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Continuous and automated data during field tests

Summary

Development cycles are becoming ever shorter and the requirements for product quality are becoming ever higher, and this holds true not only in the automotive industry. In order to master these challenges, it is essential to conduct extensive series of measurements in the course of practical field tests. The interaction of controller software with the mechanical, hydraulic and electrical components is becoming increasingly more complex. With regard to agricultural machines, this is especially relevant for tractors, self-propelled harvesters and attached implements.

One may well ask: what are the requirements for such autonomous data loggers, which are used in parallel to development on the one hand, and directly in customers' vehicles, on the other? For the purpose of long-term studies, one would need particularly robust systems, which are capable of withstanding extreme environmental conditions such as heat, cold, spray water and shock. The requirements for data loggers are just as stringent with regard to online billing and storage. Thus, machine data have to be recorded continuously and/or in an event-driven manner and synchronised with GPS coordinates, video sequences, analogue or digital measurement channels (temperatures, pressures, paths, forces, vibrations, etc.).

Afterwards, the collected data is automatically transmitted via the mobile radio network and provided to the test engineer via a web front end. Even with the field test still in progress, the test engineer is already able to conduct an automated evaluation of the initial measurement data and apply the acquired insights to the implementation of the test. The requirements are presented by using the self-propelled sugar beet harvester "Maxtron 620" of the company Grimme Landmaschinenfabrik GmbH & Co. KG as an example.

Prepared with information of Dr. rer. agr. **Johannes Sonnen**
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Maxtron 620 of the company Grimme Landmaschinenfabrik GmbH & Co. KG

Application Note #40
Vehicle Testing
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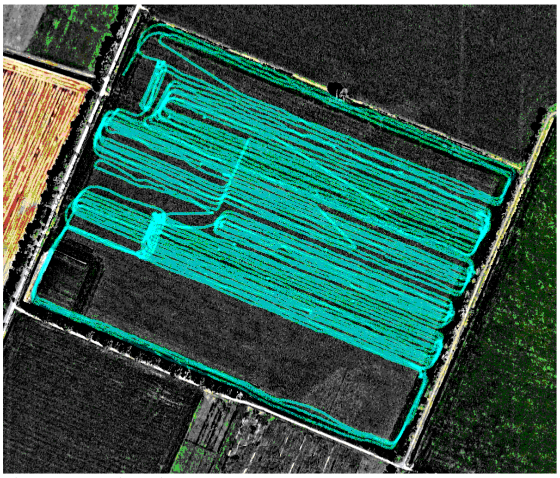
Introduction *Grimme's objectives*

In the beginning, there was the concept of continuous monitoring of the machines during operation. One needed a small, robust device, which would be reliable even in harsh environments, and which has the capability of logging analogue and CAN bus signals, as well as coordinates, via GPS. In addition, further possibilities for analysis, such as online grading, are needed. With the aid of these grading data, one has to create regionally dependent load configurations for the individual driving and lifting elements. And since one should be able to monitor the machines at any location, the process has to be implemented wirelessly by means of a commercially available network and without human intervention.

It must be possible to automatically retrieve full measurement series from the memory card. In order to adapt to fast-changing requirements, measurements and analyses, one should also be able to remotely reparametrise the data logger.



GPS data - sugar beet harvester

Requirements for data logging

Measurements under special environmental conditions such as heat, cold, spray water and shock require accordingly protected measuring devices. This applies, in particular, to long-term measurements in the open air and to test vehicles. One of the highest standards for resistance against temperature, dirt and shock.

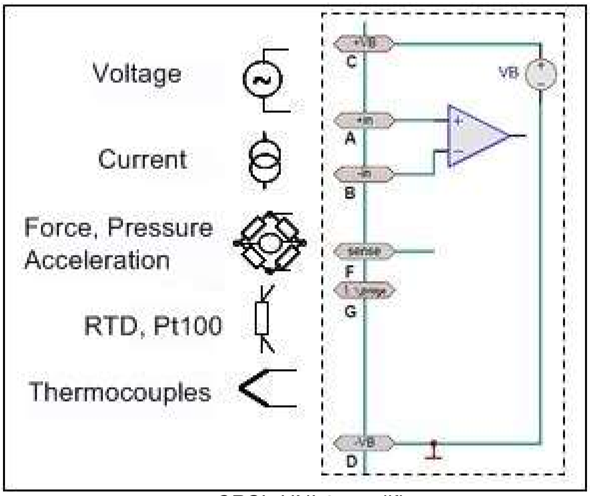
CRONOS SL-4

CRONOS SL complies with the following norms:

- MIL STD810F, 6ms semi-sine, 60 g
- Rail Cargo Vibration Exposure;
- U.S. Highway Truck Vibration Exposure)
- IEC 61373 (30ms semi-sine, 300m/s² ~ 30g)

The aim of data logging is to capture the condition of the machine through the measurement of electrical, mechanical, thermal or other physical parameters. These parameters are either measured directly, as voltage (± 10 volts) or current signals (4...20mA), or indirectly, via a special signal conditioning. A **universal amplifier** (UNI-8) is used to provide the right conditioning for each sensor.

The amplifier can be connected to a full-bridge, consisting of four resistors, a quarter- or a half-bridge. The voltage drop in the feeder cable can be detected via the sense wire and the voltage can be accordingly adjusted.



CRSL-UNI-8 amplifier

The measurement of temperature is made possible by PT100 or various thermocouples. Here, the temperature compensation and linearization of the sensor is implemented directly in the system. The analogue inputs can be measured with a sampling rate of up to 100 kHz and a bandwidth of 48 kHz (-3dB).

Digital signals

With regard to the acquisition of digital signals, a distinction is made between switching operations and digital sensors to measure the so-called incremental encoders, paths, revolutions or angles of rotary machines and establish parameters such as speed, location, frequency or certain events.

CAN bus – common field-bus systems

It often happens that signals are already available at digital field buses, such as the CAN bus for example, because these buses are needed for controlling and regulating the machine. The busDAQ-X can be expanded with 2 or 4 CAN bus nodes. Both high-speed (ISO11898) and low-speed CAN buses (ISO11519) are directly supported with the appropriate software configuration (LIN bus and FlexRay are also available). All these very different signals must be synchronously collected, evaluated and stored.

Visual Control 80 with CAN BUS connection

Intelligent data management

Permanent measurements create a considerable amount of data, which has to be evaluated at some point. To address this issue, one can apply intelligent methods for data reduction, without loss of interesting raw data. Powerful trigger and memory modes are just as important here as intelligent methods for data reduction or the free mathematical calculation of channels. Since the data stream is being received continuously, all this processing has to be done in real time, without interruption of the monitoring. The free calculation of channels also involves the establishment of derived measurement parameters, which describe the status of a measurement object as a result of the mathematical modelling of processes, the monitoring of threshold values for the measurement parameters or logical links. All data obtained in this way represent the current state of the monitored object,

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which can be saved in the measuring system on-site. Thus, the result is a full history log for the unit, which is available for statistical analysis. These data also form an essential basis for maintenance planning.

Alarms, warnings and messages provide information about condition and status.

Depending on parameterisation, modern measuring and monitoring systems react to such messages with optical or acoustic signals on site. It is possible to intervene in the process by executing control and regulatory measures, as well as to dispatch warning and alarm messages, or obtain more extensive error logs via SMS, fax or e-mail.

Transmission of measurement data via WLAN or mobile radio

If the measurement system (Grimme uses busDAQ-X) is equipped with a router, i.e. a device known from telecommunications, computer networking and the Internet, it is possible not only to send warning and alarm messages via SMS or e-mail, but also to conduct full-fledged measurement campaigns.

