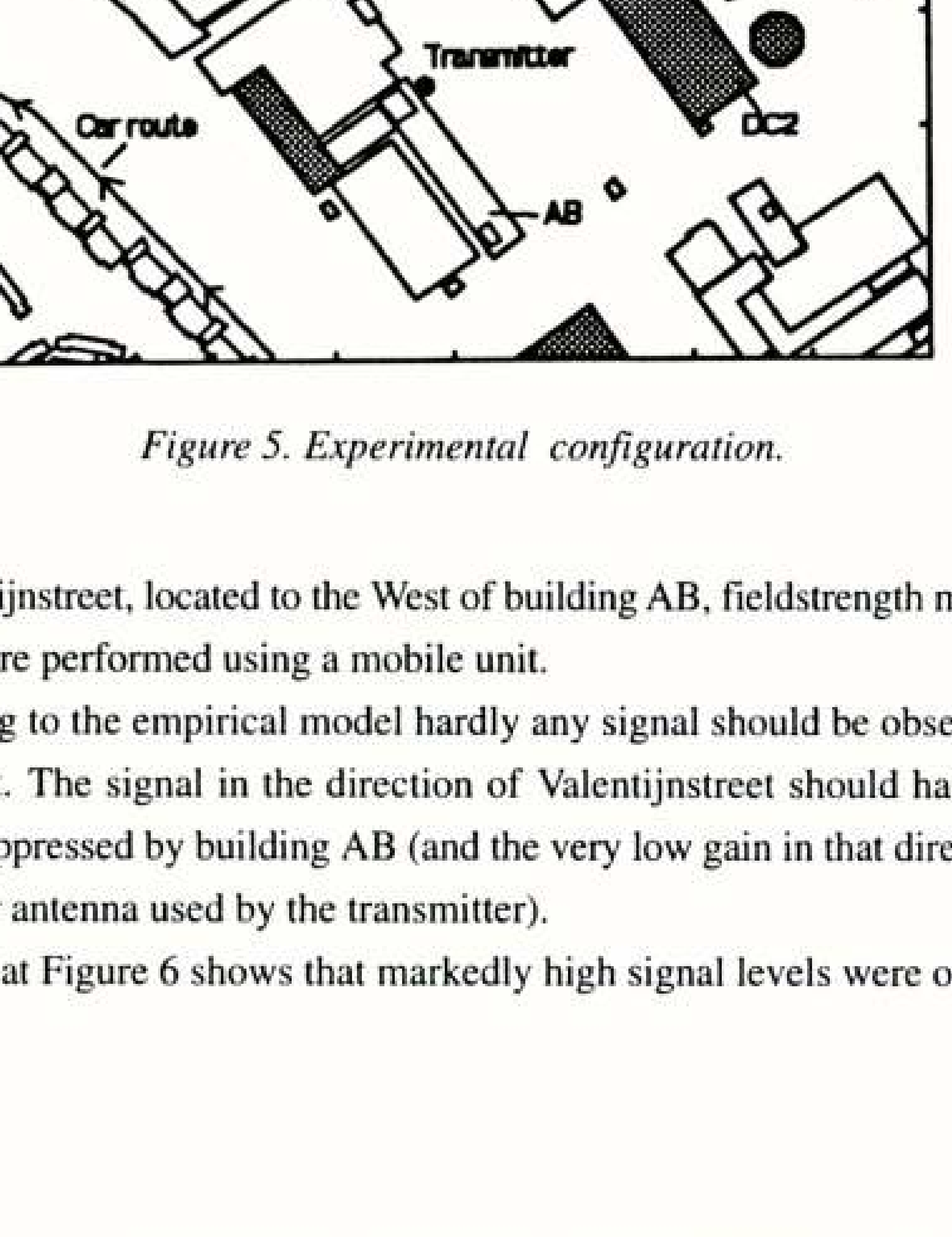


Figure 6. Measured & predicted signal.

at Valentijnstreet. The ray angle measurements show that backscatter of the radio waves by building DC2 is the dominant mechanism by which power is transferred to Valentijnstreet. In this figure is also shown the signal level predicted by FIPRE. The correspondence between measured and predicted signal levels is good (RMS error of 4.8 dB).

Finally, since the fundamental model inherently predicts the physical propagation components (the ray amplitudes and propagation path lengths or delays) it produces in a natural way the channel characteristics which radio system developers need in order to optimise their radio modulation design.

5. Conclusions

Propagation data and models are of paramount importance to both developer of radio modulation systems and planners of cellular networks.

Empirical propagation models at the moment still have their merits (e.g. reasonably accurate, simple to use and fast). However it becomes more and more difficult to modify and update these models in anticipation of new applications (e.g. microcells, 'smart antennas', broadband systems such as UMTS). For these new applications a new class of models, the so called fundamental models, must be used. The fundamental model FIPRE developed by the Eindhoven University of Technology represents at the moment one of the most advanced propagation prediction tool available. The tests carried out at PTT Research has shown that FIPRE, with further developments, has the potential to become a universal tool for propagation analysis for cellular applications.

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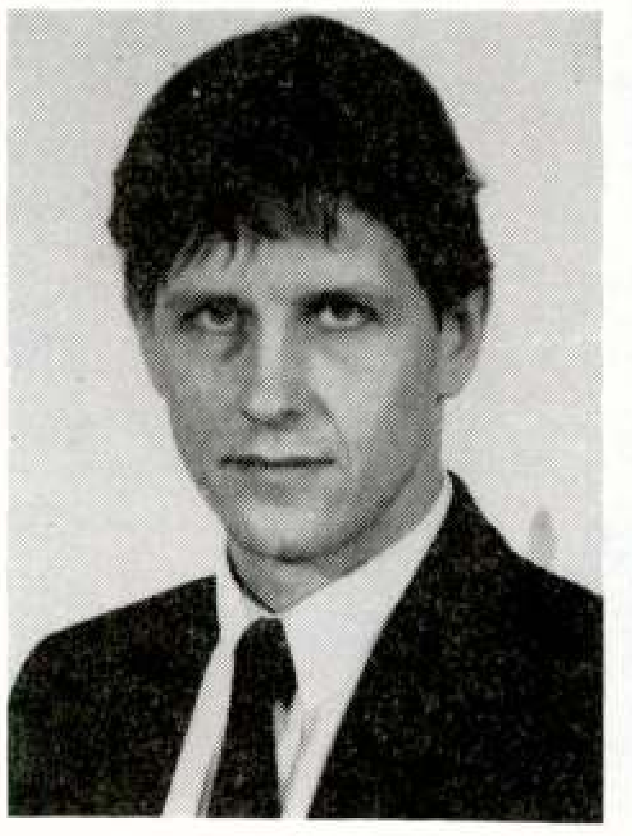
CHARACTERISTICS OF MILLIMETRE WAVE INDOOR RADIO CHANNELS

Ir. P.F.M. Smulders
Eindhoven University of Technology

Impulse response measurements have been carried out in various indoor environments at the Eindhoven University of Technology in order to determine the characteristics of millimetre wave indoor radio propagation. In addition simulations have been performed based on geometrical ray tracing. Both methods are briefly discussed and results are presented that globally express the characteristics of the millimetre wave indoor radio channel and their dependency on the antenna radiation characteristics. These results have been used to estimate the performance of millimetre wave indoor communication.



1. Introduction

The millimetre wave frequency range from about 25 GHz to 65 GHz is receiving major attention in European telecoms research initiatives such as the COST, RACE and ACTS programme [1,2]. The driving force behind this is the impossibility to accommodate the increasing capacity required for new radio applications such as high bit rate wireless LANs in the lower frequency bands. The millimetre wave bands are of special interest for indoor applications because of the possibility of frequency reuse between neighbouring rooms. The severe attenuation of most inner walls at these frequencies makes that the relationship between cell boundaries and the physical layout of the indoor environment is more easily determined facilitating indoor cell planning. Since millimetre waves might still "escape" through windows the band around 60 GHz is especially advantageous with respect to frequency reuse between buildings because of the specific attenuation due to atmospheric oxygen of 15 dB/km.

The indoor radio channel is an adverse multipath channel which might be highly frequency selective for the high bit rates of interest (e.g. 20 Mbit/s for high volume transfer, 45 Mbit/s for high resolution image retrieval). Therefore it is the main contributor to many of the problems and limitations that beset broadband wireless systems. Consequently, for the development, design and network planning of such systems, it is essential to provide accurate information about the characteristics of millimetre wave indoor radio channels. This information can be most reliably obtained from wideband propagation measurements. The measurement results can be used to describe the indoor radio characteristics in terms of statistical distributions and moments (statistical modelling). In addition to measurements the millimetre wave propagation characteristics can be simulated on the basis of geometric ray tracing (deterministic modelling). In turn statistical and/or deterministic models can be used for the design and optimization of the highly sophisticated signal processing required at the receiving end.

The main objective of the measurements and simulations was to obtain a large number of impulse responses from which the channel characteristics can be derived. Two simple parameters can be derived from each impulse response that are useful in describing the overall characteristics of the received signal.

A useful parameter in estimating the signal to noise ratio of communication systems is the *normalised received power* which is defined as the ratio of the total received power P_r and the transmitted power P_t. This ratio can be written as

$$\frac{P_r}{P_t} = \frac{1}{f_{\max}-f_{\min}}\int_{f_{min}}^{f_{max}} |H(f)|^2 df \quad , \tag{1}$$

in which $H(f)$ is the transfer function of the channel under consideration between the frequencies f_{min} and f_{max}.

The other parameter is the *rms delay spread* which is a measure of the channel dispersion (i.e. the temporal extent of the impulse response) which relates to performance degradation caused by intersymbol interference (ISI). In accordance with common practice we will define rms delay spread s_{rms} as

$$\sigma_{rms} \equiv \sqrt{\overline{\tau^2}-(\overline{\tau})^2} \quad , \tag{2}$$

where

$$\overline{\tau^n} \equiv \frac{\int_0^{\tau_{max}} \tau^n |h(\tau)|^2 d\tau}{\int_0^{\tau_{max}} |h(\tau)|^2 d\tau} \quad , \quad n = 1,2 \quad ,$$

in which $h(\tau)$ is the complex equivalent low-pass impulse response of the channel under consideration and hence the complex low-pass equivalent of the inverse Fourier transform of $H(f)$. τ_{max} is the maximum excess time up to which $h(\tau)$ is taken into consideration.

2. Measurements

Wide-band measurements have been performed in eight different indoor environments at the Eindhoven University of Technology. The measurement system is build up around a HP 8510C vector network analyzer, which performs frequency domain measurements of the channel transfer function $H(f)$ (S_{21} determination). A schematic diagram of the setup is shown in Figure 1.

The measurement system is essentially the same as an antenna measuring system. In fact it was also used for determining the radiation patterns of the applied antennas. It is important to notice that these antennas are part of the radio channel and that their radiation patterns have impact on the channel's propagation characteristics. The antennas applied are identical biconical horns exhibiting an omnidirectional radiation pattern in the horizontal plane and a narrow beam (3 dB beamwidth is 9°) in the vertical plane [3].

