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FEATURES

A Ballard fuel cell stack. In this issue we review the different fuel cell technologies available for electric vehicles.

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Foreword

James Irvine, Editor

Although British mobile operators are still suffering a hangover from paying some of the highest prices for 3G spectrum licenses (totalling $32 billion), they must at least be consoling themselves that they are not in the railway business. The UK Government has just presented details of its $90 billion ten-year plan to improve the country's rail infrastructure.

This is the latest stage in a saga which started with the Government trying to divest itself of responsibility for the railways, only to end up more embroiled than ever. The railways in the UK were sold off in a complicated privatisation which saw the fixed infrastructure sold to one company (Railtrack), the rolling stock to 3 others, the rights and responsibilities to run trains to 25 train operating companies, and maintenance, etc, to numerous others. Railtrack has been in trouble recently due to increased track renewals in the light of gauge corner cracking, the cause of the Hatfield derailment. The UK Government, which provides subsidies to operate the network, placed the operating company in administration in October 2001 by withdrawing backing from a financial vehicle which would have provided short term support.

The Government found itself in some political hot water. Its claims that the company was on its last legs financially were refuted by subsequent figures showing increased profits for its patent company. Also, the promised short-term quick fix of a three to six month period of administration, followed by the setting up of a not-for-profit replacement, is turning into a one to two year administration, with very little certainty about a replacement. A number of infrastructure projects are on hold as a result.

One of the main problems for Railtrack was the recent success of rail travel in the UK, with passenger numbers up by 20%. The regulatory regime was based on an assumption of little or no growth, and separating train and infrastructure operation meant that Railtrack gained little revenue through increased traffic while facing increased maintenance in track occupations on which penalties had to be paid. Technology also paid its part. Increased capacity on the crowded West Coast Mail Line, between London and Birmingham, Manchester and Glasgow was to have been provided by CBTC. When this proved to be too high a commercial risk, the alternative was to lay additional tracks. On the overcrowded UK, the cost of the upgrade has trebled towards $10 billion.

The lesson here – apart from the obvious, that the UK model is not a good one for privatising transport utilities – is the very long term view which needs to be taken of transport investment. $90 billion is no small amount of money, but is less than the Germans plan to spend on their railways over the same period. The Big Dig in Boston is a 19 year $14 billion project for one city. More relevantly for the IEEE, such expenditure requires large numbers of skilled engineers. A welcome aspect of the ten year plan is a National Rail Academy to increase the pool of trained staff; the UK has seen a number of projects cancelled or delayed due to a lack of signalling engineers.

Land transportation may only form a small proportion of a small society like the VTS, but, surprisingly given the current world situation, a recent poll in the UK placed transport as second only to health as an area for concern for voters. Your governments need you!

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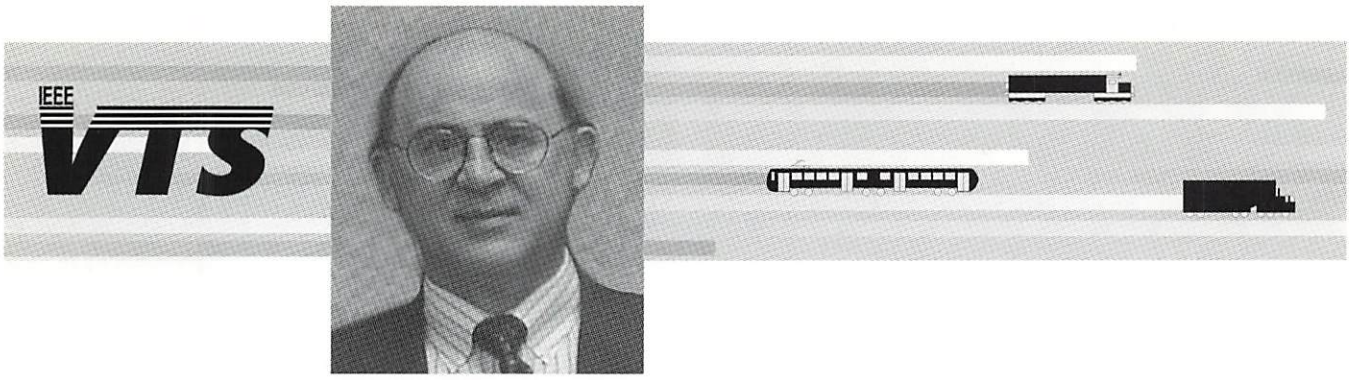

Ultra-Wide Band Radio: A New PAN and Postioning Technology

Kazimierz Siwiak, Time Domain Corporation

UWB (Ultra Wide Band) signaling is the modern art of reusing previously allocated RF bands by hiding signals under the noise floor. Government regulators are testing UWB emissions to ensure that adequate protection exists to current users of the communications bands, and are on the brink of authorizing its use. Technology basics for short-pulse time position coded UWB and for a direct sequence coded UWB approaches are described, along with applications of UWB devices are for both commercial and government uses. Short pulse low power techniques have enabled practical through-the-wall radars, centimeter precision 3-d positioning and communications capabilities at the high data rates.

Introduction

Ultra Wide Band emissions can be said to date back from the 100 year old spark gap "impulse" transmissions of Guglielmo Marconi, who in 1901 sent the first ever over-the-horizon wireless transmission from the Isle of Wight to Cornwall on the British mainland. Radio subsequently developed along analog techniques – voice broadcasting, and telephony – and recently transitioned to digital telephony. Through the years, a small cadre of scientists have worked to develop various techniques and uses for UWB technologies. Before 1970 the primary focus was on impulse radar techniques and on government sponsored projects. In late 1970s and early 80s, however, the practicality of modern low power impulse radio techniques for communications was demonstrated using a time coded Time-Modulated Ultra-Wide Band™ (TM-UWB™) approach. Digital impulse radio, see [1-4], the modern echo of Marconi's century-old transmissions, now re-emerges as Ultra-Wide Band radio.

Alternate methods of generating signals having UWB characteristics are being developed, including the use of continuous streams of pseudo-noise coded impulses which resemble CDMA signaling at a chip rate commensurate with the emission center frequency, see [5]. The industry is now moving closer to regulatory acceptance and to commercial deployment. Given its enormous benefits, it appears that UWB is less a question of "if" and more one of "when and how."

Technology Basics

UWB radio is generally accepted as the art of transmitting and receiving ultra short electromagnetic energy impulses and is the generic term describing radio systems having very large bandwidths. The US Federal Communications Commission (FCC), for example, has tentatively defined UWB systems as "having bandwidth greater than 25% of the center frequency measure at the 10 dB down points," or "RF bandwidth greater than 1.5 GHz" whichever is smaller.

Various developers have perfected a number of different ways for creating and receiving these signals, and for encoding information in the transmissions. Pulses can be sent individually, in bursts, or in near-continuous streams, and can encode information in pulse amplitude, phase, and pulse position. Modern UWB radio is characterized by very low power transmission (in the range of tens of microwatts), by wide bandwidths (greater than a gigahertz).

At least two commercially useful UWB communications techniques are sufficiently documented in the literature to allow further discussion. These are Time-Modulated UWB (TM-UWB) and direct sequence phase coding UWB (DS-UWB). Both systems use transient switching techniques to generate brief (typically sub-nanosecond) impulses or "monocycles" having a small number of zero crossings, thereby spreading the energy over a very wide bandwidth. The impulses are radiated by specialized wide-band antennas, for example see [6]. Although wide spectra are generated in each method, the radio techniques, signal characteristics and application capabilities vary considerably.

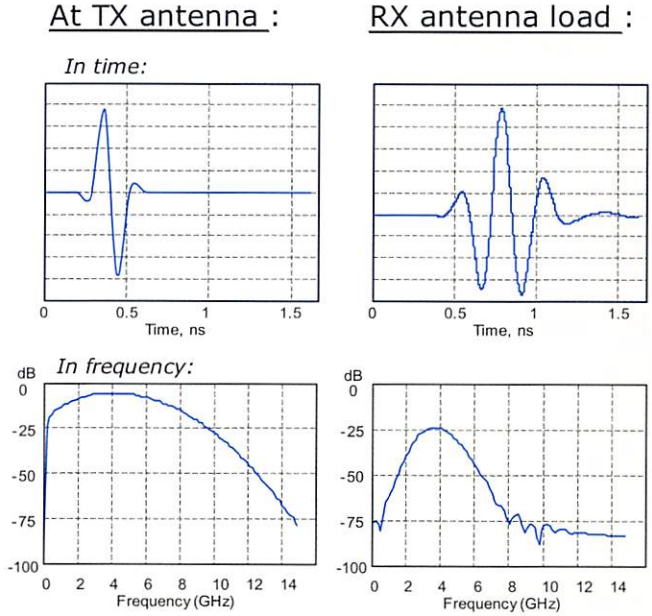

Figure 1 Transmitted and received monopulses. Source: [7]

The monocycle waveform is shown in Figure 1 with its frequency spectrum. The monocycle center frequency and the bandwidth are completely dependent upon the monocycle's width. Actual on the air waveform and spectra as well as the received waveform and spectra are further shaped by the band pass and transient response characteristics of the transmitting antenna as seen in Figure 1. If the pulses had been sent at a regular intervals, or without pseudo noise encoding, the resulting spectrum would contain undesirable "comb lines" separated by the pulse repetition rate. The resulting peak power in the comb lines would undesirably limit the total transmit power as measured in any 1 MHz bandwidth. Instead, to smooth the spectrum, make it more noise-like and provide for channelization, the monocycle pulses are pseudo noise modulated.

TM-UWB impulses are transmitted at high rates, in the order of tens to hundreds of millions of impulses per second. However, the pulses are not necessarily evenly spaced in time, but rather they may be spaced at random or pseudo-random time intervals, a process that creates noise-coded channels as well as a noise-like signal in both the time and frequency domains. Data modulation is applied by further dithering the timing of the pulse transmissions, or by signal polarity. A coherent correlation-type receiver down-converts the UWB pulses to a baseband signal which has a bandwidth commensurate with the data rate. The correlation operation and subsequent integration filtering provide significant processing gain which is effective against interference and jamming. Time coding of the pulses allows for channelization, while the time dithering, pulse position, and signal polarity provide the modulation. UWB systems built around this technique, and operating at very low RF power levels, have demonstrated very impressive short and long range data links, positioning measurements to within a few centimeters, and high performance through-wall motion sensing radars.

DS-UWB uses a high duty cycle phase coded sequences of wide band impulses transmitted at gigahertz rates. The sequences of impulse "chips" encode data at rates of up to 100's of chips per data bit, for scalable data rates from a megabit to 100 Mbps. The modulation is by pulse polarity, and resembles a carrier-less CDMA system with the chipping rate commensurate with the center frequency. The PN (pseudo-noise) encoding per data bit provides some measure of multipath delay spread tolerance and allows for channelization and provides processing gain against interferers. A direct sequence-type of receiver can be used to correlate with the PN code and down-convert the integrated impulses to data rate bandwidths.

Time dithered using a pseudo noise (PN) sequence is used in TM-UWB to place single pulses to a 3 pico-second accuracy within a time window equal to the inverse of the average pulse repetition rate. Figure 2 illustrates a waveform sequence, or "pulse train" that has been PN time coded. In

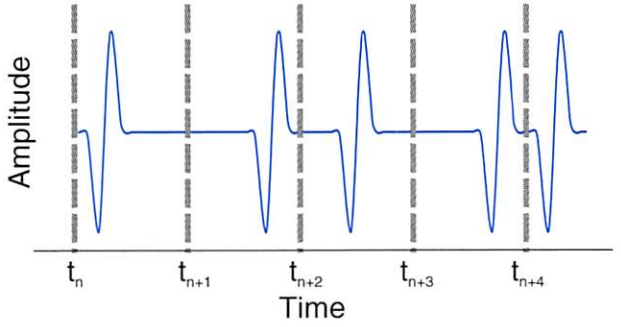

Figure 2 Time coded monopulse waveform sequence in the time domain

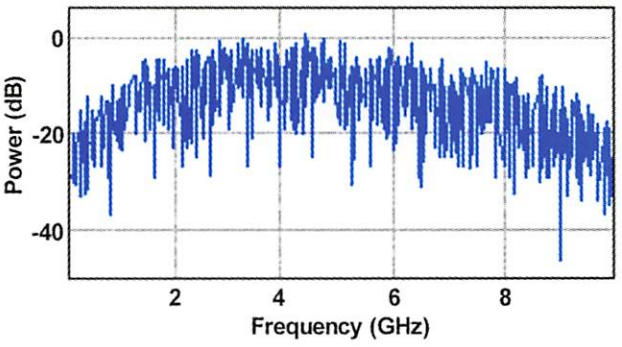

Figure 3 Spectrum of the PN coded monopulse sequence

DS-UWB the pulses are polarity modulated using PN codes. Figure 3 illustrates the resulting noise-like frequency domain characteristics of PN encoded UWB signals.

Signal Propagation

Conventional radio is plagued by multipath within and around buildings, has difficulty with precision tracking in locations that have significant multipath, and has difficulty resolving targets in environments with lots of clutter. Furthermore, multipath and diffraction phenomena conspire to degrade the propagation characteristics of "continuous wave" conventional radio, especially inside buildings. Some UWB techniques, on the other hand, thrive indoors, enable positioning accuracies better than a few centimeters, and generally follow a free space propagation law [8]. Further indoor channel characteristics are in [9–11]. Additionally, UWB is potentially more difficult to detect than traditional radio. TM-UWB systems, for example, transmit millions to billions of coded pulses per second at emissions below the noise floor and across an ultra wide bandwidth using receiver/transmitter pairs communicating with a unique timing and PN codes. These transmissions have a very low extant RF signature, providing intrinsically secure transmissions with low probability of detection and low probability of interception.

Multipath fading, the bane of RF communications, is the result of coherent interaction of signals arriving by many paths. Spread spectrum IS-95 cellular and PCS systems with a 1.228 MHz spreading bandwidth can resolve multipath signals having differential delays of slightly less than one microsecond. Some communications channels, particularly outdoors, can have delays measuring many microseconds, so some multipath components can be resolved and received using rake techniques. However, in-building communications channels exhibit multipath differential delays in the several to tens of nanoseconds and can not be resolved in the relatively narrow band IS-95 channel. Systems like IS-95 must therefore contend with significant Rayleigh fading which requires signals as much as tens of decibels above the static signal level for a given measure of performance.

Properly designed UWB systems can have bandwidths exceeding a gigahertz and are capable of resolving multipath components with differential delays of less than a nanosecond. Figure 4 shows a multipath scenario for a direct impulse path and a reflected paths 1 and 2. When the reflected path 1 is more than a pulse length longer than the direct path, the reflected impulse appears as a distinct delayed signal carrying additional energy to the receiver. When the differential delay between the reflected path 2 and the direct path is smaller than the pulse length, the replica pulse overlaps the direct pulse. As long as the overlap is

Generating UWB

TM-UWB Technology

TM-UWB transmitters emit ultra-short monocycle waveforms with tightly controlled pulse-to-pulse intervals. The waveform pulse widths are between 0.2 and 1 nanoseconds, corresponding to center frequencies between 5 GHz and 1 GHz, and pulse-to-pulse intervals of between 25 and 1000 nanoseconds. The systems typically use pulse position modulation. The pulse-to-pulse interval is varied on a pulse-by-pulse basis in accordance with two components: an information signal and a channel code. The TM-UWB receiver directly converts the received RF signal into a baseband digital or analog output signal. A front end cross-correlator coherently converts the electromagnetic pulse train to a baseband signal in one stage. There is no intermediate frequency stage, greatly reducing complexity. A single bit of information is generally spread over multiple monocycles. The receiver coherently sums the proper number of pulses to recover the transmitted information.

TM-UWB systems use pulse position modulation by positioning the pulse one quarter cycle (60 ps for a 240 ps pulse) early or late relative to the nominal PN coded location, or by pulse polarity. Modulation further "smoothes" the spectrum of the signal, thus making the system less detectable.

A TM-UWB Transmitter

Figure A shows a high-level block diagram of a TM-UWB transmitter. The transmitter does not contain a power amplifier. Instead the transmitted pulse is generated by a pulse generator at the required power. The programmable delay implements the pseudo-noise time coding and time modulation. Alternatively, modulation can be encoded in pulse polarity. The precise timing capability of the timer operation (several picoseconds resolution) enables not only precise time modulation and precise PN encoding, but also precision distance determination. The pico-second precision timer, implemented in an integrated circuit, is a key technological component of the TM-UWB system.

A TM-UWB Receiver

The receiver, shown in Figure B, resembles the transmitter, except that the pulse generator feeds the multiplier within the correlator. Additionally, baseband signal processing extracts the modulation and controls signal acquisition and tracking. Baseband signal processing also drives a tracking loop which locks onto the time coded sequence. Modulation is decoded as either an "early" or "late" pulse in time modulation or as a positive or negative pulse in polarity modulation. Different psuedo-noise time codes are used for channelization. Precise pulse timing inherently enables exceptional positioning and location capability in TM-UWB systems.

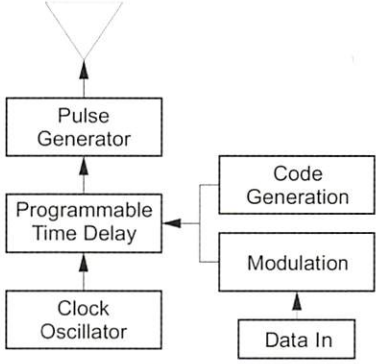

Figure A A TM UWB transmitter

DS-UWB Technology

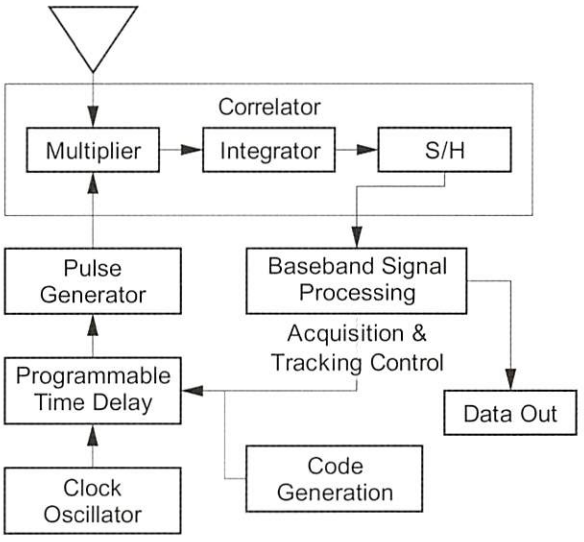

Figure B A TM-UWB receiver.

A second method of generating useful signals having UWB spectra comprises a DS-UWB approach, not unlike RF carrier-based CDMA radios. Impulse sequences at duty cycles approaching that of a sine wave carrier are direct sequence modulated to spread the signal. A PN sequence provides spectrum spreading, channelization and modulation. The chipping rate is some fraction 1/N of the "carrier" center frequency. For illustration, Figure C shows the approximate spectral envelope of a 4 GHz impulse sequence that is DS modulated by a zero mean PN code for the cases N=1 and N=2. Actual PN sequences are relatively short and the spectra contain more features. Both signals in Figure 6 have the same power in a 1 MHz bandwidth at 4 GHz, but the N=1 signal has the greater total power in the spectrum, thus total power and occupied bandwidth can be traded off subject to emissions limits. Data whitening techniques are used to keep the spectrum noise-like.

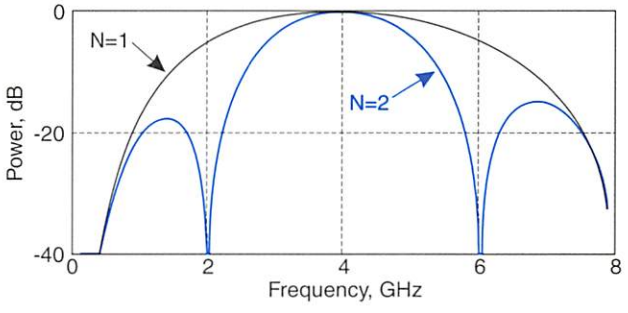

Figure C Spectral envelope of DS-UWB signals with N=1 and N=2.

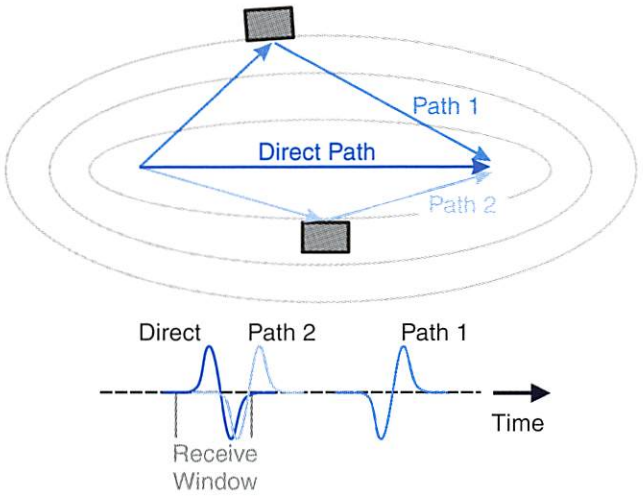

Figure 4 Direct and reflected impulse paths

less than half of the pulse length, this delayed pulse contributes positively to received energy, since the reflected impulse was polarity inverted by the reflection. No margin for Rayleigh fading is needed because there are no overlapping sine waves to introduce destructive interference. In fact, the multiple delayed replica impulses can be integrated or rake-received to provide *gain* over a single direct path in the multipath environment.

The usefulness of ultra-wide band signals follow from their very wide bandwidth. This makes it possible to share the spectrum with the other users of the spectrum with a certain co-coverage sense and constitutes an effective way to mitigate the multipath difficulties of the radio channel. This yields special propagation characteristics allowing some special applications which will be described below. Wide band signals have an additional benefit in being excellent for location determination applications where high accuracy is required.

Wide signal bandwidths also mean that current narrow band users of the spectrum "see" only a slight, if any, increase in the background noise – and then only if within a few meters of an active UWB source, see for example [11]. Wide signals also mean large processing gains for the UWB system to work in the presence of high power narrow band users. UWB emissions are targeted to be lower than currently allowed for unintentional emitters – for example, less than 500 microvolts per meter at 3 m distance for frequencies above 2 GHz measured in a 1 MHz bandwidth (current FCC Part 15 rules for unintentional emitters in the US). Actual UWB limits are subject to regulatory rulings globally. UWB is different enough from traditional narrow band radio that the specific emission measurement methods themselves are under development.

Potential Applications

First conceived as a means to create more bandwidth in the increasingly crowded radio spectrum, TM-UWB uniquely delivers three distinct capabilities through a single technology. In addition to improvements in wireless communications, the technology delivers high definition radar and precise positioning enabled by the pico-second timing precision inherent to the time coded approach. This fusion of capabilities dramatically expands the potential applications for the technology in critical areas such as public safety, military effectiveness, aviation safety, medical applications, and consumer and business products and services. TM-UWB provides exceptional performance in complex, highly cluttered reflective (multipath) environments; low cost, software defined, digital radio architecture; intrinsic security; and excellent tolerance of interference.

Recent trends toward lightweight autonomous sensor systems and unmanned vehicles reinforce the need for solutions that perform multiple functions. Achieving the power consumption, weight and performance parameters required for these new systems is possible only with "clean sheet" technology where fusion has been designed-in from the beginning, as in TM-UWB. The resulting unique characteristics enable the three capabilities of communications, advanced radar, and precision tracking and location.

DS-UWB techniques and other long pulse train systems are suitable mostly for data communications applications, and can be cost optimized for that purpose.

Communications

Secure communications with greatly reduced probability of detection are a consequence of the noise-like spectral characteristics of UWB signals. UWB technology has been proposed as the physical layer in short range local area networks, as documented in work of the IEEE802 group, see [12].

Advanced Radar Sensing

The precision timing of pulses inherent to TM-UWB, and the successful development of advanced timer technology has enabled through the wall radar capable of detection, ranging and motion sensing of personnel and objects through walls with centimeter precision. The technology also enables precision terrain mapping radar for mobile platforms, and effective vehicle anti-collision radar as well as low cost and light weight imaging radar and ground penetrating radar.

Precision Location and Tracking

Precision time coding further enables equipment ID tags and inventory control as well as remote, secure, real-time tracking and telemetry. A typical TM-UWB indoor 3-d precision location and tracking system uses four reference radios to track a tagged robot in three dimensions yielding centimeter precision. This system is capable of fused tracking and communication. Precision UWB guidance systems like this augment GPS capabilities.

Current Developments

TM-UWB wireless technology has been proven over the course of ten years of design, development, and demonstration. Projects and prototypes, demonstrated or in progress, include:

- **Full duplex 1.3 GHz Radio System** – Demonstrated system has an average output power of 250 microwatts, and a variable data rate of either 39 kbps or 156 kbps. The radio was tested to beyond 16 kilometers in range.
- **Full duplex 1.7 GHz Hand Held Radio** – Demonstrated system has an average output power of 2 milliwatts, a data rate of 32 kbps and a range of 900 meters. The unit was also capable of measuring the distance between radios with an accuracy of 3 cm.
- **Simplex 2.0 GHz Data Link** – System has an effective average output power of 50 microwatts, a data rate of 5 Mbps at less than 10-8 bit error rate without forward error correction at a range of 10 meters through multiple walls inside an office building.
- **Through-Wall Radar** – RadarVision 2000 (RV2000), a man-portable radar, is being tested to assist law enforcement and public safety personnel in clearing and securing buildings more quickly and with less risk by

providing the capability to detect human presence and movement through walls.

- **Man Overboard Personnel Tracking** – US Navy program demonstrates the feasibility of using TM-UWB technology for personnel position, location, and tracking (PLT) system within a ship to locate sailors and identify when a sailor is overboard.
- **Radio Frequency Identification (RFID)** – This is an effort to develop an RF identification asset tag that would be attached to a sensor which would monitor the status of equipment in warehouses or in hospitals and transmit sensor data to a central network along with location information. Primary advantages of using TM-UWB for this application include extremely low power RF emissions (an especially critical characteristic for devices near hospital equipment), extremely precise 3-d PLT, and immunity to multi-path.
- **Firefighter (PLT) Radio** – This program demonstrates the feasibility of using TM-UWB radio as a precise, self-referencing, 3-d position location tracking and voice communications system for firefighters inside and outside of buildings. While traditional radio frequency (RF) approaches have considerable problems within high multi-path environments such as buildings, TM-UWB radios are able to take advantage of multi-path, thus making them ideal for this application. Optical and GPS based systems will not work inside smoke filled buildings, but a TM-UWB system will. This program should produce a commercial-off-the-shelf product to help save the lives of firefighters.
- **Radar Enhancement Security Dome** – Security domes based on precision radar can be used to detect motion near protected areas, such as high value assets, personnel, or restricted areas. The dome is software configurable to detect movement passing through the edge of the dome, but can disregard movement within the dome.
- **Rubblevision Radar for Victim Detection** – This comprises RadarVision 2000 prototypes for use in search and rescue missions in collapsed buildings and rubble. Several benchmark tests have been completed with promising results at the Fairfax County and Miami-Metro Dade, Florida, Rubble Rescue training grounds.

Spectrum and Regulatory Issues

UWB operates at ultra-low power, transmitting impulses over multiple gigahertz of bandwidth. Each pulse, or pulse sequence, is pseudo-randomly modulated, thus appearing as "white noise" in the "noise floor" of other radio frequency devices. UWB operates with emission levels commensurate with common digital devices such laptop computers, Palm Pilots, and pocket calculators. Today we have a "spectrum drought" in which there is a finite amount of available spectrum, yet a rapidly increasing demand for spectrum to accommodate new commercial wireless services. The defense community continues to find itself defending its spectrum allocations from the competing demands of commercial users and even other government users. UWB exhibits incredible spectral efficiency that takes advantage of underutilized spectrum, effectively creating "new" spectrum for future and existing services by making productive use of the "noise floor." UWB technology represents a win-win innovation that can make available critical spectrum to government, public safety and commercial users.

Time Domain Corporation has been seeking regulatory approval for intentional UWB emissions since 1989. The issues center around interference concerns, and methods of measuring UWB emissions for regulatory purposes. In June 1999, the US Federal Communications Commission (FCC) granted a waiver of Part 15 of the FCC's rules to allow the company to market and sell RadarVision, a through-wall motion detection device that permits law enforcement, firefighters, and rescue personnel to detect motion on the other side of a wall or through rubble.

In May 2000, the FCC initiated a Notice of Proposed Rulemaking on UWB. The volume of data and analysis submitted before the FCC on UWB is now more extensive than almost any other FCC proceeding. Time Domain and other UWB companies are committed to ensuring that UWB technology, with its many significant benefits, will not cause harmful interference with GPS and other safety-of-life services. Tasks related to several of Time Domain's defense contracts involve the use of GPS collocated with UWB. The defense community and commercial customers are demanding that GPS and UWB operate in a compatible manner.

