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SETUP POSSIBLE SOLUTION FOR A MODULAR AUTONOMOUS MONITORING SYSTEM FOR METEOROLOGICAL PARAMETERS THAT DEFINE ROAD SAFETY

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One of the important problems that the countries of the world road administration to address in recent years is to achieve some system of sensors and specialized equipment, placed along the road to provide guidance on meteorological factors on which a driver-in case of travel-facing and needs the most relevant information on state time.

Besides the wind intensity and direction of this fog (but not yet and its density), soil and air temperature, level of sun radiation, pressure, weather factors that exist in current practice weather stations, in recent years literature numerous signals projects to supplement this information with data on the layer of water, snowfall, degree-specific characteristics and melting snow, ice appearance and conditions in which this can be prevented.

Determined to these challenges, on the one hand, new sensors , and on the other, to develop new specialized equipment, including in their structure this new sensors,able to collect these data, process them and, hence, to transmit to large-signal and display systems located along streets with high traffic and that, in certain situations, presents features that require special measures (case of road sections characterized by high water or snow fall, more common possibilities of appearance of ice , fog, aqua-planning and others).

That information appeared on weather systems (Road Weather Information System - RWIS) with a critical role in the deployment of a safe traffic, with no incidents, generating economical savings (if we consider the figures provided to show that if the installation of such systems, generate increased traffic speed, were avoided stagnation that often were accompanied by economical loss, appeared possible that the information given drivers to adapt the speed and decreased the number of casualties).

The "Swedish Road Weather Information System", appreciating the importance that knowledge of weather parameters met in crossing some roads which were areas of disruptive weather factors and generated by accidents - in the case of Sweden, especially icy roads, those who after a rain it turns into a layer of ice, snow layers whose depth is not known and the soil temperature to predict when without human intervention, it can melt - mounted such equipments, coupled in a network that can provide throughout the country relevant information on state roads in terms of time and the main weather parameters.

Furthermore, such informations are necessary for road maintenance teams , who will act either mechanically or by the road surface treatment chemicals (sodium chloride, magnesium chloride) or by spreading sand. Knowing the exact condition of the road will enable the operator maintenance of the road to manage the quantities of substances strictly necessary for defrosting the road, avoiding corrosion of, environmental protection and economical savings.

"Heat map" of the road are an essential part of the information system on road meteorological parameters to determine the best places where can be placed a station and can transmit distance information.

In the winter season Swedish Meteorological and Hydrological Institute transmit satellite or radar images, at least once per hour. .

Telecommunications network, mobile telephony, LAN and WAN is used for communication between central system and system component stations.

In 2007 the system contained over 720 stations and over 200 video-camera for monitoring and information system could be purchased based on request by other parties too.

An issue as important as the achievement of weather stations for monitoring road condition, is the realization of the computer system up with these stations, to acquire such data, process them and the result, as a message to be sent to users, finally, to the traffic system on a highway or public road circulated.

Such a system consists of hardware components, software and interfaces required to collect information on weather, road status after their analysis, for transmission to a user.

A weather station that collects data can be considered a "cell" of the chain of stations that make up weather station network for roads and their management is done by the network computer system.

The importance of this sector is great especially in winter conditions, when rainfall strongly affects the transport sector, and weather forecasts allow substantial reduction of road maintenance costs.

Such a system Wether Road Information System (RWIS), should ensure the functions in Figure 1.

Gathering information

Data provided by sensors that equips a weather station for monitoring the condition of roads is collected in data acquisition systems. Their complexity depends on the type of station and functions that must be met.

The categories of environmental sensors are given in Fig. 2 types of sensors and their number depending on the complexity of monitoring for free. In the table are some examples of environmental sensors to various parts of the road.

The sensors are placed in fixed and mobile stations, in some cases, they are willing construction on poles or metal placed near the road.

Information received from environmental sensors are supplemented with local observations, they settled on messages to be transmitted as useful elements for weather forecasting and the likely state of the roads

Transmission of information

Weather station sensors fitted to transmit information about the status of that road: the road surface temperature and in substrates, wind speed, pressure and extremely important, information on rainfall, snowfall, rain intensity and height layer of water, ice and deposits ice. This information should be carefully considered because they will be transmitted by systems display to the drivers or other beneficiaries. Correct transmission of data is an important function of information systems.

Usually, this information is transmitted to weather forecasting offices and, in the case of large computer systems, to weather forecasting centers.

Processing information

This activity involves a large number of information processing, a reliable collection of such data, comparing operations and validation results. Developing software is a powerful activity that accompanies the development of hard, realised by stations constructors or by the beneficiaries.

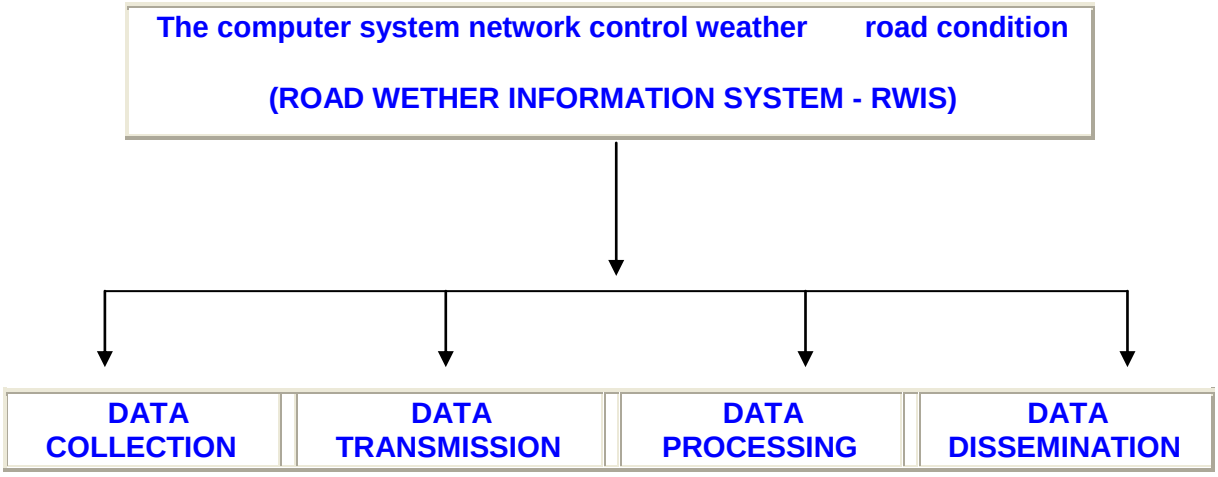


Fig. 1

Categories of environmental sensors (SCM)