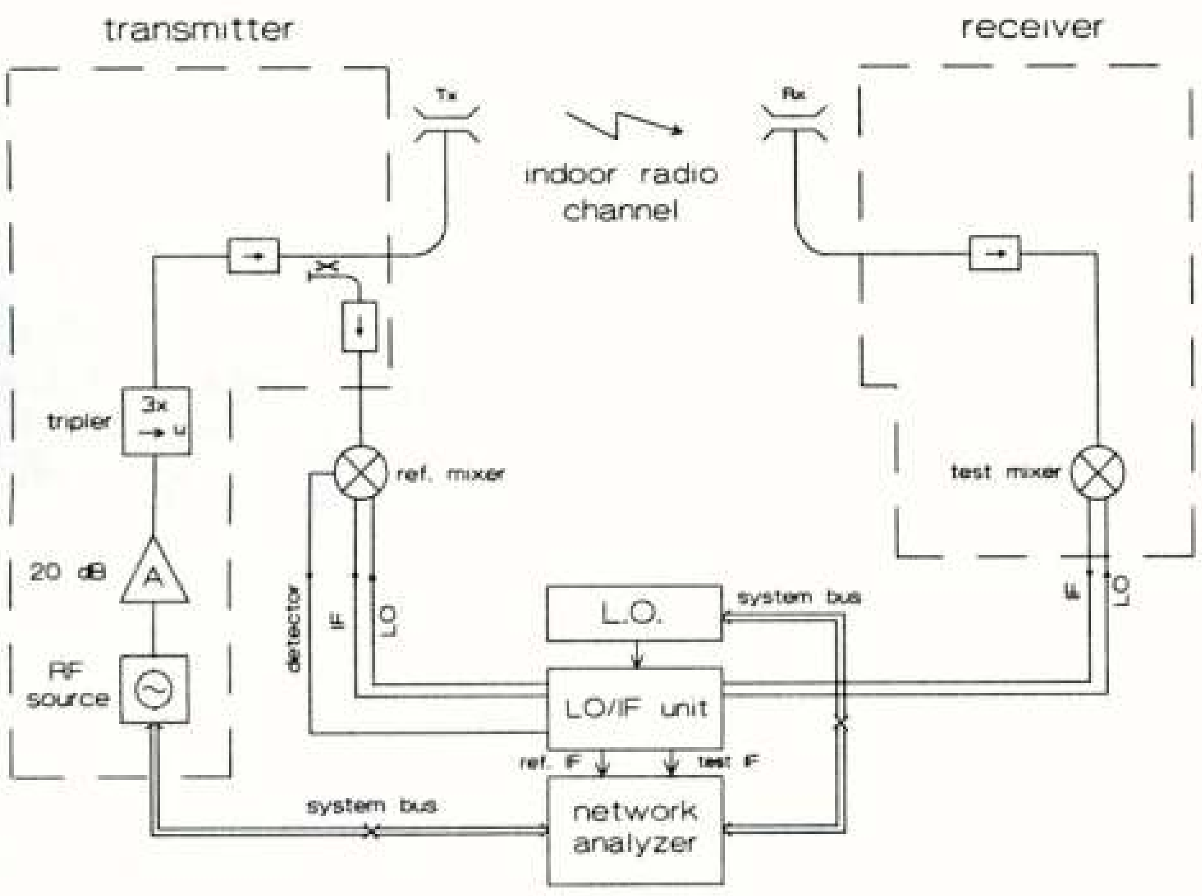


Figure 1: *Measurement setup.*

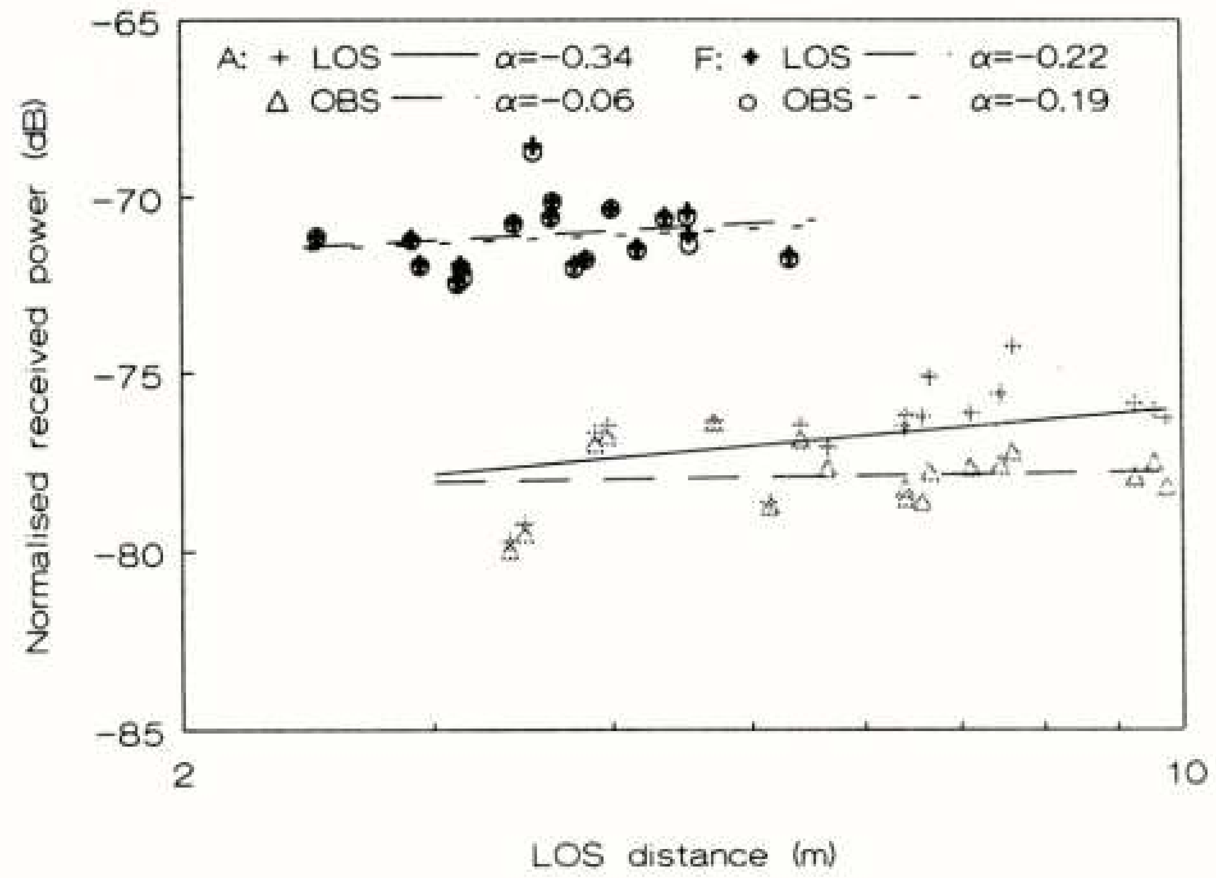


Figure 2: NRP values obtained in environments A and F.

The configuration considered consists of a base station (in our case the receiver) centrally located in the indoor area and remote stations (transmitter) around. The base station antenna is fixed at 3 metres height in the middle of each environment. The antenna of the remote station is fixed at 1.4 metres height.

The measured environments consist of one single room, a single corridor or a single hall only, because millimetre waves are severely attenuated by inner walls. In what follows these environments are denoted A to H. Table 1 lists the approximate dimensions, dominant wall material and associated return loss (i.e. reflection attenuation measured at perpendicular incidence) of each environment under consideration. More detailed descriptions can be found in [4].

Env.	Dimensions (m^3)	Wall material	Return loss (dB)
A	24.5*11.2*4.5	wood	-8
B	approx. 30*21*6	wood	-8
C	approx. 43*41*7	concrete	-2
D	33.5*32.2*3.1	concrete	-2
E	44.7*2.4*3.1	metal	0
F	9.9*8.7*3.1	metal	0
G	12.9*8.9*4.0	wood	-13
H	11.3*7.3*3.1	concrete	-2

Table 1: Environment data

The measurements are carried out at about 20 randomly chosen positions for the remote station in each environment. The transfer function of each channel has been measured in the frequency band from f_{min}=57 GHz to f_{max}=59 GHz. The results are used to determine the NRP according to (1).

Figure 2 shows scatter plots of NRP versus separation distance r on a log scale for both unobstructed LOS path (LOS) and obstructed LOS path (OBS) situations for Environment A and Environment F.

The lines are linear fits based on the minimum mean square error with the relationship

$$10\log\left(\frac{P_r(r)}{P_t}\right) = 10\log\left(\frac{P_r(1m)}{P_t}\right) - 10\alpha\log(r) \quad , \qquad (3)$$

in which $P_r(1m)/P_t$ is the (fitted value of the) NRP at the separation distance of 1 m, while α represents the power-distance decay rate exponent. NRP values are typically between about -70 and -82 dB. High values are found for environments with much metal within, while relatively low values are found in environments with only low reflective materials within like wood.

Measured values of α were typically much smaller (<0.5) than those reported for indoor UHF radio channels. This is because with our setup the value α is not only determined by the LOS distance r, but by the antenna gain function in elevation as well [3]. In addition it occurs that, per environment, the spread in NRP values as well as the differences in NRP values between LOS and corresponding OBS situations are only a few dBs. By comparing the NRP values obtained at 57-59 GHz (Figure 2) with results obtained at 41-43 GHz which have been undertaken in the same rooms, at the same positions and with biconical horn antennas having the same dimensions in terms of wavelength, a constant difference of about 4.5 dB in received power is found [3]. This can be accredited to the lower free-space loss.

Figure 3 shows the cumulative distribution functions of RDS values for both LOS and OBS situations obtained in the environments B, C, D and E. RDS values tend to increase with increasing reflectivity of the

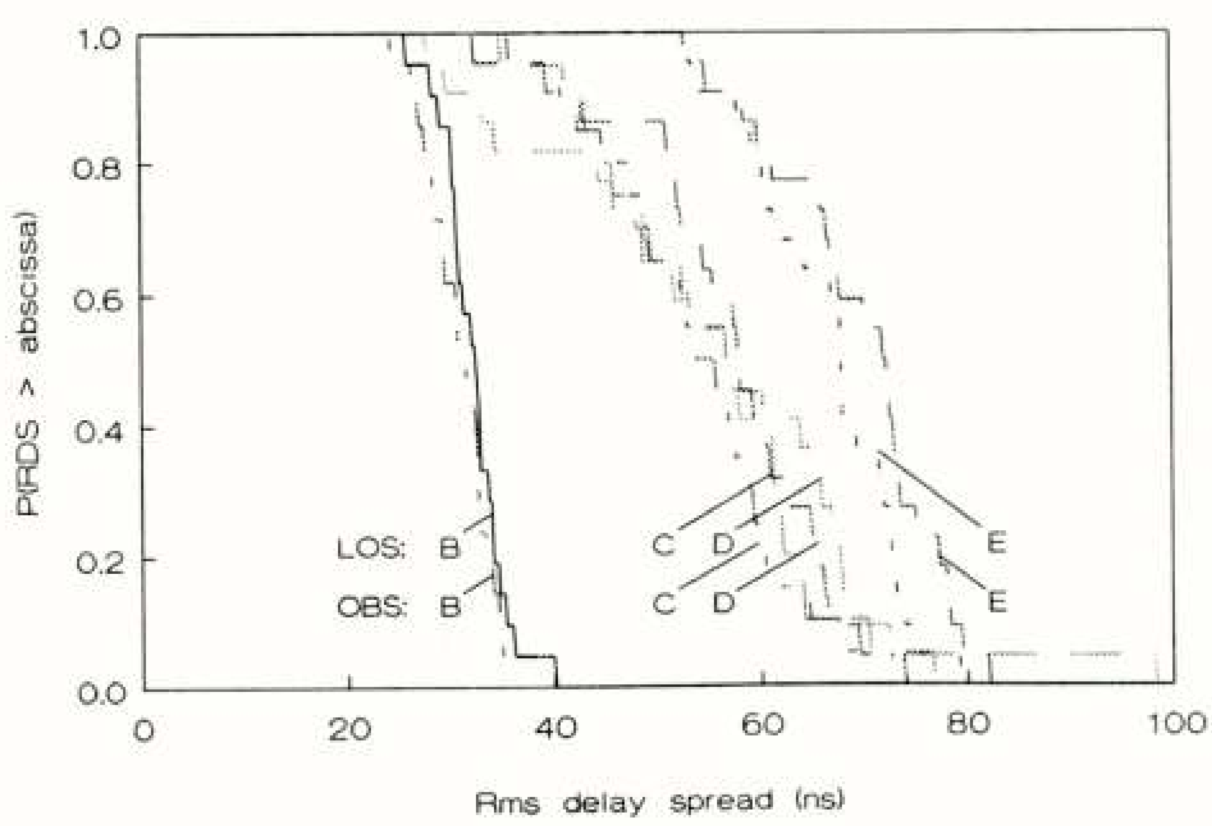


Figure 3: Cumulative distributions of RDS in environments B, C, D and E.

walls and with increasing environment dimensions. Obstruction of the direct path does not necessarily imply that RDS has to increase. Both increases and decreases are observed. Values of 13 ns to 98 ns have been found. The values obtained range from 13 ns (Environment G) to 98 ns (Environment C).

3. Simulations

For simulating the propagation characteristics of millimetre waves in a multipath environment we developed the simulation package PROSIM. The underlying algorithm traces possible reflected rays between transmit and receive antenna in a pre-defined environment according to the concepts of classical Geometrical Optics (GO). Since we consider the millimetre wave part of the frequency spectrum we exclude diffraction effects and transmission through walls. This enables fast ray tracing that can be interactively applied. PROSIM can be used for the examination of polarization effects, effects of antenna directivity and orientation, effects of LOS obstruction etc.

3.1 Accuracy checking

The accuracy of the applied propagation model is examined by comparing simulation results with results obtained from actual measurements. The simulation results are based on the reflectivity data as listed in Table 1.

Figure 4 shows a typical measured and simulated impulse response (magnitude only) obtained in Environment A with biconical horn antennas. The simulated and measured amplitudes of the most dominant rays comply fairly well. In addition it can be observed that the moments of occurrence of those dominant rays in the simulated response agree well with the ones in the measured response. However, in the measured response the spacings in between the dominant rays are filled up with lower level rays whereas in the simulated profile deep nulls are present. This difference may be attributed to diffraction and scattering from small details in the room including surface roughness etc. which are not taken into account in the propagation model.

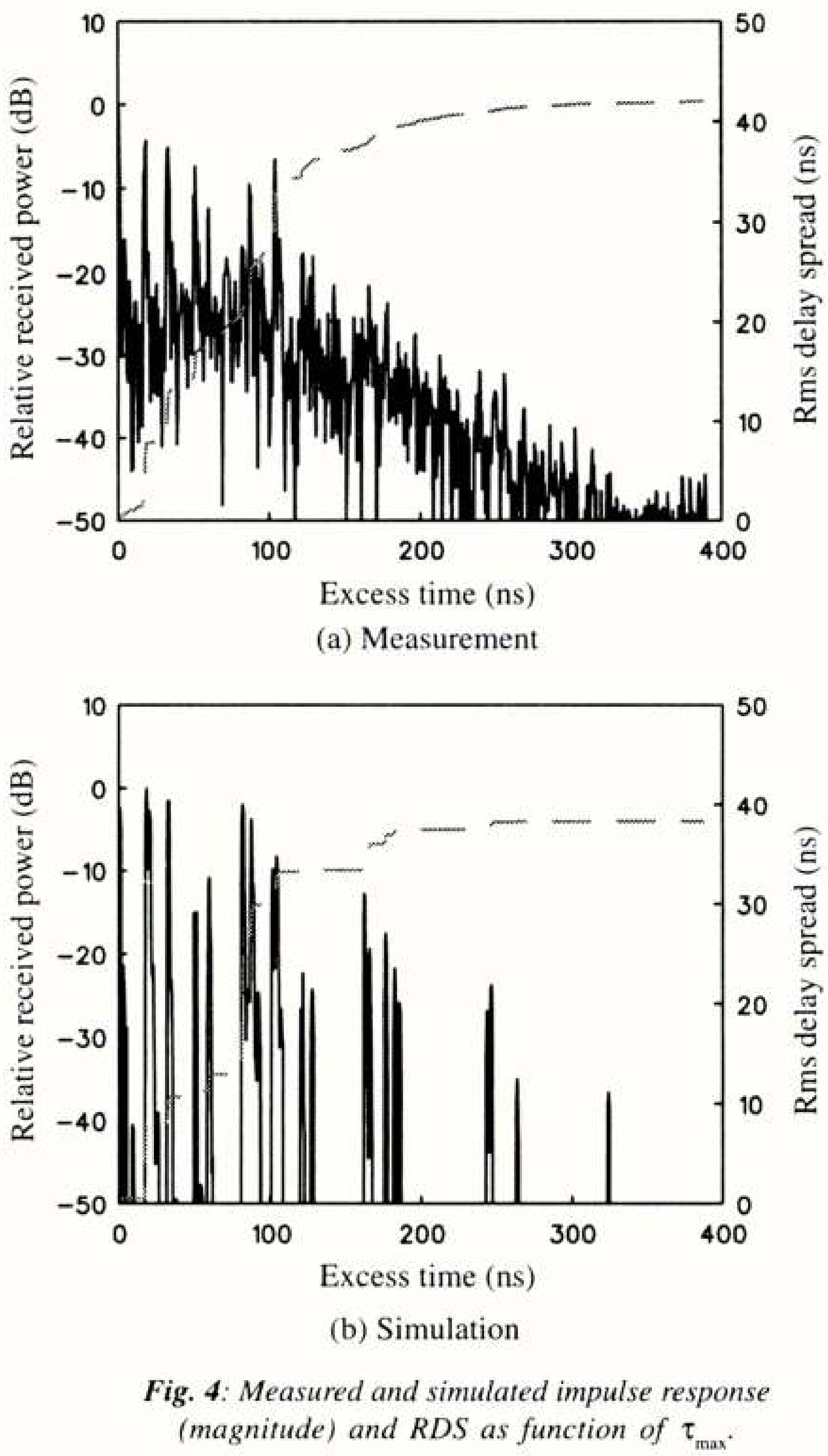


Fig. 4: Measured and simulated impulse response (magnitude) and RDS as function of τ_{max}.

