IEEE
VEHICULAR TECHNOLOGY SOCIETY
NEWSLETTER

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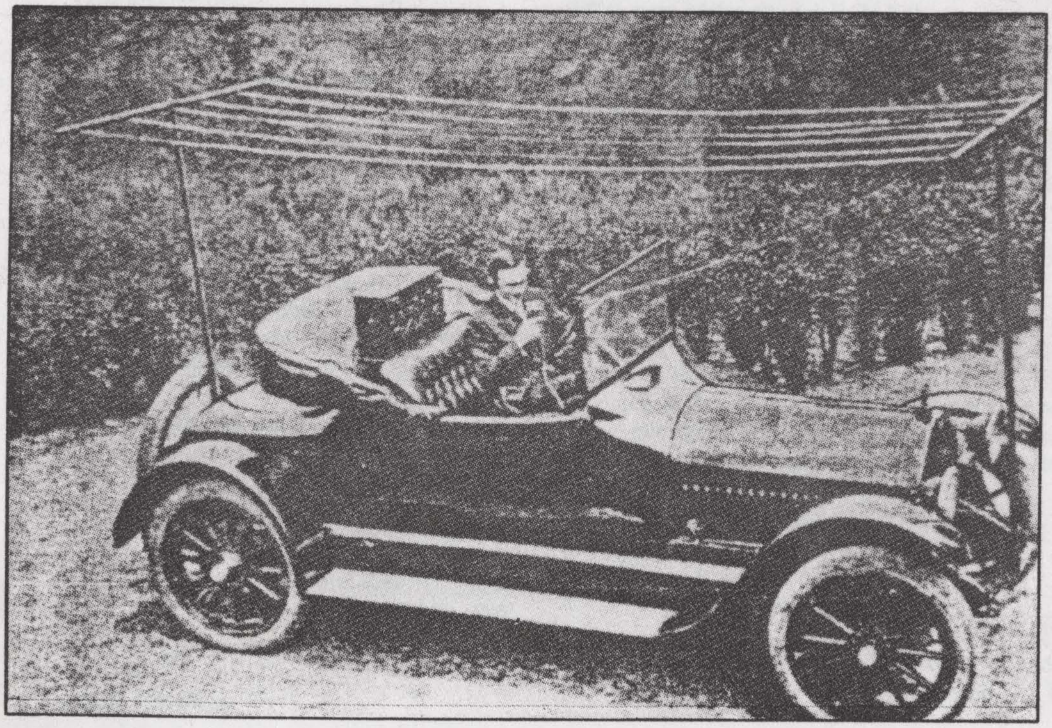
Going Mobile: The Long Road



From Clothesline Antenna to . . .

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President's Message

Stuart Meyer
President
IEEE Vehicular Technology Society

We need your help! I have committed myself to increase the activity of our Chapters. In a number of instances, Chapter Secretaries are not sending in the annual reports, which are necessary to give proper credits, obtain meeting notice mailing reimbursements as well as a number of other items. In a few instances, Chapters have become inactive and we are not always able to locate the person or persons to help us reactivate these units. Furthermore, we need these reports in order to make the proper Chapter of the year awards.

Please drop a line to Gaspar Messina or myself with any information that you may have about your Chapter. Please prod your local Chapter Officers to make sure that the correct reporting is being done. If additional information is needed, feel free to contact our Chapter Activities Chairman, or myself and we will see that you or the appropriate person is supplied with the necessary information.

Recently, Gaspar has been sending out letters to all Chapter Officers (of record) encouraging them to contact us relative to yours truly meeting with your group. Often, it is possible to work something out (with sufficient lead time) in conjunction with a major event around the country. Additionally, your Chapter may be able to schedule a meeting to coincide with a major event.

Please do get in touch.

Most Sincerely,

Stuart Meyer
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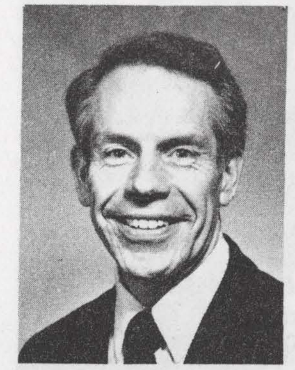
Editor's Notes



A. Kent Johnson
Newsletter Editor

As the November issue of the VTS newsletter goes to press, the time is once again approaching when the IEEE is looking for Fellow nominations from among its' ranks. We are always anxious to see qualified members of VTS receive this honor. We urge any of you who know of a qualified VTS member who has not yet been nominated to receive the rank of Fellow to submit such a nomination. The new IEEE Fellow nomination kits are available and will be furnished upon request from:

Staff Secretary, IEEE Fellow Committee
345 East 47th Street
New York, NY 10017
Telephone (212) 705-7750

If you need help in this nomination process, our VTS Fellow Awards Chairman is:

R.A. Isberg
1215 Henry Street
Berkeley, CA 94709

and he has offered to provide such assistance. A reminder that only Senior Members are eligible to be nominated for Fellow rank and we are aware that many out there are eligible to be Senior Members and Mr. Isberg can provide assistance and necessary forms for that process also.

Month of Issue	Final Copy to be Rec'd By VTS Editor	Target Mailing Date
February	12-30-87	1-27-88
May	3-10-88	4-14-88
August	6-09-88	7-13-88
November	9-13-88	10-15-88

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AWARDS FOR DEVELOPMENT OF CELLULAR TECHNOLOGY PRESENTED BY IEEE

Three pioneers in cellular radio technology were awarded Alexander Graham Bell Medals by The Institute of Electrical and Electronics Engineers, Inc. (IEEE) in recognition of their fundamental contributions to the development of mobile communications systems.

The three, Joel S. Engel, Richard H. Frenkiel and William C. Jakes, Jr., were members of the technical staff at AT&T Bell Laboratories when they did the work for which they are being honored. Engel is now Vice President of Research and Development at MCI Communications; Frendiel is Head of Cordless Telephone Development at AT&T Consumer Products Laboratory; and Jakes recently retired as Director of the Transmission Terminals and Radio Laboratory at AT&T Bell Laboratories.

The awards were made at the IEEE Medals Presentation in Los Angeles, California on June 20 at the Los Angeles Hyatt Regency Hotel.

Cellular radio systems have greatly expanded the number of channels available for mobile systems and significantly improved transmission quality. In a cellular system, a geographical area is divided into a honeycomb of hexagonal cells each served by a relatively low-power transceiver (combination transmitter and receiver). Ordinary voice and data telephone lines connect cells to mobile switching offices which set up connections between mobile phones and local telephone offices. Many more customers are served because the same channel can be assigned to different cells and used for many conversations simultaneously.

Today cellular radio enjoys a highly competitive, steadily growing market. Engel is committed to the technology not only as a developer, but as a user: "I am deeply honored to receive such a prestigious award, the Alexander Graham Bell Medal, "Engel said. "It is gratifying to see the ever increasing number of automobiles equipped with cellular telephone and to enjoy personally the benefits of this technology."

Cellular systems was a major development involving very large numbers of engineers and scientists. Frendiel acknowledged the effort required, saying "It is a thrill to be recognized for contributions to this important technology. Hundreds of bright, talented people contributed to the development of cellular mobile communications and I feel I am representing all of them in receiving this award."

The Alexander Graham Bell Medal was established in 1976. It is awarded annually to an individual or group of individuals for exceptional contributions to the advancement of communication sciences and engineering.

Among the past recipients is Charles Kuen Kao of ITT. Kao was awarded the 1985 Bell Medal for his pioneering contributions to optical fiber communications.

DETROIT MILESTONE CEREMONIES

On May 8, 1987 the Detroit Police Department was honored by the IEEE for the implementation of the first one-way radio communications. The ceremony was held at 7:00 p.m. at the Harbormaster Station House, located on Belle Isle on the Detroit River.

Dr. James A. Holte, the IEEE Midwest Region Director and representative of the IEEE Board of Directors presented the commemorative plaque that will be displayed at the Harbormaster Station House which was the site of the original radio station.

Retired Detroit Police Department Inspector, Walter Williams spoke on the development of the radio system and some of the technical problems encountered. Original radio equipment and microphones were on display.

In April 1928, the first successful one-way radio link was used as a link between police headquarters and the police cars. The utilization of the one-way radio system made it possible for the news of crimes in progress to be communicated from the station house to police cars patrolling the streets.

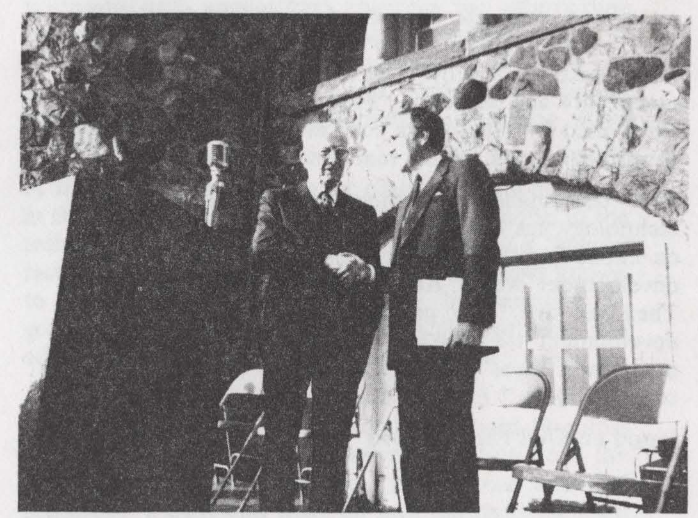
Chief of Police William C. Hart accepted the IEEE milestone award on behalf of the Detroit Police. Lieutenant Russell Robinson was also recognized with a certificate of appreciation from the IEEE Vehicular Technology Society for his efforts in organizing the awards ceremony. The certificate was presented by Evan B. Richards - IEEE Vehicular Technology Society Board of Governors.

A banquet was held prior to the award ceremonies and was attended by many of the people involved with the original experiments and developments.

Evan B. Richards
IEEE VTS
National Conference Chairman

Walt Williams, William Hart, and Evan Richards

Russell Robinson and Evan Richards



Walt Williams and Evan Richards

FROM CLOTHESLINE TO CHICKEN WIRE: AUTO ANTENNAS OF YESTERYEAR

For early motorists, the biggest problem about having a car radio wasn't finding a place to install the radio--it was finding a place to put the antenna. In the pioneering days of broadcasting, even an AM home radio needed over 100 feet of antenna wire to get good reception, and the challenge of stringing this much wire on an automobile was met in some very unusual ways.

Clem W. Rowan and Carlos A. Altgelt, both of the Ford Motor Company, have traced the early history of the auto antenna from 1937 back to its very first installation. They presented their findings to the Society of Automotive Engineers during a session of the 1987 SAE International Congress and Exposition. According to the authors, car radio antennas had a "bizarre and somewhat haphazard development through the first forty years of auto production. Every possible antenna scheme common to home radio in that early era was utilized in one way or another on motor cars."

The first known mobile antenna, developed in 1897 by Guglielmo Marconi, was mounted on the roof and resembled a wire smokestack. However, being nearly four times as tall as Mr. Marconi himself, the design was not very practical for highway travel. It was soon replaced by the "clothesline" antenna, so named because it looked like six lengths of clothesline strung between poles at the front and rear of the car. In admiration of its benefits, an observer of the day noted that "the city dweller may now go on his vacation and remain able to extract business information, stock quotations and the day's news from the ether."

