



D5.3 - Final report and updates on dissemination, exploitation and standardisation activities

Project number:	730830
Project acronym:	Safe4RAIL
Project title:	Safe4RAIL: SAFE architecture for Robust distributed Application Integration in roLLing stock
Start date of the project:	1 st of October, 2016
Duration:	27 months
Programme:	H2020-S2RJU-OC-2016-01-2
Deliverable type:	Report
Deliverable reference number:	ICT-730830 / D5.3 / 1.1
Work package	WP 5
Due date:	December 2018 – M27
Actual submission date:	22 nd of January, 2019
Responsible organisation:	TEC
Editor:	Mario Münzer
Dissemination level:	Public
Revision:	1.1
Abstract:	This report includes a record of activities related to dissemination, exploitation and standardisation that have been undertaken. Furthermore, this report addresses activities going beyond the project lifetime as well as includes a list of completed and planned communication activities. This is a cumulative report and represents the update of deliverable D5.2 (M12).
Keywords:	Dissemination, exploitation, standardisation, communication



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730830.

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Executive Summary

This document is dedicated to dissemination, exploitation and standardisation of the Safe4RAIL project including records of undertaken activities. Within WP5, two tasks were devoted to drawing attention to the project achievements and spreading its results as well as a separate task in place for exploiting the said results. Since project dissemination and exploitation are key activities for a successful project, dedicated plans for these domains were defined and followed over the full duration of the project.

The dissemination plan, defined at early stage of Safe4RAIL, consists of three phases. During the second project period (M13-M27), the focus was on the last phase, which is oriented on project results. Over the project lifetime, 44 dissemination activities were reported. This includes 22 participations in events including presentations, conferences, exhibitions and workshops. To keep the Safe4RAIL community informed about the project and its results, a website (www.safe4rail.eu) was created and maintained over the entire term, and a social media channel utilized. This document includes statistical information on website and social media usage, which demonstrates the efficiency of the approach.

The dissemination strategy is based on a common project identity, which materializes in a corporate design. Respective dissemination materials and numerous presentation media were created – ranging from written information to a podcast and an animated video – which are listed and briefly described in this document. Besides that, the target audiences were specifically addressed by two conferences, which were organized and held at the end of first period, and at the end of the project lifetime respectively.

Exploitation activities aim at using research results to create value, respectively knowledge within all participating organizations in order to improve their competitive advantages, develop new solutions and pave the way for product innovation. The project's exploitation strategy was centralized around medium and long-term goals. Pre-defined individual partner exploitation plans, defined at early state of the project, were updated, accordingly to the latest status. Due to confidentiality reason, the updates of exploitation plans are not provided within this document.

Standardization is addressed in one of the six key objectives. In order to successfully obtain objective 6 of Safe4RAIL, several standards (technical as well as safety and security related standards) were aimed at during the project lifetime, which will support the adoption of the said technology on the railway market.

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Chapter 1 Introduction

Dissemination and exploitation activities are considered as key enablers for the success of the Safe4RAIL project. The overall aim of dissemination and exploitation activities is to use research results in order to create value within all participating organisations, thus improving their competitive advantage. Wherever possible, research results will be used for the creation and support of new products, services or processes and will substantially contribute to the benefit of the targeted constituents. Dissemination activities ensure the visibility and awareness of the project and support the widest adoption of its results among potential users. For the project Safe4RAIL the following user groups have been identified as stakeholders and beneficiaries of the project impacts: e.g. research, commercial, investment, social, environmental, policy making and setting standards. Raising awareness among stakeholders involves the setting up of basic instruments and awareness-raising presentations about the project and the impact it aims to tackle. Thus, during the project lifetime, we focused on the following main activities with respect to WP5:

- Setting up a **visual project identity** (common project design, templates for documents and presentations) as a cornerstone of every project engagement at European level.
- Creating and maintaining the **project website and designing project information materials** (such as a leaflet and an introductory off-the-shelf presentation, which can be easily distributed at events and or B2B-meetings).
- Giving **presentations at conferences and workshops about the challenges and goals** of Safe4RAIL in order to raise awareness among the scientific and industrial stakeholders and to establish the basic brand name of Safe4RAIL.
- Organization of **two dedicated project dissemination events** targeted at railway stakeholders. These events are the perfect opportunity to present the project results obtaining feedback from a broader audience and to optimize project impacts.

This deliverable provides the final report and updates on the partners' dissemination and communication activities. It includes a record of activities related to dissemination, exploitation and standardisation that have been undertaken and those still planned as well as a report of completed and planned communication activities. This deliverable of type "report" is a cumulative report and represents the update of deliverable D5.2.

The initially planned dissemination and communication activities are described briefly in Chapter 2. Afterwards, all activities, from publications, workshops and presentations, as well as the project website, social, print- and e-media are presented. To conclude, our dedicated one-day public dissemination events, where project results were presented, are summarized.

Chapter 3 is dedicated to the project exploitation and in this regard the exploitation strategy of Safe4RAIL is described. Furthermore, partner inputs, describing their individual model and their initial hypotheses, have been captured in a so-called "Business Model Canvas" (BMC) sheet and individual exploitation plans updated. For confidentiality reasons, the BMC sheets and updates on individual exploitation plans per partner are integrated in the 2nd periodic report (at CO level) of Safe4RAIL and not within this document.

In Chapter 4 the project standardisation activities are described and explained in detail.

Finally, Chapter 5 sums up the content of the deliverable and gives a general conclusion and future outlook.

Chapter 2 Dissemination and Communication

The dissemination strategy aims to ensure visibility and awareness of the project results, which have been depicted already in deliverable D5.1 “Internal and external IT communication infrastructure and project website”. Some indicators have also been selected in order to return a measure of the achieved goals and evaluate how effective the dissemination activities have been executed. This document reports on all the dissemination activities executed during the second period (M13-M27, respectively from October 2017 to December 2018) of Safe4RAIL and discusses the achieved targets after monitoring of the activities. Furthermore, we report on the overall activities that have been executed during the whole duration of the project.

2.1 Dissemination Strategy

The Safe4RAIL dissemination strategy adopted for the entire project duration is based on the following pillars:

- Presentation of the project to the general public (Section 2.2 and Section 2.3)
 - Project website (Section 2.3.1)
 - Social media (Section 2.3.2)
 - Print- and e-media (Section 2.3.3)
- Presentation of the research results within the scientific community (Section 2.3.4),
- Presentation and demonstration at dedicated events (Section 2.4).

The dissemination plan of Safe4RAIL is grouped in three project phases. In the following table, we will concentrate on the last phase (phase III) of Safe4RAIL’s dissemination plan. The first two project phases (I and II) of the dissemination plan were already summarized in deliverable D5.2.

