58

GIS in telecommunications

C FRY

By any measure, telecommunications is big business. The huge amount of outside plant, the many and varied communication links, and the need to attract and keep customers in a changing world are all significant reasons to use GIS. Surprisingly, however, it is only in recent years that GIS has become widely accepted. Telecommunications companies are increasingly becoming very large users of GIS technology. Today GIS is extensively used to plan, build, and operate telecommunication networks and associated services. The applications of GIS include activities such as planning transmission capacities, locating cellular telephone transmitters, recording customer complaints, and using geodemographic information to find new customers.

1 INTRODUCTION

Telecommunications (or telecoms) and information technology are set to overtake the automotive sector in the line-up of the world's biggest industries. According to the International Telecommunications Union (ITU), global telecommunications equipment and service revenues annually exceed US$575 billion (£360 billion). Technological convergence means that, in future, almost any telecommunications technology will be able to carry almost any broadcast transmission medium. This will create a completely new competitive environment, where telephone companies are able to compete with TV networks, and where software companies will have the same ability to distribute information as telecommunication companies.

In recent years, deregulation has opened up the telecommunications market to new companies, putting pressure on existing organisations to become more efficient or lose customers. New technologies, such as fibre optic cables, more efficient terrestrial broadcasting, and satellites are offering greatly increased bandwidth. This has made possible the transmission and reception of data from computer networks, TV programmes, interactive video, and conventional telephone and fax communications at greatly reduced costs. These changes have forced companies to redesign their networks and rethink their operational procedures. Many now face the dilemma of whether to extend existing copper networks to incorporate fibre and radio technology, or to build new infrastructures from scratch. Customer expectations have risen as new firms have introduced additional services to the marketplace. These demands have forced the pace of change in the telecommunications industry. Creating and maintaining up-to-date records on network infrastructures, engineering works, buildings, transport routes, and customer account and address details, have become vital for survival.

Telecommunications companies have begun to recognise that many of their work practices have spatial elements and data can be used more efficiently if shared between all departments. In the past, operators recorded information on the locations, compositions, capacities, and conditions of network equipment on a variety of maps, diagrams, and reports. These were often dispersed throughout the company and, if engineers needed to access data about any part of the network, they would first have to find the relevant papers and then interpret the records of previous workers. Often, the details would be inaccurate, or even obsolete, and users would have to make costly field inspections before beginning work.

The need to cut costs and improve services has forced companies to rethink how they manage their information. More and more, departments are having to compete with other projects for funding, companies are less willing to spend money on long data conversion and capture projects, and there is the need to demonstrate rates of return on project investment. Although many organisations introduced computer technology into network records management some years ago, this was often limited to automating the planning, design, and engineering operations of the company. While some inefficiencies could be tolerated when the organisation was run as a monopoly, deregulation has changed this. Increased competition has turned telecommunications providers into marketing-led organisations, primarily concerned with how to attract and retain customers by delivering better services, faster.

2 WHO USES GIS IN TELECOMMUNICATIONS?

GIS is now a standard technology applied throughout the telecoms industry. Telecommunications service providers such as Nextel, Pacific Bell, and others use the technology to plan, build, and operate telecommunication networks and associated services (Magalhaes 1997; Moy and Austin 1997). Network equipment and systems suppliers require information systems when designing entirely new networks. For example, in 1994, as part of a US$4 billion deal with the Saudi Arabian Ministry of Post and Telecommunications (MOPTT), AT&T contracted the US-based Intergraph Corporation to supply an interactive computer graphics system and automated mapping/facilities management/geographical information system (AM/FM/GIS) to monitor the network's development (see Meyers, Chapter 57, for a discussion of AM/FM/GIS). Worth US$76.8 million, the contract included 280 personal workstations, 14 servers, and Intergraph's Facilities Rule-based Application Model Management Environment (FRAMME). The GIS was needed to replace a 20 year old manual system that had become costly and inefficient to manage. In all, 30 000 paper and mylar documents needed to be digitised (Pyramid Research Africa 1995).

