IEEE

VEHICULAR TECHNOLOGY SOCIETY NEWSLETTER

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FCC issues opinion and order on digital radio systems

Friends of electrical engineers are in short supply

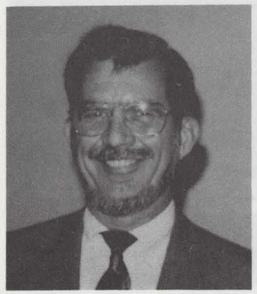
Railroad installs a digital radio system to replace an open-wire pole line.

Vehicle collision avoidance systems are developed

Wireless personal communications meeting is in June at Virginia Tech

Call for Papers: Satellite systems & travelers' services

Madden's Message



Roger Madden
President

We have a new Newsletter Editor, Bob McKnight, who takes over from Kent Johnson who was elected Treasurer of the Society. My heartiest congratulations to Kent not only on his election but for his outstanding achievement of editing the Newsletter for over a decade with much success.

It has been mentioned that something should be done to make the Newsletter look more professional so that it better reflects the professionalism of the Vehicular Technology Society and its membership. In this respect, you may have noticed a change in the last issue. It was typeset by the IEEE at their Piscataway Services Center. We will continue that practice.

This May VTS Conference provides a unique opportunity for the radio and vehicular electronics people to mingle with railroad and transit people from our Land Transportation Division. Not only can everyone get to know each other, but I am sure there are much items of interest to both groups. Also, we have one common attribute, we are electrical engineers.

So I offer this suggestion to both groups, let's mingle, talk with each other and attend sessions in both Vehicular Technology and Land Transportation.

My thanks to all those who have worked to make this St. Louis conference the success it deserves, and these good wishes go not only to the various committees handling registrations, lunches, tours and the various technical sessions, but to the many authors who have prepared these fine technical papers. Heartiest congratulations to you all.

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Editor's Corner

Robert W. McKnight

As you can see, a new editor has arrived at the Vehicular Technology Newsletter. For one thing, I offer my heartiest congratulations to Kent Johnson for his splendid stewardship of the VTS Newsletter for over a decade, In fact in looking back we find that Kent became editor with the November 1978 issue and interestingly it was the issue in which Roger Madden became President of VTS. In the February 1991 Newsletter, Kent announces his change from Editor to Treasurer, and Roger Madden is the new President. So the circle has been completed.

A couple of housekeeping items such as:

- Who am I?
- Will there be changes in the Newsletter?

As for me, I have a Bachelor of Electrical Engineering from Clarkson University, 1950, and studied Journalism at Syracuse University. From 1951 to May 1958 I was associate editor of Railway Signaling & Communications, then editor to November 1973, when I became editor of The Signalman's Journal until October 1981 when I joined the Association of American Railroads Communication & Signal Division. I am now a Life Senior Member of IEEE having begun as student member of the AIEE and IRE in my college days.

Changes, some in style and format which you will perceive as slightly different appearance. For one, the type face will be Meridien 10 on 12, slightly larger,

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hence easier to read. And interestingly, the bold headings on departments and articles is Avant Garde Book Bold. IEEE Services at Piscataway, NJ does an excellent job of printing, type setting, etc. They type set the February 1991 issue, and will do so for future issues. They are professional graphics arts and printer specialists.

In addition to appearance, I hope we can bring you, the VTS members into participation in the Newsletter via Letters to the Editor, a forum of discussion section where various views can be printed concerning some aspect of the technology or impact of the technology on VTS, etc.

We are looking for articles on the application of technology in the areas of vehicles and transportation.

And that leads me into a name change for VTS from Vehicular Technology Society to Transportation Technology Society.

Transportation covers all types of vehicles and more including not only communications, but computers and control technology of vehicles and systems.

In 1975 Transportation Systems was begun in the VTS Newsletter with Ronald Rule as editor, then David B. Turner took over in 1980 and I picked it up in 1985. Early issues dealt with people movers, magnetic levitation and rapid transit in various forms, although most subways (heavy rail transit), some light rail, etc.

Thus there is some precedent for calling VTS the Transportation Technology Society. The November 1977 Newsletter had on its cover drawings of an airplane, train, bus, truck, automobile, people mover and communications tower.

As for technology, we are dealing with radio, controls and control systems, computers, safety and information collection and delivery where it is needed.

Interestingly, the IEEE does not have a Transportation Society, so with a new name, TTS, we could fill a much needed nitch in professional engineering organizations

In the latest issue of VTS Newsletter, it was pointed out that Dr. Isaac R. Barpal was elected Fellow of IEEE for "Leadership in introducing modern electronic TRANSPORTATION TECHNOLOGY in developing regions." I added emphasis on TT.

Keep those cards and letters coming.

Chapter News and Meetings

Gaspar Messina,
Chapter News Editor

Philadelphia Chapter of Land Transportation is active

For the first three months of 1991, the Philadelphia Chapter, Land Transportation Division, Vehicular Technology Society, has mixed practical railroad and transit subjects with railroad modeling.

The January meeting, which had 43 in attendance, featured Belknap Freeman, P.E., retired from Amtrak, and Michael McNamara, electrical engineer with Stone & Webster, and formerly with TAD Associates, discussed the Advanced Train Control System. ATCS is a joint venture of the Association of American Railroads and the Railway Association of Canada to apply computer and digital radio communications techniques to better manage today's railroads.

Considerable work is being done by the Southeastern Pennsylvania Transportation Authority (SEPTA) to improve its physical plant to serve the Philadelphia-Camden metropolitan area via rapid transit and commuter rail operations. At the February 1991 meeting, Frederick R. Childs, SEPTA project engineer, described system improvements on SEPTA's Chestnut Hill West Line (commuter rail).

In March, this LTD group went to the Franklin Institute to view the model railroad on display there and to hear Michael Littman, Associate Professor at Princeton University's Department of Mechanical & Aerospace Engineering, describe the workings of the computerized model train layout.

At the February meeting, 33 were in attendance and 34 were at the Franklin Institute meeting.

On May 17, 1945, the Federal Communications Commission made assignments to railroads, including 60 clear channels, each 60 KHz wide, in the 152-162 MHz band, and also shared channels in the 44-108 MHz band and 186-218 MHz band.

Meeting to be held on wireless personal communications in June

The Virginia Polytechnic Institute & State University at Blacksburg, VA will hold a symposium on wireless personal communications June 3-5, 1991. Held at the Donaldson Brown Center for Continuing Education, the symposium is sponsored by Virginia Tech's Mobile & Portable Radio Research Group and the Division of Continuing Education in cooperation with the IEEE Communications Society and the Vehicular Technology Society.

Starting at 9 am on **June 4, Session I** includes:

- An Overview of Emerging Wireless Communication Services
- In Quest of Truly Universal Communications by Donald C. Cox, Bellcore.
- Cellular Radio Perspective in a Large Market by William C. Y. Lee, PAC-TEL
- CDMA Cellular Systems for Personal Communications Networks by Donald L. Schilling, City College of New York.
- IEEE 802.11 Standards for Radio Local Area Networks by Chandos Rypinski, LACE.
- the Iridium Project by Bary Bertiger, Motorola.
- Can We, Should We, and Will We All Exist Together? Panel Discussion.

Session II begins at 2 pm.

- Research for Advanced Wireless Communications.
- Research Emphasis and Results of WINLAB by David Goodmam, Rutgers University.
- Advanced System Technologies for Wireless Communications by Joseph McGeeham, University of Bristol.
- Advanced Microcellular Handoff Strategies by Stephen Rappaport, State University of New York.
- Integrated Voice and Data Service over Wireless Local Area Networks by Dhadesugoor Vaman, Stevens Institute.
- Adaptive Cancellation of Acoustic Noise in Mobile Communications by John Proakis, Northeastern University.
- Mobile & Portable Radio Research Group Emphasis and Results by Ted Rappaport, Virginia Tech.
- Technology Drivers for Personal Communications, Panel Discussion
- 8 pm The History of Land Mobile and Personal Communications from the 20's to the 90's by Stuart Meyer, Past President, IEEE Vehicular Technology Society.

Session III 9 am June 5

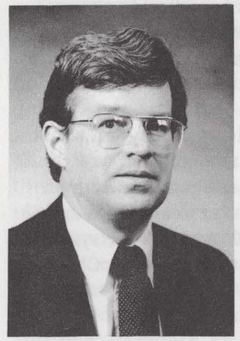
- Field Trials and Market Results.
- CDMA Spread Spectrum for Cellular Radio by Allen Salmasi, Qualcomm.
- Performance Results of WaveLAN by Bruce Tuch, NCR.
- Shared Spectrum Considerations in Design of Direct Sequence Personal Communications Networks, by Larry Milstein, University of California at San Diego.
- The Role of RAKE in Personal Communication Systems by Allan Schneider, Contel Technology Center.
- Distribution Techniques for Microcells by Tien Hou, AT&T Bell Laboratories.
- Comments from an Impartial Observer, Roger Newell, Microcell Report.
- The Role of Standards in Emerging Communication Systems, Panel Discussion.

Session IV 2 pm Open Floor Discussion and Closing Remarks.

Symposium registration fee is $185 and for more information call (703) 231-5182.

For lodging accommodations call (703) 231-8000 For more information contact Jack Lilly at the Donaldson Brown center at (703) 231-4849.

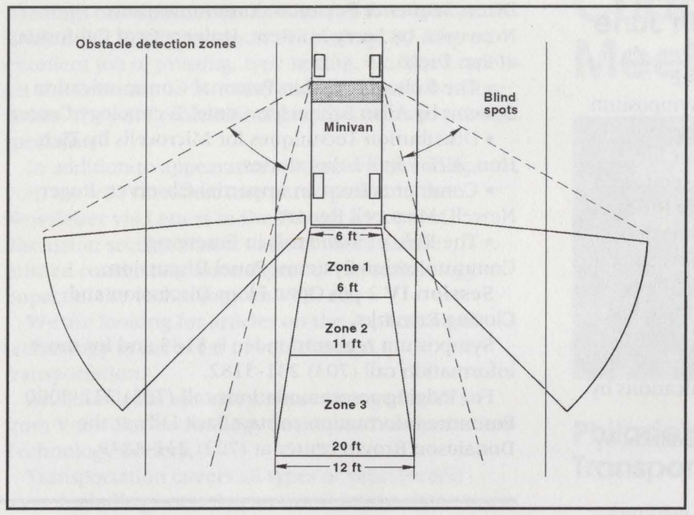
Vehicular Electronics



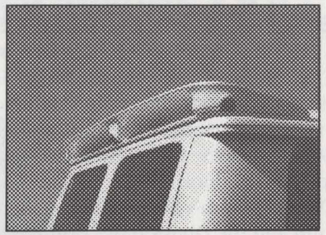
Bill Fleming,
Vehicular Electronics Editor

Chrysler Radar/Vision Warning Systems — Chrysler is interested in a new microwave sensor-based system that helps drivers avoid collisions during vehicle back-up and lane-change [I]. The system has been developed jointly by Safety First Systems Ltd. and General Microwave Corp.

FM-CW microwave sensors are utilized to obtain close-in range data for obstacles within 20 feet of the car. Putting the car in reverse gear activates the back-up parking aid [2]. Obstacles of dimension of about three-foot-square are detected at a range of 20 feet. One of three lights over the rear window flashes to alert the driver to a rear-end obstacle. Green light indicates that no obstacle is within 20 feet, amber if something is within 12 feet, and red if something is within 6 feet [1].



OBSTACLE DETECTION ZONES (BLIND–SPOT ZONES AND BACK-UP ZONES) FOR MICROWAVE SENSOR-BASED SYSTEM [1,2].



VIDEO CAMERAS MOUNTED ATOP THE SPOILER OF GM'S VISION ENHANCEMENT VAN [2].

TIM LEULIETTE'S THREE CHALLENGES [3].

If the car is in a forward gear, and the driver signals a lane change with the turn signal, the system spots approaching vehicles within blind zones on both sides of the car [2]. For warning, a red light flashes in the side-view mirror, alerting the driver to the presence of an approaching vehicle in area of blind vision.

To avoid potential liability issues, Chrysler is said to be promoting the system not as a collision-avoidance system, but rather as a parking aid [1]. The system will retail through car dealerships and audio shops for less than $500. A prototype system was recently demonstrated for NHTSA on a Chrysler minivan [1].

General Motors Vision Enhancement Van — GM combines miniature-camera TV vision (five onboard cameras) with microwave radar-based obstacle detection (two microwave sensors) [2].

Two of the TV cameras are up front and three are in the rear. Inside the van, three 5-inch, liquid-crystal, color flatpanel displays are mounted in place of the rear-view mirror. These give unobstructed view in all directions, with the driver selecting the desired three views from the five available camera inputs. (This sure sounds like the Hertz Rent-A-Car Bus rear-TV system to me.)

Just like the Chrysler system, the GM micro-wave system provides warning of obstacles when the car is backing up or changing lanes [2]. This is achieved using two sensors located at the corners of the rear bumper of the van.