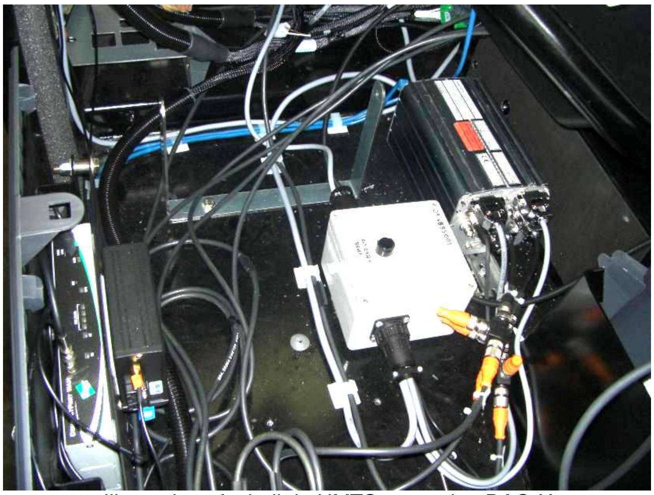

Illustration of a built-in UMTS router, busDAQ-X, a reset and time relay box

Measurement and remote monitoring via the Internet and Intranet

A modern, web-based condition-monitoring interface (www.webdevices.de) allows users to become more familiar with the operation of the harvester under real operating conditions. The developer receives data during testing and actual operation. The measurement data and results are used for the optimisation of models or the creation of an optimised maintenance plan and they provide information and clues for design improvements. WebDevices realises the concept of providing remote measurement control from any terminal in the world connected to the Internet. In case of remote monitoring tasks, the results of threshold value monitoring are automatically transmitted by the measuring device and then sent to authorised users. Considering that WebDevices uses commercial telecommunications services and the Internet, it represents a simple and uniform solution for the supervision and monitoring of measurements of individual or distributed devices. The management of many measuring and monitoring systems and their control and configuration can be done over an Internet platform.

The Internet portal, in conjunction with a data server, fulfils the requirement that measurement can be observed and controlled from any Internet terminal in the world by using just a standard browser. In case of remote monitoring tasks, the results of e.g. threshold monitoring get automatically transferred by the measuring instrument to the platform and then warnings and alarms are dispatched to authorised users via SMS or e-mail.

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Wireless data transmission worldwide?

The Internet provides a global network infrastructure based on the TCP-IP transmission protocol, which describes the method of data exchange between computers. Modern communications services such as e.g. UMTS, EDGE or GPRS allow for wireless access to the Internet from any location in the world. Mobile operators in Germany and many other European countries already offer flat-rate tariffs, which makes the implementation of monitoring for agricultural machines very cost-efficient, even if large amounts of data are transmitted.

However, the mere possibility of transferring data over the Internet does not represent a satisfactory solution for the stable and, above all, secure monitoring of agricultural machines, because monitoring is available only if the monitored system is located within the range of the mobile radio network and not in zones without coverage. Grimme solved this problem by installing an additional reset and time relay box which keeps the measuring system and the router “online” for an adjustable period of time after the machine is switched off in order to transmit any unsent data collected during the day of harvesting in time for the recording day.

In addition to the security of transmission and measurement systems, special attention should also be paid to availability and the costs of mobile radio transmission abroad.

Challenges to mobile data transmission

While just a few years ago operators used to manually “call up” such machines via the GSM network (using a mobile phone), the common method nowadays is to use fast mobile radio systems. In terms of data security, however, these systems are fundamentally different from a “one-to-one” data connection such as GSM dial-up.

In order to be accessible via high-speed mobile networks, the machine has to connect to the Internet during operation by means of the mobile radio provider's infrastructure. Thus, the machine is part of a public network and it must be separately protected with special security measures.

The company imc offers its clients a custom-configured mobile radio network, which is specifically coordinated with the mobile radio providers and cannot be accessed by any other mobile subscriber. The network is available worldwide and uses the infrastructure of the mobile service provider and that of the corresponding roaming partners.

This makes it feasible to establish a very fast connection to the machines because there is no need for extra overhead, such as cumbersome encryptions. The mobile service provider ensures the isolation of the private network via its own technologies.

Such embedded systems receive a globally unique, predefined IP address which always stays the same. Machines can be easily accessed and queried.

Automated data retrieval with WebDevices

It is difficult to keep track of when and for how long a mobile system is located within the range of a mobile radio network. The transmission of larger quantities of data under such circumstances could become quite complicated, especially if time differences for systems operating abroad would also have to be considered.

The software monitors the mobile radio (as described above) or WLAN network and initiates individually configurable data transmission from the machines. The user receives the transmitted data via a web browser and is continuously kept informed about the state of the machines connected to the system.