Figure 4 also shows curves representing the RDS as a function of τ_{max}. These curves give a good impression of the amount each individual ray contributes to the total RDS. It occurs that the lower level rays in the measured response which are present in between the dominant rays (i.e. the rays which also appear in the simulated response) do not yield a significant contribution to the total RDS. This fact clearly acts in favour of the accuracy of the applied model.

For the responses depicted in Figure 4 it occurs that τ_{max} should be at least about 200 ns. For our measurements and simulations we took τ_{max} = 400 ns allowing also accurate calculation of the largest RDS values of about 100 ns.

With respect to the measured and simulated NRP and RDS results obtained in all environments it occurs that the simulated results lie close to the measured results. The worst matches are obtained for the irregularly shaped environments. For one exceptional case the measured and simulated results showed significant mutual differences of about 50% for Environment F with highly reflective (metal) walls. This was however due to the limitation in the calculation of the number of reflections to 4 in the simulations which causes the responses to terminate too quickly.

3.2 Additional simulations

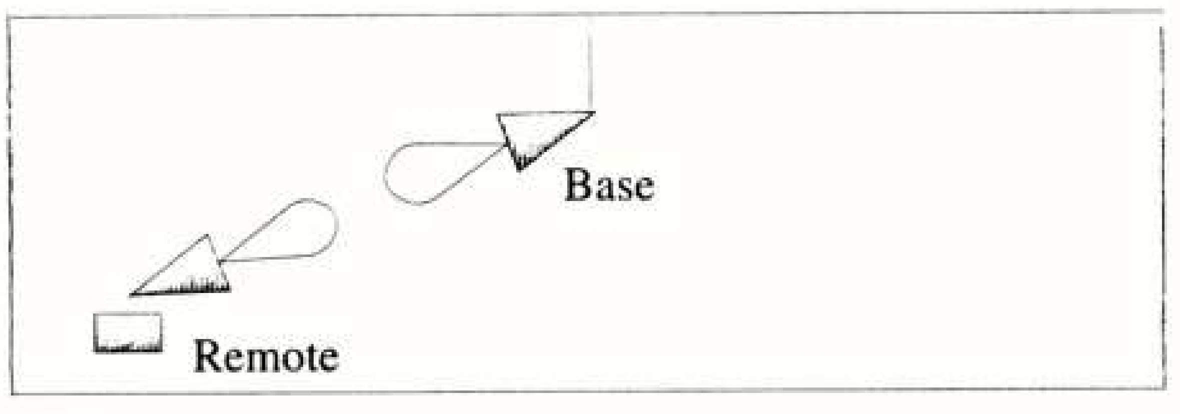
Since good agreement was found between the simulation and measurement results we continued with using PROSIM for a more thorough examination of the influence of the environment and antenna characteristics on NRP and RDS. The relation between NRP and RDS on the one side and the shape and orientation of antenna radiation beams on the other is evaluated under both LOS and OBS conditions. To examine the influence of wall reflectivity two rooms are considered having equal dimensions similar to those of Environment A. One room has low reflective walls (return loss at perpendicular incidence equals -10 dB) whereas the second room has walls with high reflectivity (return loss at perpendicular incidence equals -1.5 dB). In both rooms, the receive antenna (representing the base station antenna) is located at 3 metres height in the middle of the room, whereas the transmit antenna (representing the remote station antenna) is placed 1.4 metres above the floor at 24 randomly chosen positions throughout the room (as with the measurements). For every position of the transmit antenna the impulse response is calculated. Next, the NRP and RDS are derived from each obtained profile.

The antennas implemented in PROSIM are smooth walled sectorial horn antennas and biconical horn antennas. In contrast with the omnidirectionally radiating biconical horns sectorial horns might produce highly directive radiation beams. To examine the influence of antenna directivity antennas are implemented in PROSIM with various beam directivity values; the directivity of the biconical horn beams were in the range of 6.9 to 12.7 dBi whereas the directivity of the sectorial horns ranged from 9.1 to 25.2 dBi.

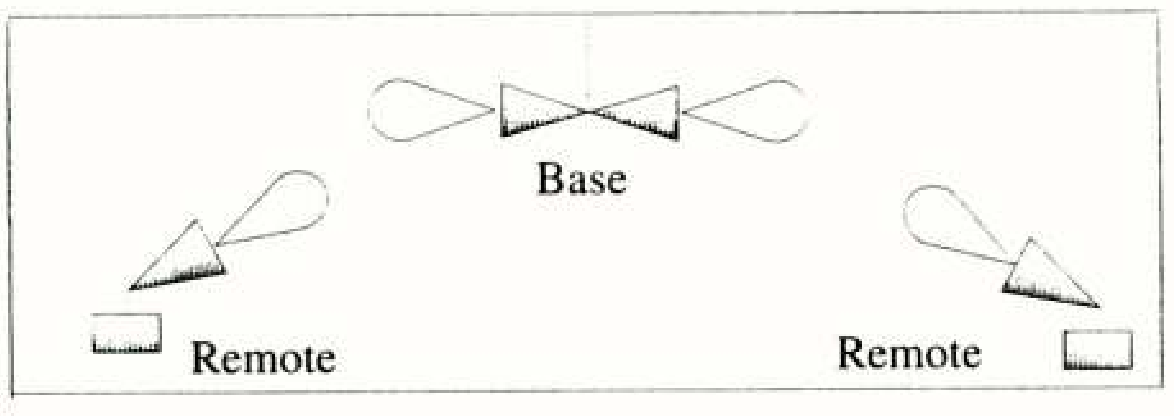
Simulations are performed for the three different antenna setups depicted in Figure 5. Figure 5a. shows the antenna setup with a sectorial horn at both the remote and base station, denoted as the "sec-sec setup". Figure 5b. depicts the antenna setup with a sectorial horn at the remote station and a biconical horn at the base station, called the "sec-bic setup". Figure 5c. shows the antenna setup with a biconical horn at both the remote and base station, the "bic-bic setup".

The sectorial horns in Figure 5a. are pointing towards each other, eventually with a certain amount of mispointing in order to examine the effects of pointing errors. The orientation of the error angles at the remote and base station are mutually independent and randomly chosen. In the antenna setup of Figure 5.b the sectorial horn at the remote station is pointing towards the biconical horn. Here, pointing errors are only introduced in the radiation beam of the sectorial horn at the remote station. In the antenna setup of Figure 5c. both biconical horn antennas are radiating in the horizontal direction.

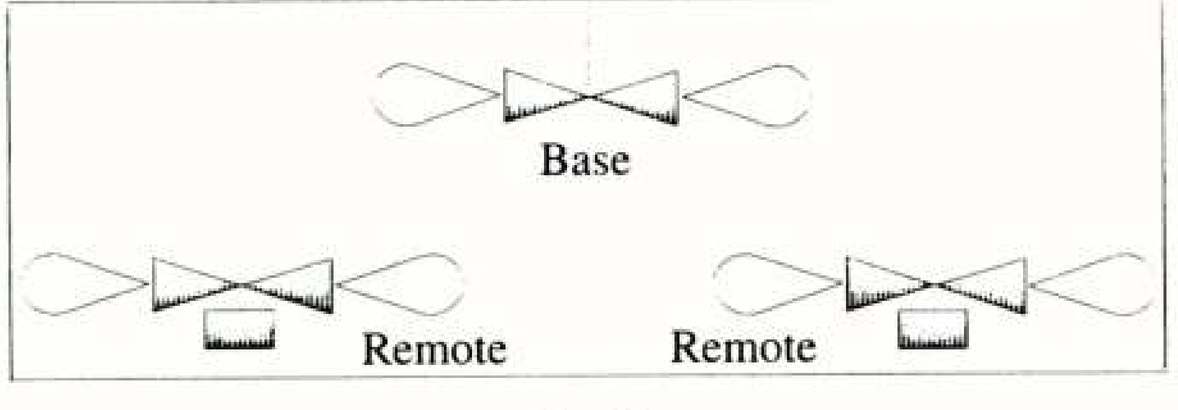
With respect to the sec-sec setup it could be observed that an antenna setup with 25.1 dBi sectorial horns at both ends yields the lowest RDS values and the highest NRP values when compared with the other examined



(a) sec-sec



(b) sec-bic



(c) bic-bic

***Figure 5**: Simulated antenna setups.*

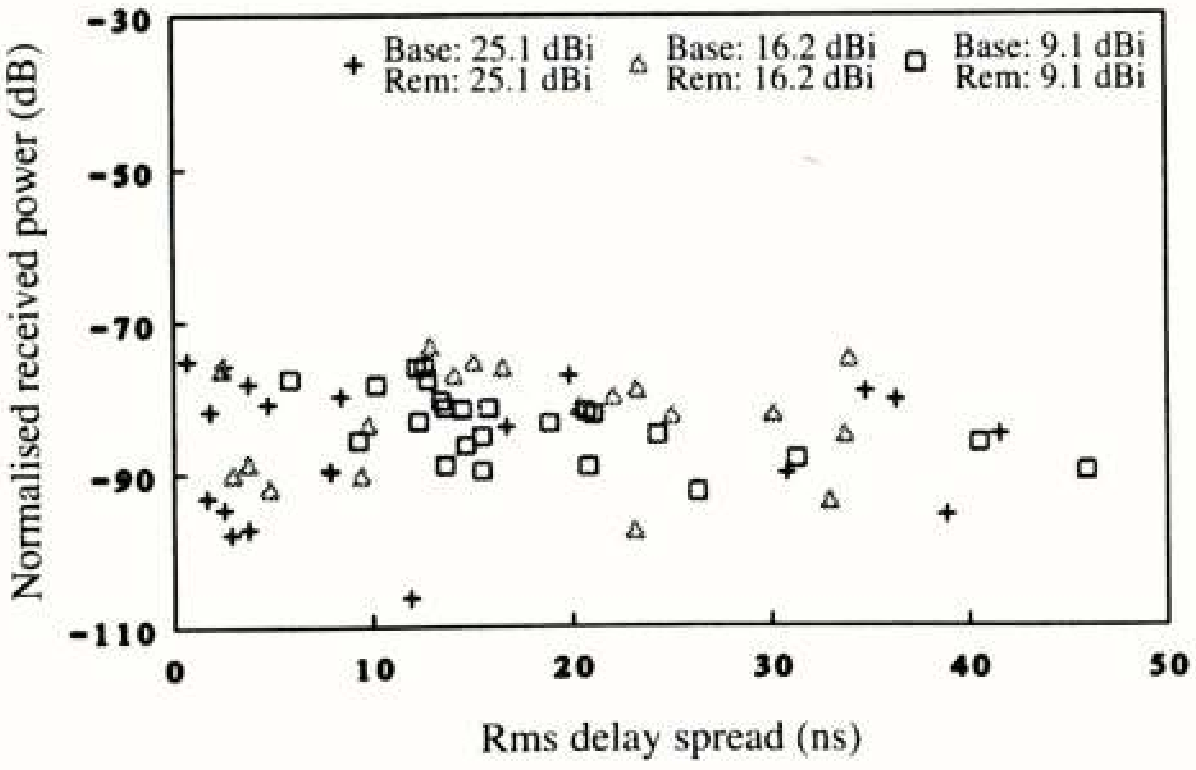


***Figure. 6**: Results for the low reflective environment with "sec-sec" setup and obstructed LOS*

configurations, provided that there is no obstruction of the LOS path and provided that the antenna beams are exactly pointing towards each other. The sec-sec setup is however highly sensitive for LOS obstruction and mispointing. This is illustrated in Figure 6 and Figure 7, respectively which show the NRP versus RDS for every position of the remote station. The combination of LOS obstruction and 5° mispointing results in a fairly uniform spread in RDS and NRP. A higher reflectivity of the walls results in higher NRP values as well as higher RDS values.