Table 1: Dissemination Plan of Safe4RAIL – Phase III, M13-M27

Core Dissemination Activity	Target Group	Partners	Influence on achievement of expected impact
Results of Phase III (M13-M27) – Identification of Gaps and Proposal for Adaptations and Modifications			
Dedicated one-day public dissemination event of Safe4RAIL and CONNECTA, presenting project results from Phase III.	Shift2Rail members, railway stakeholders	All; TEC as host of the event	Inform key stakeholders proactively about the project results, discuss with stakeholders in an open context about evaluation and directions, and assure project impact. The event was co-hosted in conjunction with CONNECTA.

Core Dissemination Activity	Target Group	Partners	Influence on achievement of expected impact
Results of Phase III (M13-M27) – Identification of Gaps and Proposal for Adaptations and Modifications			
<p>Papers on concepts and results for</p> <ul style="list-style-type: none"> • Networking backbone for railway use cases. • Safety and security concept • Functional distribution architectures • Network simulation of Ethernet-based drive-by-data networks for timing and reliability evaluation of TCMS application functions • Safe electronic braking 	Scientific and industry audience	SIE, TTT, IKL, IFS, IAV, ELE, NIER	<p>Communicate results to scientific and industry community and obtain feedback, e.g. at <i>nets4trains</i> workshop, Joint Rail Conference, <i>WCRR 2018</i> and <i>VDB-Verband der Bahntechnik</i>.</p> <p>Arising interest among scientific groups, kicking off discussions on performed work, future cooperation.</p>
<p>Presentations about the safety assessment of functional distribution architecture, with focus on railway applications, e.g. <i>safe.tech</i>, <i>EXPO Ferroviaria</i>, <i>USENIX</i> conferences; workshop on project results, vision for the implementation in the new safety platforms.</p>	Railway industry audience and operators	TÜV, TTT, ELE, UNI, SIE, IKL, NIER	<p>Arising interest among industrial groups within the railway, automotive and automation functional safety. Communication and interaction with Railway industry and railway operators.</p>
<p>Presentation of the impact of Safe4RAIL results for railway operators: trade fair poster display and/or presentation at InnoTrans 2018.</p>	Railway industry audience and operators	IAV, NEW, TTT	<p>Spread of the concept allows gaining partners for the productizing and the roll-out after M24. Inclusion of the new product / function possibilities based on Safe4RAIL results in the next project requirement specifications for rolling stock.</p>
<p>Technology Transfer and Training activities</p>	S2R-CFM-IP1-02-2018 and S2R-OC-IP1-01-2018 project partners	All	<p>News partners to familiarize with the Safe4RAIL project results and facilitate the future implantation activities by both, the Call-for-Members (CFM) and Open Call (OC) projects.</p>

2.2 Dissemination Activities

The project and its results have been disseminated by invited talks at conferences, by publications at scientific and industry oriented conferences and by organizing technical workshops within the project. All dissemination activities undertaken by the consortium have been made visible via the public project website (<https://safe4rail.eu/news>), including published scientific publications (<https://safe4rail.eu/results>). The following section presents our dissemination activities in order to document the extent to which we have executed our above mentioned dissemination strategy.

2.2.1 Dissemination Activities

All scientific publications, presentations, conferences and workshops are listed in an action overview list and are updated by the partners on a regular basis. In total, there have been 44 dissemination activities reported over the whole project lifetime (M01-M27), 18 within the 1st and 26 within the 2nd project period respectively. The Safe4RAIL partners participated in 22 events including presentations, conferences, exhibitions and workshops in the past 27 months. Furthermore, 22 press releases have been published and several dissemination activities have been performed. In the following tables (split up per period), all the activities are listed, reporting the type of activity and the dissemination target, and all the details about the event.

Table 2: List of dissemination activities reported within 1st project period (M01-M12)

No	Type of activities	Main leader	Title	Date			Place	Type of Audience ¹						Size of audience	Type and goal of the event	Countries addressed
				Day	Month	Year		A)	B)	C)	D)	E)	F)			
1	Website	TEC	Safe4RAILs Twitter Account	3	10	2016	Online	X	X	X	X	X	X	N/A	Social medium at: https://twitter.com/SAFE4RAIL	International
2	Press release	TEC	Safe4RAIL Announcement Letter	7	10	2016	Online	X	X	X	X	X	X	N/A	Safe4RAILs announcement letter available on: https://safe4rail.eu/downloads/SAFE4RAIL_Announcementletter.pdf	International
3	Website	TTT	Project Brief	10	10	2016	TTTech Website	X	X	X	X	X	X	N/A	Presentation of the Safe4RAIL Project	International

¹ A) Scientific community & higher education, B) Industry, C) Civil Society, D) Policy Makers, E) Media), F) Others

No	Type of activities	Main leader	Title	Date			Place	Type of Audience ¹						Size of audience	Type and goal of the event	Countries addressed
				Day	Month	Year		A)	B)	C)	D)	E)	F)			
4	Press release	NEW	NewTec und Safe4RAIL	25	10	2016	Online	X	X	X	X	X	X	N/A	Announcing cooperation in Safe4RAIL	National
5	Website	NEW	Project Brief	25	10	2016	Online	X	X	X	X	X	X	N/A	Presentation of the Safe4RAIL Project	National
6	Website	NEW	Project Brief	25	10	2016	NewTec Internal Website	X	X	X	X	X	X	N/A	Presentation of the Safe4RAIL Project	National
7	Participation to other events	TTT	Lessons Learnt from Shift2Rail Open Calls 2016 successful participants	13	12	2016	Brno	X	X					75	Regional Infoday-Shift2RailOpenCalls 2017	International
8	Press release	TEC	Safe4RAIL Project Website Launch	16	12	2016	Online	X	X	X	X	X	X	N/A	Launch of official project website: https://safe4rail.eu/	International
9	Participation to other events	IKL	Lessons Learnt from Shift2Rail Open Calls	17	1	2017	Brussels	X	X					N/A	https://shift2rail.org/news/shift2rail-information-day-open-calls-for-proposals-2017-update/	International

No	Type of activities	Main leader	Title	Date			Place	Type of Audience ¹						Size of audience	Type and goal of the event	Countries addressed	
				Day	Month	Year		A)	B)	C)	D)	E)	F)				
10	Participation to a Workshop	TTT	Safe4Rail: Integrated architecture and Safety for Railway applications	25	1	2017	Stockholm	X	X						50	5th International workshop on the "Integration of mixed-criticality subsystems on multi-core and manycore processors"	International
11	Flyer	TEC	Safe4RAIL Project Leaflet	10	2	2017	Online	X	X	X	X	X	X	N/A	The project leaflet provides an overview on Safe4RAILs mission as well as project goals and is available on: https://safe4rail.eu/downloads/Safe4RAIL_Folder_Web.pdf	International	
12	Other	TEC	Project Logo	10	2	2017	Online	X	X	X	X	X	X	N/A	Logo will be used for all Safe4RAIL templates, deliverables, ppt, etc.	International	
13	Press release	IAV	Die Bahn lernt vom Auto - IAV-Know-how für Schienenfahrzeuge : EU-Projekt SAFE4RAIL stärkt unsere Kontakte in die	31	3	2017	IAV office locations						X	6700	Article in an internal IAV employee newsletter (IAVintern).	International	

