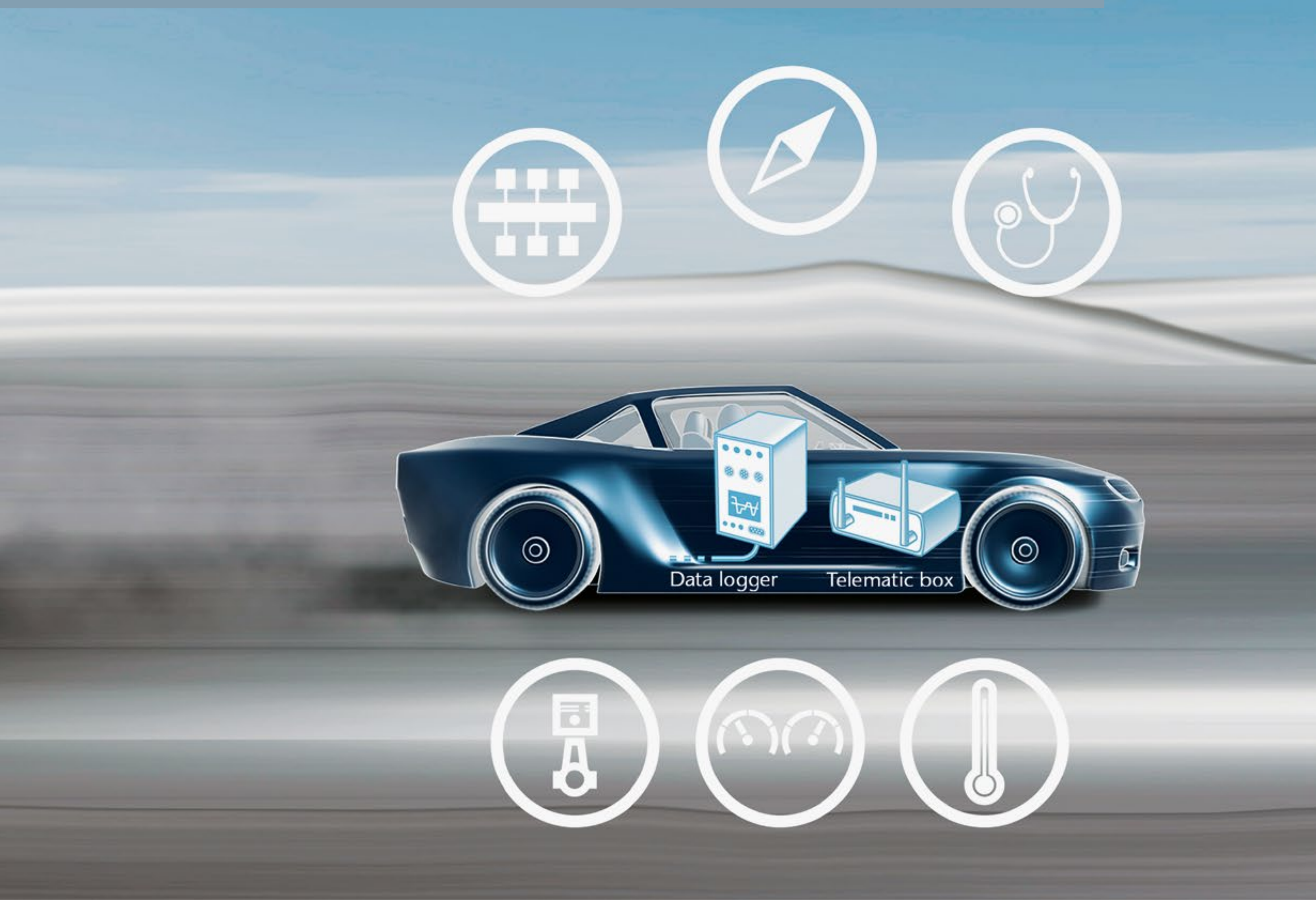
Measurement Data Management on Track for the Future

In future, Industry 4.0 will require the use of new methods, tools and IT infrastructures. Digital measuring instruments will generate previously unimagined volumes of data and this will give rise to new business visions. Bertrandt is closely involved in this field and has added data management services to its portfolio. These range from targeted data capture and efficient transmission to analysis options and long-term archiving.