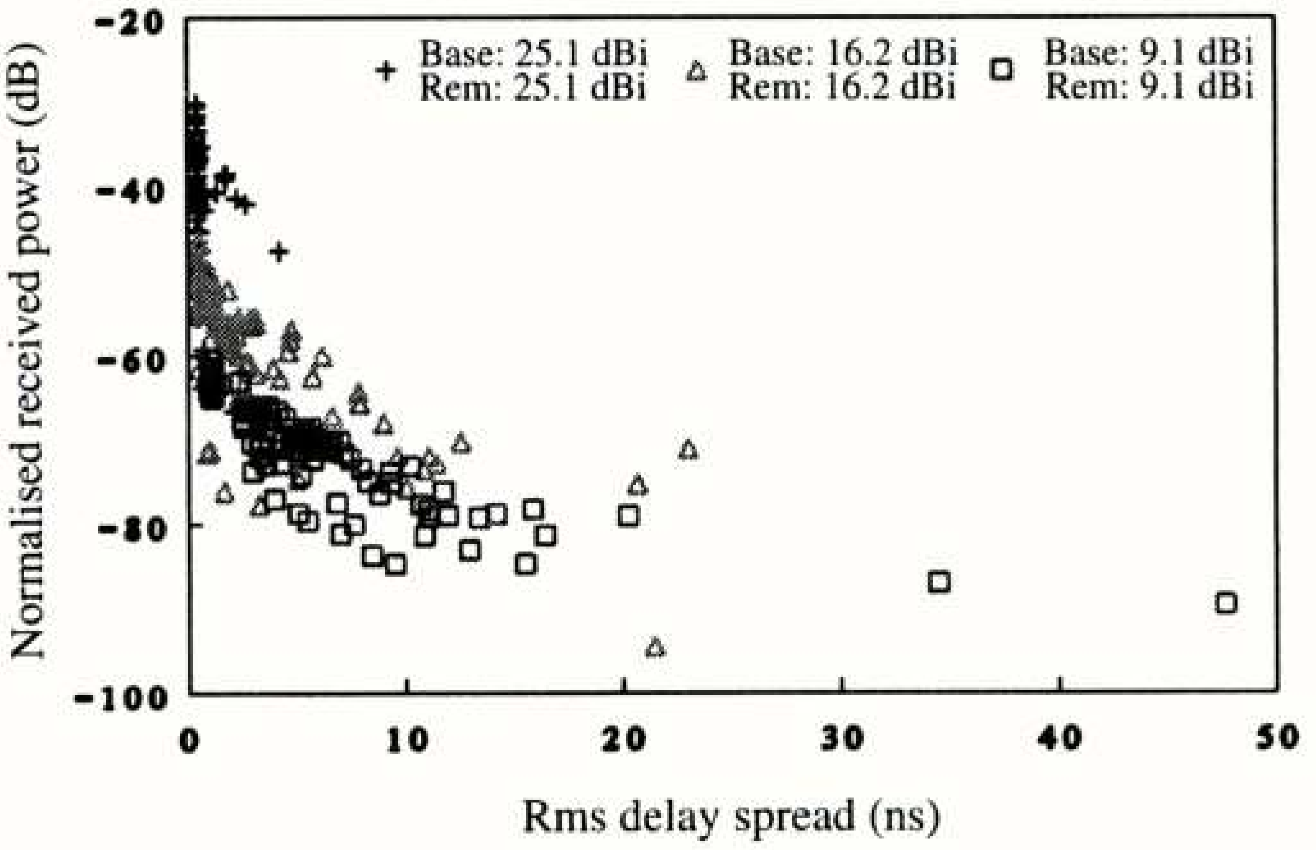


***Figure 7**: Results for the low reflective environment with "sec-sec" setup and 5° pointing error.*

As with the sec-sec setup it occurs that the bic-sec setup is sensitive for obstruction of the direct ray and mispointing. The difference with the sec-sec results is however that the minimum and maximum values for NRP and RDS for the sec-bic setup are not so extreme. The spread in NRP values is significantly lower.

With respect to the "bic-bic" setup it occurs that, in contrast with the sec-sec and sec-bic setup, an increase in antenna directivity yields an increase of the RDS values. Figure 8 depicts the results obtained with a 9 dBi biconical horn at each end for both LOS and OBS. The differences in NRP values between those two cases are only a few dB. This indicates that the bic-bic setup is highly insensitive to LOS obstruction. Furthermore the low spread in NRP values is striking. It demonstrates that with the application of properly dimensioned biconical horn antennas we can achieve an almost uniform coverage within the boundaries of an indoor coverage cell. This phenomenon is explained by the fact that for larger separation distance r, the corresponding larger free space loss is compensated by the elevation dependence of the radiation patterns [3].

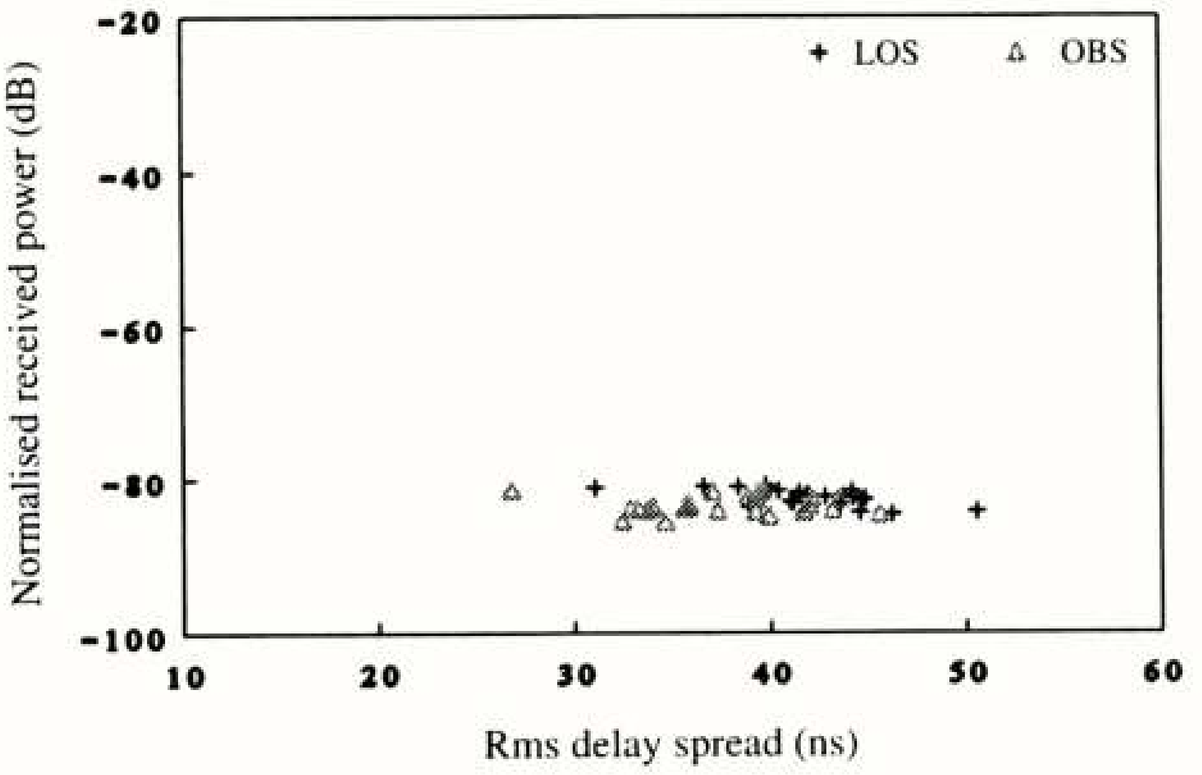


***Figure 8**: Results for the low reflective room with bic-bic setup under OBS and LOS conditions.*

The similarity between LOS and OBS and uniformity in coverage is also found for the highly reflective room with slightly higher worst-case values of about 55 ns rms delay spread and -72 dB normalized received power.

4. Utilization of the results

The results obtained from the propagation measurements and simulations have been used to estimate the performance of millimetre wave indoor radio systems. As an example Figure 9 shows outage curves for a QPSK receiver with and without Decision Feedback Equalization (DFE). The configuration considered is the bic-bic configuration in Environment A under LOS as well as OBS conditions. The outage curves indicate the percentage of locations for which the probability of bit error exceeds 10^{-3} as function of the data rate. The QPSK/DFE curves refer to a DFE with low complexity in the sense that it has only 3 forward taps. In spite of its low complexity the QPSK/DFE recei-ver can operate at a data rate that is at least one order of magnitude higher than a QPSK receiver without DFE.

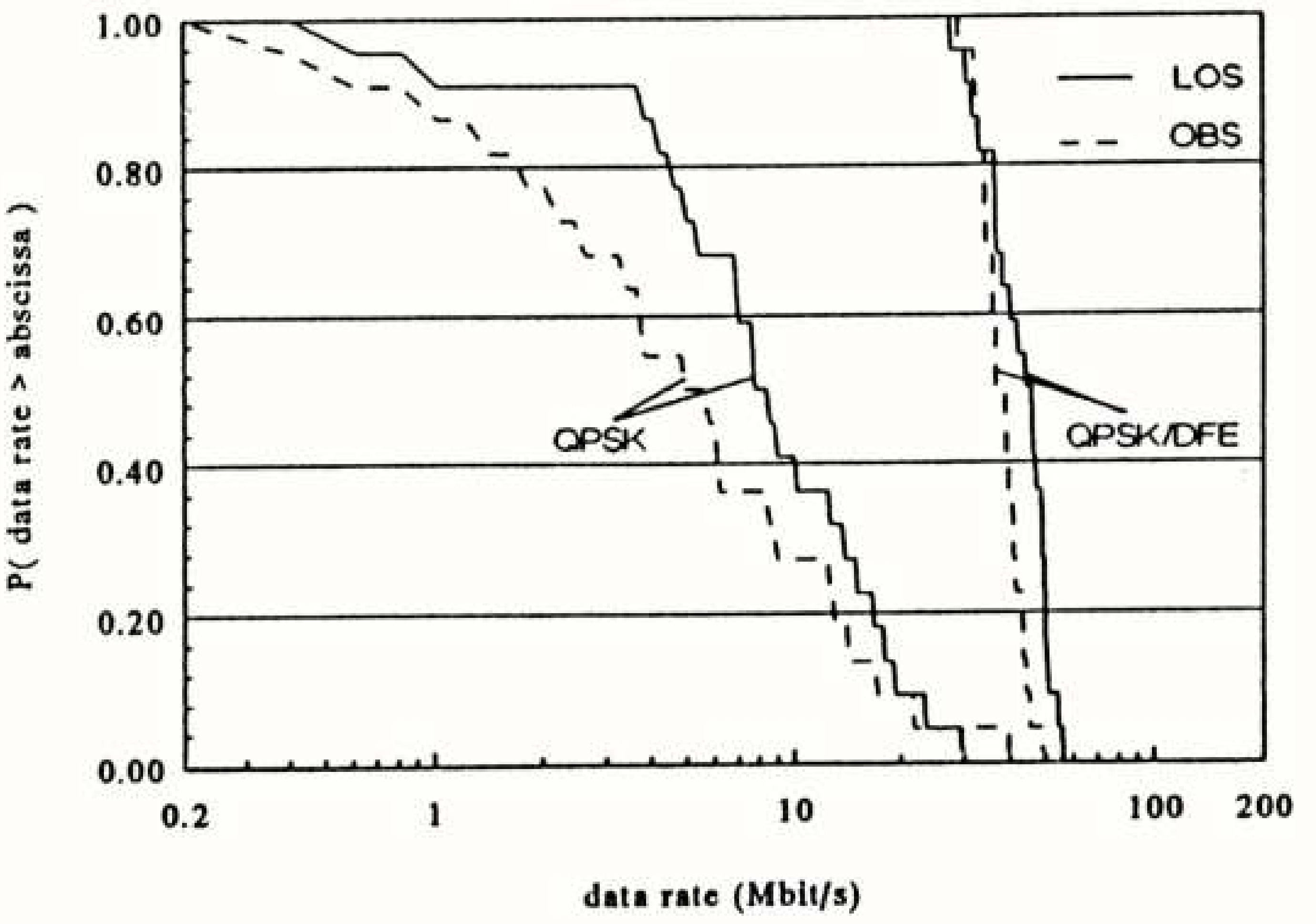


***Figure 9**: Performance results for Room A.*

5. Summary and conclusions

Propagation measurements and simulations have been performed in order to determine the characteristics of millimetre wave indoor radio propagation. Both are briefly discussed and results are presented that globally express the characteristics of the millimetre wave indoor radio channel and their dependency on the antenna radiation characteristics.

The accuracy of the simulation method is examined by comparing simulation results with the data obtained from the measurements. The indoor environments defined in the simulation software are stylized versions of the corresponding real environments in which the measurements took place. although the stylized versions only include the superstructure (walls, floor and ceiling) and lack details as tables and cabinets, the simulation results are in good agreement with the measurement results.

After it was found that geometrical ray tracing yields accurate results, we performed additional computer simulations in order to gain a more detailed insight into the influence of environment and antenna characteristics on the most interesting channel parameters. For this, we defined setups with sectorial and/or biconical horn antennas in the simulation software. A setup with sectorial horns at both ends having the highest beam directivity considered yields the lowest rms delay spread and highest normalized received power when compared with other examined setups, provided that there is no obstruction of the LOS path and provided that the antenna beams are exactly pointing towards each other. A setup with biconical horns at both ends yields results with respect to normalized received power and rms delay spread that are highly insensitive to LOS obstruction. In addition uniformity in the distribution of normalized received power values is observed. This setup also yields the lowest spread in rms delay spread values.

The propagation results have been used to estimate the performance of millimetre wave radio communication. Communication at tens of Mbit/s seems to be feasible in case Decision Feedback Equalisation is applied.

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Voordracht gehouden tijdens de 428e werkvergadering

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS
NEDERLANDS ELEKTRONICA- EN RADIOGENOOTSCHAP
429e werkvergadering

UITNODIGING voor de gezamenlijke werkvergadering van het IEEE en het NERG op donderdag 1 december 1994 in Zaal 1 van het Rekencentrum van de Technische Universiteit Eindhoven.