"Three Challenges" — Tim Leuliette — In October 1990, Tim Leuliette, CEO of Siemens Automotive, gave the final address at Convergence '90 Conference in Dearborn, MI. His words were recently summarized [3], and warrant repeating here.

As the iron age merges with the silicon age, we face tough challenges. Let us recall that an essential key to widespread success of railroads was the standardization of rail track gauge which allowed all railways to share and build upon each others right-of-ways.

Today's challenges are in the areas of data communication protocols and multiplex standards that must be standardized worldwide. This will allow cars to talk to other maker's diagnostic equipment and be equally able to communicate with highways (i.e., tomorrow's electronic highways).

Moreover, although the U.S., Japan, and Europe are each pursuing their own type of intelligent vehicle highway system, we don't need three different IVHS systems. We don't have the money, or the people, to reinvent the wheel three times over. If we do this, we all lose. Industry will lose lucrative markets, governments will be criticized for inability to handle problems, and traffic jams will degenerate into gridlock.

Just as railroad prosperity came when rail gauges became standardized, so will transportation electronics find unparalleled levels of prosperity when multiplex, data protocol, and IVHS systems converge onto common standards.

Finally, Tim Leuliette points out that to do this we'll need leaders, not managers; leaders who encourage risk-taking and the entrepreneurial approach to technical endeavors [3].

Electronic Crash-Sensing Breakthrough — There were 38 papers in last February's SAE International Congress on the subject of automotive sensors. Everyone's consensus best new sensor development was TRW's new approach to crash-sensing [4].

Present crash sensors, whether mechanical or electronic, integrate only the magnitude of the sensor signal. Consequently, their performance is diminished by remote location for example in the passenger compartment.

What makes the TRW sensor different is not really the sensor, but the way additional aspects of the sensor signal are processed. By computing a sliding-time-window Fast Fourier Transform (FFT) of a wide-bandwidth, wide dynamic-range, micro-accelerometer signal; TRW is able to achieve early detection of crashes, even when a single sensor is mounted in the passenger compartment. The FFT signal is pre-filtered to eliminate interfering zero-frequency and body-crunch higher-frequency signal components. Thus, only mid-range frequency components directly related to the severity of the crash event itself are retained.

In essence, instead of looking at the integral of vehicle crash velocity, the FFT signal looks directly at a integral of vehicle energy, only in that portion of the frequency spectrum associated with severity of the crash event.

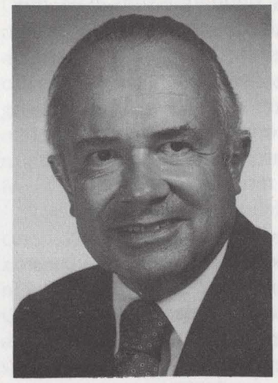
(It is noted that although Bob Diller of TRW Technar Division presented the paper, R&D colleagues of mine at TRW Vehicle Safety Systems Inc. — Brian Blackburn, Joe Mazur, and Scott Gentry — first invented this new approach to crash sensing, and a number of U.S. patents are now pending, many of which should issue by the time you read this newsletter.)

REFERENCES

1. "Radar Warns Driver of 'Blind Spot' Obstacles," *Design News*, p. 26, February 11, 1991.
2. W. Siuru, "Electronic Backseat Drivers Get Around Roadblocks," *Machine Design*, pp. 101-103, January 10, 1991.
3. T. Leuliette, "Three Challenges For Our Times," *Test & Measurement World*, p. 7, February 15, 1991.
4. R. Diller, "Electronic Sensing of Automotive Crashes for Airbag Deployment," SAE Paper 910276, SAE International Congress, Detroit, MI, February, 1991 (*SAE Special Publication P-242*, pp. 65-68).

In 1952 the Baltimore & Ohio Railroad built transistor amplifiers into each telephone subset used in their telephone train dispatching system which permitted those on the ends of long circuits to clearly and distinctly hear the dispatcher.

Professional Activities



Frank E. Lord
Professional Activities Editor

Friends of engineers are in short supply

The title of the column is taken from a piece that Bob Rivers (F) originated recently which I will quote from extensively, adding a few remarks of my own. Bob started promoting the interests of engineers in the early seventies through a subcommittee of the Microwave Theory and Techniques Society (MTT). There were other similar committees that sprung up throughout institute entities at that time all of which played a role in the eventual amendment of the IEEE Constitution that permitted us to pursue professional goals for engineers. The employment climate in those times was much like that of today, not too favorable for engineers. Incidentally, Rivers was subsequently elected President of MTT and later served on the Institute Board of Directors.

The goals referred to are stated in an IEEE document listing professional needs of engineers. The term "needs" is used in the sense that Maslow employed when formulating a hierarchy of needs that must be met if a person is to function constructively and effectively in life and, by extension, in a professional life. Bob's article discusses two of six needs that were established, namely:

1. A lifetime career with adequate compensation and retirement benefits.
2. A positive work environment that provides technical challenges and incentives for creativity.

He observes "We can give little credit to IEEE for success in meeting these goals."

Bob continues, "Despite the goal of a lifetime career, we see significant numbers of engineers

exiting the profession, starting at age 50, with a median age exit of 63. Adequate compensation has not been achieved, since salaries have been lagging the CPI adjusted figures, since the mid sixties. Retirement benefits, except for the establishment and then downscaling of IRA and some early retirement incentives to avoid age discrimination suits, have not been enhanced. Far from it, we see massive corporate recapture of retirement funds. The work environment has not been significantly enhanced, since we see continuing use of engineers in sub-professional tasks. Every effort to obtain incentives for creativity through patent reform has been stymied by industry resistance.

"The above two items define areas of conflict between Engineers, the Government, Managers, Industry Leaders and Educators, where Engineers are defined as those DOING engineering. Government, through its National Science Foundation, has been a promoter of engineering enrollment aimed at producing a supply of engineers 'erring on the side of plenty,' while other elements of NSF were promoters of gross SHORTAGE claims.

"Managers and industry Leaders are promoters of enrollments and excess supply, so that each can choose from the top 10% of any graduating class. Since most Managers and many Industry Leaders have only a 3 month optimization horizon, they have little concern for the effect of excess supply on the careers of those in the profession and those entering the profession. The need for 3 month optimization forces the decision to treat Engineers as commodities, to be selected and retained on the basis of optimum short-term price/performance. Through their membership and dominance of Engineering organization, they tend to prevent any action disturbing their desired optimization.

"Educators are heavily represented in Engineering organizations. They tend to promote activities aimed at increasing engineering enrollments, even though their tenured status allows them to promote Professional goals of Engineers. Such enrollment promotes an excess supply of engineers and threatens those in the profession.

"The friends of Engineers are not Government, Managers, Industry Leaders or Educators, but Engineers. And not all Engineers. Not the Engineers who get laid off, think "it must be my fault," and learn nothing from the experience. Not the Engineers whose overwhelming apathy precludes their doing anything for the profession. Not the new graduate Engineers who think "I'll keep my nose to the grindstone, and my innate genius will prevail." The friends of Engineers are in short supply."

Although my own observations generally agree with Bob's, I hasten to point out that I observe quite a few educators working for an improved profession. After all, it could be the easier way to keep the classrooms full. I also observe members who would certainly be considered managers working toward the achievement of professional goals. Some of them realize that their rewards as engineering managers, although somewhat better than those of whom they lead, nevertheless, merely track them. Unfortunately, I have also observed member office holders who not only speak against professional activities, but actively attempt to hinder them. These people are actually acting against the Constitution and if too small to decline to hold office, should be removed by other action. Perhaps we should require the taking of a loyalty oath.

Any member is welcome to express himself/herself on this subject in this column by submitting their thoughts to me.

Call for Papers

Satellite systems & travelers' services papers wanted

The IEEE Journal on Selected Areas in Communication in cooperation with the IEEE Transactions on Vehicular Technology is issuing a call for papers on an issue to be devoted to emerging mobile and portable satellite systems aimed at providing different communication and radiolocation services for travelers.

Original contributions describing new results of applications of existing or future mobile and portable satellite systems employing geostationary and nongeostationary satellites are invited.

The following aspects of mobile satellite systems and services are desired:

- Communication and navigation system and services.
- Frequency management and sharing.
- Terrestrial/satellite mobile system compatibility and integration.
- Propagation and performance measurements.
- Multiple access and channel modeling.
- Digital and analog voice schemes/codecs.
- Modulation schemes, coding, interleaving, synchronization.
- Signal processing (baseband and IF/RF) for a mobile/earth/space segment.
- Power amplifier and antenna technologies.
- Miniaturization and power consumption issues.

Prospective authors are to submit 6 copies of their manuscript to one of the following Guest Editors by September 2, 1991:

Dr. Andy D. Kucar, Bell Northern Research, 249 Temby, Ottawa, Ont. K1T 2W6, Canada. Phone: (613) 765-2733. FAX (613) 765-2592.

Dr. Yasuo Hirata, KDD, 2-3-2 Nishishiauku, Shinjuku-ku, Tokyo 163, Japan, Phone: (813) 347-7102, FAX (813) 347-6362.

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FCC News

FCC adopts new rules for 220-222 MHz band

The Commission has established service rules for use of the 220-222 MHz band by private land mobile licensees. Creation of these new service rules for land mobile use will aid in promoting the evolution and further development of narrowband technology. (PR Docket 89-552) (March 14, 1991)

In 1988, the Commission reallocated the 220-222 MHz band from the shared fixed, land mobile, and amateur services to private and federal government land mobile use only. The Commission's objective in reallocating these frequencies was to provide unused spectrum for the development of spectrally efficient narrowband technologies. Today's action established rules by which the Commission can grant licenses for land mobile service in the reallocated band.

The 2 MHz available in the 220-222 MHz band will be allocated in 400 five kHz-wide frequencies, paired to create 200 narrowband channels. Channels will be set aside for nationwide and local applicants. Ten of the nationwide channels will be set aside exclusively for Government use. All of the local channels will be available on a co-equal basis for Government and non-Government licensees.

The Commission said that all applications for licenses in this band will be granted on a first-come, first-served basis. Applications filed on the same day for more than the number of channels or channel groups available will be subject to a lottery. Non-nationwide licenses will have a five-year liceense term and must be constructed and placed in operation within eight months of the license grant. Because nationwide licensees will need a significant period of time to implement their systems, they will have a 10-year license term and their systems must be constructed and placed in operation according to a schedule of benchmarks at 2, 4, 6 and 10 years.

Finally, applications may be filed only for primary land mobile uses, although fixed and paging uses ancillary to land mobile operations will be permitted. All transmissions must meet certain technical standards. The Commission is adopting fixed mileage separation criteria to permit co-channel reuse for non-nationwide channels.

Applications will be accepted for filing beginning the second day after publication of this Report and Order in the *Federal Register*. Applications for nationwide licenses must be accompanied by the appropriate filing fee ($35 per call sign — a separate call sign is required for each channel in each geographic area). For example, a 10-channel nationwide system serving a required minimum number of 70 geographic areas would have a filing fee of $24,500.

Nationwide licensees must meet financial and construction entry criteria for an application to be acceptable for filing. Because Commission collection of information regarding these criteria is subject to Office of Management and Budget (OMB) approval, applications for nationwide licenses may initially be submitted without this information. While this guarantees applicants a "place in the processing line," the Commission will, after OMB approval, require this information to determine final acceptability of filed applications.

Amateurs must discontinue all operations in the 220-222 MHz band 90 days following the effective date of these rules.

"We encourage the development of advanced technologies to relieve congestion. A prime example is the Intelligent Vehicle Highway System, which integrates a driver, the vehicle, and local highways through electronic guidance, warning, and control systems. High speed railroads and magnetically levitated trains hold promise for the future, and are encouraged by this bill. We are also supporting state of the art toll collection systems that can electronically 'read' specially marked cars and register a toll without requiring the car to stop. The driver can then be billed through the mail."

So stated Transportation Secretary Samuel K. Skinner in announcing the Administration's Transportation Assistance Act of 1991.

In 1951, the Richmond, Fredericksburg & Potomac Railroad installed a complete road-train radio system which provided two-way communication between the dispatcher's office and trains as head-to-rear and train-to-train. On the 110 miles between Richmond, VA and Washington, DC, 5 unattended wayside radio stations were connected to the dispatcher's telephone line circuit.

Transportation Technology

Radio-based system replaces pole line

CSX Transportation has replaced an open-wire pole line with a radio-based code line. A paper describing this system was presented by W. J. Sch Scheerer, Chief Engineer, Train Control, CSX Transportation, and M. D. Bauer, Director Research & Development, Safetran Systems Corp. at the Communication & Signal Division, AAR, annual technical conference in Atlanta, GA in 1990. It is reprinted here with thanks to C&S, AAR, and the authors.

