GPS-based Vehicle Localisation

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ABSTRACT: The paper describes the processor-based equipment designed for the purpose of traffic means localisation. Data transmission is realised through GSM modem as a standard component of GSM phones. Control station gets a data set from GPS receiver based on the given command and identification through SIM module. Data is used to determine exact time, transaction date, geographical position, instantaneous velocity as well as azimuth. After transferring data into digital map the operator can observe a place of traffic means. Transaction requires transmission of minimal data volume (ca 80 Byte) which is a minimal load for created mobile phone connection. The paper describes essential technical details characterizing the developed equipment and obtained experience.

1 INTRODUCTION

Data transmission using a small volume of data in mobile means is a relatively simple and mastered technology today. If the mobile means is equipped with a GSM modem and GPS receiver then the automatic means placed in a vehicle can respond to commands coming from the control centre. The paper presents results of the possible technical solution realized by the authors. The GPS receiver provides a data set that can be appropriately selected by the user. If one needs to know geographical position, time, date, velocity, course, then the GPS sentence with the GPRMC prefix may be used. Setting of the GPS receiver for reception of just the given sentence only simplifies problem solution. The transfer speed has been set to 19200 bps (for the M35 Siemens cell phone) corresponding to the GSM transfer speed (standardly set to 4800 bps).

2 OEM GPS RECEIVER AND NMEA PROTOCOL

One of the problems to be solved results from existence of two sources of data signal that are switched over by the automaton to one control center. If we want to activate corresponding automaton placed inside the vehicle, by default the modem must be set to GSM communication. Once the arrival message (for the sake of simplicity only one recommended and known symbol) has been evaluated the automaton switches over the communication channel to the GPS source. The GPS receiver works permanently despite data is not valid (analyzed by the user).

As mentioned before each GPS receiver generates a set of data ordered into so called sentences according to the NMEA protocol. This protocol provides data expressed in ASCII code that can be shown directly at computer monitor without any formatting. The user must set the serial link (RS232) to the transfer rate of the GPS receiver. The maximum speed of data update by GPS receiver is 1 second however the user may choose a longer interval (Černý & Steiner 2003).

Each GPS receiver sentence starts with the $ symbol. This flag helps to identify beginning of the sentence. Information content of the sentence follows the prefix GPRMC (Garmin). Individual data in the sentence is separated by the "," (comma symbol, in the ASCII code the value 2Ch). Particular data can be evaluated based on the number of these symbols. As an example we can choose 80 symbols of the GPRMC sentence including the flag. Thus a part of the sentence is stored in the memory of microcomputer. After switching the communication source back to the default state content of the given part of memory may be transferred to the control centre where transaction is being finished and obtained data processed. As a result we can find out if the vehicle goes in a required direction (according to the oriented map), is standing or moving, breaking the speed limit etc.

The GPRMC contains following information at first 80 positions:

- the $ flag, followed by
- GPRMC, followed by the 1st separator ",",
- Time (given in UTC), followed by the 2nd separator ","
- Data validity, followed by the 3rd separator ","
- Latitude, followed by the 4th separator ","
- Half-world sign, followed by the 5th separator ","
- Longitude, followed by the 6th separator ","
- Half-word sign, followed by the 7th separator ","
- Velocity in knots, followed by the 8th separator ","
- Movement course (azimuth), followed by the 9th separator ","
- Data, followed by the 10th separator "," .

Numbers of symbols of particular data is not given intentionally since they may be different according to the type of GPS receiver.

Table 1. Conversion of ASCII symbols to the displayable data set of the GPRMC sentence in the NMEA protocol.