THEMA: MEDISCHE ELEKTRONICA

PROGRAMMA:

10.30 - 11.00 uur	Ontvangst en koffie
11.00 - 11.05 uur	Welkom **DR.IR. J. VANDERSCHOOT** IEEE Benelux Section
11.05 - 11.50 uur	Gerontechnology: applying technology for the aged and the aging; A new challenge for electrical and information engineering **DR. J. RIETSEMA,** Eindhoven University of Technology
11.50 - 13.00 uur	Lunch
13.00 - 13.45 uur	Speech processing and its application in the medico-social sector **PROF.DR.IR. J.P. MARTENS,** University of Gent
13.45 - 14.30 uur	Automated processing of neurophysiological signals basic and applied research issues **DR.IR. P.J.M. CLUITMANS,** Eindhoven University of Technology
14.30 - 15.00 uur	Tea Break
15.00 - 15.45 uur	Low power sensor interface systems for intelligent, telemetric implants **PROF.DR.IR. R. PUERS,** University of Leuven
15.45 - 16.30 uur	Instrumentation for multichannel high quality bio-electric measurements **PROF.DR.IR. C.A. GRIMBERGEN,** University of Amsterdam

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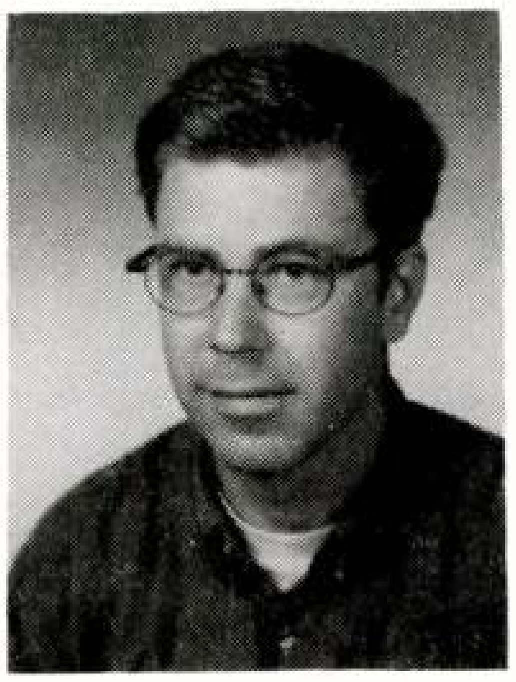
GERONTECHNOLOGY: APPLYING TECHNOLOGY FOR THE AGEING AND THE AGED

A new challenge for electrical and information engineering

Dr. J. Rietsema, Prof.dr. J.L. Fozard, Ir. J.A.M. Graafmans
Institute for Gerontechnology
Eindhoven University of Technology
P.O. Box 513, NL-5600 MB Eindhoven

Summary



Gerontechnology is cross-cutting through all traditional technical disciplines and connects these with other disciplines such as social sciences, medicine, economics, etc. The problems that must be addressed by gerontechnology are emerging from the goals, needs, preferences and abilities of the ageing and the aged. This is done in five ways: prevention and delay of age associated decline of capacities; enhancement of the opportunities of elderly in new roles; compensation of declining capacities; assisting caregivers; and technology can support the research on ageing.
Gerontechnology is user-oriented. It is technology directed towards a class of people, the ageing and older adults. Gerontechnology addresses changes in human preferences, aspirations and capacities. The unique feature of a user-oriented technology is that people's preferences and aspirations are identified. This is done both by feed-back and by feed-forward.
Electrical and information engineering can play a role in the development and design of applications of technology for a comfortable future of all consumers including the elderly.

Introduction

The title of this paper is: Gerontechnology: applying technology for the ageing and the aged. A new challenge for electrical and information engineering. It would be better to write 'a new challenge also for electrical and information engineering', because gerontechnology includes all other engineering disciplines. This multi-disciplinary character will become clear in this paper. Most readers, however, might be especially interested in electrical and information engineering and therefore the examples of applications are from these areas. The paper describes the definition of gerontechnology, and two important features. After this the goal, transcribed in five objectives, is discussed. These objectives are illustrated with examples of products and research projects. Then, the possibilities for user-involvement in the design of successful applications of gerontechnology is described. Finally a risk for the development of gerontechnology is presented.

Definition

The term gerontechnology is a composite of two words:'gerontology' and 'technology' (1). Gerontology is concerned with research on the biological, psychological, social and medical aspects of ageing. Gerontechnology is formally defined as the study, development and design of products and techniques for the benefit of a preferred living and working environment and adapted medical care for the elderly. Gerontechnology is based on the knowledge of the ageing process and on information about the preferences and tasks of the elderly. Two important features of gerontechnology are embedded in this definition.

Multi-disciplinarity

Firstly, the multi-disciplinarity of this area. Gerontechnology is based on the knowledge of the ageing process and on knowledge about the elderly. This refers to research in socio-economic, medical and behavioral sciences. Gerontechnology also includes the whole spectrum of technical disciplines. The innovations required by today's society can not be developed with the knowledge of one discipline. The multi-disciplinarity requires special skills from a gerontechnologist. She or he must be able to integrate the knowledge from the other disciplines in her/his technical specialism. This is an learning objective of the educational curriculum at Eindhoven University of Technology. This University recently founded the Institute for Gerontechnology. The Institute is the focal point for the development of gerontechnology. It initiates and coordinates education, research and development at the University and stimulates the knowledge transfer from the target group, the elderly, and trade and industry, especially the small and medium sized enterprises, to the academic researchers and vice versa. To fill in the knowledge that is not available at the University, it collaborates with other institutions and industries in The Netherlands and abroad.

User-orientation

The second feature of gerontechnology is the user-orientation. The definition states that gerontechnology is based on the information about the task and preferences of the elderly. The elderly themselves are at a central position. Many existing technologies are designed for young, healthy males. The capacities and preferences of the elderly are rarely taken into account. It might be that this creates the so-called 'techno-fear' among the elderly. User-orientation will be discussed in more detail.

The focus on the young, healthy people creates a gap between existing technology and the preferences of the elderly. This gap is influenced by two reasons. First, the age distribution of the population is changing and the relative numbers of elderly persons will increase until the mid of the next century. In The Netherlands, the number of persons of 55 and older was 22% in 1990 and will grow to 28 % in the year 2010. This elderly population spends 28% of the National Product and this will increase to 41% in 2010.

The second reason that influences the gap is the evolution of technology itself. This means that adults of all ages will be confronted with an ever more rapidly changing technical environment, that will continue to do so.

Goal

Closing this gap is the goal of gerontechnology. To achieve this goal, five objectives of gerontechnology are formulated.

First, the most effective use of technology is in *prevention*. It has been shown that the decline in capacities are modifiable through long-term interventions such as physical exercise, strength training and changes in lifestyle. The preventive role of technology includes the design of fitness equipment that is useful and challenging for the elderly and the design of monitoring equipment that gives feed-back about the effectiveness of the interventions.

Another example of the preventive role of technology is the application of speech synthesis and voice recognition in various products. A voice operated light switch at a staircase, can avoid dangerous situations for persons with mobility limitations. More general, speech synthesis and voice recognition can be applied in various alarm systems.

Second, gerontechnology can provide the technology to *enhance* the opportunities of elderly in new roles. These new roles include changed work, leisure, living and social situations.

An example is the development of user-friendly communication technology to facilitate remote contacts, to make new contacts and to participate in educational activities. The possibilities of the ISDN telecommunication network creates new opportunities for various applications, e.g. videotelephony. One of the effects of videotelephony may be increased social integration of older people.

A well developed research area associated with enhancement is adaptable housing and the use of 'domotics' (introduction of information and communication technology into home installations and appliances) to suit the different needs of people during the life cycle of the family.

Third, technology plays a role in the *compensation* for declining capacities. This is the most fully developed aspect of gerontechnology and include products and techniques for sensory and perceptual losses, task redesign and technologies that compensate for loss of strength and ability.

Existing applications for example are hearing aids, telephone amplification, an alarm-button that can be used to increase the crossing time of pedestrian traffic lights for people with mobility impairments and a smart pillbox designed to remind people when to take their medication.

Fourth, gerontechnology can address ageing by *supporting caregivers*, both the professional as well as the non-professional care givers.

An important trend is that many products that were originally developed for use in hospitals and rehabilitation centres, are currently or potentially made available for home care of the elderly. This has the positive effect that they can stay longer in their own homes. Examples include an electrical digital blood pressure monitor that is easy to operate, an eye drop applicator and a blood glucose measurement system with speech feed-back, to enable visually impaired diabetics to individually monitor their blood glucose level.

Finally technology aids the elderly indirectly by *improving research on ageing*. Technology is applied for imaging organs and tissues, signal processing of neurological events and noninvasive biochemical measures, thereby revolutionizing the scientific study of the biological and physiological processes of ageing. At Eindhoven University of Technology, department of Electrical Engineering a research project is studying the effects of general anaesthesia on cognitive functioning in the elderly. To guarantee the success of this study, application of advanced signal processing, incorporating the physiological knowledge, is necessary

User-oriented design

Gerontechnology is user-oriented. It is technology directed towards a class of people, the ageing and older adults. Gerontechnology addresses changes in human preferences, aspirations and capacities. The unique feature of a user-oriented technology is that people's preferences and aspirations are identified. This is done both by feed-back and by feed-forward. Feed-back means an evaluation by users of available products and environments; feed-forward is the identification of needs and preferences based on an early involvement of consumers in the development and dispersal of technology.

Users can be involved in a variety of ways in the early creation process of a product or service. First, the consumer can play a role in the design and development teams and share their ideas and experiences with the technical experts. This method is called the participatory design method.

Second, elderly consumers can evaluate prototypes. Rapid prototyping means that simple prototypes, describing only part of the functionality are tested with users. The results are used in the next step of the design process and implemented in a new prototype that is again evaluated. This is done till the product satisfies the user needs.

Third, the consumer plays a role in consultation exercises using presentations or demonstrations of new products or services

Fourth, data collection about the preferences and tasks by questionnaires, interviews or observations.

INTERMEZZO

The Senior Citizen Technology Centre is a response to the need for a facility where the collaboration with the elderly consumer can be implemented. The Centre has an intermediary function between elderly on one side and teaching and research institutions, care professionals, trade and industry on the other side. The Senior Citizen Technology Centre has the function of a market development centre for products and services for especially the elderly. It provides facilities for prototype testing and pilot experiments and for data collection about preferences, aspirations and capacities of ageing and aged persons. Through the centre it will be relatively easy to involve senior consumers as members of design or development teams or make use of their expertise in a panel. The developments are initiated on indication of industries, but with the elderly as a leading factor. The centre is an infrastructure for research and education activities of Eindhoven University of Technology. The interaction between students and targetgroups of gerontechnology encourages a change in their attitude from technology-oriented engineering towards user-oriented engineering. Since the Senior Citizen Technology Centre is the only facility of its kind in The Netherlands, high interest from industry and researchers in various fields is shown and more is expected.

Stigmatizing

A risk for gerontechnology is that senior-friendly products are considered stigmatizing. Marketers are afraid for this effect and for this reason not many elderly persons are mannequin in advertisements. It becomes apparent, however, that design for the elderly addresses the need for products that enhance the comfort and quality of life for users of all ages. 'Design for all' or 'transgenerational design' are strategies for eliminating this stigma (2,3). This approach insists on products and environments being designed from the very outset to accommodate a 'transgenerational' population, which includes the young, the middle aged and the elderly.

Conclusion

The overall conclusion of this paper is that gerontechnology strives for a comfortable future for especially the elderly, but a much larger segment of the population will benefit from it. Gerontechnology is technology for our own comfortable future.

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Voordracht gehouden tijdens de 429e werkvergadering

NEDERLANDS ELEKTRONICA- EN RADIOGENOOTSCHAP
430e werkvergadering

UITNODIGING voor de werkvergadering van het NERG op donderdag 8 december 1994 in het Europaviljoen van PTT Research, Winschoterdiep oz 46, Groningen.

THEMA: MULTI-MEDIA TOEPASSINGEN

Deze laatste werkvergadering van 1994 zal plaatsvinden bij de vestiging van PTT Research in Groningen waar een aantal toepassingen gebaseerd op nieuwe multi-media technologieën, zullen worden gepresenteerd en getoond.

PROGRAMMA:

14.00 - 14.30 uur	Ontvangst
14.30 - 15.00 uur	PTT Research, een introductie
15.00 - 15.30 uur	Europublishing presentatie en demonstratie door **IR. W.M. REMMERS**
15.30 - 15.45 uur	Pauze
15.45 - 16.15 uur	Multimedia Mailservices presentatie en demonstratie door **DRS. L.J. TEUNISSEN**
16.15 - 16.45 uur	Groupeware: Tele-samenwerken meer dan E-mail alleen presentatie en demonstratie door **IR. W.H. TIMMERMAN**
16.45 - 17.30 uur	Afsluiting en borrel

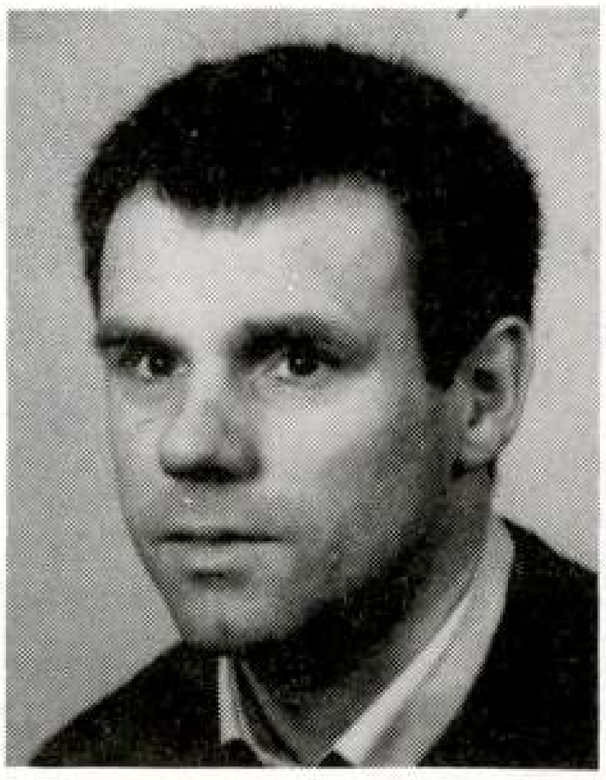
Aanmelding voor deze middag dient te geschieden vóór 1 december aanstaande door middel van de aangehechte kaart, gefrankeerd met een postzegel van 70 cent.
Leden van het NERG en studenten hebben gratis toegang. De kosten van deelname voor niet-leden bedragen *f* 15,00.
Betalingen dienen vóór 1 december te zijn ontvangen op girorekening 94746 t.n.v. Penningmeester NERG, Postbus 39, 2260 AA Leidschendam.