Independent telecommunications consultants, such as CDI Telecom, use in-house GIS software to provide engineering and construction services. Information systems integrators and telecommunications applications developers like Bellcore, AT&T Network Systems and NTT International, and regulatory agencies all rely on geographical technology to enforce telecommunications' licensing rights. Additionally, research and educational institutions including universities, schools of electrical engineering, and the communications departments of business schools use GIS packages to teach network planning, operational, and marketing skills.

3 USES OF GIS IN NETWORK PLANNING

In North America and Western Europe, the degree of change to external plant networks has been substantial, with fibre-optic cables replacing copper wire, and microwave or satellite links replacing fixed, long-distance landlines. For example, in New York, fibre is replacing the entire conventional copper telephone network, while in the UK, Cable and Wireless Communications has bought in excess of US$20 billion in new infrastructure, primarily fibre-optic cables. GIS have been used to determine the most suitable method of transmission (wireless or cable), plan network layouts, and target customers.

Topography, population density, and predicted population trends are important considerations when considering transmission method, while detailed demographic information, including employment, affluence, and neighbourhood characteristics, help telecommunications providers to assess the best potential areas for new customers (see Birkin et al, Chapter 51, for an outline of the sorts of GIS operations that this involves and Martin, Chapter 6, for an overview of some of the problems inherent in such applications). Geodemographic information is important because telecommunications companies need money upfront, although affluence indicators are not used in the same way as much other customer targeting – it is poorer people who tend to use cable technology.

With traditional technologies, one of the most important considerations is where duct space is available. This is because bandwidth is limited by space, so to send a signal along a tortuous route using up available duct space can be cheaper than increasing the duct space along a direct route.

With an up-to-date GIS, engineers can generate maps showing existing networks and shape their plans accordingly.

In countries with less well established networks, companies have used GIS to plan entire networks involving thousands of telephone lines. This is the case in the Philippines, for example, where in April 1997 the international services provider and fixed network operator Isla Communications contracted Siemens Public Communications Networks Group to install 350 000 telephone lines and 20 000 wireless lines (Pyramid Research 1997). The advantage with starting from scratch is that operators can build a database designed to meet the needs of both network planners and sales and marketing departments. This maximises a company's competitive advantage by enabling it to design networks for providing services to as many homes as possible.

The European Union's Medora project used a GIS to assess the telemetrics requirements of poorly connected rural areas throughout Europe. The planners hoped that introducing effective communication systems to rural areas would reduce isolation and slow migration to urban centres. Several pilot planning studies were carried out. In Germany, the Medora pilot tested the demand-forecasting capabilities of the data model. Engineers studied highway and railway network datasets to estimate travel time to major urban centres, analysed land use and soil characteristics to determine excavation time for cable laying, and studied population and other socioeconomic characteristics to estimate the purchasing power of communities (Baumann 1995).

An area where GIS has become particularly important is in cellular network planning. In the last decade revenues from the mobile telecoms markets have risen exponentially. Numerous new companies have entered the field, each vying for a proportion of the market. This market expansion has been particularly great in countries with poor cable telephone networks. In Lebanon, where the communications infrastructure was badly damaged during 17 years of war, the cellular phone industry is booming. Mobile markets in Eastern Europe are also growing rapidly. Eastern Europe, the Baltics, and the Commonwealth of Independent States now hold over 50 cellular operators serving over half a million subscribers. A 1995 market study by Pyramid Research predicted that the number of cellular subscribers in these regions could reach 5.5 million by the year 2000. It further suggests that Poland and Hungary will both hold more than one million subscribers by the turn of the century (Pyramid Research 1995).