Polelines and physical wire circuits have occupied railroad rights-of-way since the introduction of telegraph in the 1800's as a means of dispatching trains. Originally, Morse code messages were transmitted to wayside telegraph operators providing the basic permit to proceed. Later, control currents were used via wire to set flags or signals to accomplish this task.

Today, polelines continue to be used for wayside communications circuits as well as for signal functions such as codelines, vital signal control circuits, and signal AC power distribution. The addition of signaling carriers and signaling protocols to the non-vital communications links have provided higher speeds and more flexible signaling circuits.

The one element which has remained common to the signaling system during this evolution is the physical wire on the poleline.

Polelines and their physical wires, despite their historical contribution to our industry, are vulnerable to storm damage, vandalism, and expensive rehabilitation costs as they deteriorate with age. They are expensive to operate due to the constant need to maintain poles, wires and insulators as well as the continuing need for brush and tree removal. Trains are frequently delayed due to line wire breaks during ice and wind storms, and by malfunctions associated with leakage currents caused by rain or frost.

Signal and communication engineers have considered many alternatives to polelines over the years, but due to the cost of available technology, AC power distribution problems, the requirement for dispatcher block telephones, and the use of DC code transmission schemes, the elimination of existing polelines did not prove to be economically feasible. Today, this economic picture has changed dramatically, primarily because of new developments in both signal and communication technology.

Open wire communications facilities are rapidly disappearing. Micro-wave radio, fiber optic-cable systems and "800" in-watts services coupled with fewer line-of-road headquarters locations have eliminated message and long distance trunk lines as a means of providing administrative telephone services.

The open wire circuits used by dispatchers for train operations have likewise been replaced by micro-wave and fiber while wayside radio and highly sophisticated radio control systems have made the wayside telephone obsolete.

This evolutionary process in the communications field has left signal circuits the only remaining occupant on many miles of once joint communications and signals poleline. Economical elimination of signal poleline demands that all three Functions, i.e., vital signal control circuits, AC power distribution and signal codeline be removed from the poleline simultaneously.

The introduction of highly reliable microprocessor based electronic track circuits have resolved the vital signal control issue by performing this task using rails rather than wires as the transmission medium for exchanging bidirectional vital data. At the same time these devices provide for control of automatic signals without the use of relays, a significant benefit in its own right.

The AC power distribution problem is easily and effectively solved by providing commercial power feeds at those locations where commercial power is readily available. At locations which are inaccessible or where costly power line construction is required, recent advances in solar power have proven to be an effective method of providing the necessary, power supply.

The final poleline function, which is the signal codeline, has proven to be the most difficult problem for CSX. Several alternatives to the traditional open wire codeline for the control and indication data associated with traffic control signaling have been used over the years with varying levels of success. Micro-wave links and fiber-optic drops have high levels of cost for the limited data delivery and transmission requirements at each control point. Leased lines (where available) have lowered the initial cost, however, the monthly lease costs have escalated costs to levels similar to those of poleline maintenance. Underground cable has also been used, however installation costs are high and exposure to cable cuts has proven to be significant. Clearly, what we needed was a technology that was economical to install, economical to operate, required no physical conductors, and which provided all the services presently provided by existing codelines including a voice channel for maintenance use. Furthermore, such a system should be able to replace existing relay type code equipment with a minimum of field wiring changes and a minimum of change to the control system located at our centralized operations center in Jacksonville, Florida.

The alternative of a radio based code control scheme appeared to have the potential to meet the challenge.

One such alternative is point-to-point radio with 6 to 12 channels. The number of channels available and the moderate cost per installation for installations averaging only 5 to 10 miles apart serve to limit its success.

Another alternative and the one ultimately selected, is **point-to-point multipoint radio**. Interest in this technology has grown steadily over the past few years due to its inherent low cost for data channels which utilize a narrow band radio channel. The operation of a point-to-multipoint radio system is similar to that of a mobile radio system. The remote radios, however, are at fixed points.

Having selected a point-to-multipoint scheme for data, attention was focused on frequency selection. VHF radio was investigated first, however, FCC Rules applicable to VHF railroad radio frequencies require that data be on a secondary basis to voice. Voice and data sharing protocols were explored with minimal success. Management of the voice user in relation to the data application being the limiting factor.

A review of other frequencies authorized for primary data application shows that the 450 Mhz splinter (12.5 Khz) and the 928-952 Mhz band to be available for Signal Control and Data Acquisition. Although the 450 Mhz splinter has antenna height restrictions, the 928-952 Mhz frequencies do not. The effect of the height restriction requirement is somewhat reduced due to the fact that radio range at 450 Mhz is generally greater for a given antenna height than at 900 Mhz.

The 928-952 Mhz frequency band, while attractive, is shared by all land mobile services. Utilities, pipelines and various businesses were using all available frequencies in certain areas. A release of additional frequencies was under consideration by the FCC (and released for assignment in 1990), but with the number of users waiting, it did not appear promising for use in an application intended to operate over a wide area.

What was clearly needed was a group of frequencies dedicated to the Railroad industry. Such a group of frequencies exists in the group assigned for use by ATCS systems, however, ATCS requires a contention protocol. The standards for signal code control systems on the other hand, had evolved almost exclusively into polled protocols. The exception is the relay time code systems which are much too slow to be compatible with the high speed ATCS protocol.

The AAR was approached concerning the use of the ATCS frequencies on a demonstration system

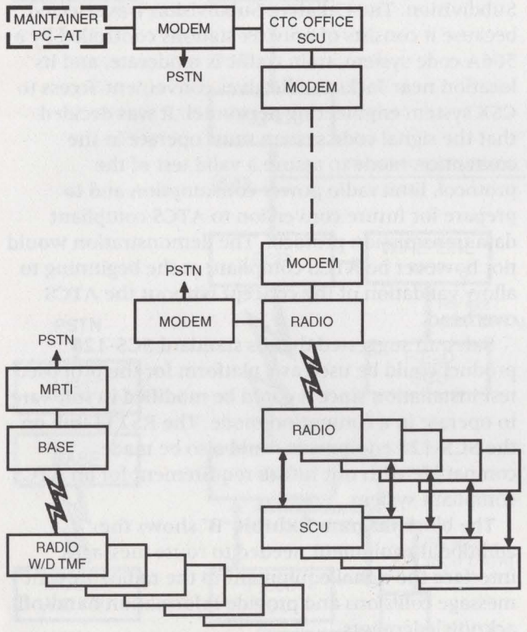


Exhibit A: Polled Signal System

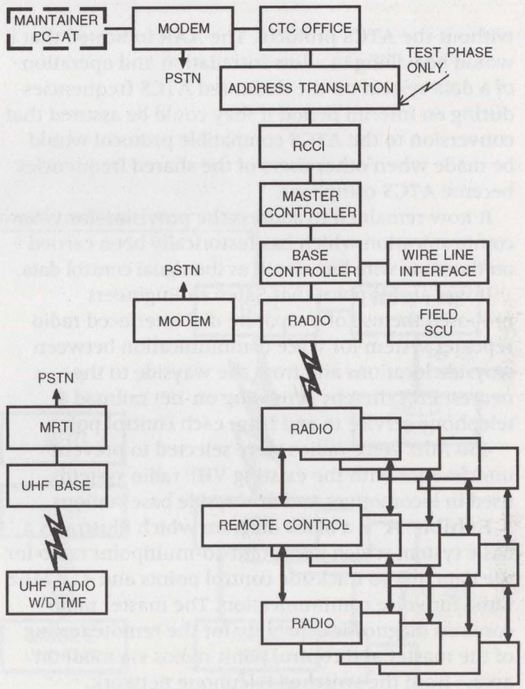


Exhibit B: Contention Mode Demonstration

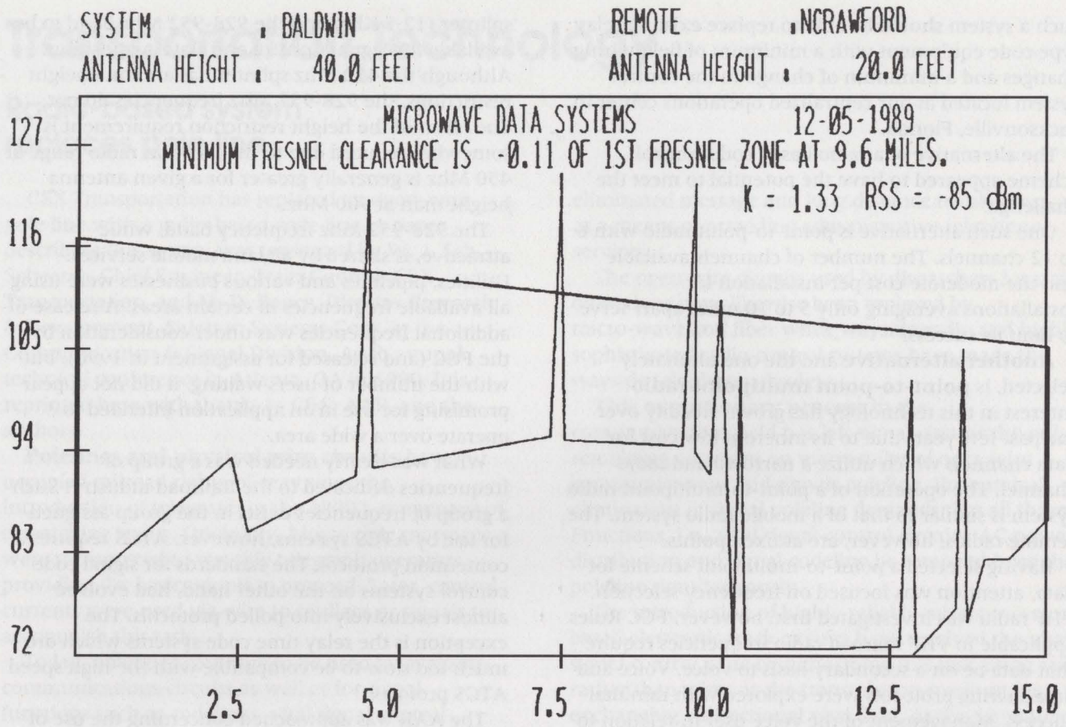


Exhibit C

without the ATCS protocol. The AAR indicated that it would be willing to allow installation and operation of a data system on the dedicated ATCS frequencies during an interim period if they could be assured that conversion to the ATCS compatible protocol would be made when other users of the shared frequencies became ATCS compliant.

It now remained to address the provision for voice communication which has historically been carried on the same wire line circuit as the signal control data.

It was at this point that Safetran Engineers proposed the use of a separate dial interfaced radio repeater system for voice communication between wayside locations and from the wayside to the nearest PBX thereby providing on-net railroad telephone service to and from each control point.

450 Mhz voice radios were selected to prevent interference with the existing VHF radio systems used in locomotives and at wayside base stations.

Exhibit 'A' is a block diagram which illustrates a basic system which uses point-to-multipoint radio for the data link to trackside control points and 450 Mhz radio for voice communication. The master radio contains diagnostic capability for the remote testing of the master and control point radios via modem access from the switched telephone network.

In order to determine the feasibility and reliability of the proposed system, CSX made the decision to install a demonstration system on its Callahan Subdivision. The Callahan Subdivision was selected because it consists of only six stations controlled by a 506A code system, train traffic is moderate, and its location near Jacksonville gives convenient access to CSX system engineering personnel. It was decided that the signal code system must operate in the contention mode to assure a valid test of the protocol, limit radio power consumption and to prepare for future conversion to ATCS compliant data transmission protocol. The demonstration would not however be ATCS compliant at the beginning to allow validation of the concept without the ATCS overhead.

Safetran suggested that its standard SCS-128 product could be used as a platform for the proposed test installation since it could be modified in software to operate in a contention mode. The RS232 link on the SCS-128 equipment could also be made compatible with our future requirement for an ATCS compliant system.

The block diagram **Exhibit 'B'** shows the additional equipment needed to route messages, interface the signal equipment to the radio, prevent message collisions and provide information hand-off acknowledgments.

The terrain traversed by the Callahan Subdivision is relatively flat over a near surface water table.

Cypress and southern pine are the predominate vegetation. The master radio site will be located at the Baldwin control point providing the opportunity to test a non RF link to that control station. The site is also ideally placed for future expansion of the system from Baldwin to Wildwood, Florida. The five remote stations served by the master radio locate at points ranging from 3.5 miles to 19.0 miles from Baldwin. A typical path profile for an intermediate remote control point is shown as information as **Exhibit 'C'**.

The SCS-128 equipment will be interfaced to the existing type KP final stick relays by connecting to the existing wiring near the existing 506A LCS unit. This will minimize the number of wire changes that must be made within the existing control point bungalow.

The interface to the control machine will be accomplished by providing an SCS-128 standard polled protocol to the Safetran master controller from a standard RCCI (Remote Code to Computer Interface) which presently drives the 506A line, The master controller will then provide the conversion necessary to provide the contention mode operation and protocol used by the radio transmission scheme. The radio link will support up to 4800 bps data rates without the ATCS protocol.