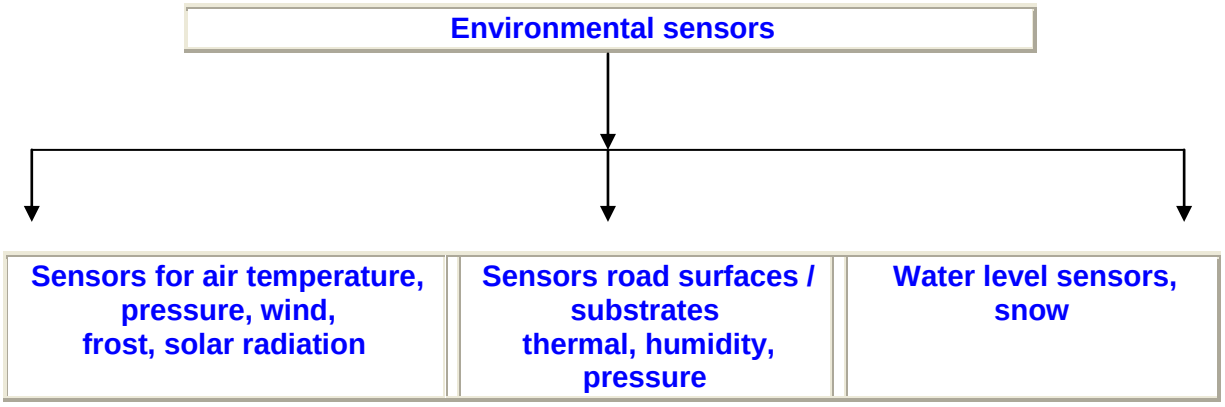


Fig. 2

Examples of environmental sensors (MS)

Element of road	Sensor
Air temperature	Thermometer
Water vapor (dew point, relative humidity)	Hygrometer
Pavement temperature, freezing of the road pavement chemical concentration	Pavement sensors
Substrate temperature of the road (0-50 cm)	Temperature sensors
Precipitation	Weather detector sensors snow frost
Rainfall intensity	Detector weather, specialized sensors, radars Maps
Visibility `	Vision sensors

This activity has a special role, because, besides of radio - informations, sound-informations, light - informations, transmission of images recorded by cameras or satellite, may give indiccations on areas where ice deposits may occur, ice etc.

Information dissemination

Reaching the drivers involved in circulation has a great importance especially in terms of occurrence of high intensity weather factors: snowfall, formation of ice, deposits of ice, wind gusts and storms.

Information dissemination is done through radio ads that announce events or areas of display systems ready for the road along.

Ultimately, this activity is the result of the activities developed in the other stages.

Fluency and traffic safety justify development of such systems not only by decreasing the high number of accidents that the statistics it signals in the world, but also by the positive economic impact it induces a safe traffic movement. It is about 3 million hours to be saving in the U.S. and, most important: the costs of maintenance of roads, which currently exceed U.S. $ one billion per year, can be substantially reduced.

It shows, for example, by high thermal paper road, it can provide when it is a disturbing phenomenon and that, to be removed, costs. For example prevent the 3-6 hours before the areas where it can brighten or snowfall occurs, allow a ***timely*** intervention, administration of substances to defrost ***when you need*** and consume ***as much must*** ultimately this means reducing operating expenses A ROADS.

Analysis of possible monitoring systems

For data acquisition and control systems are built around a PC (or equivalent), having a variety of structures and configurations. In Figure 3 is presented the flow of information transfer in the data-acquisition process.