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BIG DATA, ANALYTICS AND INTERACTING WITH THE NEW WORLD

In the age of Work 4.0, we use not only mobile phones and computers to communicate with one another, but also many other things. The word things has a special meaning in this case, because the Internet of Things (IoT) is presenting the automotive industry with completely new challenges and also opportunities. For several years, vehicles have been sharing data with a variety of different web services (on the cloud), but this has only involved a few functional data items being sent to the vehicle. The exchange of data has not been bidirectional, despite that being precisely what you might expect from a networked vehicle. Increasingly, this is all about accessing individual vehicles directly from a backend system. For this reason, Bertrandt is taking the approach of dividing the world into many cluster areas. Information will be provided for each of these areas, including weather, traffic and infrastructure data. As soon as a vehicle enters a specific cluster area, it subscribes to the information content of the area via an MQTT protocol (message queuing telemetry transport). This guarantees that the newly available data reaches the vehicle immediately. A structured data management solution which has been carefully planned from the start is essential in ensuring that the information is always accessible and correct.

Against this background, Bertrandt has added data management services to its portfolio, **FIGURE 1**. This includes data capture, efficient transmission and a range of analysis options, together with long-term archiving. Bertrandt's technical competence in this area is complemented by accompanying services such as software development, training, process re-engineering and user helpdesk creation.

FROM VISION TO BUSINESS

But how can the theoretical "from the innovation to the product" approach be put into practice? The theories in the scientific papers on the subject of big data have to be proved by means of specific projects. However, the first question must always be the added value for the customer. In order to identify this, the existing tools, processes and procedures must be analysed, so that the potential for change for the end consumer can be highlighted. New tools and processes are not introduced automatically. People create them on the basis of long-term practical experience and new technical knowledge.

This is the foundation on which the b.competent 1.0 project was established in the Bertrandt Group. Existing internal sensor data from the vehicle were fused to produce enhanced functionality, more added value for the driver and more driving functions. The second stage of the project involves transmitting the sensor data from the car via the mobile network to server structures, carrying out analyses using fused data from other vehicles and third-party providers and returning the resulting information and potential recommended actions to the vehicle, **FIGURE 2**. The initial goal is to improve the safety and comfort of the assistance systems by using swarm intelligence, among other things. The possibilities and applications are almost unlimited, from cars to building energy management.

CLASSIFICATION, APPLICATIONS AND DATA MANAGEMENT WITH AN ONLINE CONNECTION

Bertrandt is currently implementing a range of different use cases. These make it possible to identify certain situations with the help of data from an individual car and a fleet of vehicles, supplemented with external and internal information from the backend system. This includes predictive route data, driver classification as well as recognition and detecting risky situations, such as the end of a traffic queue or black ice. These data are identified, analysed and made available to other vehicles completely automatically. The location of the dangerous situation is also a very important consideration which Bertrandt is working on. It should ideally be possible to identify the location to within 0.5 m or a maximum of 1 m.

The innovation project covers other areas such as online diagnostics, long-term studies, vehicle energy management and the live configuration of assistance systems. In all the use cases, the first step always involves setting up the data management system. Unstructured