During the project's test phase, the 506A code data format will be converted to SCS-128 format by intercepting and converting all control and indication messages between the Jacksonville control machine and the RCCI. The code conversion module is a microprocessor based device built and programmed by CSX. This method of interfacing the control machine allows switching between the existing 506A system and the Radio Based System to be completely transparent to the control machine hardware and software. Final cut-over requires only the retabling of the control machine's line data base from 506A to SCS-128 and removal of the code conversion module. The RCCI will be retained so that all codeline diagnostic and emergency dial backup systems will continue to operate without the necessity for special software support within the control machine environment. Continued use of the RCCI will also make the conversion from the ATCS non-compliant to ATCS compliant systems transparent to the Jacksonville control center equipment.

Exhibit 'D' illustrates the equipment arrangement envisioned for the fully ATCS compliant system. While the demonstration system is very similar to the compliant system, it simply does not have all the features incorporated at the outset thereby allowing the testing of system concepts prior to development of ATCS compliant software. The software and packaging of equipment are the major differences between, the two.

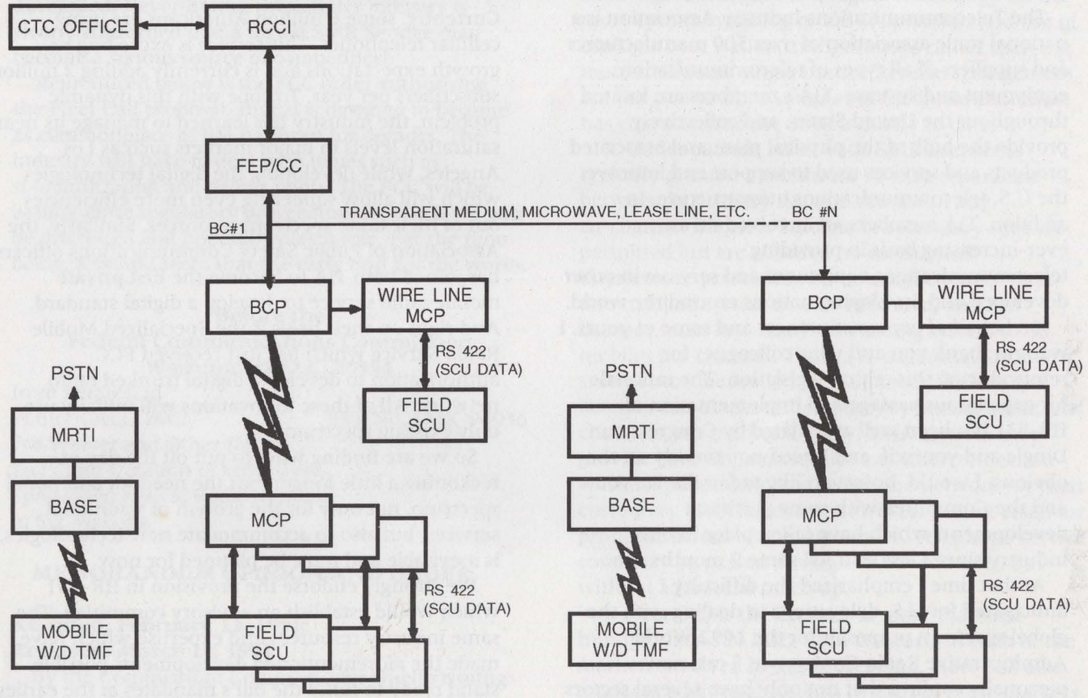
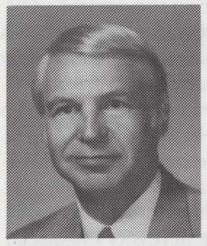


Exhibit D: ATCS Signaling System

Washington News



Eric Schimmel,
Washington News Editor

TIA gives Congress views on spectrum

Appearing before the Subcommittee on Telecommunications and Finance of the House Committee on Energy and Commerce, Eric Schimmel, vice President, Telecommunications Industries Association, presented TIA comments on House Bill HR-531. Below is his testimony.

Mr. Chairman and Members of the Subcommittee, I am Eric Schimmel, Vice President of the Telecommunications Industry Association, where I am responsible for matters related to mobile radio, microwave, and satellite telecommunications.

The Telecommunications Industry Association is a national trade association of over 500 manufacturers and suppliers of all types of telecommunications equipment and systems. TIA's members are located throughout the United States, and collectively provide the bulk of the physical plant and associated products and services used to support and improve the U.S. telecommunications infrastructure. In addition, TIA members are involved on an ever-increasing basis in providing telecommunications equipment and services in other developed and developing nations around the world.

On behalf of my constituency, and some of yours, I want to thank you and your colleagues for reintroducing this critical legislation. The rationale for expeditious passage and implementation of HR-531 has been well articulated by Congressman Dingle and yourself, and I need not amplify on the obvious. I would, however, like to familiarize you and the Committee with some pertinent developments which have taken place in our industry since I last testified some 9 months ago.

At that time I emphasized the difficulty I anticipated for U.S. delegations in dealing with the global spectrum proposals for the 1992 World Administrative Radio Conference. I can now personally confirm that not only have several sectors of the U.S. telecommunications community been unable to submit positions in the preliminary forums, but they cannot even negotiate specific spectrum issues because the FCC cupboard is essentially bare. Simply stated, we do not know to what we can agree because the FCC does not know what it can deliver. Obviously this makes it very difficult for U.S. negotiators to assume a leadership role.

Frustration is also commonplace domestically. Our cordless telephone industry, albeit somewhat short on status and visibility, sold an estimated 12 million units in the U.S. last year, representing a contribution to our G.N.P. approaching one-billion dollars. It is estimated that the ten channels available for this service are accommodating some 30 million cordless phones. Let me repeat: Thirty-million transmitters on only 10 radio channels, half of which aren't even exclusive. What is really interesting about this is that these channels are primary government frequencies, negotiated for sharing by the FCC and NTIA. Now, with over six (6) years of successful sharing experience, the industry has been unsuccessful in persuading the FCC or NTIA to expand this meager allocation. The failure of the two agencies to resolve their own differences has not helped. The "ours" and "theirs" mentalities must give way to a mutual interest in solving this country's spectrum problems. We believe that the enactment of HR-531 can be the catalyst in accomplishing that goal.

TIA has serious concerns about the impact of spectrum limitations on the growth of our industry. Currently, some 6 million Americans are using cellular telephones. This service is exceeding its growth expectations and is currently adding 2 million subscribers per year. To cope with this dynamic problem, the industry has learned to manage its near saturation levels in major markets such as Los Angeles, while developing the digital technologies which will allow squeezing even more efficiencies out of their finite spectrum resources. Similarly, the Association of Public Safety Communications officers has joined with TIA to become the first private mobile radio service to develop a digital standard. And right on their heels is the Specialized Mobile Radio Service which has just received FCC authorization to develop a digital trunked radio network. All of these innovations will initially use only existing spectrum.

So we are finding ways to put off the day of reckoning a little longer, but the need for additional spectrum, not only for the growth of traditional services, but also to accommodate new technologies, is inevitable and must be planned for now.

We strongly endorse the provision in HR-531 which would establish an advisory committee. The same industry resources and expertise which have made the aforementioned developments possible, stand ready to fulfill the bill's mandates at the earliest opportunity. In the past, the private sector's access to NTIA spectrum data has been stifled by its classified status. I suggest that this impediment could be largely relieved by qualifying designated industry representatives for the necessary clearances. Certainly this is not unusual for government contractors and if made applicable to the implementation of HR-531, could in my opinion expedite achieving the intended results.

Lastly, on a personal note, I would like you to know that last week the Board of Directors of the IEEE's Vehicular Technology Society, of which I am a Director, adopted a motion to endorse the adoption of HR-531.

Competition, Innovation, or both due to FCC

Digital is definitely coming to Land Mobile Radio. Hot on the heels of the cellular telephone industry's adoption of digital technology, are a couple of private mobile radio services. The Associated Public Safety Communications Officer's Association has initiated its Project 25, which will jointly develop digital standards with TIA (Telecommunication Industry Association). Somewhat more dramatically, a segment of the specialized Mobile Radio Service has proposed to digitize its blocks of trunked channels to provide a cellular-like service. While this effort by Fleet Call, Inc. may produce a de-facto standard, no industry-wide standardization effort has yet developed. Nevertheless, the cellular industry is clearly concerned that a digital SMR Service may become a serious source of competition.

Reproduced below is the FCC order authorizing the Fleet Call proposal. Digital is destined to become as commonplace as FM has been for decades. The industry will have to deal with issues such as standardization and patent rights. The FCC will be issuing more regulatory proceedings in which we will be interested and hopefully play a role. For the time being, it would seem that the early bird got the worm.

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

In re Request of
FLEET CALL, INC. File No. LMK-90036
For Waiver and Other Relief
To Permit Creation of Enhanced
Specialized Mobile Radio Systems
in Six Markets

MEMORANDUM OPINION AND ORDER

Adopted: February 13, 1991;
Released: March 14, 1991

By the Commission: Commissioner Quello issuing a separate statement.

INTRODUCTION

1. Fleet Call, Inc., and its subsidiaries (Fleet Call) have asked the Commission for waiver and other relief to permit creation of wide-area digital Specialized Mobile Radio (SMR) systems in six frequency congested markets: Chicago, Dallas, Houston, Los Angeles, New York, and San Francisco. We have before us this waiver request, together with comments and reply comments filed in response to our Public Notice of April 12, 1990, soliciting comments on the Fleet Call proposal. Review of this record convinces us of the general merits of Fleet Call's proposal. We conclude, however, that is not necessary or appropriate to grant Fleet Call the full scope of the requested relief. Hence, we will provide Fleet Call with a waiver of the one-year construction period provided by 47 C.F.R. § 90.631(e).

BACKGROUND

2. We created Specialized Mobile Radio (SMR) as an open entry, competitive service, believing that this approach would stimulate the development and production of spectrally efficient trunking technology, provide the flexibility necessary to meet existing and new user needs, and enhance the development of new techniques and services. Over the years, we have affirmed our commitment to competition and flexibility and have encouraged SMR licensees to develop new, more efficient operations. SMR licensees have responded to this challenge. Substitution of digital technology for the more common analog mode of operation and use of multiple base station configurations rather than the more traditional single transmitter site arrangement are but two recent examples of the innovation that has characterized the SMR industry to date.

3. Under current rules, each SMR licensee is typically granted a minimum 70 mile separation between its primary site and the site of any co-channel licensee. Satellite or secondary sites are permitted but are afforded no co-channel interference protection. To be assigned more than one trunked system in a 40 mile area, an SMR licensee must first "load" its existing system to 70 mobiles per channel. Thus, a five channel SMR system must be loaded to 350 mobiles before the licensee can obtain either a new system or additional channels in a market. Finally, SMR systems may provide both dispatch service and interconnection with the public switched telephone network for their customers. SMR licensees, however, cannot resell for profit the actual telephone service. Telephone service costs may be passed through to the end user, but without additional mark-up.

4. Fleet Call is the licensee of more than one hundred fifty 800 MHz SMR channels in each of the markets involved in this proceeding. Fleet Call also manages additional systems in each of these markets. Fleet Call represents that it currently provides

dispatch, interconnect, and related services to more than 150,000 users. It asserts, however, that the explosive growth of demand for SMR services in these markets is exhausting the capacity of its systems. As a result, Fleet Call states, it has looked for innovative ways to use its available spectrum more efficiently to increase capacity and provide the full scope of private mobile radio communications services, desired by today's diverse array of users. To this end, Fleet Call introduces in its waiver request what it calls Enhanced Specialized Mobile Radio (ESMR) service.

THE FLEET CALL PROPOSAL

5. Fleet Call states that its proposed service will provide high quality, innovative, and spectrally-efficient mobile communications service to the public. Fleet Call wishes first to convert its existing analog systems to digital transmission systems using Time Division Multiple Access (TDMA) multiplexing technology. According to Fleet Call, conversion to a digital TDMA system will allow a minimal of six digital channels from each existing 25 kHz wide 800 MHz analog voice channel. Fleet Call will then combine all of its channels in each market into a multi-site, low-power base station configuration employing frequency reuse throughout the system. The individual low-power base stations will be operated through a centralized switching facility providing seamless "hand-off" of communications on mobile units moving throughout the service area. Fleet Call claims, in this regard, that the combination of TDMA digital transmission technology and frequency reuse through multiple, low-power base station sites will achieve a fifteen-fold (or more) increase in the capacity of its systems over the capacity of existing analog trunked systems in each of the congested markets.