Mobile telephone companies use radio propagation models to find the best sites for building transmission stations, as shown in Plate 48. The models show engineers the sorts of terrain and obstacles that a radio signal will have to contend with. Since companies need to place their transmitters where there is as clear a signal path as possible, their engineers need to identify sites that are higher than the surrounding areas and away from buildings or vegetation that might interfere with the signals. Predicting radio propagation accurately depends largely on the environment surrounding the mobile phone and the transmitter. Environmental effects are neutralised by including 'clutter' and 'height' layers in the model. Examples of clutter classes include 'urban', 'suburban', 'water', and 'vegetation'. These are extracted from paper maps, aerial photography, and satellite imagery using manual interpretation or multispectral classification. Height information is usually held as raster grids, with each pixel representing a height value. Common sources of height information are paper maps, stereo aerial photography, and stereo satellite imagery (Hurcom 1996).

UK analogue and digital mobile phone coverage provider Vodafone Ltd uses GIS to plan radio networks and target new markets. Since the company switched on its analogue network in 1985, it has expanded its radio base station network from 200 analogue sites to over 2000 analogue and digital sites. Initially Vodafone engineers used a VAX-based application called PACE (Prediction And Coverage Estimation) to plan the physical network. It now uses its own graphic tool, Vodafone GIS, together with Tydac Technology's SPANS software, to combine network planning and marketing activities. For example, Vodafone staff overlay network information with population details to expose areas of high population with poor signal coverage that are likely to yield new customers. As competition in the cellular marketplace increases, the trend towards planning networks for strategic advantage is likely to continue (Dair and Oldfield 1996).

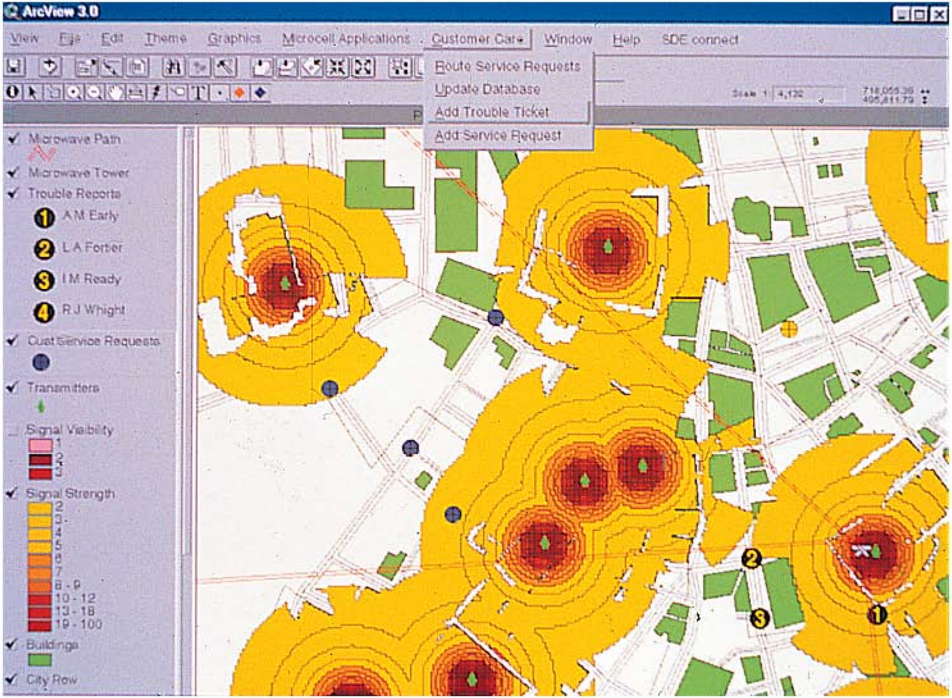

Plate 48
Use of GIS to locate cellular transmitters based on signal interference.