	$	G	P	R	M	C	,	2
ASCII	24	47	50	52	4D	43	2C	32
	1	2	1	2	9	2	9	,
ASCII	31	32	31	32	39	32	39	2C
	A	,	4	9	1	5	.	6
ASCII	41	2C	34	39	31	35	2E	36
	0	7	,	N	,	1	2	3
ASCII	30	37	2C	4E	2C	31	32	33
	1	0	.	5	3	7	,	W
ASCII	31	30	2E	35	33	37	2C	57
	,	0	0	0	.	0	,	3
ASCII	2C	30	30	30	2E	30	2C	33
	6	0	.	0	,	1	1	1
ASCII	36	30	2E	30	2C	31	31	31
	1	9	8	,	0	2	0	.
ASCII	31	39	38	2C	30	32	30	2E
	3	,	E	*	6	8		
ASCII	33	2C	45	2A	36	38		

The indicated procedure makes the technical solution possible with minimum requirements to programming environment of the automaton. In any case the GPS receiver must be configured according to GSM communication needs. For the GPS OEM receivers by Garmin there is a cost-free programme available that can be used to set individual parameters of the GPS receiver. As an example the GPS18 module can be mentioned. Running the file SNSRCFG.EXE the corresponding serial COM port is being set, interconnected to the GPS receiver (COMM preamble). The preamble contains two items: SETUP and CONNECT. Once the communication has been activated the programme is searching for the transfer rate of the GPS receiver which is indicated at the monitor showing gradually all transfer rates tested. When choosing the preamble CONFIG, two items are available: SENSOR CONFIGURATION and NMEA SENTENCE SELECTION.

The items GET CONFIGURATION FROM GPS and SEND CONFIGURATION TO GPS are activated as soon as the communication link has been established using the command CONNECT. All sentence preambles generated by the receiver and repeated periodically within adjustable intervals are transferred to the computer using GET CONFIGURATION command. If all received parameters are in accordance with user requirements the programme run may be terminated (EXIT in the FILE menu).

More frequent requirement concerns about changing some GPS receiver parameters. If some of them are different from intended the preamble SENSOR CONFIGURATION can be chosen and data proposed according to the planned purpose. Number and type of GPS receiver sentences may bet set through the preamble SELECT SENTENSES. Data prepared in this way can be sent to the GPS receiver using the preamble SEND CONFIGURATION TO GPS as the last step of the configuration process. The chosen options can be re-called by the preamble VIEW, item NMEA TRANSMITTED SENTENCES when the GPS receiver generates data according to new conditions. Newly established parameters are kept in the GPS receiver even after disconnecting the power supply.

If parameters of the GPS receiver cannot be modified or the GPS receiver is made by a different producer (G symbol in the GPRMC preamble means Garmin) the automation programme must be adapted in the following way. The transfer rate is standardly set to 4800 bps. The user must respect this fact and adapt the communication transfer rate to new conditions. If the receiver repeats sending more sentences of the NEMA protocol the programme for receipt of required data must be adapted. If we insist on checking the sentence check-sum (always generated by the GPS receiver) this is also possible at the expense of receiving the whole sentence. If data is to be validated just at the first reception, analysis of data following the second symbol "," must be performed. The indication "A" confirms validity of data, all other combinations denote invalid data (most often "V"). All data from the GPS receiver are provided in the ASCII format. All newly defined parameters become valid after the reset (switch-off and and-switch-on) of the GPS receiver.

Software simulating the NMEA protocol seems to be a very effective tool for laboratory tests (without need to have the physically moving means with the GPS receiver and GSM modem). The program (GPSsimul) is licensed and its current version makes generation of 50 sentences of the NMEA protocol possible only. The simulator then continues generation of chosen protocol sentences but without sending them to the serial port (number as an optional parameter). Older versions of the programme

