AN EFFICIENT TOOL FOR OVERCOMING COMMUNICATION BARRIERS IN RAILWAY TRANSPORT

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ABSTRACT

Weak communication between rail personnel while running trains leads to mistakes, operating costs, accidents and incidents. In this paper a coded language to facilitate communication between rail operations personnel is presented. Examples for the use of the coded language are developed. The code is being incorporated in a message management system for rail software applications, demonstrating significant potential for market up-take.

Keywords: railway operations, communication, simulation

1. MOTIVATION

Rail transport has been recognised as an environmentally-friendly transport mode with a significant potential to contribute to the sustainability agenda of today. The concept of “Europe without borders” brings many benefits to nations but also requires standards, harmonization and uniformity. When running trains abroad the rail personnel face the challenge of communication. If there is no seamless communication in place severe accidents may occur on the rail network causing damages, injuries and death.

On the other hand seamless communication improves system performance and increases efficiency in the rail network and hence the rail service is of better quality as well as at lower cost.

Motivated by this situation we developed an efficient tool for improving communication between rail personnel. More specifically, for the purposes of this discussion a coded language for facilitating communication between rail operations personnel is discussed. The very first effort of this initiative has been presented by

Marinov et. al. (2012).

2. DEVELOPMENT

For the development of the coded language the existing situation in the bi-lingual Belgian railways (SNCB/NMBS) considering the Dutch and French language has been examined. Official Belgian (SNCB/NMBS) manuals B-TC.61 and B-TP.61 (“Veiligheidsmededelingen per radio of per telefoon/ Geplastificeerde Fiches”) have been used as a starting point. Specifically, the traffic rules set up the standard. The communication procedure suggests the order of information exchange between rail personnel involved in the complex train movement. To describe the communication procedures oriented-graphs can be used. Examples of how the coded language should be used in daily operations with freight trains have been elaborated.

3. THE CODE

For the purposes of Code of Language the following 9 categories have been identified:

- Category 1 Staff;
- Category 2 Incidents;
- Category 3 Location;
- Category 4 Orders;
- Category 5 Velocity;
- Category 6 Train;
- Category 7 Network;
- Category 8 Delays;
- Category 9 Gauge.

The identified categories were transformed into a suitable shape for the purposes of international rail freight transport and a rail freight corridor in Europe (RETRACK). Those categories were coded to facilitate communication between personnel involved in cross-border operations with freight trains.

Coding of categories aimed at facilitating the procedures of communication on running trains abroad.

The categories identified encompass a number of components describing them and are coded as shown in Table 1.

Table 1 Categories and Codes

Category 1	**Staff**
Code:	
S1	1.1 Train Driver (Train);
S2	1.2 Dispatcher (Track side);
S3	1.3 Traffic Manager (Track side).
S4	1.4 Yard Manager (Track side);
S5	1.5 Engine Driver (Train);
S6	1.6 Shunting Personnel (Track side).
S7	1.7 Police (External);
S8	1.8 Fire Brigade (External);
S9	1.9 Medical Services (External).
S10	1.10 TCC Retrack (Rolling stock Planning & Crew Management)
Category 2	**Incidents**
Code:	
I1	2.1 Derailment:
I1.1	2.1.1 of Locomotive;
I1.2	2.1.2 of Wagon;
I1.3	2.1.3 of the entire Train;
I1.4	2.1.4 of Block of Freight Wagons;
I1.5	2.1.5 of Locomotive + Block of Freight Wagons
I2	2.2 Collision:
I2.1	2.2.1 Train;
I2.2	2.2.2 other Vehicle;
I2.3	2.2.3 Person/People;
I2.4	2.2.4 Infrastructure element/component;
I2.5	2.2.5 Animal;
I2.6	2.2.6 Other Objects.
I3	2.3 Infrastructure, signalling and ATP
I3.1	2.3.1 Signal and/or ATP error;
I3.2	2.3.2 Malfunction of Points/Switches;
I3.3	2.3.3 Collision danger;
I3.4	2.3.4 Damaged Track;
I3.5	2.3.5 Broken Rail;
I3.6	2.3.6 Broken Catenary.
I4	2.4 Signal Passed at Danger
I4.1	2.4.1 Train Signal Passed at Danger;
I4.2	2.4.2 Shunting Signal Passed at Danger;