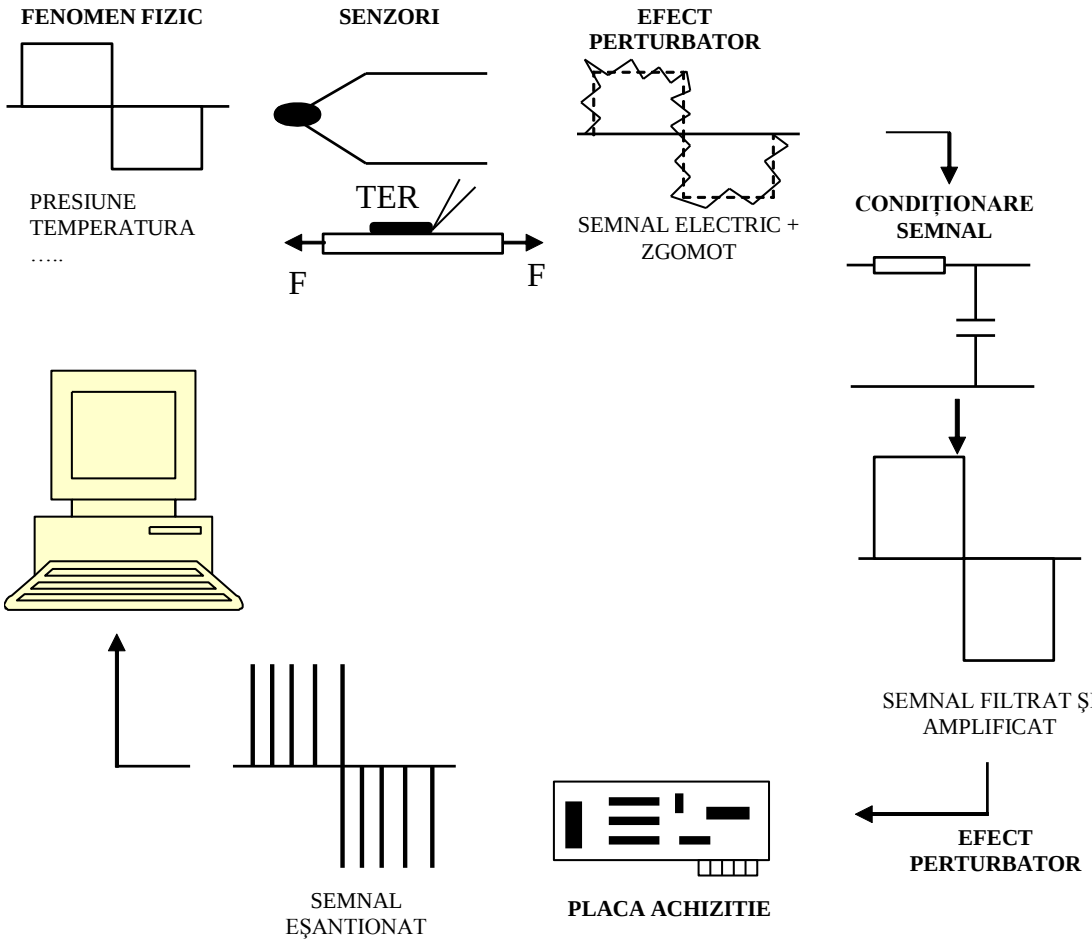


Fig. 3 Information flow in the system acquisition

It can be mentioned as the main components of such a system, each of which is important for accurate measurements, processing and storage of data:

- *sensors and transducers;*
- *connecting cables;*
- *signal conditioning circuits;*
- *hardware for data acquisition;*
- *software application;*
- *Basic computer (or equivalent).*

Setting up the data acquisition system designed and control. In many applications the flexibility of PC's configuration allows acquisition system in various forms to provide certain benefits. For this purpose it is necessary to use hardware and software as close to capacity. Setting the pattern is influenced by the environment in which to operate the system: laboratory, industrial environment, remote locations. The number of required sensors and actuators, signal conditioning circuits are other factors that influence decision configuration.

The most common configurations are:

- *PC plug-in boards input / output (I / O).* Airframe mounted computer, these plates provide a compact structure. It is one of the methods with low cost price and good results can be achieved by using different configuration options for: plates with multiple analog inputs, multiple outputs analog plates, plates with digital I / O, specialized tools. Depending on the desired application can choose the card to ensure price / parameters needed (eg. No channel input / output) optimal.
- *Input-output distributed.* A large class of sensors are located at considerable distance from basic computer that coordinates the purchase. Appropriate industrial type environments where sensors and actuators can be located in hostile environments and a large area. It is difficult to transfer signals over long distances to reduced long. One of the most common is by using digital signals and serial interface RS-232 or RS485. A solution of this kind is shown in Figure 4.

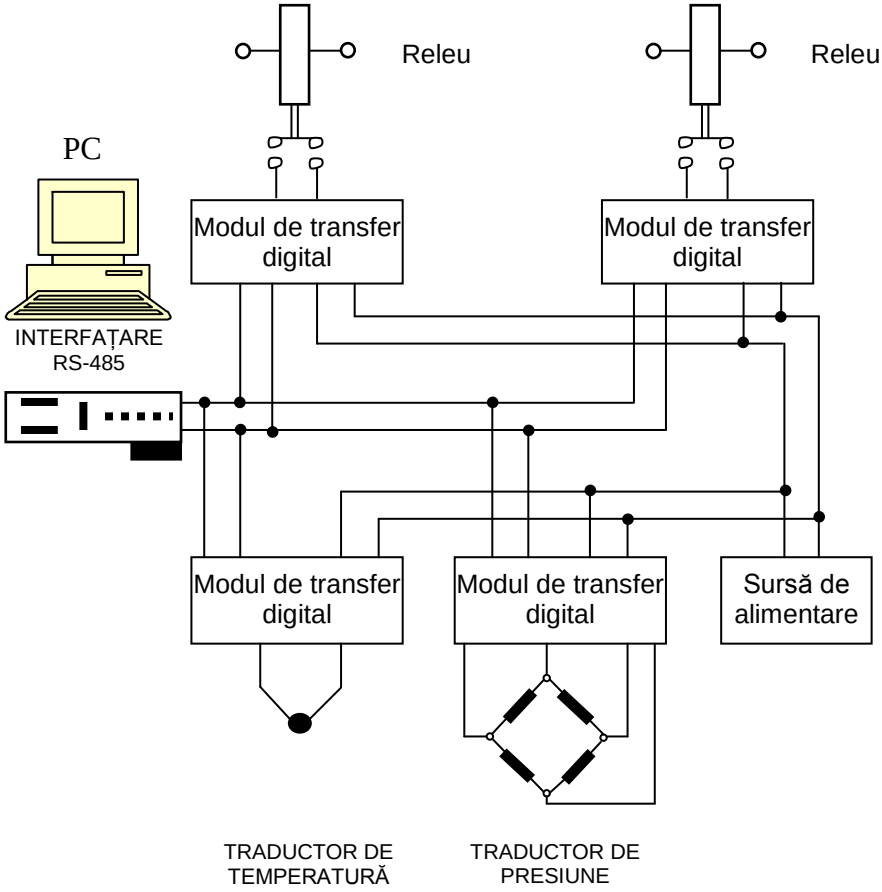


Fig. 4 Variant of data distributed configuration and data digital transfer

Digital transfer modules contain the necessary elements for conditioning the signal. It's possible to connect a large number of modules (up to 32 modules) for distances up to 10 km.

