COMPUTER CONTROLLED RADIO INFORMATION SYSTEM FOR PUBLIC VEHICLE OPERATIONS

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Summary. Radio control centers for Public vehicle operations has long been an essential instrument to control and monitor schedules and operations. However, due to the rapid development of city and urban traffic the capacity limit of the small amount of voice channels is already reached, especially during rush hours. Moreover the dispatchers are overburdened, so that adherence to schedule and safe operations cannot be guarantied.

Data communications is the means to increase the efficiency and the capacity of the existing system. AEG-TELEFUNKEN has conceived an advanced system TELETRANS utilizing computer control and radio monitoring. This system makes improved use of the existing channel capacity without infringing on current FCC regulations. Through the use of co-channel transmission, which is a special type of transmit diversity, large areas with diameters up to 40 km (25 mi.) can be covered. This system is flexible, so that requirements of small and large public transportation authorities can be fulfilled economically.

Introduction. At most public transportation authorities the vehicle driver (bus, trolley, underground, train) uses the voice net to transmit traffic situations (engine malfunction, accident, congestion) and vehicle information such as free seat capacity, amount of standing room, ticket cancelling machine inoperative etc. Moreover he has to accept verbal instructions, which can easily be misunderstood due to traffic noise.

All these burdens can be alleviated through an automatic data collection and information system. Additionally coded instructions could be transmitted to the driver by lighting up a button with the corresponding symbol, such as instructions for start of run, skipping the next stop, return to garage, wait (for a connecting route).

Data handling and storage can be controlled by a computer in the central station, thus giving the dispatchers the means to analyse the processed data more meaningfully and take appropriate action.

There are some systems now operable [1] [2] [3] which exhibits some or all of these features. Based on these systems we started to investigate in which areas improvements could be made, without violating existing FCC and the German Post Office regulations.

As a result of the study the TELETRANS system was formed, drawing upon know-how acquired in partially similar projects, using existing hardware modified to fit the system requirements.

System description. The system (Fig. 1) consists of' the following components:

1. a network of electronic location posts acting as geographical markers,

2. vehicle electronic equipment, composed of location, radio and data handling units.

3. fixed radio stations for complete area coverage

4. a central station with a process control computer and peripheral equipment, dispatcher's desks and displays, wall projection equipment, and the data distribution unit to the fixed radio stations.

Electronic location posts. If a vehicle passes within 15 m of a location post, the X-Band pulse signals of the vehicle location transmitter will be received at the location post, and serves to trigger to location post transmitter. In this manner the location post address will be received, demodulated and stored in the vehicle data storage. The operating bandwidth is 40 MHz, the bit rate is 2400 b/s. One battery 3,5 Ah capacity is required, to be replaced annually. The location post overall dimensions (incl. antenna) are: width 20, height 10, depth 7 cm.

Because of its flatness a location post can be mounted easily on house walls, masts etc. In order to save location posts, it is recommended to place them so to be able to serve different routes.

Because of the limited range and the rather high operating frequency the probability of interference from other sources is extremely low, nor will it cause interference.

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[1] A.V. Gould, "Automatic Vehicle Monitoring Applied to Bus Operations", IEEE Trans. on Vehicular Technology, Vol. VT-22, No. 2, pp. 42-45; May 1973

[2] H. Bertschmann, "Modernes Leitsystem fur den Nahverkehr", Verkehr und Technik, Vol. 2, pp. 51-64; 1973

[3] G. Maurer, "R.A.T.P. Paris: Die ganz groBen Probleme kommen erst" Online, No- 9, pp. 580-581; 1973

Vehicle electronic equipment. The equipment consists of three major components:

1. a location unit

2. one or more radio units

3. a data handling unit.

The location unit is quite similar to the electronic location post, however it is only 10 cm wide due to the absence of a battery. At regular intervals it transmits a single X-Band pulse modulated by a 20 kHz signal, which serves as trigger for the electronic location post transmitter. After correct demodulation and decoding the transmit cycle is stopped for a specified interval so that if the vehicle stops, near the location post it will not be triggered repeatedly, thus draining off the battery capacity.

The radio unit serves to establish data and voice communication with the central station. Separate data and voice radio are possible, however not necessary. For data communication a semi-duplex channel is recommended, whilst for voice communication simplex channels are sufficient. If no frequency pair exists, then data communication can also be handled through a simplex channel. The cycle period (the time to poll all vehicles) will increase by 50 % through the use of a simplex channel.

For less than 10 channels (including one semi-duplex channel) TELECAR TS (Fig. 2) is recommended, for more channels up to 60 TELEDUX (Fig. 3) can be used. Major characteristics are:

1.	Frequency range	: 68 to 87.5 MHz, 146 to 174 MHz or 450 to 512 MHz	
2.	Channel interval	: 20, 25 or 50 kHz	
3.	HF-modulation	: FM	
4.	Output power	: 6 w	
5.	Receive sensitivity	: < 0-35 µV for 20 dB SNR	
6.	Supply voltage range	: 11.3 to 30 V	
7.	Dimensions in mm	: TELECAR TS	TELEDUX
	height	60	96
	width	188	266
	depth	215	421
8.	Weight in kg	2.4	7.5

The data handling unit has the following functions:

1. stores the address of the last location post

2. optionally stores the amount of travel after passing the last location post in 50 m increments

3. stores all pertinent vehicle data

4. demodulates, detects for errors and decodes messages coming from the central station. These messages could either be:

   - a query for data

   - a command or group command for switching to a selected voice channel, contained in the message

   - a group command to transmit an alarm, if any.

