ROAD/RAIL MEASURING VEHICLE

1. INTRODUCTION

A traffic security is more and more watched at present time and the quality of performed work on rail/tram tracks is pushed forward. Increasing machinery requirements performing this work need to check the quality of work.

From the traffic security point of view it is important the regular checking of geometric position of tracks and other parameters influencing this security. ROT-HSware spol. s r.o., in conjunction with VUZ Praha s.o. ,offers Road/Rail Measuring Vehicle (below "RRMV") which shoud be able to supply complex measuring and diagnostics of the tracks including surrounding structures.

Advantages of RRMV:

- high level of the all-system mobility
- it does not require technological work before – and after measuring
- high performance and utility value
- operating staff safety
- modular measuring systém
- advantage ratio price/utility value
- energy supply independence (own generator)
- possibility of the measured data rating just in vehicle
- communication by way of the GSM network (voice & data services)
- on-line processing and rating
- on-line printing graphs and defect reports
- measuring speed 10…60 km/h
- speed of transport up to 120 km/h (on road)
- climatic conditions independence (possibility of measuring from –10 …to 50 deg.C), climatic conditions report in the record of measuring

2. BRIEF CONCEPCION DESCRIPTION

On the base of long time experience from the measuring devices construction, especially from the construction and operation of the measuring draisine and the measuring car, and with regard to performed analyses, the measuring system using the method of contactless measuring has been projected. Contactless measuring brings some advantages. One of the biggest ones consits in decreasing operational costs and increasing measuring performance. These facts prefere contactless measuring to contact one. By the massive development of electronics in the last several years, here is offered the possibility of using electronic devices in the branch of measurement as well. But only one recording component has still been known recently – recording device with a mechanical binding. Now it is possible to replace this complex mechanism by "a few of sq. mm of silicon". The fast PC developement enables to use the most complex mathematical algorithmes and so get the results in real time. The contactless measuring sensors do exist on the world market at present which satisfy even the most important criteria. The prices of these sensors are able to compete the contact sensors prices now, in many cases.

Our company has been engaged both in contactless measuring of lenghts for a long time and contour measuring by lasers working on trigonometrical principle. It has been further engaged in using gyroscopic and acceleration sensors. Knowledge gained by using these sensors was used in the projection and construction of RRMV.

Regarding to decreasing operational expenses of measuring vehicle, increasing its performance and quality of measuring and also regarding to operational staff security, the carrier vehicle has been chosen as the "road/rail" one. The most available vehicle type seems to be the Czech vehicle PRAGA. The vehicle is being offered just with a rail adapter and has been approved for the both rail and road operations. This vehicle has cross-country character and enables to enter the rails even under off-road conditions. It is possible to install the measuring system to another road-rail vehicle too. Possibility of the road transport increases mobility of measuring device and cuts time necessary for its transport to the measured sector.

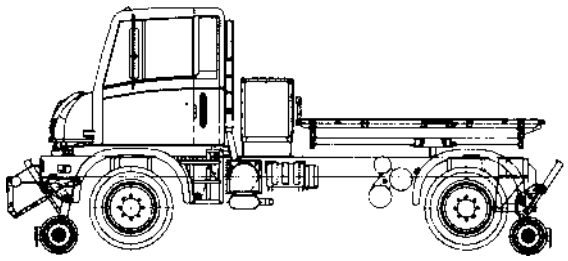

Fig.1: Road/rail measuring vehicle

3. MEASURING SYSTEM DESCRIPTION

The entire system has been structured as modular one in order a system sufficient flexibility is ensured. So it is possible to equip this system with any of offered measuring modules. The core of the system is a central computer. Its task is to control the process, to visualize, to support communication with the staff and support the mileage and time synchronization of the whole system. It means to ensure uniform setting up and data pasportisation (by the central boot files), uniform mileage measuring process, setting of answer-back codes for all files, time synchronization of measuring and assembling all measured data from each of the system.

With such a small measuring device,ensuring complex measuring, it is rather technically impossible to visualize and set up the parameters for each measuring module individually. The number of monitors and keyboards would exceed the reasonable limit and the measuring itself would make an exertion to operational staff orientation. Therefore here is chosen a version of one central system. The staff is not so uselessly strained. Mutual module connection is done through the fast LAN network. The high resolution LCD display and keyboard enable data visualization from all measuring modules and their setting up. LCD displays basic measuring information, as the identification measuring data itself, distance moved, the measured sector, the measuring speed etc. It also displays exceeding of limit values from all measuring modules. Here is possible to watch curves of measured values from the chosen measuring module as well.

All of the measured data can be printed by the connected printer. Data files can be archived on the portable hard-discs and it is possible to record them by the connected recording CD-RW device.

