





Development of Functional Requirements for Sustainable and Attractive European Rail Freight

D2.7 – Continuous Data Transfer from the Locomotive to the Landside

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EXECUTIVE SUMMARY

The apply condition based and predictive maintenance program is an essential and fundamental process step in the communication, distribution and training of the modified maintenance program to ensuring a consistent application. For this reason, the DB CARGO Service Centres, ECM 2, ECM 3 and ECM 4 are involved at an early stage in the development and validation of the condition based and predictive maintenance program to ensure a smooth and complete knowledge migration.

The underlying factor is that without a stringent and consistent application and compliance of the defined condition and predictive maintenance strategy, the determined lifecycle cost savings and the increased technical availability can't be realized in the planned time period.

It is therefore essential that data is transferred from the locomotives to the land side. Otherwise it is not possible to enable predictive maintenance successfully.







ABBREVIATIONS AND ACRONYMS

n/a







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1. INTRODUCTION

The concept of data gathering is based on IT-supported usage of existing operational data (e.g. kilometres or operating hours), the usage of existing data from on-board unit systems (e.g. MTU engine monitoring system or on-board units for freight wagons developed in WP3) and finally the usage of additional technical equipment and sensors. In addition to the IT-based measurement methods, analogue measurement methods can be used for gathering the reference variables in the maintenance shops. Depended on the state of technology the data will be recorded and transferred to landside at pre-defined intervals. Alternatively the data will be selectively read out by hand at the maintenance shop during maintenance layover and afterwards manually transferred to landside.

It will be essential to provide the data quality with a sufficient degree of safety and availability. The higher the safety relevance of a component and the associated maintenance measure, the higher are the requirements on data quality. These requirements need be taken into consideration when designing and developing the measurement technology (software and associated hardware).





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2. CONTINUOUS DATA TRANSFER FROM THE LOCOMOTIVE TO THE LANDSIDE

Data quality monitoring dashboard

Structure

The dashboard consists of three levels:

- 1) An overview level (level 1), on which it is shown for the entire fleet and individual series, how many locomotives are equipped with telematic boxes and from how many of these equipped locomotives we received data last.
- 2) A series level (level 2) at which certain data quality KPIs are presented for individual series (or more generally: locomotive groups).
- 3) A locomotive level (level 3) that displays data quality KPIs for a single locomotive.

You can toggle between the levels using the tabs at the top of the page and by clicking on certain elements:



The visualizations of the individual levels are explained below. For most visualizations, the IT platform context menu appears when you mouse over the visualization. It can be used to display the underlying search (magnifying glass icon) or to download the results as a CSV file (download icon).

Overview level (level 1)

Filters

Übersicht Ausrü	stung			
Time Interval		Model range		
Last 30 days	~	All	۸ 😧	Suche starten
		All		
	_	185		
Ausgerüstete		189		Lokomot

The period can be selected in the upper left corner. Default: 30 days. If there is data in the IT platform for a locomotive within this period, it is defined as "sending". See also: Restrictions above.

To the right you can select individual locomotive type. Default: All locomotive type. "All" currently means all locomotive type defined in the dashboard. or appear in the Thing Registry.

After changing the filter values please press the "Start search" button to update the visualizations.







Export options

Activity ~ Help	r ✓ Find
DB	Datenqualitäts-Monitor
	Export ~
	▲ Download Stammdaten

In the upper right part of the window, the "Export" button can be used to create a PDF of the first dashboard level, e.g. for reporting purposes.

Below that, the "Download Master Data" button offers the possibility to download the currently stored Thing Registry as a CSV file.



Equipment status

This visualization shows the number of locomotives (of the locomotive type selected above) in DB Cargo's stock and how many of them are equipped with a telematics box are equipped. The basis for these numbers is the currently stored Thing Registry. A locomotive is defined as "equipped" if in of the corresponding line of the Thing Registry the field "box_serial" is not empty.

A click on the pie chart opens the second level of the dashboard with the filters set above ("Drilldown"). Depending on, which part of the pie chart was clicked, only locomotives with or without a telematics box will be displayed.







Data dispatch



This visualization shows the number of locomotives equipped with telematic boxes of the locomotive type selected in the filter above (Definition of "equipped": see above) and of how many of them we have any data in the IT platform in the period selected above.