- *Distributed autonomous instruments.* Autonomous equipment is designed by definition to work independently from the existing basic computer and dedicated to coordinate data acquisition. These devices have all the features to programm the conditioning of the signals and have the opportunities to programm through the serial

interface or PCMCIA mobile card. Such a possibility is shown in Figure 5. Serial interface RS-232, for distances limited to 50 m, is an another possible version of data transfer (Fig. 6).

A distribution of sensory elements and actuators on a large surface may lead to a variant of data transfer similar to that in Figure 7. In the system structure is introduced a way of classical communication - telephone, radio communication by calling the appropriate modem.

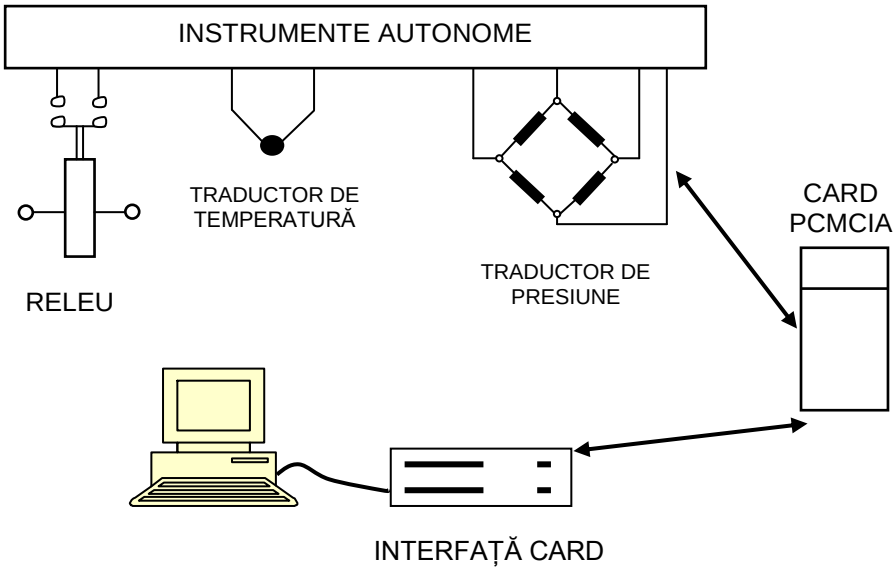


Fig. 5 Portable PCMCIA card used in data acquisition

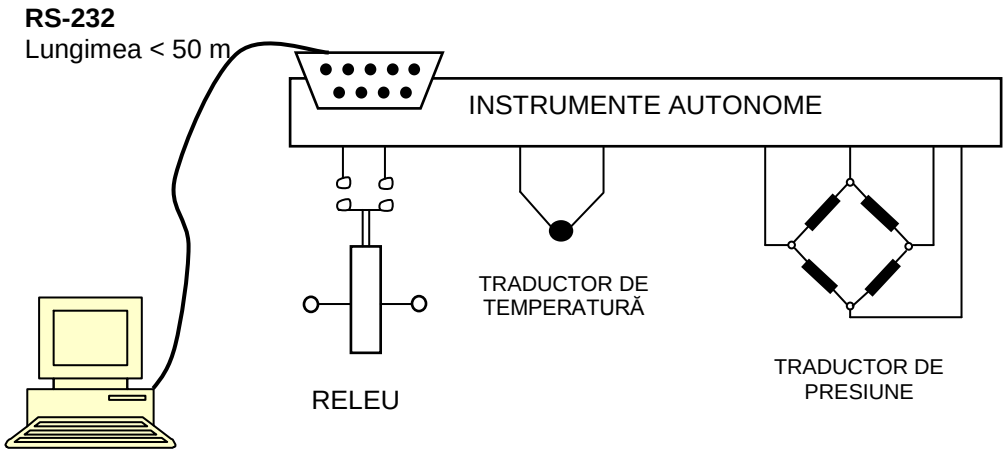


Fig.6 Direct connection of autonomous instruments through RS-232 serial interface

Instruments / recorders can be connected in a multi-drop network (the network nodes are connected remotely through a single line of communication). The "host" computer is connected via a serial interface RS-232 to l the first nod via RS-485 serial interface. Serial communication allows the independent programming of autonomous components existing in the network nodes. It can be used to programming and transfer programs using portable card. Such a possibility is illustrated in Figure 8.