During the 1920's, the clothesline approach gave way to "frame" antennas that made it appear as though a small bed frame had been fastened to the top or side of the car. While probably difficult for vandals to snap off, these were soon followed by even better designs. One such improvement was the "chicken wire" antenna, consisting of chicken wire woven into the soft roof of the automobile itself. Others involved stringing wires either under the car or along the running boards.

Since it was difficult to weave chicken wire into the metal roofs of 1932 cars, chicken wire returned to restraining chickens instead of receiving signals. In 1937, the familiar "whip" or "rod" antenna was introduced, and proved to be a design with both practicality and longevity. However, even it has been threatened by antennas in such diverse locations as the windshield, trunk lid and rear window defroster.

The combination of imagination and advancing technology has even led engineers to once again work on imbedding the antenna in the roof of the vehicle, a development which Rowan and Altgelt find ironic. They say this "only proves that auto radio antenna development has gone full circle in fifty-five years, and many 'new ideas' are only as new as the people who conceive them."

Based on SAE Paper 870090

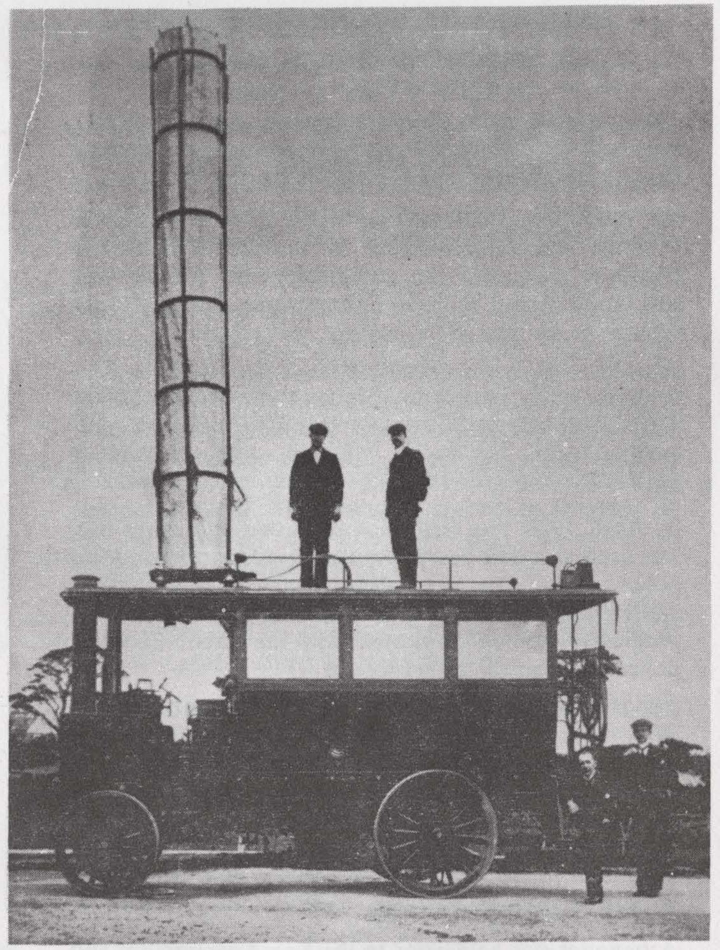


FIGURE 1

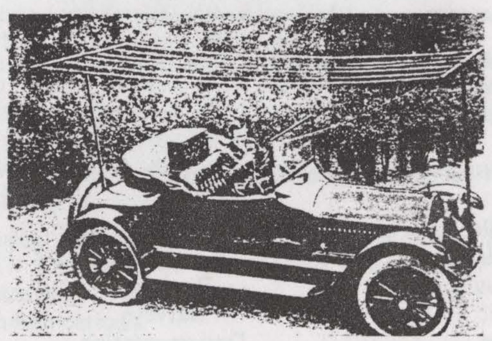
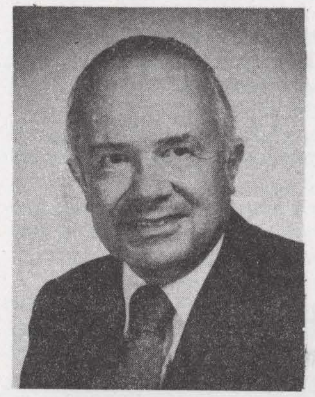


FIGURE 2

Professional Activities



Frank E. Lord
Professional Activities Editor

WHAT IS PACE?

I still hear this question fairly often even though the Institute has been officially active in professional activities for almost fifteen years and Professional Activities Committees for Engineers (PACE) have existed in one form or another for that entire period. I also encounter members who have no idea of the scope of activities under the aegis of the United States Activities Board (USAB) that they may find beneficial to their own careers and to which they may want to lend active support from time to time. Consequently, I think it is worthwhile to highlight some of the PACE/USAB activities here with material that is drawn largely from a brochure available from me or the Washington Office entitled simply *PACE*.

PACE, the Professional Activities Committees for Engineers that are established in each geographical and technical unit of the IEEE, is the network through which IEEE's professional purposes, programs and interests are developed and implemented throughout the U.S. Regions within the Institute.

On a national basis, the United States Activities Board, reporting to the IEEE Board of Directors, formulates policy and develops guidelines that set the direction on issues affecting members who reside in the United States. But on the Section, Region, Group Chapter, Society or Division level, PACE is the focal point of professional activity.

PACE is the unit that delivers services directly to IEEE members. It tailors national programs to local needs and interests, and it brings local conditions to the attention of national leaders for action and support. It is the means by which IEEE members get involved in professional issues.

IEEE has long and short-term goals to influence national priorities. These goals include strengthening programs that benefit members, their employers and the public. A strong, knowledgeable and active PACE throughout the nation is the basis for IEEE programs that have impact on solving pressing national and local problems and changing policies that affect the engineering profession.

One of the goals of PACE is to improve delivery of professional services to each individual IEEE member. PACE leaders are the local experts on a variety of professional issues. They are informed about the special services IEEE provides, and they are available to provide assistance to their colleagues.

Equitable resolution of professional issues affecting career practice is of vital importance to every engineer, as well as to the health of industry and the conduct of national policy. Ensuring the appropriate availability of skilled technical manpower and its utilization as a valuable human resource is a key factor in meeting national engineering needs, continued productivity growth, and U.W. technical pre-eminence in the world marketplace. PACE provides guidance to members concerned with the issues that may present constraints to lifetime career practice.

These matters are addressed by specialized committees which carry appropriate designations such as Manpower, Pension, Intellectual Properties, Ethics, Career Maintenance and Development, Age Discrimination, Licensure and Registration, Service Contracts, and Student Professional Awareness. USAB and the committees have data available to them obtained from periodic survey of the members. Such data is used not only to establish priorities, but often can be applied to a specific problem definition under consideration by a committee.

Outputs of committee efforts include action recommendations to USAB, guidance material for members, position papers, testimony before legislative bodies and interaction with other organizations with similar goals.

Another goal is to promote the needs and voice the professional and public policy concerns of IEEE members. The informed support of members, their communities, and the entire nation is needed in solving urgent local and national problems. An effective program is based on members' awareness of socio-technical issues and how to address them. Each Region, Division, Section and Society of IEEE must reach out to the community to promote understanding of technology and its impact on the public welfare.

IEEE has issued a call for a comprehensive national technology policy with five major thrusts: continuing development of U.S. technological knowledge and its transfer abroad; decreasing the lead time between invention and application; ensuring the appropriate availability of skilled technical manpower and its utilization as a valuable human resource; restoring the growth of productivity and enhancing capital formation; reforming regulations to balance costs against benefits.

A final goal is to bring about changes in public policy at the local, state and national levels. As leaders in the technical community, members exercise a special responsibility to speak out and make their views known to government leaders, and to be sensitive to governmental needs for the technical assistance and advice that engineers are uniquely qualified to give.

At the national level, the Committees and Task Forces of the IEEE United States Activities Board monitors legislation and drafts legislative proposals on the professional and technology policy concerns of members. PACE may assist all such efforts at the local level. Timing is essential in influencing government decision-making. When a bill of interest to IEEE nears a vote in the U.S. Congress, a Legislative Alert is sent to members. PACE leaders can lend support and advice to members in a letter-writing campaign or arranging visits to Congressmen in their home districts.

Each PACE leader receives information of USAB programs, publications, and resources. All PACE units are continually updated with survey data, guidelines, reports, legislative information and IEEE positions, to keep PACE informed on national activities, PACE activities in other areas, and new materials available.

USAB publishes a national newsletter especially designed for communication among PACEs. IMPACT is used to disseminate information and opinions throughout the PACE network and to USAB. It is edited by volunteer members and produced by the IEEE Washington Office. In addition, Section and Society newsletters may be used to communicate professional concerns to members, as we do in this column.

The staff of the IEEE Washington Office exists to support professional activities. Staff members provide counsel and assistance on programs and disseminate information through legislative reports, surveys, and other publications. Members may always obtain further information by contacting the Washington Office, 1111 19th Street NW, Washington, DC 20036, Phone (202) 785-0017 or by contacting their PACE Chairman/Coordinator.

Transportation | Systems

Bob McKnight
Transportation Systems Editor

ATCS makes progress toward complete system development

The Advanced Train Control System project of the Canadian and U.S. railroads is making steady progress. Several task forces and component specification drafting committees are at work along with three consulting firms in developing specifications for the several hardware and software modules.

At a hearing held earlier this year by the Federal Railroad Administration looking into railroad communications, ATCS Executive Director Peter J. Detmold, made some cogent and pertinent comments about ATCS.

His 12 key statements about ATCS were:

1- ATCS is a re-engineering from basics of the way in which we can control train movement using the full range of recent microprocessor and communication technologies in addition to presently available techniques. All techniques we need are available today.

2- The principal objectives of ATCS are to provide the safest most efficient, most economical method of controlling the movement of trains. The officers of the project do not regard safety, efficiency and economy as divisible objectives but part of one single objective. After all, how could any transport system that wasn't safe hope to be efficient or economical?

3- Accidents due to human error may be close to elimination by these technologies. ATCS predicts sources of danger in advance and prevents their occurrence rather than reacting to them after they've occurred. Also, it controls all aspects of train movement including protection of track forces as part of a single system. Now, we fully appreciate the extent of the vigillance needed to engineer a sound system of this level of technology.

4- ATCS is supported by 14 US and Canadian railroads to make available about 60 excellent railroad officers with great experience across the whole span of railroad technologies. During the last 3½ years, a larger portion of the work has already been completed as a result of this railroad industry initiative.

5- ATCS is not a single system. It's a series of modular components designed to combine a range of compatible systems suited to the discretion of each railroad to the needs of routes of varying traffic in various terrain conditions permitting trains to run through safely and efficiently from one railroad to another through this compatibility that we shall achieve. The flexibility of the ATCS cost structure will enable safety to be improved across the entire North American railroad system not only the parts of the system that are signaled at the present time.

6- The central function of our project team is to design the system architecture and to specify the functions, the acceptable technologies, the size, the interfacing arrangements of each component. To this purpose, we employ four specialist engineering companies and all our specifications will be placed in the public domain.

7- Every aspect of ATCS design and every decision that's taking is accepted on behalf of the industry of our two countries, by task forces of prominent railroad officers in such fields as communications, motive power, operations, dispatching, computers, signals and systems management. Thus, what we have is not some independent research team working in isolation from the industry. Rather, ATCS is run by the officers who run the railroads of our two countries and who also superintend-the technologies of those railroads.