worked without this limitation. In addition, the user can chose a type of the NMEA protocol sentence, geographical position, elevation above sea level, speed, course, repeat interval and check sum. The clock and date is taken over from the computer where the software is installed. The user defines time shift to UTC provided by the GPS. The software is also a very useful aid when solving problems related to dynamics of elaborated GPS data. Based on the given speed and course it generates relevant geographic coordinates that are transmitted via serial link. In this way one is able to substitute the real GPS receiver that usually does not work inside buildings and if provides some data it is of static nature. Figure 1 shows the software window with parameters modifiable by the user (indicated with arrows) or through the item SETUP SCREEN.
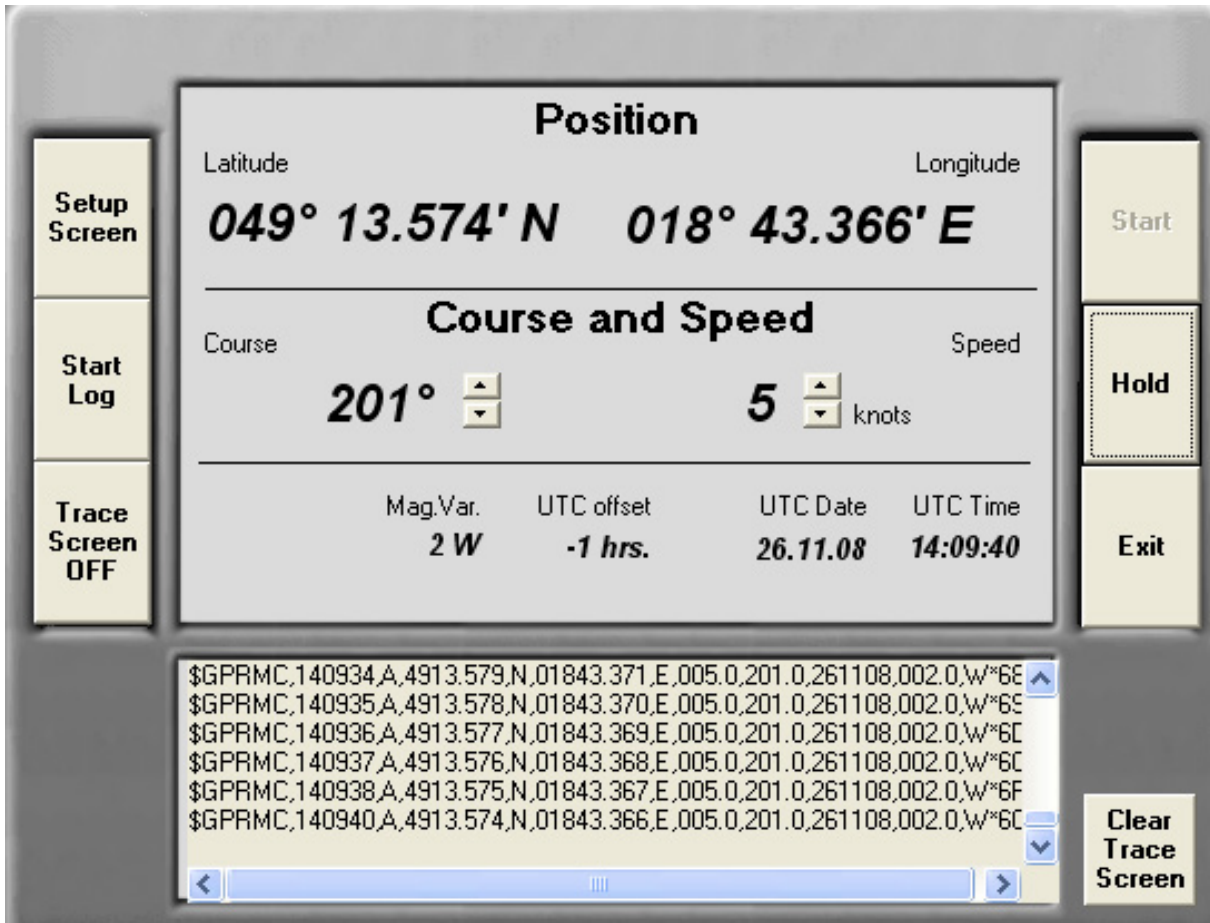

Figure 1. Control window of the GPSsimul programme.