The measuring IRC card gives an exact mileage position of the measuring system on the track. It is important for synchronization of the each particular measured data and consequently for their assignment to the real position and to the RRMV speed.

The GPS system is instrumental for the absolute position determination. GPS data can be used for the choice of the boot file of measuring – simplification of the choice according to the initial vehicle location. The GPS enables to watch and archive operations of RRMV too and it influences decreasing operational costs and easier staff ´s off-road orientation.
It could significantly contribute for searching the vehicle in case it is stolen.

The GSM module is instrumental for communication with the centre through the GSM mobile phone network and the internet one. It enables to transfer

measured data, boot files, to perform service actions and watch the RRMV operation.

The A/D converter module is connected with operational conditions measuring sensors. These data are transferred and recorded in the measuring protocol. It enables to ensure that the measured data can be statistically sorted even regarding to operational conditions, under which they were gained (temperature has the most significant influence). On the basis of these found out operational conditions it is further possible to block measuring itself and so guarantee the system against destruction.

3.1. Central computer optional extension – track corrector

The track corrector is instrumental in track correction. It is located on the front-seat-operator dashboard. The track corrector shows a track passed on its LCD display and enables the track correction, in case that the definition of objects is needed as well. This system allows even synchronisation with mileage stones. Objects in track are understood for example: bridges, railway crossings, switches etc.

4. MEASURING SYSTEM

The measuring system has been projected as the modular one, which can be put together from particular modules, enabling defined measuring. It means it can be supplemented discretionarily or matched to customer requirements.

The measuring system will perform the measurement of these parameters:

GPK - geometrical track position
PHK - rail head profile
PKV - rail profile in switches
VLN - corrugation of rails
PSL - railway bed profile
PPT - structure clearance profile of tunnels and other objects
MKV - trolley line crankiness
MHL - noise level measuring
OPT - closed TV circuit
DEF - flaw detection of the rails
GEO - subgrade structure – georadar

4.1. GPK measuring module

The GPK module is instrumental in the geometrical track position measuring. This is the basic system of the track measurement.

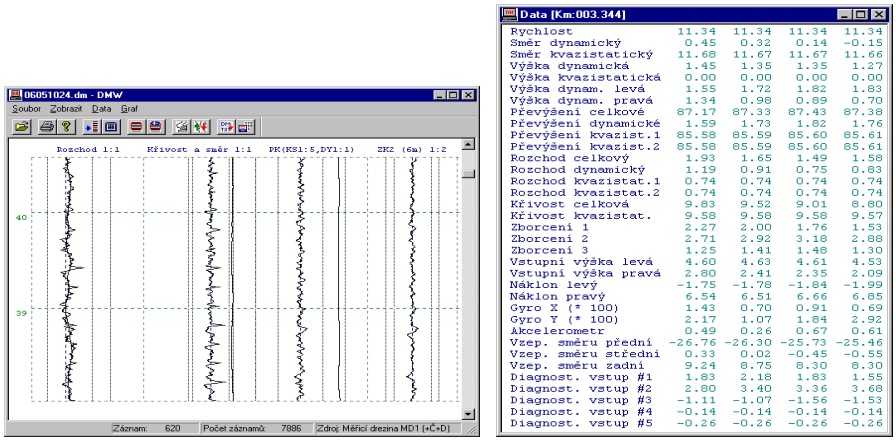

Fig.2: Geometrical track position graph

Outputs of individual parametrs are taken as the basis for track security judgement. Regarding contactless measuring requirement there was chosen an inertial system measurement. The system uses a six-axial gyroscopic sensor ensembled with accelerometers. Sensor signals are led to a fast analog card where they are processed and subsequently transformed into the digital form. Further the signals are processed by mathematical analyses so that each of measured magnitudes can be separated individually.

However, measuring of geometrical track position by the inertial system has its own imperfection, too. With regard to the fact that the dynamic response of the whole system is being measured, it is impossible to guarantee the measurement within all range of speeds especially speeds getting to zero. At present time it is possible to use inertial sensors used in space technology program for the satellite guidance system. These sensors are very precise and they guarantee excellent parameters even at low speed of measurement. So it is possible to get even below 10 km/h. For the track gauge measuring, as the fundamental GPK parameter, it is necessary to equipe this system with the laser track-gauge sensor. Calculation of the track gauge can be tied with the measuring system of the cross section profile of the rail head. It causes significant saving of acquisition costs.

The GPK module is the fundamental one within the whole system. The GPK module outputs are used for the other measuring modules where they create a reference base.