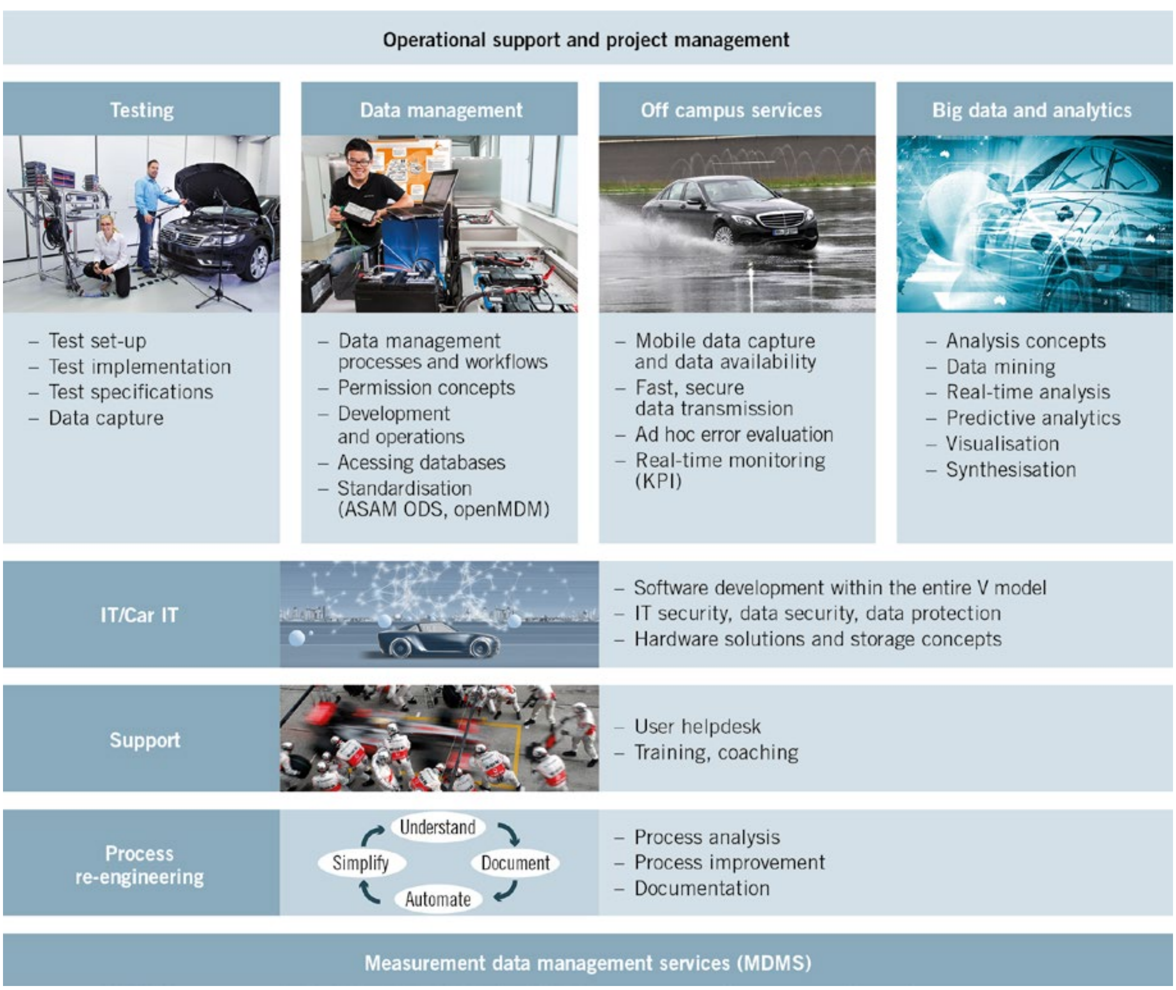

FIGURE 1 Bertrandt engineers are gradually putting together the pieces of the puzzle for the big data and business analytics megatrends to produce customer-focused solutions (© Bertrandt)

big data would otherwise bring no benefits, because the analysis would require an excessively long latency period. As a result, the transfer of data from the car via GSM to the backend system, including analysis, and then returning it would take several seconds.

FROM DATA CAPTURE TO RECOMMENDED ACTIONS

The first step consists of storing and indexing sensor data from a test vehicle in a backend infrastructure, together with information from third-party providers, such as weather forecasts or predictive route data. The subsequent analysis of the structured datasets allows the options for improving the driver's safety and comfort to be identified. By linking the data together in a meaningful way to create simple dependencies, it is possible to generate information and recommended actions that will help to ensure that the occupants of the car have a safe and comfortable journey. In the next step, the engineers fine-tune the recommended actions by incorporating data from many other vehicles into the analysis.

During the first phase of this cross-site project, a microcontroller with an accompanying software architecture was developed which can access all the CAN and FlexRay signals in the car. In the second phase, an M2M (machine to machine) connection box was added to the hardware architecture. The box can communicate with the external backend system via a LAN, a WLAN and GSM. There is also the option of having the WLAN function as a hotspot in the car, which will allow a device connected to the WLAN to read the information directly from the bus. A development or diagnostics laptop can access the bus while the car is moving and use the data in real-time. Communication from the car to the backend via the WLAN also allows large quantities of data (for example from a data logger) to be transferred to a network without manually transporting data media such as hard disks.

The initial use cases have demonstrated the added value of a data management system of this kind. The modular structure and expansion options of the system also allow additional customised applications based on customer requirements to be defined. Depending on the scenario, pre-filtered signals can be sent via the GSM network to the backend system are then analysed and the results can be returned to the vehicle in the form of recommended actions. The M2M box maintains a constant connection with the backend throughout this process to ensure that the data is always secure.