A click on the pie chart opens the second level of the dashboard with the filters set above ("Drilldown"). Depending on, which part of the pie chart was clicked, then only locomotives with telematics boxes will be displayed, from which we can see in the have either received data or not. In the latter case, many visualizations will remain empty there, because there are no data are available whose quality could be assessed.



Series overview





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This visualization is a combination of the two pie charts above, divided by locomotive type. Accordingly, changing the locomotive type filter at the top of the dashboard has no effect on this visualization. A click on the individual parts of the bar chart opens the second level of the dashboard with the corresponding locomotive type and the period selected above ("drilldown"). And of course, depending on the area clicked, unequipped locomotives or equipped locomotives are displayed with or without data dispatch in the selected period.

Series level (level 2)

Filters

Datenqualität der Baureihen									
Time Interval	Model range	Loknr.	Ausgerüstet		Daten empfangen		Rows Count		
Last 30 days 🗸	× 185	× All	Ja	3 -	Yes	© -	10	0 -	Suche starten

In addition to the selection of the time window (please note the section "Restrictions" at the top of the page!), further filters can be set here. The default values of the filters depend on which element was clicked on the first dashboard level.

Series: Here the selection of the locomotives can be limited to one or more series.

Locomotive number: Here you can select one or more locomotives of the locomotive type selected in the locomotive type filter.

Equipped: This filter is based on the fields "supplier" and "box_serial" in the Thing Registry.

- "All" means that all locomotives are displayed, regardless of the value of the above fields.
- "Yes" only shows locos with non-empty entries in both fields.
- "-" shows locos with empty "box_serial" attribute (but not empty "supplier" attribute?).
- "Railnova" / "Nomad" displays locos with non-empty "box_serial" attribute and the corresponding "supplier" attribute.

Receive data:

- "All" shows all locos (based on the locomotive type and locomotive number filters), whether data has been received or not.
- "Yes" shows only those of the selected locos that have sent any data to the IT platform in the selected time period.
- "No" shows only those locomotives for which we have no data in the selected period.

Rows Count: This value determines how many lines per page are displayed in the loco-sharp KPI overview table.

After changing the filter values, please press the "Start search" button to update the visualizations.

Export option







Using the "Export" button, a PDF "printout" of the current dashboard can be generated, e.g. for reporting purposes.

Received data per data source



The number of the IT platform events of each source type per time unit (e.g. per Day; the time unit selects the IT platform depending on the selected time interval (automatically) are available. Which source types are displayed depends on the selected locomotives and their associated attributes in the Thing Registry. In concrete terms, the union of all non-empty attributes of the selected locos in the Thing Registry that end in "_interval". For example, a non-empty attribute of the Name "diag_interval" of a locomotive of the locomotive type 185 to count all events of the source type "rsi_br185_diag".

Data integrity





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Vollständigkeit Zeitspanne



Perhaps the most complicated data quality KPI. As described for the visualization "Received data per data source", the considered source types are determined by the selected locos and their "*_interval" attributes in the Thing Registry. A value of the attribute "sensor_position_interval" of 60 means that a locomotive type 185 locomotive should send a IT platform-event every 60 seconds during its journey, i.e. 30 events during a 30 minute journey.

The IT platform production timetable data (ABZT_IST - ANZT_IST) is used to determine the trip duration and the total trip duration for each locomotive is within the selected time period (dedicated dropdown menu "Completeness Time Span"). As described above, the result is the total number of expected IT platform-events per source type within the period under review.

The number of expected events is then aggregated across all selected locomotives and compared with the number of events actually registered in the IT platform of these locomotives. locomotives of the same source type and the result is displayed as a green bar. Values above 100% (e.g. due to incorrect production timetable data) are rounded down to 100%. The difference between this number and 100% is displayed in red.

Warning: This KPI should be used with caution because

- the production timetable data in the IT platform is of insufficient quality,
- the expected reception rate of each source type in the IT platform can only be an estimate,
- Events of certain source types (e.g. diagnostic data) are not sent regularly by a locomotive, but only when such events are Diagnostic data occur at all, for example, due to a technical problem with the locomotive. They are then processed, for example, within 120 seconds sent to us. This means that other 120 second intervals of this locomotive are even good without diagnostic data. (the locomotive may not have had any technical problems) and may not necessarily be a data quality problem. Nevertheless a completeness KPI is also calculated for these source types for consistency reasons.