UWB emissions, especially impulse emissions, present significant regulatory and measurement precedents and challenges. For example, although impulse UWB emissions appear very noise-like in a 1 MHz measurement bandwidth, they could begin to take on structure in a 50 MHz wide IF of receiver. The UWB world is one of transient behavior, while current technologies and regulations are designed around "steady state" and narrow band behavior. A new understanding and new regulations are needed to precisely define how to specify and measure not only the average power, but also the peak to average ratio of the emissions to ensure EM compatibility with all users of the spectrum.

Conclusions

UWB capabilities and limitations have been extensively covered in the media, see for example [13-15]. UWB's best applications are for indoor use in high clutter environments. UWB products for the commercial market will make use of recent technological advancements in receiver design and will transmit at very low power (microwatts). UWB technology enables not only communications devices but also positioning capabilities of exceptional performance. The fusion of positioning and data capabilities in a single technology opens the door to exciting and new technological developments.

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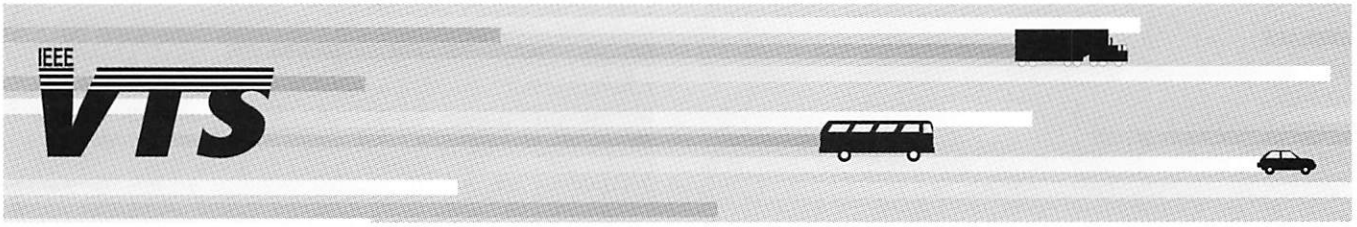

Fuel Cell Systems for Electrical Vehicles : an Overview

M.C. Péra, D. Hissel, J.M. Kauffmann, INRETS

This paper proposes an overview about the integration of fuel cell power systems into electrical vehicles. At the present time, many car manufacturers around the world are presenting no emission vehicles build around fuel cells. But what about the general architecture of these vehicles? What type of fuel cell is preferably used? How can the global efficiency of the whole powertrain be optimized and using what kind of simulation model? This paper will attempt to present some elements to answer these interesting questions.

Introduction

Auto manufacturers around the world have launched important research programs on fuel cells (FC) as major long-term energy-conversion solutions because they offer high fuel economy and substantially lower emissions, particularly of CO_2. Of course, many of these manufacturers have already demonstrated buses or cars that are powered by fuel cells (most of them by Polymer Electrolyte Membrane FC). In association with the fuel cells manufacturers, great efforts have been done in order to improve the stack performances [1]. However, in most cases, the efficiency of the global power system is still reduced due to the lack of specific and optimised auxiliaries.

In a first part of this paper, example of series or parallel hybrid vehicles solutions are presented. Of course, pure electrical power sources solutions can be envisaged. This is the case of fuel cell vehicles as the aim is to replace the internal combustion motor by a fuel cell. Five different kind of fuel cells exist at the present time on the market. Among them, three seem to present characteristics that fit automotive applications. In a second part of this paper, a short description of these three types of fuel cell is provided. A distinction is also made between the solutions that can provide the whole power for the vehicle and the solutions that are mostly advocate for auxiliary power units solutions. Finally, the last part of this paper is dedicated to the presentation of a Matlab/Simulink simulation model of a fuel cell power generation system. This model is a simple and efficient system-oriented model of a fuel cell system, designed to be used for the optimisation of auxiliaries (compressors, expanders, converters,...) and their control laws. This model has been developed under the assumptions that the fuel cell is already in operation and has reached a steady-state point considering the temperature. The temperature is then supposed to be kept constant thanks to the coolant circuit. Simulation results are validated thanks to experimental tests on a real fuel cell system.

Car powered by fuel cell : an alternative for the future

Electrical vehicle is one of the solution for the reduction of fossil fuel consumption and pollutant emissions of gas, responsible for the green house effect. However, pure battery-electric vehicles have shown their limitations, because of their low specific power reducing the vehicle habitability so as its range. Adding different kinds of power supply in the same vehicle allow to take advantages from their different characteristics. This is the principle of hybridization. Various sources and various configurations are possible and can be classified for instance from parallel to series hybrid vehicles [1].

Parallel hybrid vehicles

One hybridization can be the association of an internal combustion (IC) engine and an electrical motor. The wheels can be driven by both of them (Figure 1).

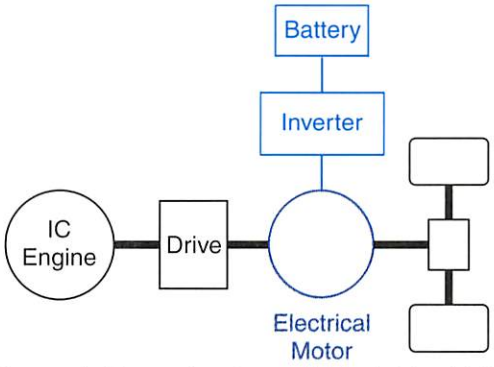

Figure 1 Example of parallel hybrid vehicle

Complete electrical motorization is used for city traffic to avoid any pollutant emissions. Batteries are then used to supply the electrical motor during pure electrical mode. On road and highway, the internal combustion (IC) engine delivers the traction power, and loads batteries during deceleration or idle speed, those are used as storage. An example of that type of vehicle is the Honda Insight, already available on the market.

Series hybrid vehicles

In the series hybrid vehicles, the driving motor is an electrical ones. Hybridization implies only different power supplies sources for the motor. Electrical power is mainly generated on board, for instance by the association of an IC engine and a generator (Fig. 2). Batteries or supercapacitors can be added as energy storage and for energy recovery.

Intermediate structures can be considered, mixing series and parallel options as for the Toyota Prius. It is already series produced : more than 40 000 cars have been sold since 1997.

In order to have a complete zero emission vehicle and to increase the global efficiency of the powertrain, the association of the diesel engine driving an electrical generator can be replaced by a fuel cell system [2]. Hybridization of a fuel cell with batteries or supercapacitors can also solved some of the issues of a complete fuel cell vehicle. First, desionized water, always present in the system, can freeze and damage the fuel cell in case of temperature under 0°C. The presence of batteries allow a pre-heating of the system before a start at low external temperature. Second, fuel cells are still expensive so it can be interesting to limit the power of the fuel cell to nominal conditions; an efficient energy management between the different electric power sources allows then to provide energy for transient behaviors.

As shown in the next section, polymer electrolyte fuel cell is one of the most promising technologies for transportation applications. Nevertheless, many technical issues have to be solved and the complete system should be considered to reach a real optimization for commercial purposes. Simulations allow to define the most interesting structures of hybrid vehicles before experimental validations. It is with this aim in view that our fuel cell system model, described in section IV, is developed.

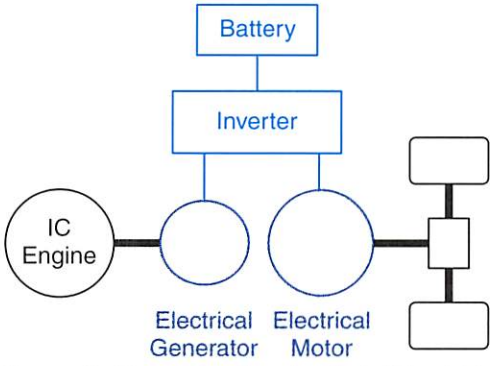

Figure 2 Example of series hybrid vehicle

Fuel cell for automotive applications

A. Fuel cells for motorization

An hydrogen – air fuel cell generator is a stack of elementary cells, made of an anode where hydrogen is oxidised and a cathode where oxygen is reduced, separated by an electrolyte, good ionic conductor and electronic insulant. Among the five existing technologies, three could be interesting to power vehicles : Alkaline Fuel Cell (AFC), Solid Oxide Fuel Cell (SOFC), Proton Exchange Membrane Fuel Cell (PEMFC), this classification refers to the electrolyte nature [3].

1) Alkaline Fuel Cells

It is the oldest technology. It was the alkaline fuel cell that took man to the moon with the Apollo missions. Demonstration alkaline fuel cells were used to drive agricultural tractors (1960), power cars (1971), provide power to offshore navigation equipment and boats, and so on [4]. Reactions on the electrodes are the following:

$$\text{Anode} \quad H_2 + 2OH^- \rightarrow 2H_2O + 2e^- \tag{1}$$

$$\text{Cathode} \quad \frac{1}{2}O_2 + 2e^- + H_2O \rightarrow 2OH^- \tag{2}$$

The electrolyte needs to be an alkaline solution and among the various possibilities, a potassium hydroxide solution is most commonly used. AFC operate around 80°C, with an electric efficiency of about 50%. They show an high areic power. At the present time, their power range is between 1kW and 50 kW. However, three important drawbacks limit their development for automotive applications : the important risk of leakage of the alkaline electrolyte, the low dynamic electrochemical response and the high sensibility to CO_2. Indeed, the carbon dioxide in the air reacts with the potassium hydroxide electrolyte according to :

$$2KOH + CO_2 \rightarrow K_2CO_3 + H_2O \tag{3}$$

The potassium hydroxide is thus gradually changed to potassium carbonate, reducing the concentration of OH^- ions. The performance of the fuel cell is therefore greatly reduced. For this reason, most of the notable achievements of AFC have been done using pure hydrogen and pure oxygen. However, in case of use of AFC for automotive applications, it is essential to remove the carbon dioxide from the air. This can be done, but of course increases costs, complexity, mass and size.

There is only one company which develops this type of fuel cells for automotive applications and presents prototypes: Zetek Power Inc. Zetek Power Inc. has developed an hybrid taxi powered by a 10kW AFC and a 200Ah battery, tested in London, UK.

2) Solid Oxide Fuel Cells

This technology has improved in the past few years. The electrolyte consists in a solid ceramic, that becomes a good ionic conductor at 800°C. The reactions on the electrodes are the followings, underlining that a negatively charged ion O^{2-} is transferred from the cathode through the electrolyte to the anode:

$$\text{Anode} \quad CO, H_2 + O^{2-} \rightarrow CO_2, H_2O + 2e^- \tag{4}$$

$$\text{Cathode} \quad \frac{1}{2}O_2 + 2e^- \rightarrow O^{2-} \tag{5}$$

Due to the ionic conductivity of the ceramic, SOFC must operate around 800°C. This high operating temperature means that precious metal electrocatalysts are not needed. The product water is formed at the anode. Development can be traced back to 1899 when Nernst was the first to describe zirconia (ZrO_2) as an oxygen ion conductor. As it can be seen from equations 4 and 5, both hydrogen and carbon monoxide can be fuels for this type of fuel cell.

The electrical efficiency is the highest that is currently obtained using fuel cells : around 60%. The high operating temperature is, for automotive applications, both an advantage and a drawback. Indeed, before operation, the temperature must be increased to reach 800°C, resulting in a longer time response of the whole system. On the other hand, it is much more simple to size up the heat exchanger. The power range of SOFC is very large : from a few kilowatts to some 100kW, making it possible to use this kind of fuel cell for automotive or stationary applications. At the present time, we don't know any company that has used this type of fuel cell to supply the whole needed power to a vehicle. Nevertheless, some car manufacturers are very interested and have launched important research programs on using SOFC for vehicle Auxiliary Power Units (APU). This will be discussed in the next section.

3) Proton Exchange Membrane Fuel Cells

Although this kind of fuel cell has been used in the NASA Gemini spacecraft in the 1960's, the development of PEM cells went more or less into abeyance in the 1970's and early 1980's. The electrolyte, that is here solid, is an H^+ ion (proton) conduction polymer membrane and the reactions are the following:

$$\text{Anode} \quad H_2 \rightarrow 2H^+ + 2e^- \tag{6}$$

$$\text{Cathode} \quad \frac{1}{2}O_2 + 2e^- + 2H^+ \rightarrow H_2 0 \tag{7}$$

The main reasons that explain the disinterest for this technology during the 1970's and the 1980's are the problem of water management in the electrolyte (one of the most important constraint is the fact that the electrolyte membrane must be always maintained in a well-hydrated state) and the huge quantity of platinum catalyst that were needed (about 28mg of Pt for each cm^2 of electrode compared to 0.2mg.cm^{-2} or less today). However, in the early 1990's, there was a renaissance of interest in this type of cell [5], resulting today in making PEMFC the most promising technology to power electrical vehicles.

PEMFC operate at low temperatures (around 80°C), which brings the advantage that a PEMFC can start quickly. Onto each side of the electrolyte is bonded a catalysed porous electrode. The anode-electrolyte-cathode assembly (also called membrane electrode assembly : MEA) is thus one item and is very thin. The MEAs are then connected in series using bipolar plates (Figure 3). These bipolar plates serve in the same time as a means of feeding oxygen to the cathode and hydrogen to the anode. The thinness of the membrane electrode assemblies means that compact fuel cells can be made. Moreover, there is no corrosive fluid hazards and the fuel cell can work in any orientation. All these advantages, including the fact that the electrolyte is a solid one, mean that PEMFC are particularly suitable for use in vehicles applications.

Figure 3 A PEM Fuel Cell stack (20 MEAs)

The electrical efficiency of PEMFC is about 55%. The developments over recent years have brought the current densities up to around 1A.cm^{-2} or more, while at the same time reducing the use of platinum by a factor of over 100. These improvements have led to huge reduction in cost per kW of power.

At the present time, many car manufacturers have presented demonstration vehicles. For example, it is possible to name the series of *Necar* (I to V) proposed by Daimler-Chrysler, the *Think FC5* proposed by Ford, the *Opel Zafira* proposed by General Motors, the *Demio FCEV* proposed by Mazda, the *Partner/Berlingo* proposed by PSA and so on. Most of them are single powered by fuel cells, some hybrid solutions have also been presented.

All the vehicles employing PEMFC and running on hydrogen may be termed "zero-emission", because the only emission from the vehicle is water (according to (6) and (7)). Unfortunately hydrogen does not occur naturally as a gaseous fuel, and so for practical fuel cell systems it usually has to be generated from another fuel source. Another big problem that has to be overcome before commercial fuel cell vehicles appear on the market is the distribution network problem : how can hydrogen be provided to the customers and stored on-board ?

B. Auxiliary power units on board

Electrical power needed on board of conventional vehicles has greatly increased as equipment is more and more important : air conditioning, power steering, anti lock brake system, multimedia ... In 30 years, alternator power has been multiplied 6 times and battery capacities 3 times. Electrical power should double in the next few years as hydraulic auxiliaries like pumps for instance will be electrified to increase efficiency and reliability. To face this evolution, the association of the alternator rotated by the IC engine and the battery could be replaced by a fuel cell as an auxiliary power unit (APU).

The American car supplier Delphi is associated with the car manufacturer BMW since April 1999 to develop this option. The French car manufacturer Renault has joined them during year 2000, and a collaboration between Delphi and TotalFinaElf has begun since May 2001. Delphi and BMW have unveiled the prototype of a conventional vehicle with a fuel cell APU. The electrochemical generator is a solid oxide fuel cell, a 5 kW gasoline reformer provides hydrogen on board. This solution is promising for two reasons. The first one is the reduction of gasoline consumption (50% during a city cycle) as the efficiency of the fuel cell system is greater than the one of the association IC engine and alternator. Secondly, auxiliaries can be powered even if the IC engine is shut down. However, improvements are needed for integration in the vehicle, because the reformer and the fuel cell generator occupies a great part of the trunk.

Modelling of a Polymer Electrolyte Fuel Cell System for Automotive Application

Main car manufacturers perform research programs on vehicles powered by PEMFC. They have already unveiled prototypes like Daimler Chrysler with the *Necar* series. However, many improvements should be done concerning, for instance, integration of the system and global efficiency. The design of specific auxiliaries, adapted to this application, implies to take into account the global system and the interactions between the different elements. It is with this aim in view that a model of fuel cell generator has been developed — the next step being the integration in a larger model of the whole vehicle.

A. General structure of the model

Many different kinds of physical phenomena (electrochemical, thermodynamical, thermal, etc) are involved in the evolution of the stack. Furthermore, the electrical response of the fuel cell depends not only on the stack but also on the response of the auxiliaries that are located around the stack (Figure 4). A modular structure of the model has been chosen in order to separate the functions of each circuit, and interactions between the elements are taken into account through the input and output data (Figure 5). The single cells are supposed to be identical and to have the same behavior. The stack is then modelled as a unique cell. Depending on the control chosen for the system, the reference value can be either the power or the current. The power or the current are both imposed by the load, i.e. by the power converter and the electrical motor in case of use in an automotive system. The electronic flow is then calculated according to the Faraday law (8):

$$qe^{-} = \frac{N.I}{F} \tag{8}$$

where : N is the number of cells,
I is the considered reference current,
F is the Faraday constant.

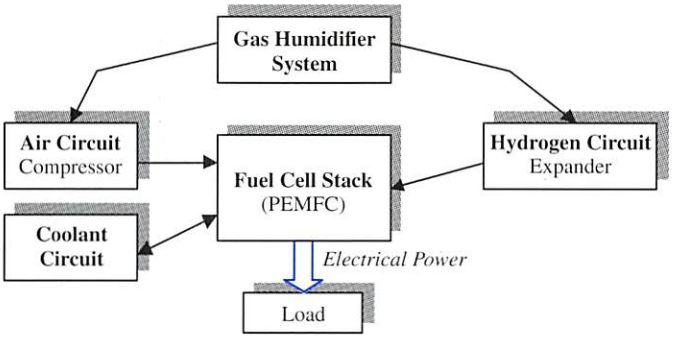

Figure 4 General design of the fuel cell system

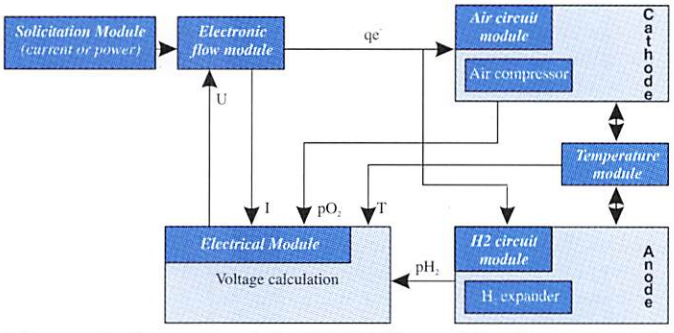

Figure 5 Synoptic of the PEMFC model with power reference

B. Modules description

1) Hydrogen circuit module

In the model, the assumption that the hydrogen is stored under 200 bars (or over...) and directly on the vehicle has been done. This implies that no reformer has been taken into account at the present time. This assumption can be justified considering the position of most automotive manufacturers, who consider that on-board reforming of H_2 from fossil fuels can only be a transient solution and that the final solution must be the direct storage of hydrogen [6]. Moreover, if we consider captive floats, such as city buses, the direct re-fuelling of hydrogen cannot be considered as a problem. An expander, located at the exit of the hydrogen tank, lowers the hydrogen to a regulated pressure. Dry, pure hydrogen is supposed to be used and to follow ideal gas law.

The length of the pipes, from the H_2 expander to the stack is here supposed to be 3 meters (model parameter). This length is obtained considering the bus case, where the expander is located on the roof of the bus and the fuel cell stack on the floor of the bus. The pressure propagation speed is sound speed: 300m/s, so pipes are supposed to be responsible for a 10ms dead time. The expander is modelled by a valve submitted to a pressure balance. If the pressure in the anode compartment falls bellow the reference value, the valve opens and hydrogen enters into the anode, if it raises above, the inlet flow becomes zero. A delay due to the time response of the expander has been estimated to 20ms.

The consumed hydrogen flow is calculated according to the current reference and the anodic oxidation reaction:

$$q_{cH2} = \frac{NI}{2F} \tag{9}$$

with : q_{cH2} : consumed hydrogen flow ($mols^{-1}$),
N : number of cells,
F : Faraday constant.

The anode compartment is supposed to be operating in "dead end mode". So, the hydrogen outlet is closed and the whole incoming hydrogen is oxidized. Of course, due to the accumulation of water and nitrogen, migrating from the cathode, through the membrane, in the anode compartment, regularly time-spaced hydrogen flushes should be done to maintain the nominal stack behaviour. However, this phenomena have not been taken into account in the first development of the model. The instant mole number of hydrogen in the anode compartment is calculated considering the balance between the incoming flow and the consumed hydrogen flow. The hydrogen pressure is then calculated by the ideal gas law.

2) Air circuit module

Inlet gas is supposed to be ideal and water saturated. Thus, it is composed of oxygen, nitrogen and steam. A model of the air compressor can be easily integrated, thanks to the chosen modularity, on the air circuit for tests on the fuel cell stack.

Flows of different gas (oxygen, nitrogen and steam) are calculated by the balance between the input number of moles, the output number of moles and the moles used (or produced in the redox reaction). For example, the consumed oxygen flow is calculated according to the reduction equation :

$$q_{cO2} = \frac{NI}{4F} \tag{10}$$

where q_{cO2} is the consumed oxygen flow ($mols^{-1}$).

In order to increase the chemical efficiency of the reaction, the input oxygen flow has to be higher than the one needed to get the desired current according to (11). The ratio between the input number of oxygen moles and the consumed number of moles is called the cathode stoechiometric factor F_{sc}. This factor can be parameterised by the user, the value of the regulation cathode pressure too. Notice that this pressure is regulated thanks to a control gate that is placed at the output of the cathode compartment.

$$q_{iO2} = F_{sc} \cdot q_{cO2} \tag{11}$$

where q_{iO2} is the incoming oxygen flow ($mols^{-1}$).

The cathode compartment is open because a constant gas flow has to be maintained in order to drain the nitrogen and the water. The pressure drops between gas inlet and gas

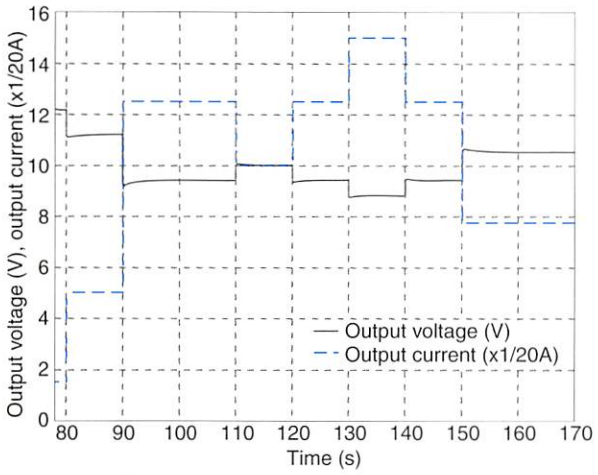

Figure 6 Simulated output current and voltage versus time

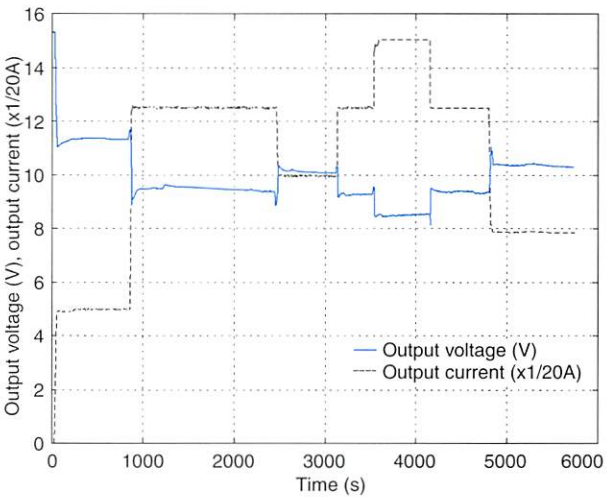

Figure 7 Experimental current and voltage versus time

outlet inside the stack are modelled using a simple but efficient Darcy-Weisbach law.

As the stack temperature is supposed to be maintained constant, the partial pressure of steam in the cathode compartment is also constant. This partial pressure, for water saturated gas, is in fact only depending on the temperature over the range of considered cathode pressures. Notice that even if the temperature evolution has not been taken into account till yet, the modularity of the proposed model makes it possible to build afterwards a new module computing the stack temperature [7]. Researches in that direction are already in progress in the laboratory.

3) Electrical module

The output voltage depends on the current, on the temperature and on the logarithms of hydrogen and oxygen local partial pressures [8]. As the modelling is a macroscopic level, we take into account the input gas partial pressure in the anode and cathode compartments, calculated by the corresponding modules, instead of local values, and the temperature is supposed to be constant. The fuel cell voltage is then calculated as follows :

$$U = U_0 - rI + \alpha T \ln P_{O_2} + \beta T \ln P_{H_2} + \gamma T \ln I + \delta . T \qquad (12)$$

where :

I : output current (A),

P_x : input partial pressure of x,

α, β, γ, δ, r are coefficients that are identified from an experimental test.

In our case, we have chosen a least squares method to identify these five coefficients. Of course, due to the natural logarithm of current I, this relation cannot be used on the whole current domain. Nevertheless, it's commonly accepted that this relation fits for currents over 10% of the nominal value [9].

C. Results of simulation and experiment

The identification of the parameters of equation (11) has been done from an experimental test on a 5kW stack. The reference current evolves in 2 steps : 0-100A and 100A-300A. On this experimental test, temperature evolves from 20°C to 80°C. As, in our model, this temperature is supposed to be constant and equal to 80°C, the terms U_0 and δT have been calculated as one.

According to the aim of the model, the most important characteristic is the evolution of the fuel cell versus the current, as any electrical generator. Simulation and experimental voltage are then presented and compared, when the current reference changes (Figures 6 & 7). Results concerning other parameters of the fuel cell, as pressure and gas flows, can be found in [10-11].

Voltage drops are very well reproduced by the simulation. For instance the first step current of 150A leads to a voltage drop of 1.8A.

However, dynamic behaviour has not been correctly taken into account. As a matter of fact, it is mainly induced by times delays due to the length pipes, the response of the expander and the compressor. The test bench is fed by an air reservoir, not by a compressor and pipe length is not known. Furthermore, the acquisition frequency is slow, results are means of 200 acquired points and the time base is not always correctly calibrated. Another test bench, where the dynamics of the system will be more representative to those encountered in automotive applications is currently under development in the laboratory [12].

Conclusion

Several hybridisation solutions for electrical vehicles have been presented. Until yet, the only commercial hybrid vehicles combine an internal combustion engine with, most of the time, electrical batteries. To achieve the aim of the commercialization of no emission vehicles, an interesting solution could be the use of a fuel cell power generation device instead of the internal combustion engine. Several kind of fuel cell technologies can be envisaged. Among them, the most promising ones seem to be the polymer electrolyte fuel cells for the power generation or the solid oxide fuel cells for auxiliary power units. A short description of these fuel cells has been provided.

After having done the choice of a fuel cell technology, several milestones have to be overcome before fuel cell vehicles appear on the market at a competitive price. One of them is the optimization of the global efficiency of the whole powertrain, from the well to the wheel. To achieve this aim, powerful and efficient but also simple enough simulation tools are necessary. This paper proposes basis for such a simulation tool. The simulation results are validated through experimental tests on a 5kW fuel cell stack.

Acknowledgment

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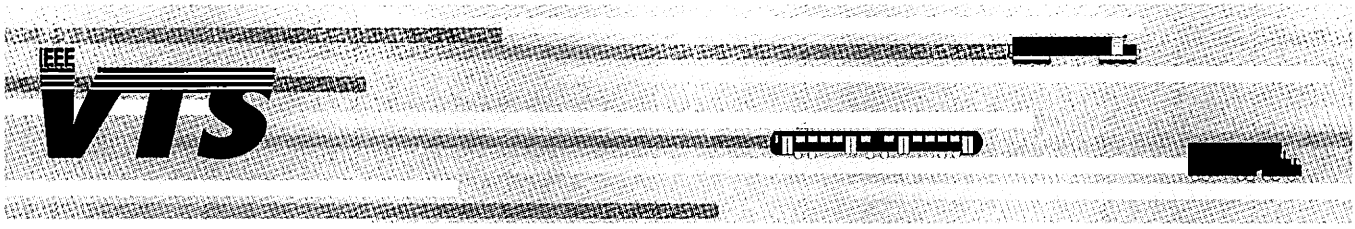

GERAN – the GSM/EDGE Radio Access Network

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GERAN denotes a radio access network combining GSM and EDGE bearer service capabilities. With its ability to operate in existing 2G spectrum GERAN efficiently parallels other 3G radio access technologies such as WCDMA. The presently standardized feature of connecting to the UMTS core network further facilitates this. This article presents an overview of the GERAN standard as well as discusses some fundamental Radio Resource Management aspects outside the scope of the standard. A performance evaluation of the GERAN concept is also provided. It is seen that a variety of services may be supported with high capacity and controlled quality.