5. formats the stored data and modulates them prior to handing over to the radio unit

6. give commands to the radio unit to switch to a voice channel

7. counts time from the receipt of the last message from the central station.

If no message is received in three times the cycle period, then in the presence of a carrier the data handling unit has to assume that an interfering carrier is nearby. Therefore it gives the command to switch to a preselected voice channel, and transmits its data through this channel.

Data modulation is performed here by differential phase-shiftkeying with a data rate of 2400 bit/s.

If the vehicle driver desires to talk, he depresses the call button. The data handling unit and the radio unit will hunt for an unoccupied voice channel, however will accept any messages from the central station. If a free channel is found, it will transmit the vehicle garage number and location post address, through this channel and switch back to the data channel. The central station will report the call to all dispatchers, and at the moment one of them accepts the call will begin to build up the voice link by assigning a voice channel to the di spatchers and informing the vehicle data handling unit to switch to the assigned channel. At the same time the call button will glow and a buzzer will sound. By pushing the call button the driver can talk now. For a study it was found that the whole procedure will be finished in about 0.5 s under the assumption that the first three voice channels were occupied.

In case the driver touches the alarm button, then in 1 to 5 s (according to customer's setting) the regular polling query for alarms will come from the central station. The data handling unit will accept the query and instructs the radio unit to transmit the vehicle garage number and location post address. After data transmission, it switches over to voice transmission on the assigned channel, which was contained in the query for alarm. The radio unit alternates between transmission and reception according to customer's specifications.

Fixed radio sites. If a large area is to be covered, there are two principal solutions:

1. use a tall antenna and one radio station

2. use many small antennas and radio stations(cellular system).

For areas with one outstanding feature as e.g. a city hill or tower naturally one antenna will do. However, if these features are absent, and if building codes prohibit the use of an antenna enough to cover the whole area, then the only solution is to have many radio stations, each with its own antenna. However, if they transmit at the same time, there will be interference zones where their coverage overlap. While this cannot be eliminated for voice communication, AEG-TELEFUNKEN has developed and operated successfully for another project a system to suppress the interference. This is achieved by letting the carrier frequency difference and phase difference of the data signals from all radio stations within very stringent limits. With this method the area coverage can be greatly increased. At the fixed radio sites only frequency modulation and demodulation are performed. The radio units are identical to that used for vehicle radio units.

Central station. The heart of the central station is the computer, which controls all monitoring activities. Depending on the amount of vehicles AEG-TELEFUNKEN offers:

1. a 60/07 wiih a core memory of 8 to 32 k words of 16 bits for those transportation authorities with up to 300 vehicles

2. a TR 86 with a core memory of 32 to 64 k words of 24 bits for those with more than 300 vehicles.

The division in only two computer types results in an optimal work load, while at the same time providing some leeway for expansion and future planning.

Amongst the functions of the computer are:

1. Control of the messages going to the vehicles, also for group messages.

2. Plausibility and comparative tests, error detection tests on the incoming messages.

3. Computation of schedule deviations, comparison against allowed tolerances for each run and route,

4. Monitoring the voice channels and control of the dispatchers call lists.

5. Updating of the data banks for all routes through incoming data.

6. Processing the data for display in the form wanted by the dispatcher.

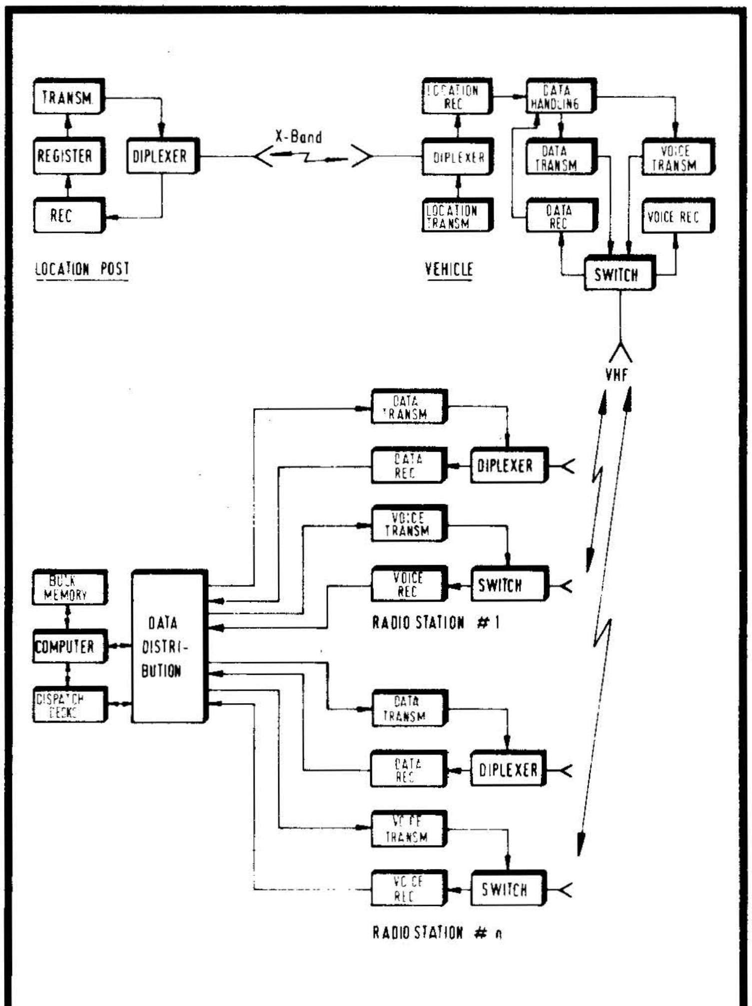
7. Support in the production of accident reports.