4 MAINTAINING AND OPERATING TELECOMMUNICATIONS INFRASTRUCTURES

The process of maintaining and updating records is central to a company's continued success within the telecommunications industry. Information is now recognised as a valuable resource, and many telecommunications companies initially implemented GIS purely to simplify the task of maintaining up-to-date records. The sheer volume of data generated by planning, designing, building, and altering telecommunications infrastructures, coupled with the pressure to operate efficiently, makes the job impossible without a certain level of automation. Standard AM/FM systems enable operators to reduce or eliminate the need for paper documents, easily update cadastral and network information, and produce maps at a variety of scales to show any part of the infrastructure. Portuguese telephone company Telefones de Lisboa e Porto (TLP) switched from keeping manual records to a digital system in 1995 (Barata 1996). In 1984, the company concluded that maintaining its manual method of record keeping would render 60 per cent of its records out-of-date within ten years. It purchased SICAD GIS from Siemens Nixdorf Informationssysteme to automate the management of its records. These covered 200 000 hectares and incorporated data on one million subscribers, 3200 kilometres of cable conduit and 12 600 kilometres of pipe, plus 6000 topographic maps at 1:1000 scale and 15 000 cable and duct plans. The maintenance department at TLP now uses the GIS to:

- update topographic maps supplied by city councils;
- overlay routing and network elements and prepare cabling and piping maps;
- prepare cabling diagrams incorporating cable junctions and connection boxes;
- update all these maps, plans, and diagrams in pre-determined time scales;
- prepare maps, drawings, and sketches required by external bodies, both for work to be carried out by engineers in the field and in reply to specific requests made by third parties for data capture and conversion.

5 SALES AND MARKETING

In a deregulated telecommunications market, the need to cut costs, attract new customers, and remain ahead of the competition are the business-driving forces. No longer are pieces of telecommunications equipment upgraded simply according to age: rather, investment is allocated first to those parts of the network that are likely to yield more customers. This change in emphasis has forced companies to change not only their general approaches, but also the way they manage their information. Whereas network planning, design, and maintenance used to be the main uses for GIS and AM/FM systems, nowadays having the means to visualise demographic data such as population, types of neighbourhood, average income, and customer preferences is at least as important. As broadband technologies have increased the types of services companies can offer, so companies have had to employ more aggressive marketing strategies to maintain and increase their shares of the market.

The best way for telecommunications service providers to target new markets is for them to be able to compare information about their networks with data about present and potential subscribers. The burgeoning cable communications sector has been one of the first parts of the telecommunications industry to adopt GIS software for marketing as well as engineering purposes. Cable companies have two key aims: to build networks economically and effectively, and to generate a fast return on investment by prioritising sales efforts in areas of greatest immediate potential. The effectiveness of sales and marketing strategies within a geographically-defined territory, such as a cable franchise, demands a knowledge of potential customers in that area. Companies therefore use geodemographic systems to find out about customer preferences in a particular area. Experian's MOSAIC is such a system as it classifies neighbourhoods according to the lifestyles of their residents. Based on a mixture of census, electoral roll, credit, and UK post office data, it provides neighbourhood descriptions for individual unit postcodes (generally 15 households). By distinguishing the types of neighbourhoods that are likely to have cable service customers, cable companies can accurately target their marketing efforts. In the UK, the majority of cable operators, including Telewest, SBC, CableTel, and franchises of Bell Cablemedia (now part of Cable and Wireless Communications) and General Cable, use MOSAIC for this purpose (Fuller 1995).

6 TELECOMMUNICATIONS AROUND THE WORLD

Global trends within the telecommunications market are towards deregulation and increased competition. The speed at which this is happening varies from region to region and country to country. On 8 February 1996, President Clinton signed the first major overhaul of the 1934 Communications Act. This has opened up the US market and paved the way for all manner of mergers, acquisitions, and partnerships across the industry as telephone, cable television, wireless, and information services are freer to compete in each others' markets.

In Europe, the Union has been attempting to open up the markets of its member states since 1987. The main problem is that not all countries have moved in unison to adopt the necessary measures to implement liberalisation and a two or even three speed Europe is the result. Thirty per cent of the member states (Greece, Ireland, Spain, Portugal, and Luxembourg) have been allowed to opt out of liberalisation until 2003, while the remaining countries planned deregulation by 1 January 1998 (Woollam 1997). In some countries, old, slow networks are being upgraded, while in others networks are failing to be built because of stalled liberalisation. Only those countries with the optimum regulatory environment and little existing infrastructure are now able to install new, very fast fibre networks.