Introduction

In line with the recommendations for IMT-2000 radio interfaces issued by the International Telecommunications Union (ITU) [1], the global mobile communication standardization group 3GPP, (3rd Generation Partnership Project) including Japanese, American and European standardization bodies, released the first standards of third generation cellular systems in early 2000. The Universal Mobile Telecommunications System (UMTS) employing a Wideband Code Division Multiple Access (WCDMA) technique [2] is tailored to offer third generation services, i.e. high user data rates for real-time as well as less delay sensitive applications, in the UMTS/IMT2000 spectrum and 1900MHz band. Enhanced Data rates for Global Evolution (EDGE), is tailored to be an evolution of current GSM and TDMA (TIA/EIA-136) systems. It thereby provides coverage for third generation services in existing spectrum bands (including 450, 480, 850, 900, 1800 and 1900MHz bands). Both these systems fulfil the requirements on IMT-2000 systems as defined by the ITU. With the continuing efforts in the standardization bodies, the GSM/EDGE Radio Access Network (GERAN) will, just like WCDMA with its associated UMTS Terrestrial Radio Access Network (UTRAN), be fully UMTS capable. Thus, both UTRAN and GERAN can, independently or in a complementary way, be connected to the same UMTS core network.

The first steps towards what we today refer to as GERAN began in the European Telecommunications Standards Institute (ETSI), with the standardization of a packet data service for GSM, General Packet Radio Service (GPRS). With this packet data service, new nodes were introduced in the GSM network with a focus on data transfer. GPRS did not however mean any significant changes to the physical radio interface of GSM and steps for increasing the physical transmissions rates came about in later work, commonly re-

ferred to as EDGE. With EDGE, a higher level modulation was introduced in the GSM standard, allowing transmission rates about three times higher than with GPRS and High-Speed Circuit Switched Data (HSCSD). The denotations Enhanced GPRS (EGPRS) and Enhanced Circuit Switched Data (ECSD) are commonly used to refer to the packet and circuit switched mode of EDGE modulated transmission modes in GSM/GPRS. With EDGE, a highly sophisticated ARQ protocol was also introduced, including both Link Adaptation (LA), i.e., changing code and modulation mode depending on radio link quality, and an Incremental Redundancy mode (IR) enabling efficient retransmission of additional redundancy for erroneously received blocks/packets.

In addition, efforts were made in both ETSI and the American telecommunications groups Universal Wireless Communication Consortium (UWCC) and Telecommunications Industry Association (TIA), to introduce support for EDGE as a packet data solution in TIA/EIA-136 networks. These efforts resulted in specifications for systems including a circuit switched part on 30kHz carriers, according to the TIA/EIA-136 standard, and a packet switched part served by 200kHz carriers according to the ETSI GSM standard, including the EDGE modulation. Also, a time-synchronized EGPRS version was standardized, denoted EDGE COMPACT, named after its scarce spectrum requirements [3].

The work done on GSM and EDGE in ETSI has gradually been transferred into 3GPP groups. With the dismantling of the radio interface and radio protocol group, ETSI Special Mobile Group 2 (SMG2), forming 3GPP Technical Specification Group GERAN, the momentum of further evolving GSM and EDGE can now justly be called a 3GPP activity.

By introducing this higher level, 8PSK, modulation in the GSM radio interface, EDGE provides support for high data rates. The next step in the GSM/EDGE evolution is to provide support for conversational and streaming service classes (real-time services) [4]. A driver of this evolution is the shift within the telecommunications world from circuit switching to packet switching. This shift is valid for traditional non-real-time data services, such as e-mail and Web browsing, as well as for real-time services, such as video conferencing and voice over IP (VoIP).

The second-generation packet-switched core network, originally defined for GPRS, and the current GSM/EDGE radio access network must each be modified to support real-time services. This includes adopting an interface to the third-generation UMTS core network, similar to that used with UTRAN. This interface is commonly referred to as the Iu interface. Doing so simplifies the alignment with services that will be provided in UMTS, and enables connection to the same third-generation core network.

In the 3GPP standardization, this next phase of evolution is called GSM/EDGE radio access network or GERAN. The two main objectives of GERAN are

- ✦alignment of GSM/EDGE and UMTS services—this mainly relates to enhanced support for conversational and streaming services; and
- ✦introduction of the ability to interface with the third-generation UMTS core network over the Iu interface used in UTRAN.

An overview of the general standards development process, including the relationship between different standardization bodies, can be found in [5]. With regard to GERAN, several papers have been published on a number of different aspects, concept overviews may be found in e.g. [5–14], whereas [15–24] focus more on specific issues. This paper provides an overview of the GERAN standard as well as discusses radio resource management issues outside the scope of the standard. It also summarizes some of the performance results from [6–24]. The paper is included in a series of articles on future radio technologies, wherein the first article dealt with cdma2000, the evolution of TIA/EIA95-based systems [25]. The paper begins with a motivation of the GERAN concept. This is followed by an overview of recent enhancements of the GERAN standard, mainly related to UMTS alignment. Next, a few radio resource management aspects and techniques for efficient utilization of spectrum are discussed. A performance evaluation of the full GERAN concept is then provided. Finally some concluding remarks are made.

2 Why GERAN?

The motivation behind the standardization activity for evolving GSM/EDGE towards, and aligning it with, UMTS can perhaps best be described in terms of target group—that is, in terms of operators, vendors, and end-users.

For mobile operators, the prime driving forces are directly related to reduced operating costs and increased revenues. Operators want to use existing (relatively cheap) GSM frequency bands as a complement to the newly acquired UMTS bands. And because GERAN offers the same third-generation bearer services as those defined for UMTS, any new investments that operators make in equipment for the GSM bands will be secured for the foreseeable future. Operators might also look forward to closer cooperation and integration between their different networks (GSM/EDGE and UMTS). This can partially be achieved through an interface between the base station controller (BSC) and radio network controller (RNC).

Vendors want the solutions for implementing GSM/EDGE to facilitate convergence with the development and manufacturing processes for UMTS. Happily, the prerequisites for achieving this objective are provided through the GERAN enhancements, whose prime goal is alignment with UMTS. This requirement also guarantees long-term revenue streams from GSM/EDGE equipment.

Obviously, end-users must also perceive the benefits of the new technology, for example, by being able to seamlessly roam between different radio access technologies (GERAN or UTRAN) to access third-generation UMTS services, such as real-time IP multimedia. And because application developers will now have a uniform environment for creating new and advanced third-generation services, these services can thus be made available to end-users in a timely manner.

3 The GERAN Standard

This section gives an overview of the latest enhancements of the standardized parts of the GERAN concept. This includes the services provided, the system architecture and interfaces, as well as the protocols used to communicate between the different system nodes. Additionally, a review is given on the key EDGE elements for enhancing data rates compared to standard GPRS: 8PSK modulation and Link Quality Control. Sections 3.1 – 3.5 are largely a condensed version of [13]. More details may also be found in 3GPP's overall GERAN description [14]. Overviews of previous standard releases may be found in e.g. [6–9].

3.1 GERAN Services

Second-generation radio access technology brought mobile telephony to a broad market. By contrast, third-generation radio access technology will extend beyond basic telephony: a common, IP-based service platform will offer mobile users an abundance of real-time and more traditional non-real time data services.

Typical services with real-time requirements are voice and video, as well as delay-sensitive applications, such as

traffic-signaling systems, remote sensoring, and systems that provide interactive access to World Wide Web (WWW) servers.

The challenge is to support end-to-end services based on the Internet Protocol (IP). The main benefit of running IP end-to-end—including over the air interface—is service flexibility. Indeed, flexibility more or less eliminates dependencies between applications and underlying networks, for example, access networks. To date, cellular access networks have been optimized in terms of voice quality and spectrum efficiency for circuit-switched voice applications. However, for services such as IP multimedia, which includes voice, the main challenge is to retain comparable quality and spectrum efficiency without decreasing service flexibility. Today, for example, considerable protocol overhead is suffered when bridging the air interface with Real-Time Protocol (RTP), User Datagram Protocol (UDP) or IP packets (which carry media frames). Needless to say, this runs counter to the goal of spectrum efficiency.

To achieve spectrum efficiency, different packet data streams can instead be characterized in terms of bandwidth and delay requirements. Characterization of this kind is useful when implementing admission-access algorithms that accommodate multiple user data streams in available spectrum. Different methods of limiting data (such as header compression and session signaling compression) must also be applied to obtain adequate spectrum efficiency.

In order to adequately support the application domain on the network side, GERAN offers a multitude of bearer services that can fulfill different QoS requirements. Those QoS requirements can be further classified according to the UMTS definitions described below.

3.2 QoS classes in UMTS and GSM/EDGE

Because frequency spectrum is a scarce resource, the benefit of classifying traffic to guarantee system capacity and quality of service (QoS) is readily seen. By differentiating traffic flows in the network, four application-related QoS classes have been defined within UMTS and GSM/EDGE [4]:

- The conversational service class is used for real-time services, such as ordinary voice telephony, IP-telephony and video-conferencing. The vital characteristics of this class are low transmission delay and preserved time relationships, or low-delay variation, in the traffic flow.
- The streaming service class applies to real-time audio and video-streaming applications. In contrast to the conversational class, this category comprises one-way transport.
- Typical applications associated with the interactive service class are WWW browsing and telnet. The fundamental characteristic of this service class is a request-response pattern. Consequently, the round-trip delay is an important factor.
- The background service class is used for best-effort traffic. Examples of services in this class are electronic mail (e-mail), Short Message Service (SMS), and file transfer. In this service class, the requirements that apply to transfer delay are less stringent.

These four QoS classes are supported in GERAN and UTRAN by adequate radio access bearers.

3.3 GERAN System Architecture

One might think that providing support for packet-based real-time services and the adoption of the UMTS QoS architecture would require that changes should be made to the second generation GPRS core network. However, an alternative solution is to connect GERAN to the third generation UMTS core network,

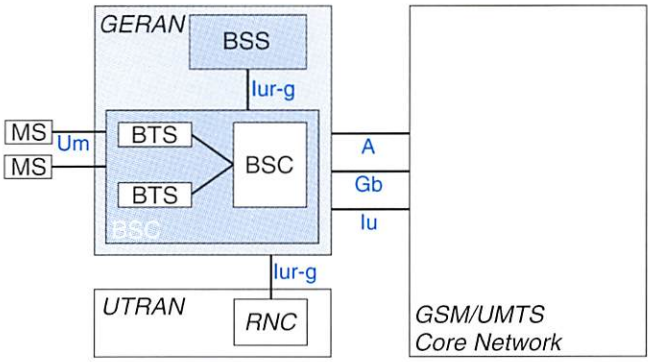

Figure 1 The GERAN reference architecture. GERAN parallels UTRAN within UMTS system architecture

which supports real-time services and the UMTS QoS architecture. This approach, as depicted in Figure 1, employs a common core network (i.e. MSC and SGSN) for both UTRAN and GERAN over a common interface.

To connect to the third generation UMTS core network (a 3G MSC and SGSN), GERAN uses the so-called Iu interface (3GPP Release 5 of the specification, scheduled for March 2002). This interface can be seen as comprising two parts: the Iu-ps connects to the packet-switched domain of the core network, whereas the Iu-cs connects to the circuit-switched domain. Note: the two parts of the Iu interface share the same control plane (the radio access network application part, RANAP, protocol) and have similar user planes.

Figure 1 further shows that GERAN also connects to the second generation core network (2G MSC and SGSN) using the A and Gb interfaces. For packet switched domain, the Gb interface is needed for support of Rel-4 (and earlier) terminals. The Iu-ps interface could not be used for legacy terminals, since for the Iu-ps interface, the functional split between the radio access network (RAN) and the core network differs from that for the Gb interface. The preferred solution is thus to support legacy terminals over the A/Gb interfaces.

The radio interface between the mobile terminal (also called mobile station, MS) and GERAN, called the Um interface, is based in part on the radio link interface of GERAN Release 99. However, several enhancements being specified on different radio link protocol layers will provide adequate radio bearers for real-time packet services. Examples of these enhancements are support for handover for the packet-switched domain, separation of the user and control planes, and transparent modes in radio link protocol layers.

3.4 Radio Access Bearers Supported by GERAN

Radio Access Bearers (RAB) provide bearer services through the radio access network. Each radio access bearer is associated with a set of attributes that specifies the required quality and supplies information on the characteristics of the traffic flow. Some examples of attributes are service class, maximum bit rate, service data unit (SDU) loss rate, residual bit error ratio, transfer delay, and guaranteed bandwidth. This information is essential for providing a connection with good quality through the radio access network and for using spectrum efficiently. The different QoS classes specified for UMTS are characterized by specific value ranges for different RAB attributes.

The radio access bearer services provided by GERAN will be aligned with those supported by UTRAN through adapting and supporting the complete UMTS QoS model. The UMTS service concept is thus reused and each QoS class can be supported independently of the radio access network.

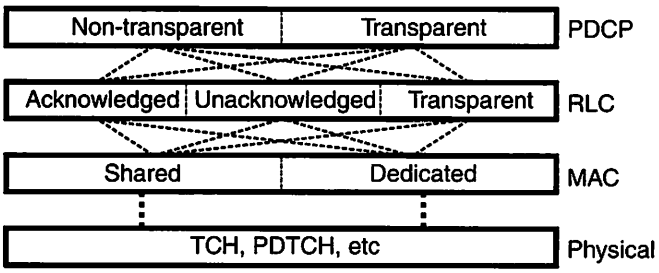

Figure 2 Simplified GERAN radio interface user plane protocol architecture. Different protocol modes are combined to realize different radio bearers.

GERAN currently supports interactive and background service classes over the Gb interface (Release 99). Further enhancements to the cell re-selection procedure, which will shorten the interruptions during cell changes, will enable support for the streaming service class in Release 4 (Rel-4, March 2001). Finally, all four service classes specified for UMTS will be supported by GERAN Release 5 (Rel-5) when a GERAN MS is connected to the core network via the Iu interface. Such an MS is said to be operating in the *Iu mode*. In other words, in the 3GPP standardization, it was decided that the conversational service class will solely be supported in Iu mode. Consequently, handover mechanisms with pre-allocation of resources for the packet-switched domain are being introduced in GERAN Rel-5 specifically for the Iu mode of operation.

Radio access bearers with varying QoS characteristics are realized by combining different modes of operation of the radio interface protocols.

3.5 GERAN Protocols and Radio Bearer Realizations

When introducing the Iu interface in GERAN, the designers endeavored to interject as few changes as possible to the protocols that relate to this interface as well as to the core network nodes and to UTRAN. Consequently, they adopted the associated Iu protocols—mainly the RANAP protocol. However, on the radio side, the introduction of the Iu interface meant that the protocol stacks of GSM/GPRS had to be modified (see Figure 2, which shows the resulting radio link protocol stack).

To support the large variety of radio access bearers in a flexible and efficient way, different modes of the radio-near protocols Packet Data Convergence Protocol (PDCP), Radio Link Control (RLC) and Medium Access Control (MAC), are used. By combining these modes with a set of physical layer parameters several radio bearers can be realized.

The user plane protocol structure for GERAN is depicted in Figure 2. The same PDCP as for UTRAN is used to offer bearers to the Core Network in the same way as for UMTS. PDCP contains e.g. header compression functionality. The RLC protocol provides e.g. segmentation and re-assembly in the unacknowledged mode, extended by incremental redundancy ARQ functionality in the acknowledged mode. The MAC protocol enables multiple users and flows to share a common transmission medium. Shared or dedicated channels may be allocated depending on which type of multiplexing is desired. Transparent modes of each protocol enable minimized overhead in case the functionality is not required. The physical layer supports different types of logical channels, characterized by different modulation formats (8PSK or GMSK), channel coding (punctured convolutional codes) and interleaving depths. Examples of such logical channels are different dedicated-type Traffic Channels (TCH) and shared-type Packet Data Traffic Channels (PDTCH), each associated with a set of coding schemes, interleaving depths and modulation formats. The GERAN overall description from 3GPP provides a more detailed description of the different protocol layers and their modes, as well as list of references to detailed specifications for each layer. The remainder of this chapter focuses on two of the most crucial EDGE-related parts of the GERAN user plane protocols, the 8PSK modulation and the EGPRS link quality control.

3.6 The EDGE Physical Layer

In order to achieve higher data rates, EDGE introduces the new modulation scheme; linear 8PSK. For compatibility and co-existence with GSM, EDGE has many physical layer parameters in common with GSM. This includes 200 kHz channel spacing, 8 timeslots per TDMA frame and 4.615 ms TDMA frame duration. Together with the GSM symbol rate of 271 ksymbols/s, the 8PSK modulation facilitates a maximum gross data rate of 554 kbps/carrier, which is three times higher than for standard GSM. The standard GMSK modulation of GSM may still be used in situations where a more robust modulation is needed. The 8PSK modulation is continuously $3\pi/8$ phase shifted. This decreases the peak to average ratio, but also enables the receiver to distinguish between 8PSK and GMSK modulated training sequences, thus allowing blind detection of modulation. The selection of 8PSK for EDGE in favor of e.g. QAM-based modulation schemes was based on its relatively low peak-to-average power ratio, together with its ability to fit in the same spectrum mask as GMSK.

3.7 The EGPRS Link Quality Control

A characteristic of cellular systems is the varying radio link quality within a cell. Typically, different modulation and coding schemes are optimal for different link qualities. This can be utilized by dynamically adapting the modulation and code rate with respect to the current link quality – which is also referred to as Link Quality Control (LQC). GERAN employs a combined LQC scheme with both Link Adaptation (LA) and Incremental Redundancy (IR). In short, the modulation and coding scheme for initial block transmissions may be selected based on link quality measurements. If retransmissions are needed the robustness is increased through joint decoding of all transmission attempts. A more detailed overview is given in, e.g. [15].

Regarding other link layer aspects, as for standard GPRS, selective repeat ARQ is used. To improve protocol performance the window size is however increased for EGPRS. Additionally, support for segmenting and compressing ACK/NACK bitmaps is introduced to further avoid protocol stalling. Also the Medium Access Control (MAC) functionality is similar to that of standard GPRS, supporting both shared and dedicated channels.

The overheads introduced by the RLC and MAC layers reduce the peak bitrate interfacing the RLC layer to 59.2kbps per timeslot. At maximum, all 8 timeslots on a carrier can be allocated to one mobile station, hence yielding a peak bitrate of $8 \times 59.2 = 473.6$kbps.

4 Radio Resource Management

Offering multiple services with controlled QoS and high capacity is crucial for 3rd generation cellular systems. As discussed above, the GERAN standard indeed provides the necessary tools for reaching this goal. To go all the way however, the tools also have to be used in a proper manner. Roughly, this is the task of the Radio Resource Management (RRM). For GERAN, important RRM components include fractional load planning, admission control, channel allocation, scheduling, and service-based power setting.

This section very briefly discusses the use of these different techniques.

4.1 Fractional Load Planning

For GERAN-based systems, the highest capacity is reached under interference limited operation when hard blocking due to channel shortage does not limit the served traffic. This may be achieved through Fractional Load Planning (FLP) [16], which through tight frequency reuse yields more channels (frequencies) per cell, thereby avoiding hard blocking. Ever-improving transmitter and receiver techniques enable tighter and tighter reuse patterns, and at the same time increased fractional load. In fact, designs rendering even 1-reuse systems blocking limited are foreseeable in the near future. Using Channel Allocation Tiering (CHAT) [17] however, arbitrarily low frequency reuse patterns (below 1) are possible, hence always avoiding blocking limitation.

4.2 Admission Control

A property of interference limited systems is that for traffic loads beyond the system capacity limit, user quality may degrade to unacceptable levels. To avoid such overload situations an admission control scheme may be used to limit the admitted traffic load to levels yielding acceptable quality for admitted users. For single service scenarios, admission control schemes may simply be based on a maximum number of admitted users per cell or set of cells. In a multiple service system however, users of different services may generate different amounts of interference, and the number of users that can be supported varies with the service mix. In a system employing service-based power setting however (see below), the maximum power load (sum of all users' power) is roughly independent of the service mix, and therefore constitutes a suitable basis for admission control.

4.3 Scheduling and Channel Allocation

Despite targeting interference limited operation, there will be cases where channel availability is limited; situations that might be even more common with large fractions of terminals with increased multiple timeslot capability. In such cases, *which* users get to transmit and *when* become important. Different channel allocation and retention priorities together with different scheduling weights may be used to balance quality between service groups and thereby maximize capacity. Scheduling and channel allocation are further discussed in e.g. [18] and [19].

4.4 Service-Based Power Setting and Dynamic Power Control

Another property of interference limited systems is that QoS is determined by the carrier-to-interference ratio (C/I). Moreover, with shared spectrum between services and interference averaging techniques such as random frequency hopping, the interference distribution experienced by different service groups will be equal. Thus, the distribution of C/I for each service group may be determined merely by the output power. In such scenarios Service-Based Power Setting may be used to maximize capacity, i.e., the highest traffic load that can be supported while maintaining sufficient quality for all service groups, see e.g. [20]. In principle this is done through balancing the power resource between the service groups so that quality requirements are simultaneously reached. Service-based Power Setting also works together with dynamic power control schemes. Note that system planning is kept simple; despite the services' different link quality requirements, only one frequency reuse is required.

4.5 Link Quality Control

GERAN offers Link Quality Control, combining both Link Adaptation (LA) and Incremental Redundancy (IR). Modulation and coding schemes may be selected based on link quality measurements and, if retransmissions are needed, the robustness is increased through joint decoding of all transmission attempts. In terms of maximizing throughput, an efficient and simple solution is to employ pure IR, i.e., not adapting between different modulation and coding schemes but always using the initial code rate of 1 (equivalently uncoded). In situations with very poor link quality pure IR may, however, lead to quite large numbers of retransmissions required for each block, which in turn may result in long block delays or protocol stalling. To mitigate these effects, the number of retransmissions required may be limited by using an initial code rate lower than 1 and/or adapt between different code rates. See also [15], [21] and [22].

4.6 A Simple, High Capacity, Multiple Services and Controlled QoS Solution

It may be noted that whereas FLP maximizes overall capacity through interference limited operation, this is also the most beneficial condition for Service-based Power Setting and Power-based Admission Control, preserving capacity for multiple services and controlling QoS respectively. Thus, combining these three basic techniques provides a simple, high capacity, multiple service solution with controlled QoS. System complexity is kept low, only one traffic channel frequency reuse is used, and dynamic channel allocation is not required. A further discussion and evaluation of this solution is planned in [23].

5 GERAN Performance

Several different GERAN performance evaluations have been made both on link and system level. Since GERAN supports multiple services and both circuit- and packet switched access, the number of possible scenarios to evaluate is very large. This section summarizes some recent voice and interactive data performance figures for GERAN, in single as well as multiple service scenarios.

Taking voice as a first example, a comparison between two different deployment strategies is made. A traditionally planned, mainly blocking limited system with 4/12 frequency reuse is compared with a system utilizing more ad-

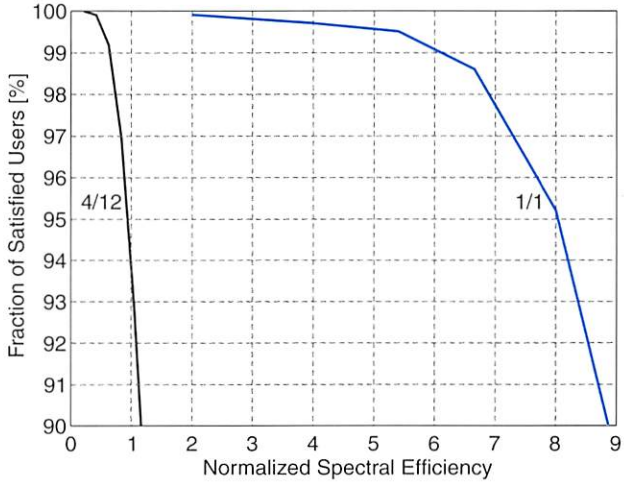

Figure 3 Voice Performance. Compared to a traditionally planned 4/12 frequency reuse system a fractional load planned 1/1 frequency reuse system provides gains in the order of a magnitude

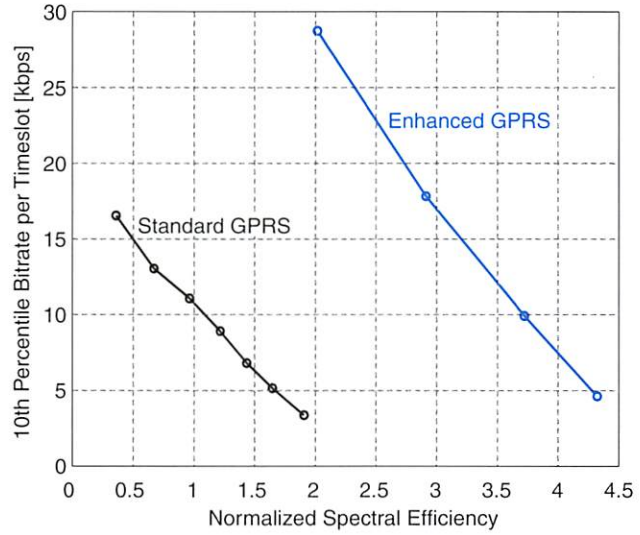

Figure 4 Enhanced GPRS vs. GPRS performance. Depending on the required bitrate Enhanced GPRS improves capacity some 2.5-6 times over standard GPRS

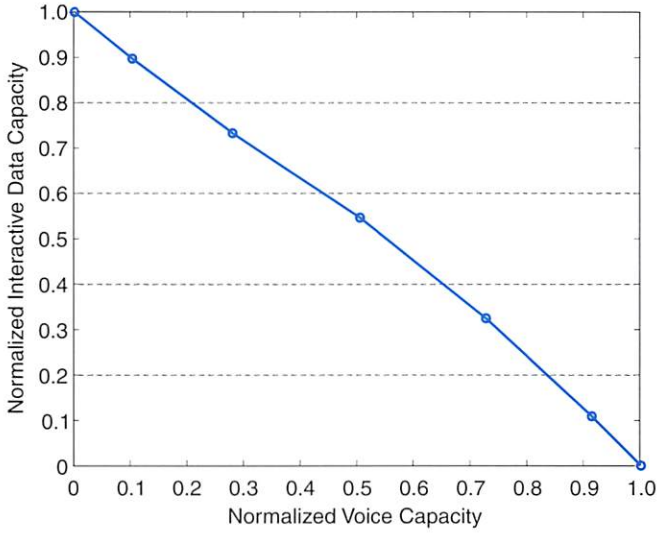

Figure 5 Mixed voice and interactive data performance. The single service capacities are in a relative sense preserved in mixed service scenarios

vanced RRM techniques thereby coping with tighter frequency reuse. The latter system is represented by fractional load planned system with frequency reuse 1/1 [24]. Users are assumed to be satisfied if they are not blocked and their speech quality is acceptable, which in turn requires a certain maximum Frame Erasure Rate (FER). Figure 3 shows the fraction of satisfied users in the two systems plotted against the normalized traffic load. It is seen that for a given fraction of satisfied users the interference limited 1/1 reuse system outperforms the channel (or blocking) limited 4/12 reuse system in terms of spectral efficiency, or equally number of supported users, with roughly an order of magnitude

Next, a comparison between standard GPRS and EDGE-Enhanced GPRS is made. Figure 4 shows measures of GPRS and Enhanced GPRS bearer quality, represented by 10^{th} percentile bitrates (i.e. measured close to the cell border) per timeslot, plotted against normalized spectral efficiency. Generally, the lower the bitrate requirements, the higher the spectral efficiency becomes. Comparing GPRS and Enhanced GPRS, the spectral efficiency for any given bitrate requirement is always significantly higher for the latter, the gain is typically a factor 2.5-6. The explanation for this is the higher level modulation and the fact that Enhanced GPRS through its use of Incremental Redundancy can always make better use of the current signal quality than can GPRS. Thus, Enhanced GPRS not only supports higher bitrate requirements, but is also several times more spectral efficient at any given bitrate requirement. A comparison of standard GPRS and Enhanced GPRS similar to the one presented above may be found in [12].

GERAN also efficiently supports streaming services. Such results are not presented here, but may be found in e.g. [18].

The above performance evaluations are made for single service data and voice system. However, future networks will host a mix of services in the same network, sharing the same channels. As mentioned above, Service-based Power Setting is one way to maximize system capacity at a low complexity cost. In Figure 5, an evaluation of a mixed service voice and interactive data system is shown [20]. The X- and Y- axes represent the normalized spectral efficiencies for voice and data respectively. For each service this is defined as the actual spectral efficiency in the mixed case divided by the maximum spectral efficiency of that same service in the single service case. The area delimited by the curve corresponds to feasible traffic loads for which acceptable fractions of satisfied users for both services are sustained. It may be noted that the capacity exceeds the reference case of 'preserving relative individual capacities', which corresponds to a straight line between single service endpoints. Through appropriate power setting the same behavior may be achieved also when mixing more than two service types, including e.g. streaming and interactive data services with different quality requirements.