The Figure 1 shows symbolically simulation of two types of sentences of the NMEA protocol (GPRMC and GPVTG) with a second data generating. The simulated speed is 5 knots with the course 201 degrees. Geographical data is generated and shown in the first line. Time data represents the UTC from 14 hours 09 minutes 34 seconds to 14 hours 09 minutes 40 seconds on date 26 Nov 2008.

3 GSM MODEM

Work with the GSM modem assumes use of AT commands. Since there a lot of them only selected commands used in the application are mentioned here. Certain problems arise when working with GSM terminals. Transfer rate of the computer is 19200 bps (valid for the used Siemens M35 model).

If we use the GSM modem it is also necessary to set activation of the SIM module from computer (instruction AT+SCIM = number of SIM card). After a certain time the activation is confirmed with OK, or according to the previous command ATV0(ATV1). All this is realized at the transfer rate 9600 bps via wireless GSM channels. Some GSM modems do not enable permanent setting of some parameters. In that case each interruption of power supply re-call default values that do not need correspond to our intention. It is mostly a matter of the S0 value of the modem register, specifying a number of rings after which the receiver circuits of the GSM are automatically activated. This value is usually set to 000 which indicates no response of the receiver to ringing. The transmitter then (after a certain time) indicates absence of the carrier frequency (or announces there is no answer). The value kept in the S0 register

can be found using the preamble ATS0?. The answer given by the GSM modem is for example 000. It means that the modem will not answer the incoming call (Končelík 2004a, b).

Table 2 shows example of listing of actual data from the GPS receiver through the wired modem at the rate 19200 bps with requirement from the centre to send data via GSM wireless link. Table 2 also contains information about who creates the data, whether the user or the modem or the GPS receiver.

Table 2. Sample of data listed by the automaton.

User	atdtXXXXXXXXX
Modem	CONNECT
GPS Rec.	**$GPRMC,070436,A,4912.1986,N, 01845.3541,E, 000.0,207.1,220108,003.3,E*7E**
Modem	OK (based on the +++ user-choice)
User	ath
Modem	OK

The first data following the comma (in the GPS sentence) declares UTC. Time shown in the upper table gives the value 7 hours, 4 minutes, 36 seconds. The 9th comma is followed by date declaring 22nd January 2008.