No	Type of activities	Main leader	Title	Date			Place	Type of Audience ¹						Size of audience	Type and goal of the event	Countries addressed
				Day	Month	Year		A)	B)	C)	D)	E)	F)			
			Bahnbranche													
14	Flyer	TEC	Project Newsletter (Issue 1)	30	5	2017	Online	X	X	X	X	X	X	N/A	The intention of this newsletter is to open a new communication channel in order to provide news on the project progress and to discuss ongoing topics relevant to Safe4RAIL. The Newsletter is available on: https://safe4rail.eu/downloads/Safe4RAIL-Newsletter-Issue1.pdf	International
15	Flyer	TEC	Project Poster	13	6	2017	Online	X	X	X	X	X	X	N/A	The project poster provides the same overview on Safe4RAILs mission and project goals as the project leaflet does and is available on the SVN.	International
16	Website	TTT	Project Brief	1	8	2017	Mixed-criticality Forum website	X	X	X				N/A	Presentation of the SAFE4RAIL Project	International

No	Type of activities	Main leader	Title	Date			Place	Type of Audience ¹						Size of audience	Type and goal of the event	Countries addressed
				Day	Month	Year		A)	B)	C)	D)	E)	F)			
17	Participation to a Conference	TTT	Next-Generation Integrated Modular Architectures: A Cookbook for Scalable and Reusable Ethernet-Based Embedded Platforms	26	9	2017	Ft Worth, TX, USA	X	X	X	X	X	X	N/A	SAE Aerotech 2017	International
18	Participation to a Conference	TTT	Secure deterministic L2/L3 Ethernet Networking for Integrated Architectures	26	9	2017	Ft Worth, TX, USA	X	X	X	X	X	X	N/A	SAE Aerotech 2017	International

Table 3: List of dissemination activities reported within 2nd project period (M13-M27) and beyond project completion

No	Type of activities	Main leader	Title	Date			Place	Type of Audience ²						Size of audience	Type and goal of the event	Countries addressed
				Day	Month	Year		A)	B)	C)	D)	E)	F)			
19	Participation to a Conference	SIE	Execution Environment for Mixed-Criticality Train Applications based on an Integrated	16	10	2017	Palestine	X	X	X	X	X	X	N/A	ICPET 2017	International

² A) Scientific community & higher education, B) Industry, C) Civil Society, D) Policy Makers, E) Media), F) Others

No	Type of activities	Main leader	Title	Date			Place	Type of Audience ²						Size of audience	Type and goal of the event	Countries addressed
				Day	Month	Year		A)	B)	C)	D)	E)	F)			
			Architecture													
20	Participation to a Conference	SIE	Evaluation of Time-Triggered Traffic In Vehicular Time-Sensitive Networks Using the Opnet Simulation Framework	27	11	2017	Torino	X	X	X	X	X	X	N/A	Vehicular Networking Conference 2017	International
21	Flyer	TEC	Project Newsletter (Issue 2)	1	12	2017	Online	X	X	X	X	X	X	N/A	The intention of this newsletter is to open a new communication channel in order to provide news on the project progress and to discuss ongoing topics relevant to Safe4RAIL. The Newsletter is available on the project website as well as on: https://safe4rail.eu/downloads/Safe4RAIL-Newsletter-Issue2.pdf https://safe4rail.eu/downloads/Safe4RAIL-Newsletter-Issue1.pdf	International
22	Organisation of a Conference	TTT, UNI, TEC	Safe4RAIL Mid-Term Conference	25	1	2018	Prague	X	X	X	X	X	X	N/A	Publicly announce initial results of the project to interested parties (including but not limited to other JU projects)	International
23	Participation to a Conference	ALL	Safe4RAIL Mid-Term Conference	25	1	2018	Prague	X	X	X	X	X	X	N/A	Publicly announce initial results of the project to interested parties (including but not limited to other JU projects)	International

No	Type of activities	Main leader	Title	Date			Place	Type of Audience ²						Size of audience	Type and goal of the event	Countries addressed
				Day	Month	Year		A)	B)	C)	D)	E)	F)			
24	Participation to a Conference	TTT	Next-Gen Train Control / Management (TCMS) Architectures: "Drive-by-Data" System Integration Approach	31	1	2018	Toulouse	X	X	X				N/A	ERTS - European Congress on Embedded Real Time Software	International
25	Participation to a Conference	SIE	Fault Injection Framework for Time Triggered Ethernet.	16	4	2018	Vienna	X	X	X	X	X	X	N/A	Transport Research Arena 2018 and How digitalisation is transforming transport & mobility systems	International
26	Participation to a Conference	IFS	Train-to-Ground communications of a Train Control and Monitoring Systems: a simulation platform modelling	16	4	2018	Vienna	X	X	X	X	X	X	N/A	Transport Research Arena 2018 and How digitalisation is transforming transport & mobility systems	International
27	Participation to a Conference	TTT	Novel highly reliable safe architecture for robust integration of on-board train control applications	16	4	2018	Vienna	X	X	X	X	X	X	N/A	Transport Research Arena 2018 and How digitalisation is transforming transport & mobility systems	International
28	Exhibition	TTT	Visibility at Shift2Rail booth	16	4	2018	Vienna	X	X	X	X	X	X	N/A	Transport Research Arena 2018 and How digitalisation is transforming transport & mobility systems	International

No	Type of activities	Main leader	Title	Date			Place	Type of Audience ²						Size of audience	Type and goal of the event	Countries addressed
				Day	Month	Year		A)	B)	C)	D)	E)	F)			
29	Participation to a Conference	TÜV	safe.tech	25	4	2018	Munich		x		x			150	https://www.tuev-sued.de/akademie-de/congress/automobil-bahn/safe.tech	National
30	Participation to a Conference	IFS	Evaluating TCMS Train-to-Ground communication performances based on the LTE technology and discrete event simulations	17-18	5	2018	Madrid	X	X	X	X	X	X	N/A	http://nets4workshop.etsist.upm.es/	International
31	Participation to a Conference	SIE	Distributed Co-simulation for Software-in-the-Loop Testing of Networked Embedded Systems	10-14	6	2018	Budva	X	X	X	X	X	X	N/A	http://embeddedcomputing.me/en/mediterranean-conference-on-embedded-computing-2018	International
32	Participation to other events	IFS	Co-simulation Platform for Train-to-Ground communications	12	6	2018	Sweden	X	X	X	X	X	X	N/A	http://www.charmec.chalmers.se/NJS18/	International
33	Flyer	TEC	Project Newsletter (Issue 3)	13	6	2018	Online	X	X	X	X	X	X	N/A	The intention of this newsletter is to open a new communication channel in order to provide news on the project progress and to discuss ongoing topics relevant to Safe4RAIL. The Newsletter is available on: https://safe4rail.eu/downloads/S	International