In emerging Asian countries such as Thailand and Malaysia, the telecommunications markets are set for rapid change. In Thailand, the fourth version of its Telecom Development Master Plan was presented to the Cabinet in mid 1997. This laid down plans for:

- privatisation of the Telephone Organisation of Thailand (responsible for local and national telecommunication access and cellular services);
- establishment of the Communications Authority of Thailand (responsible for international telecommunication access, cellular, and postal services);
- liberalisation of the sector and the establishment of an independent regulator;
- the setting up of a framework to introduce additional competition in the Thai telecommunication sector.

While privatisation is the goal for telecommunications companies around the globe, the provision of telecommunications remains uneven. However, despite signs that the divide between developed and developing countries has widened in recent years, there are indications that this is changing. In May 1996, government ministers from major countries met in South Africa to debate how to create a truly global information society. In a world dominated by increased social, economic, and political interdependence, deficiencies anywhere in the infrastructure could have serious implications for everyone.

6.1 Case study: Bell Canada

In 1994, a study showed that Bell Canada's revenues were down 22 per cent (US$700 million) on 1992 figures. This was accompanied by a marked decline in the company's net income because it had not increased rates in 12 years, its market share was dwindling, and it had increased its investment in sales and marketing. At the same time, the company was facing long distance competition, which the government had introduced in 1992. As a result of the study's findings, Bell began a three-year transformation plan (1994 to 1997) centred on targeted marketing and sales, the generation of revenue, and investment in technology. Central to this plan was IMap (intelligent mapping, accounting, and provisioning system), a project to:

- provide on-line access to up-to-date network records;
- eliminate inefficient manual record-keeping procedures;
- mechanise work-order design processes;
- improve response time to information queries;
- create software versatile enough to meet future needs.

Bell's engineers had already recognised the need for an AM/FM/GIS and there had been some work towards this goal since the 1980s. In 1992, the company's software developers built the first version of its IMap AM/FM/GIS on OS/2. By 1993, a project was under way to convert paper records, using surplus staff and operations budgets. The conversion was not expected to be completed before 2005 because of limited availability of resources and funding.

The transformation plan built upon the existing work and continues the development of a relational database management system version of IMap. The whole system includes digital land-base mapping software built on Enghouse Systems Ltd's

CableCAD and GeoNET. It comprises an engineering CAD workplan tool, an integrated graphical network environment, a tool to locate and maintain networks, network administration software, an analysis and planning tool, network database management software (Oracle 7 for IMap version 4), and a work order pricing tool. In short, it enables all departments needing access to spatial data to query one database.

Bell Canada provides telecommunication services to seven million customers distributed across 2.6 million square kilometres. Its equipment includes ten million access lines, 1040 switching centres and 75 engineering centres. By mid 1997, Bell Canada had converted 70 per cent of its existing records. The conversion rejection rate at this stage was between five and fifteen per cent and falling. Although the conversion part of the project had to be extended by seven months – it took longer than expected to teach the software suppliers the complexities of the telecoms infrastructure – the overall project cost increased by less than five per cent.

Bell Canada recognises that it learnt a number of lessons from the project. These include the importance of ensuring an accurate land-base, and the need to ensure that sufficient time is spent drawing up a detailed specification to enable staff to monitor the quality of the software as it is developed and coordinate input from the different vendors involved. Three years after beginning the project, the company has met its annual savings objective of Can$26 million (Connor 1997).