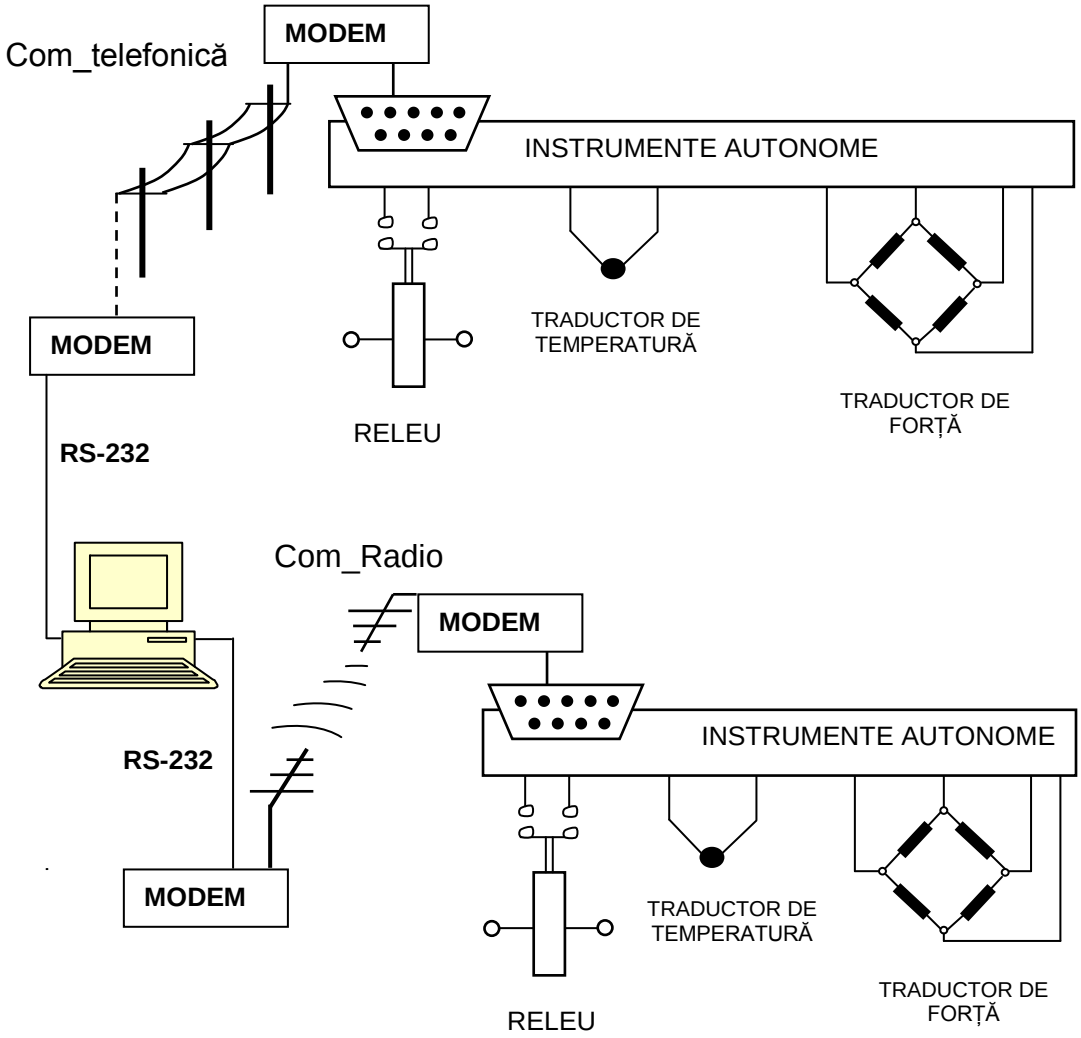


Fig. 7 Data transfer via telephone line or radio communication

- *Connection with the overall IEEE-488 interface (GPIB - General Purpose Interface Bus).*

IEEE-488 interface and other options in this category allow simultaneous connection of an appreciable number of instruments and high speed data transfer. Current autonomous instruments have the serial connectors and GPIB interface too. In addition, National Instruments company provides multiple connection cables. Such a variant of connection is shown in Figure 9.