No	Type of activities	Main leader	Title	Date			Place	Type of Audience ²						Size of audience	Type and goal of the event	Countries addressed
				Day	Month	Year		A)	B)	C)	D)	E)	F)			
															afe4RAIL-Newsletter-Issue3.pdf	
34	Flyer	TEC	Project Newsletter ("Conference Issue")	13	9	2018	Online	X	X	X				N/A	The intention of this newsletter is to open a new communication channel in order to provide news on the project progress and to discuss ongoing topics relevant to Safe4RAIL. The Newsletter was released on the conference only.	International
35	Press release	NEW	NewTec macht TRDP echtzeitfähig Im Rahmen des Safe4RAIL-Projektes entwickelt NewTec das TCN-Protokoll TRDP v2 mit TSN-Fähigkeit (Time-sensitive Networking) mit.	17	9	2018	Online	X	X	X	X	X	X	N/A	Announcing cooperation in Safe4RAIL	National
36	Exhibition	NEW	InnoTrans	18	9	2018	Berlin	X	X	X	X	X	X	N/A	Presentation of NTTTrainSolutions, TRDP and SAFE4RAIL	International
37	Exhibition	UNI	UNI booth at InnoTrans	18	9	2018	Berlin	X	X	X	X	X	X	N/A	Future Innovations of UNI train Ethernet network devices with respect to the Safe4RAIL results http://www.unicontrols.cz/index .	International

No	Type of activities	Main leader	Title	Date			Place	Type of Audience ²						Size of audience	Type and goal of the event	Countries addressed
				Day	Month	Year		A)	B)	C)	D)	E)	F)			
															php/en	
38	Organisation of a Conference	TEC, TTT	Joint Final Conference	26	9	2018	Paris, France	X	X	X	X	X	X	N/A	Publicly announce final results of Safe4RAIL and CONNECTA to interested parties (including but not limited to other JU projects)	International
39	Participation to a Conference	ALL	Joint Final Conference	26	9	2018	Paris, France	X	X	X	X	X	X	N/A	Publicly announce final results of Safe4RAIL and CONNECTA to interested parties (including but not limited to other JU projects)	International
40	Video/Film	TEC	Video about Safe4RAIL, explaining the project vision, mission and results	26	9	2018	Paris, France	X	X	X	X	X	X	N/A	https://safe4rail.eu/ https://vimeo.com/292945778	International
41	Press release	UNI	Joint Final Conference	27	9	2018	UNI Website	X	X	X	X	X	X	N/A	http://www.unicontrols.cz/index.php/en	National
42	Website	UNI	Information about Safe4Rail project and the results achieved	27	9	2018	UNI Website	X	X	X	X	X	X	N/A	http://www.unicontrols.cz/index.php/en/research-and-development	National
43	Flyer	TEC	Project Newsletter Final Issue (Issue 4)	9	1	2019	Online	X	X	X	X	X	X	N/A	The intention of this newsletter is to open a new communication channel in order to provide news on the project	International

No	Type of activities	Main leader	Title	Date			Place	Type of Audience ²						Size of audience	Type and goal of the event	Countries addressed
				Day	Month	Year		A)	B)	C)	D)	E)	F)			
															progress and to discuss ongoing topics relevant to Safe4RAIL. The Newsletter is available on: https://safe4rail.eu/downloads/Safe4RAIL-Newsletter-Final-Issue.pdf	
44	Other	TEC	Safe4RAIL podcast	9	1	2019	Online	X	X	X	X	X	X	N/A	Interview with the project coordinator Arjan Geven describing some of the challenges and outcomes of this effort and looks at the future of railway transportation. The podcast is available on Technikon's Vimeo channel: https://vimeo.com/310762004	International

2.3 Communication Activities

The dissemination activities present the project’s results to the general public, which rely on communication activities, respectively on the diffusion of news on the website, the usage of social media, newsletters, and other publications targeted at potentially interested people.

2.3.1 Project Website

The project website <http://www.safe4rail.eu> serves as the most versatile information and communication tool, as it provides information for a worldwide audience and it enables a working platform for the project team. Therefore, it provides a user-friendly and informative environment which functions as one of the most important dissemination channels, providing continuously updated information on the project, its activities and results. Furthermore, the website provides contact details and partners information as well. The core functionality as well as the structure of the project website was already described in detail in deliverable D5.1 “Internal and external IT communication infrastructure and project website”.

To maximise the visibility of the project, all project partners are encouraged to promote the project and its news on their company websites and also link to the project website.

2.3.1.1 Web Performance

A statistical analysis of access (both unique visitors and overall visits) to the Safe4RAIL project website (graphical visualisation) has been created which can be found below. In order to obtain these figures, we used *Google Analytics* as statistical tools.

The following figures will give attention to the second project period, respectively to months M13-M27, starting from the 1st of October 2017 to the end of December 2018.

The two illustrations below (Figure 1 and Figure 2) provide an overview of the number of unique visitors and the total number of requests (visits). While the visitors are counted just for the first time of their website visit, visits are counted for each request of the website.