Namens het NERG,
Ir. W. van der Bijl, programmamanager
Tel. 070 - 332 51 12 (administratie NERG)

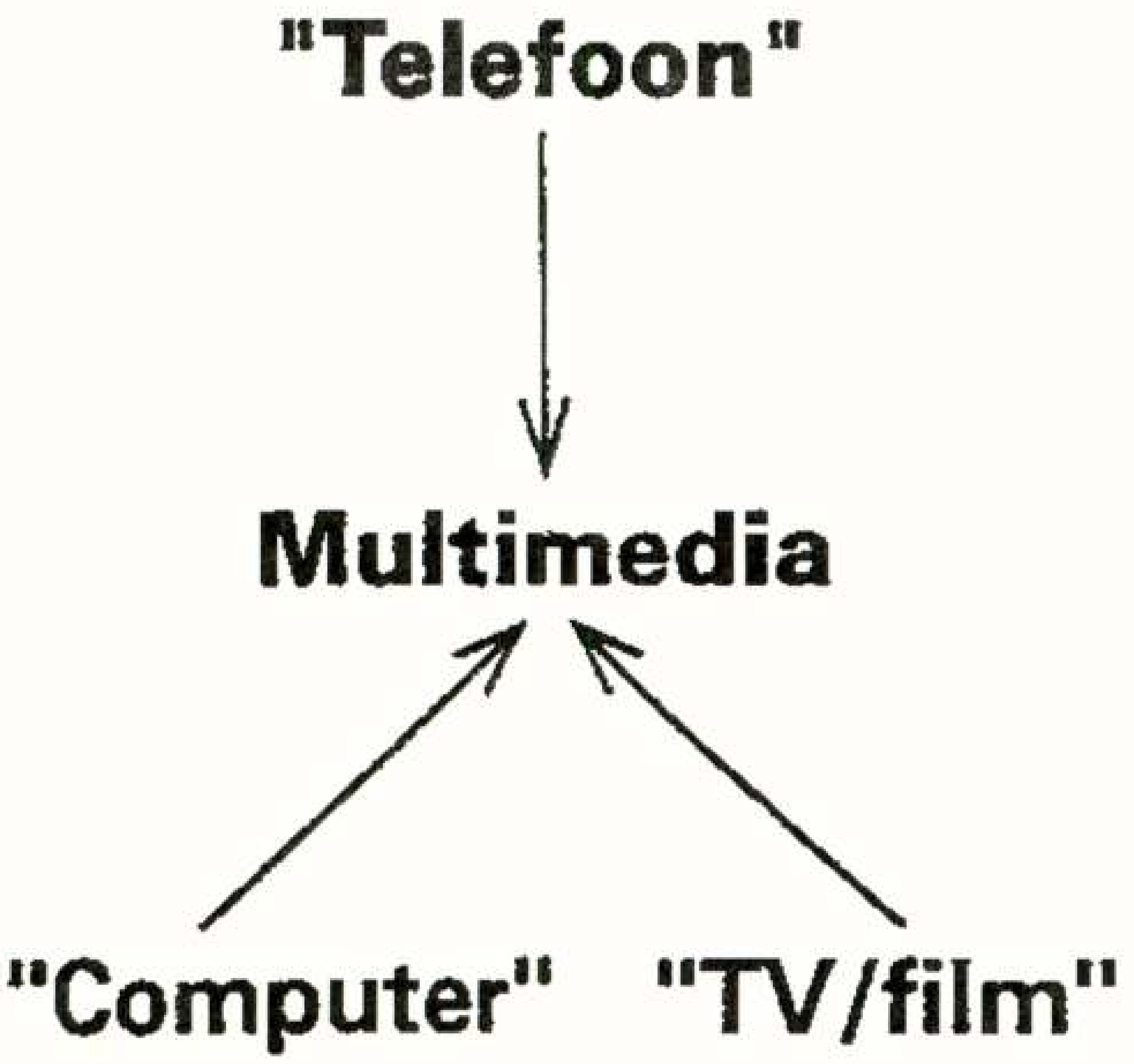
MULTIMEDIA TELESERVICES

Drs. L.J. Teunissen
PTT Research

Summary
Multimedia can be associated with services integrating voice, video and computer-data, enhancing each other into a single service, "a medium". Multimedia applications have their origin from one of three different "worlds", telephone, computer and entertainment. It seems there is a total convergence to multimedia from all of these worlds. However it is better to state that in the overlapping areas there will be a migration to multimedia applications and -services.

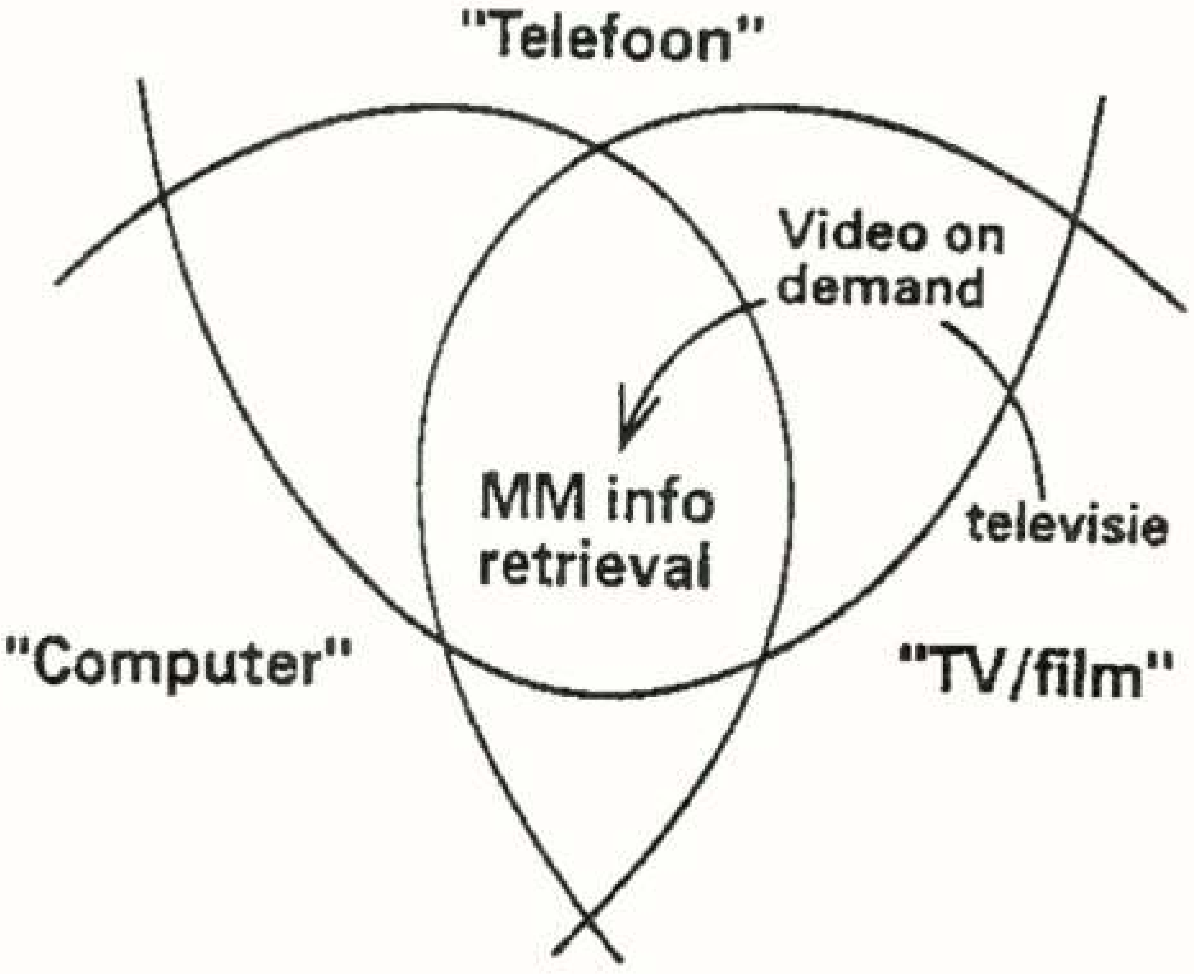


Inleiding
Multimedia heeft betrekking op die diensten waarbij geluid, video en computer-gegevens elkaar aanvullen in één dienst, tot één 'medium'. Er zijn drie 'werelden' van waaruit multimedia applicaties ontstaan, te weten die van de telefoon, de computer en entertainment. Toch is die groei naar multimedia geen convergentie; beter kan gezegd worden dat in de overlap-gebieden migraties naar multimedia-applicaties en -diensten plaatsvinden.



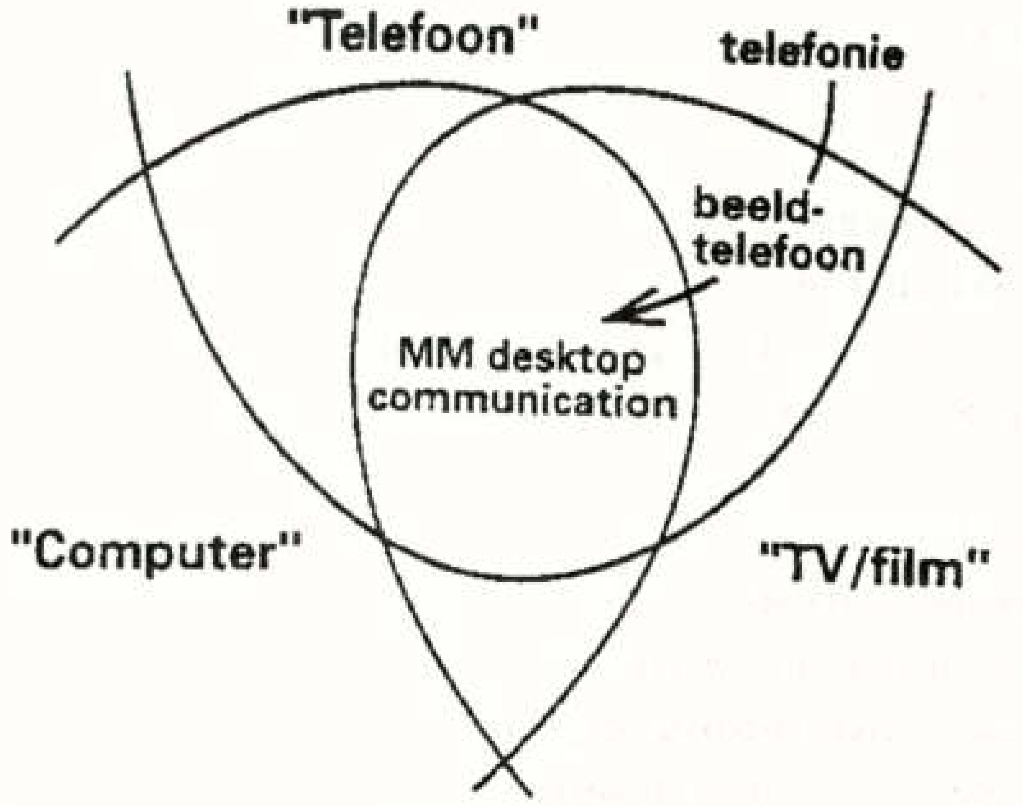
Figuur 1. Vanuit drie verschillende 'werelden' vindt er een evolutie plaats richting multimedia.

Door evolutie vanuit de televisie wordt dit medium interactief. Je kunt binnenkort als in een videotheek thuis kiezen welke film men wil zien, die dan vervolgens via de telefoonlijn of de kabeltelevisie wordt uitgezonden. Tevens kan men vanachter de TV winkelen, bankzaken beheren, enzovoort.



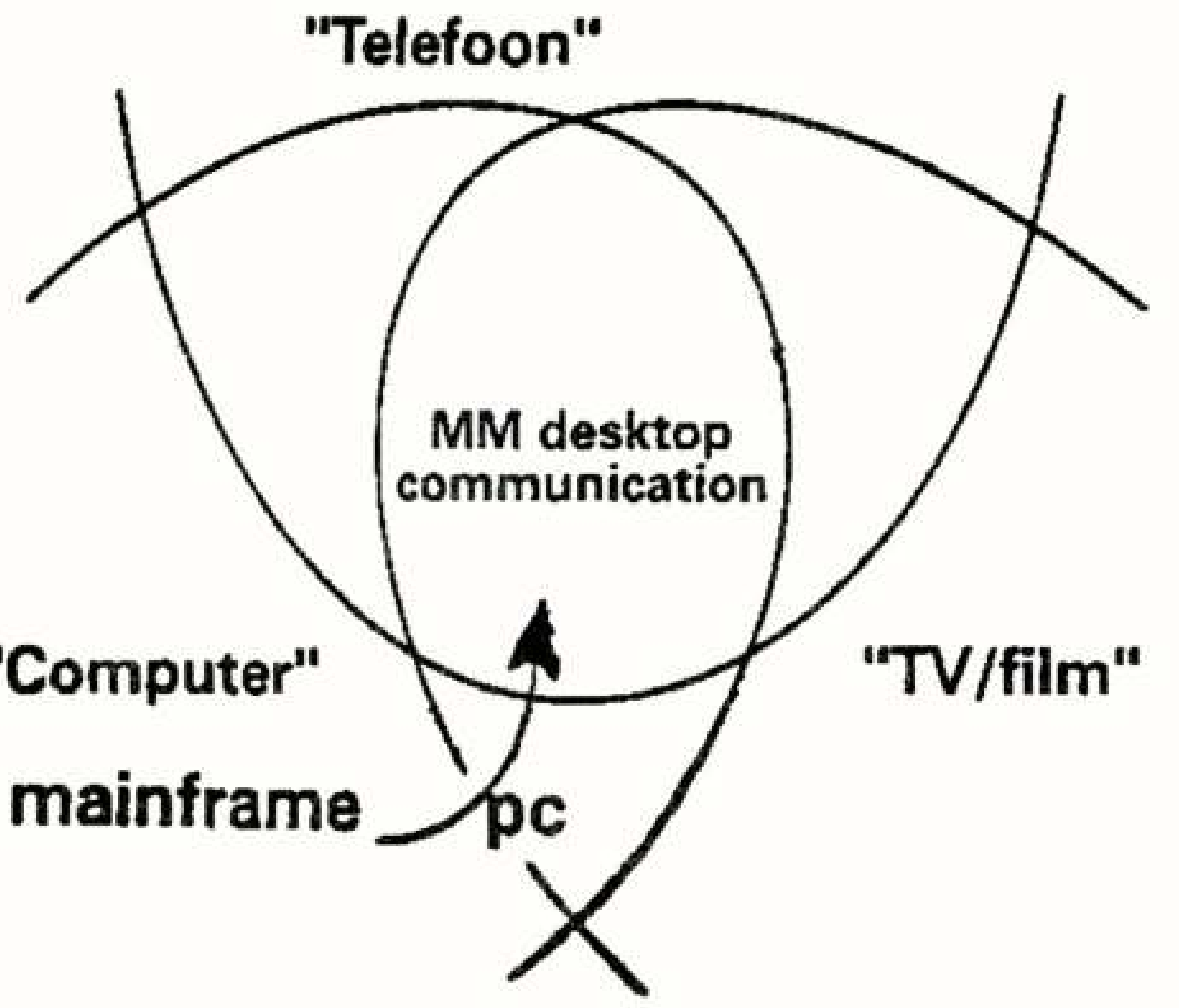
Figuur 2. Migratie van 'televisie' via 'video on demand' naar 'multimedia information retrieval'.