6 Conclusions

The continuous GSM/EDGE standardization in 3GPP offers a common evolution path for GSM and TDMA that provides a cost-effective means of providing third-generation services within existing GSM/TDMA frequency bands. With Release 99 of the ETSI standard, circuit-switched voice and packet-switched services without strict delay requirements (such as Internet access for Web browsing and e-mail) can be efficiently supported with adequate radio bearers. With the concept currently being standardized in 3GPP for Release 5, the GSM/EDGE radio access network (GERAN) will provide extended support for third-generation wireless services. This includes support for all the service classes specified for UMTS, which in particular includes support for the conversational service class with its real-time requirements. Furthermore, interfacing to the third-generation UMTS core network over the Iu interface yields greater alignment with UMTS.

The GERAN standard also supports flexible radio resource management. Through combining techniques like Fractional Load Planning, Service-based Power Setting and Power-based Admission Control, simple high capacity solutions for offering multiple services with controlled quality may be found.

For data services GERAN offers capacities 2.5-6 times higher than standard GPRS, together with peak bitrates exceeding 384kbps. Recent enhancements also provide voice capacities an order of a magnitude higher than in traditionally deployed GSM systems.

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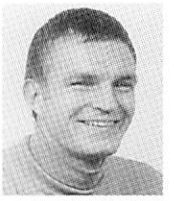
Peter de Bruin joined the corporate unit Ericsson Research in 1996. Peter currently holds a position as project manager, heading a team working with radio resource management for mixed services in GSM/EDGE systems. He received his M.Sc. degree in Electrical Engineering from Chalmers Institute of Technology, Gothenburg, Sweden, in 1992.



Anders Furuskär has a background standardizing GERAN in ETSI and 3GPP. He currently shares his time between radio network research at the corporate unit Ericsson Research, and Ph.D. studies at the Center for Wireless Systems at the Royal Institute of Technology, Stockholm, Sweden. Both activities focus on the area of multiple service management.

Christofer Lindheimer received an M.Sc degree in engineering physics from the Lund Institute of Technology, Lund, Sweden. He joined Ericsson in 1996, and has since 1998 participated in the development of EDGE as a third-generation solution for radio access.

Frank Müller joined Ericsson in 1995 and has been responsible for the standardization of EDGE in ETSI. Since 2000 he has worked with systems management where he is responsible for the GERAN standardization. In addition, he is Ericsson's standards coordinator for GERAN and work item rapporteur for the UMTS alignment in 3GPP. He holds an M.Sc. degree in electrical engineering from the Ruhr University in Bochum, Germany.

Joakim Sorelius received the M S degree in electrical engineering in 1994 from Uppsala University, Uppsala, Sweden, where he also received his Ph.D. degree in 1999. His main research interests were system identification, order estimation and wireless digital communications. He joined Ericsson Research in 1999 where he developed algorithms and simulation tools for adaptive antennas in WCDMA systems. Since 2000 he has been working with the GSM / EDGE radio access network and standardization.

Dalibor Turina joined Ericsson Radio systems AB in 1993, as a member of the technical staff at the Access Networks department at Ericsson Research. In 1997 he became manager of the Air Interface Architecture unit at the Access Networks department. In 2000, he became head of the GSM / TDMA / EDGE standardization strategy. He holds an M.Sc. degree in telecommunications from the Faculty for Electrical Engineering and Computer Sciences at Zagreb University.

Transportation Systems

Harvey Glickenstein, Senior Editor

Houston voters supported light rail. Opponents of light rail in Houston managed to get a proposition placed on the November ballot to stop the construction of the light rail system in Houston. The proposition was defeated, allowing construction of the 7.5-mile line to continue.

The construction is underway in five separate line sections, from downtown to south of Reliant Park. Cars will have a capacity of 200 passengers. The line is designed for a peak hour capacity of 8,000 passengers. Revenue operation is planned for 2004.

Light rail service in Los Angeles is being expanded. The Los Angeles Blue Line to Long Beach has increased train size to three cars. The line had been substantially overcrowded, with a record of 69,400 weekday boardings last August. The line recently completed a 16-month program to lengthen platforms at 19 stations to accommodate the 3-car trains. The Los Angeles Green Line is also being expanded with the addition of 2-car trains.

Construction continues on Phase I of the Los Angeles to Pasadena light rail line. This line, originally known as the Blue Line, will now be called the Gold Line. This will distinguish it from the Los Angeles to Long Beach Blue Line. The original plan was to build a connection between the Long Beach Line and the Pasadena Line west from Union Station to the existing terminus of the Blue Line in Los Angeles. Since construction of that section has been eliminated and the two lines will no longer connect, it was decided to rename the Pasadena Line. The Gold Line will use similar vehicles to the Long Beach Line, however. Trains will have up to three cars and are expected to run every 8 to 10 minutes during peak hours and every 30 minutes off peak. Ridership at opening in July 2003 is anticipated to be 30,000 per day, rising to 68,000 per day by 2015.

Phase 1 of the project, shown in Figure 1, is 13.7 miles long. It will operate from Union Station in Los Angeles to downtown Pasadena. Stops include Chinatown, Lincoln Heights, Highland Park, South Pasadena, and Pasadena. Six of the stations are in Los Angeles, one in South Pasadena, and six in Pasadena.

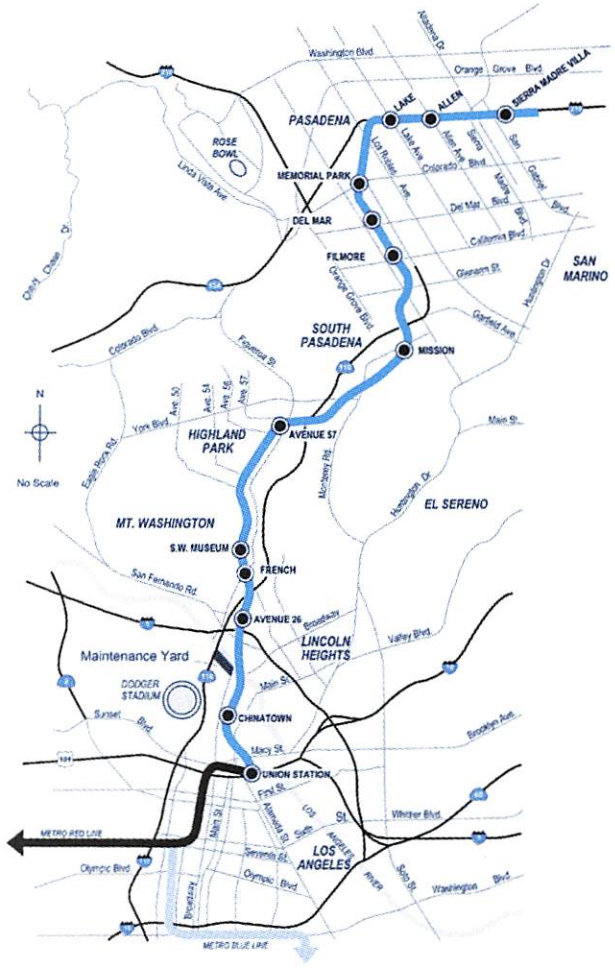


Figure 1 Los Angeles to Pasadena light rail line phase 1

An extension of the line east from Union Station in Los Angeles is under design. That extension was originally planned to be part of the Red Line, but has been modified to become part of the Pasadena Line after the huge overruns on the Red Line construction.

A future 24-mile Phase II of the Gold Line (Figure 2) is also envisioned. This line would extend the system 24 miles further east to Claremont.

Figure 2 Phase 2 of the Gold Line

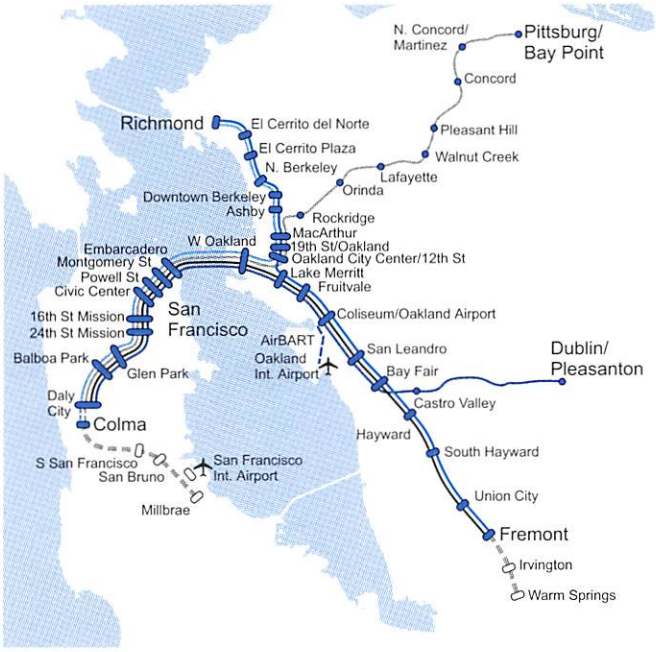


Figure 3 BART in the San Francisco area

Bay Area Rapid Transit (BART) in the San Francisco area has approved an agreement with the Valley Transportation Authority (VTA) of San Jose to extend its system to San Jose. The agreement had been previously approved by VTA.

BART is presently designing an extension from its terminus at Fremont on the southeast of San Francisco Bay 5.4 miles to Warm Springs. The Warm Springs extension is being funded by Alameda County.

The Warm Springs extension will be built on the right-of-way of the former Southern Pacific Railroad. It will be primarily at grade, with a depressed section under Fremont Central Park.

The VTA agreement covers extending BART 16 miles to serve Milpitas, San Jose, and Santa Clara.

The agreement with VTA calls for VTA to be responsible for funding the construction and incremental maintenance and operating expenses of the new line.

Shenzhen Metro in China has ordered 114 cars from a joint venture of Bombardier and Changchun Car Company. The cars will be operated in 19 six-car trains.

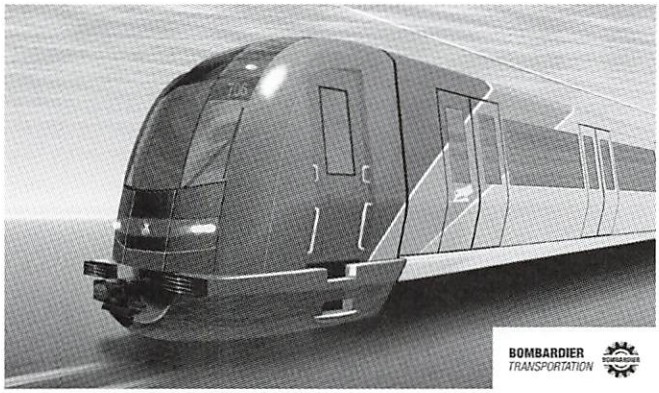


Photo by Bombardier Transportation

Figure 4 Bombardier Transportation's metro car for Shenzhen

Shenzhen is located in southern China near Hong Kong and Guangzhou. The cars will be used on Phase 1 of the metro system, which is currently under construction. The system is planned to be placed in revenue operation in December 2004.

Portland, Oregon's Tri-Met opened its Airport MAX Line in September of last year. During the first month of operation, the service averaged 3,400 passengers per day. This was more than twice the number who had used the airport bus service. The ridership was even more surprising since the airport usage was down about 17%. Taxis appear to have been a major loser with the opening of the MAX Line as their ridership dropped 29%, while paid parking at the airport was down 21%.

The Westside MAX service was originally projected to reach 25,200 daily rides by 2005, but actually reached that figure by April 2000. The current ridership averages 27,600 rides per weekday. Systemwide, MAX averages over 80,200 rides per day.

Amtrak opened a new station on the Northeast Corridor (NEC) to serve Newark Airport. The station, which opened last fall, was built with funds from the $3.00 departure tax levied on all flight leaving the airport. As a result, the station was built with no access to Haines Avenue, the street that goes over the NEC at that location. Several airlines had sued to prevent the Port Authority of New York and New Jersey that collects the fee from using the revenue off the airport. The courts ruled that since the station could not be used by people who weren't going to or coming from the airport, the departure fee could be used to fund the station.

The on-airport monorail was extended to serve the new station. Baggage checking facilities were built at the new station, but since the station went into service after September 11, the baggage checking facilities have not been placed in service.

The station is served by 43 Amtrak trains and 123 New Jersey Transit trains every weekday. Except for Acela Express and certain peak hour Amtrak and New Jersey Transit trains, all trains on the NEC stop at the airport station.

The Central Phoenix/East Valley Light Rail Project placed four proposed vehicle exterior concepts on their web site last November in order to obtain public comment. The proposed vehicles will be about 90 feet long and capable of being operated in trains of up to three cars each.

The 20.3-mile starter line will connect the Arizona cities of Phoenix, Tempe, and Mesa. Other cities in the valley, including Scottsdale, Glendale, and Chandler are considering funding extensions of the starter line. The starter line is planned to begin revenue service in 2006.

The Orange County Transportation Authority (OCTA) has approved the alignment for a 20-mile light rail line. The line would connect the cities of Irvine, Costa Mesa, and Santa Ana. The vote on the alignment was taken after the city councils of the three southern California cities formally requested OCTA to activate the project. OCTA will now request federal funding for preliminary engineering. The start of construction of the light rail is not expected before 2006.

The largest airport Automated People Mover (APM) in the world is being designed for the Dallas/Ft. Worth airport. The APM, which will replace the existing 30-year-old train system that is now in service, will

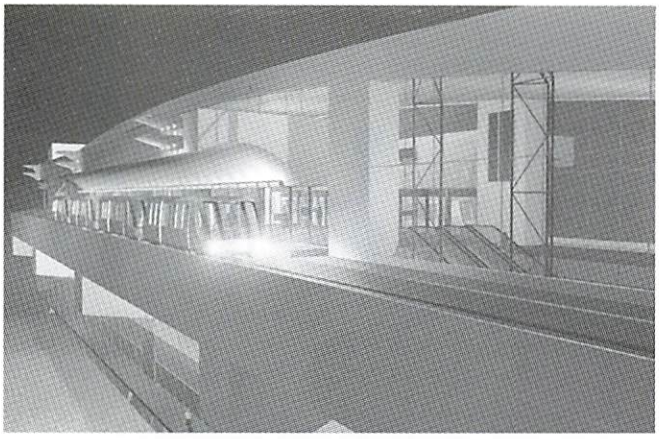


Figure 5 Artist's impression of the Dallas/Ft. Worth APM

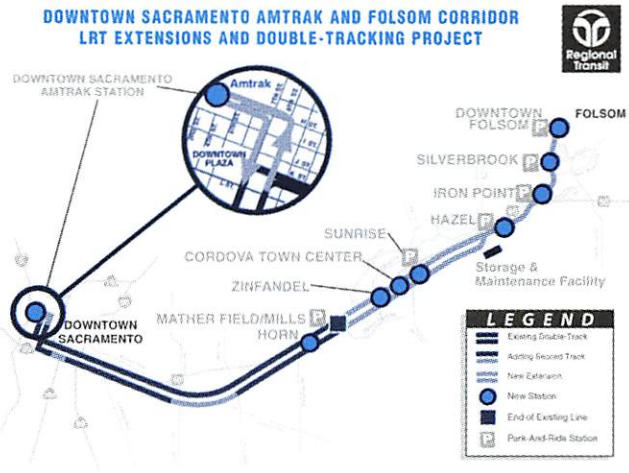


Figure 6 Amtrak/Folsom light rail extension

be a 4.81-mile dual-lane guideway. It will be elevated 50-70 feet above the ground and connect the existing terminals A, B, C, and E and the new international Terminal D that us under construction and the future Terminal F. End-to-end running time is expected to be nine minutes.

Unlike the existing system, the new system will be located on the airside, meaning that passengers using the system will have already gone through security and passengers transferring from terminal to terminal will not need to leave and reenter the secure portion of the airport.

The $846 million project is expected to be completed in 2005.

The Dallas Area Rapid Transit (DART) light rail line to Plano is expected to open in December 2002. This will be six months earlier than planned.

Metra, the commuter rail operation serving Chicago, has installed a new system to provide train location information to commuters. The trains are all located by means of GPS receivers on the vehicles. Like a similar system on New Jersey Transit, the system triggers on-board announcements of station stops. In addition the system is able to provide on-board announcements generated from the Train Operations Control Center.

The GPS data, which includes both train location and speed, is transmitted from the train to the Control Center, providing train dispatchers with more detailed information on the trains than just the current location of them.

The system was rolled out on the SouthWest and Milwaukee North lines in 1999 and extended to the rest of the Metra system late last year.

Light Rail Transit in the Norfolk, Virginia Corridor of the Hampton Roads area received a boost from the Norfolk City Council when they approved matching funds for construction. Norfolk will provide one-fourth of the funding for the 8-mile $360 million Minimum Operable Segment. This line will have 11 stations.

Fare collection integration in the New York City metropolitan area took a large step forward. The Port Authority of New York and New Jersey (PANYNJ)has adopted a program to integrate the fare instruments on their Port Authority Trans Hudson (PATH) operation with those of the New York City Transit and New Jersey Transit. Both the MetroCard used presently on New York City Transit and smart cards will be used on PATH when the new system goes into operation. This will be the first implementation of the MetroCard beyond the properties of the Metropolitan Transportation Authority (MTA). MetroCards are currently used on the commuter rail as well as the transit properties of the MTA. The $51 million PATH project is expected to take two years to implement.

Utah Transit Authority (UTA) has opened its University Line. The east-west University Line meets the north-south line to Sandy in downtown Salt Lake City. Both lines were completed to provide service to the Olympics. Originally the University Line was to be 11 miles long and operate between the airport, west of downtown and the University, east of downtown. The line was to handle patrons going from the airport terminal to the rental car area as well as to downtown and on to the University. Funding limitations caused the line to be pared down to 2.3 miles and serve the Rice-Eccles Stadium, with a future extension to the University of Utah Health Sciences Center.

The Sacramento Regional Transit District started construction of its Amtrak/Folsom light rail extension. The extension starts at the newly completed Mather Field/Mills Station and will extend light rail into the city of Folsom. It also includes a half-mile downtown extension to the Sacramento Amtrak Depot.

The first portion of the extension, to Sunrise Boulevard, could open as early as September 2003. The balance of the extension is scheduled to open for revenue service in December 2003.

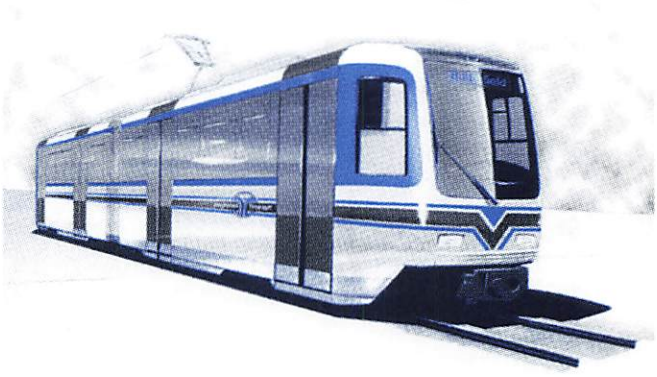


Figure 7 Artist's impression of Sacramento's new vehicles

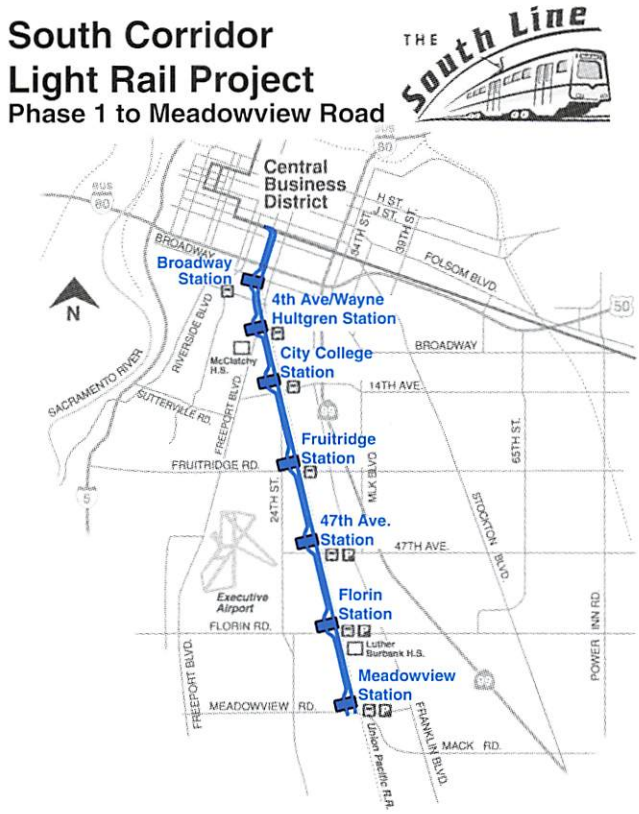


Figure 8 6.3-mile South Corridor Project

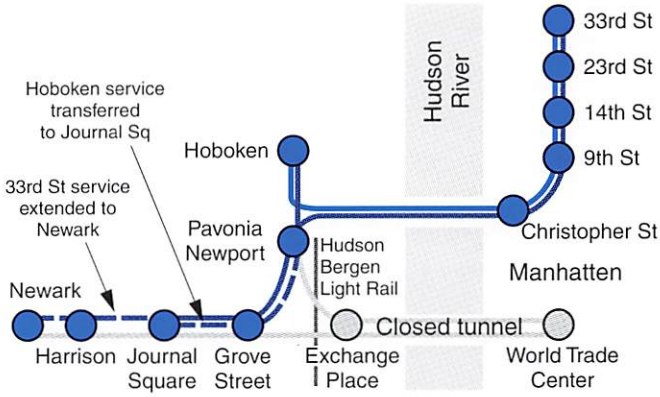


Figure 9 The PATH network

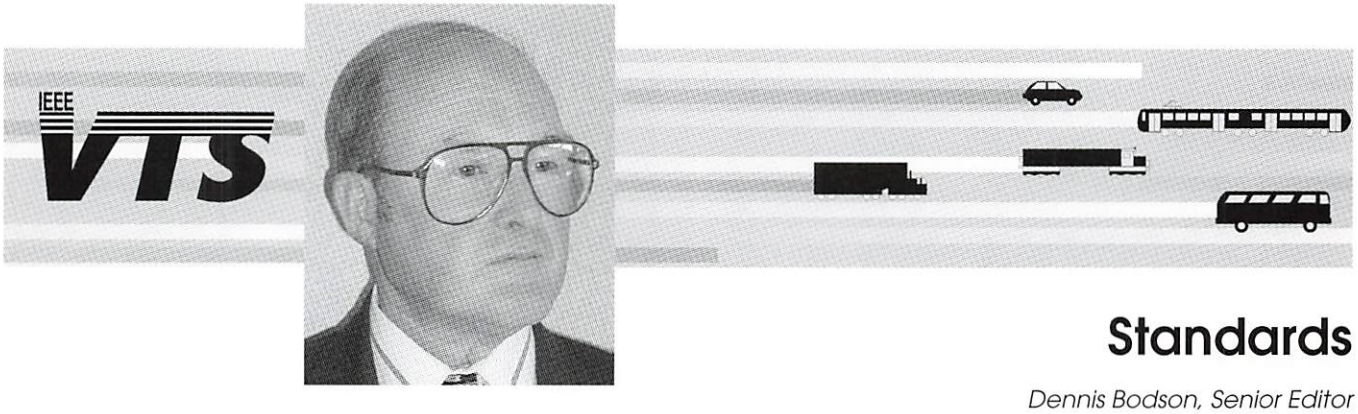
The project includes 14 new light rail vehicles, a new light rail maintenance facility west of Hazel Avenue, and miscellaneous improvements to existing facilities.

Sacramento is also building the 6.3-mile South Corridor Project. This will extend the system south to Meadowview Road. It is scheduled for completion next year. The two extensions will double the size of the existing system. A further extension south to Elk Grove is now in preliminary engineering and environmental and alternatives analyses have begun for a light rail north through Natomas to the Sacramento International Airport.

The Board of Commissioners of the Port Authority of New York and New Jersey announced a $544 million program to restore PATH service to lower Manhattan. Before September 11, the World Trade Center station was the busiest station on the PATH system.

The plan envisions opening the Exchange Place Station in New Jersey in around June 2002 and a temporary station at the World Trade Center site in Manhattan around December 2002. Trains presently do not serve Exchange Place, just west of the tunnel to lower Manhattan, because there are no facilities to turn trains at that station. The tunnel to Manhattan has been temporarily plugged to prevent water from backing up into the tracks on the New Jersey side. The project will include installing turnback tracks to allow Exchange Place to serve as a terminal station. The Exchange Place area is home to an extensive office complex. Workers presently use PATH to the Pavonia Newport station and transfer there to the Hudson Bergen Light Rail Line to reach Exchange Place.

The Board of Commissioners also approved $10 million in planning money for a permanent World Trade Center station and another $10.5 million in planning money to consider World Trade Center site redevelopment.



Standards

Dennis Bodson, Senior Editor

IEEE-Standards Association (IEEE-SA) Board of Governors (BOG) Meeting

The IEEE-SA BOG met in West Palm Beach, Florida during the period November 29-30, 2001. A major item of interest relates to a major revision in the IEEE Bylaws. The goal is to streamline the Bylaws and make them more user friendly without changing current policy. Another goal was to increase the empowerment of the organizational units, one of which is IEEE-SA. The details of the proposed changes, which were approved by the IEEE Board of Directors at their November 2001 meeting and affects IEEE-SA are as follows:

I-300: The governance clause that was included in each organizational unit bylaws has been incorporated with minor modifications.

I-301.10: This clause contains a revision to language on how appointments for vacancies for Directors can be filled.

This affects the IEEE-SA BOG President position, since as a Director of the Institute, an election has to be run to fill this position or the IEEE Assembly will fill the appointment (if the President-Elect is affected).

I-304.6: This clause covers the scope of the IEEE Standards Association. The only change per se is that the Secretary is now included in the count of the BOG as a non-voting member, hence raising the total members of the IEEE-SA BOG to 14.

I-304.9: This clause explains the basis for the actions concerning the organizational unit bylaws. All operating procedures are now contained in an organizational unit operations manual. These manuals cannot conflict with anything in the IEEE Bylaws. In addition, these operations manuals or any amendment to them cannot be adopted until they have been reviewed by the Executive Director and/or his/her designee, and legal counsel when appropriate.

I-403: This clause now contains the IEEE-SA membership clause (former S-500). The text is exactly the same.

The next meeting of the IEEE-SA BOG will be held in Piscataway, NJ at the IEEE Operations Center on February 25-26, 2002.

IEEE-SA Standards Board (IEEE-SASB) Meeting

The IEEE-SASB met in New York City on December 5, 2001. An item of interest to the Vehicular Technology (VT) Society was a Project Authorization Request (PAR) P1616 entitled, "Motor Vehicle Event Data Recorder (EDR)". This PAR was approved by the Standards Board. The next meeting of the IEEE-SASB is scheduled for March 19, 2002 in Piscataway, NJ.

DRM for digital radio broadcasting below 30 MHz

The System Specification of the DRM (Digital Radio Mondiale) standard has been published by ETSI as TS 101 980. This standard specifies a digital sound broadcasting system which can be used as a replacement of the current analogue AM sound broadcasting services in the LW, SW and MW bands. The DRM system provides audio quality which is by far superior to analogue systems even in the worst propagation conditions. As the new system fits into the current channel raster, a smooth transition from analogue to digital services can be achieved. For more details about DRM and also to listen to audio samples from the various field tests, visit the web site of the DRM Consortium on http://www.drm.org

Motorola Involved in 3GPP2 Adoption of CDMA2000 1xEV-DV Baseline Framework

Motorola's Global Telecom Solutions Sector (GTSS) claimed to take a leadership role in the adoption of 1xEV-DV, the baseline framework for the evolution of third generation (3G) Code Division Multiple Access (CDMA) 2000 1X wireless services.

A consensus was reached on the baseline framework for CDMA2000 1xEV-DV (data and voice) by the standards body on Oct. 18 during meetings in Korea. The 1xEV-DV standard is scheduled 3G Partnership Project 2 (3GPP2) publication in March 2002 and International Telecommunications Union (ITU) 3G approval in May 2002.

This next evolution technology is designed to provide integrated voice with simultaneous high-speed packet data, video and video conferencing capabilities. 1xEV-DV will be backward compatible with IS-95A/B and CDMA2000 1x, allowing for a graceful operator evolution of their currently deployed systems.

"We are pleased and very excited that we can move forward with CDMA2000 1xEV-DV technology solutions," said Keith Ten Brook, senior director of advanced technology for Motorola's GTSS. "Motorola continued its leadership role in this standardization process by soliciting the support of operators, network vendors and suppliers for the adoption of a baseline framework that combines elements of the two leading proposals before the standards body. Our main goal was to move this standard along in order to develop products that will deliver the simultaneous voice and high-speed data services that CDMA network operators have indicated they want," said Ten Brook.