8- About 40 supply companies work with the railroad officers and engineering contractors to develop the system architecture and the specifications in which ATCS components will be built. They include both traditional railroads and other major high tech companies. While these companies will cooperate in insuring the development of satisfactory standards, suppliers will market their products under fully competitive market conditions. Thus, the ATCS project is highly centralized technically, but very decentralized commercially.

9- Where does the work stand at present? All specifications of the essential functions of ATCS have been drafted and are currently under discussion with supply companies. We are about to begin the process of finalizing the technical details of the specifications. This process should be completed during the third calendar quarter of this year.

10- The remaining work is mainly a thorough process of checking out our decisions by independent engineering specialists of component testing, of software verification which is highly important, of system testing as well as of rule writing and of course of adequate training programs. A full safety audit will be carried out before the first ATCS installation.

11- By the second half of 1988, ATCS will be ready to enter service on a limited scale. We are confident that we shall maintain the targeted date for our work program.

12- It would be unrealistic to suppose that the process of developing ATCS will be problem free. No such system ever is. You don't believe it, we don't believe it. The railroads of our two countries consist of engineering professionals and of a powerful force of supply companies that intend to mobilize whatever additional expertise we shall need to overcome such problems as and when they arise and to establish new standards in train control that will serve us well for many years.

Various ATCS components in test stages

Several railroads have test installations of pieces of ATCS in service. Here are some examples:

Union Pacific is equipping about 160 miles of main line working west from North Platte, Nebraska with various ATCS components. Locomotives are equipped with computers and radio data link equipment. Transponders mounted on ties in the roadbed provide accurate location information. When locomotives pass over transponder, the on-board computer notes the location, which is also sent via radio to a central dispatch office. Instructions to the engineer are sent via data radio to him and displayed on a CRT in the locomotive cab.

Burlington Northern is installing equipment in locomotives and in wayside locations in northern Minnesota iron range in which the Department of Defense Navstar satellites are used to provide positioning information to the dispatching office. Locomotives are equipped with on-board computers, display terminals as well as radio links to the central dispatch location.

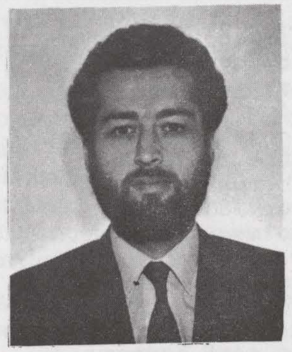
Denver & Rio Grande Western has a test installation using transponders in the track to locate trains, with on-board computers in locomotives and data radio links to the dispatching center.

CP Rail on its line between Calgary and Edmonton, Alberta, has an ATCS test installation in which the locomotive equipped with data radio links can monitor hand-throw switch positions and also control two power switches at one passing siding. The on-board computer also alerts the engineer to a restricted speed zone.

Burlington Northern, Norfolk Southern and Union Pacific have made radio data link tests in various types of terrain. These tests have used radios operating in the 160 MHz and the 800 MHz ranges.

ATCS is moving along, and preditions are that in 1988 several railroads will have some installation in full service.

Communications



J. R. Cruz
Communications Editor

ABSTRACTS

"Multipath Fading Characterization of L-band Maritime Mobile Satellite Links," W.A. Sandrin and D.J. Fang, Comsat Technical Review, Vol. 16, No. 2, Fall 1986.

Models of the maritime multipath fading process oriented toward communications systems engineers are presented. These models are primarily based on experimental data obtained from several sources and include both fading amplitude and time/frequency models. The fading amplitude models consist of both a Ricean model for fading statistics, which is applicable for most of the time, and a specular reflection model that assumes a smooth sea. The models are described parametrically in terms of elevation angle and ship earth station antenna gain. Fading (or Doppler) spectrum, fade duration times, and correlation bandwidths are also characterized. Finally, methods for combating multipath fading applicable to commercial maritime communications are surveyed.

"INMARSAT and the Future of Mobile Satellite Services," A. Ghais, G. Berzins, and D. Wright, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 4, May 1987.

This paper reviews the demand for mobile satellite communications and radiodetermination services from the maritime, aviation, and land mobile communities. It briefly examines existing alternatives and the factors that are affecting the growth and development of mobile satellite communications, with particular reference to INMARSAT. Future mobile earth station standards and services are described as are the key technological developments and challenges, which need to be met before mobile satellite services-on aircraft, the smallest of vessels, and land vehicles - become widely available at significantly lower costs than today. The authors are cautiously optimistic that the 1990's will see a rapid growth of mobile satellite services, but such growth will depend in large part on the resolution of certain institutional and technical problems, particularly relating to the limited mobile satellite spectrum available at L-band.

"The Future of Satellite Communications in Europe," P. Bartholome', IEEE J. Select. Areas Comm., Vol. SAC-5, No. 4, May 1987.

Europe has so far launched four experimental and six operational communications satellites successfully. Fifteen more spacecraft are scheduled to be launched before the end of 1990. As everywhere in the world, requirements for new telecommunications services are emerging very rapidly, and it is becoming increasingly apparent that the planned developments in terrestrial networks (ISDN, radio cellular networks) will fail to meet all the needs adequately, either in scope or in time scale. Against this background, it is shown that satellites of conventional design, carrying transparent payloads, are well suited to satisfying many of the new requirements in the short term. For the longer term, i.e., from the year 2000 onwards, innovative system concepts are being developed in which the satellite is called upon to perform more sophisticated functions requiring very advanced antennas, on-board processing, and intersatellite links.

"Japan's Space Development Programs for Communications: An Overview," T. Mori, and T. Iida, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 4, May 1987.

Japan now operates the communications satellite CS-2. A test communications satellite, CS-1, was launched in 1977, and CS-3 will be launched in 1988 as a successor to CS-2. On the other hand, in the area of mobile satellite communications development, Japan is proceeding with an experimental program, ETS-V/EMSS (Engineering Test Satellite-V/Experimental Mobile Satellite System), for which a satellite will be launched in 1987. A follow-on experimental ETS-VI program is planned and will be launched in 1992 as a 2000-kg weight class satellite. Japan has also begun an Experimental Platform Study as a step toward the Geostationary Communication Platform. This paper reviews and explains the scenario, activities, and objectives of satellite communications development in Japan.

"A Reliable Pipeline Protocol for the Message Service of a Land Mobile Satellite Experiment," T.Y. Yan, and V.O.K. Li, IEEE J. Select. Areas Comm., Vol. SAC-5 No. 4, May 1987.

This paper describes and analyzes a pipeline protocol for the data message communications network. A demand-assigned multiple access protocol using pure ALOHA for making reservation requests has been developed for MSAT-X under error-free assumptions. Preliminary propagation studies indicate that the short-term bit error rate of satellite channels in a mobile environment can be as high as 10^{-3}. Therefore, error-control schemes must be developed to ensure reliable transmissions. In this paper, we propose a retransmission scheme using selective repeat to minimize the end-to-end delay. We also use slotted ALOHA for making reservation requests to increase the overall system throughput. Since the number of channels available for reservation and data channels is essentially fixed for a given voice call blocking probability and a fixed call arrival rate, the analysis presented in this paper is also applicable to the integrated voice and data services of MSAT-X. Various operational scenarios have been investigated.

"The Maritime Satellite Communication Channel-Channel Model, Performance of Modulation and Coding," J. Hagenauer, F. Doloinsky, E. Lutz, W. Papke, and R. Schweikert, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 4, May 1987.

Towards the year 2000, maritime satellite communications using the INMARSAT system will employ a second and third generation of satellites and new ship earth stations (SES). The new SES standards will use very small antennas with gains between 0 and 15 dBi. At the lower end of SES there will be no antenna stabilization. The communication channel for such small stations is described by a model including multipath fading, Doppler shift, and noise. The results of an extensive measurement program were used to determine the parameters of the channel model, which depend on antenna type and elevation angle. Analytical calculations as well as synthetic and stored channel hardware simulations have been used to determine the performance of several modulation schemes. A complete data link using PSK modems with AFC/Costas loop, interleaving, and FEC codecs at 1.2 kbits/s was built up around a hardware maritime channel simulator, to study the performance of data transmission on the small SES maritime channel. Theoretical and measured results are given for interleaved Viterbi decoding with channel state information and Reed-Solomon codes. The measurements show that the interleaved FEC schemes, the required E_b/N_0 for a BER 10^{-5} is in the range of 9-15 dB and the effects of multipath fading are almost compensated for.

"Universal Digital Portable Communications: A System Perspective," D.C. Cox, H.W. Arnold,a nd P.T. Porter, IEEE J. Select Areas Comm. SAC-5, No. 5, June 1987.

In our highly mobile society, the provision of voice and data communications to a person away from his/her wireline telephone has become a major communications frontier. The early penetration of this frontier has been based on very limited portable communications approaches, e.g., cordless telephones, mobile radio telephones, and radio paging. Each of these approaches only partially satisfies portable communications needs. This paper describes an approach to providing universal digital portable communications integrated into telephone networks. A system configuration employing time-division multiple-access radio link architecture and frequency reuse is described. Issues affecting radio link transmission rates and radio system coverage are discussed. Characteristics and parameters of a possible system to supplement the wire (or fiber) loop are indicated.

"Advanced Cordless Telecommunications Service," A.J. Motley, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 5, June 1987.

Present analog cordless telephones suffer from lack of privacy, limited facilities and can support only a relatively low density of users. This restricts their benefits and market opportunities. hence the need for an advanced cordless telecommunications service (ACTS). Consideration is given here to the needs of this service in terms of requirements, demand, system aspects, spectrum needs, propagation, and performance. This leads to a proposed system design for the service which is already under consideration within Europe. It uses 32 kbit/s speech encoding and time-division duplex operation to achieve both-way speech communication on a single 100 KHz-wide radio channel. A pool of radio channels are available to choose from at both base and handset in order to minimize overall interference and maximize system capacity. The addition of another aerial at only the base unit can provide the full spatial diversity improvement to both directions of transmission. The service is due for introduction in the United Kingdom in 1987.

"Channel Requirements for a Cordless Telephone Spectrum Allocation," J.E. Padgett, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 5, June 1987.

Planning for a permanent cordless telephone spectrum allocation requires that the number of channels necessary to meet the long-term needs of cordless telephones be estimated. To provide the analytical basis for such an estimate, we determine the relationship between the number of channels available to cordless telephones and their performance in a suburban residential environment. Multiple cordless telephones in a community can use the same channel simultaneously, so performance ultimately will be limited by cochannel interference. We therefore develop a mathematical model of the carrier-to-interference ratio. This model accounts for shadowing, polarization, and multipath propagation effects observed in field measurements, as well as the random locations of cordless telephones. A performance measure is developed and evaluated for cordless telephones that can access all available channels and are operating in a suburban residential environment. The results indicate that for carrier frequencies in the low UHF band (300 MHz to 1 GHz), an allocation of 30-40 duplex channels can accommodate universal use of cordless telephones in that environment. For lower carrier frequencies, shadowing is less severe and fewer channels would be necessary. For example, at 50 MHz, 20 duplex channels would suffice.

"Perfect-Capture ALOHA for Local Radio Communications," B. Ramamurthi, A.A.M. Saleh, and D.J. Goodman, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 5, June 1987.