Data following the 2nd comma indicates validity of received data. Data following the 3rd, 4th, 5th and 6th comma gives geographical data (latitude, North sphere, longitude, Eastern sphere). The 7th comma is followed by the speed in knots. Knot is a unit not used in Europe (1 kn = 1.852 km/h). The sample shows that the GPS receiver is not in movement. Next data represents course – in this case invalid due to zero speed. Data following the decimal point has no sense for this purpose. Data following the * symbol gives check sum calculated as modulo 2 sum of data of the whole sentence from $ flag to * symbol. Then there are used two symbols CR and LF that are not displayed (corresponding to the ENTER key). AT commands for GSM modem control are generated according to the type of modem.
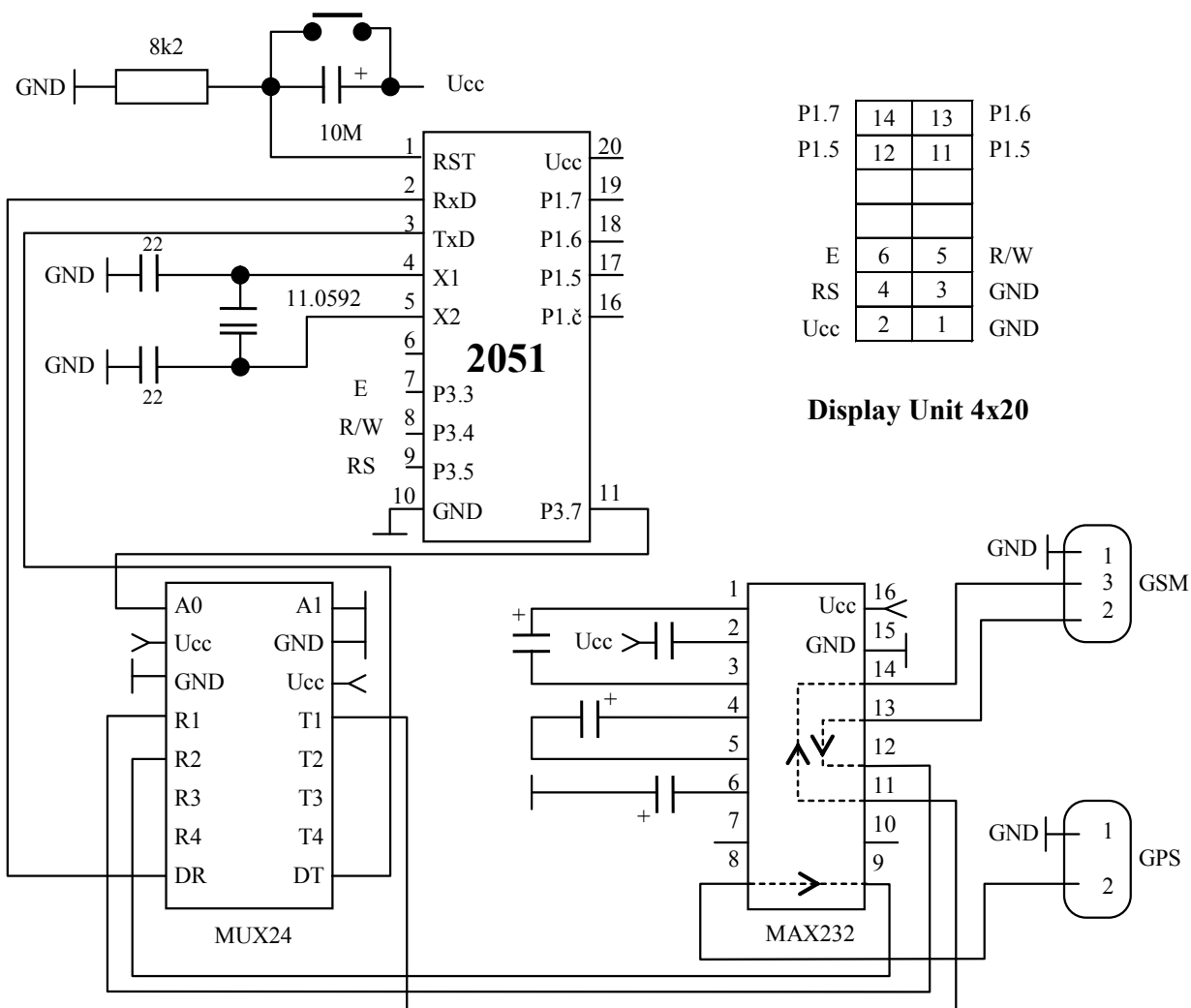

Figure 2. The scheme of the circuit for reporting the mobile means movement.

4 CONTROL ALGORITHM AND PROGRAMME INTERPRETATION OF THE AUTOMATON EQUIPMENT

Programme for operation of GSM and GPS modules is configured by default to monitor serial link from the GSM modem periodically. If any symbol is received it is compared with the "F" symbol (a flag defined by the authors). In the case of positive result of comparison the built-in multiplexer switch over the signal to data receive from the GPS receiver. Then data at the serial link from the GPS receiver module is monitored searching for the flag "$"that represents beginning of NMEA protocol sentence. Other symbols received are being stored in operation memory of the microcomputer. Special attention is paid to observing number of commas, separating individual data of NMEA sentence having a different length. The 2nd separator is followed by data expressing validity of data of the sentence in question. If the programme evaluates the symbol "A" (ASCII symbol 41hex) next reading is continued, followed by storing data in operation memory of the microcomputer. Reading cycle can be performed in two ways. If we know amount of data in advance the reading cycle may be pre-set exactly. Otherwise, the programme is waiting for the symbol ending the sentence (0Dh, 0Ah). Then data flow is re-directed back to the serial link of the communication modem that is still in the CONNECT state, sending data from the operation memory of the microcomputer to the information source that initiated connection. If data from the GPS receiver appears at the monitor then connection is terminated with the sequence +++ (modem response is OK) followed by the command ATH (end of transaction). If we want to continue with getting new data in dosing interval under existing connection, the symbol "F" is sent again.