6.2 Case study: Telecom Italia

In 1993, Telecom Italia implemented a GIS to locate and repair faults in its public telephone network more quickly, and to set up a network for authorising electronic payments for telephone calls. It chose an open, rather than a proprietary system, so that it could operate various subsystems and integrate existing technology. The public telephone infrastructure in Italy comprises 450 000 public telephone terminals, 100 000 on the street and 350 000 inside buildings such as railway stations. The primary task for the GIS was to improve Telecom Italia's response to reported telephone faults. In 1993, the average roadside telephone terminal recorded 14 faults a year. Multiplied by the number of terminals, that meant the company was dealing with 1 400 000 faults per year, or over 3835 per day. For the remaining 350 000 telephone terminals inside buildings, there were 1438 faults recorded daily.

For each faulty terminal, the company needed to know which company manufactured the equipment and who was responsible for repairing it. At the same time, it needed to be able to check the status of authorisation methods. Callers in Italy can choose several cards with which to pay for telephone calls, including Visa, Mastercard, American Express, and pre-paid Telecom Italia cards. Even if a phone is working, but the network is unable to authorise a payment, the public sees this as a service failure. The GIS has a separate function to collect information concerning the fault recording and the payment method. However, both the information on the fault repairs and the status of payments is stored centrally in a Sybase database. Both systems have local area networks and remote links that allow regional offices to share the data collected.

The system has enabled Telecom Italia to analyse its data with a view to identifying areas of poor customer service. According to Nicola (1996) the company is using it to:

- assess the quality of the equipment it buys;
- evaluate and improve levels of service;
- calculate the volume of traffic and the profitability of each public telephone in the network;
- fine-tune the number of response staff in each area to the demand for their services;
- monitor the test marketing of services in particular areas;
- identify areas that need more telephone facilities.

6.3 Case study: British Telecommunications

British Telecommunications (BT) first set about implementing GIS in the 1980s. One system it used was GFIS, an IBM system used mainly for duct capacity planning. In the early 1990s the company turned to GIS again, this time to help it analyse where its network was in relation to existing and potential customers. It wanted to protect its earlier investments in digitised telephone exchange boundaries at the same time as being able to use the latest postal boundaries, provided by the Automobile Association (a private digital database provider). Attempts to link the two datasets met with some difficulties. Firstly, the coastlines were not well matched and secondly, the exchange boundaries existed in digital form but in an unstructured format. BT solved this problem by developing an 'editor' tool to highlight inconsistencies in the data and to automatically eliminate them. It was then able to use the tool to target customers for its Integrated Services Digital Network (ISDN) and Virtual Private Network services (Saeed 1993).

In 1997, BT decided to reassess its information management once more. This time it wanted to make its data accessible to all departments by:

- modernising the management of its external network planning and recording;
- creating a database management system that could hold the network model and link seamlessly with information on customers, faults, repairs, marketing, and asset management.

It was hoped that the system would reduce planning and building costs, automate processes that were still being done manually, and increase the quality of its records which were failing to meet the legislative requirements. This involved digitising 188 000 maps, 168 000 duct and cable prints, and 2 662 000 duct records. For the data conversion, BT focused its investment on records of areas that had experienced the greatest changes to the network, had the highest operational costs, or held high numbers of customers. Now, planners, repair and maintenance engineers, and marketing staff all have real-time access to a single information source. This has increased productivity, created a multi-skilled workforce, and standardised work processes throughout the company (Ridley 1997).

6.4 Case study: Association Liègeoise d'Electricité

A growing demand for cable TV in France prompted Association Liègeoise d'Electricité (ALE) to implement a GIS to help it cut its design times and improve the accuracy of its drawings. ALE's Teledis department has been distributing TV programmes to viewers since 1969. It mainly uses GIS to design cable infrastructures.

When setting up a network in a new city, ALE engineers first create a map of the city. This enables them to see where major features such as rivers, streets, and buildings are located. The next step is to design a preliminary network and check its feasibility in the field. Then the engineers design a trunk network. This involves positioning amplifiers and splitting devices and designing the connecting trunk line. The design is taken onto the streets so the engineers can check practicalities such as whether a pavement is wide enough to install an amplifier.

