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Off-board diagnostics to increase availability and reduce cost

Pilotfish Bus Insight

Availability as a major factor of cost in public transport

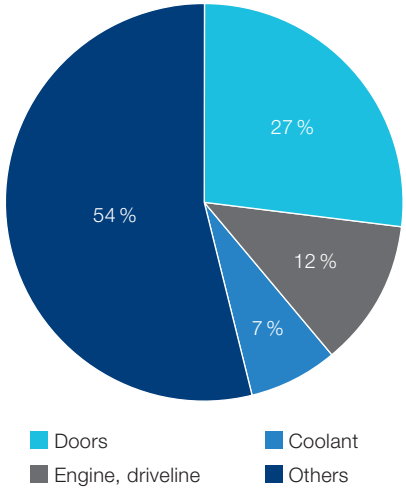
Punctuality and reliability are among the most important reasons why people choose public transport (PT). To meet these expectations, availability is one of the most important key performance indicators (KPI) for every Public Transport Operator (PTO). Here, the transition from traditional corrective maintenance to a predictive maintenance strategy is key. And improving availability affects the number of spare vehicles needed, and consequently, has a direct impact on the cost of operations.

Among the most mentioned reasons for poor availability of vehicles are issues involving doors, even though the doors themselves are often just the visible symptom of a larger problem. Often times, the bus type, the bus's operation and even the topography at a bus stop can be contributing factors.

Engine trouble, including the driveline, is the second most common reason for poor vehicle availability, followed by problems with the coolant circuit. Other reasons are the electrical circuit, heating systems and air condition as well as the brake system, including the air pressure supply.

Aside from these vehicle-related components, the onboard IT systems have an increasing influence on the availability, too. If, for example, the ticketing system is not working, the whole bus will be unavailable. And if the traffic-priority system doesn't work, a bus cannot keep its schedule in regular city traffic – and must be taken out of operation.

Pic. 1: Availability: Overview of reasons for a bus's failure on the road (own research)



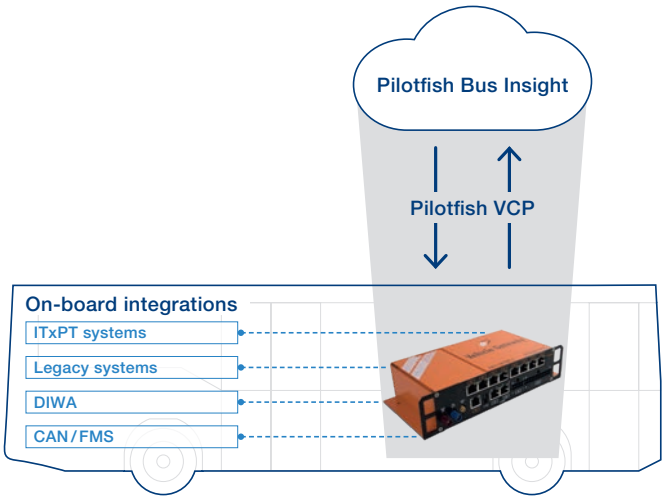
Technical solution

To increase availability, a transition to predictive maintenance is key. Making use of data from the vehicle itself and from operation is a perfect starting point. As the backbone of communication, the CAN bus is protected against unaothorized access, the standardized FMS interface provides relevant data from CAN in a read-only mode. Pilotfish Bus Insight combines these data with other data sources like proprietary diagnostic interfaces. It could be from the transmission as well as the data from the IT systems in a bus, regardless of whether they are already ITxPT compliant or legacy systems.

When the systems are ITxPT compliant, these data enable an insight into the status of the component, but even for legacy systems, visibility of basic data like MAC or IP address can help to identify and declare basic status.

So, the vehicle-side architecture of Pilotfish Bus Insight covers both sides, the “technical” part of the driveline and the “informational” part of the on-board IT systems. See picture 2.