6. Fleet Call states that its systems will offer greater capacity for the broad array of private land mobile radio services that SMRs are now permitted to offer. Fleet Call claims, for example, that it will be able to provide wide-area dispatch communications coverage throughout the congested markets. This coverage will include, because of system design, automatic hand-off of calls as mobile units travel throughout the market area. Further, Fleet Call says that its advanced system will allow it to customize voice dispatch service, non-voice dispatch service, and mobile data communications. Fleet Call states that it will be able to offer location-specific sub-fleet or single mobile dispatch services in which a dispatcher dynamically identifies the specific mobile units closest to a desired location and calls only those units. This, according to Fleet Call, reduces the number of radio links necessary for dispatch communications and minimizes the geographical area blocked by each transmission.

7. Fleet Call also asserts that increased capacity will improve capacity to interconnect to the public switched telephone network. Fleet Call states that the capacity that its proposed systems promise will allow it to provide interconnected service with blocking levels comparable to those of the public switched telephone network. Fleet Call will not, however, resell interconnection service for profit. Finally, Fleet Call maintains that the digital nature of the proposed service will furnish police and fire departments, local governments, and other public-safety related communications entities a higher level of communications privacy than has been possible on traditional SMR systems.

RELIEF REQUESTED

8. To establish and operate its systems, Fleet Call seeks relief in several areas. First, Fleet Call requests that we issue for each of its six markets a single system-wide license that will authorize construction and operation of multiple, low-power base stations, each one permitted to operate on any of the 800 MHz channels licensed to Fleet Call within that market. Low-power base stations will be located at least 48 miles from any co-channel station, a distance that Fleet Call asserts will assure interference protection from these stations equivalent to the protection from traditional high-power SMR operations that the 70 mile requirement affords. To allow periodic refinement and modification of its frequency reuse plan, Fleet Call asks that it be allowed to construct and operate additional low-power base stations with notice to the Commission but without prior Commission approval.

9. A central feature of Fleet Call's proposal is the ESMR Geographic Area (EGA), an area roughly defined by the composite 35-mile service areas of existing Fleet Call base stations that would basically serve as the systems' defined areas of operation. Any totally or partially enclosed space would be included within the EGA, as co-channel separation distances would not normally permit co-channel separation distances would not normally permit co-channel licensing under present rules. A 35-mile "buffer zone" around the area create is also included in the Fleet Call proposal. Within the EGA, Fleet Call requests authority to reuse all frequencies licensed to it at any established transmitter site, provided that it meets the co-channel protection requirements discussed above. New co-channel systems would not be permitted in the EGA or buffer zone, however, Fleet Call considers this restriction essential to the stable RF environment that it needs to "fine tune" and refine its system to meet changing demand. Other licensees could locate outside of the buffer zone and serve areas within the buffer zone so long as their base stations were at least 70 miles from an existing Fleet Call base station.

10. To achieve the full benefits of its proposed service, Fleet Call seeks waiver of the 40 mile rule to allow it to include in its system-wide license stations that it now manages but cannot acquire under strict interpretation of that provision. Given that aggregate loading of its existing SMR stations in each market meets Commission requirement of 70 mobiles per channel. Fleet Call suggests that formal waiver may be unnecessary. Should the Commission conclude otherwise, however, Fleet Call asserts that its record as an actual provider of SMR service, coupled with its commitment to the development of ESMR, assures us that it will not hoard spectrum but will instead put all channels to immediate use. Finally, Fleet Call asks for waiver of our station identification rules so that it may transmit a single identifier for each system using digital modulation.

DISCUSSION

11. The Communications Acts directs us to "[s]tudy new uses for radio, provide for experimental uses of frequencies, and generally encourage the larger and more efficient use of radio in the public interest." Certainly, Fleet Call's proposal falls squarely within the spirit of our statutory mandate. We therefore seek to encourage the development of Fleet Call's networks within existing rules and policy where possible and with rule waiver where necessary and appropriate. Waiving Section 90.631(e) of our rules to allow Fleet Call to have more time to construct its systems is consistent with our grant of similar waivers to authorize extended construction periods for unique communications systems proposed by other entities. The public interest, convenience, and necessity favor this regulatory approach and we adopt it here. We will not, however, grant much of the broad relief requested by Fleet Call and, further, will defer consideration of other requested relief pending the resolution of rule making proceedings.

12. Over 30 comments and 15 reply comments were filed in response to our Public Notice. One group of commenters, comprise principally of SMR licensees, applauds Fleet Call's proposal but seeks guarantees of protection and flexibility for other licensees in the markets involved. A second group of commenters, those representing the common carrier industry in particular, raises procedural objections to the proposal. This group argues that rule making, rather than waiver, is the appropriate administrative vehicle for this request and contends that Fleet Call's service will constitute common carriage. A third group of commenters questions the economic consequences of Fleet Call's proposal for individual SMR customers, raising such issues as the availability of alternative services and the possibility of equipment obsolescence. We consider each of these areas in turn.

13. *Technical Issues:* Our rules governing the SMR service establish technical and operational standards for the industry. They allow, by design, flexibility to foster and accommodate innovation. Hence, Fleet Call's proposal generally falls within the rules and policies governing the Specialized Mobile Radio Service. Indeed, our regulatory scheme itself provides much of the latitude that Fleet Call seeks. At the same time, though, we acknowledge the need to preserve for existing licensees in Fleet Call's markets both the protection from interference guaranteed them by our rules and the flexibility they too require to operate competitively and effectively. This necessity firmly guides our consideration of Fleet Call's proposal.

14. Fleet Call seeks waiver of Section 90.621(b) of our rules to allow it to obtain a single station authorization for all of its channels in each market so that it may construct and operate multiple low-power base stations at any location within a defined service area; including locations that are closer to co-channel stations than the rules normally allow. Section 90.621(b) provides interference protection for each SMR base station by precluding the assignment of any co-channel facility located less than 70 miles from the primary base station. The use of fixed mileage separations provides us with an administratively convenient method to assure a reasonably good quality of service and to promote spectrum efficiency through frequency reuse without having to perform a case-by-case engineering analysis. We have, however, entertained waiver requests of the minimum mileage separations from applicants that either obtain concurrence from affected co-channel licensees or that demonstrate through technical showings that short-spacing will not result in harmful interference because of the terrain of an area or the technical features of a particular system.

15. We are currently analyzing our short-spacing waiver procedures in PR Docket No. 90-34. In the Further Notice of Proposed Rule Making in that proceeding, we have proposed to amend the rules to permit separations less than the standard mileages without a waiver if the applicant can demonstrate through an appropriate technical showing that no harmful interference will result from short spacing. If adopted, this proposal would obviate the need to give Fleet Call a system-wide waiver of Section 90.621(b). We will therefore defer consideration of these system-wide requests for waiver of Section 90.621(b) during the pendency of PR Docket No. 90-34. If the proposed rule is not adopted, we will proceed to act on Fleet Call's waiver requests.

16. We note that Fleet call has not filed specific applications seeking relief from the requirements of Section 90.621. Fleet Call instead seeks blanket authority to locate low-power stations anywhere within a defined service area so long as they maintain the 48 mile separation standard, and then merely to notify the Commission of the location of the stations. Fleet Call seeks this relief so that it may

dynamically reconfigure its systems to respond quickly to changes in user demand, without burdening the Commission's limited processing resources. The low-power stations would receive no co-channel protection *per se*, rather, they would fall under the umbrella of protection to its high-power stations, even when they are ultimately dismantled and replaced by the low-power network. Again, this would provide Fleet Call with its desired stable RF environment.

17. Basically, Fleet Call is seeking protection from new co-channel stations in its intended service areas. The markets in question, however, are among the most congested markets in the United States. Indeed, the fact that there are no 800 MHz SMR channels available in these markets is the very reason why Fleet Call wishes to reuse its own channels in a low-power multiple-transmitter configuration. It is our decision that providing Fleet Call blanket protection from new co-channel licensees is not necessary to the implementation of its proposal. Our analysis shows that the current operating environment in these markets already provides Fleet Call with much of the protection it requires from new applicants. That is, the co-channel protection that is afforded all SMR licensees in these areas, including Fleet Call, essentially precludes the assignment of new stations. We therefore see no reason to place a formal restriction against new co-channel applications in Fleet Call's intended service areas.

18. Fleet Call also seeks relief from various administrative rules so that it may construct and operate low-power base stations within its service areas without need for it to submit, or the Commission to approve, each new or modified facility. In lieu of filing individual applications. Fleet Call seeks to construct low-power base stations and then merely notify the Commission of the station's specifics. Fleet Call maintains that it requires this flexibility to experiment with system design and that its proposed notification procedure, which is permitted in the cellular service, would not be overly burdensome upon it or upon the Commission.

19. We fully recognize the technical difficulty that Fleet Call faces in reconstructing its existing systems from single high-power sites to multiple low-power sites. The public interest, convenience and necessity favor a regulatory approach that encourages such endeavors when they lead to the development and implementation of unique and spectrum efficient communications systems. It is, however, unnecessary to grant Fleet Call the specific relief that it requests. Fleet Call can, if it wishes, proceed to license its low-power sites individually, consistent with current application requirements. As is the case with any application for an SMR station received by the Commission, the sites applied for will receive co-channel protection from subsequently filed applications.

20. In addition, if Fleet Call requires additional flexibility to experiment with its system configuration, it can do so under Section 90.137 of our Rules, 47 C.F.R. § 90.137. This section allows licensees to operate multiple base stations at indeterminate locations throughout a defined geographical area. Under the authority contained in this section, Fleet Call may apply for authority to construct and test numerous base station sites throughout its proposed service areas without filing separate applications for each proposed or modified site. No specific protection will be provided, however, to transmitters constructed under the authority contained in this section. Therefore, if Fleet Calls believes that any new station will not fall under the umbrella of protection that it receives from its existing high-power stations, it may file an FCC Form 574 to license that station and normal SMR co-channel protection will then be afforded the station.

21. We will, however, provide Fleet Call administrative relief in the following manner. Section 90.631 requires that trunked systems must be constructed within a one-year period. For the reasons discussed in paragraphs 25-27, *infra*, we will grant a waiver of this section and instead provide Fleet Call five years to construct any stations that would be part of its digital networks. As usual, the five year period will begin on the date of issue of any license associated with the networks. Regardless of the methods employed in the system design and implementation stage, each station placed into regular operation must ultimately be licensed individually.

22. Fleet Call's request for relief from Section 90.627, 47 C.F.R. § 90.627, the "40 mile rule," is not seriously challenged. Indeed, relief from this rule is unnecessary. The 40 mile rule is designed to assure that spectrum is fully utilized and not hoarded. As noted earlier, the aggregate loading of Fleet Call's licensed and managed systems exceeds 70 mobiles per channel in each market. Fleet Call therefore substantially complies with the rule and has already earned the right to exclusive use of the channels within the six markets. Fleet Call is using its licensed channels fully and has satisfied us through its detailed proposal that it will continue to use these channels fully and efficiently. The objectives of Section 90.627 are clearly met under these circumstances. In similar circumstances, we have ruled that a multiple site arrangement like that proposed here constitutes a single system for purposes of the 40 mile rule and, thus, the rule does not need to be waived. Accordingly, we consider the requirements of Section 90.627 to have been met.

23. Fleet Call has also asked for waiver of Section 90.207, 47 C.F.R. § 90.207, so that it may use time division multiple access (TDMA) digital transmission. Waiver of this rule is unnecessary. Section 90.645(f), 47 C.F.R. § 90.645(f), provides the necessary authority for Fleet Call to use TDMA. The provision takes precedence over the limitations of Section 90.207. *See* Section 90.601, 47 C.F.R. § 90.601. Concerning Fleet Call's request that we waive our station identification using digital transmissions on the systems' control channels we have decided to defer action until we address the issue by separate Rule Making order in the near future. Any change in the station identification rules would likely be made long before Fleet Call is ready to commence digital operations. If, however, we decide not to modify the station identification rules, we will proceed to act on its waiver request as on file or as amended or re-submitted.

24. Procedural Challenges: Some commenters argue that we may consider Fleet Call's request only in a notice and comment rule making rather than by waiver. Several parties have argued, however, that Fleet Call has not established unique circumstances justifying the degree of waiver relief it has requested. As a preliminary matter, we note that much of the objection to waiver relief would appear to be ameliorated by our decision to reject the more extensive waiver relief sought by Fleet Call, i.e., the EGA concept with limitations on applications by others, the request that Fleet Call be permanently relieved from filing individual applications, and the broad restriction on entry of new applications in the six markets. In addition, some of the commenters' concerns regarding waiver relief appear to be tied to their misapprehension that Fleet Call will dispense with dispatch service, thereby fundamentally altering the nature of its SMR service.

25. In light of the limited nature of our relief and the teachings of *WAIT Radio v. FCC*, 418 F.2d 1153 (D.C. Cir. 1969), we believe it appropriate to proceed in this case through waiver rather than rule making. There, the court made clear that "[t]he agency discretion to proceed in difficult areas through general rules is intimately linked to the existence of a safety valve procedure for consideration of an application for exemption based on special circumstances." 418 F.2d at 1157. We are directed to consider seriously meritorious applications for waiver, and are reminded that a general rule, "deemed valid because its overall objectives are in the public interest, may not be in the 'public interest' if extended to an applicant who proposes a new service that will not undermine the policy served by the rule that has been adjudged in the public interest." *Id.* As we make clear in this *Order*, we believe this to be such a case with respect to the one-year construction rule.

