Rail Track Worker Protection App

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***Abstract*—Railway track workers are in imminent danger of being hit by trains. Infrastructure construction and maintenance companies reduce this risk with human (e.g. safety attendants) and technological (e.g. warning horn with wired contacts) efforts. Drawbacks of this approach include overhead costs for additional employees as well as complexity in handling the technology. This paper describes an innovative rail track worker protection app, which addresses the problem in a different way. With this app the track workers can be warned individually and directly about an approaching train, in addition to or instead of a horn, at very low cost and without any additional complexity in handling. Our vision is that every railway employee wearing a reflective west should have this app on his or her mobile phone.**

Keywords—Train Collision Avoidance; SmartPhone; Track Worker; Rail2X Communications; TETRA; T2T

I. Introduction and Motivation

Although rail transport is extremely safe, collisions of railway vehicles happen occasionally. According to the recently published ERA-report “Railway Safety Performance in the EU 2016” there are at least around 100 significant collisions between rail vehicles in Europe per year, excluding those in shunting and at railway crossings [1]. The Train Collision Avoidance System (*TrainCAS*) safety overlay system adopts a concept very successful in aeronautics for avoiding the collision of trains [2]. It combines three core technologies: a direct train-to-train communication system, an accurate autarkic localization system and a cooperative situation analysis and decision support system. Opposed to “traditional” technical train safety systems, the system does not require any technology in the infrastructure, i.e. along the railway track, but entirely relies on on-board technology. But not only train-to-train collisions can be avoided. Official statistics reveal that railway track workers suffer from a high risk during their everyday work. For example in the UK, being struck or crushed by trains is the second highest workforce personal injury risk [3], causing 55 workforce incidences of the evaluation 2015/2016 (see Fig. 2). So a non-neglectable number of workforce injured in the UK in one year because of being struck or crushed by train – despite the existence of all traditional preventive measures which should have prevented exactly this, making it a strong business case for an alternative solution! A further set of downsides of protection technology of the art such as horn systems includes semi-fixed long wired installation, providing protection on track- and direction selective base only. Such drawbacks are addressed with the creative and innovative rail track worker protection app (see Fig. 1) which is introduced in the following sections. With this app the track workers themselves can be directly warned about an approaching train, in addition to or instead of traditional human efforts or technological solutions.

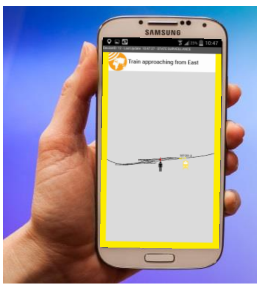

Fig. 1. The app

Safety Overview	2011/12	2012/13	2013/14	2014/15	2015/16
Fatalities	**53**	**49**	**39**	**45**	**45**
Passenger	5	3	4	3	8
Workforce	1	2	3	3	0
Public	47	44	32	39	37
Major injuries	**471**	**516**	**497**	**529**	**483**
Passenger	258	312	274	298	288
Workforce	172	162	177	182	157
Public	41	42	46	49	38
Minor injuries	**12965**	**12776**	**12785**	**13195**	**12603**
Passenger	5954	6383	6388	6880	6690
Workforce	6824	6213	6234	6136	5694
Public	187	180	163	179	219
Incidents of shock	**1512**	**1217**	**1264**	**1089**	**958**
Passenger	262	238	236	253	205
Workforce	1247	973	1026	833	746
Public	3	6	2	3	7
Fatalities and weighted injuries	**125.11**	**124.93**	**113.13**	**121.56**	**116.42**
Passenger	42.54	46.45	43.60	44.95	48.84
Workforce	30.98	29.79	32.48	32.28	26.22
Public	51.59	48.70	37.05	44.33	41.37

Fig. 2. According to RSSB’s recent Annual Safety Performance Report [3] there were 6597 incidents in the UK involving workforce in 2015/2016, of them 55 being caused by being struck or crushed by train. The situation is similar to previous years.