Pic. 2: Collecting data in the vehicle and forwarding to the cloud

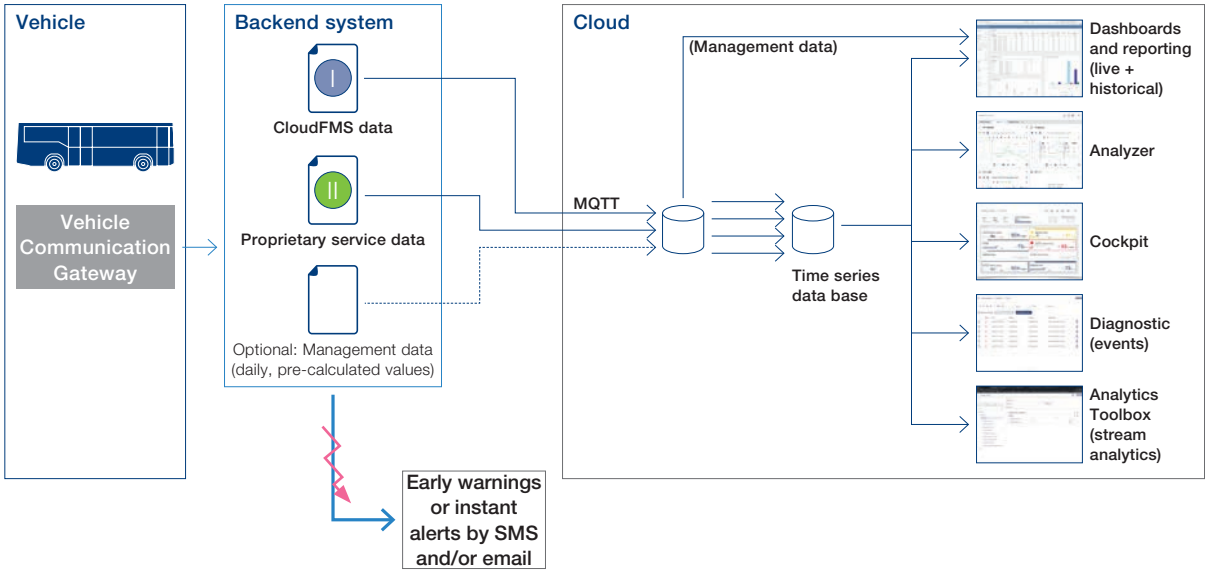


Basic IT architecture

A system to enable the PTO to improve the efficiency of operation and maintenance must provide instant alerting functions as well as the capability for deeper analytics, enabling predictive measures. The signals transmitted from the vehicle are instantly monitored by dedicated thresholds, and the system generates instant alerts via SMS or email to dedicated recipients in combination with input to work log. As an example, this enables the workshop manager to follow up on the incoming tasks.

For long-term purposes, all data are stored in the cloud. Dedicated KPIs, extremal values or just statistical incidences are visualized in dashboards for certain personas, oriented to their individual tasks and daily work journey.

Pic. 3: Layout of the basic structure – data sourcing in the vehicle, backend and cloud-based analytics



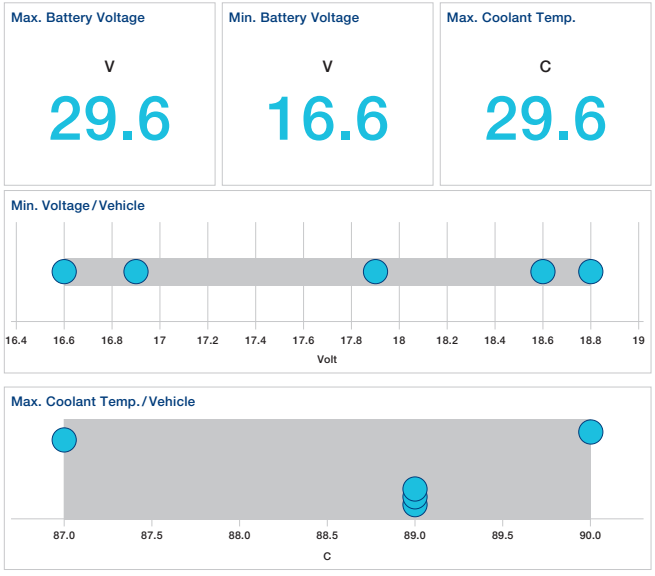
Strategies for a higher availability – transition to predictive maintenance

A first step to initiate predictive maintenance is to monitor trends of dedicated signals and to identify outlier values. As an example, this can be applied for the voltage of the electric circuit announcing an upcoming breakdown of the 24 V battery or the coolant temperature, indicating service needs for the coolant circuit. Both are visualized on the top dashboard for the workshop manager, and the identification of the relevant bus is just one click away. See picture 4.