Motorola has led the way toward developing a 1xEV-DV solution for CDMA2000. In March 2000, an initial CDMA2000 1xEV-DV proposal was submitted to 3GPP2. Many of the concepts from that Motorola-backed proposal have been included in the current 1xEV-DV proposal to improve the performance, including: four-channel hybrid ARQ (automatic request for retransmission), concatenation of multiple Walsh codes, adaptive modulation and coding, and fast cell selection.

Motorola is the only network vendor in the world to successfully demonstrate technology elements of a CDMA2000 1xEV-DV solution. Ten Brook said that if the standard is finalized in May 2002, 1xEV-DV services could be commercially available in the first half of 2004.

Wireless Personal Area Networks Featured in IEEE Network Magazine

Handheld devices are rapidly becoming an integral part of our daily lives. But problems arise where these devices do not have compatible communication interfaces or the cable connections are too complex to configure correctly. The September issue of IEEE Network Magazine takes a look at how the application of Wireless Personal Area Network (WPAN) solutions might solve these common problems. Specific articles tackle low-power and low-cost WPANs, coexistence between Wi-Fi (802.11b) and Bluetooth, and the use of wireless Inter-PANs for mobile meetings. The guest editorial, written by the experts in the field, is accessible at http://www.comsoc.org/ni/Public/2001/Sep/index.html

Cell Phone Carriers Get Extension on E911 Locator System

Emergency response operators in the U.S. won't be able to trace the location of an estimated 45 million calls made from cell phones this year. Back in 1996, the U.S. Federal Communications Commission (FCC) ordered cellular carriers to begin building an "E911" system by October 2001 that would locate the geographic origin of cell phone calls to within 150 feet. But in early October, U.S. cellular carriers asked for an extension. Carriers explained that the technology to trace the source of mobile calls isn't ready, wireless network equipment is not compatible and the costs of building the system will run into the billions. The FCC listened to these arguments and granted the wireless carriers more time. For more information see http://news.cnet.com/news/0-1004-200-7419928.html

Software Radio Approach Delivers Increased Software Content

The role of software and digital signal processing in radio has grown to encompass re-configurability at all levels of the protocol stack. Research has ignited wider commercial interest in these concepts, which have been endorsed by all segments of industry, from software applications providers to component manufacturers. According to "Software Radio Technologies," a new book from IEEE Press and John Wiley

& Sons, the software radio approach will increase software content for commercial wireless systems and is a potential solution to the need for increased efficiency in service delivery. Additional information may be found at http://shop.ieee.org/store/product.asp?prodno=PC5871

IEEE Publishes New Wireless Personal Area Network Standard

The IEEE has published a new standard to define Physical Layer (PHY) and Wireless Medium Access Control (MAC) specifications for wireless connectivity with fixed, portable and moving devices within or entering a Personal Operating Space (POS). The purpose of the standard is to provide low complexity, low power consumption wireless connectivity to support interoperability among devices within or entering the POS. This includes devices that are carried, worn, or located near the body. For more information, visit http://shop.ieee.org/store/product.asp?prodno=UE5896.

IEEE 802.11g Standard Approved

A next-generation wireless networking standard has been approved that will work with older wireless networking technology, allowing companies and consumers to keep existing equipment and possibly boosting the number of wireless connections in homes and businesses.

The new IEEE standard, called 802.11g, promises data transfer rates of up to 54 megabits per second, compared with 11 megabits on the current 802.11b standard. Wireless networks allow consumers and business to connect laptops and PCs with each other and to the Internet without wires, and have become increasingly popular in airports, Internet cafe and in hotels.

The latest wireless standard is compatible with 802.11b, also known as Wi-Fi, because the two standards, b and g, both run in the frequency spectrum of 2.4 GHz. Another standard, 802.11a, is now found in access hubs and computer cards, but it runs at a higher frequency, in the 5 gigahertz range and isn't compatible with the b standard. It also gives transfer rates of 54 megabits per second.

"g is a very nice upgrade route because I can maintain compatibility with all the current, b-products," said Allen Nogee, an analyst with market research firm Cahners In-Stat Group. "You don't have to start from scratch. I think g is really going to help move along b, especially in areas where the data rate of b was holding it back" Nogee said, adding that he ultimately expects wireless networking kits that incorporate both 802.11a and 802.11g to be available.

Wireless local area network (LAN) chipmaker Intersil and chipmaker Texas Instruments had been pushing competing technologies to become the g standards, Nogee said, adding that the IEEE nearly scrapped the entire standard because Texas Instruments and Intersil couldn't reach agreement. In the end, elements of both will be used or available in the 802.11g standard.

Nogee said that products – both the transmitting and receiving hubs, known as access points, and computer receiver cards that are inserted into desktop PCs or laptops – based on the 802.11g standard will be available by late next year. 3Com Corp., Cisco Systems Inc. and Intel Corp. are among the largest makers of wireless LAN equipment.

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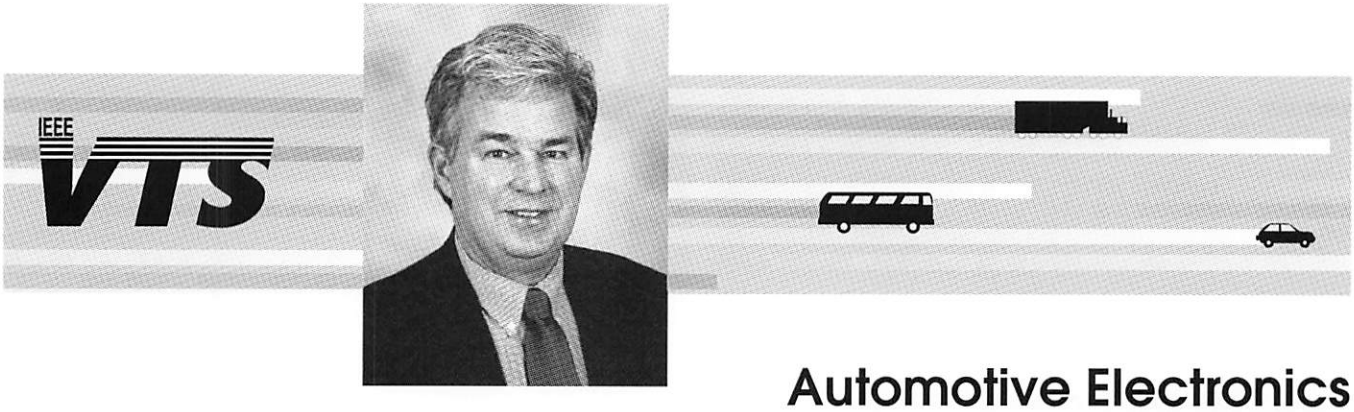

Automotive Electronics

Bill Fleming, Senior Editor

4-Wheel Steering Debut

Japanese sport-luxury vehicles offered 4WS (4 Wheel Steer) systems in the 1980s. This year it was announced that GM, jointly with Delphi Automotive Systems and Dana Corp., will offer 4WS on GMC's '02-model full-size Sierra Denali pickups to make them more maneuverable [1,2]. GM will have the distinction of being first to offer this option on full-size pickup vehicles. GM calls this option *Quadrasteer*, and although price isn't set yet, it will cost somewhere between $2000 and $3000. The option will give large GM vehicles a much tighter turning diameter. For example, when equipped with Quadrasteer, the Denali's turning diameter is reduced by 21 percent, from 47 feet to 37 feet.

Akin to an off-road loader, for improved parking and close-quarters maneuverability, rear wheels are counter-steered ("crabbed"), turning opposite the front wheels, providing tighter low-speed turns. At highway speeds, the rear wheels co-steer with positive-phase, turning in the same direction as the front wheels, to allow precise (without rotation, translation only) high-speed vehicle lane-change maneuvers.

Front wheels are steered conventionally, whereas rear wheels are steered electrically by wire/motor — one implementation is described in [3]. If the system is damaged, it makes a controlled return to regular 2W steering. At highway speeds, when Delphi's 4WS system operates with positive-phase steering, trailing stability is improved with re-

duced sway (because lateral forces are reduced at the rear of the vehicle). At low speeds, Delphi's 4WS simplifies trailer towing because the "crabbed" negative-phase steering allows trailers to more closely follow the true vehicle path [1].

Cylinders-On-Demand Debut

Resurrecting another 20-year-old idea, GM is boosting fuel economy in large vehicles (such as their Chevrolet Silverado and GMC Sierra 8-cylinder pickup trucks) by 6-to-12 percent, and 25 percent under certain conditions [4]. This could improve highway fuel economy from the current 20 mpg to as much as 25 mpg. When driving loads are light, the engine closes both the exhaust and intake valves for every other cylinder, thus cutting off their air and fuel supply. The engine always starts with all eight cylinders, and then it runs with just four cylinders, only adding other cylinders as needed.

Two technology advances allowed GM to make the Cylinders-On-Demand concept work: firstly, today's throttle-by-wire where the mechanical throttle cable is replaced by an electric throttle-positioning motor; and secondly, today's 32-bit engine computers that have 100 times more memory and 25 times faster clock speed than available 20 years ago. The Cylinders–On–Demand system operates so smoothly, "you won't know if you're in eight cylinder or four cylinder mode [4]."

S-Class Mercedes V8 Diesel Electronics

The 2001 Mercedes S 400 CDI diesel engine includes the following electronics features [5]:

1. Common rail fuel injection with electronically actuated diesel fuel injectors, which utilize pilot injection before the main fuel injection occurs. The small quantity of pilot injection ignites early in the combustion cycle and preheats the combustion chamber. This provides better ignition of the main injected fuel which burns more completely (for lower emissions) and with less pressure-rise (for reduced audible noise).
2. Electropneumatically controlled intake air duct cutout system that temporarily switches off one of the intake ducts in the partial load range. This intensifies the swirling motion of the air/fuel mixture for more complete combustion and lower emissions.
3. Use of dual hot-film flow sensors in the intake air duct for more precise mass airflow measurements, which provide more accurate air/fuel control (for lower emissions).
4. Use of two electrically actuated valves, one in each cylinder bank, to control EGR (Exhaust Gas Recirculation). This works in conjunction with a throttle positioning motor, which permits significantly greater EGR rates for lower emissions.
5. Each cylinder bank exhaust manifold feeds into a fast-lightoff oxidizing catalytic converter, followed by a larger backup oxidizing catalytic converter. In total there are four catalytic converters to control HC and CO emissions on this diesel engine (to satisfy EU-3 emissions regulations).
6. An oil quality sensor monitors oil-level, age, and temperature — the sensor was described in a 1997 SAE paper [6]. On the basis of sensor-derived data, actual wear on the engine oil is determined. Oil change intervals can be as long as 40,000 km (25,000 mi) under ideal vehicle operation. In addition, when stopped for fuel, the driver can also press a button on the steering wheel to remotely check oil level.

2002 BMW 7-Series Electronics

BMW's 2002 7-Series sport-luxury car similarly includes many new features, starting with the industry-first 6-speed automatic transmission, 60 control modules, and 85 electric motors [7]. Here are some of its new electronic features:

1. Frequently used driver controls (headlights, wipers, etc.) remain where they usually are, but all others (700 different functions) are assigned to the new iDrive (i stands for intuitive) mouse/joystick input (with tactile feedback) mounted on the center console. On-screen menu functions are displayed on a central monitor in the dash. The functions in iDrive generally fall into four basic categories: communication, climate control, entertainment, and navigation; plus four secondary categories: help, configuration, vehicle information and BMW ASSIST (breakdown service).
2. An active roll-stabilization system uses special anti-roll bars to reduce lean angles in turns. Each bar (one front, one rear) contains an electrohydraulic motor, energized by pressure from an engine-driven pump, which opposes body roll completely up to 0.3g, and by 80-percent at 0.6g.
3. Active suspension control is achieved using electrically adjustable dampers; both comfort or sport settings are driver selectable. In addition, two electric motors adjust eight reaction levers to provide drive-by-wire load control.
4. By touching a dash-mounted button, the parking brake is electrically actuated via Bowden cables. When automatic mode is selected, the car is automatically kept from creeping, even on grades, without pressing the brake pedal. Deactivation is automatic when the accelerator pedal is applied.
5. Both intake and exhaust valves have electrically actuated, continuously variable, timing.
6. A variable intake manifold includes eight rotating drums on two support shafts. Air intake runner length can be adjusted between 9 and 27 inches. Electric motors turn the drums through their full rotational range within 1 second.
7. A shift-by-wire control scheme uses steering-wheel mounted buttons, and a mechatronic module inside the transmission that actuates the gear shifts (either manual or automatic shifting is selectable).
8. The 7-Series includes 10 air bags, plus 5 pyrotechnic belt tensioners (one for each seat), and 2 active head rests. The front seats include frontal bags, side bags, and knee bags for both driver and passenger (6 bags). The rear seats include frontal bags, and side bags for the outboard passengers (4 bags). Front-seat-mounted active headrests include a small gas generator that repositions the headrest forward to minimize whiplash injury in a rear-impact crash.
9. Front seats offer programmable heating, with 38 small fans pumping air through the seat cushions and backrests.
10. The engine can be started with a push button instead of a key, once rf identification is made with the driver's key fob.
11. Door checks hold vehicle doors open at predetermined angles. (One implementation of this feature is an electrically actuable magnetorheological damper that serves as an adjustable door check, based on door opening/closing speed [8]. When the door speed slows below

a threshold, the damper is electrically stiffened to check the door).

12. The doors also feature a "soft close" that secures any of the four doors when they're moved within a quarter inch of the fully latched position (made possible by an electric motor latching mechanisms).

13. Power sunshades for the rear and quarter windows are actuated from mechanisms within the door trim panels.

Instrument Panel Control Function Identification

No-look identification of IP (Instrument Panel) control functions has been demonstrated. The IP is equipped with both capacitive and infrared sensors. As the driver, without looking, moves his or her hand toward, for example, the fan setting in the HVAC module area; a head-up display confirms that the HVAC module zone has been entered. Next, the display confirms that the desired control within that area is being touched. The display then asks if the fan should be adjusted higher or lower. A push of the button confirms the new desired setting. A prototype of this concept, called Phantom (from Pi Technology, Cambridge, England) has been shown [9]. The Phantom system is designed to help solve driver distraction problems.

Spotlight on Headlight Glare

No other vehicle safety NPRM (Notice of Proposed Rule Making) from NHTSA (National Highway Traffic Safety Administration) has ever received so many responses from the public. As of mid-November 2001, NHTSA received over 1100 responses on this NPRM. Most of these responses focus on ride-height aiming of headlights, and concern about the use of fog lamps or HID (High Intensity Discharge) headlights. Although HID headlights light the road better, they've become the object of wrath by motorists caught in their oncoming glare [10]. NHTSA wants to explore whether or not, as in Europe, HID lamp installation should be made contingent on automatic on-vehicle headlight aiming.

Non-Radiating Passive Vision Through Fog

The Holy Grail for low-visibility driving has always been imaging through and into the fog-shrouded roadway ahead. Currently, millimeter-wave radar detects up to 20 different vehicles and objects — but radars radiate. A radiometer captures the scene in front of it much the same as a camera. Non-radiating passive-vision radiometer systems "see through fog" by detecting millimeter-wave (15-to-40 GHz) blackbody radiation that naturally emanates from roadway vehicles and objects. A two-dimensional, millimeter-wave, focal plane array radiometer, with 1,040 gallium arsenide detector elements, has been demonstrated by TRW's Space and Defense group [11]. Weather-piercing millimeter-wave radiometers don't radiate, thereby eliminating electromagnetic interference and compatibility problems that must be addressed by present-day vehicle radars (that radiate). This technology may eventually find its way into automobiles.

What's Really Far Out the Future?

"Nanotechnology" — it will fundamentally change the way electronic systems are designed [12]. A director at IBM's T.J. Watson Research Center predicted that, "nanotechnology will eventually replace the silicon transistor." Here's some predictions [12]:

0 to 10 years in the future
Increasing use of synthesis and self-assembly in conventional microelectronics. Organic electronics used in niche applications. Increasing use of heterogeneous technologies in sensors.

10 to 20 years in the future
Chemically synthesized nano-building blocks replace semiconductor logic and memory devices.

20 to 50 years in the future
Increasing use of hierarchical self-organization. Systems approach biological levels of complexity.

I don't know about you, but I'm 59 years old, and I didn't learn about nanotechnology when I was in school 30+ years ago. I either have a lot of reading to do, or this is something that may best be left to our next-generation of engineers.

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Mobile Radio

Javier Gozalvez, Senior Editor

Technology and research news

Telecom administrations and the mobile communications industry have reached an agreement on a framework for methods to support the unrestricted movement of 3G terminals. This is called "Global Circulation" and represents the right of users to carry their personal terminals into a visited country and the ability to use them wherever possible. This new agreement is to sit within a new ITU Recommendation that provides the technical basis for global circulation and the avoidance of harmful interference.

Tantivy Communications announced that its patented I-CDMA technology has been successfully tested and proven over-the-air in both rural suburban and dense urban environments in South Korea. In the rural suburban testing, the technology achieved high-speed data rates at distances exceeding 6km from the cell site. An average forward link data rate of 263kbps per user was measured, while the data rate for the reverse link was 176kbps. In the dense urban testing, the technology achieved high-speed data rates at distances exceeding 2.3km from the cell site. An average forward link data rate of 283kbps per user was measured, while the data rate for the reverse link was 179kbps.

The European Commission has announced a call for proposals for indirect research and technological development actions to support trials of 2.5G and 3G applications and services at a pan-European level. Focus will be on: interoperability/interworking and roaming issues; security, safety and privacy; quality of service and service customisation aspects; seamless end to end provision of value-added services and applications; user identifications, billing and payment issues. The proposed trials are expected to have a duration of 18 months or less.

The Korean Government has announced that it is to start research and development into 4G systems. The Government has created a "Beyond IMT-2000" task force launched in November and with an initial investment of $11million.

Scientists at Motorola Labs have demonstrated a prototype of an integrated ceramic-based miniature direct methanol fuel cell (DMFC) system and have also built several of the key components required for a miniature, ceramic-based reformed methanol to hydrogen fuel cell (RHFC). Miniature fuel cells are candidates to power, in the future, cell phones among other electronic devices. NEC and two research institutions, the Japan Science and Technology Corp (JST) and the Institute of Research and Innovation (IRI) have announced the joint development of a miniature fuel cell for next generation mobile devices. Using nanotechnology, the cells can generate electrical energy at 10 times the rate of a conventional lithium-iron battery of the same size. The University of Montreal in Canada has announced that it has developed a new iron phosphate material to replace the costly and volatile cobalt used in making electrodes for rechargeable lithium cell phone batteries. The University has set up a company, Phostech Lithium Inc, to commercialise the technology. Applied Digital Solutions has announced a breakthrough miniature thermoelectric generator that converts body heat flow into 1.5 volts of electricity but it doesn't store power. The company expects to use this generator into its Digital Angel devices that can transmit wireless data via CDPD and CDMA. The products will include GPS functionality and sensors that can monitor temperature and pulse and even detect sudden falls.

France Telecom R&D has presented, in partnership with Amphicom, a system allowing telephone communications with a diver working underwater. The system comprises a buoy fitted with a GSM phone relay that handles two-way communications with an underwater terminal. The terminal is connected to the buoy by wire and is equipped with a dial pad, a special mouthpiece, a light and a buzzer.

ICE International from Norway is developing a device that automatically switch off plane passenger's mobile. The company's antenna box uses Bluetooth to send signals to switch off phones within a specific range.

Qualcomm announced an evolutionary path which it projects would enable CDMA2000 operators around the world to increase their voice network capacity by a factor of two when the evolved handsets are widely deployed. The improvements are achieved within the existing technical specifications for CDMA2000, eliminating backward and forward compatibility issues and the need for development of a new standard. This doubling of voice capacity can be accomplished by the combination of advances in speech processing, introduction of dual-antenna, dual-receiver handsets coupled with advanced signal processing techniques and simple and pragmatic diversity reception techniques. Nextel and Motorola have also announced enhancements to the iDEN wireless networks expected to lead to a doubling of wireless voice capacity.

National Semiconductor unveiled a new handheld conceptual device that integrates wireless video communication and phone, digital camera, video camcorder, MP3 audio, PDA, internet access, email and Microsoft Windows Embedded XP OS in a flexible unit that folds and unfolds. The Geode Origami Mobile Communicator was developed under a joint agreement with Studio Red and CoCom International. It is about the size and weight of a small digital camcorder and uses Bluetooth for network connectivity.

Envoy Networks announced it has successfully completed testing on its cellular network architecture by linking an IS-95 air interface with SIP (Session Initiation Protocol). The demonstration validates the concept of using IP technology in the Radio Access Network. It used an intelligent iBTS (IP Base Station) developed by Envoy Networks, a standard IS-95 CDMA compliant handset and a SIP-enabled Cisco 3600 VoIP gateway.

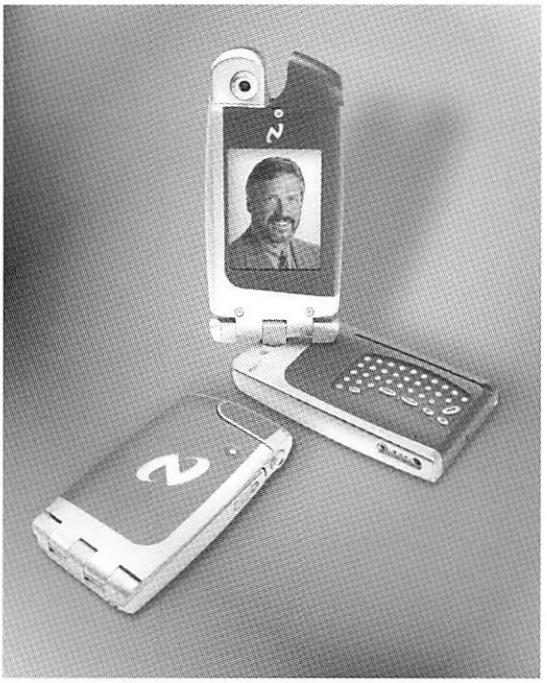


Photo by National Semiconductor

Figure 1 National Semiconductor's Geode Origami Mobile Communicator

Nokia has announced it will license separate terminal client components and a smartphone software platform to mobile handset manufacturers. The company will offer a number of terminal client components to the industry, including MMS and SMS clients, WAP/XHTML browser and a SyncML-based synchronisation engine. The terminal client components will be open software modules that can be run on the manufacturer's own operating systems.

Lucent Technologies' Bell Labs announced a software architecture, called Common Operations (COPS), that will enable global roaming across all network types, including 3G technologies and 802.11. The software features a protocol gateway capability that translates data from networks employing a variety of protocols into a single, common language.

Texas Instruments has announced that its OMAP wireless architecture will support the Linux operating system. The company's architecture is used to deliver embedded solutions for 2.5G and 3G mobile devices.

Korea Telecom Freetel (KTF) has begun a public trial of the magic n multipack service, which run's on Qualcomm's BREW applications platform. The platform will allow subscribers to easily customise their wireless phones with a variety of wireless applications, including games and entertainment options, as well as messaging and navigation services. The service is based on the CDMA2000 1X network.

Analog Devices unveiled a new DSP for 3G base stations, called TigerSHARC DSP, equipped with Layer 1 software that together reduce baseband system costs of 3G infrastructure by up to 50%. The company claims it is the only DSP solution with performance to enable an "all software" approach and is the only fully-programmable solution that allows quick migration between major 3G modes.

Advanced Communications Technologies has announced that it has demonstrated what it claims is the world's first mobile wireless phone call on a Software Defined Radio (SDR) platform using the CDMAone (IS-95B) protocol. The call was processed on the company's SpectruCell SDR base station and was made without the use of any protocol specific hardware or Qualcomm chipsets.

M-commerce and location-based services

Nokia, Nordea and Visa International have started the world's first Electronic Mobile Payment Services based on dual chip technology. The dual chip concept consists of a chip card that can be issued by a bank and a GSM SIM card. In the pilot, the chip card, which accommodates WIM application, is inserted into the WAP enabled phone. Visa International has also announced a new security specification, called "Mobile 3-D Secure" for mobile commerce payments. Visa said the specification was developed in co-operation with 15 major firms (including Motorola, Ericsson and Oracle Mobile) and will be incorporated into its authenticated payment e-commerce program.

According to the report from the Yankee Group, "Mobile Payments: What Are They Worth", an estimated 50million US mobile phone users will buy goods and services using wireless Internet connections. Mobile commerce in the US will account for roughly $15billion in spending and represent about 2% to 3% of all non-cash transactions nation-wide five years from now.

Lucent has filed a patent in the USA patent office that claims to enable the location of a cell phone to be tracked by a single cell site. Currently location tracking requires two or more cell sites to locate the user by triangulation. According to the patent: "a distance between the wireless mobile unit and the base station is calculated utilising a round trip (RTD) delay value of a signal received from the wireless mobile unit. Thereafter, an angle of arrival (AOA) of the received signal is determined using measurements of the received signal from each of a plurality of antenna sectors of a multi-sector antenna. The angle of arrival is determined based upon stored antenna signal measurements of the multi-sector antenna, wherein a combination of different sector signal measurements corresponds to a single angle measurement. Using the determined distance and angle of arrival, the location of the unit can be determined". Lucent claims the system will work in CDMA, TDMA and GSM networks.

The European Commission has selected Helios Technology as management consultants to assist in developing a Europe-wide implementation strategy for enhanced emergency service (E-112). The service is similar to the E911 service being developed in the US.

Nokia launched, at the Nokia Mobile Internet Conference, the mPosition for WCDMA and the Enabling Mobile Location Center. Nokia's system offers a fast and smooth evolution path from the current mPosition for GSM solution. It supports various 3GPP standardised location methods such as Cell ID based (SAI+RTT), Observed Time Difference of Arrival (OTDOA) and Assisted Global Positioning System (A-GPS).

Europolitan Vodafone and SOS Alarm AB have developed an alarm service that will let a cell phone user hit a button to send an alarm to a call center that will identify the user's location to within a square meter using GPS technology.

Wireless Data

NTT DoCoMo has announced that it will increase the downlink packet transmission speed of its "i-mode" and "DoPa" mobile Internet services from the current 9.6kbps to 28.8kbps. The company is planning to launch its upgraded service around spring 2002. The company also said it has released guidelines in English to the basic specifications of i-mode. The specifications cover protocol stack, security, user interface, downloading and messaging. NTT DoCoMo reached an agreement with KPN Mobile under which the Japanese operator will transfer and license technologies to KPN to launch Mobile Internet services, similar to i-mode, in the Netherlands and Belgium.

Xpedio, a Swedish software vendor, has developed software that converts WAP content (based on the version 1.2.1 of the WAP protocol) to i-mode content.

Ericsson has delivered the first Mobitex system for Mobile Internet services to a Chinese operator. The new Mobitex network, initially capable of serving approximately 500,000 subscribers, will cover Beijing and north regions of China. The operator will initially focus on services for stock trading and messaging, as well as high-revenue vertical markets for remote control, such as point-of-sale, telemetry, logistics and public safety.

Atlantic-ACM released a study of the US mobile data market, "Wireless Data Overview 2001: Past, Present and Future". The study forecasts that the emerging market will reach revenues of $13billion by 2006 compared to $164million last year. The Yankee Group believes the future prospects and even viability of many wireless companies depends on mobile data services. The company expects that by 2006 there will be 288million data users, representing 82% of the total mobile user base in Western Europe.

FCC & US mobile market

The Federal Communications Commission (FCC) announced that discussions have concluded between the government, the auction 35 winners and Nextwave. Under the terms of the agreement: "Nextwave will surrender all the C and F block licenses it had previously won; the wireless carriers that won these licenses in the Auction 35 reauction will receive them and be able to put them into use for the public shortly; and the American taxpayer will receive $10billion, more than twice the amount that would have been received had Nextwave kept the licenses in accordance with recent court rulings". The winners of the auction will pay the $15billion they originally bid for the spectrum. The government would then pay NextWave $9.55bn, which after payment of taxes and other expenses would be left with close to $6billion. The dispute started when NextWave bought its licenses in 1996 for $4.7billion but filed for bankruptcy before paying for the licenses. The Government then confiscated and reauctioned the licenses. However, an appeals court ruled that the Government action was illegal and order to return the licenses to NextWave.

The FCC voted to gradually phase out the spectrum cap, which restricts the amount of broadband Commercial Mobile Radio Services (CMRS) spectrum an entity can hold in a particular geographic area. The FCC will: "sunset the CMRS spectrum cap rule by eliminating it effective January 1, 2003; raise the cap immediately to 55MHz in all markets until the sunset date; and immediately eliminate the cellular cross-interest rule in Metropolitan Statistical Areas, but retain the rule in Rural Service Areas". Until now, the spectrum limit was 45MHz.