The GPK module measures and calculates:

- track-gauge (it is possible from the rail head profile measuring system)
- track direction - alignment
- longitunal height - level
- crosslevel or cant
- twist

4.2. Rail head cross-section profile measuring module PHK/PHV

The system is instrumental in the detection of both vertical and side rail wear. These measured data show a safety factor, identify the most exposed places (curves, switches ,etc.) as well as help to schedule the needed track maintenance. All that contributes to the safety factor increasing, as well as minimize costs concerning maintenance (keeping the neccessary safety factor). The vertical wear is measured just in the rail axis and the side wear is measured 14 mm below the top of the rail head. The system enables to identify even a type of measured rail (under certain conditions – the system is able to determine the entire rail cross-section – railway bed without through ballast bed). By using mathematical algorithmes, this system enables to calculate the gauge of the rail. According to the new preparing European standards, this system enables to measure the gauge even from the rail points which are placed at the nearest position to the next rail. This magnitude enters the GPK measuring. Let us note that if the system were not equipped with the cross-section rail profile measuring then it is necessary to equip the system with the rail gauge measuring laser sensors.

The rail cross – section profile measuring system can be equipped with the sensor for measuring switches. This sensor has the same function as the one for measuring the rail cross-section profile, however it has adjusted its sensor geometry and modified for scanning the cross-section profile within switches, especially for scanning cross-sections of the flaps and frogs.

The speed of measuring is 20 samples per second. The system indicates both the vertical and side wear and they are compared with the limit values and in case of exceeding them the warning message appeares. During the post-processing it is possible to get statistical information concerning the speed of wear depending on the track loading, the localization of the most exposed places as well as to schedule track maintenance in advance and so on.

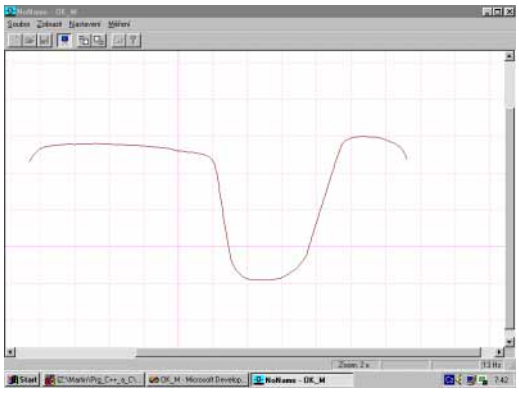

Fig.3: Rail cross-section profile

4.3. Corrugation measuring module VLN

The corrugation measuring module serves to continuous measuring of microgeometry of the rail top surface. Corrugation causes an increasing noise level as well as it shortens the service life of undercarriages. A microgeometry is
scanned by the couple of accelerometers and laser sensors. These sensor outputs are electrically adjusted and subsequently transformed into the digital form and then processed by mathematical analyses.

The results of measuring are used by the diagnostics of corrugation and slip waves and by the checking of the work performed. If the measured corrugation exceeds given limit value, information appears on display.

4.4. Track structure clearance and the cross-section profile of a railway bed measuring module PPT/PSL

The PPT module is instrumental in the track spatial clearness recognition. The clearance is scanned by the triplet of laser sensors. Each particular laser sensor works on the principle of the rotating laser. Scannig speed of the whole railway clearance is up to 60 shots per second. It is necessary to know the track axis location for the clearance calculation. This parameter is calculated from the GPK data. The system compares a measured clearance with the clearance defined by standard and the warning message of scheduling will appear if the defined clearance is disturbed. Stored data serve in scheduling of the excessive load routes. 3D extension of scoring program enables to display clearence and roadblocks including their dimensions and simulation of the passage of an excessive train set. The distance of each particular clearance cross-sections

depends on running speed and results from max. number of shots per second. It is necessary to know track bed conditions (eventually the conditions of the tramway track concrete building panels) in order the railway superstructure can be totaly scored. The shape of track bed is the most important just in the railroad tie top area, where insures the total rigidity of the track grid especially for the contactless rails. The measured cross-section profile (both track bed one and clearance) is compared with the cross-section profile defined by standard. In case of breaking regulations, information concerning relevant limit is displayed.