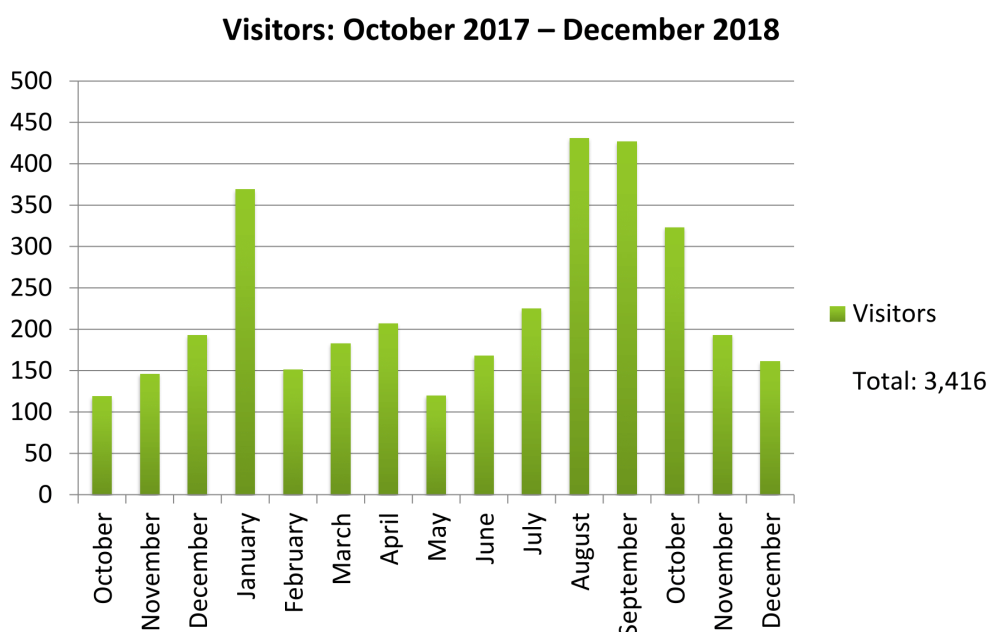


Figure 1: Safe4RAIL website statistic of unique visitors

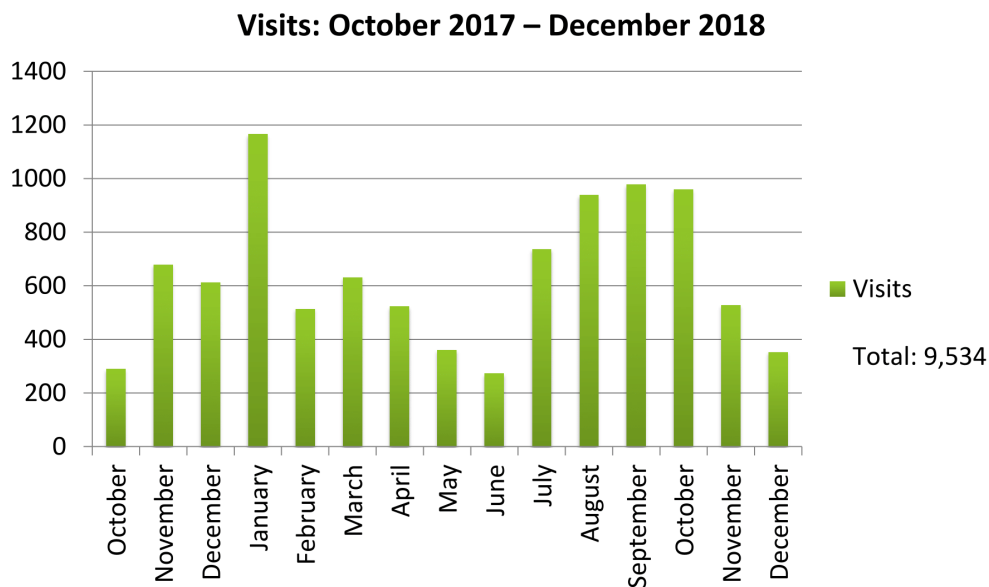


Figure 2: Safe4RAIL website statistic of non-unique visits

During the second project year, the Safe4RAIL website has been visited 9,534 times in total by 3,416 unique visitors. In comparison to the first project period, the numbers were tripled. In terms of numbers, there were 3,850 visits by 1,097 unique visitors counted in the previous period of interest.

The following website statistic depicted in Figure 3 illustrates the geographical distribution of the visitor's location. Since Safe4RAIL is a European research and innovation action project, the major interest lies of course within Europe (represented by 80.4% of the total visitors). Nevertheless, it has to be highlighted that the project raised also an interest in Asia (12.3%) as well as in America (North and South of America and the Caribbean, 6.5%). The remaining percentage is spread over Africa and Oceania (Australia, New Zealand and New Guinea).

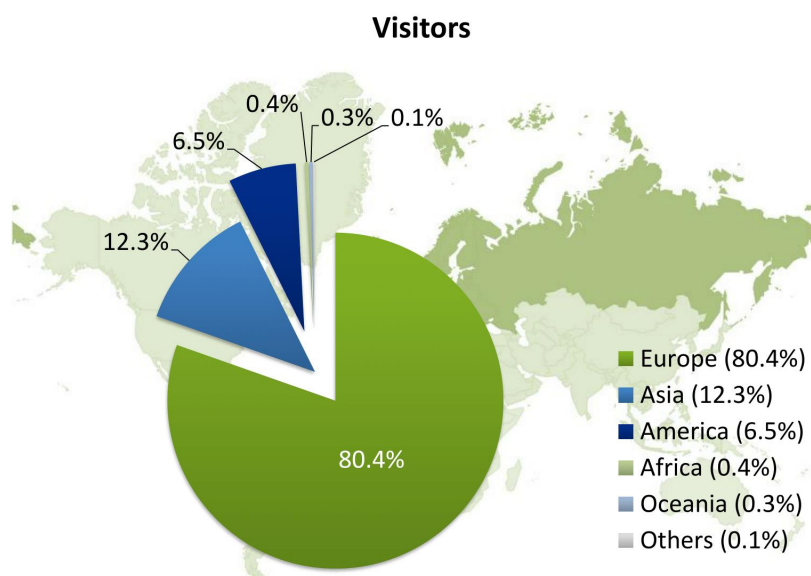


Figure 3: Safe4RAIL website statistic of the geographical distribution of visitor's location

With respect to the following statistic in Figure 4, it has to be pointed out that in the second project period of Safe4RAIL, the website has been able to attract a considerable amount of new visitors, represented by almost 84% of the total visitors.

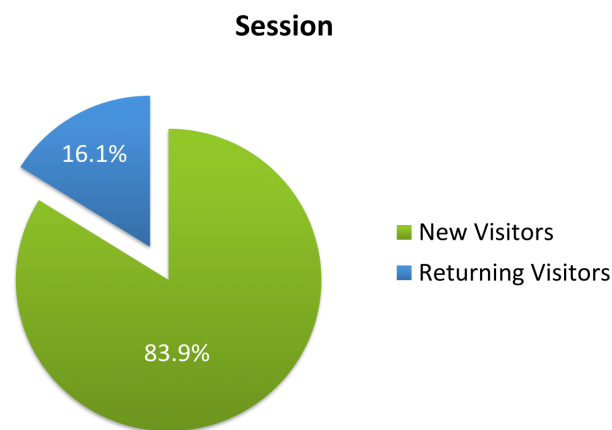


Figure 4: Safe4RAIL website statistic of the distribution of the type of the visitors

2.3.1.2 Analysis of the project website

As reported above, website statistics allow to easily evaluate the level of awareness of the project website by means of the number of visits and the number of unique visitors. Based on the number of visits and unique visitors in Section 2.3.1.1, an average rate of 2.8 pages per visitor with an average duration of stay of 3 minutes and 5 seconds is resulting. In conclusion, a visitor remains almost 3 minutes (02:50) on the Safe4RAIL website while reading almost 3 pages per visit.

2.3.2 Social Media

Making use of the advantages of social media helps spreading project information to a larger audience. As a consequence, social media are valuable means to disseminate project ideas and results. *Twitter* is an online social networking and micro-blogging service that enables its users to send and read text-based messages of up to 280 characters, known as "tweets". During the project lifetime, we have tweeted 18 entries, 9 in the 1st project year and 10 in the 2nd project year respectively. We continuously informed interested community and the broad public with tweets about the latest project news and press releases. Figure 6 depicts a snapshot of Safe4RAIL's Twitter webpage, which is accessible via: <https://twitter.com/SAFE4RAIL>.