26. Waivers of our Part 90 rules are appropriate where "unique circumstances are involved and . . . there is no reasonable alternative solution within existing rules." 47 C.F.R. § 90.141. *See also Northeast Cellular Telephone Co. v. FCC*, 897 F.2d 1164, 1166 (D.C. Cir. 1990) (a waiver is appropriate only if special circumstances warrant a deviation from the general rule and such deviation will serve the public interest); *National Cable Television Association, Inc. v. FCC*, 914 F.2d 285, 289 (D.C. Cir. 1990), *rehearing denied*. December 7, 1990 (in cable/telephone cross-ownership cases Commission must explain "why the advantages to be derived from [waiver] cannot be realized in the absence of waiver"). We believe that Fleet Call's innovative proposal to increase spectrum efficiency through use of multiple, low-power SMR facilities on an integrated basis in each of six major markets, while generally consistent with the SMR service, presents unique and special circumstances justifying waiver of the one-year construction rule. Because of the expense and technical complexity of developing integrated SMR systems, and the fact that most SMR spectrum is already licensed in major markets to a variety of licensees, it is unlikely that there will be many, if any, comparable proposals by others. The novelty and complexity of Fleet Call's proposal make it virtually impossible for it to meet the one-year construction deadline. Moreover, because Fleet Call seeks only to reconfigure a fully loaded existing system, there is little, if any, risk of spectrum hoarding or failure to construct. While we do not grant relief to the extent requested by Fleet Call, we believe that the benefits of Fleet Call's unique proposal cannot reasonably be accommodated in an expeditious fashion without the minimal waiver relief granted herein. We have limited the requested waivers to the maximum extent feasible and our sole waiver has only extended its required period of construction. Given the substantial public interest benefits to be gained by SMR users from Fleet Call's spectrum efficient proposal, we conclude the public interest is better served by waiving our one-year construction rule and permitting the system to proceed expeditiously.

27. We also believe our approach here applies clear standards that will "prevent discriminatory application" of our waiver policy and "put future parties on notice as to its operation." *Northeast Cellular*, 897 F.2d at 1166. The waiver of our construction requirements follow existing waiver policies, which we intend to continue to apply in a similar fashion. *See, e.g., American Mobile Data Communications, Inc.*, 4 FCC Rcd at 3805 (one-year SMR construction rule waived where the proposal is "a novel one that will require experimentation and adjustment as it develops"); *Advanced Train Control System*, 3 FCC Rcd at 428 (eight-month non-SMR construction rule waived where the proposal is "extremely complex" and a "substantial undertaking"); *IBM Research and Development*, 53 RR 2d at 677 (eight-month non-SMR construction rule waived for "highly innovative" and "technically

advanced system"); *Millicom Radio Telephone Co.*, Letter, No. 7320-12 at 2 (Land Mobile and Microwave Division, May 17, 1990) (one-year SMR construction rule waived in light of "complexity and innovation" of proposal).

28. These challenges on procedural grounds also assume as a basic proposition that Fleet Call's SMR service will differ so substantially from traditional SMR service that rule making is the only appropriate avenue for its authorization. Commenters thus maintain that the SMR service was established to provide traditional dispatch service to small businesses and not to provide primarily interconnected communications service, as Fleet Call, they assert, intends. These commenters further contend that Fleet Call's concentration on interconnected service, combined with its multiple base station configuration, renders it a common carrier rather than a private carrier for regulatory purposes. As a final matter, commenters in this group maintain that a grant to Fleet Call will establish new operating standards for the SMR industry. Changes of this magnitude must be examined in the broad context of rule making, they argue.

29. We reject this line of reasoning. The Commission's current rules and policies permit a multiple base station digital configuration for SMRs. Furthermore, the services that Fleet Call will provide in its enhanced networks are not functionally different from any service that it currently provides through its existing stations. Fleet Call states that it will provide traditional dispatch service, wide-area dispatch service, customized voice dispatch service, non-voice dispatch service, and mobile data communications. Additionally, Fleet Call will be able to provide location specific sub-fleet or single mobile dispatch services, as well as interconnected telephone-type services. SMR systems are permitted, under current rules, to provide all of these services, including interconnection with the public switched telephone network. Through use of vastly improved technology, however, Fleet Call will be able to offer more of all permitted services in the spectrum available to it.

30. We note, with specific regard to the allegations regarding Fleet Call's proposed services, that Fleet Call does not propose to abandon dispatch service. In fact, it has specifically stated its intention to continue providing dispatch service to fleet users, both large and small. Fleet Call even states that it plans on using new digital technologies specifically designed for *dispatch-oriented* SMR systems. Interconnection with the public switched telephone network is an accepted SMR service permitted by our rules and is even discussed within the Communications Act. Given that digital technology and multiple base station configurations are also permitted under current rules, we must conclude that Fleet Call's proposal does not create a *de facto* new service.

31. Commenters also argue that Section 332 will no longer apply to Fleet Call because the nature of its new service will be common carriage. They assert that the legislative history of Section 332 indicates that the test for whether an entity is a private land mobile carrier is a functional one and is meant to encompass entities which primarily provide dispatch services. With respect to the regulatory status of Fleet Call's SMR service, commenters' reliance upon service offerings and system configuration is misplaced. Section 3(gg) of the Communications Act, 47 U.S.C. § 3(gg), defines a private land mobile service as "a mobile service which provides a regularly interacting group of base, mobile, portable, and associated control and relay stations (whether licensed on an individual, cooperative, or multiple basis) for private one-way or two-way land mobile radio communications by eligible users over designated areas of operation." Section 332(c)(1) and (2) of the Communications Act, 47 U.S.C. § 332(c)(1) and (2) further provides that the term, private land mobile service, includes SMR services, among others, "regardless of whether such service is provided indiscriminately to eligible users on a commercial basis," and that these services "shall not be deemed . . . common carrier[s] for any purpose under this Act." The primary test for inclusion in the private land mobile radio service, established by 47 U.S.C. § 332(c)(l), is that a licensee not resell interconnected telephone service for profit. So long as a licensee continues to meet this requirement, and nothing in the record suggests that Fleet Call will not do so, it remains a private carrier for regulatory purposes. If it were to violate this principle, we would initiate enforcement actions for violations of the terms of the authorizations. Common carriage is simply not permitted on the frequencies in question. *See American Teltronix*, 5 FCC Rcd 1955 (1990). Turning finally to the impact of Fleet Call's proposal on the SMR industry as a whole, our regulatory scheme for this service, as we have noted, emphasizes flexibility and innovation over conformity and standardization.

32. *Economic Consequences*: Some commenters express concern of economic harm to customers of Fleet Call and to other SMR operations. Conversion to Fleet Call's digital system will render existing equipment obsolete, they argue, forcing Fleet Call customers either to purchase expensive new equipment or to find another SMR operator using their equipment. Such operators will be difficult to locate in these congested markets. however, commenters assert. Moreover, they argue, Fleet Call's SMR service will undoubtedly he more expensive than traditional SMR service, leaving customers who cannot find substitutes for traditional service nowhere to go. Commenters also maintain that conversion will disrupt service for current Fleet Call users as channels are withdrawn from use for its new SMR system implementation.

33. We foresee no such dire consequences. First and foremost, Fleet Call's proposal is driven by the need to offer its end-users more capacity. We seriously doubt that Fleet Call would modify its existing stations if it believed that such an action would cost it its existing customer base. Certainly, Fleet Call has no logical incentive to jettison thousands of current system users. Nor would we expect it to risk its corporate image with a series of severed customer relationships. Furthermore, we note that it will take Fleet Call several years to complete construction of the low power systems. This will provide its end users that wish to convert to the digital service with additional time to amortize equipment costs.

34. Also, it is important to recognize that our rules for private carriers provide no protection for end user equipment investment. But, as one SMR licensee notes in its pleadings, the industry today employs several incompatible signaling formats. SMR operators commonly convert from one format to another, with their customers either converting with them or migrating to other systems. Furthermore, mobile radios are improving so consistently that many customers prefer lease to purchase. The SMR industry, in short, is a dynamic one, with change a constant feature. Fleet Call's SMR systems are, in this respect, consistent with industry practice, not alien to it. Finally, if any Fleet Call end-users do not wish to convert to the digital service, they will be able to migrate to other private land mobile systems in these markets.

35. Commenters' concerns about Fleet Call's SMR service fees and about the availability of other SMR service to those seeking it reflect an assumption that Fleet Call will stifle competition in its markets. We find no basis for this assumption. As for the conversion process itself, Fleet Call states that it can accommodate all existing users during the implementation period, moving them from the system to system as required. It has offered as well to assist customers not wishing its new SMR service to migrate to other SMR systems in the market. We are satisfied that wholesale disruption is unlikely under these circumstances.

SUMMARY

36. Fleet Call proposes to build an ambitious private land mobile radio system that promises improved spectrum efficiency without requiring additional spectrum. Our task in reviewing this proposal is simplified by the fact that current rules already afford Fleet Call most of the latitude it requires to construct wide-area digital SMR systems. It is, therefore, unnecessary to grant Fleet Call the EGA concept proposed in its waiver request, with limitations on applications by others. Our rules, and the degree of protection currently afforded its existing stations, already provide Fleet Call with the protection necessary for it to proceed with its business plans. Further, it is unnecessary to waive Sections 1.911, 90.117, 90.119, and 90.135 of our rules because our current application procedures provide a workable framework under which Fleet Call can construct and license its systems. Similarly, because our rules permit time division multiple access digital transmissions, waiver of Section 90.207 is also unnecessary. Finally, because Fleet Call's channels are loaded with the requisite number of mobiles that it will serve on its systems, waiver of Section 90.627 is not required. Although it would be necessary under current rules to waive the mileage separation requirements of Section 90.621(b) and the station identification requirements of Sections 90.212 and 90.647, we defer action on these aspects of Fleet Call's proposal pending the outcome of future Rule Making proceedings. Accordingly, at this time, the only waiver relief we grant is the relief from the one-year construction requirement.

ORDERING CLAUSE

37. According, IT IS ORDERED. pursuant to Sections 1.3 and 90.151 off the Commission's Rules, that the request of Fleet Call, Inc., for Authority to Assign SMR Licenses and Waiver of Certain Private Radio Service Rules, IS GRANTED to the extent indicated herein, and IS DENIED OR DEFERRED in all other respects as indicated herein.

FEDERAL COMMUNICATIONS COMMISSION
Donna R. Searcy
Secretary

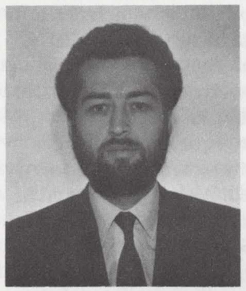
SEPARATE STATEMENT OF COMMISSIONER JAMES H. QUELLO

In Re: Request of Fleet Call, Inc,, for Waiver and Other Relief to Permit Creation of Enhanced Specialized Mobile Radio Systems in Six Markets

I have followed closely Fleet Call's request for waivers and the comments filed in response. I believe the technological concept of digital cellular specialized mobile radio services will move private land mobile services technology into the next century. This advanced technology will use spectrum efficiently and help ease congestion especially in large urban areas.

Some parties questioned the Commission's use of waivers rather than rule making to address issues raised by Fleet Call. I, too, want to be assured that the Commission acts in a procedurally correct fashion. I am concerned, however, that our procedures not be abused by those seeking to stifle possible competition. Our procedures should not be used as a delaying tactic. I encourage the Private Radio Bureau to address Fleet Call's request in an expeditious and procedurally correct manner. I believe this is particularly important in markets where spectrum and its use is at a premium.

Communications



J. R. Cruz,
Communications Editor

Abstracts

"Performance of Adaptive Matched Filter Receivers Over Fading Multipath Channels," Kaveh Pahlavan and James W. Matthews, *IEEE Transactions on Communications*, Vol. 38, No. 12, 1990.

Various types of noise inherent in the channel estimation process for a fading multipath channel are examined and modeled. Performance degradation due to noisy channel estimation in the adaptive matched filter receiver is analyzed, and some numerical results — contrasting reference-directed and decision-directed channel estimation — are presented for the troposcatter channel.

"Interference Rejection in FFH Systems Using Least Squares Estimation Techniques," Ronald A. Iltis, James A. Ritcey, and Laurence B. Milstein, *IEEE Transactions on Communications*, Vol. 38, No. 12, 1990.