I5	2.5 Fire:
I5.1	2.5.1 on Locomotive;
I5.2	2.5.2 on Train;
I5.3	2.5.3 on Track;
I5.4	2.5.4 by (alongside) the line.
I6	2.6 Limited Visibility:
I6.1	2.6.1 due to Smoke;
I6.2	2.6.2 due to Weather;
I6.3	2.6.3 due to Object obstructing Visibility.
I7	2.7 Technical Problems on Train;
I7.1	2.7.1 Loss of Traction Power;
I7.2	2.7.2 ATP malfunctioning;
I7.3	2.7.3 Brake malfunctioning;
I7.4	2.7.4 Air pipe malfunctioning;
I7.5	2.7.5 air pipe / coupler malfunctioning.
Category 3	**Location**
Code:	
L1	3.1 in front of;
L2	3.2 in rear of;
L3	3.3 on top of;
L4	3.4 under;
L5	3.5 between;
L6	3.6 on my Track;
L7	3.7 on the Opposite Track.
L8	3.8 Left;
L9	3.9 Right.
L10	3.10 on another Train.
Category 4	**Orders**
Code:	
O1	4.1 Stop, evacuate;
O2	4.2 Stop, wait further orders.
O3	4.3 Go without reduction of speed;
O4	4.4 Go with ;
O5	4.5 Go until next signal;
O6	4.6 Go to next station;
O7	4.7 Go to next yard;
O8	4.8 Go to next siding;
O9	4.9 Go on sight.

O10 O11 O12 O13 O14 O15 O16 O17 O18 O19	4.10 Request for orders; 4.11 Request for order because of delay in departure; 4.12 Request for order because of delay in arrival; 4.13 Change locomotive; 4.14 Change locomotive and continue; 4.15 Change crew and continue; 4.16 Drop Off wagons; 4.17 Drop Off wagons and continue; 4.18 Pickup wagons and continue; 4.19 Terminate service.
Category 5	**<u>Velocity</u>**
Code: V1 (+/-) V2 (+/-) V3 (+/-) V4 (+/-) V5 (+/-) V6 (+/-) V7 (+/-) V8 (+/-) V9 (+/-) V10 (+/-) V11 (+/-) V12 (+/-) V13 (+/-)	 5.1 10km/h; 5.2 20km/h; 5.3 30km/h: 5.4 40km/h; 5.5 50km/h; 5.6 60km/h 5.7 70km/h; 5.8 80km/h; 5.9 90km/h; 5.10 100km/h; 5.11 110km/h; 5.12 120km/h; 5.13 130km/h.
Category 6	**<u>Train</u>**
Code: T1 T1.1 T1.2 T2 T2.1 T2.2 T2.3 T2.4 T2.5 T2.6 T2.7 T2.8 T2.9 T3 T4 T5	 6.1 Locomotive: 6.1.1 Diesel; 6.1.2 Electrical. 6.2 Wagons; 6.2.1 Passenger wagons; 6.2.2 Hooper; 6.2.3 Covered wagon; 6.2.4 Flat (container) wagons; 6.2.5 Tank wagon; 6.2.6 Lorry wagons; 6.2.7 Reefers; 6.2.8 Semi-trailers; 6.2.9 Specialised wagons. 6.3 Pantograph; 6.4 Engine; 6.5 Bogies;

T6 T6.1 T6.2 T6.3 T7 T8 T9 T10 T11	6.6 Braking System: 6.6.1 Service Brakes; 6.6.2 Parking Brakes; 6.6.3 Emergency Brakes. 6.7 Coupling System; 6.8 Buffers; 6.9 Suspension; 6.10 Wheels; 6.11 Axles (including *Hot Boxes*).
Category 7	**Network**
Code: N1 N2 N2.1 N2.2 N2.3 N3 N4 N5 N6 N7 N8 N9 N10 N11 N12 N13 N14 N15 N15.1 N15.2 N15.3 N15.4 N16 N16.1 N16.2 N16.3 N17 N18 N19	 7.1 Passenger Station; 7.2 Yard: 7.2.1 Shunting Yard; 7.2.2 Marshalling Yard; 7.2.3 Gravity Yard. 7.3 Main Line; 7.4 Secondary Line; 7.5 Sidings; 7.6 Dead-end Track; 7.7 Adjacent (neighbouring) track; 7.8 Switch/Point; 7.9 Junction Level Crossing; 7.10 Bridge; 7.11 Tunnel; 7.12 Fly-over; 7.13 Catenary voltage change over (VCO); 7.14 Arched Catenary Support. 7.15 Signals 7.15.1 Main Signal; 7.15.2 Main Attention Signal (“voorsein” can only show go or approach and not red and is meant to warn for a main signal); 7.15.3 Permissive Signal (“P-sein” and automatic signal not controlling a switch/point); 7.15.4 Dwarf Signal. 7.16 Signs: 7.16.1 SMB permissive sign; 7.16.2 SMB non-permissive sign; 7.16.3 Speed Sign. 7.17 Origin Point of Service; 7.18 Destination Point of Service; 7.19 Interchange Point.