We consider a set of uncoordinated users employing an ALOHA protocol to transmit packets to a central base station in a local radio environment, e.g., in an urban area or within a building. Because of the different distances between the various users and the base station, the signals received from different users have substantially different power levels. This near/far phenomenon gives rise to a capture effect at the receiver such that when several packets are transmitted simultaneously, the receiver has a good chance of accurately detecting the packet arriving with the highest energy. Moreover, capture can be made near perfect in this environment through the use of properly design spread-spectrum signaling technique that enables the receiver to differentiate among the arriving packets based on both power differing arrival times.

We investigate variations to the conventional ALOHA protocols that take advantage of perfect capture to reduce the delays and increase the throughputs of all users, including the furthest one. Three protocols are introduced and compared, which we call "persistent ALOHA with capture' (PAC), "gated ALOHA with capture" (GAC), and "gated ALOHA with capture/exhausted" (GAC/E). Two goals are considered in the comparison: an equitable delay profile among the users, and a small expected number of simultaneously transmitted packets. The latter is quite relevant for the practical implementation of a perfect-capture receiver. We conclude that the GAC/E protocol is most desirable from the twin points of view of delay profile and receiver implementation.

"Design and Experimental Results for a Direct-Sequence Spread-Spectrum Radio Using Differential Phase-Shift Keying Modulation for Indoor, Wireless Communications," M. Kavehrad, and G.E. Bodeep, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 5, June 1987.

We report on our design and measurements that have been made for a direct-sequence spread-spectrum radio using differential phase-shift keying modulation for a wireless PBX. We describe the design and implementation of a transmitter and a receiver using a surface acoustic wave (SAW) filter matching the spread-spectrum code of a user. The receiver performance is within 1 dB of the theoretical performance of a differential phase-shift keying (DPSK) receiver in the presence of additive white Gaussian noise. We also show receiver performance in a multipath fading indoor environment with multipath fade notches of up to 50 dB depth. The indoor channel multipath fading can be overcome by using an equal gain diversity combiner which is suitable when DPSK modulation is used. We confirm that the indoor mean power level attenuation follows the inverse fourth power of the distance. Also, we investigate the multiple-access capability of the system by introducing an interfering transmitter with a different spread-spectrum code sequence.

"The Hybrid Transmission Scheme of a 900 MHz Digital Land Mobile Radio System," A. Eizenhöffer, C. Gravel, and V. Wellens, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 5, June 1987.

The hybrid transmission scheme of MATS-D uses different transmission principles on both directions of a duplex radio link. Based on the analysis of the radio transmission characteristics and of multiple-access methods, the two directions are designed independently from each other. In the downlink (from base station to mobile station) a combination of TDM and CDM is applied. In the uplink (from mobile station to base station) single channel per carrier FDMA with generalized tamed frequency modulation (GTFM) is employed.

Both transmission schemes have been implemented. Measurements with fading generators as well as field tests were carried out. Experimental results are presented for the performance of both transmission schemes, expressed in terms of the bit error rate versus the signal-to-noise ratio and the signal-to-interference ratio.

"Cellular Efficiency with Slow Frequency Hopping: Analysis of the Digital SFH900 Mobile System," J.L. Dornstetter, and D. Verhulst, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 5, June 1987.

The new digital cellular SFH900 mobile system, based on "mixed" slow frequency hopping (SFH) combined with time division, is described in detail. The system includes Viterbi quasi-coherent demodulation of GMSK for which performance measurements in multi-path conditions are presented. A concatenated coding scheme that takes full benefit of built-in frequency diversity and interference diversity is introduced.

A model for SFH cellular performance evaluation is presented and the quality-versus-capacity tradeoff for SFH900 is given for various frequency reuse patterns. With advanced 16 kbit/s speech coding techniques, and including a 25 percent overhead for management and signaling, the spectrum efficiency of a many-celled SFH900 network is around 3.5 users/cell/MHz, a significant increase in comparison to conventional analog systems. SFH provides intrinsic adaptability to varying traffic conditions and enhanced flexibility for multiservice operation. The SFH900 principles, which have been recently validated through field tests, are very promising for second generation cellular systems.

"Cell Boundary Detection in the German Cellular Mobile Radio: System C," M. Greiner, K. Löw, and R. W. Lorenz, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 5, June 1987.

The efficiency of frequency utilization in mobile radio strongly depends on the performance of handoffs. Criteria for handoffs are usually derived from measured carrier-to-interference ratios (C/I). However, in mobile radio signal levels vary so rapidly that channel allocation cannot be performed in real time for optimum C/I. On the other hand, too many handoffs reduce frequency efficiency. The determination of cell boundaries, which are not only governed by C/I, but allocated to geographical lines in the terrain avoid unnecessary handoffs. In addition to C/I auxilary data are measured in the German system C and processed to detect the cell boundaries. The improvements gained from this procedure are demonstrated by measured results.

"Multipath Time Delay Jitter Measured at 850 MHz in the Portable Radio Environment," D.M.J. Devasirvatham, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 5, June 1987.

Time delay jitter in digital personal communications systems, caused by moving the antenna by a few wavelengths, was studied at two office buildings and two residences at a frequency of 850 MHz. A wide-band pseudonoise code technique was used. The results indicate that peak-to-peak time delay variations on the order of 375 ns may be encountered. The worst case jitter was not necessarily found when there was a large time delay spread. It was also found that the excess mean delay and the root mean-square (rms) time delay spread of the delay distribution profiles were approximately the same.

"Macroscopic Diversity in Frequency Reuse Radio Systems," R.C. Bernhardt, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 5, June 1987.

Macroscopic diversity is a technique that can facilitate high quality and ubiquitous communications between low-power portable radiotelephones and data terminals, and radio base stations (ports) that are connected to the local network. It uses radio signals from several base stations to mitigate the effect of shadow fading, a variation of signal strength over space created by the presence of buildings, foliage, and terrain variations. With a path loss exponent of four and a shadow fading standard deviation of 10 dB, four-branch macroscopic diversity results in a 13 dB improvement in signal strength and a 15 dB improvement in signal to cochannel interference ratio for high user capacity interference-limited operation. (Both figures are for 99 percent statistical coverage of the service area.) The improvement in signal to co-channel interference ratio is equivalent to a factor-of-five savings of spectrum.

"On the Capacity of Radio Communication Systems with Diversity in a Rayleigh Fading Environment," J.H. Winters, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 5, June 1987.

In this paper, we study the fundamental limits on the data rate of multiple antenna systems in a Rayleigh fading environment. With M transmit and M receive antennas, up to M independent channels can be established in the same bandwidth. We study the distribution of the maximum data rate at a given error rate in the channels between up to M transmit antennas and M receive antennas and determine the outage probability for systems that use various signal processing techniques. We analyze the performance of the optimum linear and nonlinear receiver processor and the optimum linear transmitter/receiver processor pair, and the capacity of these channels. Results show that with optimum linear processing at the receiver, up to M/2 channels can be established with approximately the same maximum data rate as a single channel. With either nonlinear processing at the receiver or optimum linear transmitter/receiver processing, up to M channels can be established with approximately the same maximum data rate as a single channel. Results show the potential for large capacity in systems with limited bandwidth.

"The Effects of Time Delay Spread on Portable Radio Communication Channels with Digital Modulation," J. C-I Chuang, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 5, June 1987.

Frequency-selective fading caused by multipath time delay spread degrades digital communication channels by causing intersymbol interference, thus resulting in an irreducible BER and imposing a upper limit on the data symbol rate. In this paper, a frequency-selective, slowly fading channel is studied by computer simulation. The unfiltered BPSK, QPSK, OQPSK, and MSK modulations are considered first to illustrate the physical insights and the error mechanisms. Two classes of modulation with spectral-shaping filtering are studied next to assess the tradeoff between spectral occupancy and the performance under the influence of time delay spread. The simulation is very flexible so that different channel parameters can be studied and optimized either individually or collectively. The irreducible BER averaged over fading samples with a given delay profile is used to compare different modulation/detection methods, while the cumulative distribution of short-term BER is employed to show allowable data symbol rates for given values of delay spread. It is found that both GMSK and QPSK with a raised-cosine Nyquist pulse are suitable for a TDM/TDMA digital portable communications channel.

"Highly Efficient Digital Mobile Communications with a Linear Modulation Method," Y. Akaiwa, and Y. Nagata, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 5, June 1987.

Although linear modulation methods can achieve high spectrum efficiency, very little attention has been directed to their use in mobile radio systems. This is mainly due to the fact that the nonlinearity of the transmitter power amplifier tends to spread the spectrum and thus eliminate any spectrum efficiency advantage gained through the use of linear modulation methods. In this paper, a linear modulation system is proposed, which solves the above difficulty and which gives higher spectrum efficiency than conventional digital FM. The modulation/demodulation method is $\pi/4$ shift QPSK and phase-shift detection with a limited-discriminator and an integrate-and-dump filter. By introducing a cartesian coordinate negative feedback control, 35 percent power efficiency at 10 W output power and -60 dB relative out-of-band radiation are simultaneously achieved with a class "AB" amplifier, owing to the 29 dB feedback gain. The receiver configuration is easy to realize and gives immunity against fast fading through the use of noncoherent detection with limiter-discriminator. By using novel decision method, bit error rate performances under both nonfading and fading condition are comparable to those obtained by digital FM. These results make it possible for linear modulation methods to achieve higher spectrum efficiency than is possible with conventional digital FM methods in mobile radio communications.

"Mean-Square Error Optimization of Quadrature Receivers for CPM with Modulation Index 1/2," M.S. El-Tanany, and S.A. Mahmoud, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 5, June 1987.

Detection of continuous phase modulation (CPM) signals can be accomplished using quadrature coherent detectors which include a pair of linear and time-invariant postdetection filters. Performance of the quadrature detectors is highly sensitive to the postdetection filters response. This paper presents a rigorous derivation of an optimum postdetection filter response. The derivation is based on minimizing the mean-square interference subject to the constraint that the filter noise bandwidth is held constant. The amount of computations involved is fairly small and increases linearly with the receiver observation interval. Performance analysis results for several modulation techniques are presented.

"Features and Performance of 12 PM3 Modulation Methods for Digital Land Mobile Radio," F. Muratore, and V. Palestini, IEEE J. Select. Areas Comm., Vol. SAC-5, No. 5, June 1987.

A number of continuous-phase modulation methods suitable for digital land mobile radio applications has been grouped in a common class, which has been named 12PM3 (12-state, phase modulation with correlation over three consecutive bits). This paper introduces the definition of this class of modulation schemes, and presents some of its features. With reference to the scheme that gives the best spectral compactness, some effects of typical implementation imperfections of the modulation circuits are discussed.

The performance of some 12PM3 modulators associated with a frequency discrimination receiver is then computed with reference to both AWGN (additive white Gaussian noise) channels and the typical propagation conditions envisaged for SCPC/FDMA digital land mobile radio systems in urban environment. The adopted pre and postdiscrimination filters of the receiver are optimized for the best performance. Different decision techniques are considered, namely 2-TH (2-threshold), 4-TH, mixed 2-TH/4-TH and MLSE (maximum-likelihood sequence estimation) techniques.

"A Comparison of Digital Speech Coding Methods for Mobile Radio Systems," R.D. Hoyle, and D.D. Falconer, IEEE J. Select. Comm., Vol. SAC-5, No. 5, June 1987.