If the GPS receiver provides invalid data it is not transmitted but the title INVALID DATA is generated. Solution of such a situation depends on the user of stationary equipment. Either transaction may be terminated or new data of the NMEA sentence may be asked by sending the "F" symbol. The problem of versatility of the application consists in the fact that each GSM communicator may have different parameters used to set its operation (what is not a problem in the control centre). In mobile means the required data must be pre-set in advance. Automaton for establishing connection to a selected phone number has no chance to use variant solution. Despite the number of instructions for establishing of pre-defined GSM connection is relatively low the individual parameters must be set in advance according to the particular type of the GSM modem.
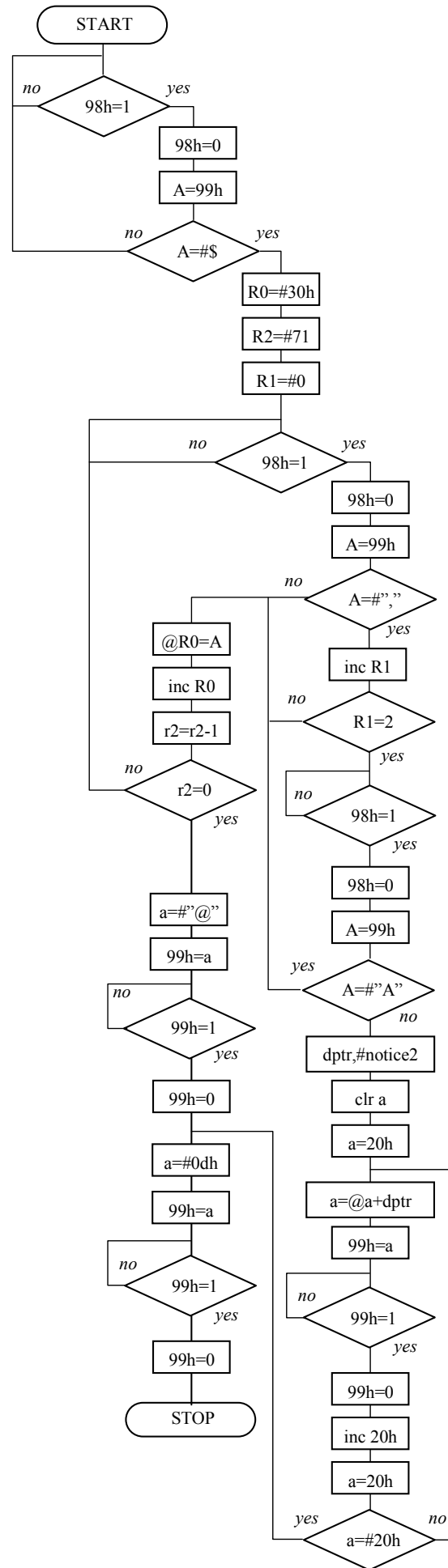

Figure 3. Flowchart for reading the GPRMC GPS sentence and for storing data from the address 30h

Figure 3 shows the flowchart describing the procedure of reading the GPRMC GPS sentence and storing data from the address 30h. Validity of is checked. In the case of invalid data the message IN-VALID DATA is communicated.