The data is encrypted with the help of certificate authorities and VPN connections, depending on the security rating of the signal. The reliability, latency period (when a connection is restored) and efficiency of both the available encryption methods are currently being evaluated. It should be possible to make use of existing security and encryption concepts and to adapt them to meet customers' requirements.

The unreliable mobile network coverage is being assessed separately. Each M2M box buffers the data in internal memory until the data can be transmitted securely and without errors. If the network goes down, the box resends the data when the connection is restored and ensures that every signal has been received in full and without ambiguities. The MQTT protocol is used for this purpose, which has become the standard in the Internet of Things. This open messaging protocol for M2M communication is ideal for unstable networks and network connections with high latency because of its straightforward and efficient monitoring mechanisms. It simplifies the process of developing design patterns, **FIGURE 3**.

INTELLIGENT DATA MANAGEMENT IS THE CRUCIAL FACTOR

The large volume and often highly dynamic nature of the data requires a flexible and, at the same time, extremely efficient storage structure. The data sent by the vehicle can be stored and managed in

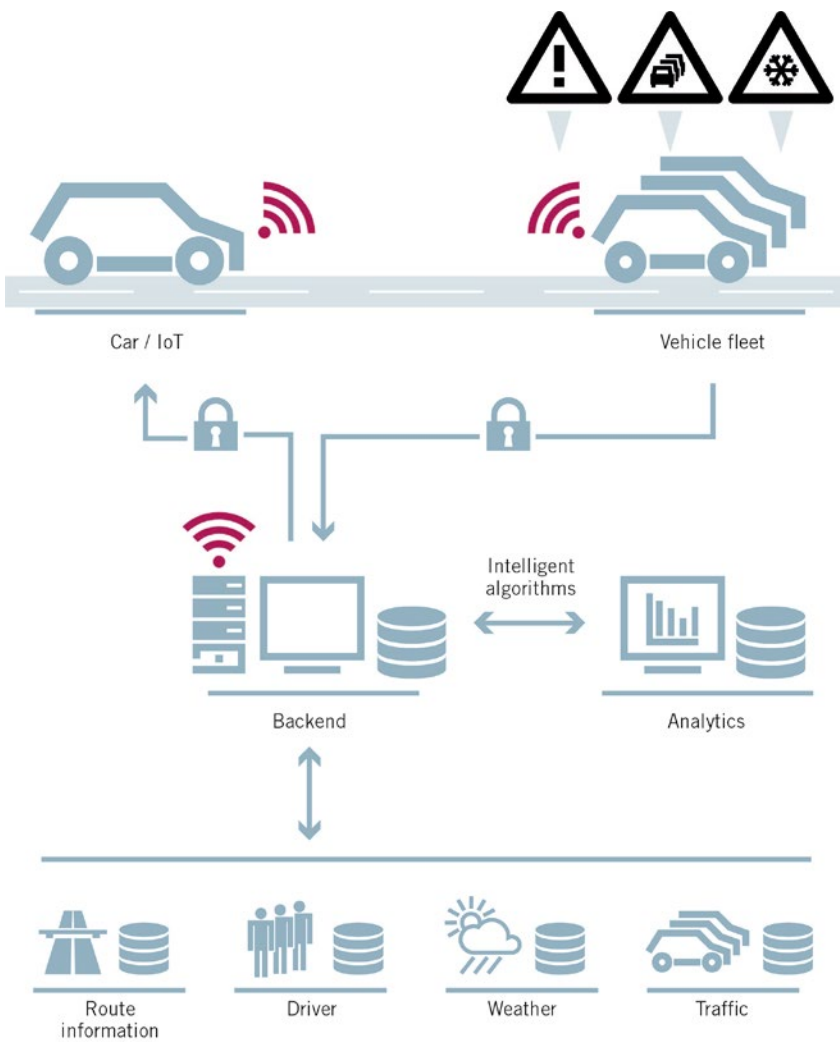

FIGURE 2 The concept of swarm intelligence with data fusion (© Bertrandt)