Sending locomotives per data source









Similar to the visualization "Received data per data source", the number of locomotives sending at least one event of this source type per time unit is displayed for each relevant source type.

Equipment development



For each calendar week, the total number of locomotives already equipped with a telematics box and the number of locomotives that have sent data to the IT platform during this calendar week is shown for the selected locomotives. The definition of "equipped" here is analogous to the diagrams on the first dashboard level, but here the attribute "date_loco_equipped" from the Thing Registry is also taken into account.

This diagram is rather a by-product and does not replace a professional boot curve!

Note: Depending on the selected filters and entries, the displayed numbers may look unexpected, e.g. if for a locomotive in the Thing Registry no box serial number is stored, but this sends data to the IT platform (number of equipped locomotives < number of sending locomotives). In addition, this visualization seems to be particularly susceptible to problems resulting from too long selected periods of time of the filter on the header of the page (keyword: data model acceleration period).

Unique Events / Duplicates



For all relevant source types of the selected locomotives, the proportion of unique events or multiple received events ("duplicates") is displayed here, on the left in the trend over individual





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calendar weeks, on the right overall over the entire time window selected in the filter area of the dashboard at the top.

The definition of when two events are duplicates is basically different for each locomotive type and each source type!

Latency



The visualization on the left shows how high the proportion of events of each relevant source type with a latency of less than 5 minutes is of the total events within each calendar week. On the right is the proportion of all events within the selected period that fall into a specific "latency category". Latency" here basically means the length of time that elapses between the Sending of sensor data / occurrence of a diagnostic event on the locomotive and its indexing in the IT platform.

The definition of the latency is basically different for each locomotive type and each source type!

Gesa	ntubers	licht								
BR 0	Loknr. 0	Letzte Daten 0	Ausrüster 0	Duplikate: diag 🗘	Duplikate: sensor_position 0	Duplikate: sensor_telematic 0	Gültige GPS Signale 0	Latenz <=5min: diag ≎	Latenz <=5min: sensor_position 0	Latenz <=5min: sensor_telematic 0
185	004	08-11-2018 10:07:50	Railnova	0.00 %	0.07 %	0.12 %	99.50 %	83.66 %	100.00 %	08.38 %
185	005	08-11-2018 09:40:05	Railnova	0.19 %	0.18 %	0.31 %	99.77 %	50.24 %	93.89 %	93.98 %
185	005	08-11-2018 10:07:46	Railnova	0.21 %	0.17 %	0.49 %	99.80 %	55.09 %	94.47 %	93.07 %
185	007	08-11-2018 10:07:28	Railnova	0.08 %	0.16 %	0.22 %	99.83 %	67.90 %	92.39 %	91.19 %
185	008	08-11-2018 10:03:32	Railnova	0.00 %	0.02 %	0.16 %	99.77 %	51.42 %	96.77 %	96.68 %
185	011	08-11-2018 08:02:04	Railnova	0.10 %	0.01 %	0.22 %	99.80 %	78.63 %	96.45 %	95.87 %
185	012	08-11-2018 10:07:37	Railnova	0.08 %	0.01 %	0.19 %	99.64 %	55.44 %	96.25 %	96.44 %
185	014	08-11-2018 09:43:51	Railnova	0.14 %	0.13 %	0.18 %	99.85 %	48.53 %	93.00 %	93.35 %
185	064	08-11-2018 09:17:24	Railnova	0.12 %	0.00 %	0.20 %	99.79 %	69.14 %	85.12 %	84.85 %
185	070	08-11-2018 10:07:12	Railnova	0.26 %	0.04 %	0.18 %	99.85 %	58.55 %	05.03 %	95.61 %
									* prev 1 2 3	4 5 6 7 8 9 10 next>

Complete overview

This table shows all selected locomotives with their KPIs for the selected period. For details on the calculation of these KPIs, please refer to the corresponding descriptions. The KPIs are highlighted in color: up to 75% red, up to 90% yellow, from 90% green.

New is the "Last data" column, which indicates the last time we received data from this locomotive. The color coding means: older than 30 days red, older than 7 days yellow, otherwise green.

The number of locomotives displayed per page depends on the "Rows Count" filter at the top of the dashboard.

Using the CSV export function (download icon, which appears when you move the mouse over the table), you can export this table export. This is particularly suitable for obtaining a list of all locomotives of a particular telematics supplier, for example, depending on the filters set./ a list of all locomotives that didn't send any data.