Category 8	**Delays**
Code:	
D1	8.1 <= 15 minutes;
D2	8.2 30 minutes;
D3	8.3 60 minutes;
D4	8.4 1,5 hours;
D5	8.5 2 hours;
D6	8.6 3 hours;
D7	8.7 4 hours;
D8	8.8 5 hours;
D9	8.9 6 hours;
D10	8.10 7 hours onwards.
Category 9	*Gauge*
Code	
G1	9.1 height
G2	9.2 width
G3	9.3 weight
G4	9.4 traction (i.e. 25 kv, 1500b, diesel)
G5	9.5 brake % (i.e. depending on gradients on the track/route)

Operational rules:
The operational rules set up the standard. The communication procedures define the order of information exchange between the personnel involved in international freight train movement. To describe the communication procedures oriented-graphs are used.

The communication procedure is subordinated to the operational rules employed and is, as follows:

- Train Driver (S1) texts Dispatcher (S3);
- Dispatcher (S3) texts Train Driver (S1);
- Dispatcher (S3) texts Traffic Manager (S2);
- Traffic Manager (S2) texts Dispatcher (S3).

- Dispatcher (S3) replies to Train Driver (S1);
- Train Driver (S1) replies to Dispatcher (S3);
- Traffic Manager (S2) replies to Dispatcher (S3);
- Dispatcher (S3) replies to Traffic Manager (S2).

Every message begins with the code of the sender. For instance, if a massage is sent by the Train Driver, the code is "S1". If a message is sent by the Dispatcher, the code then is S3 and so on.
The code of the sender is followed by two dots, namely ": ". For example, a message sent by the Traffic Manager is "S2:" .

The two dots after the code of the sender are followed by coded message. The coded message terminates with two dots and the word “over”.

Next, the receiver acknowledges receipt by sending an immediate reply with the word “roger” followed by “:” and the code of the receiver.

Consider the following example: Train Driver texts Traffic Manager. The communication procedure is, as follows:

S1: (coded message)over
roger:S2

Put into Practice:
In this section the language code developed is presented. Typical and critical situations of daily operations with freight trains are described including both safety and productivity aspects. Practical examples are provided to demonstrate the use of code of language.

Example 1:
Consider that a freight train is standing at Red Signal for “some time” in the middle of a railway main line. Because of damaged point ahead the movement on this line has been interrupted. According to the schedule this train should have arrived at the next station an hour ago. However due to the occurred situation this train will now arrive at the next station with a significant uncertain delay. The train driver has already informed the dispatcher responsible for the daily planning of freight train services for this situation, so the dispatcher can anticipate rescheduling the locomotive and the crew. A few kilometres ahead there is an adjacent track with restricted capacity that is currently used for the movement of trains. The trains move with reduced velocity over the adjacent track. A queue of 2 passenger trains has been formed before the freight train in question. In a few minutes the freight train driver received an order from the Dispatcher to go to the next signal. Right after the freight train arrived at the next signal the driver received another order: “Go with 40km/h” until the next signal. At the next signal the freight train driver received a new order from the dispatcher: “Go to the Next Station with velocity of no more than 80km/h”. The service of the freight train terminates at the next station. Because of the degraded situation the freight train in question will arrive at its destination point with a significant delay.

The Code of Language for this situation is used as follows:

S1: O11:over
Roger:S2

S2:I3.2L1:O2:over
Roger:S1

S2: O5:over
Roger:S1

S2:O5V4:over
Roger:S1

S2:O6V8:over
Roger:S1

S1:N2D4:over
Roger:S2

Example 2:
Consider a freight train which locomotive is losing traction power. After having detected the cause of the problem the train driver informs the dispatcher and the TCC (possibly for repair support or locomotive exchange and delay information). The train driver informs the dispatcher and the TCC that the velocity of their train will be 40km/h maximum. The situation requires that the locomotive of this train needs to be changed in the nearest shunting yard. However, the nearest shunting yard is some 30 kilometres away. The freight train is running on a mixed traffic line, where also passenger trains are run. According to the EU priority traffic rules passenger trains are given highest priority, meaning passenger trains run before freight trains.

In a few minutes the train driver received an order from the dispatcher to go to the next siding, which is some 10 kilometres away and stop there. This is because there is a passenger train behind the freight train requiring a slot. The freight train will now be handled according to degraded situation procedures.

After the passenger train overtook the freight train, the freight train driver received an order from the dispatcher: Go to next yard with 40km/h. Change the locomotive and continue.

The train driver informs the TCC and indicates his train and track-number.

The TCC will next plan further actions such as:

- Contacted his technical support staff and the Traffic Manager
- Make a new locomotive available (from – to: path allocation, staff allocation)
- Make sure the track is known and suitable for re-arranging the train (replacing locomotives)
- Provide a new timetable to continue the operation of this freight train
- Provide further orders to repair the damaged loco

It should be noted that based on the foregoing information the Traffic Manager is able to re-allocate resources efficiently and hence mitigate the negative effect of degraded situations on the service provided.