The FCC has approved requests by five wireless companies to extend the timetable for introducing Enhanced 911 services. October 1 was the deadline to offer the Enhanced 911 services. Meanwhile, Sprint PCS has started selling Samsung phones with GPS location functionality. Allen Telecom Inc's Grayson Wireless division said it has completed installation of the nation's first wireless E911 caller location system that complies with the FCC's new E911 Phase II location accuracy standards. The Grason Wireless Geometric position determining equipment began providing detailed location co-ordinates to the St. Clair County, Illinois, Public Safety Answering Point for E911 calls made by customers of a major wireless carrier on October 22, 2001.

The FCC adopted rule changes to accommodate the authorisation and deployment of a new generation of radio equipment known as software defined radios (SDRs). SDRs can be quickly reprogrammed to transmit and receive on multiple frequencies in different transmission formats. Under the previous rules, if a manufacturer wanted to make changes to the frequency, power or type of modulation for an approved transmitter, a new approval was required, and the equipment had to be re-labelled with a new identification number. Under the new rules, software modifications in a SDR can be made through a "permissive change", which has a streamlined filing process. The FCC identification number will not have to be changed, so equipment in the field will not have to be re-labelled. These permissive changes can be obtained only by the original grantee of the equipment authorisation. To allow for changes to equipment by other parties such as software developers, the Commission will permit an optional "electronic label" for software defined radios, in which the FCC identification number could be displayed on an LCD or similar screen. It will allow another party to obtain an equipment approval in its name and become the party responsible for compliance instead of the original grantee.

The FCC adopted a First R&O/MO&O in the New Advanced Wireless Services proceeding. The report adds a mobile allocation to the 2500-2690MHz band to provide additional near-term and long-term flexibility for use of this spectrum making this band potentially available for 3G and future systems. However as the band is already used by ITFS and MMDS licensees, the FCC is not relocating the existing licensees or modifying their licenses. Instead the FCC will rely on market forces. The FCC has also said it will hold in June an auction of spectrum in the 700MHz band. This area of spectrum is currently occupied by television broadcasters in the channels 60-69 area which do not have to move off the spectrum until the end of 2006. The FCC has allowed those companies to negotiate pricing terms with the wireless companies to move out of the spectrum. The FCC together with the Department of Defense and the NTIA has unveiled a plan for the assessment of 3G spectrum. The new bands under consideration are the 1710-1770 and 2110-2170MHz bands. The 1770 to 1850MHz band is not part of this assessment.

3G trials and roll-out

NTT DoCoMo has announced it will expand its 3G FOMA service to the southern part of the Kanto region surrounding Tokyo and Yokohama. The service was initially launched in Tokyo at the beginning of October. The company plans to virtually cover all major Japanese cities by spring 2002. The company also said it would begin delivery of short video clips under a new service called "i-motion". The service will deliver short news reports, mini music videos and sports highlights and will be viewable on the FOMA N2002 handset built by NEC Corp.

South Korea's SK Telecom has launched the world's first synchronised CDMA2000 1X EVDO, Evolution-Data Optimized service. The field test of the service will be conducted in some areas of Seoul, Kwachon and Anyang, then a full-fledged commercial service will be offered around Seoul and Kyonggi Province. The company expects to expand the service to 26 cities in April 2002.

Nokia and AT&T Wireless announced they completed the first live EDGE data call using GSM/EDGE technology and a live GSM network environment. The call was made using the 1900MHz Nokia UltraSite base station, prototype Nokia EDGE handsets and the release'99 standard. The call used EDGE 8-PSK modulation in both directions of the air interface.

Qualcomm announced what it claims is the world's first video-streaming demonstration through a CDMA2000 1X/Bluetooth connection. The demonstration used a 3G CDMA2000 1X handset based on the company's MSM5100 Mobile Station Modem and a system software solution con-

nected through a laptop via a Bluetooth dial-up network. Ericsson and Verizon Wireless demonstrated seamless, high-speed packet data services with an industry-first multi-access demonstration via Ericsson's CDMA2000 1xEV, 802.11b WLAN and Bluetooth solutions at the CDMA Americas Congress in the US.

Nortel Networks and Mercury Corporation have completed what they claimed is the world's first multi-vendor test voice call using the WCDMA standard. The call was made using a UMTS base station and Radio Network Controller from Nortel Networks, and a Mobile Switching Center and Home Location Register from Mercury Corporation.

Orange and Alcatel announced they conducted the first voice, data and video communications on the Orange UMTS mobile infrastructure pre-commercial network installed in Paris by Alcatel. The network carries voice communications in circuit mode and data and video transfer on packet mode. Calls between UMTS terminals, a UMTS terminal and a GSM terminal, and between a UMTS terminal and the fixed network were conducted.

Group 3G and E-Plus have agreed to cooperate in building the 3G networks in Germany by sharing aerials, cables, transmitters and radio network controllers. mmO_2 (formerly BTWireless) and KPN Mobile have also signed an agreement to cooperate on the roll-out of their 3G networks in the Netherlands, but each company will separately develop its own core network.

One2One (UK) said it pushed back the launch of its 3G system to 2003. Swisscom and TDC Switzerland also announced similar postponements. The Portuguese government said it would delay the date by which licensed operators had to offer 3G services to 31 December 2002.

Mobile satellite communications

Iridium Satellite LLC has submitted a preliminary proposal to the Federal Aviation Administration suggesting that Iridium's satellite network could be used to monitor cockpit voice and flight data in real-time. The agency previously published deadlines for submissions regarding upgrades to airport or plane security. Qualcomm has also demonstrated a set of aviation safety solutions using the Globalstar Satellite Communications System and onboard hardware incorporating CDMA technology. The MDSS Globalstar Communications System's two-way communications capability allows access to and from ground services, private networks, Web sites and email with speeds up to 128kbps. The system can support potential aviation safety applications, including real-time video and audio monitoring of aircraft cabins and cockpits; an Air Traffic Control service to alert aviation authorities of emergency situations; remote control of onboard aircraft cameras; transmission of real-time aircraft flight data to the ground; on-the-ground access to and possible automated real-time monitoring of flight data and cockpit voice recorders; dedicated voice communications for Air Marshals to the cockpit and ground; in-flight emergency safety and medical services; and back-up transponders with aircraft identification, altitude, speed and location information.

Doubts have been raised on the European Galileo satellite programme after the ministers of the 15 EU countries refused to provide the E450 million required for the third phase - the construction and launching of satellites. A final financing decision should be taken by March next year. Previously a cost benefit study of the project, produced by PricewaterhouseCoopers, was released. The report can be found at http://www.galileo-pgm.org/reportsdoc/ exec_summ_final_report_v1_5.pdf

COMSAT Mobile Communications (CMC), a business unit of Lockheed Martin Global Telecommunications, announced that it will be a premier provider of the Inmarsat Fleet family of new global high-speed and cost-effective data communications services. CMC plans to be among the first to provide Fleet service to the maritime community, currently anticipated to be commercially available beginning in the first half of 2002. COMSAT also said that a ruling by the Federal Communications Commission has opened the door for the company to launch a nation-wide service throughout the US. The company can now offer voice, data and high speed data services, including direct Internet access. The ruling also includes a blanket CMC license for Inmarsat terminals enabling operators to use the terminals in the US.

Globalstar announced a contract with the Italian Navy to install fixed maritime phone units into its more than 100 major vessels. Eutelsat is also managing an initiative, which proposes new maritime telecommunication services. The initiative, based on D-Sat technology using Seatel receivers and transmitters, was presented at SAT EXPO in Vincenza. The system, which has a real GSM cell fitted on the vessels in order to receive the satellite line, has been installed on a number of Brittany Ferries ships, Navy vessels of the French Government and on a number of cruise ships owned by a Greek ship owner.

Mobile satellite operator Inmarsat selected Ericsson for the development of its next generation core network for the company's Broadband Global Area Network (B-GAN) planned for launch in 2004. Inmarsat's B-GAN service will offer 3G compatible services over nearly the entire globe. The company is planning to focus on providing high-bandwidth services in areas where existing telecom infrastructure does not exist or cannot support content-rich applications. Data rates of up to 432 kbit/s will be offered.

XM Satellite Radio Holdings and Sirius Satellite Radio won conditional temporary licenses to use ground-based repeaters to deliver new satellite digital radio services.

Mobile phones and health concerns

A study from researchers at the American Health Foundation, Memorial Sloan-Kettering Cancer Center and four other US medical centers has found no statistical link between cell phone use and brain cancer. The study, published in the Journal of the American Medical Association, looked at 469 people with primary brain cancer and 422 who did not have any brain cancer between 1994 and 1998. On average, cancer sufferers used their mobile phone for 2.5 hours per month over a period of 2.8 years while those not having cancer used the phone an average of 2.2 hours per month for a similar period of time.

Oxford Industry Analysts published "In Health and 3G rollout", a report on health issues concerning base stations and their impact on the rollout of 3G networks. The authors state that the health concerns could greatly affect the market and that the industry has to ensure and demonstrate to the public that the phones and infrastructure are safe.

GSM Europe, the European Interest group of the GSM Association, announced a set of 'good practice' recommendations to better address public concerns about base stations. The main elements of the recommendations include clear information exchange between local authorities and other key stakeholders, proactive operators' site sharing initiatives when feasible, environmental sensitivity considerations, and more efficient and detailed availability of data. The 'good practice' recommendations are available on: http://www.gsmworld.com/gsmeurope/index.html

Wireless industry forecasts and surveys

The report "Wireless Java: Handset and Application Revenue Streams" from ARC Group predicts that 421 million

handsets will use Java by 2003; this figure will rise to 1billion by 2006. There are currently almost 8million Java users in Japan who are using NTT DoCoMo's i-appli service. The enhanced security and graphical capabilities of Java would be at the heart of its success.

A report from Analysys forecasts that there will be 110million GPRS users across Western Europe by 2006, representing 35% of the cellular subscriber base. The users will generate US$750million in mobile data revenue for the region in 2002 and will rise to an annual value of US$20billion in 2006. The report concludes that while volume-based pricing might be most appropriate for basic GPRS network access as the range of GPRS services expands, operators and service providers must relate price levels and structures to the perceived value of the services to the users if they want to maximise their revenue.

Another study from the ARC Group, "Mobile Advertising-New Business Models and Interactive Branding", found that the "intrusiveness" factor often associated with mobile advertising is not a prime concern for mobile users. The consumer survey carried out, in association with the Wireless Advertising Association, across Europe and the US indicates that around 30% of consumers in Europe and the US are either extremely or very willing to provide personal information in exchange for ads which are relevant to them.

A survey carried out by the HPI Research Group on behalf of Nokia Networks has highlighted the potential for upcoming mobile multimedia messaging services. The survey, conducted in six markets (UK, USA, Germany, Italy, Brazil and Singapore) found that access to a messaging device is high, mainly via a mobile phone or a PC, and the access varies from 81% in the US to 43% in Brazil. The greatest demand is for services offering functional improvements to messaging. Services offering visual enhancements were also welcomed by more than half of the population sampled.

A report from IMS estimates that at the end of 2000 the CDMAOne/CDMA2000 subscriber base had reached 82.2million, which accounted for 11% of all cellular subscribers. The figure is expected to rise to 278.1million by the end of 2006. The study forecasts 218million CDMAOne users (78.5%), 33.3 million CDMA2000 1XRTT/EVDO users (12%) and 26.4million CDMA2000 3XRTT/EVDV users (9.5%).

According to a study released by the Shosteck Group, "Mobile Phone Games: the Market through 2005", wireless games will start to flourish when 2.5G systems, not 3G systems, become widespread. The current wireless games market is hampered by slow transport and proprietary systems for delivering and playing the games. Once these problems are rectified, the revenues from the market will triple to about $1.2billion by 2005. Technologies like Qualcomm's BREW and Sun's J2ME will enable easier downloading of games. The study predicts multiplayer games, that run off the device and use the wireless network to connect to other players, to be the most popular games.

According to a study by Allied Business Intelligence global deployment of smart antenna systems will grow to over 1million systems by 2006 from under 100,000 this year.

A study from ARC Group, "MVNO Strategies – Building Successful Partnerships towards 3G", estimates the number of Mobile Virtual Network Operator (MVNO) users to account for 195million of the world's 1.9billion mobile subscribers by the end of 2006. The company expects a 127% Annual Average Growth Rate of subscribers to virtual operators between 2001 and 2006, compared to a 17% for mobile subscribers as a whole.

Spectrum licenses

Denmark has awarded four 20-year UMTS licenses at a price of $118million each. The winners of the licenses were TDC Mobile International, HI3G Denmark, Telia Mobile and Orange. The winners have to achieve a 30% coverage by 2004 and 80% by 2008. Sharing to build the network is not allowed until they achieve 80% coverage and the companies may only cooperate for the remaining 20%. Slovenia has awarded one UMTS license to the incumbent GSM operator, Mobitel, for $87.5million. Macedonia awarded Greece's OTE Telecoms the country's second mobile phone license. The company paid $25million for the 22-year license. Belarus has awarded its second GSM license to Russia's MTS for $21million. The license requires a 90% population coverage by 2005. Millicom has been awarded five 10-year GSM1800 regional licenses in Russia. France has announced changes to its 3G licenses. The initial fee will now cost $570million followed by annual payments based on the company revenue. The license term has also been extended from 15 to 20 years. The new conditions will apply to Orange and Vivendi licenses and to the two remaining licenses which will be offered at the beginning of 2002. Spain has also modified its 3G conditions and approved a 62.5% reduction in its radio spectrum tax.

Hong Kong has awarded four 3G licenses to the only four bidders, Hutchison 3G, SmarTone Telecommunications, Sunday 3G and CSL. The winners have to pay 5% of network revenue over the next 15 years or a minimum $6.4million per year in the first five years and rising thereafter. According to the spectrum sale's terms, each network owner must make 30% available to Mobile Virtual Network Operators. Saigon Postel said it received a license for a $230million project to develop Vietnam's third mobile phone network using CDMA technology. Malaysia has decided to just allocate 3G spectrum to three network facility providers while the country has currently five providers. The licenses will be granted for a 15-year period and the tender documents should be issued in February.

Tunisia has restarted its sale of the country's second GSM license setting January as the closing date. The initial attempt was cancelled as the government was not satisfied with the $381million offer of the highest bidder. Guinea-Bissau has launched an international tender for a 10-year 900MHz mobile phone license. The country has reserved a second license for Guine-Telecom.

Paraguay has granted a GSM license in the 1900MHz band to Paraguayan Communications Company. Colombia has opened the bidding for its PCS C-band licenses expected to be auctioned in January.

Wireless LAN and Bluetooth

Voicestream Wireless is the first US wireless operator to announce plans to use high-speed WLAN technology. The company applied to acquire the assets of 802.11b WLAN operator MobileStar Networks. Spirea AB unveiled TripleTrac, what it claims is the world's first dual band 5GHz/2.4GHz wireless LAN chip that features 802.11a, 802.11b and the European HiperLAN2 standard on a single chip. The company expects to be in full production by Q4 of 2002. The mixed-signal baseband is digitally programmable to accommodate different bandwidths for data rates reaching 22Mbps in the 802.11b mode and 108Mbps in the 802.11a mode. The company has also announced an agreement with embedded wireless devices inc to develop a tri-band (5.8GHz, 5.2GHz and 2.4GHz) chipset supporting 802.11a. 802.11b and HiperLAN. Bluetooth-based communications will be supported with just an additional radio. SkyCross has introduced the industry's first embedded antenna that provides simultaneous coverage of the 800MHz cellular, 1575MHz GPS, 1900MHz PCS and 2450MHz (802.11b and Bluetooth) frequency bands. Nokia and Sonera, the main Finnish operator, have conducted the

world's first WLAN roaming based on GSM technology. The Nokia Operator Wireless LAN technology uses the existing GSM core network and roaming infrastructure. The subscriber uses a SIM card installed inside the WLAN card making possible to use the card anywhere where GSM coverage is provided. A report defining the requirements concerning the interworking of HIPERLAN/2 and 3G systems has been published. The report "Requirements and Architectures for Interworking between HIPERLAN/2 and 3rd Generation Cellular systems" is available at http://pda.etsi.org/pda/home.asp?wki_id=7078.

Proxim announced its Symphony HomeRF product line, which the company claims is the first to support the HomeRF 2.0 standard. The products offer speeds of up to 10Mbps, i.e. more than six times the 1.6Mbps limit of previous HomeRF products.

ABI predicts in its report "Wireless LAN Public Hotspots: Assessment of Business Models, Service Rollouts and Revenue Forecasts" that the number of WLAN nodes shipped world-wide will reach 47.4million in 2006 from 1.22million in 1999 and 4.4million in 2000. In 2000, the North American hotspot subscriber revenue was $1.1million and is expected to rise to $868million in 2006. The WLAN market is expected to grow at 51% a year between now and 2005 in the Asia Pacific region (excluding Japan), according to a study by IDC. The revenues from WLAN sales are expected to reach $350million by 2005 up from $45million in 2000. In its study "Public Wireless LAN Access: Market Forecasts", Analysis forecasts that more than 20million people in Western Europe will be using WLAN services by 2006. The study also predicts there will be more than 90,000 hot spot locations and that WLAN services will generate E3billion for public WLAN operators. The company expects that by 2006 two-thirds of laptops, more than one third of PDAs and up to 20% of mobile phones in Europe will be WLAN enabled. This will amount to 75million devices in total by 2006.

Singapore's telecoms regulator, IDA, has announced it has opened up the entire 2.4GHz frequency band to allow wider use of short-range wireless technologies such as wireless LANs and Bluetooth. The IDA has also lifted the restriction on the indoor use of short-range technologies in the 2.4-2.4835GHz frequency band. Until now part of the 2.4GHz frequency band was used by the electronic road pricing system of Singapore' Land Transport Authority. Netario, a British start-up, has launched in Manchester what it calls the first public-access Bluetooth wireless network in the world. The trial 2.4GHz network provides speeds between 300 and 400kbits/s. The company expects by February to have 70 wireless hot spots in the city. Pricing to access the network will be roughly equivalent to charges at cybercafes. The company is planning to expand the initiative across Europe and is also considering supporting the 802.11b standard.

Qualcomm announced what it claims is world's first Bluetooth version 1.1-compliant CDMA2000 1X commercial chipset, the MSM5100 Mobile Station Modem solution. The chipset features position location and multimedia features. It also supports the BREW applications platform. Sony Ericsson announced the launch of the Ericsson Bluetooth Handsfree HBH-20, a device designed as a wearable accessory that eliminates the physical connection to the phone but incorporates the familiar design of a traditional handsfree. It consists of a small Bluetooth unit and a separate earpiece, connected by a short wire, which also contains the microphone. The system weights 26g and has a talk time up to 4 hours. The Bluetooth Special Interest Group Inc's Car Working Group released a definition on how Bluetooth wireless technology will enable hands-free use of mobile phones in automobiles as part of its Hands-Free Profile.

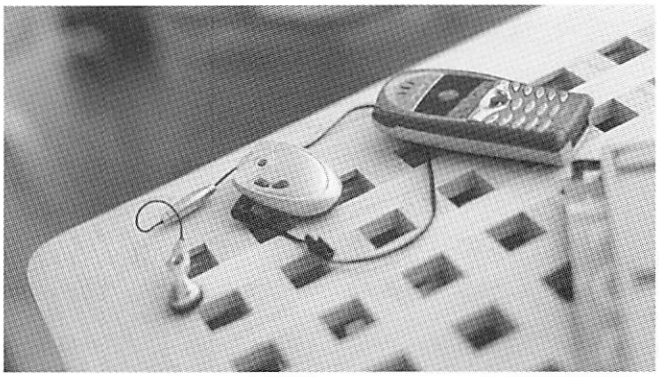


Photo by Ericsson

Figure 2 Ericsson Bluetooth Handsfree HBH-20

According to a report from the ARC Group the market for the Bluetooth mobile handsets will grow from 1.5million devices this year to 26.2million in 2002 and will reach almost 100million in 2003. The company estimates that by 2006 779.7million handsets sold will be Bluetooth enabled representing 71% of the total sales in that year. Forrester Research expects the shipment of Bluetooth enabled devices to reach the 1billion mark in 2007 from 1.2million this year. In its report, "Bluetooth Overtakes 802.11x with 2001 Shipments on Track", Cahners In-Stat Group estimates that 13million Bluetooth chipsets will be shipped during 2001 which represents according to the company twice the shipments of 802.11b chipsets. The shipments should increase to 780million units in 2005.

African mobile market

The ITU TELECOM AFRICA 2001 event, the fifth regional telecommunications Exhibition and Forum for the Africa region, was held from 12 to 16 November at Johannesburg (Republic of South Africa). AFRICA 2001 was the watershed event at which it was announced that mobile subscribers across the continent now outnumber their fixed-line counterparts, and that Sub-Saharan telephone density had finally breached the one per cent subscriber barrier considered essential to economic growth. Projections by the ITU now forecast that there will be more than 100 million mobile cellular subscribers in Africa by the year 2005. Although the number of mobile networks has increased from 33 in 1995 to 100, six African countries still don't offer access to mobile telephony. Prepaid, with four out five subscribers, remains the key driver of the mobile market in Africa. During the event it was also announced the implementation of the first NEPAD (New Partnership for Africa's Development) initiative, the *e-Africa Commission*, which will be responsible for developing e-strategies and projects at continental level. The e-schools project will be the first project of the Commission and is aimed at ensuring that every high school student in Africa is e-literate within the next five years. The Exhibition at AFRICA 2001 attracted 15,000 telecommunications professionals, 236 exhibitors from 28 countries. The Forum at AFRICA 2001 was attended by nearly 2,000 people. The Forum encompassed a Policy and Development Summit, an Infrastructure and Applications Summit, and a Youth Forum. During the week of AFRICA 2001, non-exclusive Memoranda of Understanding (MoU) were signed by the ITU's Secretary-General with Alcatel and Siemens within the framework of its Centres of Excellence (CoE) Initiative. These two European manufacturers will make an in-kind contribution in equipment and capacity building to manage and administer networks in Africa, Arab States, Latin America and the Caribbean. A third MoU was also signed between the ITU and Cable & Wireless

at the event, to commemorate the tenth anniversary of the ITU/C&W Training Scheme. Under the agreement the UK operator will extend remote learning opportunities to telecommunication professionals in LDCs, by providing scholarships through the Global Telecommunication University (GTU), the ITU's flagship programme for distance learning. AFRICA 2001 was also the venue for the launching of a new ITU publication, *African Telecommunication Indicators 2001*, which provides analysis and statistics on every country in Africa. Next year the ITU will be organising its sixth regional ITU TELECOM event for the Asia-Pacific region, Asia 2002.

Wave Wireless Networking, a division of SPEEDCOM Wireless Corporated, announced it was selected by the United Nations Development Program (UNDP) to provide secure broadband wireless communications for several projects in Africa. The first project has been taken place in Brazzaville (capital city of People's Democratic Republic of Congo) but the UNDP plans to implement similar networks in Africa with the possibility of world-wide implementation.

Nigeria's Nitel, the State telecoms company, launched the country's third GSM network with an initial 5,000 lines and a pledge to connect 120,000 lines by December. The other two GSM operators, MTN and Econet, launched their network in August. Nitel has been running an analogue mobile network for some years.

According to a report published by BMI-TechKnowledge (BMI-T) while the number of fixed lines grew by 30% to 17.6million in the African continent, excluding South Africa, the number of mobile subscribers grew by 54% to 7.5million. The report also claims that 90% of mobile users in Africa, excluding South Africa, are prepaid. The company also estimates that at the moment 55% of the mobile users live in South Africa.

Initiatives and Forums

The CDMA Development Group (CDG) announced the launch of an applications initiative to promote the development and deployment of applications for CDMA-based technologies. The purpose of the initiative is to provide content and application developers a forum where they can work with operators and manufacturers to deliver advanced services for CDMAOne and CDMA2000 networks. More information can be found at www.cdg.org

The GSM Association and the WAP Forum have established a co-operative alliance to formalize and strengthen their working relationship over the next three years. The two organisations plan to collaborate on work areas such as: identification of network operators and service provider requirements, device, protocol and application requirements; roaming and billing; development of WAP specifications; and interoperability.

A number of industry leaders have announced a commitment to create a global and open mobile software and services market with the launch of the open mobile architecture initiative. The companies will conduct mobile software development in full compliance with the specifications of the key industry standardisation organisations such as the 3GPP and the WAP Forum. The scope of this initiative encompasses terminal client software modules for mobile terminal vendors and the corresponding server solutions for mobile operators.

Thirty three major companies have formed an alliance, called Liberty Alliance Project, to develop and deploy an open, federated solution for network identity, enabling ubiquitous single sign-on, decentralised authentication and open authorisation from any device connected to the internet including cellular phones. More information can be found at www.projectliberty.org.

Other news

VoiceStream has signed contracts with Ericsson and Nortel to provide GSM and EDGE network infrastructure for its US network. Within its agreement, Nortel is providing Adaptive Multi-Rate (AMR) vocoder. Cingular Wireless has also announced an important network upgrade, contracted to Ericsson, Nokia and Siemens, to deploy GSM, GPRS and eventually EDGE on its national network. Cingular plans to add EDGE to its existing TDMA and analog networks via an evolution from a GSM network that uses the 850/1900MHz bands. VoiceStream and Cingular Wireless have also announced plans to share their networks in New York City, California and Nevada.

Sprint PCS has become the first US operator to open its wireless network to a Mobile Virtual Network Operator (MVNO) by forming a joint venture with the Virgin Group. Virgin has set another MVNO joint venture with SingTel in Singapore.

Four Canadian carriers (Bell Mobility, Microcell Connexions, Rogers AT&T Wireless and Telus Mobility) have agreed to allow cell phone users to exchange short messages over their phones regardless of which operator they use. Bell Mobility and Telus Mobility have also agreed to share their networks in a ten-year deal.

The CDMA Development Group has announced that there are nearly 55million CDMA subscribers in North and South America, representing more than 30% of the total wireless subscribers in the region. Over the past year, the CDMA subscriber base in the region grew by 74%. The Universal Wireless Communications Consortium (UWCC) has said the number of TDMA subscribers increased 53% over the past year, reaching 82.1million subscribers world-wide. The TDMA technology continues to serve as the prevalent technology in Latin America and the Caribbean. According to the GSM Association, the number of GSM users world-wide has reached 600million.

Sprint PCS has announced it would employ the Java2 Micro Edition software in handsets when the carrier's CDMA2000 1X network goes live in 2002. The company joins then Nextel Communications as a US-based provider of Java-enabled phones. Motorola has unveiled two new iDEN Java-based phones.

Report on VTC2001-Fall

The 54th Vehicular Technology Conference was held in Atlantic City from the 6th to the 11th of October 2001. Given the location of Atlantic City, many delegates to the conference would travel via New York or Washington, and with the terrorist attacks on September 11th, many people left it late to decide whether or not to attend. VTC was not as severely affected as PIMRC had been the previous week in San Diego; people had been encouraged to start travelling again, and invited to spend money in New York by its mayor. About two thirds of attendees for the first day tutorials came to the conference. However, those arriving later on that day for the conference itself registered beside a somber television set giving news of the start of bombing in Afghanistan. The atmosphere at the conference was, therefore, not the usual one for VTC, and by the end of that day, only about half of those who had registered for the conference turned up. Overall, about 400 of the expected 650 delegates attended the conference, with 37% from the US, 29% from Asia, 24% from Europe and 9% from elsewhere.

The conference was opened by Art Greenberg, who noted VTC had suffered the "double whammy" of the terrorist attacks, and a downturn in the technology sector which had restricted companies spending on things like conference attendance. For a former, it was not just an understandable reluctance on the part of some people to be travelling, but also company travel policies and insurance. In the case of one multinational, the local North Jersey-based branch prevented employees even from driving to the conference, while the same company had almost full attendance from its European offices. Fortunately the travel restrictions did not apply to IEEE conference services, who did a great job in very difficult circumstances. Those that continued to work hard, away from home, in such worrying times, deserve our thanks.

Notewithstand all this, there were still a number of innovations at the conference. There was renewed vigor given to the vehicular technology part of the conference programme with two invited sessions on different aspects of the technology. It is hoped that this momentum will be maintained at future VTCs. Another innovation which fell victim to the reduced number of attendees was a number of industrially-focussed workshops which were planed for the final day.

The opening plenary speaker was George I. Zysman, formerly Chief Technical Officer of Lucent Technologies' Wireless Networks Group, where he still acts as a consultant. Dr. Zysman spoke of the market drivers and enabling technologies of 3G wireless and beyond. He noted that markets and services are the stimulus for technology. Notwithstanding the current difficulties, the future for services will be very bright. A major driver in this will be data services, which will have to have increased capacity available. The key to data is mobility, he said, and with 30% mobile penetration, the US lags much of the rest of the world. An example is i-mode in Japan, where 50% of the data across the network is IP. This is giving in the order of $4 billion per year of subscription revenue, and of the average monthly subscription of $12–13 per month, 9% goes to NTT DoCoMo.