A fast frequency-hopped (FFH) receiver is described which employs a prewhitening filter to reject narrow-band interference. By using an appropriate fractional tap spacing, it is shown that the interference can be estimated independently of the desired signal. Bit error rate results are then presented for the receiver for linear square-law combining. The results are shown to compare favorably to those obtained by a near-optimal automatic gain-control (AGC) combining technique. The performance of the prewhitening filter interference rejection method is also shown to be superior to that of a nonparametric self-normalizing receiver. Finally, simulation results are presented for an FFH receiver using the complex least mean-square (LMS) algorithm to update the prewhitening filter coefficients.

"Frequency-Hopped Spread-Spectrum Transmission with Band-Efficient Modulations and Simplified Noncoherent Sequence Estimation," Yiu Ming Lam and Paul H. Wittke, *IEEE Transactions on Communications*, Vol. 38, No. 12, 1990.

Frequency-hopped spread-spectrum transmission employing band-efficient modulations that are phase-continuous during each hop, is presented. A range of system parameters are considered, including: signaling spectrum, reception, system complexity, and performance in the presence of noise and jamming. The particular cases where the hopped modulation is minimum-shift keying (MSK), duobinary minimum-shift keying (DMSK), or tamed-FM (TFM) are studied in detail. As well, results are presented for various modulation indexes, rectangular and raised cosine pulse shapings, and a range of hop interval lengths.

Sequence estimation on a hop-by-hop basis is considered. The noncoherent likelihood sequence receiver must keep all possible paths and so the computation and complexity becomes large for systems transmitting many bits per hop. Therefore, a simplified noncoherent Viterbi-like sequence estimation algorithm with reduced complexity is introduced. System Performance has been evaluated in Gaussian noise, partial-band jamming and multiple-tone jamming, using bounds and a system simulation. The compact nature of the hopped spectrum when a number of bits are transmitted per hop, offers greater spectrum utilization and the prospect of improved performance in the presence of multiple-tone jamming or interference.

"Performance Analysis and Improved Detection for DMSK with Nonredundant Error Correction," H. Weining, *IEE Proceedings*, Vol. 137, Pt. I, No. 6, 1990.

The paper presents a method to analyse theoretically the performance of the narrow band DMSK with nonredundant error correction. The effect of the performance of the demodulation channels, e.g. the data channel and the parity channel, to the overall system performance is clarified, based on which an improved detection scheme is proposed which uses the two-bit DMSK as the data channel an the four-bit DMSK as the parity channel, and which is shown to be capable of achieving approximately 1.0 dB improvement in E_bN performance, as compared with the conventional DMSK with nonredundant error correction, without increasing the system complexity. Finally, computer simulation is made both to verify the theoretical result and to evaluate the effect of the IF hard-limiter to the overall error-rate performance.

"Distributed Scheduling of CDMA Networks with Minimal Information," A. Kershenbaum and M. J. Post, *IEEE Transactions on Communications*, Vol. 39, No. 1, 1991.

An algorithm is presented with produces conflict-free communication schedules in mobile multihop radio networks. These schedules are produced in a completely distributed manner. The algorithm is based on a globally known permutation on the nodes of the network. As a result the only knowledge needed on the part of individual nodes is the number of nodes in the network. This permutation guarantees that conflict-free schedules may be produced in a distributed manner. We then discuss two extensions to this basic permutation. The first enables neighboring nodes to enhance their communication schedules in a fast, robust, distributed manner. The second extension allows the algorithm to operate in the presence of secondary conflicts.

"A New Method for Phase Synchronization and Automatic Gain Control of Linearly Modulated Signals on Frequency-Flat Fading Channels," Abbas Aghamohammadi, Heinrich Meyr, and Gerd Ascheid, *IEEE Transactions on Communications*, Vol. 39, No. 1, 1991.

We present a full-digital receiver structure which consists of a new arrangement for optimally smoothed phase synchronization and AGC on frequency-flat fading channels. Periodically inserted known symbols at the transmitter allow the receiver to perform unambiguous coherent demodulation and accurate baseband AGC of linearly modulated signals. We use a general setting for a systematic presentation of the new scheme and for a mathematical analysis of the receiver performance. Compared to noncoherent methods such as *M*-ary differential phase shift keying (M-DPSK) or to coherent reception with FDM pilot tones, the proposed method is much more efficient. First, the irreducible error floors (due to random FM) known from noncoherent methods is practically eliminated. Second, depending on the fastness of the fading, large power gains over the noncoherent methods are achieved. Third, unfavorable analog signal processing and/or high bandwidth inefficiency of the FDM-pilot coherent methods are avoided.

"Two Classes of Convolutional Codes Over GF(q) for q-ary Orthogonal Signaling," William E. Ryan and Stephen C. Wilson, *IEEE Transactions on Communications*, Vol. 39, No. 1, 1991.

Two classes of nonbinary convolutional codes for error control in communication systems employing *q*-ary orthogonal signaling are studied. These classes include as special cases the dual-*k* codes [1]-[3] and the codes treated by Trumpis [4]. We describe each type of code, present extensions of previous bounds on free distance, and discuss the noncatastrophic condition for these codes. We then present codes obtained by computer search, optimal in the sense that the truncated transfer function bound on the probability of symbol is minimized. We also show how some "good" convolutional codes may be constructed from block codes. The paper is concluded with a discussion of applications of the codes.

"A Buffered Two-Node Packet Radio Network with Product Form Solution," Hsien-Chuen Yu and R. Lee Hamilton, Jr., *IEEE Transactions on Communications*, Vol. 39, No. 1, 1991.

We consider a packet radio network with two nodes; both nodes access a single radio channel using the slotted-ALOHA protocol. This model results in a network of two interfering queues. Networks of interfering queues seldom have closed-form expressions for the equilibrium probabilities. However, when certain constraints are placed on the network parameters, the network will have a product form solution for the equilibrium probabilities. These constraints are called PFS-controls. We consider three cases. In the first two cases, PFS-controls are found which control the new packet arrival rate. When operating under these PFS-controls, the two-node network has a simple, closed-form solution of the equilibrium probabilities, the expected throughput, and the expected packet delay. Moreover, the throughput-delay performance under these PFS-controls closely approximates that of an "exact" two-node packet radio model. In the third case, a PFS-control is found on one node's transmission probabilities. When operating under this PFS-control, the transmission probabilities approach asymptotic values as the packet backlog increase. The network tends to adjust its transmission probabilities to reduce large unequal packet backlogs.

"GMSK with Limiter Discriminator Detection in Satellite Mobile Channel," Israel Korn, *IEEE Transactions on Communications*, Vol. 39, No. 1, 1991.

We derive a formula for the error probability of partial response frequency shift keying with limiter discriminator detection with and without decision feedback for the satellite mobile channel which contains, as special cases, the Gaussian channel and the land mobile channel. We apply the formulas to Gaussian minimum shift keying, and we compute the probability as a function of energy-to-noise ratio and other system parameters (Doppler frequency, maximum Doppler frequency, bandwidth of Gaussian filter, ratio of powers in the direct and diffuse signal components, and time delay between direct and diffuse components).

"A Metropolitan Area Radio System Using Scanning Pencil Beams," Anthony S. Acampora, Ta-Shing Chu, Corrado Dragone, and Michael J. Gans, *IEEE Transactions on Communications*, Vol. 39, No. 1, 1991.

A new metropolitan area radio system is proposed which provides continuous 360$ coverage over a large service region from a centrally located base station. This new approach differs from others in that the base station blankets the service region with a raster of very narrow pencil beams which can be rapidly scanned to any position in synchronism with the switching sequences of a Time-Division-Multiple-Access (TDMA) assignment. By deploying multiple scanning spot beams, the allocated spectrum can be reused many times, resulting in a very high capacity design without a commensurate increase in required spectrum. A centralized network controller, executing an efficient TDMA assignment algorithm, dynamically allocated the resources of a small transceiver pool among the far larger number of beam positions in response to real-time requests for service. By varying the dwell time at each beam position in response to the traffic intensity of that position, highly efficient resource utilization is provided. The high antenna gain enjoyed by the base station antenna provides adequate rain fade margin to permit operation in the relatively uncongested portion of the ratio spectrum above 20 GHz. Overall, the system is particularly well suited to newly emerging, direct-to-end-user wide-b and digital service offerings.

"An Experimental TDMA Indoor Radio Communications System Using Slow Frequency Hopping and Coding," Adel A. M. Saleh, A. J. Rustako, Jr., Leonard J. Cimini, Jr., G. J. Owens, and R. S. Roman, *IEEE Transactions on Communications*, Vol. 39, No. 1, 1991.

We describe the general principle, implementation, and performance of an experimental 1.5 GHz radio communications system within a medium-sized office building. The system features 1 Mb/s TOMA (for service flexibility), and slow frequency hopping and coding (for immunity against multipath fading and interference). Our measurements show that, with a hallway-mounted distributed antenna system installed on one floor of the building, and with the mobile unit transmitting only 1 mW of peak RF power from anywhere on that floor, only a single 384 b frame out of a total of about 200 000 transmitted frames suffered an unrecoverable error. This kind of performance is comparable to that of wired data modems. Similar performance was obtained from a central antenna covering the same floor. However, the required transmitted power in this case was 100 mW. In larger office buildings, the central-antenna approach would have required much higher power, and would not have allowed the 1 Mb/s signaling rate without an equalizer.

In conclusion, we have demonstrated experimentally that our signaling approach (possibly in conjunction with a distributed-antenna system) makes possible the implementation of reliable, flexible, low-power, radio communications systems whose performance is virtually building-independent and in indistinguishable from wired services.

"Computer-Aided Modeling of Spread Spectrum Packet Radio Networks," Elvino S. Sousa, John Silvester, and Thomas D. Papavassiliou, *IEEE Journal on Selected Areas in Communications*, Vol. 9, No. 1, 1991.

Closed-form expressions for the performance of radio networks are generally not available. For spread spectrum networks, it is not even clear how to represent the underlying network, since the existence of links is heavily dependent on activity in other parts of the network. We have developed a set of computer-based modeling tools to help understand the performance and behavior of these networks. These tools allow for numerical evaluation of important network performance measures and experimentation with network parameters. A connectivity model for a direct sequence bead spectrum packet radio network has been developed. This model allows the computation of network throughput and can be used to study routing techniques. Our current model places direct sequence spread spectrum networks on an equal footing with narrowband networks which have been modeled using the collision channel and transmission range concepts. We describe the mathematical models and algorithms used to evaluate network performance and present several examples to demonstrate the impact of various parameters.

"Asynchronous CT2/CAI Telepoint Separation Requirements," J. E. Button, *Electronics Letters*, Vol. 27, No. 1, 1991.

With the increasing growth of Telepoint coverage within the UK and the development of Common Air Interface (CAI) CT2 equipment, the situation of multiple Telepoints each being required to cover a common, area may lead to unacceptable system performance if minimum separations between unsynchronised Telepoint base units are not maintained. Results of computer simulations are presented which show Telepoints with a common coverage area require a minimum separation of about 10 meters, to ensure a satisfactory service is obtainable by all operators.

"Soft RS Codes for Half Rate GSM Channel," S. A. Atungsiri, P. Sweeney, R. Soheili, A. M. Kondoz, and B. G. Evans, *Electronics Letters*, Vol. 27, No. 2, 1991.

After the adoption in 1987 of the RPE-LTP coder as the 22.8 KBPS Pan European Mobile Speech Communication standard (full rate GSM or F-GSM), the next stage in the project is the development of a CODEC (source and channel) operating at 11.4 KBPS (half rate GSM or H-GSM). Many speech coding algorithms under evaluation are meet the stringent quality specifications of H-GSM. However, during operation the channel perturbations are expected to be twice as bad for H-GSM as for F-GSM. Despite this, an error control scheme which uses less redundancy and provides performance which for the most part is superior to the scheme for F-GSM is expected. A high performance FEC scheme is presented which employs soft decoded Reed-Solomon (RS) codes on the H-GSM channel.

"Wireless Communications and Spectrum Conservation: Sending a Signal to Conserve," Janice Obunchowski, *IEEE Communications Magazine*, Vol. 29, No. 2, 1991.

Every reader of this magazine probably knows a dozen ways to improve spectrum efficiency to facilitate new personal communications and other wireless applications, but other engineers in the late 1960s knew how to improve gas mileage in automobiles and did little about it. When customers do not know or care about coming shortages, neither do the executives who set engineering priorities. What was true of the impending energy crisis in the late '60s is even more true of the impending spectrum shortage of the '90s: All of the expertise of spectrum engineers, all of their science, and all of their capacity for hard work will be irrelevant to spectrum efficiency unless we can somehow build incentives to make their customers and clients care about it.

"Personal Communication Services: Expanding the Freedom to Communicate," Sam Ginn, *IEEE Communications Magazine*, Vol. 29, No. 2, 1991.

Now, as the "broadcast century" comes to a close, we are poised to add yet another dimension of freedom to human communication. New services, dubbed Personal Communications Services (PCS), are making communication independent not only of time and distance, but also of location.

"Wireless Network Directions," Ian M. Ross, *IEEE Communications Magazine*, Vol 29, No. 2, 1991.