When this plan has been approved, the designers work out a cabling and distribution infrastructure for carrying power from the trunk line to cable TV subscribers. The GIS enables the engineers to place devices such as amplifiers and directional couplers, see which ports are available for connections, and calculate signal strength along sections of cable. If the signal falls below a given level, the system sends a warning to the designer.

The final document is a detailed drawing at a scale of 1:1000 or 1:500. For a city of 25 000 inhabitants, around 100 trunk amplifiers are used to distribute cable TV signals. In an average year, the company produces over 500 such drawings. Switching from manual drawing methods to a GIS enabled ALE to cut its design times by a factor of five (Foulon et al 1996).

7 THE FUTURE FOR GIS IN TELECOMMUNICATIONS

With businesses now reliant on fast and efficient telecommunications infrastructures, the coming years are likely to see continued investment in telecommunications projects around the world. While even the smallest companies are likely to use GIS for automating localised tasks such as network design and planning, the larger telecommunications operators will increasingly be looking to gain strategic advantage by standardising information throughout their organisations. Thus, marketing staff will be able to use the same data to map customer distribution as the engineers use to design fibre networks. All data will be held in a structured database with seamless interfaces to separate systems used by individual departments. The ongoing trend towards privatisation is likely to be the driving force behind this, although the speed at which this happens looks set to vary from country to country. As new technologies such as broad bandwidth and fibre-optics become the way forward for telecommunications operators, countries with little or no existing networks may find themselves at an advantage compared to countries with well established networks. Just as the countries with simple networks will be able to install the new technologies from scratch, so companies that have not yet automated their information management procedures will be able to adopt enterprisewide GIS without the burden of legacy systems.

References

Barata P 1996 Portugal Telecom: ready for the Communications Century. *GIS Europe* 5(3): 46–8

Baumann J 1995 Making connections: GIS helps to link Europeans. *GIS Europe* 4(3): 32–3

Connor P 1997 Assisting Bell Canada's business transformation by implementing a world class access network facilities management system. Paper presented at 'Becoming a Lean Communications Provider, Managing Network Infrastructure'. Saint-Paul-de-Vence, Unisys International Industry Forum, France, 11–13 June

Dair B, Oldfield B 1996 Cellular radio: planning and analysis using GIS. *GIS Europe* 5(3): 40–2

Foulon F, Breemersch H, Pallage M 1996 The art of networking. *GIS Europe* 5(9): 36–7

Fuller N 1995 Sell as you build: GIS helps cable companies build viable networks. *GIS Europe* 4(3): 42–3

Hurcom S 1996 Radio propagation modelling. *Mapping Awareness* 10(8): 22–5

Magalhaes G C 1997 Telecommunications outside plant management throughout Brasil. *Proceedings AM/FM International Conference*. Aurora, AM/FM International: 386–92

Moy C C, Austin R F 1997 TIME Telekon's network inventory system: AM/FM/GIS in the big durian. *Proceedings AM/FM International Conference*. Aurora, AM/FM International: 683–90

Nicola G de 1996 Staying on-line in Italy. *GIS Europe* 5(3): 44–5

Pyramid Research 1995 Cellular and PCS markets in Eastern Europe and the Newly Independent States. London, The Economist Intelligence Unit

Pyramid Research 1997 *Telecommunications Development Report* 15 May. London, The Economist Intelligence Unit 12: 18

Pyramid Research Africa 1995 *Middle East Newsletter* 2(2): 3. London, The Economist Intelligence Unit

Ridley M 1997 The case for network information systems: the BT. Paper presented at 'Becoming a Lean Communications Provider, Managing Network Infrastructure'. Saint-Paul-de-Vence, Unisys International Industry Forum, France, 11–13 June

Saeed S E O 1993 British Telecom uses GIS to gear investment to the marketplace. *GIS Europe* 2(1): 10–12

Woollam R 1997 European liberalisation, the final countdown. *Telecommunications Magazine Online.* June