Between 1985 and 1996, the cost per unit device fell by factor of 10, while cumulative usage increased by a factor of 100. We see the progression of use from when mobile phones were the preserve of high ranking businessmen, through real estate agents, to the point today where they replace calling cards. In the future, there may go to the stage of being used as an intercom. However, they aren't making spectrum any more, so the only solution is innovation. This year, data rates in wireless will become comparable with wireline Internet users. 94% of US residential users have IP service at 56kb/s or below. With 3rd generation mobile services, wireline will have to catch up with wireless. This means spectrum will be consumed very rapidly. More terminal options will be required – input is very difficult on a phone. PDAs offer more utility, but the full multimedia experience will require a laptop.

Dr Zysman summarized by identifying a number of trends, the key one being that next-generation systems would be defined by services. The coverage of high data rate services will not be ubiquitous, although the network will be unified with an IP backbone. Dynamic resource management will be required to maximize the bits per second per hertz per dollar, while dynamic network allocation will also be required at the higher layers of the system.

A number of questions centered on the issue of spectrum, such as where it was most likely new spectrum would be available. Dr Zysman saw the main problems being political. The entire mobile industry in the US started on poorly utilised television channels. Refarming of TV channels is possible, given the spectrum utilisation of home shopping channels. However, the problem is political will. This also affected the future of ultra wide band (see also the article on Page 4). He foresaw two challenges: technical and political. The technical problems can be resolved, but the political problems of interference to existing users are more difficult. Since the spectrum has already been sold, in effect operators who are already occupying the spectrum are being asked to give up some of their capacity to a competitor.

Dr William Lee organised and chaired a panel session on Monday evening on the subject of advanced wireless technologies and systems. The session was slightly abbreviated due to the fact that Dr Roberto Padovani, EVP from Qualcomm, who was due to talk on cdma2000, was stranded in Denver on the way to the conference by a late connecting flight. Dr. Kota Kinoshita, CTO of NTT DoCoMo, was not able to attend due to company travel restrictions, but his presentation was given by Dr. Lee.

The first presenter was Håkan Eriksson, Vice President of Research at Ericsson, who reviewed the current position of mobile, with GSM as the dominant standard, which he saw as continuing for some time. In China, an extra 5 million GSM subscriptions are added each month. Two Internet industries are being formed, fixed and mobile. This is important, since with existing telephony what was on the fixed system was provided in a mobile manner. He believed that this will not be the same for the Internet. A distinction can be drawn between 3G mobile and Wireless LAN. 3G pro-

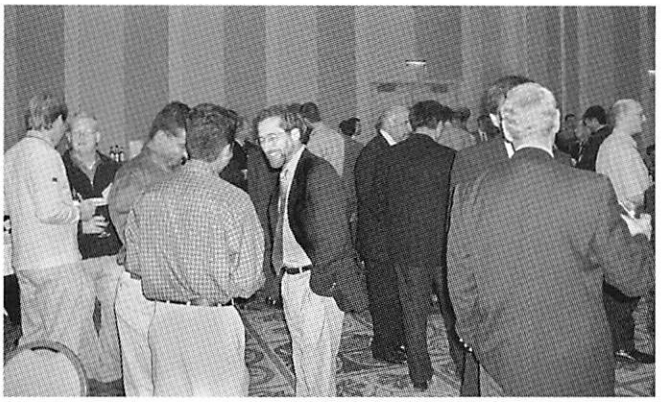


Figure 1 VTS President J. R. Cruz (center) welcomes delegates at the opening reception

vides "any time, anywhere" services of up to 2 Mbps, or 384 kbps in wide areas. Wireless LAN on the other hand provides "some time, somewhere" coverage up to 5 Mbps. This will increase initially to 11 Mbps with 802.11b, but in the foreseeable future up to 20 to 54 Mbps. However, one wide area mobile cell provides about the same coverage as 10,000 Wireless LAN cells. An interesting area of study is roaming between WCDMA and Wireless LAN, or cdma2000 and Wireless LAN. A new entry into marketplace was Bluetooth, with 300 products listed as of August 2001, approximately 80 of which are consumer products. A key development for the Internet is the move towards IP version 6. There are currently too few IP version 4 addresses, and those that are available are unevenly distributed, with MIT, for example, having more than China. IPv6 guarantees mobile Internet viability.

3G is twice as spectrally efficient as second generation systems, so 3G is not just about the mobile Internet, but also about capacity and voice. Håkan Eriksson suggested the future, towards fourth generation, would be about 'ABC' – always best connected. There has been a pattern of decades of research: the Eighties for GSM, the Nineties for WCDMA, EDGE, cdma2000 and other 3G technologies, so the 2000s will need to be the decade of research for 4G. We are just at the start of this.

The second speaker was Dr. Rajiv Laroia, founder and Chief Technical Officer of Flarion Technologies, who discussed OFDM technology. He noted the goals of a data system: affordability, in terms of price per MB; a scalable architecture; broadband user experience, which implies a high burst rate, though not necessarily a high sustained rate; low delay; and end to end IP, in fact a seamless extension of the Internet, so that all current applications work. He noted that currently 3G systems do not meet these requirements. Current systems are designed for voice, but voice and data are different; radio is unreliable, but the Internet is designed around a reliable link. OFDM has a number of advantages for data applications, having an efficient air interface (which can be up to about three times as efficient as current systems), high granularity of resource allocation (without the overheads of TDMA), and no requirement for a contention based access since a large number of channels are available. This allows a low delay which is better for interactive services, and a true make before break handover without requiring soft handover.

Dr William Lee, as Chairman of LinkAir Communications, discussed a new technique called code division duplexing. Current systems use either Time Division Duplexing (TDD) or Frequency Division Duplexing (FDD). Using TDD for CDMA causes difficulties with interference between base stations and mobiles in neighbouring cells, in terms of timing and synchronisation issues for larger cells. The new system of CDD has been trailed in Shanghai over a 1.6 MHz unpaired band with voice and video. CDD requires "smart codes", with low auto and cross correlation within a set time window. This allows interference and multipath to be ignored.

Dr Lee also gave the presentation on behalf of Dr. Kota Kinoshita, CTO of NTT DOCoMo. In Japan, cellular passed fixed in terms of penetration in the middle of 1999. 57% of phones as of March 2001 have i-mode capability, and Japan was about to launch FOMA – Freedom Of Mobile multimedia Access. The 'F' also stands for Frontier, Future and Flexibility. FOMA will have 384 kbps on the downlink, and 64 kbps on the uplink. Services will include an enhanced i-mode, with 384 kbps on the downlink, allowing 10,000 character e-mails and attachments. There will also be a video phone service at 64 kbps. M-stage visual will be a video delivery service, in addition to which will be a high-speed data communication packet data service, and a 64 kbps circuit data service. Multiple access to simultaneous voice and packet service will be available, and voice will have land line sound quality. As regards charging, the voice service will be charged at an equivalent level to current voice services. The 64 kbps data service will have a charge about 80% higher than voice. Packet services will be charged at 0.02¥ per packet. Three types of phone will be available at launch – a standard voice phone, a video phone, and a data card for a laptop. Future plans include i-motion, with video over i-mode towards the end of 2001, an M-stage video distribution service in Spring 2002, and later a music distribution service as well. Dual network service, with the same number for FOMA and conventional PDC, will be available in the Summer 2002, with international roaming following when other services roll out. The initial area of operation is within a ring about 30 km from Tokyo, starting on 1st October 2001.

Figure 2 The opening plenary

The Awards Luncheon was held on the Tuesday. Details can be found in the article on Page 45.

Dr Juergen Schroeter, Division Manager of Speech Processing Software and Technology at AT&T Labs, addressed the Tuesday evening banquet on the subject of the Latest Advances in Speech Synthesis. He started with a video demonstration of a speech enabled application. The drivers for such technology are cost reduction, the ability to offer new products and services, perhaps location based, and providing information access to mobiles on occasions where the reviewing of data is inconvenient, as well as on small de-

Figure 3 Two of Atlantic City's casinos

Figure 4 The neighbors!

vices where displays are not possible. There are three approaches to speech synthesis: articulatory synthesis (from a voice box), format synthesis (from speech phonemes) and concatenative synthesis (snippets from recorded speech). The last technique has the potential for the most natural sound, but it is necessary to use very many different snippets rather than trying to use signal processing to the massage the pitch, etc, to match the desired sound. The more signal processing used, the lower the signal quality. However, large numbers of snippets require storage and processing. His company has optimised computation to the point where 60 streams can run concurrently on a 1 GHz Pentium 3 system.

The Wednesday lunch talk was delivered by Richard Howard, who recently retired as Vice President, Wireless Research at Bell Labs, Lucent Technologies. His talk was entitled "Where's the Beef – An Amateur's Look at The 'Real' Value Behind the Internet Hype". He pointed out that the Internet was perhaps not completely new – we have, to an extent, been here before. The wireless web was foreseen with Dick Tracy in 1946. This was done within six months of Arthur C. Clarke's geostationary satellite proposal, and since radios were at a more advanced state in 1946 than rockets (compare a walkie-talkie to a V2 rocket), the wireless web could have been expected first. However, communications satellites took 20 years, but we are still waiting for the wrist communicator with web access.

Dr Howard noted that while it was obvious that the Internet was going to facilitate change in human society, it was not obvious that is the latest in a long line of changes; "history may not repeat itself, but it often rhymes". He cautioned delegates to remember the basics. Good investments create something people want. In particular, buying entertainment is not an investment, and on the whole, investments must be worth more than the cost. Human beings are the key – machines don't purchase things. Also, humans can only pay attention 16 hours per day; time sharing is just that, no new capacity is created. Too many choices lead to people avoiding buying or doing anything!

The market is limited, at the moment, to 6 billion customers. At one stage, during the summer of 2000, the market capitalisation of Qualcomm was $120 billion. This was equivalent to $20 for every person on the planet. As a safe investment might yield 8% (prime rate), such a capitalization would mean that everyone on the planet would have to pay Qualcomm $45 in profit in ten years. Given a 10% profit margin, this would mean that they would have to buy $450 of Qualcomm products in ten years, and these figures are for no risk. If there is any risk, the investment rate should be increased accordingly. Other fundamentals are that the revenue of equipment suppliers must be less than the revenue of the service providers, and the revenue of the advertisers must be less than the revenue of the producers. However, sometimes the promoters of new technologies have ignored these basic rules.

On access to information, between 668 and 627 BC, the Royal Library at Nineveh (Assyria) had 10,000 volumes. From the third century BC to the third century AD, the library at Alexandria had 700,000 volumes. The Gutenberg Bible was published in 1455. By 1500, they were 9 million books in Europe. By the middle of 17th century, there were 300 newspapers in England, and broad access to information fuelled the Renaissance and the Reformation. In the 19th century, the telegraph changed the character of communication. In April 1844, it took one hour for a message to travel the 37 miles between Baltimore and Washington by railroad. In May 1844, this was reduced to less than one minute, with the first commercial telegraph in North America. In 1861, it took

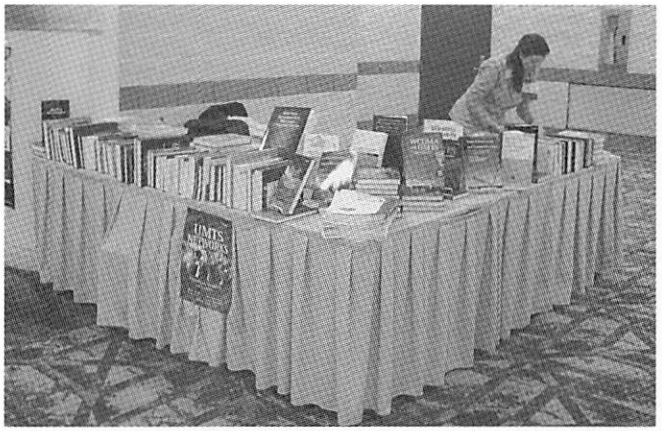


Figure 5 One of the two bookstalls. There were also a number of exhibits

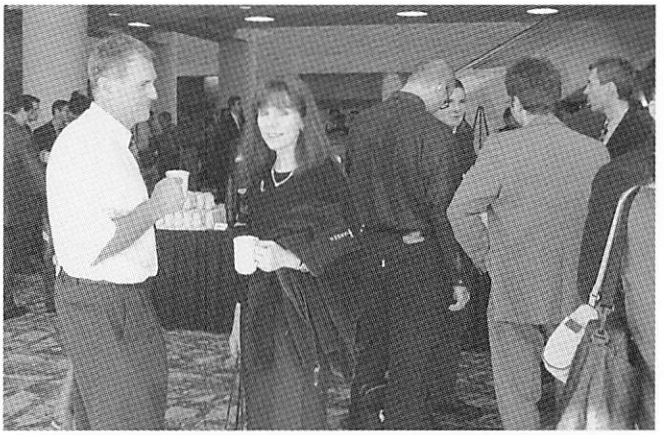


Figure 6 Networking during the coffee breaks

ten days for a message to travel 1,800 miles from St Louis to Sacramento by pony express. In 1865 transatlantic communications took 14 days by steam ships. In each case the telegraph reduced the communication time to the order of minutes, and similar quotes were being made at that time as are being made now about the Internet.

Between 1965 and 2000, the price of transistors fell by factor of 10,000,000. The web took less than seven years to reach 30% of US households, compared to 46 years for electricity, 38 years for the telephone, and 17 years for TV. 93% of worldwide information is created digitally, and only 0.003 % is in print. If the Internet improves productivity by 0.5% per year, this will result in a $1.2 trillion budget surplus over ten years. However, as any electrical engineer knows, if there is too much gain in the system with the wrong time constant, you end up with instability.

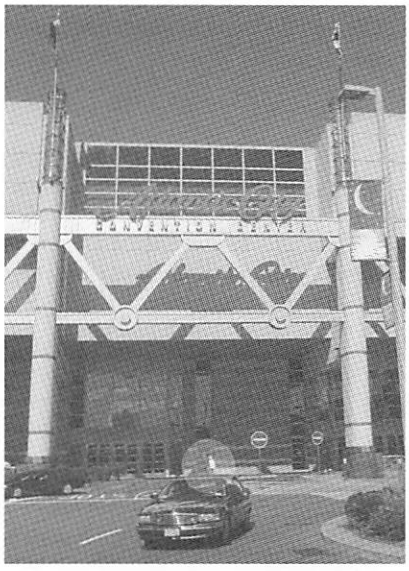


Figure 7 The Atlantic City Conference Center, with one of the camera-shy pickets (circled)

Dr Howard pointed out that data, information, knowledge and wisdom are not synonyms, and basic human intellectual capacity is not changing fast. The opportunities are there, in a wide range of information easily available, in a democratic, egalitarian, and archived form, although this latter point requires care. The format of library of Alexandria can be read today, but ten-year-old computer media may not. The key factor is that too many choices goes overload, so more attention must be given to training in searching an evaluating information. The value is not in the data itself, but in the wisdom becomes from it.

The terrorist attacks were not the only obstacle to would-be attendees. The first days of the conference were picketed, not very effectively, by local carpenters protesting about the use of non-union labor. However, in spite of all the difficulties, those who did attend found an interesting and useful conference. See you all in Birmingham!

Help Wanted – Call for Assistant Editors

Do you have a few hours to spare every quarter to help contribute to the success of the *VTS News*? We are looking for Assistant Editors to help our Senior Editors in specific areas of their remit across the full range of the Society's activities. While these positions can't offer fame and fortune (although you do get your name in the newsletter), they do offer rewards in other ways, and are a very good way of getting more involved in your society. No experience is required. If you are interested, please contact the editor, James Irvine, at j.m.irvine@ieee.org.

CBTC Standards

The CBTC working group is currently considering proposals for expanding the IEEE Rail Transit Vehicle Interface Standards Committee Working Group 2 with additional members drawn from the automated people mover community to develop a revised CBTC performance and functional requirements standard that is applicable to driverless/Automated People Mover (APM) applications

At present the only internationally used standard related to driverless automatic train operation is *ASCE 21-96, Automated People Mover Standard.* This standard is a performance/functional standard and is not specific to any particular train control technology. Also, *IEEE 1474.1, IEEE Standard Method for Communications Based Train Control (CBTC) Performance and Functional Requirements,* provides performance/functional standards specific to CBTC technology for applications in commuter rail, heavy rail and light rail transit systems with operators.

However, there are a number of train control standards efforts underway requiring coordination, including plans for IEEE 1474.1 to extend its CBTC Performance Standard to cover driverless systems, IEC WG39 work on *Railway Applications – Urban Automated Guided Transit*, and proposed IEC WG40 work on *Urban Guided Transit Train Control Standards.*

The purpose of the proposal is to provide the basis for cooperation between current individual members of the *IEEE Rail Transit Vehicle Interface Standards Committee's WG2* and the *ASCE Automated People Mover Standards Committee* in harmonized development of train control standards for CBTC technology. CBTC technology is increasing being selected as the train control technology of choice for driverless applications, regardless of whether the application is classified as an APM or an Automated Urban Transit System. CBTC suppliers and users are seeking a single standard to define the performance and functional requirements for this technology for a wide range of application, both driverless and with drivers. There already exists a high level of consistency between the existing IEEE and ASCE standards.

It is planned to update and revise both the IEEE and ASCE standards in essentially the same time frame. It is therefore proposed that the IEEE standard be expanded to encompass driverless operations and APM applications, that current members of the *ASCE APM Standards Committee* be permitted to participate in the *IEEE RTVISC WG2*. In addition, it is proposed that the ASCE standard be revised to include the same definition for CBTC technology as is used in the IEEE standard, and the ASCE standard would simply refer to the revised IEEE standard for those APM applications that utilize CBTC technology for train control functions. For further details contact Tom McGean, t.j.mcgean@ieee.org.

IEEE Leon K. Kirchmayer Paper Award

Congratulations are due to VTS member Muriel Medard from MIT in Cambridge, MA, for winning the IEEE Leon K. Kirchmayer Paper Award. She won the IEEE award for her paper "The Effect Upon Channel Capacity in Wireless Communications of Perfect and Imperfect Knowledge of Channel" published in the IEEE Transactions on Information Theory, Vol. 46, No. 3, May 2000.

Membership Matters

Fifty two VTS members were elevated to Senior Member during 2001. The members, and their sections, are as follows: **Oscar E Agazzi** (Orange County), **Massoud Amin** (Saint Louis), **Makoto Ando** (Tokyo), **Angelo Bruno** (Central & So. Italy), **Antonio Artes Rodriguez** (Spain), **Brian K. Butler** (San Diego), **Edgar H. Callaway, Jr** (Palm Beach), **Hasan Cam** (Phoenix), **Kavitha Chandra** (Merrimack Valley Subsection), **Yue Chen** (Santa Clara), **Hyung Jin Choi** (Seoul), **John P Cullen** (Louisville), **Peter Cullen** (U.K.& Rep of Ireland), **Daniel J Dailey** (Seattle), **Ramez L. Gerges** (Central Coast), **Joseph P Heck** (Broward), **James Irvine** (U.K.& Rep Of Ireland), **Whan Soon Jeon** (Seoul), **Peter B. Kenington** (U.K.& Rep of Ireland), **Rodney A. Kennedy** (Australian Capital Territory), **Cheol-Sung Kim** (Kwangju), **Ammar Kouki** (Montreal), **Thomas Kurner** (Germany), **Weng Kin Lai** (Malaysia), **Ty A Lasky** (Sacramento), **Francois Le Chevalier** (France), **Ronald A Lemp** (North Jersey), **Marco Lops** (Central & So. Italy), **Hiroshi Nogami** (Tokyo), **Tomoaki Otsuki** (Tokyo), **Ana J Perez-Neira** (Spain), **Kinh D. Pham** (Oregon), **Gregory J. Pottie** (Coastal Los Angeles), **Robert C. Qiu** (North Jersey), **Hayder Radha** (Southeastern Michigan), **R.M.A.P. Rajatheva** (Thailand), **Fernando Ramirez-Mireles** (Oakland-East Bay), **Seiichi Sampei** (Kansai), **Abu-Bakarr Sesay** (Southern Alberta), **Nava Setter** (Switzerland), **Erik G. Strom** (Sweden), **Sami Tabbane** (Tunisia), **Mitchell Tasman** (Boston), **Oguz Sunay** (Turkey), **Cesar Vargas-Rosales** (Monterrey), **Richard Dale Wesel** (Coastal Los Angeles), **Kainam T Wong** (Hong Kong), **Danny R. Webster** (U.K.& Rep of Ireland), **Weihua Zhuang** (Kitchener-Waterloo), **Brian D. Woerner** (Virginia Mountain), **Mohammed O. Zaatari** (Northern Virginia), and **John R. Zeigler** (Metropolitan Los Angeles).

IEEE members with 10 or more years of professional service are eligible to apply for election to Senior Member grade. See http://www.ieee.org/organizations/rab/md/smprogram.html for details.

VTC2002-Spring in Birmingham, AL, 5-9 May 2002

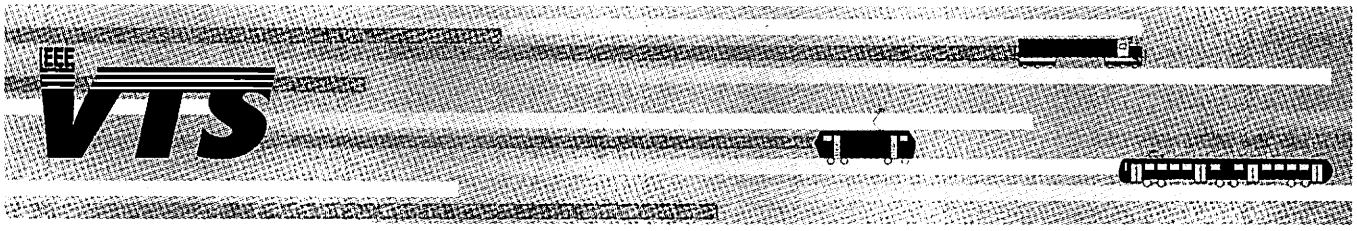
Birmingham, AL will host the IEEE Spring Vehicular Technology Conference 5-9 May 2002. The Conference will be held at the Birmingham-Jefferson Civic Center with accommodations at the Sheraton-Birmingham Hotel.

The conference will provide opportunities to participate in numerous technical sessions and to visit exhibits of state-of-the-art applications. Over 400 papers and posters will be presented on innovative mobile wireless technologies such as antennas and propagation, wireless access, transmission, networks and systems, mobile satellite, and transportation. Special sessions, with invited papers, are planned for automotive transportation topics. The conference begins on Monday, 6 May 2002 with a day of tutorials covering the latest developments in ever-changing wireless technologies.

As a part of the development of the technical program, a number of session chairs must be identified. If you wish to contribute to the success of the conference by volunteering as a session chair, please contact Dr. Charles E. Hickman, Technical Program Chair, at c.hickman@ieee.org.

Advance registration is available until March 31. The cost of advance registration for members is $500 and for non-members $575. After March 31 cost is $575 and $650 respectively. Student members and life members may attend the conference for a reduced fee of $75. Student non-members fee is $100. Special hotel rates are available for students and reservations can be made on the website. Other fees and cost of tutorials are listed on the VTC2002-Spring website, www.ieee.org/vtc02spring.

Further details of registration and the conference program itself can also be found on the web site.



Joint Rail Conference 2002

The 2002 Joint Rail Conference, sponsored by the Land Transportation Division of the VTS and the Rail Transportation Division of the ASME will take place in Washington, DC from April 23rd to 25th 2002. In this issue we reproduce the abstracts of the 11 papers accepted from the IEEE in order to give you a flavour of the conference. There will also be papers at the conference from the ASME. A registration form appears on page 47.

Electro Magnetic Interference Effects Due to Line Reactor Coil-To-Coil Short Circuits

Ross Potter, Bombardier Transportation

The effect of coil-to-coil shorts on the impedance of line reactors has been an Electro Magnetic Interference (EMI) safety issue for a number of years. This paper presents a comprehensive theoretical and experimental treatment of this issue. A circuit model was developed to evaluate the ef-

fects of coil-to-coil line reactor shorts. The circuit model was validated with experimental data. Potential failure mechanisms for coil-to-coil short circuits were developed and analyzed. Worst case values for potential shorts were established from experimental data. The system level effects for coil-to-coil short circuits are considered.

Electrical Reliability Analysis for Transit Applications

Richard Eacker

Maintaining a safe and secure environment for transit patrons has never been more important. Patrons who feel confident in the transit environment will use a transit system. If they don't, they won't. Personal safety and security is especially important in locations where people naturally tend to feel ill-at-ease such as deep, underground stations.

Sound Transit is undertaking the construction of its first major phase of 'Link' light rail. Due to the challenging topography in Seattle, lines from downtown north and east through the most densely populated areas of the city will likely be running underground at depths from 100 to 600 feet below the surface with stations from 80 to 250 feet deep. Consequently, security and reliability of the electrical power supply system are of paramount importance. Under conditions of utility power failure, continued operation of the Link trains and lights in the stations and tunnels is necessary to assure patrons' safety and security. What could be a nuisance for surface transit could become a major safety issue for a subterranean system.

During preliminary engineering of the northern alignment, questions were posed as to the reliability of various power supply configurations being proposed. Concerns were expressed by the Link Safety and Security Office, Seattle Fire Department and Seattle Police Department about the reliability of power for lights, traction power, emergency ventilation and vertical transportation equipment. The depth of most stations precludes the use of escalators, so the primary means of vertical travel will be the banks of high-speed elevators. Such equipment, along with the heavy traction power demand, limits the options available for backup power sources. Generators of reasonable size could only be used for lighting and limited elevator operation, but their location in areas near the most congested neighborhoods in the city poses environmental problems.

In order to objectively compare various schemes of providing backup power, the Systems Engineering team turned to the *IEEE Recommended Practice for Design of Reliable Industrial and Commercial Power Systems* (IEEE Standard 493-1997) to evaluate various schemes. This paper presents the issues leading up to that analysis, the theoretical basis of the Standard and the results.

Substation Nuisance Trips Result in Operational Interruptions and Force Re-Design of Protective Devices – A Case Study

Thomas Heilig, P.E. Tri-Met, Dennis L. Porter, Ralph S. Thomas, P.E., LTK Engineering Services

Tri-Met has been operating light rail in the Portland area for fifteen years without any significant traction power problems. However, early in 2001, Tri-Met suddenly began to experience multiple substation outages resulting from tripping of the substation's rail-to-earth voltage relay (ANSI 64V), which in turn caused transfer tripping of adjacent substations and circuit breaker "lock-outs. The cascading of many substations ultimately resulted in system wide service interruptions, with many substations out of service for several hours or more while the substations were re-set manually.

Tri-Met reacted quickly to identify the cause of the problem - removal of lightning arresters on the signal system connected between the rail and earth allowed the 64V relay to "see" ground faults on the electric utility's 60 Hz distribution and transmission system for the first time. Tri-Met then re-engineered the 64V relay and transfer trip scheme, and put a permanent fix into place. As a result of these improvements, nuisance tripping of the 64V relay has been eliminated, and service continuity maintained without compromising public safety. Furthermore, technical specifications for future Traction Power Substation procurements have been improved to include more specific requirements for the 64V relay.

New Radar System for Train Tracking and Control

Takuya Ishikawa, East Japan Railway Company, and Howard Zebker, Stanford University

This paper presents a design for a new train control system, which we call the Radar System for Train Tracking and Control (RSTTC). The RSTTC is based on the Communication-Based Train Control (CBTC) system, and uses radar technology with a spread-spectrum scheme. The main advantages to using the CBTC system are that it allows (1) the headway between trains to be adjustable and (2) the train traffic to be flexible. Radar is employed to identify both train position and the speed necessary for train control. The spread-spectrum technique helps prevent the system from being disturbed by noise and interference on the communication channel. A combination of Code-Division Multiple Access (CDMA) and Time-Division Multiple Access (TDMA) is used for tracking and controlling multiple trains.

The RSTTC employs a direct-sequence spread-spectrum radar system using pseudorandom code waveforms for train detection. Moreover, the base stations installed at constant intervals along train tracks have highly-directional circular dish antennas; the use of the circular dish antennas mitigates the multipath effect.

Next we analyze radar wave propagation and radar detection for this project. Free-space propagation of the large-scale path component alone is a sufficient model for the RSTTC, because the circular dish antennas are sufficiently directive to reject the multipath. The system is designed with an appropriate signal-to-noise ratio (SNR) so that the probability of detection can be high for any reasonable probability of false alarm.

For train tracking, the RSTTC uses CDMA-TDMA to manage multiple detection for many trains. We discuss some methods of measuring multiple trains simultaneously. Furthermore, to describe train-interval control, we introduce some train-motion models and the concept of a safe speed curve. Finally, we design a set of system specifications for the new RSTTC and select appropriate parameters for identifying trains located within 1,000 meters of the base stations.