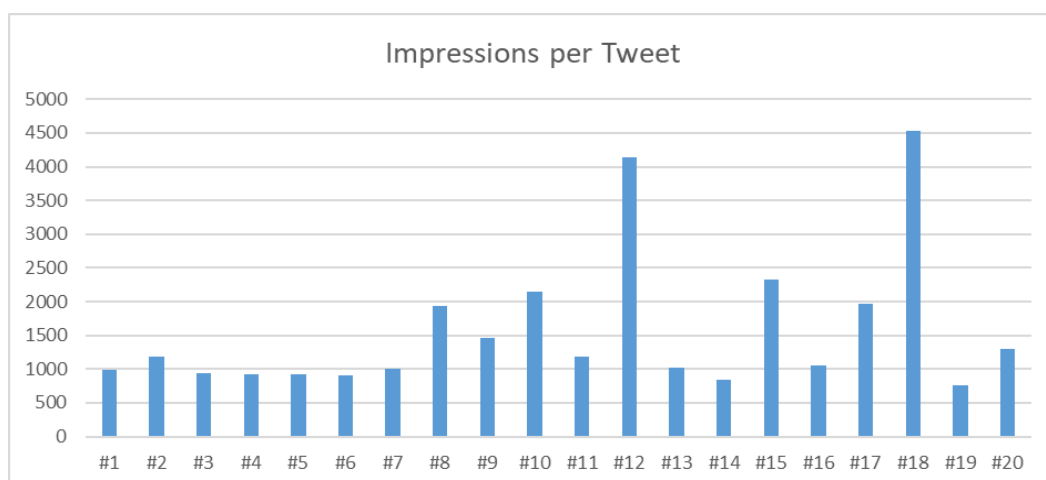


Figure 5: Impressions per Tweet on <https://twitter.com/SAFE4RAIL>

During the project lifetime, we achieved 31,500 impressions³ on our tweets on the project's Twitter page in total. As shown in Figure 5, the number of impressions slightly increased over the full duration of the project.

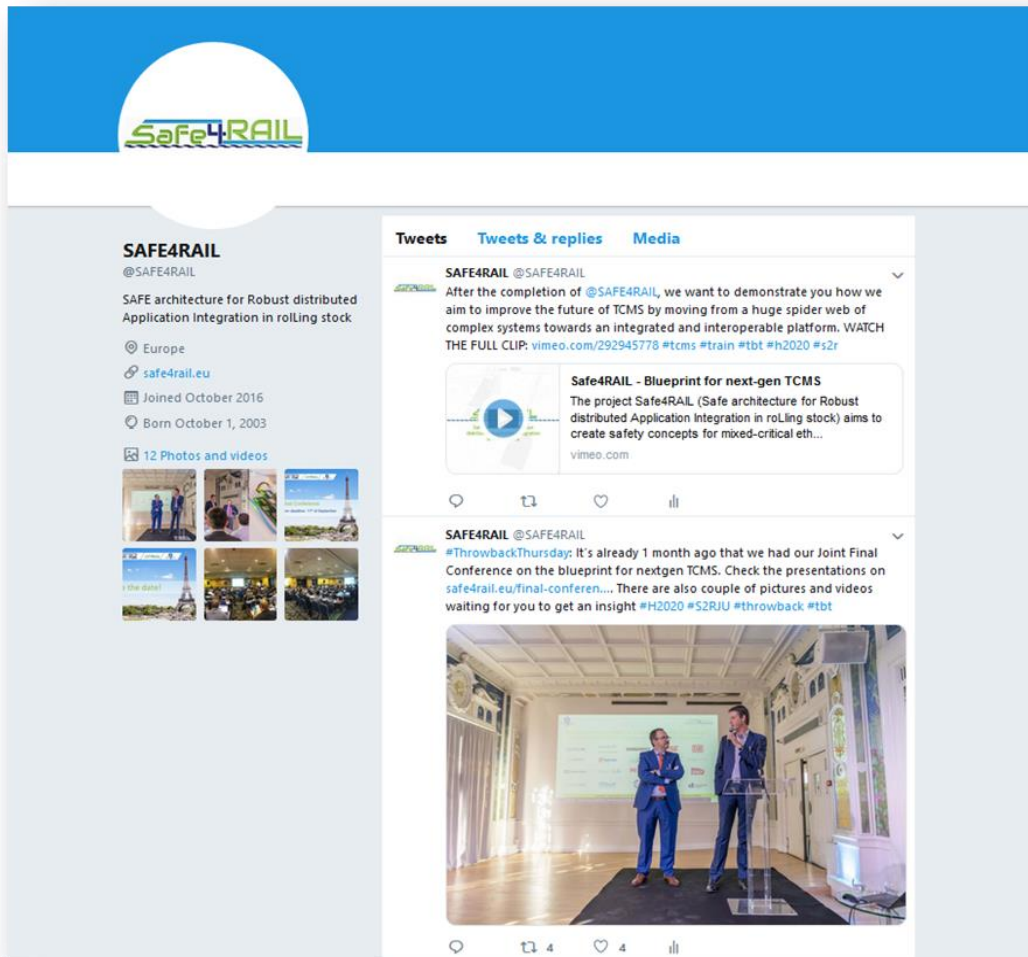


Figure 6: Safe4RAIL's Twitter webpage

2.3.3 Print- and E-Media

Dissemination media/materials, whether as printed or electronic version, contribute highly to the level of awareness of the project. Therefore, several media has been used in Safe4RAIL, respectively a project-specific leaflet, a poster and newsletter were designed and published in order to bring the subject matter as well as results of Safe4RAIL to the public.

2.3.3.1 Project Leaflet

The official Safe4RAIL leaflet, a four-page informative and graphically appealing A4 flyer, highlights mission, motivation and objectives of Safe4RAIL. The leaflet was used for distribution at conferences, such as the Mid-Term and Joint Final Conference, and certain other events, such as the InnoTrans 2018 fair, in order to provide further visibility to the

³ Impressions represent the number of times that a given Tweet has been viewed on the Twitter platform in an organic context. Impressions generated from Tweets that are seen in a promoted or paid context are not included.