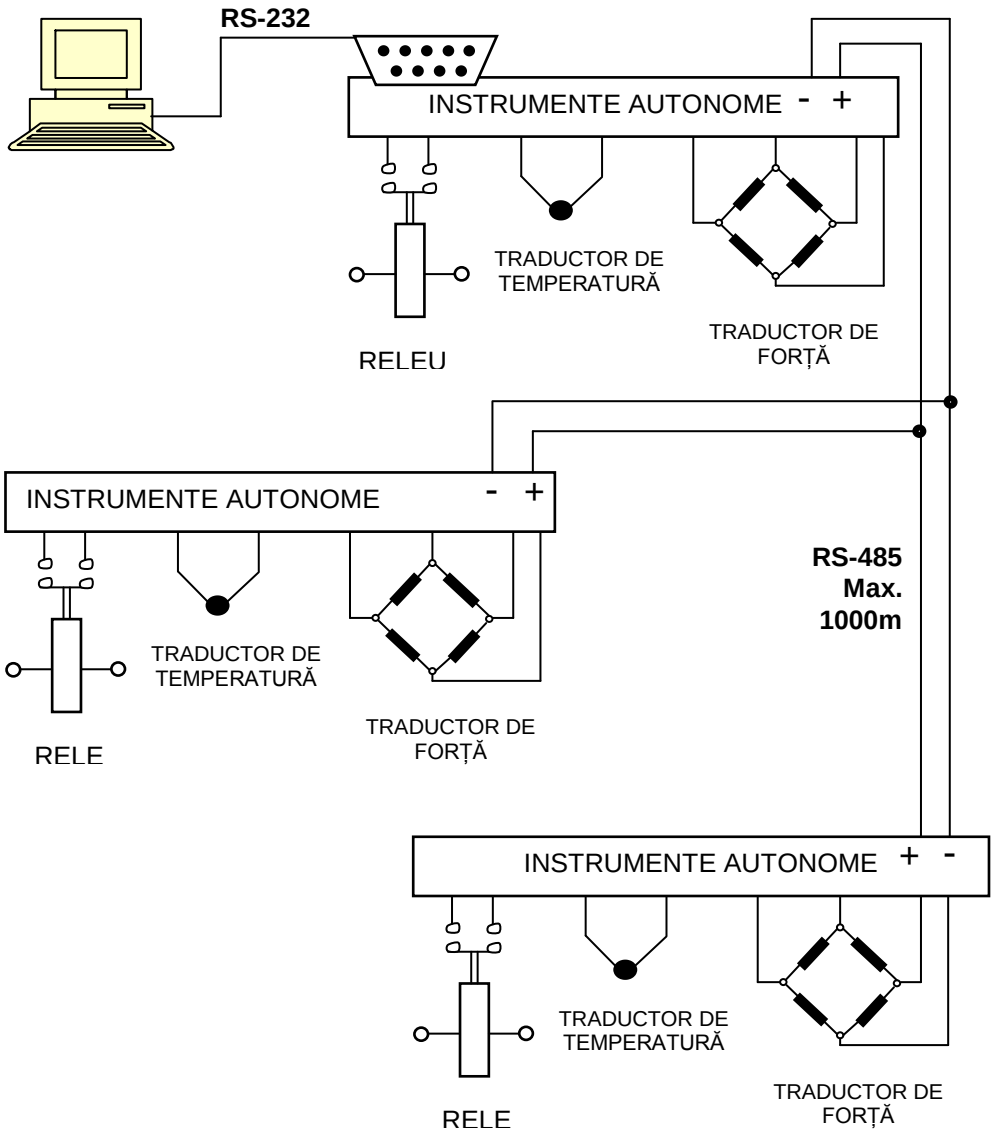


Fig. 8 Network of autonomous instruments connected through RS-485

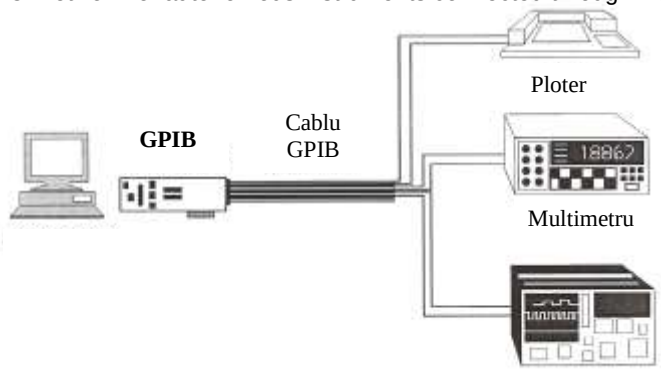


Fig. 9 Set up a DPS based on GPIB interface

Setting a possible solution for a modular self-monitoring system for meteorological parameters that define road safety

System 1
Monitoring of meteorological parameters at the level of roadway surface and display of warnings on electronic panels mounted upstream of the road

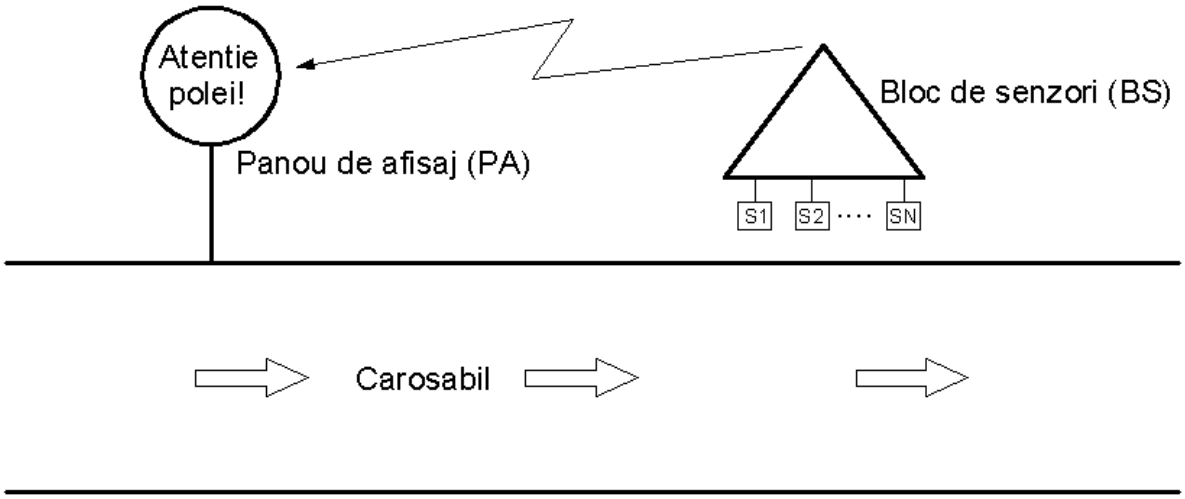
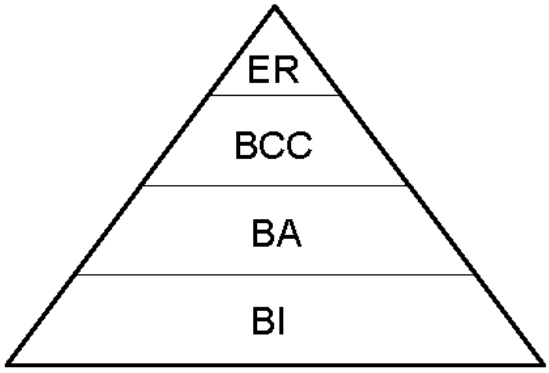


Fig.10

Detail Block sensor (BS)



ER - radio transmitter;

BCC - Block for command and control;

BA - Power Block;

BI - Block of entries.

Fig. 11

(BA) Power block , made with solar panels and batteries or transformer of conventional electricity network, provides voltages 5 V and 12V needed for radio transmitter operation (ER), for the block of command and control (BCC), and for the block of entries (BI).
(BCC) block for command and control based on microcontrollers with low power consumption, dedicated to process the digital signals received from the block of entries and to send them to the radio transmitter (ER).
(BI) block of entries encodes and transform inputs into digital signals, the analog unified measurements (4-20mA) received from transducers for humidity, pressure, temperature,

existing on the road

(ER) radio transmitter encodes and transmits by radio the data received from the block for command and control (BCC).

Detail panel display (AP)

RR - radio receiver;

BCC - Block for command and control;

BA - Power Block;

EA - Electronic Display.

(BA) Power block , made with solar panels and batteries or transformer of conventional electricity network, provides voltages 5 V and 12V needed for radio transmitter operation (ER),for the block for the command and control (BCC), and for the electronic display (AE).