Subjective quality measurements on three digital speech coders, simulated with mobile radio channel transmission, were performed using the "mean opinion score (MOS)" method. The three speech coding methods tested were: continuously variable slope delta-modulation (CVSD) coding, adaptive predictive coding (APC), and residually excited linear predictive (RELP) coding. Several versions of each coder, with transmission rates in the range of 7.3 to 16.1 kbits/s, were simulated. Five different channel conditions, including three derived from land mobile radio field experiments, were applied to the speech coders' encoded output to study the effects. The results show that of the three coders, the CVSD coder is the most robust to channel errors, but produces reconstructed output speech of unacceptable quality. The 14.4 kbit/s RELP coder produces relatively good output speech quality, exhibits a mild degree of robustness to mobile radio channel errors, and is slightly less complex than the APC coder. Of the three digital speech coders tested, the RELP coder appears the most suitable for use with land mobile radio. However none of the three coders was able to produce speech of telephone toll quality in a mobile radio environment.

"Performance Analysis of a Built-In Planar Inverted F Antenna for 800 MHz Band Portable Radio Units," T. Taga, and K. Tsunekawa, Vol. SAC-5, No. 5, June 1987.

The pattern averaging gain (PAG) method to estimate the average gain of mobile antennas in a multipath propagation environment is proposed. By using this method and a wire-grid model, the radiation characteristics of the planar inverted F antenna (PIFA) mounted on a portable radio case is analyzed. In particular, the variation of the antenna gain with the radio case dimensions and inclination angle of the radio case during operation is clarified. Also, the effect on antenna patterns of the operator holding the portable radio is experimentally investigated. Based on this analysis, the antenna configuration with the PIFA element mounted on the lateral side of the radio case is found to be most suitable for portable radio units. In addition, an appropriate selection of the radio case dimensions is found to result in further improvements in the antenna bandwidth.

"Channel Estimation for Land mobile Radio Systems," A.P. Clark, and S.G. Jayasinghe, IEE Prov., Vol. 134, Pt. F, No. 4, July 1987.

The paper describes a number of novel and promising techniques for use in the estimation of a flat fading channel with a rapid fading rate, such as occurs in many land mobile radio systems. The algorithms of the various techniques are first presented, followed by the results of a series of computer simulation tests, carried out on these algorithms when operating with an idealised model of the channel. The quantities measured in the tests include the mean-square error in the channel estimate, with the correct detection of the data symbols, and the error rate in the detected data symbols, with perfect channel estimation and also when operating with a channel estimator. The channel estimate considered here is the one- or two-step prediction of the channel that is fed to the detector. A further aim of this investigation is to study the feasibility of the simultaneous transmission of two bandlimited 4-level QAM (quaternary PSK) signals simultaneously over two independent Rayleigh fading channels to a single receiver, where both signals occupy the same frequency band and no coding or diversity techniques are employed to improve the performance, other than differential coding needed to avoid prolonged error bursts. The results obtained suggest that it should be possible to achieve the satisfactory coherent detection of a single Rayleigh-fading 4-level QAM signal, under conditions of even quite severe and rapid fading, but for the simultaneous transmission of two independently Raleigh-fading signals over the same frequency band, the appropriate diversity techniques will be required to reduce the resultant depth of the fades. The techniques proposed here should make it possible to achieve a significantly more efficient use of bandwidth in cellular mobile radio systems than is possible by conventional methods.

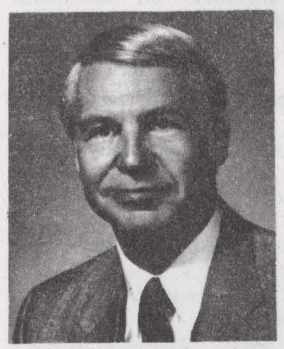
"System Applications for Wireless Indoor Communications," A.S. Acampora, and J.H. Winters, IEEE Comm. Mag., VOl. 25, No. 8, August 1987.

Buildings present a hostile environment for radio communications, with in-building radio propagation difficult to predict and continuously changing.

"Echo and Delay Problems in Some Digital Communication Systems," R.H. Moffett, IEEE Comm. Mag., Vol. 25, No. 8, August 1987.

We are currently entering an era in which digital processing techniques are being proposed or introduced to reduce the bandwidth of new communication systems. These techniques can introduce delays comparable with those of long-distance international calls.

News From Washington



Eric Schimmel
Washington News Editor

NEITHER FISH NOR FOUL

That's an apt description of the GMRS (General Mobile Radio Service), also formerly known as the Class "A" Citizen's Band Radio Service. Over the years it has lost many of its feathers by having most of its channels reallocated to the Business Radio Service. The remaining eight pairs of frequencies in the 462 MHz and 467 MHz bands are available for licensing to individuals as well as to just about any organizational entity, and have provided considerable relief to two-way radio vendors in high density markets who needed an alternative to saturated Business Radio Service channels. This has been a thorn in the side of those advocating that eligibility in this service be limited to individuals, and is one of the important issues in FCC Docket 87-265.

The FCC proposal reprinted below is the most recent of several efforts to revisit the subject of Personal Communications. If you have outgrown CB, don't want to be a ham, and can't afford a cellular telephone, you may find this proceeding interesting. You have until November 30 to file comments. Additional information is available from the Personal Radio Steering Group, an advocate organization located at P.O. Box 2851, Ann Arbor, Michigan 48106. Their phone number is 313/769-1616.

Before the
Federal Communications Commission
Washington, D.C. 20554

PR Docket No. 87-265

In the Matter of

Amendment of Subparts A and E
of Part 95 to Improve the
General Mobile Radio Service
(GMRS).

NOTICE OF PROPOSED RULE MAKING

Adopted: July 16, 1987; Released: July 31, 1987

By the Commission:

BACKGROUND

1. In an *Inquiry* in PR Docket No. 86-38, 51 FR 5212, February 12, 1986, we explored today's personal communications needs as they are being met in the two small UHF segments now assigned to the General Mobile Radio Service (GMRS). We determined to decide at a later date whether to initiate a proceeding to examine some specific rule changes to improve the existing GMRS. *See Report and Order*, PR Docket No. 86-38, 52 FR 15516, April 29, 1987. We had in mind two rule making petitions associated with PR Docket No. 86-38: RM-5058 and RM-5242.[1] This proceeding is based on some of the recommendations made in those petitions.

2. The GMRS is a Part 95 Personal Radio Service. However, GMRS rules permit both personal and business communications. The GMRS was originally the Citizens Class A Radio Service and was created 40 years ago for use by individuals and organizations who were not eligible for licenses in the public safety, industrial and transportation (PSIT) services. (At that time none of the commercial operations who are now eligible in the Business Radio Service were eligible in the PSIT services.) Consequently the regulatory structure of the service is patterned after a traditional view of land mobile operation, namely, a base-to-mobile dispatch operation employing assigned frequencies in a specific geographic location.

3. Things have changed. The modern GMRS user has available wide range of equipment. Hand-held mobile units are capable of accessing any of the GMRS frequencies through synthesized frequency controls. Mobile relay stations (repeaters) permit easy communications between persons carrying hand-held units. Business and pleasure travel takes people far from their home area, but their communications needs do not disappear. As presently written, our GMRS rules limit the flexibility of users to employ the technology that is now available.

PROPOSAL

4. We propose to modify the GMRS rules to allow this service to achieve its full potential. Specifically we propose (1) to limit eligibility for GMRS system licensing to individuals;[2] (2) to eliminate the need to re-license a GMRS system before changing channels; (3) to add interstitial channels; (4) to provide for transient use of mobile relays (repeaters); (5) to broaden station operator eligibility and (6) to create the concept of a small base station to enhance GMRS utility for the mobile-unit-oriented personal user.

5. *System licensing eligibility*. Unlike the restrictive eligibility of the private land mobile radio services in Part 90, eligibility for the Part 95 personal radio services is very broad. Entry to the GMRS is virtually unrestricted except for requirements of minimum age and the statutory requirement of not being a representative of a foreign government. In its previous pleadings and comments in RM-5058 and RM-5242 the Personal Radio Steering Group (PRSG) has documented the incompatibilities between large commercial users and the numerous but smaller in scope personal users. PRSG maintains that in areas of large population density use of GMRS channels by high-traffic-volume business dispatch operations has often effectively precluded personal use. PRSG is of the view that personal users are frequently forced to compete for channel time with the oftentimes extended and unrelenting dispatch operations of commercial users. As a result, according to PRSG, many personal users find themselves unable to engage in legitimate personal communications because commercial dispatch operations are unwilling or unable to share the channels.

6. For the large commercial user, eligibility in another of the private land mobile radio services offering comparable communications performance is available. Personal users, on the other hand, generally are not eligible in the other private land mobile services in which comparable resources (repeaters, FM quieting and capture, freedom from "skip," etc.) exist.[3] Similarly, there are no comparable, affordable alternatives to the GMRS for the small entrepreneur or sole proprietorship.

7. We do not propose to change the permissibility of business use of GMRS. But, considering the very limited number of channels in the service, it appears that larger commercial enterprises could generally better satisfy their needs in the Business Radio Service. Accordingly we are proposing to limit eligibility for system licensing in the GMRS to individuals. We recognize that at this time roughly one-half of all the system licensees in the GMRS are commercial users. We propose to grandfather those commercial GMRS systems that are licensed as of the release date of this NPRM. Subsequent non-individual licenses would not be granted.

8. *Station operator eligibility*. In line with re-orienting the GMRS toward personal use, we propose to liberalize station operator eligibility. A station operator would be any licensee or family member for whom the licensee is willing to take responsibility. To facilitate the use of GMRS repeaters in different GMRS systems by personal users while travelling we propose to permit use of a GMRS system repeater by any other GMRS licensee who has the permission of the licensee of the system with the repeater. We envision that permission to include the transient licensee and the transient licensee's family members. Thus, the spouse of a GMRS licensee, for example, could travel from city to city using a station in the licensee's

system to access any available GMRS repeater. We construe the proposed rules to mean that any GMRS open repeater would be a repeater for which the system licensee had given tacit permission for such transient use. We request comment on the validity of this approach, and on whether we need to require system licensee permission for transient use of GMRS repeaters at all.

9. *Channel selection.* Management of the GMRS spectrum has historically been grounded in the compound space-, frequency-, and time-division approach. Each GMRS licensee has received authorization for only one specific shared channel or channel pair at one specific location. Under this approach, a GMRS station is unable to transmit if its assigned channel or channel pair is in use, even if other channels or channel pairs are clear. To use a different channel, the licensee has to obtain a license modification.

10. With increased emphasis upon personal use in the GMRS, the frequency-division approach would appear to be both unnecessary and unwarranted. Therefore, we are proposing rules to permit each GMRS licensee to select the channel or channel pair for the stations in a GMRS system as needed. We believe that this should permit more efficient and effective use of the GMRS spectrum by giving GMRS licensees for the first time the ability to choose any available "clear" channel or channel pair.[4]

11. The proposed rules would limit channel selection to one channel or channel pair for a station in a GMRS system at any given time. In other words, a single GMRS licensee may not use two or more GMRS channels or channel pairs simultaneously, lest one or two licensees with fleet dispatch operations completely usurp all channels in an area. This is consistent with current FCC assignment of only one channel or channel pair.