II. Selected Technological Aspects

A. Communications Architecture

TrainCAS itself is independent from any component in the infrastructure or along the track, particularly because of its direct TETRA-based train-to-train communication approach [4]. The Android app extends the TrainCAS architecture by a mobile version of a railway traffic situation analysis and conflict detection algorithm running locally on a smartphone. As there is no TETRA-bearer available on ordinary smartphones, the app uses one of the bearers available (3G/4G or even WiFi) through the cloud to interact with the trains given that there is network coverage at the location of usage. Obviously this breaks with the desired independency from the infrastructure, however, this disadvantage disappears with the upcoming integration of TETRA and LTE-systems. Today the app may be used already by track workers along the majority of railway networks as there is coverage along most sections of them. Alternatively the app can be used on Android based TETRA-phones.

B. Localization

Given the data received about trains in the vicinity of the app user, the app monitors the risk of being hit by a train based on a local map of the track network nearby. The track map on the track worker's mobile device enables the situation evaluation algorithm to estimate the level of danger with higher precision than for instance just distance based algorithms determined using GPS or signal time of flight.

Because of the potentially very long braking distance of a train, it is a priority to warn the track worker about the approaching train over warning the train driver about the track worker in his track: The track worker can de-escalate the situation even in the last second by making a jump out of the track, whereas the train can't leave the track. This fact also relaxes the accuracy requirement of the localization on the track worker side: While the TrainCAS onboard sensors and sophisticated algorithms enable a track selective accuracy better than GPS on the train side, the localization on the track worker side is sufficiently accurate for the app using just the smartphone sensors together with the local track map.

III. Ease of Use

The app hides all the complexity of information exchange, localization and situation determination behind an intentionally simplistic graphical, acoustic and haptic user interface designed with the particular daily work situation of track workers in mind. It just visualizes the location of the track worker in relation to any train on the nearby track network. It is not even assumed that the track worker shall monitor the app all the time – s/he shall perform the work s/he is paid for by his employer. If worn with a sports armband (see Fig. 3) or as part of the work clothes, the app makes use of the smartphones acoustic and haptic actuators to bring the imminent danger of a collision to the track worker's awareness.

Fig. 3. Interacting as simple as tapping on the smartphone

It is easy to combine the app also with loudspeakers/ beepers in a track worker's helmet (see Fig. 4) or a vibrating belt which can also be used to indicate the direction of an approaching train.

Fig. 4. Rough conditions for track workers © Network Rail UK

The severity of the imminent danger is signaled in three defined levels (see Fig. 5), whereas the level is determined depending on the speed, distance and other parameters of the approaching train. The first level ("yellow") is intended to inform the track worker about a train getting closer, but still fairly far apart. The second level ("orange") is raised once the train gets close. This is considered a pre-alarm with continuous acoustic and haptic signaling, which however can be quit as easy as tapping on the phone two times in short interval as is illustrated in Fig. 3 – no need to click any graphical buttons or press any key. Just seconds from passing by and the track worker is too close to the occupied track, the alarm ("red") is raised which cannot be quit. In any case, it is very easy for the track worker to de-escalate the situation even in the last second by just stepping aside.

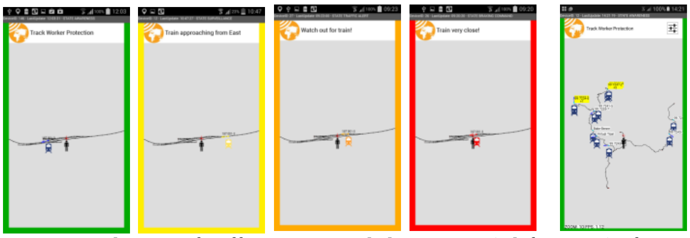

Fig. 5. Visualization of traffic situation and alarm stages (4 left images). If zoomed out, the app may be used to monitor all live traffic (right image).

Customer versions of the app will also include a working profile and personal preferences dependent alarm level determination.

The app requires Android version 4.4.2 or higher. Optimal appearance is given with for instance Samsung Galaxy S6.

References

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