It is known that the loading time of this table is very long, and some patience is currently requested from the user.







Validity of GPS signals



This graphic shows the number of valid, invalid and missing GPS signals (events with GPS coordinates) for the selected locomotives and the last days. This is invalid if the GPS coordinate (0, 0) was sent. Missing means that the corresponding data field is empty. All other data is considered valid.

Locomotive level (level 3)

Filters

Datenqualität und Stammdaten einer einzelnen Lok								
Time Interval Model range Loknr.								
Last 30 days	· 185 🔇 🔻	185-012	⊗ ▼	Suche starten				

Here you can select a single locomotive and the observation period. If you click on an element of the second dashboard level to get here, the corresponding locomotive is already preselected and the period corresponds to the previously selected period.

After changing one of the filters, please press the "Start search" button.

Export option



Using the "Export" button, a PDF "printout" of the current dashboard can be generated, e.g. for reporting purposes.

Mileage





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"0 km"-Werte a	anzeigen				
Kilomet	erstand				
2,413,000) ————				
토 오,412,000					- •
and				<pre>/</pre>	
5 2,411,000					
ي <u>اب</u> ب ب ب					
	-				
	Mon Oct 15 2018	Mon Oct 22	Mon Oct 29	Mon Nov 5	Mon Nov 12
			Zeit		
(2981 km errech	nete Fahrleistung im durc	hsuchten Zeitraum)			

The kilometre reading of the locomotive is displayed aggregated for the selected period. The interval length (and thus the number of data points displayed) is automatically determined by the IT platform is specified as a function of the selected period (e.g. one mileage data point per day). All Mileage data of the locomotive is aggregated for each point in time, so only the maximum mileage per period is displayed. Jumps the mileage in the visualization between two displayed data points, this is not necessarily due to problems with the Data.

Since the scaling of the y-axis is automatic, zero kilometre readings are hidden by default for better display (= not is displayed). This behavior can be changed in the Show 0 km Values drop-down menu.

At the bottom is the difference between the smallest (or first?) and the largest (or last?) value transmitted in the selected time period. mileage is given.



Data integrity





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State of movement

Bewegungszusta	and												4 ¥ 0
Time 0	Mileage 0 LOCOSTATE 0	GPS_Speed 0	Velocity 0	KMDRIVEN ©	NODATAFLAG 0	DATAGAP 0	COND1 0	COND2 0	COND3 0	TIMEDIFF 0	TIMEDIFF_HOUR 0	TIMEDIFF_MEDIAN 0 r	si_tl_fd_lst_ZWG ः
2018-11-14 16:07:45	2412326 Lok steht				0	0	0	0	0			41	
2018-11-14 16:07:04	2412325 Lok fährt		43.90 km/h	0.5000	0	0	1	1	0	41	0.011389	41	
2018-11-14 16:06:23	2412325 Lok fährt		43.90 km/h	0.5000	0	0	1	1	0	41	0.011389	41	
2018-11-14 16:05:42	2412324 Lok fährt		87.80 km/h	1.0000	0	0	1	1	0	41	0.011389	41	
2018-11-14 16:05:01	2412323 Lok fährt		86.75 km/h	0.9880	0	0	1	1	0	41	0.011389	41	
2018-11-14 16:04:19	2412322 Lok fährt		86.75 km/h	1.012	0	0	1	1	0	42	0.011667	41	
2018-11-14 16:03:38	2412321 Lok fährt		87.80 km/h	1.0000	0	0	1	1	0	41	0.011389	41	
2018-11-14 16:02:57	2412320 Lok fährt		122.03 km/h	1.3898	0	0	1	1	0	41	0.011389	41	
2018-11-14 16:02:39	2412319 Lok fährt		176.61 km/h	0.8781	0	0	1	1	0	18	0.005000	41	
2018-11-14 16:02:16	2412318 Lok fährt		149.99 km/h	0.9583	0	0	1	1	0	23	0.005389	41	
											« prev 1 2	3 4 5 6 7	8 9 10 next +

This table assigns one of the three movement states "locomotive running", "locomotive stopped" and "locomotive stopped" to each transferred kilometre reading data point of the locomotive. The logic behind it comes from Philipp Richter and is explained in detail in this Jira ticket. This table is only intended for debugging purposes because of its complexity and shall be replaced by the "Movement state grouped" table.

REFERENCES

n/a