12. *Small base stations.* Many GMRS personal users merely wish to acquire and operate one or more mobile units, on occasion using them to operate from a fixed location, such as the home or office. For such users, it is desirable to keep licensing complexity to a minimum. It is also desirable to encourage such users to operate stations that are unlikely to cause significant interference to other lawful uses and users. To this end, we propose to create small base stations, analogous to small control stations. A small base station would employ no more than five watts effective radiated power and would employ an antenna no more than twenty feet above the ground or above the building or tree on which it is mounted. To facilitate use of low-power "mobile" equipment as small base stations, we would permit small base stations the frequency tolerance currently allowed for mobile stations (0.0005%), rather than the frequency tolerance currently required for base stations (0.00025%). We encourage most GMRS users to utilize short range equipment so that more users can be accommodated.

13. *Interstitial channels.* We have proposed the addition of 12.5 kHz offset (interstitial) GMRS channels to facilitate personal communication and repeater control. The direct communications range of a UHF transceiver is roughly line-of-sight. Thus, for personal communications to be viable in the GMRS, at least some communications need to be transmitted through a mobile relay station to increase the range. Current GMRS rules provide for such operation. However, many personal communications exchanges can be conducted without a repeater. Such range can be achieved with low power stations transmitting on interstitial GMRS channels. Since these non-repeated personal exchanges would be on channels that are not available for mobile relay stations, they would have a somewhat greater degree of protection from interference by mobile relay station transmissions. To this end we propose to add three interstitial channels in the 462 MHz segment[5] for non-repeated mobile station and small base station use.

14. It also appears that interstitial channels in the 467 MHz segment[6] for repeater remote control might be helpful. Therefore, we propose that four 467 MHz interstitial channels be established for this purpose. Transmissions on these channels would be restricted to low power one-way non-voice communications solely for repeater control.

15. We chose 462.5625 MHz, 462.6125 MHz and 462.6375 MHz as the three non-repeated mobile station and small base station interstitial channels. We made this choice on the basis of interference potential. We considered the following factors: (1) PRSG's statement in its Petition for Rule Making in RM-5058 that 462.675 MHz, 462.600 MHz and 462.575 MHz are, in descending order, the most heavily used 462 MHz channels for mobile relay station operation; and (2) the existence of non-GMRS high-power paging on 462.750 MHz. We chose 467.5625 MHz, 467.6125 MHz, 467.6375 MHz and 467.7125 MHz as the four repeater remote control interstitial channels. We also made this choice on the basis of interference potential, relying upon information that 467.675 MHz, 467.600 MHz and 467.575 MHz are, in descending order, the most heavily used 467 MHz channels for mobile relay station operation.

16. *Additional considerations.* We seek comment on whether it may be desirable to allow use of more than one channel or channel pair in the GMRS should the FCC no longer assign channels. Additionally, we encourage comment on whether the abolition of FCC assignment of a particular channel or channel pair should lead us to consider other technologies such as trunking in the GMRS. We also seek comment on whether the input and output channels of mobile relay stations require regularization in order to minimize possible harmful interference, and whether the FCC should consider discouraging or prohibiting simplex operation on mobile relay input frequencies. Finally, we also seek comment on whether we should consider requiring that repeaters be capable of automatic monitoring of 462 MHz channels to minimize mobile relay station interference.

17. *Regulatory review.* As part of our continuing regulatory review we also propose: (1) to make certain changes to the GMRS rules to conform to new Field Operations Bureau classification of certain field offices; (2) to remove advisory rules recommending that GMRS radios be repaired only by technicians approved by some organization with the consensus of GMRS users, because there is no such organization in this service; and (3) to update the FCC addresses for filing GMRS applications.

PROCEDURAL MATTERS

18. The proposed amendments to the Commission's rules, as set forth in the attached Appendix, are issued under the authority contained in Sections 4(i) and 303(r) of the Communications Act of 1934, as amended, 47 U.S.C. §§154(i) and 303(r). They include certain changes to the GMRS rules solely to account for new Field Operations Bureau classification of certain field offices.

19. Under procedures set out in Section 1.415 of the rules and regulations, 47 CFR §1.415, interested persons may file comments on or before **November 30, 1987,** and reply comments on or before **December 31, 1987.** All relevant and timely comments will be considered by the Commission before final action is taken in this proceeding. In reaching its decision, the Commission may take into consideration information and ideas not contained in the comments, provided that such information is placed in the public file, and provided that the fact of the Commission's reliance on such information is noted in the Report and Order.

20. In accordance with the provisions of Section 1.419 of the rules and regulations, 47 CFR §1.419, formal participants shall file an original and 5 copies of their comments and other materials. Participants wishing each Commissioner to have a personal copy of their comments should file an original and 11 copies. Members of the general public who wish to express their comments are given the same consideration, regardless of the number of copies submitted. All documents will be available for public inspection during regular business hours in the Commission's Public Reference Room at its headquarters in Washington, D.C.

21. For purposes of this non-restricted notice and comment rule making proceeding, members of the public are advised that *ex parte* contacts are permitted from the time the Commission adopts a notice of proposed rule making until the time a public notice is issued stating that a substantive disposition of the matter is to be considered at a forthcoming meeting or until a final order disposing of the matter is adopted by the Commission, whichever is earlier. In general, an *ex parte* presentation is any written or oral communication (other than formal written comments/pleadings and formal oral arguments) between a person outside the Commission and a Commissioner or a member of the Commission's staff which addresses the merits of the proceeding. Any person who submits a written *ex parte* presentation must serve a copy of that presentation to the Commission's Secretary for inclusion in the public file. Any person who makes an oral *ex parte* presentation addressing matters not fully covered in any previously-filed written comments for the proceeding must prepare written summary of that presentation. On the day of oral presentation, that written summary must be served on the Commission's Secretary for inclusion in the public file, with a copy to the Commission official receiving the oral presentation. Each *ex parte* presentation described above must state on its face that the Secretary has been served, and must also state by docket number the proceeding to which it relates. *See* generally, Section 1.1231 of the Commission's rules, 47 CFR §1.1231.

22. The proposal contained herein has been analyzed with respect to the Paperwork Reduction Act of 1980 and found to decrease the information collection burden which the Commission imposes on the public. This proposed reduction in information collection burden is subject to approval by the Office of Management and Budget as prescribed by the Act.

23. We have determined that Section 605(b) of the Regulatory Flexibility Act of 1980 (Pub.L. 96-354) does not apply to this rule making proceeding because these rules, if promulgated, would not have a significant economic impact on a substantial number of small entities. Although these proposed changes allow the personal radio community greater flexibility and convenience, they will not cause a significant economic impact on small entities.

24. IT IS ORDERED, That a copy of this Notice shall be sent to the Chief Counsel for Advocacy of the Small Business Administration.

25. For information about this proceeding contact John J. Borkowski, 202-632-4964.

FEDERAL COMMUNICATIONS COMMISSION

William J. Tricarico
Secretary

APPENDIX

Subparts A and E of Part 95 of Chapter 1 of Title 47 of the Code of Federal Regulations would be amended as follows:

Part 95 -- Personal Radio Services

Subpart A -- General Mobile Radio Service (GMRS)

1. The authority citation for Part 95 would continue to read:

Secs. 4, 303, 48 Stat. 1066, 1082, as amended; 47 U.S.C. 154, 303.

2. Section 95.1 would be revised to read:

§ 95.1 The General Mobile Radio Service (GMRS).

(a) The *GMRS* is a mobile radio service available to individuals for brief two-way messages to facilitate the activities of licensees and their immediate family members. Each licensee manages a system consisting of one or more stations.

(b) An individual eligible for licensing under this subpart is eligible to obtain an authorization in the 31.0 to 31.3 GHz band for personal communications, provided that the technical standards in Part 94 applicable to the band are observed. Individuals applying for stations in the 31.0 to 31.3 GHz band for personal communications must use FCC Form 402.

(c) Entities other than individuals eligible for licensing in the GMRS under prior rules which were granted authorizations prior to [the release date of this *Notice*] may continue to operate in accordance with such authorizations and may renew them (see 95.5(b)), but only to facilitate the business of the licensee.

3. Paragraphs (a) and (b) of Section 95.3 would be revised to read:

§ 95. 3 License required.

(a) An individual must obtain a license (a written authorization from the FCC for a GMRS system or for a station in a GMRS system) before transmitting on any stations in the GMRS at any point (a geographical location) within or over the territorial limits of any area where radio services are regulated by the FCC.

(b) An individual may obtain a license for a station in the GMRS only if the station is part of that individual's GMRS system.

*****

4. Section 95.5 would be revised to read:

§ 95. 5 License eligibility.

(a) An individual is eligible to obtain a new license if that individual is eighteen years of age or older and is not a representative of a foreign government.

(b) Entities other than individuals not eligible to obtain a new license under paragraph (a) of this section but which were authorized in the GMRS under prior rules before [the release date of this *Notice]* may renew their existing authorizations (see 95.89), but may not modify any such existing authorizations to:

(1) increase the power of any transmitter;
(2) increase the number of mobile units;
(3) add any stations;
(4) increase any antenna heights;
(5) change any land station location; or
(6) change area of operation.

5. Paragraph (a) of Section 95.7 would be revised to read:

§ 95. 7 Channel sharing.

(a) Channels or channel pairs used by GMRS systems are available only on a shared basis and will not be assigned for the exclusive use of any licensee. All operators and licensees must cooperate in the selection and use of channels to reduce interference and to make the most effective use of the facilities.

*****

6. Paragraph (e) of Section 95.25 would be redesignated as paragraph (f). A new paragraph (e) would be added to Section 97.25 to read:

§ 95. 25 Land station description.

*****

(e) A small base station is any base station that:

(1) has an antenna no more than 6.1 meters (20 feet) above the ground or above the building or tree on which it is mounted (see 95.51); and

(2) transmits with no more than 5 watts effective radiated power.

*****

7. Section 95.29 would be revised to read:

§ 95. 29 Channels available.

(a) The licensee of the GMRS system must select the channel or channel pair for the stations in the GMRS system (see 95.75(c)) from the following lists:

(1) For a base station, mobile relay station, fixed station, or mobile station, the following 462 MHz (megahertz) channels:

462.550 462.600 462.650 462.700
462.575 462.625 462.675 462.725

(2) For a mobile station, control station, or fixed station in a duplex system, the following 467 MHz channels:

467.550 467.600 467.650 467.700
467.575 467.625 467.675 467.725

(b) Only one channel or one channel pair (one 462 MHz channel and its counterpart 5 MHz spaced 467 MHz channel) may be used by a station in a GMRS system in the simplex mode.

(c) Only one channel pair may be used by a station in a GMRS system in the duplex mode. (An example of a channel pair is channel 462.600 MHz and channel 467.600 MHz.)

(d) Mobile units and small base stations may also use the following 462 MHz channels:

462.5625 462.6125 462.6375

(1) These channels may only be used for voice communication.

(2) These channels may be used only when the following conditions are met:

(i) all stations operating on these channels must transmit with no more than 5 watts effective radiated power;

(ii) these channels may be used only for simplex two-way voice communications to other stations authorized to operate on them; and

(iii) paging is not permitted on these frequencies.

(e) Mobile units and small control stations may also use the following 467 MHz channels:

467.5625 467.6125 467.6375 467.7125

(1) These channels may only be used as non-voice control channels.