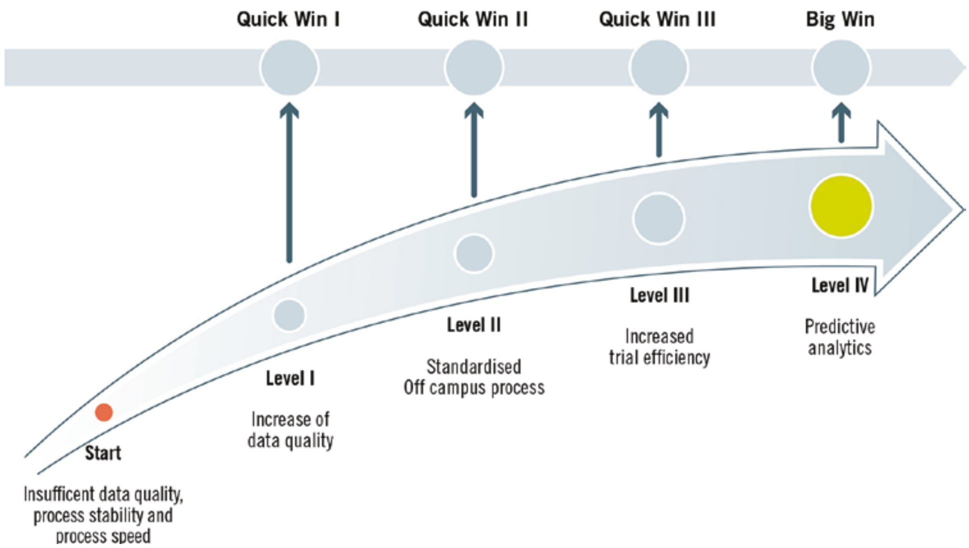

FIGURE 3 Data are the raw materials of the future – the gradual introduction of an intelligent data management system customised to meet the needs of the business and the customer will help to ensure the individual success of the company (© Bertrandt)

the backend system in almost any type of database (for example Oracle, MSSQL, Cassandra, Hadoop). Similarly, any sort of server (Windows, Linux, OSX) and service can be used and customised to meet customers' requirements. As part of the data management process, it is possible, for example, to categorise all the relevant data captured from a specific corner during the course of a specific event (such as cornering). On the one hand, this makes it easier for the analysis algorithms to access the data they need and, on the other, it allows initial trends to be identified. Because of the expected complexity of the various data configurations, Bertrandt's in-house environment has been designed to be both modular and virtual.

Before the first trends in the data can be determined, the data undergo a plausibility check. The specialists are currently developing concepts to investigate in particular the physical plausibility of the data arriving in the backend system. A dynamic range of values is being defined for each sensor signal, which covers the reasonable figures. Any deviation from this scale can be regarded as an implausible data point. In the event that no error has occurred, this becomes a point of interest. Depending on the other parameters that were recorded at the same time, the point may be able to provide information about the source of the irregularity.

After the filtering, grouping and preparation phase, some data are sent by the backend to the vehicle for the purpose of carrying out analyses relating specifically to the vehicle. As a result of the fusion of all the available backend data and the current configuration of the vehicle (load, fuel level, tyre pressure etc.), the vehicle can generate individual added value and calculate the relevance of this itself. The analyses involved may be highly complex and time-consuming, which means that a multicore processor is needed. The real-time capability of the algorithms alone requires multiple cores, which is why the project described here is closely involved with this technology.

However, additional algorithms are also required which differ significantly from those used in the analyses carried out in the vehicle in terms of their complexity and the amount of resources needed. The focus of these algorithms is on long-term learning. The analysis algorithms will set up non-model-specific searches for dependencies between different parameters and also use more complex methods, such as neural networks and RDF graphs. Defining and fine-tuning the rules for learning on the basis of the situation on the road and the performance of the systems in the vehicle will be one of the challenges in this area. As well as the algorithms tailored specifically to the situation on the road, driver-related analysis methods will be used, which evaluate the driving style, for example, and integrate it into the driving process by making the driving style available to individual systems.

BIDIRECTIONAL DATA SHARING AS THE BASIS

The Internet of Things is still in its infancy as far as the automotive industry is concerned. Until recently, data only travelled in one direction from the backend system to the vehicle. As a result, existing solutions often fail to provide any genuine added value for end customers. By creating a bidirectional connection between the vehicle and a cloud service with a sophisticated data storage architecture and intelligent and efficient evaluation algorithms, it is possible to generate added value using swarm intelligence, in the form, for example of recommended actions. These will lead to safer and more comfortable journeys as a result of the predictive recognition of risks and to more efficient use of time and energy. The Bertrandt b.competent innovation project has laid the foundations for developing these processes further. It is not yet clear when and in what form these new technologies will be incorporated into production vehicles and made available to the wider public. The first large-scale projects are already underway and generating new ideas.