Door evolutie vanuit de telefoon is de beeldtelefoon ontwikkeld. Dit is integratie van telefoon en video. Een volgende stap is het mogelijk maken van het met meerdere partijen gemeenschappelijk werken op een computer, vanuit meerdere lokaties via de telefoon. Hierbij is de computer geïntegreerd met de telefoon.



Figuur 3. Migratie naar 'Multimedia desktop communicatie' vanuit de telefoon.

Door evolutie vanuit de computer kan nu al worden gewerkt met losse beelden, en binnenkort ook met bewegend beeld, video. Geluidskaarten zijn al gemeengoed bij moderne PC's. Via Local Area Networks of telefoonlijnen kunnen computers aan elkaar gekoppeld worden voor interactieve communicatie.



Figuur 4. Migratie naar 'Multimedia desktopcommunicatie' vanuit de computer.

Oorspronkelijk hebben telefonie, computer en televisie ieder hun eigen netten. Door de groei in een gemeenschappelijke richting ontstaat multimedia. Vanuit elke achtergrond ontstaan nieuwe applicaties met dezelfde ingrediënten. Het gevolg is dat verschillende netten ontstaan met diensten die veel op elkaar lijken, maar verschillend zijn. Door veelheid van multimedia toepassingen ontstaat vraag naar een flexibel netwerk tegen lage kosten. Asynchronous Transfer Mode (ATM) is de techniek die dat kan, maar vooralsnog domineren de andere netwerken, zoals die voor de telefoon en de kabelnetten.

MultiMedia Mail (MMM)

MultiMedia Mail is de voortzetting op de huidige systemen voor elektronische post. Het stelt gebruikers in staat om berichten uit te wisselen die niet alleen bestaan uit tekst, maar ook uit andere informatie-typen zoals grafische afbeeldingen, geluidsfragmenten en video. Door een ingebouwd conversiemechanisme kunnen al deze informatie-typen uitgewisseld worden tussen verschillende computersystemen. Deze conversie blijft echter volledig transparant voor de gebruiker.

Markwaarde

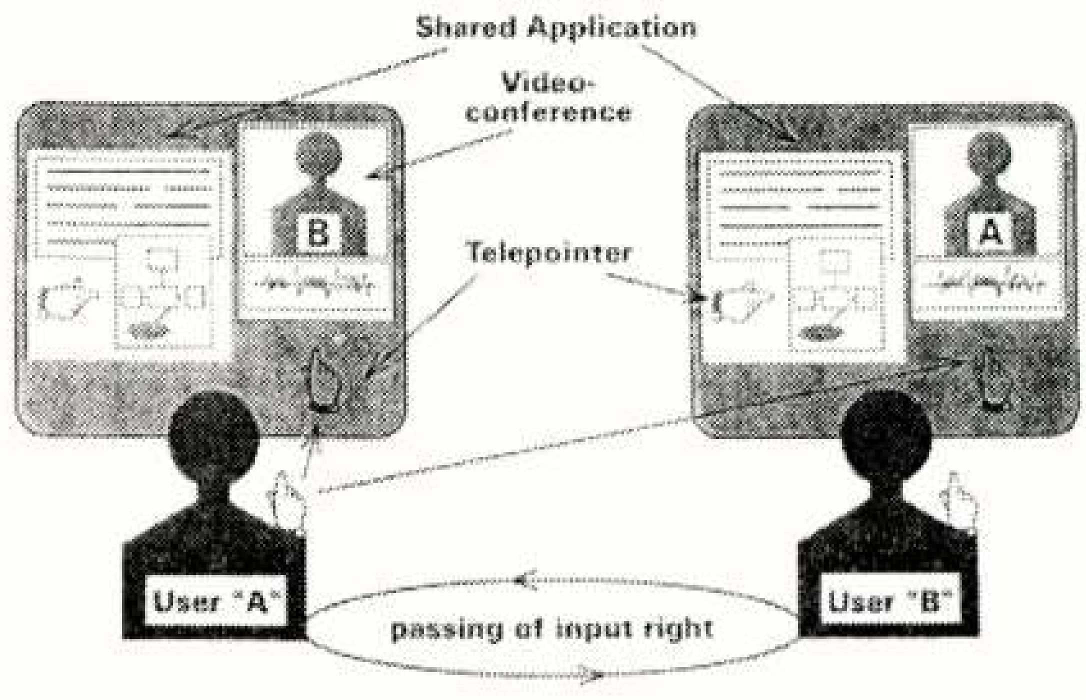
De meeste interesse voor MultiMedia Mail wordt in eerste instantie verwacht in de middel- en grootzakelijke markt. MultiMedia Mail zal niet alleen de efficiëntie verhogen van de communicatie binnen het bedrijf, maar ook tussen het bedrijf en zijn omgeving. Het biedt immers nieuwe mogelijkheden b.v. voor hergebruik van documentatie of spreadsheets tussen verschillende computersystemen.

Technologie

Technologische ontwikkelingen op diverse gebieden maken deze vorm van communiceren nu mogelijk. Belangrijke basis-technologieën in dit verband zijn de ontwikkelingen op het gebied van gebruikersinterfaces en de mogelijkheden voor digitale opslag en transport van informatie. Verder kan als gevolg van standaardisatie -activiteiten op de genoemde gebieden, uitwisseling van informatie plaatsvinden tussen systemen van verschillende fabrikanten.

PTT Research

Door middel van het RACE-project CIO (RACE 2060) werkt PTT Research mee aan de ontwikkeling van MultiMedia Mail. Hierbij richt PTT Research zich met name op de specificatie en de implementatie van de MMM-service. Bij de definitie van deze dienst wordt ondermeer gebruik gemaakt van de bestaande (1988) X.400-aanbevelingen voor elektronische post. Om de ideeën in de praktijk te toetsen en te kunnen demonstreren worden protypes ontwikkeld die geschikt zijn voor SUN, NeXT en PC. Deze prototypes maken gebruik van diverse netwerken, waaronder ISDN, ethernet, FDDI en ATM.



Figuur 5. Multimedia teleconferenties vanaf de werkplek.

Multimedia Teleconferencing

Zowel telewerken als het werken in groepsverband kan aanzienlijk worden verbeterd met behulp van geavanceerde informatie-technologieën. Een voorbeeld hiervan is het houden van videoconferenties. De functionaliteit van de huidige videoconferentie-systemen kan echter nog sterk uitgebreid worden, waarmee een betere omgeving voor groepwerk en telewerken ontstaat. Nieuwe conferentiesystemen zullen vanaf de werkplek toegankelijk worden en extra faciliteiten bieden, zoals het gelijktijdig samenwerken met programmatuur met volledige multimedia ondersteuning.

Samenwerking

Gebruikers kunnen vanaf hun werkstation samenwerken met één of meer partners op verschillende lokaties. Ze kunnen hun conferentie-partners niet alleen zien en horen, maar kunnen ook gezamenlijk hun computerprogramma's gebruiken om diagrammen, tekst, audio of video te bespreken. Bovendien kan elke deelnemer een eigen 'telepointer' gebruiken om specifieke dingen aan te wijzen. De voorzitter van de conferentie kan een conferentiepartner het recht geven om de gegevens in het document in te voeren of te wijzigen.

Openheid

In zo'n samenwerkings-omgeving moeten nieuwe multimedia telediensten beschikbaar zijn op verschillende werkstations en PC's, onafhankelijk van hun verbinding met de verschillende netwerktypen zoals ISDN, ethernet, FDDI en ATM. Deze 'openheid' wordt mogelijk gemaakt door het gebruik van een gemeenschappelijk communicatie-platvorm, ofwel een multimedia transportsysteem dat elke communicatie tussen verschillende netwerken mogelijk maakt.

PTT Research

Door middel van het RACE-project CIO (RACE2060) is PTT Research betrokken bij de ontwikkeling van het multimedia teleconferentiesysteem, JVTOS. JVTOS is de afkorting voor 'Joint Viewing & TeleOperation Service' en stelt twee of meer gebruikers in staat om gezamenlijk alle mogelijke programmatuur - inclusief multimedia applicaties - gelijktijdig vanaf verschillende werkstations te gebruiken.

Voordracht gehouden tijdens de 430e werkvergadering

Van de redactie

In oktober 1994 werd een overeenkomst gesloten tussen het NERG en het in de USA gevestigde Institute for Scientific Information (ISI). De doelstelling van het ISI is op aanvraag en tegen betaling overdrukken te leveren van publicaties uit tijdschriften etc. Daartoe heeft het ISI wereldwijd de (niet-exclusieve) copierechten verworven van een aantal instellingen, bijvoorbeeld van de British Library.
Zo heeft het ISI zich ook met het verzoek om te komen tot een 'Document Delivery Royalty Agreement' betreffende artikelen uit dit Tijdschrift gewend tot het bestuur van het NERG.
Aangezien de overeenkomst de naamsbekendheid van het Tijdschrift zal vergroten en er na een uitgevoerd onderzoek geen belemmerende factoren konden worden gevonden, heeft het bestuur van het NERG een positief besluit genomen ten aanzien van deze overeenkomst.
Aan het NERG wordt in voorkomende gevallen door het ISI voor het verlenen van de licentie tot het maken van overdrukken een bepaalde vergoeding afgedragen. De overeenkomst heeft alleen betrekking op artikelen waarvan de verschijningsdatum maximaal drie jaar geleden is.

De volgende tijdschriften zijn op aanvrage bij de redactie ter inzage te verkrijgen:

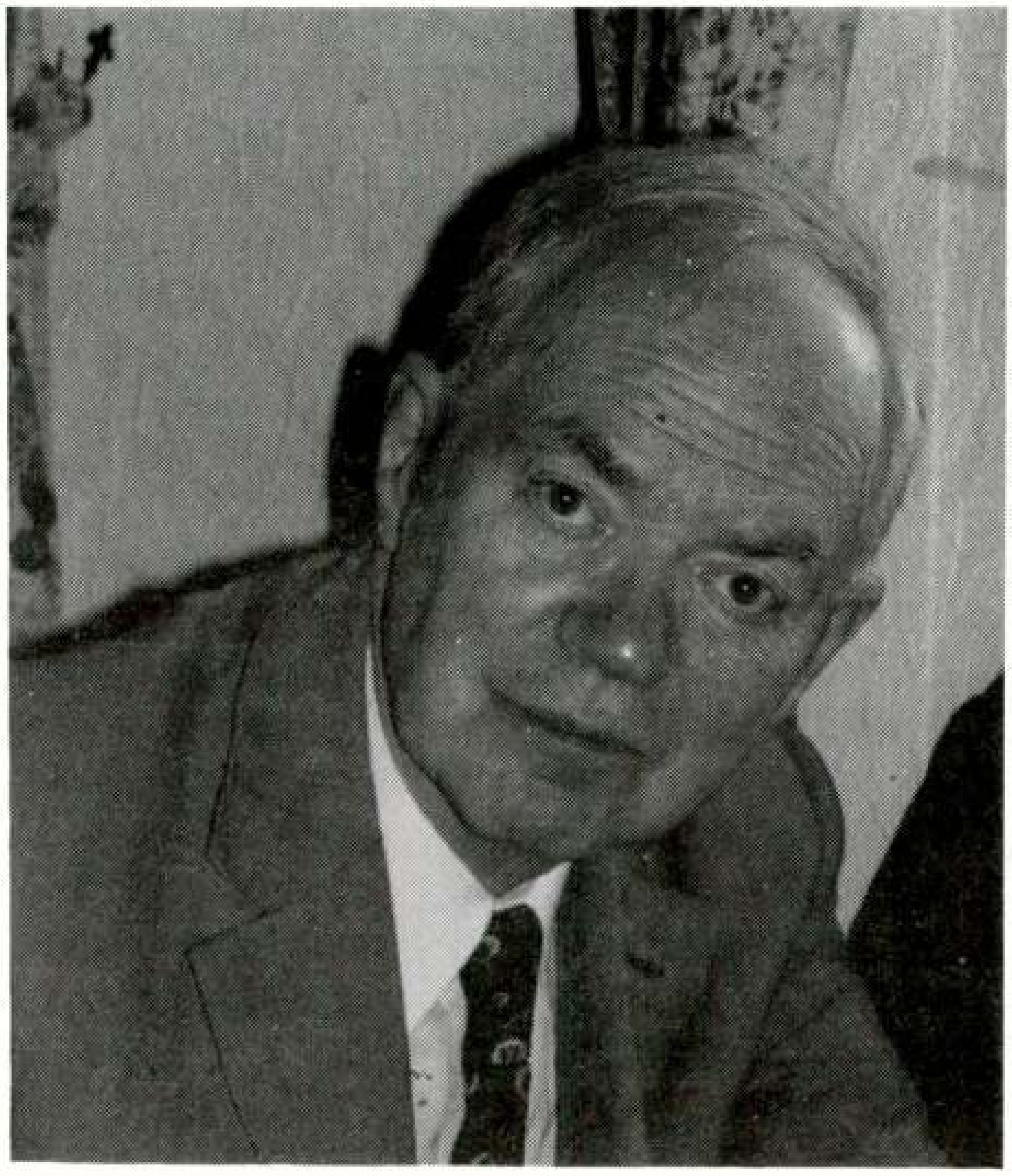
* European Transactions on Electrical Power Engineering
  (EUREL Publication)
* European Transactions on Telecommunications and related technologies
  (EUREL Publication)
* 'R & D in Europa' Maandblad over programma's voor Onderzoek en Technologische Ontwikkeling.
  EG Liaison. Publicatie van het Ministerie van Economische Zaken
* Technieuws/Bonn, Parijs, Rome, Tokio, Washington
  Publicatie van het Ministerie van Economische Zaken.
* Studieblad PTT Telecom
  Uitgave van PTT Telecom Opleidingen
* ITU Newsletter
  Published by the International Telecommunication Union (ITU) te Geneve.
* Newsletter of the International Telecommunication Union