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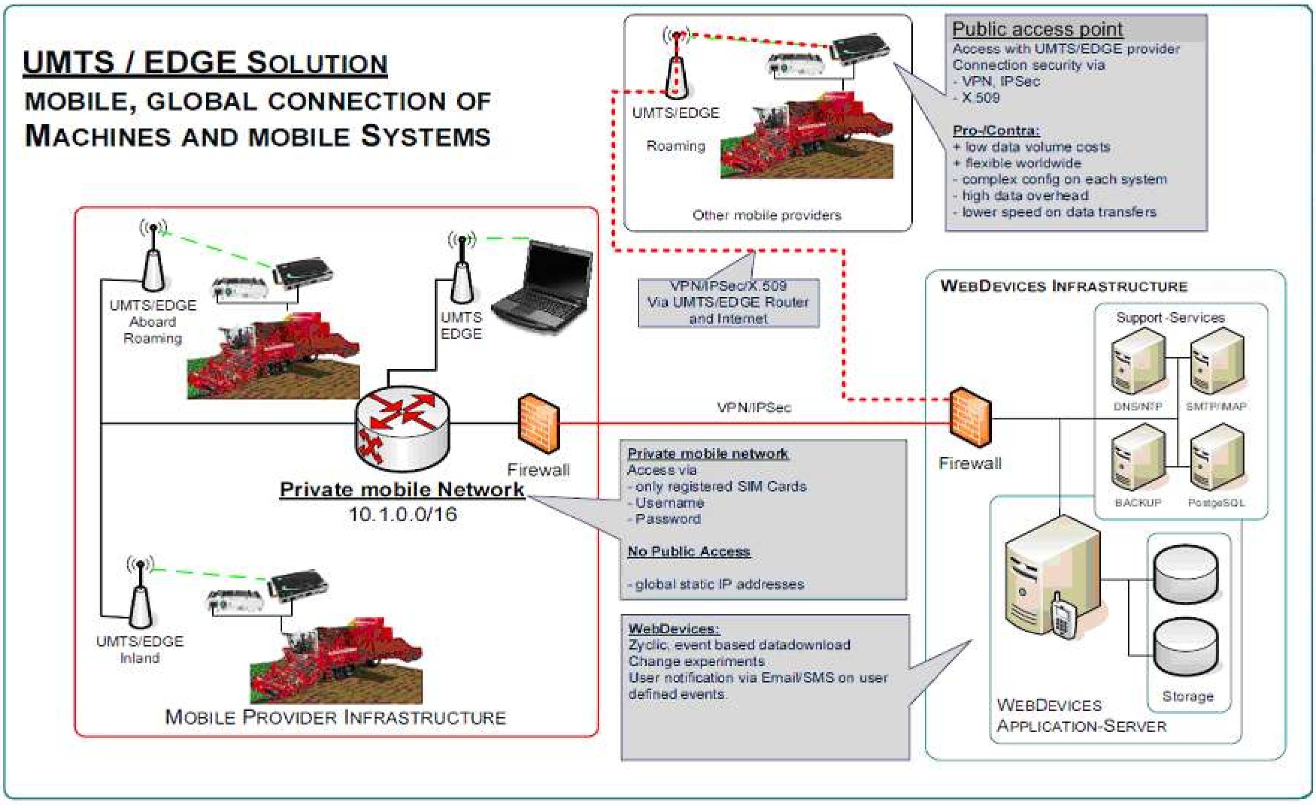

A turnkey mobile data network with the utmost data security, „private Internet“

The risks for wireless networks include:

- The retrieval of location data.
- Unauthorised and undetected access by external users.
- The circumvention of firewalls allows the intruder to intercept sensitive (measurement) data.

Conclusion and prospects for the future

In order to reduce development times, it is becoming increasingly important to carry out **virtual test drives** by means of hardware-in-the-loop simulation. These test drives allow developers to test control units as well as electrical, mechanical and hydraulic components in a non-real vehicle. Thus, in the course of testing, it is necessary to replace individual components with virtual components, such as e.g. MATLAB Simulink models and to feed realistic measurement data and measurement series obtained from field tests into the system.

Only the real test can provide reliable evidence about the vehicle’s behaviour with regard to the human component.

Only hardware capable of withstanding severe environmental conditions, combined with powerful computational algorithms, can provide the foundation for obtaining sound data and results. Withal, the continuous and automated data logging during field tests is no longer merely a concept. A permanent or temporary status monitoring is economical even for operators or manufacturers of smaller machines and equipment and it permanently increases the product quality of the series.