Computer Modeling Techniques and Analysis Used in Design of Tunnel Ventilation Fan Plants for the New York City Subway

Don Willemann, J. Greg Sanchez, MTA-New York City Transit

At the heart of the city, the largest subway network in the world concerns itself with safety for its riders. Among some of the issues is tunnel fire life safety. To this extent, New York City Transit (NYCT) is engaged in a multi-million capital program plan to bring the system to a level of safety in accordance with national standards by upgrading tunnel

ventilation capabilities. This includes rehabilitation of existing and/or building of new emergency ventilation plants.

One of the greatest challenges is the difficulty in obtaining underground space in an environment congested with literally dozens of existing underground utilities. Because of the spatial constraints, NYCT must optimize fan plant design by identifying the most appropriate ventilation modes, the lowest fan airflow capacity and the total pressure required for the fans to perform their function. In some instances, tunnel wall side pressures are a consideration in the overall design for system stresses; on some projects, over a mile of track closures are required.

The optimization of the design is performed through the aide of computational analysis modeling and analysis. Numerical analysis plays a key role. Operational and incident scenarios need to be postulated, performance must be predicted, alternatives need to be developed and evaluated.

This paper will discuss some of the computational modeling techniques and analysis carried out to design a tunnel ventilation fan plant for the New York City Subway in order to improve the safety level in the system. The decision making process will also be discussed. Illustrations showing results and analysis outcomes will be presented graphically and pictorially.

On-Board Electrically Peaking Drive Train for Diesel or Electric Railway Vehicles

Sébastien E. Gay-Desharnais, Mark Ehsani, Texas A&M University, Ned Snead, Bill Harris, Snead Institute, Dock Burke, and Sadler Bridges, Texas Transportation Institute

Today's railway vehicles are powered by conventional drive trains: a single energy source supplies both the average and peaking powers. This results in a non-optimal delivery of traction power to the wheels.

In the case of diesel-electric locomotives, the engine-generator directly supplies its output to the traction motors. This results in a large and non-optimal engine rating. In addition, the drive train cannot recuperate the kinetic energy of the train by regenerative braking.

Electric trains draw their traction power from an overhead line. This principle allows the use of regenerative braking, where the energy is sent back to the grid through the overhead line. However, the drive train rating is still non-optimal and the overhead line is not optimally used.

We propose to apply the hybrid drive train concept as the solution to these problems. The hybrid drive train uses the energy source (overhead lines or diesel engine) for base loading (aerodynamic drag and frictions) and on-board batteries to supply the acceleration power and absorb the train kinetic energy during regenerative braking. This drive train results in a minimum energy source rating and in a levelled power profile. This last argument is particularly valid for low-voltage, high-occupancy catenaries where the traffic is limited because of the high current density.

This paper analyses the fundamental characteristics of on-board peaking hybrid drive trains for both diesel-electric and electric railway vehicles. The replacement of the diesel engine by a fuel cell is also presented as a new concept permitted by the hybridization. The advantages of hybridization are discussed and suggestions for further work are presented.

Managing the Effects of Weather on the Rail Network

Dr John E. Thornes, Univresity of Birmingham and Dr Brian W Davis, Vaisala Ltd

Weather impacts on the railways and causes expensive delays and penalties in a variety of ways:

- ✦Hot, cold and fluctuating air/track temperatures
- ✦Snow and Ice
- ✦High Winds
- ✦Heavy Rain
- ✦Thunderstorms
- ✦Fog

It is likely that between 10% and 20% of delays to railways are weather related and that in the winter months up to 50% of delays are weather related. Despite these high percentages very little research has been undertaken to mitigate these effects.

This paper both examines how technology proven in the Highways Sector is now being used in the rail industry, along with discussing some future innovations for the Rail Sector.

The key to better management of the railways in adverse weather is through accurate monitoring, coupled with application & site specific weather forecasting. However, as there are only a handful of automatic weather stations linked to the track, there is little weather data to initialize forecast models and no feedback on the success of the forecasts.

Systems have recently been installed in the UK to both monitor, alarm and forecast adverse rail weather conditions. For example, when High Wind Gusts exceed pre-determined thresholds train speeds can now be reduced in only those areas affected. In addition, a unique non-contact sensor and weather forecast model has been developed by Vaisala Ltd to allow measurement and advance forecasting of the risk of ice/frost on the overhead contact wire and track. These developments and systems will be discussed.

The thermal mapping of highways (using a vehicle mounted infrared thermometer) was invented at the University of Birmingham and this technology transferred to Vaisala Ltd in the 1980's. The potential to apply this novel technology to the rail sector will be discussed, as only one of the potential innovations being considered to help Railway Companies and Train Operators manage the effects of adverse weather more effectively.

Automatic Fault Location and Isolation on 2x25kV AC Traction System

Krishna K. Agarwal, P.E. and Tom Carney

Efficient and punctual train operation on the electrified railroads requires uninterrupted availability of power supply to the trains. This, in turn, necessitates quick isolation of faulted sections of overhead contact system. Some railroads install automatic fault location and isolation system. Principles of the scheme implemented on recently electrified corridor of Amtrak are presented.

Amtrak operating rules require that the power supply be restored within 90 seconds of a circuit breaker tripping after which emergency plates (restrictions on the signals) are activated. Faults on the overhead contact system (OCS) are detected by the protective relays installed at the traction substations, which open the track supply circuit breakers. The breakers are equipped with automatic reclosing feature with an adjustable time delay. Since most OCS faults are transitory, the supply breakers generally hold on the first reclosure. However, in the event of a permanent fault, the breaker of the faulty track trips again. It is then necessary to detect the faulty elementary electrical section, isolate it, and to energize the remaining section of the OCS with minimal time delay. This is achieved, without any operator intervention, via Automatic Fault Location and Isolation Scheme (FL&I) installed at the traction substations and SCADA.

The FL&I scheme utilizes the protective relays to determine the type and impedance of the fault, and a Programmable Logic Controller (PLC) to determine the distance and

the elementary section with the fault. The isolation of the faulty section is achieved with the help of SCADA system.

Solution of DC power flow for non-grounded traction systems using chain-rule reduction of ladder circuit Jacobian matrices

Bih-Yuan Ku and Jen-Sen Liu

In this paper we present a novel DC power flow solution technique for ungrounded traction systems. The power networks of non-grounded DC traction systems like diode grounded systems or ungrounded systems are generically ladder-like circuits. Our approach employs chain rule to formulate the Jacobian matrix of each ladder section as the product of a sequence of small Jacobian matrices, making it efficient and simple for either manual or computer calculation.

Traditionally DC power flow of traction systems are based on grounded load model. That is, like AC power system, each train is modeled as a load with power feeding from either the overhead catenary or the third rail to ground. This model was appropriate for grounded DC traction systems in early days. As the trend migrating to non-grounded systems, the negative return path is better described as a sequence of nodes and impedance among them, similar to the positive path. Together the circuit is of ladder-like configuration and can be solved using nodel circuit analysis and other computational algorithms.

Numerical methods such as Newton-Raphson method are usually applied to implement DC power flow solution techniques. The dimension of the Jacobian matrices for Newton-Raphson methods grows with the complexity of the network, namely, the total number of nodes in the network. Our approach first solves each ladder circuit between two adjacent traction substations (TSS) in the inner loop using chain rule to convert the Jacobian matrix into the product of a sequence of small Jacobian matrices. This can reduce the computational complexity dramatically as matrix inversion is involved. Then power flow into all ladder circuits and output of each TSS are calculated in the outer loop. Again, only small Jacobian matrices are needed in computation. Finally, iterative procedures are repeated to obtain the complete DC power solution without large-scale matrix manipulations.

We apply our method to a section of the planned extension of the Orange Line of Taipei Rapid Transit System. The results show that both the inner and outer loops converge in a few iterations. Moreover, by decoupling power flow computation of each ladder circuit with the whole network we can make it easier to combine it with train performance simulation to obtain more accurate transit system simulation.

Continuous Track Monitoring from Locomotives for Track Safety

D Magnus, KLD Labs, Inc.

The task of railroad track inspection typically relies on either track geometry cars or visual inspection. These methods are accepted standards within the industry but are limited on the frequency of measure due to economic constraints and track time. However, new technology has been developed to allow continuous monitoring of the track condition from the locomotive to allow the immediate detection of track exceptions under loaded conditions.

The paper discusses the development of a laser-based measurement system to measure the track condition continuously at track speeds. This system is designed to be installed under a locomotive and perform real-time evaluation of key track parameters and remotely transmit this information directly to maintenance personnel.

The development of this system is a direct result of over 20 years of research and development of KLD's Optical Rail Inspection and ANalysis (ORIAN) system. The ORIAN system is laser-based rail measurement system that measures key rail parameters from a moving railway vehicle in real-time.

A New Twist on an Old Technology: Underground Movies Benefit Public Transportation

John Butziger, P.E., and Gaspar Messina

Submedia LLC has developed an elegantly simple, cutting edge technology which shows advertising movies and public service messages to subway riders travelling between stations. Revenues generated from advertisers are shared with transit authorities, which in turn help to offset operating losses, defray the need for fare increases and benefit the riders.

The new technology takes advantage of an unused resource: the dark tunnel walls. Riders enjoy the movies because they are entertaining without obstructing pleasing landscape views. Transit authorities enjoy a significant new revenue stream and the appreciation of the riders.

Submedia's technology takes advantage of a 200-year old technology called the zoetrope, which was the world's first motion picture machine. Based on the same principles as a pin hole camera, the zoetrope was a cylinder with verticle slits cut into the top and images inside. When the viewer spun the cylinder, the images would appear to move.

With Submedia's technology, the moving transit rider provides the motion while the images and slits are fixed to the tunnel walls. Riders on every train see a movie right outside the window. The length of the movie is limited only by the length of the tunnel wall.

Coca Cola is advertising in Submedia displays already installed in Atlanta's MARTA system and Philadelphia's PATCO system. Target will be advertising in future displays which are being installed in New York City's PATH system. Many other blue-chip advertisers are interested in Submedia displays. Submedia is based in New York City, and is currently negotiating contracts with transit authorities around the world.

Transit systems with increased revenue from such opportunities can not only attract more federal funding, but also experience increased ridership due to improved infrastructure, better vehicles and better-funded management. This, in turn, leads to less automobile useage, less pollution and reduced transportation spending per mile traveled.

9 October 2001 VTS Board of Governors Meeting Report

The VTS Board of Governors' Meeting was held at VTC 2001-Fall in Atlantic City. Attendees included Charles Backof, Treasurer, Dennis Bodson, Executive Vice President, J.R. Cruz, President, Mark Ehsani, Chair of the Electric and Hybrid Electric Vehicle Committee, Bob French, ITS Council Coordinator, John Gilsenan, Harvey Glickenstein, Vice President-Land Transportation, Charles Hickman, Technical Program Chair, VTC2002-Spring, James Irvine Newsletter Editor, Preston Jackson Chair, VTC2002-Spring, Kent Johnson, Past VTS President, Jae Hong Lee Chair, VTC2003-Spring, Joe Long Facilities, VTC2002-Spring, John Kingham Chair VTS/LTD, Melvin Lewis, Conference Coordinator, Tad Matsumoto Secretary, VTC2000-Spring, George McClure, LRP, Sam McConoughey, Reuven Meidan, Chair, VTC2001-Spring, Eric Schimmel, Vice President-Mobile Radio, Raymond Trott, Chair, Awards Committees, Charles Wood, Treasurer, VTC2002-Spring, and Jim Worsham, Past Conferences.

Treasurer's Report: Charles Backof reported that while the financial position of the Society was strong, there were many developments at IEEE level and the situation was extremely fluid. The IEEE societies had to contribute to cover deficits made by the IEEE centrally, and at the current level, the VTS would run out of reserves in six years. However, the current IEEE model is unsustainable, because in fact the VTS would be one of the last to go bust; some societies would not be able to repeat the current contributions for even one more year. The society budget for 2002 is therefore for a standstill; no cutbacks are required but there are no new initiatives either. Society president J R Cruz noted that we can't assume a steady state model. September 11 will impact on conference attendance, and the economic cycle may affect retention rate and membership.

Charles Backof also reported that there would be no **Dan Noble Fellowship Award** since there had been no applicants.

Art Greenberg reported on **VTC2001-Fall**. Income was $229,000, against an estimated worst-case expenditure of $251,000, but that included the maximum no occupancy penalty from the conference hotel. 613 people had preregistered, with 92 withdrawing prior to the conference. Of the remainder, 389 had arrived by that point (the start of the second full day), with a further 15 on-site registrations. The board expressed its thanks to Art for his work under very difficult circumstances, which include a strike in the conference centre itself.

There was a discussion of **Technical Interest Profiles (TIP)** codes. The Technical Activities Board (TAB) is reviewing these codes, and proposing to drop those codes with less than 5% of interest from society members, as some terms were outdated and could be rephrased. The land transportation code is currently chosen by 4.87% of members, although a disproportionate number choose this as their first preference. The President and Vice Presidents will draft a new list for agreement.

Publication Review: The TAB Publications Review had noted that while the Society has three areas of interest, one of these, mobile, dominated the transactions. There are good reasons for this, given that in one year, there were no papers at all submitted in one area. However, TAB Publications Committee had required the society to submit a plan to show how papers in the other areas will be encouraged. This plan had been submitted, and in a slightly amended form was recommended to be accepted, but with a yearly review.

There was also some discussion of the Society's name. There is an argument that what makes VTS distinctive is mobility, so a name involving 'mobile' might be acceptable. However, any name change is unlikely to get through TAB in the current environment, and may open discussion on the scope of the society more generally. Charles Backof noted that GE and IBM were well known brands in their own right, without the companies concerned worrying too much about what the letters stood for. 'VTS' is a brand, and it would be sensible to keep that. This was agreed.

Conferences. It had been previously been agreed at the May board meeting to have one board member on the committee of each future VTC to assist with liaison. J R Cruz had consulted other societies who have conferences of a comparable size of the case a, and such conferences are usually not run by volunteers but by conference management companies, with a separate Technical Programme Committee. There was an extensive discussion as to whether this is a pattern that the VTS should follow. A number of past and future conference chairs were present, with a wide variety of views which generally amounted to the fact that good conference management companies were well worth the money they cost, but that poor conference management companies actually created more work. Mel Lewis pointed out that Sections currently receive a proportion of the surplus for organising VTC, and this benefit would be lost; in effect, money that currently goes to sections would go to conference organisers. There is also the middle road of making more use of IEEE Conference Services. It was agreed to look further into the possibilities and the services these companies could offer.

Jens Zander made a presentation proposing Stockholm as a host for **VTC2005-Spring**. Sweden has an international reputation in the mobile communication community, but also has sizable research in the automotive field. He circulated a folder with expressions of support from local industry and government, and expected high local participation. After some discussion, it was agreed to accept the proposal.

Preston Jackson reported on **VTC2002-Spring**. Over 600 abstracts had been submitted. They propose a difference in the student price between IEEE members and non-members; IEEE student members will pay $75 compared to $100 for non-members.

Jae Hong Lee gave a presentation on **VTC2003-Spring**. This had been proposed for Seoul, but the conference committee proposed moving the venue to Jeju, since visa-free entry was easier and the costs are lower. Jeju is on Cheju Island with good air links to Seoul and other south Asian capitals. The venue change was agreed.

Vijay Barghava reported on **VTC2002-Fall** in Vancouver. The student rate will be higher – $150 dollars for IEEE students and $175 dollars for other students, but students will also be included in the meals, to give an more inclusive conference.

Past conferences: JRC1999 and JRC2000 were closed out without a surplus or deficit. There is nothing further to report on VTC1999-Spring, and further methods to pursue this will be undertaken. The seed money for JRC2001 has now been returned to the IEEE.

Board of Governors Elections: Kent Johnson reported that Charles Backof, Dennis Bodson, Tad Matsumoto, Sam McConoughey and Eric Schimmel had been elected to the Board of Governors for the term 2002 to 2004. Mel Lewis is an appointed member of the board and will remain in this position. Past presidents remain appointed members of the

Board for three years, so Kent Johnson will also stay on the Board. Vice presidents are limited to four consecutive one-year terms, so Harvey Glickenstein was not eligible for re-election. John Kingham was elected in his place as VP Land Transportation. Other office bearers were re-elected to their existing positions.

Mark Ehsani reported on the **Electric Vehicles Committee**. This has been formed with an initial membership and is growing. Invited sessions have been arranged at VTC in Atlantic City. He proposed a change in the name of the committee to the Vehicle Power & Propulsion Committee or the Vehicle Electronics, Power and Propulsion Committee. This will be decided by e-mail. Mark Ehsani is also taking over chairmanship of the **Convergence Fellowship Committee**.

Bob French reported on **ITS**. There had been a request from the ITS Council for support in justifying the updating of the ITS video. The two representatives from each society to the ITS Council have staggered terms. Bob Barrett's term expires this year, and it was agreed to reappoint him for two years.

On **chapters**, prospective sites for new chapters are being identified.

James Irvine reported on the **VTS News**. A new banner had to be redesigned at short notice for the August issue, as US postal regulations required the full title in the banner, rather than has had been thought in the top half of the page.

Harvey Glickenstein noted that the agreement with the ASME over the **Joint Rail Conference** requires two years notice to revise, so the unilateral change with regard to modifying sponsorship to technical sponsorship agreed at the last meeting is not possible. He proposed a working group of John Kingham, Charles Backof and Dennis Bodson to look at the revision of the JRC agreement in order to retain technical sponsorship, but devolve ourselves of financial responsibilities. This was agreed.

Dennis Bodson updated the board on progress on the reprint of the **Land Mobile Radio Handbook**. This is getting bogged down in the IEEE system. There are two ways of proceeding, either to print copies in the normal manner, or to use print on demand. He will get costing information on these options. He will also be asking Propagation Committee to review the existing text and suggest suitable papers for the update.

VTS Awards

Ray Trott, Awards Chairman

Awards Luncheons were held on Tuesday, May 8, 2001, at the Spring VTC01 in Rhodes, Greece and on Tuesday, October 9, 2001 at the Fall, 2001 VTC in Atlantic City, NJ.

The VTS recognizes those who contribute to & support VTS in an exceptionally worthy manner. There are several awards and fellowships that VTS considers in expressing its appreciation to members of the Society. Although all of these awards are considered, not all are awarded annually. These awards also have differing prizes: Plaques, Certificates and/or money.

At the Rhodes, Greece VTC luncheon, the following awards were presented:

Chapter of the Year Award – This award is presented to recognize the outstanding Chapter of the Vehicular Technology Society. To be eligible, a Chapter must submit to IEEE Headquarters the meeting attendance report form, L-31. The award is a plaque.

The 2000 winner was for an unprecedented fourth year in a row, the **Tokyo VTS Chapter**. The award was presented to the 2000 Tokyo VTS Chapter Secretary, Hirohito Suda.

Outstanding Service Awards – These awards are given to members to recognize outstanding service to the Society. Prizes for these awards were plaques and stipends of $250 each.

Kent Johnson – For outstanding long-term service and leadership to the Society as a Past President and Treasurer.

Melvin A. Lewis – For outstanding long-term service and leadership to the Society as Conference Coordinator.

Tadashi Matsumoto – For meritorious service to the Society and to the Board of Governors.

2000 Neal Shepherd Memorial Best Propagation Paper Award – This is to recognize the best paper relating to Propagation published in the *Transactions on Vehicular Technology*.

The award was presented to **Homayoun Nikookar & Homayoun Hashemi**, *"Phase Modeling of Indoor Radio Propagation Channels", March, 2000 Transactions on Ve hicular* Technology. The prize was a certificate and $250 for each of the authors.

The following were presented at VTC2001-Fall in Atlantic City:

VTS 2000 Best Automotive Electronics Paper Award – This is to recognize the best paper relating to Automotive Electronics published in the *Transactions on Vehicular Technology*.

The award was presented, in absentia, to **Luigi Giubbolini**, for *"A Multistatic Microwave Sensor for Short Range Anticollision Warning"*, published in the November, 2000 VT Transactions. The prize is a certificate and $500 for Dr. Giubbolini.

2000 Jack Neubauer Memorial Best System Paper Award – This is to recognize the best paper relating to Sys-

tems Engineering published in the *Transactions on Vehicular Technology*.

The award was presented to **Henry L. Bertoni & Dongsoo Har**, "*Effect of Anisotropic Propagation Modeling on Microcellular System Design*", July, 2000 VTS Transactions. The prize is a certificate and $250 for each of the authors.

Stuart Meyer Memorial Award – This is an award that recognize those members of the Vehicular Technology Society who have both served their Society and also have contributed to the development of radio technology and science in an outstanding and exemplary manner. The prize is a plaque and a stipend of $2,500.

This award was presented to **William C. Y. Lee**, LinkAir Communications, Inc., Santa Clara, CA.

James R. Evans Avant Garde Award – This is an award to recognize leadership and other contributions in promoting new technology in the fields of Vehicular / Wireless Communications, Vehicular Electronics and Land Transportation. The prize is a desk top award and a stipend of $250.

The award was presented to **Dr. Mehrdad ("Mark") Ehsani**, Texas A&M, for his contributions to the theory of Hybrid Electric Vehicles.

Special Service Award – For outstanding performance in the planning and execution of the Fall 2000 VTC, September 25 - 28, 2000, Boston, MA. The award was presented to Stuart Lipoff, Fall 2000 VTC Chairman.

VTS Awards, Mark Ehsani and the new James R. Evans Avant Garde award (top left), Tad Matsumoto with Mel Lewis (top), Ray Trott, William Lee, Henry Bertoni and Dongsoo Har (top right; clockwise from top left), Toyko VTS Chapter Chair Hirohito Suda (bottom right), VTC2000-Fall Chairman Stu Lipoff (bottom), Neal Shepherd awardee Homayoun Nikookar (bottom left), Kent Johnson (center left) and Mel Lewis (center right).

ASME/IEEE JOINT RAIL CONFERENCE

APRIL 23rd, 24th, and 25th, 2002

ADVANCE REGISTRATION

RETURN COMPLETED FORM TO:

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Status:

☐	IEEE Member	☐	ASME Member
☐	Non Member	☐	Session Chairman / Author
Membership Number			

Payment by check or money order (U.S. currency) made payable to **"2002 ASME/IEEE Joint Rail Conference"**. Also, VISA, MasterCard and American Express accepted.

Advance registration must be received by April 15th, 2002.

Credit Card Type and Number: _____

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Expiration Date: _____

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Conference fees include Proceedings and Luncheons. All prices listed below are in American Dollars.

Members: *	Full Conference	$275	$_____
	Single Day	$160	$_____
Non Members:	Full Conference	$385	$_____
	Single Day	$250	$_____
Students/ Retirees:	Full Conference	$55	$_____
	Single Day	$30	$_____
Additional Luncheon tickets: * **		$40	$_____
Additional copy of Proceedings: * **		$30	$_____
ON-SITE REGISTRATION CHARGE:		$35	$_____
TOTAL			$_____

TECHNICAL TOUR	YES	NO

* Member fee applies to Session Chairman and Authors.

** Non-members who pay full Conference rate will be eligible for one year free Membership in the IEEE or ASME (as applicable) if they fill out the application form.

*** Additional Luncheon Tickets and Proceedings will be available at the Registration Desk.

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ASME/IEEE JOINT RAIL CONFERENCE

APRIL 23rd, 24th, and 25th, 2002

HOTEL RESERVATION

MAIL OR FAX RESERVATIONS TO:

Washington Plaza
10 Thomas Circle, N.W.
Washington, DC 20005
Telephone: (202) 842-1300 or (800) 424-1140
Fax: (202) 371-9602

Please communicate directly with the Washington Plaza using this form or by phone. When you make your reservations by telephone ask for the Reservations Desk and identify with the **2002 ASME/IEEE Joint Rail Conference** to obtain the special room rate.

Room Rate is $119.00 Single night plus 14.5% tax.
Please circle accommodation required.
Single Double Smoking Non-smoking

Arrival Day/Date: _____
Departure Day/Date: _____

Name: _____

Last First Initial

Address: _____

_____

City State Zip Code

Company: _____

Telephone: ( ) ---

Reservations must be received no later than **March 29th, 2002**. After this date, rooms will be reserved on a space available basis. All major credit cards accepted. Suggested check-in time is after 3:00 p.m. Checkout is 12:00 noon. For arrival after 3:00 p.m., a reservation guarantee by a major credit card is required.

Credit Card Type and Number: _____

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TRANSPORTATION

The Airport Super Shuttle operates a round-the-clock Shuttle from BWI, Washington Reagan, and Washington Dulles Airports. See www.supershuttle.com, or call 1-800-258-3826.

LOCATION

The Hotel is located in the heart of Washington, DC's business district at the intersection of Vermont and Massachusetts Avenues and 14th and M Streets, N.W. It is a five minute walk to the White House, the Convention Center, and Metro Lines.

TECHNICAL TOUR

A technical tour is planned for the afternoon of Tuesday, April 23. Final details will appear in the advance program.

PROGRAM

An advance program will be mailed to members approximately February 2002.

Conferences of Interest

The following table shows VT-06 sponsored and co-sponsored conferences as well as related conferences not sponsored by the Society. While every attempt was made to ensure accuracy, you should contact the respective conference committee to confirm date and location.

DATE	CONFERENCE	LOCATION	WEB PAGE	
26-28 February 2002	European Wireless 2002	Florence, Italy	http://www.ing.unipi.it/ew2002	
17-21 March	WCNC2002	Orlando, FL	http://www.wcnc.org/2002/	
19-21 March 2002	11th Int. Conf. On Road Trans. Information and Control	London, UK	http://conferences.iee.org/RTIC	
4-6 April 2002	ISART2002	Boulder, CO	http://www.its.bldrdoc.gov/isart/	
23-25 April 2002	JRC2002	Washington, DC	See page 40	
28 April – 2 May 2002	ICC2002	New York, NY	http://www.icc2002.com	
6-10 May 2002	VTC 2002-Spring	Birmingham, AL	http://www.ewh.ieee.org/soc/vtc02spring/	
6-8 May 2002	3G2002	London, UK	http://conferences.iee.org/3G2002	
15-17 May 2002	Wireless Design	London, UK	http://www.wirelessdesignconf.com	
28-31 May 2002	3G Wireless 2002	San Francisco, CA	http://delson.org/3gwireless02/	
16-21 June 2002	APS International Symposium / URSI Radio Science Meeting	San Antonio, TX	http://www.ieeeaps.org/2002APSURSI/	
16-21 June 2002	IST Mobile Summit	Thessaloniki, Greece	http://www.iti.gr/summit2002	✓
18-20 June 2002	IV'02 Intelligent Vehicles Symposium	Versailles, France	http://www.ewh.ieee.org/tc/its/conf.html	
14-19 July 2002	SPECTS'2002	San Diego, CA	http://scs.org/confernc/spects02 /spects2002cfp-gen.html	
2-5 September 2002	ISSSTA 2002	Prague, Czech Republic	http://www.ure.cas.cz/isssta2002	
3-6 September 2002	ITSC '02	Singapore	http://www.ewh.ieee.org/tc/its/conf.html	
15-18 September 2002	PIMRC 2002	Lisbon, Portugal	http://www.pimrc2002.org	✓
23-27 September 2002	European Microwave Week	Milan, Italy	http://www.eumw.com/	✓
24-29 September 2002	VTC 2002-Fall	Vancouver, BC	http://www.fallvtc2002.org	✓
21-23 October 2002	Convergence 2002	Detroit, MI	http://www.convergence2002.org	✓
27-30 October 2002	WPMC '02	Honolulu, Hawaii	http://www.wpmc02.gatech.edu/	✓
17-21 November 2002	Globecom 2002	Taipei, Taiwan	http://www.globecom2002.com	✓
24-26 March 2003	Int. Symp. On Wireless Systems and Networks (ISWSN'03)	Dhahran, Saudi Arabia	http://www.kfupm.edu.sa/ee/ ISWNWeb/first_call.htm	✓
21-24 April 2003	VTC 2003-Spring	Jeju, Korea	mailto:jhlee@gong.snu.ac.kr	✓
23-25 April 2003	EMPCC2003	Glasgow, Scotland	http://www.epmcc.com	✓
11-15 May 2003	ICC2003	Anchorage, AK		
Fall 2003	VTC 2003-Fall	Lake Buena Vista, FL	mailto:mguizani@cs.uwf.edu	
Spring 2004	VTC 2004-Spring	Genoa, Italy	mailto:vatalaro@ing.uniroma2.it	

Conferences marked '✓' have open calls for papers as of 14 February 2002. This list is based upon the conference calendar at our web site, which is updated more frequently than this list can be. To access it go to the following URL: http://www.vtsociety.org/, then click on "Conference List" in the left frame.

Corrections and additions to this list are most welcome. We are particularly interested in adding listings for Automotive and Transportation conferences. Please send corrections and additions to Tom Rubinstein at t.rubinstein@ieee.org.