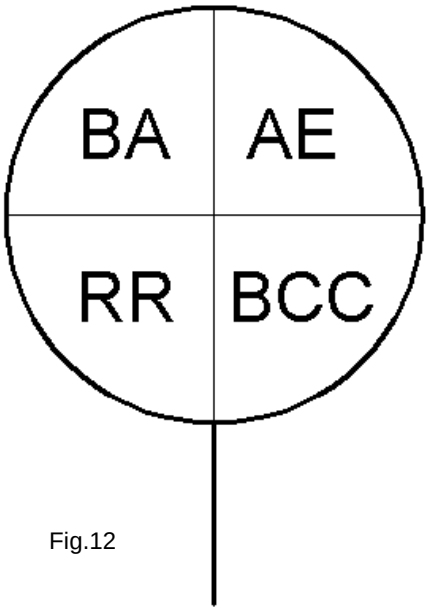


Fig.12

(BCC) block for command and control based on microcontrollers with low power consumption, dedicated to process the digital signals received from the radio receiver (RR) and to send them to the electronic display panel (AE).

(RR) radio receiver receives and decode data provided by transducers for humidity, pressure, temperature, placed at distance upstream on the road.

(AE) electronic display coupled to the block for the command and control, inform and warn road users about the status of the road and about the traffic conditions on the next road segment.

System Analysis

Solution Benefits:

- low cost;
- informations and warnings are in real time on electronic panels.

Disadvantages solution :

- Remember no history of traffic conditions;
- can not show alarm warnings from a center command (accident blocking the road, road- works);
- there may be no statistics on traffic conditions on the monitored segment;
- can not make connections with command centers and specialized data;
- information is available only locally, without the possibility of runway conditions on the time-range (web pages);
- inability to attract revenue by providing data on state road conditions to specialized international sites in providing traffic conditions and planning transportation routes.

System 2

Monitoring of meteorological parameters at the roadway surface using wireless transducers (humidity, pressure, temperature) and displaying the warnings on electronic panels mounted upstream on the road

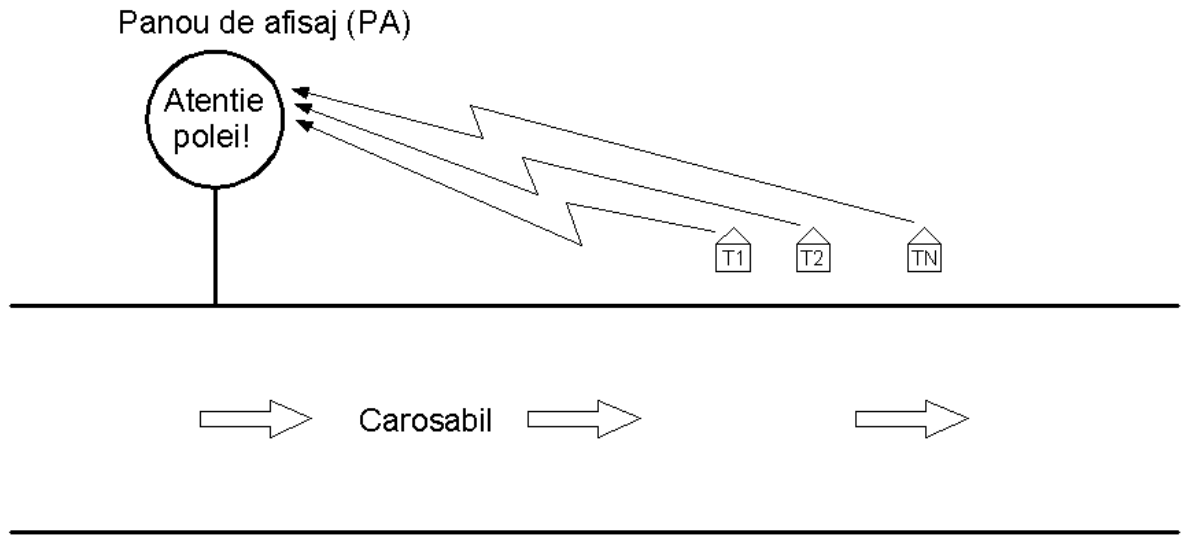


Fig.13

Detail panel display (AP)
RR – radio receiver;
BCC - Block for command and control;
BA - Power Block;
BP - Block for primary processing
EA - Electronic Display.

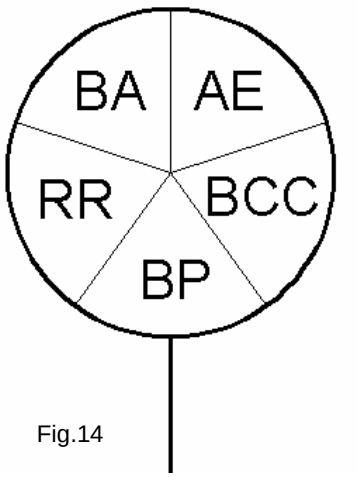


Fig.14

(BA) Power block , made with solar panels and batteries or transformer of conventional electricity network, provides voltages 5 V and 12V needed for operation of the radio receiver (RR), for the Block for Command and Control (BCC), for the electronic display (AE), and for the block for primary processing.
(RR) radio receiver receives and decode data provided by transducers for humidity, pressure, temperature, mounted at distance upstream on the road.
(AE) electronic display coupled to the block for the command and control, inform and warn road users about the status of the road and about traffic conditions on the next road segment.
(BCC) block for command and control based on microcontrollers with low power consumption, dedicated to process the digital signals received from the radio receiver (RR) and send them to the electronic display panel (AE).
(BP) block for primary processing provide the primary processing of digital signals provided by the radio receiver (RR).
(TN) wireless transducers (humidity, pressure, temperature).
Analysis System
Solution Benefits:

- no block of sensors;
- reduced costs.