Safe4RAIL project. An electronic version of the leaflet is available on the Safe4RAIL website: https://safe4rail.eu/downloads/Safe4RAIL_Folder_Web.pdf

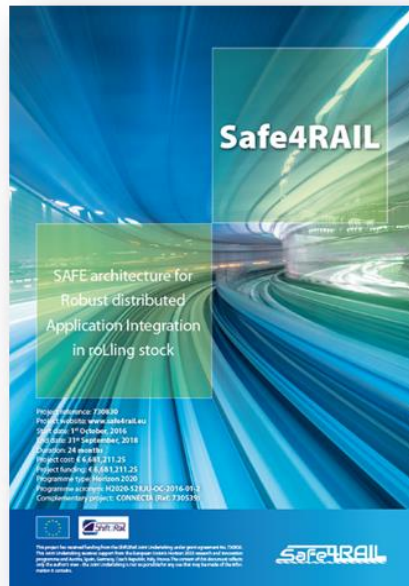


Figure 7: Safe4RAIL leaflet – front page

2.3.3.2 Project Poster

Besides the official Safe4RAIL leaflet, a project poster was designed for raising attraction at fairs, conferences and other events, similar to the target groups of the leaflet. The poster was published on the project website and the electronic version is accessible by the following link: https://safe4rail.eu/downloads/Safe4Rail_Poster.pdf.



Figure 8: Safe4RAIL poster

2.3.3.3 Project Newsletter

In M05 of the project, we launched the first newsletter issue for Safe4RAIL in order to address project related news. Since then we released four further issues of the project newsletter, respectively the November 2017 issue (issue 2), the June 2018 issue (issue 3), the Joint Final Conference issue (special edition for the public dissemination event in September) and the December 2018/January 2019 issue (issue 4), which represents the final newsletter of Safe4RAIL. All newsletter issues are accessible via our project website: <https://safe4rail.eu/news/press-news>.



Figure 9: Safe4RAIL Newsletter – Final Issue

2.3.4 Scientific Publications

During the lifetime of Safe4RAIL, the following scientific publications were published by the consortium (split up per period). In the following list, relevant information including the public access on said publications is provided. Further publications submitted to conference are pending evaluation.

Scientific publication during 2nd project period and upcoming/planned:

- Mirko Jakovljevic, Arjan Geven, Natasa Simanic-John, Derya Mete Saatci, *Next-Gen Train Control / Management (TCMS) Architectures: 'Drive-By-Data' System Integration Approach*, ERTS 2018, Toulouse, France, February 2018.
<https://www.tttech.com/fileadmin/content/general/files/pdf/company/academic/publications/2018-ERTS2017-Next-Gen-Train-Control.pdf>
- Maryam Pahlevan and Roman Obermaisser, *Next-Gen Train Control / Management (TCMS) Architectures: 'Drive-By-Data' System Integration Approach*, ERTS 2018, Cambridge, UK, March 2018. <https://ieeexplore.ieee.org/document/8374471/>
- Tobias Pieper and Roman Obermaisser, *Distributed co-simulation for software-in-the-loop testing of networked railway systems*, 7th Mediterranean Conference on Embedded Computing, Budva, Montenegro, June 2018.
<https://networked-embedded.de/es/index.php/staff-details/pieper.html>
- Mohammed Abuteir, Zaher Owda, Hamidreza Ahmadiarr and Roman Obermaisser, *Simulation Model and Environment for Mixed-Criticality Networked Multi-Core Chips*, 2018 IEEE 13th International Symposium on Industrial Embedded Systems (SIES), Graz, 2018, pp. 1-8. Doi: 10.1109/SIES.2018.8442102
- Maryam Pahlevan, Nadra Tabassam and Roman Obermaisser, *Heuristic List Scheduler for Time Triggered Traffic in Time Sensitive Networks*, 16th International Workshop on Real-Time Networks, Barcelona, Spain, July 2018.
<https://networked-embedded.de/es/index.php/staff-details/pahlevan.html>
- Hongjie Fang and Roman Obermaisser, *Virtual Switch Supporting Time-Space Partitioning and Dynamic Configuration for Integrated Train Control and Management Systems*, 21st Euromicro Conference on Digital System Design, 2018, Prague, Czech Republic, August 2018.
<https://networked-embedded.de/es/index.php/staff-details/fang.html>
- Maryam Pahlevan and Roman Obermaisser, *Genetic Algorithm for Scheduling Time-Triggered Traffic in Time-Sensitive Networks*, 23rd International Conference on Emerging Technologies and Factory Automation, Torino, Italy, September 2018.
<https://networked-embedded.de/es/index.php/staff-details/pahlevan.html>
- Tobias Pieper and Roman Obermaisser, *Network-Centric Co-Simulation Framework for Software-In-the-Loop Testing of Geographically Distributed Simulation Components*, 21st IEEE International Conference on Computational Science and Engineering, Bucharest, Romania, October 2018.
<https://networked-embedded.de/es/index.php/staff-details/pieper.html>
- Maryam Pahlevan and Roman Obermaisser, *Redundancy Management for Safety-Critical Applications with Time Sensitive Networking*, 28th International Telecommunication Networks And Applications Conference, Sydney Australia, November 2018.
<https://networked-embedded.de/es/index.php/staff-details/pahlevan.html>
- Iñigo Odriozola, Lorea Belategi, Ekain Azketa, Jorge Parra, Rosa Iglesias, Hongjie Fang, *Functional Distribution Framework for railway systems*, IEEE Transactions on Intelligent Transportation Systems OR IEEE Transactions on Industry Applications, 2018.

- Iñigo Odriozola, Ekain Azketa, Jorge Parra, Rosa Iglesias, Hongjie Fang, Bernd Löhr, *Functional Distribution Framework for future TCMS systems*, 12th World Congress on Railway Research - WCRR 2019, Tokyo, Japan, October 2019.

Scientific publication during 1st project period:

- Hongjie Fang and Roman Obermaisser, *Execution Environment for Mixed-Criticality Train Applications based on an Integrated Architecture*, In Proc. of the IEEE International Conference on Promising Electronic Technologies (ICPET), Deir El-Balah, Palestine, 2017.
<https://networked-embedded.de/es/index.php/staff-details/fang.html>
- Maha Bouaziz, Ying Yan, Mohamed Kassab, José Soler and Marion Berbineau, *Train-to-Ground communications of a Train Control and Monitoring Systems: A simulation platform modelling approach*, 7th Transport Research Arena TRA, Vienna, Austria, April 2017.
- Mirko Jakovljevic, Alvaro Soares, *Open Ethernet-Based Embedded Platforms for Integrated Modular Architectures and Autonomous Systems*, AHS Forum 73, Forth Worth, Texas, USA, May 2017.
<https://www.tttech.com/fileadmin/content/general/files/pdf/company/academic/publications/2017-AHS-Forum-73-Open-Ethernet-Based-Embedded-Platforms.pdf>
- Maha Bouaziz, Ying Yan, Mohamed Kassab, José Soler and Marion Berbineau, *Evaluating TCMS Train-to-Ground communication performances based on the LTE technology and discret event simulations*, 13th International Workshop on Communication Technologies for Vehicles – Nets4cars / Nets4trains / Nets4aircraft, Madrid, Spain, May 2017.
- Ying Yan, Maha Bouaziz, Mohamed Kassab, Marion Berbineau and José Soler, *Co-simulation Platform for Train-to-Ground communications*, 20th Nordic Seminar on Railway Technology, Gothenburg, Sweden, June 2017.
- Bernd Hirschler, Mirko Jakovljevic, *Secure deterministic L2/L3 Ethernet Networking for Integrated Architectures*, SAE Aerotech 2017, Forth Worth, Texas, USA, September 2017.
<https://www.tttech.com/fileadmin/content/general/files/pdf/company/academic/publications/2017-SAE-Secure-deterministic-L2L3-Ethernet-Networking.pdf>

2.3.5 Video

Partner TEC created an animated video to promote the Safe4RAIL project and to bring the complex technology of the project nearer to the public and interested stakeholders. The video was broadcasted through several social media channels. Among others, the video is accessible via our Twitter page and project website: <https://safe4rail.eu/> (alternatively via Vimeo: <https://vimeo.com/292945778>).