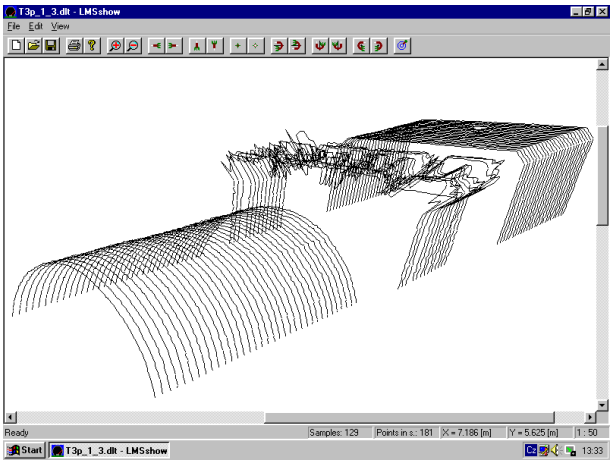

Fig.4: 3D railway clearance projection

4.5. Trolley-line crankiness measuring module

For insuring long life of trolley collectors it is necessary to ensure their uniform wear.It is ensured by the correct trolley line geometry. The trolley line geometry measuring module uses a laser sensor (similar type as for the clearance measuring) for detecting the line position. The measurement principle is retained but its range is adjusted to be able to locate exactly the trolley line position. Measured data are downloaded by measuring card. Afterwards the data are linearized and processed.

The result is the trolley line position itself. To avoid a track geometry position influence, it is necessary to load both measured data from GPK and information about the movement of the measuring vehicle into this system. If the system finds out that trolley line position does not correspond with the valid prescription, then it displays warning information.

4.6. Noise level measuring module

In connection with the introduction of new E.U. standard concerning the noise level it is possible to connect a noise level measuring terminal station to the central computer.

This terminal will be mostly used for municipal traffic measuring - tramway track measuring. The system measures and scores the noise level intensity. Track bed deterioration can be scored on the basis of the noise level measuring

and this measuring enables to the detect exceeding maximum of allowed hygienic standards and hereat an abuse of health.

Fig.5: Noise level measuring terminal station

4.7. Flaw detection system module

This system is instrumental in the non-destructive testing of defects in the rail material. The whole system is projected to be able to be equipped with this measuring facility. The central computer is adjusted to insure all the communication with this system.

4.8. Georadar system module

This system is instrumental in the non-destructive testing of the track bed subgrade. The whole system is projected to be able to be equipped with this measuring facility. The central computer is adjusted to insure all the communication with this system. Data scoring is processed by the specialized centre.

5. Closed-circuit TV

The central computer can be equipped with the video-recording module.
The connected colour camcorder takes the total track cross-section profile. Data are digitalized, processed, compressed in real time and stored on a hard-disc. The shots can be caught either in dependence on the time or on the route passed. Each shot has a text data input expressing mileage. This record is instrumental in visual checking of the track quality.

Fig.6: Closed – circuit TV record

6. POSTPROCESSING – SCORING CENTRE

Measured data can be processed in the scoring centre. It is possible to make new scoring of particular magnitudes as well as to get them printed on the text and graphic printers. The scoring of particular faults and sections, expressed in the quality marks, can be printed for section lenghts of 200 m and 1000 m. In the graphical mode there are the curves of each particular parameter printed with stationing, track object indication and with the velocity of measurement. The graph lenght-scale is adjustable. Graphical printer output can be configured. The scoring centre is calling to archive data and to perform the statistical processing. Statistical data processing enables exact investment scheduling, concerning neccessary maintenence and thus it ensures increased level of the railway traffic safety. The scoring centre software is adjusted to the customer needs.

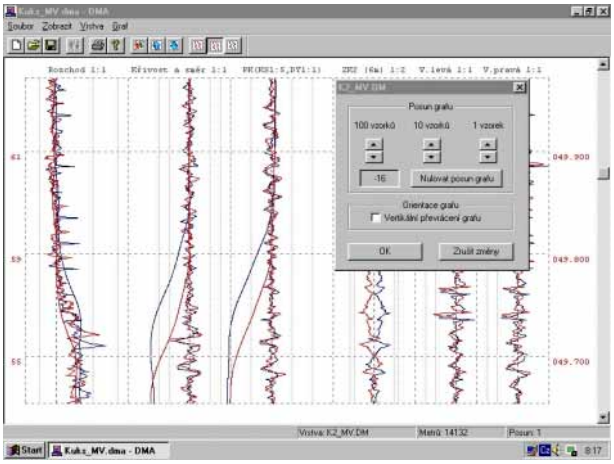

Fig.6:Data scoring computer programme

7. CONCLUSION

The fast development of electronics enables the new opportunity for the measurement technology development. During the development of this measuring vehicle all the findings from the operation of the measuring draisine MD 1 and the measuring car MV 1 were taken into account. Modular measuring system enables any configuration of measuring modules and its easy extensibility. By using of the contactless technology of measurement we minimize operational costs of the whole system as well as we enable to install the measurement system on nearly any vehicle. During the choice of a carrying vehicle we wanted to ensure as the best operation of the measuring vehicle as possible. The road-rail vehicles push themselves more and more at present time and meet these requirements.