Disadvantages solution:

- high costs for wireless transducers;
- high costs due to the necessary power supply sources for each radio transmitter.

System 3

Monitoring of meteorological parameters in the roadway with recording values in the center of command and displaying the warnings on electrical panels mounted upstream on the road.

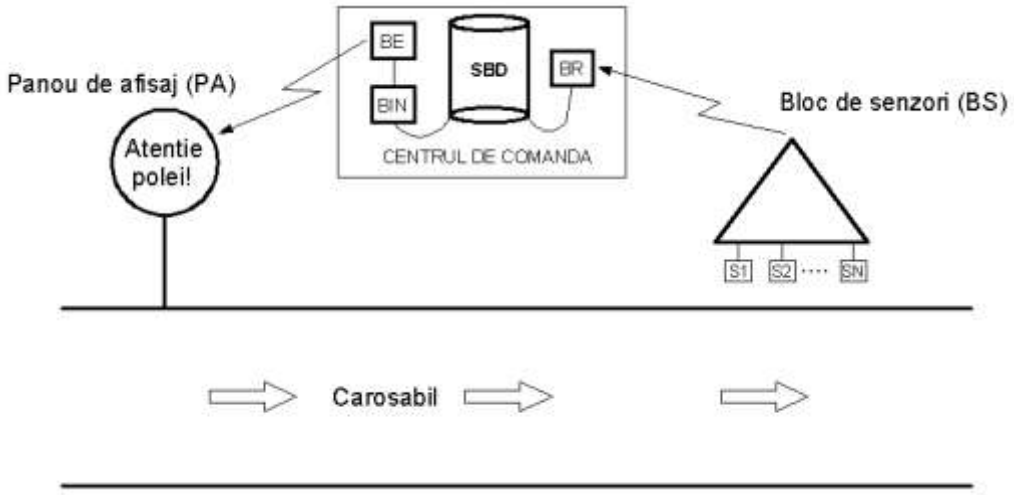


Fig.15

SBD - server / database;
BIN - block for interrogation of database;
BE - block for emission;
BR - block for reception;
PA – display panel;
BS - Block of sensors;
T - transducers (humidity, pressure, temperature).

Solution 3 has, in addition to the solution 1, the command center which includes: server / database (SBD), block for interrogation of database(BIN), block for emission (BE) and block for reception (BR).

Data from the block of sensors are sent by radio to the command center where they are stored in SQL database server.

The data of interest are selected by querying the database, published on the website and transmitted via radio waves using the transmitting block to the display panels located on the monitored segment of road.

Analysis System

Solution Benefits:

- moderate cost for software;
- informations and warnings are in real time on electronic panels;
- be stored in the history of traffic conditions in the database;
- can display alarm and alerts from he command center (ACCIDENT!, jam!, Works on the road!)
- you can make statistics on traffic conditions on the monitored segment of road;

- can make connections with the command centers and with specialized databases (POLICE, weather stations, etc.);
- information is available on the internet (web pages);
- can attract revenue by renting data on state road conditions to sites specialized in providing international traffic conditions and planning transport routes;
- possibility of drawing up maps in real time for road affected by weather conditions and directing efficient intervention of specialisedoutillages in removing snow, ice, etc..

Disadvantages solution:

- additional costs for the establishment and maintenance of command center.

Possible topologies for sensor networks

1 Configuration type star (Fig.16)

Advantages: Implementing simple and fast and low cost.

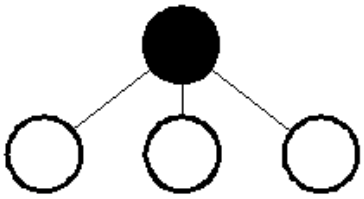


Fig. 16

Disadvantages: It can be used only for short distances.

Configuration type tree (Fig.17)

Advantages: Use the distances

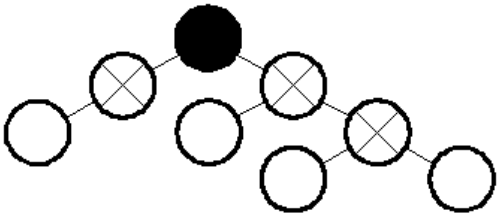


Fig. 17

Disadvantages: stop the flow of data in case a node router to crash.

Configuration type mesh (Fig.18)

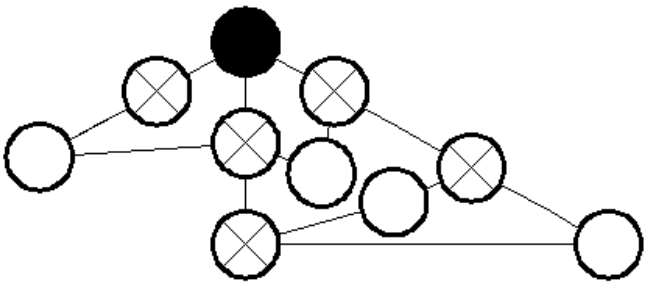


Fig.18

Advantages: Provides redundant data feed, if you take a node router to crash, a neighbor router takes the data flow (network is autoconfigureaza).

Disadvantages: low speed data transmission.

Legend:

= Final node (sensor)

= Node router

= Node gateway

Possible implementations:

I Using the SCADA system

Advantages:

- compatibility with systems in other EU countries
- resistance to working under hard conditions (dust, humidity, temperature)
- easy maintenance due to modular system
- long-term cost very little because of higher reliability.

Disadvantages:

- high initial costs.

II system using NI

Advantages:

- Low initial costs
- Easy maintenance due to modular system
- Fast implementation

Disadvantages:

- Large long-term costs.

III Using HM system (developed locally)

Advantages:

- Low initial costs
- Possibility of developing customized modules

Disadvantages:

- High maintenance costs
- The long implementation
- Maintenance difficult.

References:

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