In Memoriam

Op 27 december 1994 overleed de heer J.W. Tetteroo. Gedurende een periode van 20 jaar, namelijk van 1968 tot 1989, heeft de heer Tetteroo vanuit het Dr. Neher Laboratorium te Leidschendam waar hij werkzaam was, de administratie van het NERG verzorgd.
Mede door de uitstekende wijze waarop hij de in die periode steeds complexer wordende administratieve taak verrichtte werd in 1979 aan de heer Tetteroo de eremedaille in goud, verbonden aan de Orde van Oranje-Nassau uitgereikt.
Tijdens de jaarvergadering van het NERG in april 1989 werd zijn werkzame periode voor onze vereniging op waardige wijze afgesloten. Vele van onze leden hebben de heer Tetteroo gekend; wij zullen hem met dankbaarheid gedenken.

A.A. Spanjersberg

In Memoriam professor ingenieur Cornelis Rodenburg



Op 30 juni 1994 is professor ingenieur Cornelis (Kees) Rodenburg overleden. Kees Rodenburg was 51 jaar, toen hij in 1963 de gelederen van de derde Technische Hogeschool in Nederland kwam versterken na een gedegen ideële voorbereiding onder wijlen professor Lievegoed. De familie Rodenburg heeft in de beginjaren van de Campus dan ook intensief een rol gespeeld in het sociale en culturele campustraject. Twee hoofdperioden uit zijn loopbaan voor .het THT-tijdvak waren de middels zijn functie als HTS-ingenieur bij onder meer de Nederlandse Siemensmaatschappij in Den Haag geëntameerde ingenieursstudie Elektrotechniek aan de toen Technische Hogeschool Delft en later het werk bij de afdeling procesautomatisering bij Koninklijke Nederlandse Hoogovens en Staalfabrieken N.V. te IJmuiden. De ingenieursstudie Elektrotechniek ving hij in 1945 aan. Ze was een regelrecht gevolg van zijn geboeid zijn door de combinatie van fysisch phenomeen op zich en de menselijke exploitatie ervan in artefacten. Een met goed gevolg afgeronde HTS-studie met MULO A&B als start gaf geen toegang tot de Delftse opleiding en dus legde Rodenburg zich toe op het behalen van het Staatsexamen HBS-B. Deze oneffenheid in de mogelijkheden tot aangaan van een vervolgstudie hebben hem in later dagen mede aangezet tot het helpen tot stand brengen en uitvoeren van de Wet op de Wederzijdse doorstroming, waarin het dwarsverkeer tussen HTO- en WO-studie werd mogelijk gemaakt. In zijn studieperiode was de arbeidsintensieve assistentperiode, in 1953 bekroond met het ingenieursdiploma, bij professor Huydts een heel bepalend traject. Huydts spande zich in om de -toen nog buizen-Elektronica - van (radio)empirie naar wetenschap brengen en Rodenburg stond daarmee aan de wieg van wat later als professionele Instrumentele Elektronica zou worden betiteld. Vanaf 1960 doceerde hij met enthousiasme het Elektronicacollege onder meer voor de Delftse Werktuigbouwkundigen. Voor een afdeling werktuigbouwkunde, in de Delftse context de feitelijke Alma Mater van de Elektrotechniek, was elektronica een conditio sine qua non.In 1958 aanvaardde hij de functie van hoofd procesautomatisering van de research- en bedrijfslaboratoria bij Hoogovens, waarin naast zijn belangstelling voor techniek de soms ongrijpbare rol van de mens in de besluitvorming hem een uitdaging was. Die functie confronteerde hem met de kwetsbaarheid van geautomatiseerde productie.Toen zijn collega uit Delftse dagen Breedveld, kroonbenoemde op de leerstoel Elêktronica I, die sinds de oprichting van de THTin 1963 als formerend voorzitter van de afdeling Elektrotechniek van de TH-Twente opereerde, hem vroeg voor de functie van wat officiëel "adviseur ten behoeve van de voorbereiding van het onderwijs en het wetenschappelijk onderzoek" kwam te heten, heeft hem het nemen van die beslissing grote moeite gekost. Zijn capaciteiten stelde hij liever in dienst van het vrijere bedrijfsleven, dan in die van de meer ambtelijke sferen. Naargelang het curriculum-in-opbouw uitgroeide, zou een belangrijke activiteit onder meer de stageplaatswerving en stagebegeleiding zijn. Rodenburg was een groot voorstander van de koppeling van studie en practijk op wetenschappelijk niveau. Die invalshoek deed hem een warm voorstander zijn van het Baccalaureaat, dat de wetenschappelijke evenknie zou zijn van de beroepsgerichte opleiding van de Hogere Technische Scholen. Omdat er aanvankelijk toch wat basiscolleges gegeven moesten worden, overtuigde Breedveld hem ervan een kroonbenoeming te aanvaarden. Zo zag Rodenburg zich na ampele beraadslagingen, waarin de wenselijkheid van inbreng van practijkervaring een grote rol speelde, na een bliksemcarrière van drie maanden adviseurschap benoemd tot hoogleraar van de leerstoel Elektronica II. Zijn ervaring bij onder meer Hoogovens zou hem aanzetten tot het gestalte geven aan onderwijs, dat zich richtte op " het ontwerpen van betrouwbare elektronische professionele instrumentatie", aan de uitbouw waarvan Frits Peuscher, zijn confrater uit de Huydtse periode, jarenlang zijn beste krachten wijdde. Bij één van de weinige gelegenheden, om op grond van ontwikkelingen een passender naam aan leerstoelen te kunnen geven, doopte hij Elektronica II graag en terecht om tot Instrumentele Elektronica. Allengs betrok zijn carrière aan de THT zich meer op management en personeelsorganisatie. Daar zette hij zijn vechtersmentaliteit liever in, dan in de sferen van het wetenschappelijk beleid met betrekking tot de Elektronica van de late jaren zeventig. Op persoonlijk vlak trof men in Rodenburg iemand, die zich sterk maakte voor carrièrebeleid van zijn medewerkers. De THT-personeels-commissie kent veel bijdragen van hem aan discussies in woord en geschrift. Met name spande hij zich in, om de positie en het takenpakket van de oudere medewerker op modernere inzichten gestoeld te doen raken. Kees Rodenburg was er als chef van de vakgroep op uit, medewerkers ruimte te geven om vertrouwen in eigen weten en kunnen te ontwikkelen. Met overtuiging stelde hij: er zijn maar twee zaken belangrijk in het leven, namelijk respect voor de mens als persoon en ruimte voor het andere denkbeeld en persoonlijke groei. Hoewel een gesprek met hem bij de start vaak wat formeel kon zijn, gaf het, als het een persoonlijker wending nam, zicht op een kwetsbare, niet altijd begrepen, maar vooral gedreven man. Bij het in die tijd sterk spelende verschil tussen een HTS-ingenieur en een Hogeschool-ingenieur, trad hij vaak in het krijt, als het ging om het bevechten van een nieuwe ingenieurspositie bij een bedrijf of instelling en menig student heeft aan hem een startpositie te danken. Daarnaast was hij zeer betrokken bij de totstandkoming van de wet op wederzijdse doorstroming van HTO- en WO opleidingen. In de periode van 1973 - 1979 is hij ook mede bestuurslid geweest van het NERG.In zijn werkzame periode heeft hem de ziekte en het overlijden in 1981 van zijn eerste vrouw een zware slag toegediend. In 1982 nam dan ook een beproefde man afscheid als hoogleraar van de toenmalige vakgroep Instrumentele Elektronica. De ziekte van Parkinson, waaraan hij leed, nam in de tachtiger jaren sterk aan invloed toe. Zijn tweede vrouw is hem in dat traject tot een ware zegen geweest onder meer door hem, met zijn nimmer aflatende belangstelling voor het wel en wee van faculteit en vakgroep, te begeleiden naar een Open Dag of een alumnibijeenkomst. Nu, twaalf jaar na zijn pensionering, heeft Kees Rodenburg het moede hoofd neergelegd, moe van het gevecht tegen de voortschrijdende invloed van zijn ziekte. We zullen ons hem blijven herinneren om zijn inzet voor zijn medewerkers en zijn vakgebied.

UIT HET NERG

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ing. C.B. van de Panne	Bachlaan 28	1217 BX Hilversum
dr.ir. E. Roks	Wagenaarstraat 37	4904 MT Oosterhout
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dr.ir. A.P.M. Zwamborn	Ahornplein 13	2691 EL 's-Gravenzande

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prof.dr. A.G. Tijhuis	Vogelsgaarde 5	5673 AK Nuenen
ir. M.J. van Veen	Prins Hendriklaan 11	3761 DS Soest
S.H. Ypma	M. de Ruyterstraat 76	5684 BM Eindhoven

Nieuwe adressen van leden:

ir. J.S. Aukema	Haaksbergerstraat 131-2	7513 ER Enschede
ing. Ph.J. Huis	Meije 68	2411 PK Bodegraven
ir. J.J. van der Kam	Valkenlaan 21	6026 SG Maarheeze
ir.dipl.phys. S.Y. Kan	Lindenlaan 8	2651 TK Berkel en Rodenrijs
ing. R. van Nuland	Maaslaan 7	5691 HM Son
ir. P.R.J.M. Smits	van Bleiswijkstraat 24	2582 LE Den Haag
dr.ir. R.N.J. Veldhuis	Kastelenplein 8	5653 LL Eindhoven

Cursusaankondigingen

PATO

- Betrouwbaarheidsanalyse
  15,16 en 23,24 maart 1995 in Arnhem

- Multivariate gegevensverwerking met Biplots
  17, 24 en 31 maart 1995 in Eindhoven

- Model predictive control
  20, 21 en 22 maart 1995 in Delft

- Uitbesteden van industriële projecten
  28, 29 en 30 maart 1995 in Oisterwijk

- Userinterfaces voor visuele toepassingen
  5, 6 en 7 april 1995 in Amsterdam

- Analyse van organisatieproblemen
  24 april en 1, 8, 15, 22 mei 1995 in Delft

- Radarontwerptechniek
  27, 28 april en 18,19 mei 1995 in Delft

- Digitale video
  24, 25, 26 april en 1, 2 mei 1995 in Delft

- (Statistical) process control
  24 en 25 april 1995 in Delft

- Projectmanagement
  16, 17 en 18 mei 1995 in Oisterwijk

Studiedagen

- Maatschappijgericht ontwikkelen van technologie
  op woensdag 29 maart 1995 in Eindhoven

- Management en organisatie in verandering
  op donderdag 6 april 1995 in Jaarbeurs Utrecht

Contactadres: Stichting PATO
Prinsessegracht 23
Postbus 30424
2500 GK Den Haag
Tel: 070 3644957 Fax: 070 3562722

Conferentieaankondigingen

Fourth IFIP/IEEE International Symposium on Integrated Network Management
1 - 5 mei 1995
Red Lion Inn, Santa Barbara, California, USA
Contactadres: Mary Olson, ISINM '95
P.O. Box 22605, Santa Barbara, CA 93101
Tel: + 1 805 569 1222 Fax: + 1 805 569 2227
Email: ISIN M@cs.ucsb.edu

International Conference on Acoustics, Speech and Signal Processing
9 - 12 mei 1995
Westin Hotel, Detroit, Michigan USA
Contactadres: ICASSP-95
c/o Diversified Management Services Inc.
115 South Main Street . P.O. Box 265
Eaton Rapids, MI 48827 USA

Sixth International Conference on Radio Receivers and associated systems
26 - 28 september 1995
EUREL sponsored conference
University of Bath, UK
Contactadres: RRAS'95 Secretariat
Savoy Place
London WC2R OBLUK
Tel: + (0) 71 344 5477/5478
Fax: + (0) 71 497 3633
Email: conference@iee.org.uk

Mobile Kommunikation
27 - 29 september 1995
Neu-Ulm, Germany

Multimedia
4 - 6 oktober 1995
Dortmund, Germany
Contactadres: Dr.Ing. V. Schanz
Stresemannallee 15
D-60596 Frankfurt/Main Germany
Tel: + 49 69 630 80
Fax: + 49 69 631 29 25

Neutre MT : Quel devenir ?
Conference Internationale
7 - 8 november 1995 - La Filature
Mulhouse - France
Contactadres: SEE
Rue de la Procession 48
F-75724 Paris Cedex 15 France
Tel: + 33 1 44 49 60 00
Fax: + 33 1 44 49 60 49

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