Alexander Graham Bell's invention of the telephone over one hundred years ago launched a revolution in communications that enabled people to communicate efficiently over distance. Today, a new revolution is taking shape — a wireless communication revolution — that will at long last free customers from the tether of the phone cord.

Wireless techniques have long been used by communications carriers and the very largest of businesses. Radio technology has been used for point-to-point carrier and private microwave transmission systems as alternatives to copper wire and coaxial cable. Even today, digital radio instead of fiber is widely used for some network links. Wireless loop systems are used in rural areas for cost and terrain reasons. And satellite communication is well established for broadcast services, data networks, and voice services.

But today's wireless thrust focuses on the mobility market. This market includes paging services, cordless telephones, dispatch/mobile radio, vehicular cellular services, emerging satellite applications, and Personal Communication Services (PCS). While most of these markets are either growing rapidly or are large potential markets, this article will focus for the most part on cordless technology, cellular networks, and Personal Communications Networks (PCNs). Cordless telephones are well established in the residential market, and are emerging for business applications behind key systems and Private Branch Exchanges (PBXs). The explosive growth of cellular services is continuing unabated. The PCN with its promise of portable terminals that can be used in the home, in buildings, outdoors, and in vehicles to initiate and receive calls is the target market that has captured the attention of governments, network equipment suppliers, telecommunications carriers, and a large number of aspiring wireless product and service companies.

"Spread Spectrum for Wireless Phone Systems: The Subtle Interplay Between Technology and Regulation," Douglas G. Smith, *IEEE Communications Magazine*, Vol. 29, No. 2, 1991.

This article will attempt to categorize some of the spread spectrum proposals and outline why one must differentiate between the issues raised by the proposed wireless services versus those raised by the proposed wireless equipment. In particular, it will focus on some of the requirements for introducing wireless telephones into office systems such as Private Branch Exchanges (PBXs) and key systems. Thus far, the needs of the office market seem to have been overshadowed by discussions and debates on spectrum allocation for new telephone services.

"Spread Spectrum Technology: A Solution to the Personal Communications Services Frequency Allocation Dilemma," Jack T. Taylor and Jim K. Omura, *IEEE Communications Magazine*, Vol. 29, No. 2, 1991.

Wireless access to the public switched network in the form of personal communications services will revolutionize the way people communicate in the decades to come. In response to this change, the FCC has begun a major proceeding to identify the nature and, the spectrum needs of and the technology options available for these services.

Because of the congested nature of the frequency spectrum in the U.S., the options for spectrum are limited. Although discrete spectrum would be the preferred option for all concerned, the realization

that sharing spectrum is the only viable option is becoming apparent.

This approach, sharing spectrum between two users' groups, will mandate the choice of technology. SS technology is an ideal technology for such an environment. The interference tolerance, system flexibility, and capacity advantage of CDMA/SS make it the technology of choice for the coming generation of PCS.

"Efficient Spectrum Allocation for Personal Communications Services," Carson E. Agnew, *IEEE Communications Magazine*, Vol. 29, No. 2, 1991.

Personal Communications Service (PCS) is a general term used to describe a variety of mobile radio services that reuse the spectrum among a number of cells. PCS is intended to provide everyone with the ability to communicate wherever they are — "one person, one phone." As its name suggests, PCS is a service, not a particular technology. In fact, different technologies will be used to provide the same kind of service to different people, depending on geography and personal circumstances. One reason different technologies will be used is that, as discussed below, systems that are appropriate to densely populated areas are uneconomic in areas with lower population densities.

A corollary to the above is that unless the population density and other service requirements are uniform throughout the service area, assignment of spectrum to a single technology or service cannot be optimal.

Those making spectrum decisions must recognize the diversity of technologies that will be used to provide PCS, and that the final mix of technologies cannot now be predicted. Flexible methods of allocation and assignment are needed.

"PCN: Son of Cellular? The Challenges of Providing PCN Service," Richard J. Lynch, *IEEE Communications Magazine*, Vol. 29, No. 2, 1991.

Today, the telecommunication industry is moving to a higher level of wirelessness. Companies throughout the world are investigating and developing technologies, packaging them with names like Personal Communications Services (PCS), Personal Communications Networks (PCNs), Cordless Telephone second and third generations (CT2 and CT3), and many others. While dozens of companies are exploring these opportunities, there has not been a lot of agreement over whether they represent new services or products, where they should fall in the radio spectrum, or how they should be implemented and brought to the marketplace.

"Regulatory Flexibility in Commercial Satellite Communications," Gary K. Noreen, *IEEE Communications Magazine*, Vol. 29, No. 2, 1991.

The dramatic new capabilities of MSAT and the freedom to address new markets provided by the broad MSS allocation should lead to the development of many innovative mobile satellite services. Radio Satellite Corporation is taking advantage of the regulatory, organizational, and financial hurdles already overcome by AMSC to introduce diverse integrated mobile satellite services for consumers fully eight years earlier than if it required a new satellite system. It is doing so at a fraction of the cost of a new satellite system.

The flexible MSS regulatory structure is part of a growing trend. This trend arises from the demonstration that limited allocations have failed to justify the enormous time and resources required to implement new satellite systems. The combination of new satellite capabilities and increasingly flexible regulatory structures will accelerate the introduction of new satellite communication services.

"Personal Communications Services: The Next Technological Revolution," Richard M. Singer and David A. Irwin, *IEEE Communications Magazine*, Vol. 29, No. 2. 1991.

The telecommunications industry is witnessing the beginning of a technological revolution that may transform its role in society. Personal Communications Services (PCS) have the prospect of providing more convenient, ubiquitous, and versatile services than the public has ever received. PCS could enhance the importance of telecommunications in daily life, improve business productivity, and spawn the entry of new providers of communications services. PCS may appear in many forms, including portable coin Cordless Telephone second generation (CT-2) offerings, wireless Private Branch Exchanges (PBXs), wireless local area distribution links, and two-way portable Personal Communications Networks (PCNs), which are self-contained and interconnected with the public switched telephone network. PCS, effectively, would afford dial tone to the world.

In 1941, Santa Fe Railway System installed an extensive printing telegraph network to handle wheel reports, train consists and car information. They installed 112 printers, 114 reperforators and 101 transmitter-distributors. Also they installed carrier to derive 17,321 miles of circuits.

ATCS evaluation report developed by AREA

Factors to be considered in evaluating the advanced train control system are the subject of a report by Committee 16 — Economics of Plant, Equipment & Operations of the American Railway Engineering Association. The report is printed herewith.

The Advanced Train Control System (ATCS) project, a joint venture of the Railway Association of Canada (RAC) and the Association of American Railroads (AAR) has reached the point where several railroads have begun to test various components of ATCS and subsystems. For ATCS applications in the United States six frequency pairs in the 890-935 MHz range have been assigned by the Federal Communications Commission to the AAR, who is the radio frequency coordinator for the railroad industry. The Canadian government is also considering setting aside these frequency pairs for ATCS usage by Canadian railroads.

The RAC-AAR joint venture is nearing completion as far as specification writing is concerned by its consultants ARINC Research, Transportation & Distribution Associates and Lapp-Hancock & Associates. Guidelines for testing components and methods for system safety analysis are being developed.

Because ATCS involves a new type of train control, a study of its impact on operations is very important. Several present conditions and the operational status of the territory being considered for ATCS application should be studied. Additionally, study should be given as to how ATCS will affect operations and finally the economics and benefits determined. There are costs involved in changing over to operation under ATCS, but there are also some benefits that provide monetary and time savings.

Major factors to be considered in an ATCS study include geography, present control system in operations, present and expected future traffic, number and estimated remaining lives of locomotives to be ATCS equipped, present communications, labor agreements, other operational considerations, training and retraining and maintenance.

More details concerning costs of these factors include:

- Geography such as territory consisting of terminals, mileage, grades, curves, bridges, tunnels, cuts, single and multiple track, sidings, crossovers, urban and rural areas and industries.
- Present control systems consisting of signaling (automatic block signals, traffic control or centralized traffic control, manual block), direct traffic control (radio manual block), timetable and train orders, maximum speeds permitted for each type of control system.
- Present traffic including number of trains per day by type and direction (passenger, TOFC, stack, manifest, unit such as coal or grain, Road-Railer, locals, industrial assignments, transfers, etc.), Segment terminals of each train for territory under study, maximum permissible speeds by type of train, timetable speed restrictions for each type of train and mile post location, schedule or desired running time between terminals for each train, nominal tonnage handled by each train, horsepower per ton required to achieve desired schedule by type of train and by direction, number of opposing train meets and/or faster trains passing slower trains, flexibility of operating certain trains to minimize meets and passes.
- Present communications including telephone and wayside locations, two-way voice radio, end-to-end and train-to-wayside voice radio, data radio, one-way or two-way train to wayside, train to wayside coverage (continuous or intermittent), microwave, open-wire lines, cable or fiber optic cable to connect wayside locations with a central office.
- Labor agreements covering locomotive engineers, conductors and trainmen, interlocking or tower operators, signalmen, communications technicians, dispatchers, clerical and/or computer operators/programmers, and shop crafts.
- Other operational considerations include hot bearing detectors and other wayside detectors, interlockings and crossings with other railroads at grade, rail-highway grade crossings with or without warning systems, yards and terminals.
- Training and retraining include such items as train crews and dispatchers for operation under ATCS, maintenance personnel for on-board and wayside equipment, and programmers and operators for computers.

Maintenance is Important

ATCS is heavily dependent on computers and communications, especially data radio. ATCS will probably have more sophisticated equipment to maintain than is presently in use by railroads for operational purposes. There may be a need for more skilled maintenance personnel with ATCS compared to present control systems.

Programming and software development will be important.There is a vital and great need for documentation of software programs.

As for economics, each project will have to be studied and includes at least the following: costs for equipment, programming and software development, training and retraining, installation, maintenance, overtime and recurring costs. Any cost directly or indirectly resulting from the installation of ATCS should be included.

Economics and Savings

Implementation of ATCS will produce savings in operating costs in several areas, as well as improved service to customers.

Some of the savings should come from:

• Reduced fuel consumption due to pacing of locomotive performance with optimum meet and pass conditions pertaining. In better meet and pass planning and the on-board computer monitoring the locomotive condition and operating characteristics, trains will not run nor accelerate to high speed (high fuel consumption) and then wait at passing sidings for a considerable time to make a meet, or race to get to a yard that is temporarily plugged.

• Reduction in clerical costs at yard offices through remote data entry by the conductor regarding set-offs and pick-ups of cars. Thus, more prompt handling of work orders will improve service to customers. Also, an advantage of the ATCS work order system is the receipt of printed orders by the conductor eliminating any misunderstanding of verbal orders. Additionally, data radio transmission of work orders reduces usage of the voice radio.

• ATCS will foster centralized dispatching with savings resulting from a reduction of dispatchers required. Such centralization will bring all movement information into one location where it can be expeditiously handled. Also, it will be found to be economical to centralize motive power dispatching at the ATCS dispatch center. This can make the decision making more efficient at the railroad's operational headquarters.

• Economics can be realized with the ATCS communications providing performance monitoring of not only motive power but wayside devices such as defect detectors, highway grade crossing warning devices, etc. Remote diagnostics can be performed, thus only requiring maintenance personnel to visit field wayside devices to make repairs or replacements.

• Economics in ATCS implementation will be realized through its standardization and modular components. Designed on the building block approach, ATCS can be upgraded from lower levels higher levels without replacing equipment.

• Although not to be quantified until ATCS is in service, the concept of better and safer control of train operations should produce efficiencies in the line-haul and terminal operations because of the improved controls.

• Condition monitoring of motive power should produce economies in locomotive maintenance and servicing. As problems develop on line of road, motive power condition and diagnostics can be detected and reported promptly from the moving train to central dispatch or to motive power maintenance facilities. A real benefit is the detection of problems that otherwise are not detected until failure. Big savings are obtained in correcting before failure. Also, these maintenance facilities will be able to better plan their work, as well as handle incoming locomotive repairs promptly. With ATCS prompt reporting of failures, corrections may be made at the next terminal rather than taking the unit out of service. In some instances with the data radio capability of transmitting information to the locomotive display unit, minor corrections may be made enroute.

• The same increased efficiencies can be obtained in yards with prompt reporting by train crews of cars set off or picked up enroute. Yards are then able to plan their work better and do it more efficiently.

It should be mentioned that some railroads have already obtained some of the economies and benefits of ATCS by use of other systems and operational techniques. For example, at least three major railroads have had centralized dispatching in service for a number of years. Many roads have reduced yard clerical staffs through the use of computers and paperwork automation.

As for safety, ATCS operation must be compared with a railroad's present method of operation in the territory on which ATCS would be installed. Here again, in some territories some railroads have obtained a high degree of savings with other methods of train operation with a high degree of safety.

Thus, the benefits of ATCS will depend on each railroad's operating practices and management philosophy.

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