Already the data from the FMS interface give a first insight into the condition of the most relevant components, and the next step is to use the proprietary data from the individual diagnostic systems. One example is the diagnostic data from the Voith automatic transmission DIWA. The data from the transmission's electronic control unit (ECU) are forwarded to the cloud and analyzed automatically, triggering early warnings and alarms by email or SMS to the responsible service engineer. This logic is in use for thousands of transmissions worldwide and has led to a quantum leap in availability for the bus – especially since the data from the transmission mirror various significant data from the driveline, too. A similar application has been made already with the ECU of electric doors in terms of a proof of concept (PoC).

Looking at the failure rate of doors as an example, this is mostly not caused by the doors itself but by a wide range of surrounding factors – which advises that one must consider much more data than for example a FMS message, representing only the door status. The availability of various data, such as time series, and the option to combine these data enables the user to apply more advanced methods like machine learning or artificial intelligence (AI), too. This applies especially for doors – one of the biggest levers to increase availability – where at least for pneumatic doors no early warning from an intelligent sensor is conceivable. To detect abnormalities, one can use the door signal itself, the air pressure and combine it with, for example, knowledge of repeated attempts to close the door and operational data (like stops per kilometer or number of braking and kneeling events). This includes the air supply system itself with the air compressor in an AI-based approach to implement predictive maintenance [4].

Pic. 4: Example for visualizing the spread of service-relevant figures like maximum coolant temperature and minimum voltage – Test fleet of 5 buses



Off-board diagnostics to improve operation

Aside from increasing availability by implementing predictive maintenance, the data from off-board-diagnostics enable the user to improve operation, too. Examples for this are, e.g.:

- Times of exceeding standstill with the engine still running.
- Excessive use of the park heater when not necessary
- Longer periods of “ignition on” with engine at standstill but lighting still on

Combining dedicated parameters from CAN/FMS especially helps to identify events like that quite easily. Visualized on a map, the operation manager can assess such events individually and advise the relevant driver to improve his behavior.

Commercial impact: Cost saving and increasing availability

Looking at common applications like Fuel Economy, these normally give an immediate impact on the cost by a significant reduction of the fuel consumption. Experiences from various operators show savings from 5 % up to 10 % and even more. The potential savings from using Bus Insight are more sophisticated. The monetary effect of such an off-board diagnostic comes from the enablement of:

- Better planning for the workshop with immediate attention to upcoming service works and so a better efficiency in the workshop
- Fewer breakdowns in operation and so a reduced number of spare buses
- Reduced cost for towing and penalties resulting from fewer breakdowns on the road

In a simulation for a bus operator with a fleet of 100 buses, a reduction of breakdowns on the road by just 20 % allows for one less bus in the fleet – and remaining at the same overall availability. Similar outcomes are also described in studies from VDV in cooperation with the industry [2, 3]. If the annual cost for a spare bus is 30 T€, the omission of just one spare bus already provides an instant payback for a system like Bus Insight.

Summary

Reliability is key for making public transport the preferred choice of travel – and the availability of all assets plays a vitally important role. To improve availability of the buses on the road, a comprehensive off-board diagnosis system is essential. Pilotfish Bus Insight complies with the expectations of the operator by covering not only the driveline and its main components but the IT systems, too. It helps to identify upcoming failures and enables the transition to predictive maintenance. Thus, efficiency in the workshop will be significantly enhanced. Bus Insight helps to reduce the number of spare buses as a significant cost factor. Improving reliability leads to an immediate payback for the operator as well as enhanced passenger satisfaction and motivation to choose public transport – a win-win situation for all stakeholders.

Literature:

[1] Pilotfish BusForce: FMS Data to Support Service and Maintenance FMS Data to Support Service and Maintenance – Busforce (pilotfish.se)

[2] VDV-Schrift 881 Verfahren zur Ermittlung von Personal-Kennzahlen f. Instandhaltung. Beka-Verlag 2019.

[3] Kliewer, G.; Ott, F.; Puetz, R.: Die nächste Generation des „Fahrerarbeitsplatzes“. Tagung Nutzfahrzeuge 2011, Steyr.

[4] Wiedmann, M.; Mueller, R.: Patent Application WO 2017/129392 A1: Method for monitoring vehicle compressed air system. 2017

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