(2) These channels may be used only when the following conditions are met:

(i) all stations operating on these channels must transmit with no more than 5 watts effective radiated power;

(ii) these channels may be used only for one-way non-voice control link transmissions to mobile relay stations;

(iii) paging is not permitted on these control channels; and

(iv) transmissions on these control frequencies may not exceed five seconds in duration in any sixty-second period.

(f) Fixed stations authorized before March 18, 1968, located 100 or more miles from the geographic center of urbanized areas of 200,000 or more population as defined in the U.S. Census of Population, 1960, Vol. 1, Table 23, page 50 which were authorized to operate on frequencies other than those listed in this section may continue to operate on their originally assigned frequencies provided that they cause no interference to the operation of stations in any of the Part 90 private land mobile radio services.

8. Section 95.37 would be revised to read:

§ 95. 37 Considerations near the Canadian border.

A GMRS station may not transmit on the following frequencies within the specified distances from these points in Canada, unless previously authorized to do so by the FCC:

(a) 462.550 MHz within 75 miles of Montreal, Quebec.

(b) 462.5625 MHz within 50 miles of Malton and Sarnia, Ontario.

(c) 462.575 MHz within 75 miles of Mirabel, Ontario, and Pointe aux Trembles and Verdun, Quebec.

(d) 462.6125 MHz within 50 miles of Don Mills and Sarnia, Ontario.

(e) 462.625 MHz within 75 miles of Malton, Ontario, and Montreal and Varennes, Quebec.

(f) 462.650 MHz within 75 miles of Hamilton and Scarborough, Ontario, and Montreal, Quebec.

(g) 462.675 MHz within 75 miles of Kingston, London, Manheim, Ottawa and Toronto, Ontario, and Montreal and Quebec, Quebec.

(h) 462.700 MHz within 75 miles of the U.S.-Canadian border.

(i) 462.725 MHz within 75 miles of Burlington, Ontario.

(j) 467.5625 MHz within 50 miles of Malton, Sarnia and Toronto, Ontario, and Montreal, Quebec.

(k) 467.6125 MHz within 50 miles of Sarnia and Downsmills, Ontario, and the Province of Quebec.

(l) 467.6375 MHz within 50 miles of Malton, Ontario, and Montreal and Varennes, Quebec.

(m) 467.650 MHz within 75 miles of the U.S.-Canadian border.

(n) 467.7125 MHz within 50 miles of Ingersoll, Niagara Falls, Fonthill and Welland, Ontario.

9. Section 95.39 would be revised to read:

§ 95. 39 Considerations near certain FCC field offices.

The FCC may impose additional restrictions on a land station in a GMRS system if it is at a point within 4.8 kilometers (3 miles) of a field office equipped with long-range direction-finding equipment (formerly called a monitoring station) and the station's transmissions degrade, obstruct, or repeatedly interrupt the operation of the equipment at the FCC field office. Before applying for a license to put a land station at such a point, or before applying to change anything in a station already licensed for such a point, you should consult the FCC by writing to the Chief, Field Operations Bureau, Federal Communications Commission, Washington, D.C. 20554.

10. Paragraph (f) of Section 95.51 would be revised to read:

§ 95. 51 Antenna height.

*****

(f) The antenna for a small base station or for a small control station must not be more than 6.1 meters (20 feet) above the ground or above the building or tree on which it is mounted.

11. Paragraphs (c) and (f) of Section 95.53 would be revised to read:

§ 95. 53 Mobile station communication points.

*****

(c) A mobile station unit may transmit communications through a mobile relay station in another GMRS system, with the permission of that system's licensee, to:

(1) Control stations in the other GMRS system; and
(2) Mobile station units of any GMRS system.

*****

(f) A mobile station unit must not transmit communications, without the GMRS system licensee's permission, through a mobile relay station in another GMRS system, for retransmission to:

*****

12. Paragraph (b) of Section 95.57 would be revised to read:

§ 95. 57 Mobile relay station communication points.

* * * * *

(b) A mobile relay station in a GMRS system must not automatically retransmit, without the GMRS system licensee's permission, communications between:

* * * * *

13. Paragraph (a) of Section 95.71 would be revised to read:

§ 95. 71 Applying for a new or modified license.

(a) An individual applies for a license for a new GMRS system by filling out an application form, attaching all additional information required, and sending it to the FCC. A licensee applies to modify a license for an existing GMRS system using the same forms and in the same manner as applying for a new GMRS system. A non-individual licensee whose station was licensed prior to [the release date of this *Notice*] may not make a major modification in the system (see 95.5(b)).

(i) All applicants except governmental entities should submit their applications, together with the filing fee, to the Federal Communications Commission, General Mobile Service, P.O. Box 360373M, Pittsburgh, PA 15251-6373.
(ii) Governmental entities should submit their applications to the Federal Communications Commission, Attention: GMRS, Gettysburg, PA 17326.

* * * * *

14. Paragraph (c) of Section 95.73 would be revised to read:

§ 95. 73 System licensing.

* * * * *

(c) One form must be used to apply for the following stations in a GMRS system:

(1) the mobile stations;
(2) all small base stations (see 95.25(e));
(3) all small control stations (see 95.25(d)); and
(4) no more than six land stations which have antennas more than 6.1 meters (20 feet) high (see 95.51).

* * * * *

15. Paragraphs (c), (g), (h), (i), (j) and (n) of Section 95.75 would be revised to read:

§ 95. 75 Basic information.

* * * * *

(c) For fixed stations authorized before March 18, 1968, pursuant to Section 95.29(f), or if the applicant so chooses pursuant to Section 95.85(f), transmitting channel or channel pair;

* * * * *

(g) Transmitter power as follows:

(1) ***
(2) ***
(3) For a small base station, no more than five watts effective radiated power.
(4) For all other stations, output power in watts.

(h) Each land station point (except small base stations and small control stations);

(1) ***
(2) ***

(i) Each control point for each remotely controlled land station (see 95.127), including small base stations and small control stations;

(1) ***
(2) ***

(j) Antenna height (see 95.51) and antenna ground elevation for each land station, except for small base stations and small control stations;

* * * * *

(n) Emission designator. In the GMRS, F3E will be considered to include use of a selective calling tone or tone or digitally operated squelch (a message to call a particular station) in conjunction with voice communications;

* * * * *

16. Paragraph (b) of Section 95.83 would be revised to read:

§ 95. 83 Additional information for stations with antennas higher than normally allowed.

* * * * *

(b) Base stations and control stations with antenna heights greater than 20 feet must be separately identified on Form 574 (see 95.25(d) and (e) and 95.51(f)).

17. In Section 95.85, paragraphs (d) and (e) would be revised, and a new paragraph (f) would be added to read:

§ 95. 85 Additional information for stations near United States borders.

* * * * *

(d) Has an associated control station with other than 20 degrees beamwidth;
(e) Is part of a GMRS system that includes stations or units intended for communication with stations or units in other GMRS systems or in other radio services; or
(f) Is going to transmit on a specified channel or channel pair.

* * * * *

18. A new paragraph (c) would be added to Section 95.89 to read:

§ 95. 89 Renewing a license.

* * * * *

(c) An entity other than an individual authorized before [the release date of this *Notice*] is eligible to renew its license(s) if:

(1) the entity is:

(i) a partnership, and each partner is eighteen years of age or older;
(ii) a corporation;
(iii) an association;
(iv) a state, territorial or local government unit; or
(v) other legal entity; and

(2) the entity is not:
(i) a foreign government;
(ii) a representative of a foreign government; or
(iii) a federal government agency.

19. Paragraph (c)(2) of Section 95.103 would be revised to read:

§ 95. 103 Licensee duties.

* * * * *

(c) ***

(2) If the status of a licensed entity other than an individual changes (for example, when a corporation is dissolved and a new corporation stands in its place, or a partnership becomes a corporation), the licensee must send the license to the FCC for cancellation (see 95.117(b)).

20. Paragraph (b) of Section 95.109 would be revised to read:

§ 95. 109 License not transferable.

* * * * *

(b) If the licensee sells or gives away any GMRS system equipment, the new owner may not operate that equipment unless he/she is authorized to do so:

(1) by a license granted under Part 95;
(2) by FCC Form 574-T (see 95.71(b)); or
(3) under another existing authorization (see 95.33 or 95.179).

21. Paragraph (b)(2) of Section 95.113 would be removed and reserved.

22. Paragraphs (b) and (c) of Section 95.117 would be revised to read:

§ 95. 117 Where to contact the FCC.

* * * * *

(b) Write to the Federal Communications Commission, Attention: GMRS, Gettysburg, PA 17326:

(1) ***
(2) To file an application for a governmental entity (see §95.71);

* * * * *

(c) Write to the Federal Communications Commission, General Mobile Service, P.O. Box 360373 M, Pittsburgh, PA 15251-6373, to file an application for a new GMRS system or to modify or renew the license for an existing GMRS system, unless the application is for a governmental entity. (see §§95.71 and 95.89).

23. Section 95.121 would be removed and reserved.

24. Paragraph (b)(3) of Section 97.129 would be removed and reserved. Also, paragraph (d) of Section 95.129 would be revised to read:

§ 95. 129 Station equipment.

* * * * *

(d) Every small base station and every small control station must use an antenna no more than 6.1 meters (20 feet) high (see 95.25(d) and (e)).

25. Paragraph (a) and the caption of Section 95.131 would be revised to read:

§ 95. 131 Servicing station transmitters.

(a) The station licensee shall be responsible for the proper operation of the station at all times and is expected to provide for observations, servicing and maintenance as often as may be necessary to ensure proper operation.

* * * * *

26. Paragraph (b)(2) of Section 95.133 would be revised to read:

§ 95. 133 Modification to station transmitters.

* * * * *

(b) ***

(2) In accordance with the original manufacturer's instructions.

27. A new paragraph (e) would be added to Section 95.135 to read:

§ 95. 135 Transmitter power limits.

* * * * *

(e) A small base station must employ no more than five watts effective radiated power.

28. Section 95.137 would be revised to read:

§ 95. 137 Moving a small base station or a small control station.

(a) A small base station (see 95.25(e)) or a small control station (see 95.25(d)) in a GMRS system may be moved from the point specified on the license to any other point where radio services are regulated by the FCC.

(b) The licensee must file an application to modify the GMRS system (see 95.71) to show the new point within 30 days after the small base station or the small control station is moved.

29. Section 95.139 would be revised to read:

§ 95. 139 Adding a small base station or a small control station.

(a) If a GMRS system is licensed under the system licensing procedure (see 95.73), one or more small base stations or small control stations may be added to the GMRS system at any point where radio services are regulated by the FCC.

(b) The licensee must file an application to modify the GMRS system (see 95.71) within 30 days after each small base station or small control station is added.

(c) If a GMRS system is not licensed under the system licensing procedure, the licensee must obtain a license for the modified GMRS system before adding a small base station or a small control station.

(d) Entities grandfathered in the GMRS under Section 95.5(b) may not add any small base stations or small control stations pursuant to this section.

30. The introductory paragraph of Section 95.175 would be revised to read:

§ 95. 175 Cooperation in sharing channels.

The station operator must cooperate in *sharing* each channel with station operators of other stations by:

* * * * *

31. The first two sentences of paragraph (b), the first sentence of paragraph (c), and paragraph (d), (e) and (f) of Section 95.179 would be revised to read:

§ 95. 179 Individuals who may be station operators.