Additionally, the computer can be used to process statistical programs, e.g. rate of accidents, rate of malfunctions, budgetary measures, and to support future planning and expansion.

Fig. 4 shows a control center with the computer and its bulk storage devices (in this case a magnetic tape digital recorder), the dispatcher's console, and a wall projection of all routes. This wall projection is kept up-to-date through a direct interface with the computer.

The dispatcher's console is drawn for 3 dispatchers, however up till 16 dispatchers can carry an interactive dialogue with the computer.

Conclusion. The system presented here, although covering grounds already broken by many others, provides for improvements primarily in the fields of system optimization and area coverage, drawing on designs already proven elsewhere. It is felt that this system contains the flexibility necessary in dealing with the different requirements of various public transportation authorities. Also, because of its economical use of frequencies this system could be adapted to fulfil local communication regulation codes.



Functional Block Diagram of the TELETRANS-System

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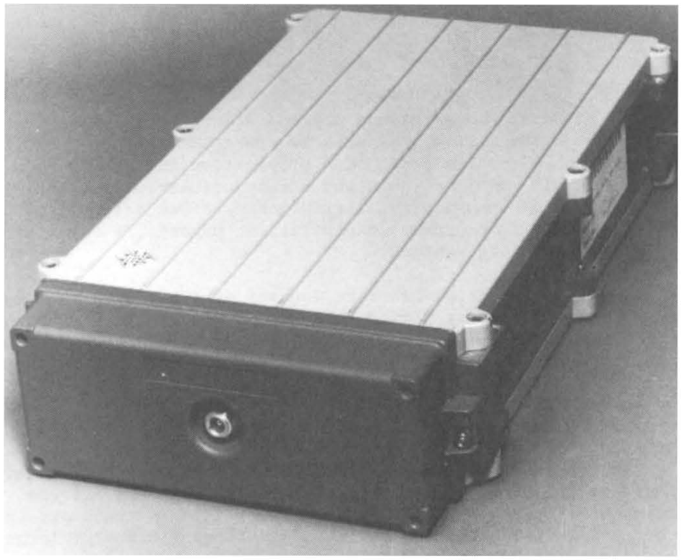

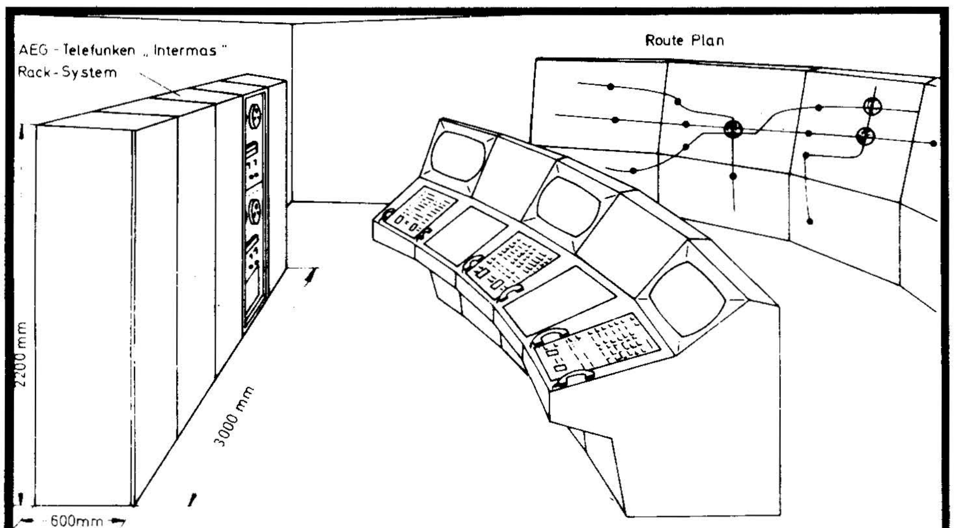

Control center with 3 dispatcher desks

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