Technical solution is quite simple and in addition to GSM and GPS modules it requires a microcomputer, multiplexer, converter of TTL to RS232. More detailed information is out of scope of the paper. As far as the electronic circuitry is concerned equipment for vehicle localization is the same as for monitoring of the vehicle movement (Figure 2). The only differences are in software of the control unit.
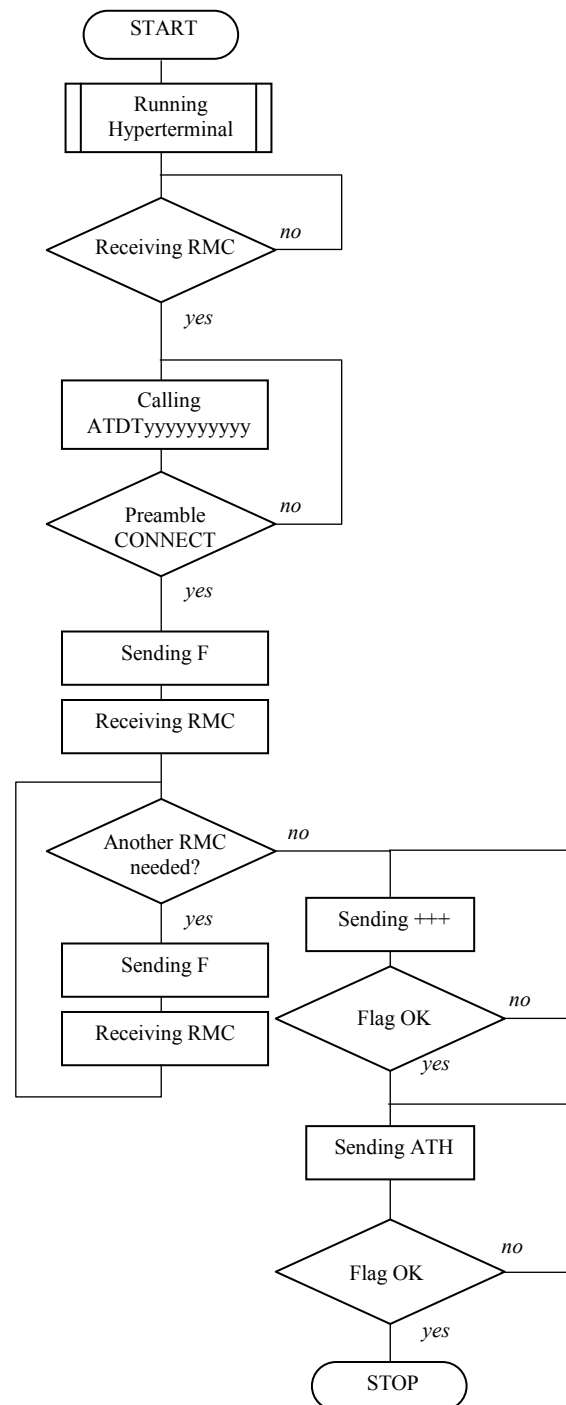

Figure 4. Control algorithm applied when received information about vehicle movement.

Figure 4 shows the control algorithm describing situation when information about vehicle movement has been received. Both diagrams shown in Figure 3-4 correspond to the used processor Intel 51 (Valášek 1989). Usage of a different kind of processor may require changes in presented algorithms.

5 CONCLUSIONS

Getting data from GPS receiver makes possible to realize other applications that generate messages in the event that a vehicle is changing its position (compared with the original condition). Nonzero speed activates the GSM modem when the automaton performs calls and connecting to the centre with continuous service. Operator in this centre gets information in the form of actual sentence of the GPRMC and based on its parameters adequate measures can be taken.

Figure 5 shows the example containing particular data that can be used to find out where the mobile means is located, including its time and speed data.

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atdt0904901578

CONNECT 9600/RLP

GPRMC,140700,A,4913.5322,N,01847.0990,E,023.0,275.9,130408,002.9,E*7A

OK

ath

OK

Figure 5. Example of application of described principle.

ACKNOWLEDGEMENTS

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