* * * * *

(b) The licensee of any GMRS system authorized before the release date of the Notice may permit certain other individuals to be station operators. These individuals may only communicate messages to facilitate the licensee's business activities.

* * * * *

(c) The licensee of any GMRS system authorized before [the release date of this Notice may permit a telephone answering service employee to be a station operator if:

* * * * *

(d) A GMRS system licensee may also permit other GMRS licensees for whom the licensee is willing to accept responsibility to be station operators in that licensee's GMRS system.

(e) The provisions of §95.33 regarding cooperative use do not apply to or govern the authority of a GMRS licensee to designate station operators in accordance with the provisions of this section.

(f) Except for emergency communications (see 95.143), only persons specified in paragraphs (a) through (c) may be GMRS station operators.

SUBPART E – TECHNICAL REGULATIONS

32. Paragraphs (a) and (c) of Section 95.621 would be revised to read:

§95.621 GMRS transmitter frequencies.

(a) The GMRS transmitter frequencies are the following channels:

462MHzChannels	467MHzChannels
462.5500	467.5500
462.5625	467.5625
462.5750	467.5750
462.6000	467.6000
462.6125	467.6125
462.6250	467.6250
462.6375	467.6375
462.6500	467.6500
462.6750	467.6750
462.7000	467.7000
462.7250	467.7125
	467.7250

* * * * *

(c) The GMRS transmitter channel frequency tolerance must be maintained within the following percentages:

Station Class	Tolerance(percent)
mobile, small base, control (including small control)	0.0005
base (except small base), mobile relay, fixed	0.00025

FOOTNOTES

[1] Proposed changes in the GMRS rules filed by the Personal Radio Steering Group (PRSG). PRSG is an all-volunteer, not-for-profit corporation created by licensees in the GMRS to provide services to and serve as an advocate for the GMRS personal-use community.

[2] We use the term "individual" throughout this discussion to refer to a single human being -- that is, one man or woman. (Children under the age of eighteen are not eligible in the GMRS, and would continue to be ineligible under the proposed rules.)

[3] In PR Docket No. 86-404, however, we are currently considering whether to expand the eligibility of SMR end users to include individuals and federal government agencies.

[4] Although all-channel authorization would be the general rule, limits on this ability may be necessary near the Canadian border. *See* proposed §95.37.

[5] Section 95.29(a)(1) defines eight channels at 462.550-462.725 MHz for base station, mobile relay station, fixed station and mobile station transmissions.

[6] Section 95.29(a)(2) defines eight channels at 467.550-467.725 MHz for mobile stations, control stations, and fixed stations in duplex system.

Vehicular Electronics

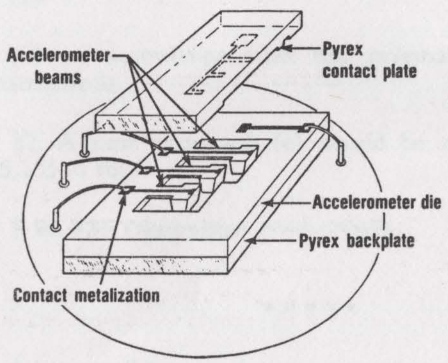
Bill Fleming

INERTIAL MICRO G-SWITCH R&D UPDATE

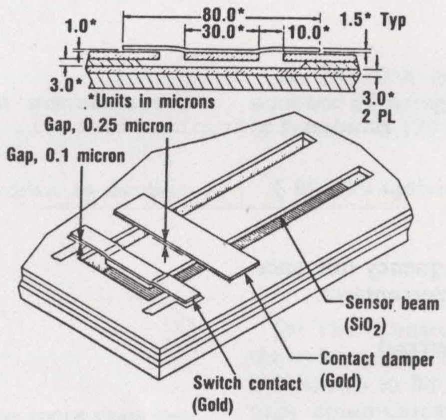
All solid-state microsensors offer important advantages of low cost and "smart" on-chip signal processing. New types of microsensors are constantly being reported, one of which, called an inertial micro g-switch has possible application to future automotive safety systems [1].

The new inertial micro g-switch was actually developed for munition fuzing applications, with threshold closure levels ranging from 230 g to 11,000 g [1]. These g-levels are far greater than those for automotive crash sensors, that typically range from 3 g to 30 g. Nevertheless, this new micro g-switch technology may someday become part of future automotive seat belt and air bag safety restraint systems.

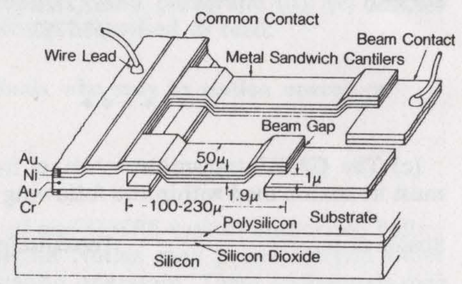
The three inertial micro g-switch designs described in Ref. 1 -- developed at Honeywell, Motorola, and Harry Diamond Laboratories -- presently suffer problems of: gold contact cold welding, poor step coverage, uneven contact closure, thermal-expansion contact interference, and microbeam breakage during semiconductor processing. Notwithstanding these problems, the authors of Ref. 1 concluded that the feasibility of inertial micro g-switch technology was demonstrated.



Honeywell Inertial Micro G-Switch [1]



Motorola Inertial Micro G-Switch [1]

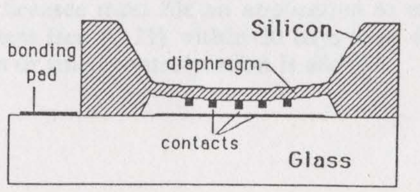


Harry Diamond Laboratories Inertial Micro G-Switch [1]

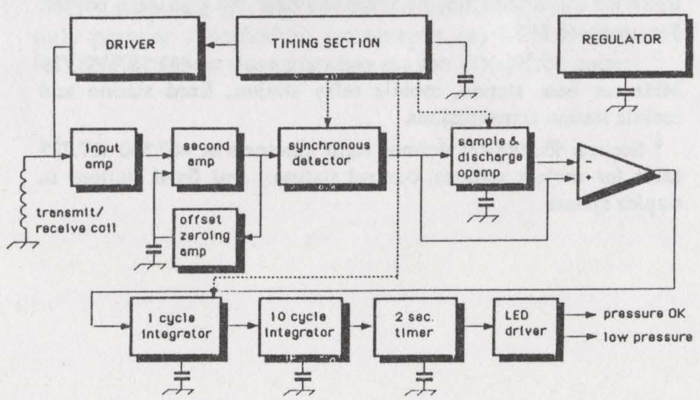
TIRE PRESSURE MICROSENSOR

Tire pressure measurement is another important input for automotive safety systems. For example, correct operation of antilock braking systems depends on proper tire inflation. In addition, under-inflation can decrease tire life by as much as 30 percent. And, although automakers now offer run-flat tires that continue to run flat for a limited number of miles, low-cost sensors to alert the driver of a flat tire condition, especially for trucks, are not yet available [2].

IC Sensors and Concha Corporation have reported a new tire pressure microsensor specifically for automotive applications [2]. A diaphragm is etched into silicon and it is sealed to a glass substrate to form a vacuum reference chamber. As long as tire pressure exceeds a specified setpoint level, sensor resistance remains low due to tire air-pressure-maintained contact between the diaphragm and the substrate. Low pressure is indicated by an abrupt increase in sensor resistance occurring when the diaphragm straightens away from, and breaks contact with, the substrate. No batteries are required because the tire pressure microsensor communicates with the vehicle by means of 160-kHz telemetry, wherein a high-level transmit signal charges a capacitor in the microsensor receiver circuit to remotely energize the microsensor on-chip circuit [2].



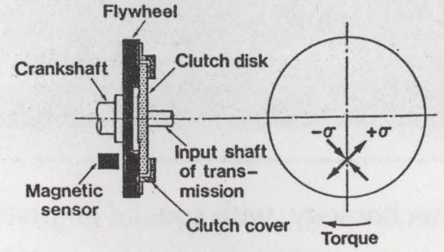
Cross Section of Tire Pressure Microsensor [2]



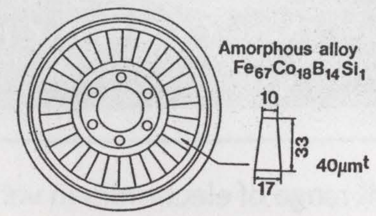
On-Vehicle Tire Pressure Signal Processor [2]

NONCONTACT TORQUE SENSOR

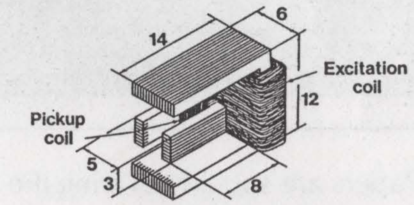
A new noncontact, magnetic-based torque sensor has been reported for automotive engine applications [3]. Installation of the sensor does not require special space or significant engine modification. Changes of magnetic permeability in the engine flywheel, caused by engine torsional stress, are measured by a noncontact Crossductor-geometry magnetic sensor. (This approach is not new, having been patented by Templin in 1979, where an electromagnetic noncontact pickup was used to measure engine flywheel torque [4]). To insure a homogeneous magnetic surface on the flywheel, 40-micron-thick films of magnetostrictive amorphous alloy material are bonded onto the flywheel. Further work is needed to overcome temperature and engine-speed sensitivities in the sensor zero offset output signal, and to verify the long-term integrity of the bond between the amorphous film segments and the flywheel.



Noncontact Torque Measurement



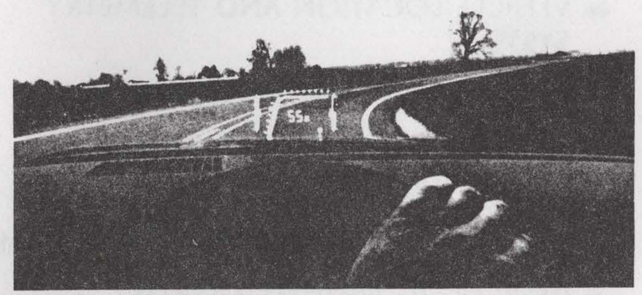
Amorphous Magnetic Film Segments Bonded to Engine Flywheel

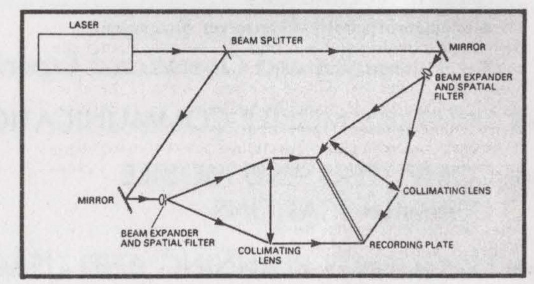


Crossductor-Geometry Magnetic Sensor

AUTOMOTIVE HEAD-UP DISPLAYS

PPG Industries and GEC Avionics have recently reported new types of head-up displays (HUDs) for automotive application [5,6]. The displays are focused ten feet in front of the windshield so that the driver can monitor it without diverting attention from the road; i.e., the driver actually looks through the HUD, not at it. A liquid crystal display presents the information, and an illuminator projects the LCD image through a series of lenses to a holographic screen in the windshield. The holographic screen is a color-selective mirror that remains transparent except for the specific color of light used in the HUD.


PPG Industries HUD Unit [5]



GEC Avionics HUD Schematic Diagram [6]

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