The Code of Language for this situation is used as follows:

S1:I7T4:over
Roger:S2

S1:I7T4:over
Roger:S10

S1:I7.1V4:over
Roger:S10

S1:I7.1V4:over
Roger:S2

S2:O8O2:over
Roger:S1

S2:O7V4O14:over
Roger:S1

4. APPLICATION

Currently the coded language developed is being incorporated in a message management system for rail software applications, demonstrating significant potential for market up-take. The idea is to use the code for the purposes of ERTMS. Figure 1 shows the architecture of ERTMS Simulator. The code has been tested using simulation modelling tools such as the TRAFFIC-SIMU and OP-SIMU packages (ERSA).

TRAFFIC-SIMU:
Traffic Simulator/TRAFFIC-SIMU (Figure 2) is the platform for controlling all trains on the specific tracks of a railway service corridor. All train movements and representative portion of regular traffic surrounding the trains have been simulated. Training has been organised in DeltaRail laboratories. The role of TC has been carried out by DeltaRail, as leader of the simulation and training. For the operational RMS training the trains can be run in automatic mode with no real train drivers needed. The trains could also be controlled manually the “dummy” drivers operating simulated trains using the ERSA OP-SIMU.

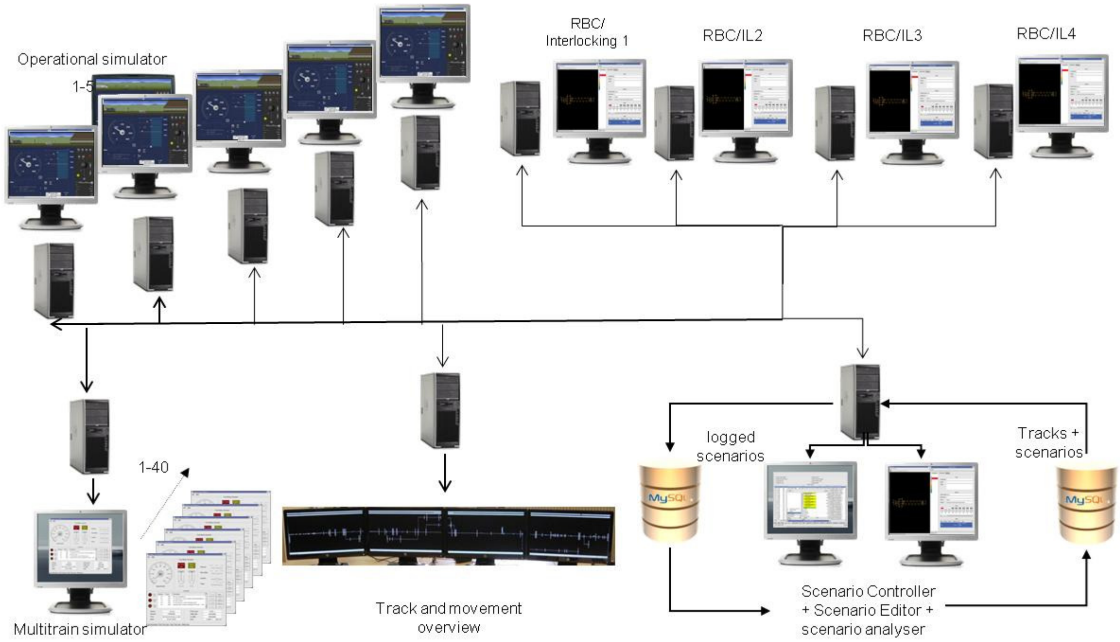

Figure 1 - ERTMS simulator

Figure 2 - Example of Traffic Simulator /TRAFFIC-SIMU

OP-SIMU:
Operational Simulator/OP-SIMU (Figure 3) train simulator is the platform for driving trains. OP-SIMU has been used as a stand-alone system not connected to the TRAFFIC-SIMU for the training of ERTMS/ETCS. OP-SIMU can be optionally connected with a 3D renderer application.

Figure 3 - Example of Operational Simulator (OP-SIMU)

TRAFFIC-SIMU connected with OP-SIMU:
For the testing of the code of language and the analysis of future situations including ERTMS/ETCS + a code of language, OP-SIMU shall be connected with TRAFFIC-SIMU for manual operational control of running trains.

5. CONCLUSIONS

To the best of our knowledge a coded language to overcome communication barriers encountered during operating processes with freight trains has not been introduced as such so far. That is why this research is believed to be one of the first steps towards the development of a standard coded language system for international railway transport.

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