Besides the online release, the video was displayed during the Joint Final Conference, which took place in September in Paris.

2.3.6 Podcast

Technikon visited the offices of TTTech in Vienna to interview Arjan Geven about the wrap-up of the Safe4RAIL project, which resulted in a podcast. In this podcast, Arjan described some of the challenges and outcomes of this effort and looks at the future of railway transportation. The podcast is accessible via our project website as well as Vimeo: <https://vimeo.com/310762004>.

2.4 Dissemination Events

As part of our dissemination strategy, we organized two dedicated one-day dissemination events. These events, the Mid-Term Conference and Joint Final Conference respectively, represented the perfect opportunity to present the project results to public railway stakeholders to obtain feedback from a broader audience and therefore to optimize so the project impacts.

2.4.1 Mid-Term Conference

On 25th of January 2018, the Safe4RAIL consortium met together with interested attendees among others from the railway domain as well as suppliers and manufacturers, safety experts and authorities of train control and communication systems at Safe4RAIL's Mid-Term Conference in Prague (CZ). An audience consisting of more than 70 participants got the main achievements and successful progress presented, which Safe4RAIL made during the 1st project year. The conference, organized by our project partner UniControls, was dedicated towards the concept for the Integrated Modular Platform, consisting of middleware and networking framework. Besides that, further presentations were held in terms of simulation and demonstration aspects. The conference was perfectly concluded by the last slot of the day, respectively the panel discussion, which led into deeper and more technical talks and thoughts, revealing interesting paths for the future.

Insights including images were summarized at: <https://safe4rail.eu/news/64-safe4rail-mid-term-conference-prague>.



Figure 10: Safe4RAIL's Mid-Term Conference in Prague

2.4.2 Joint Final Conference

On 26th of September 2018, Safe4RAIL and CONNECTA (project reference: 730539; topic: S2R-CFM-IP1-02-2016) organized a Joint Final Conference, which took place in Paris, France. According to the motto “More functionality and interoperability, lower system complexity and cost”, the conference focused on final results for next-generation TCMS and the following topics were presented:

- Drive-by-Data: Robust, modular and safe mixed-criticality Ethernet networking technology for electronic control.
- Functional Distribution Framework: Robust, modular and safe mixed-criticality middleware to provide abstraction from underlying platform hardware.

- Distributed Simulation Framework: Simulation of in-train communication networks with co-simulated end-systems to improve early validation of functionality, timing, reliability and safety.
- Train-to-Ground Communication: Development of train-side and ground-side equipment according to IEC 61375-2-6 and a corresponding interoperability test environment.
- Wireless Train Backbone: First tests in the field, under real operational conditions, of this cornerstone for the virtual coupling of trains.
- Brake-by-Wire: Concept development for a fully electronic control architecture for high-safety braking subsystem.
- Functional Open Coupling: To achieve the full interoperability at functional level, allowing consists of different manufacturers or implementing different functions to couple.
- Application Profiles: Syntactic and semantic standardisation of consist functions for easier integration and certification.

Throughout the day, the conference was accompanied by several graphical as well as a physical demonstrator, located in the conference room at Le Salon Des Miroirs. In total, CONNECTA and Safe4RAIL welcomed an audience of around 120 participants to this very successful and factful event.

Insights including images and a video were summarized at: <https://safe4rail.eu/final-conference>.

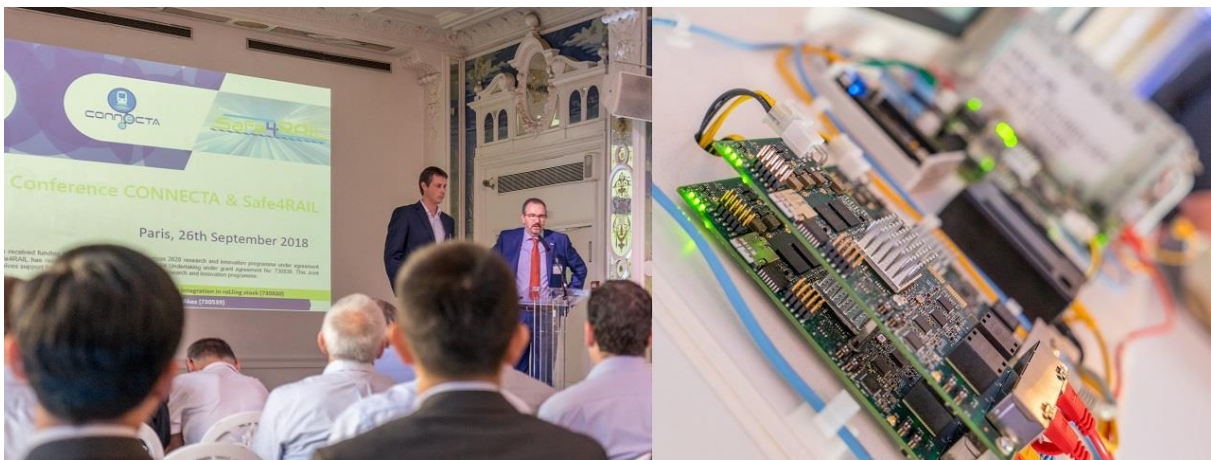


Figure 11: Safe4RAIL's and CONNECTA's Final Conference in Paris

Chapter 3 Exploitation

3.1 Introduction

The Safe4RAIL project gathers a highly competent group of partners who cover the whole value chain of product innovation. The common goal of the consortium is to create knowledge, to develop new solutions and to pave the way for commercially successful product innovation to impact the market. An exploitation plan is not just required to support the transfer from project to business level in the start-up phase, but is a vital aid to help the consortium to address potential business opportunities more effectively.

The project exploitation strategy focuses on reaching the expected impact by the activities of the project consortium in the **medium** and **long term** and targets:

- *Medium-term*: Enlarged consensus around the project scientific and industrial excellence. The strategy utilizes capitalising of reputation and networks of consortium partners; focus is on recalled attention of standards bodies to the benefits of next-generation TCMS architecture.
- *Long-term*: Uptake of next-generation TCMS architecture, respective SAFE4RAIL methodology, components and building blocks in the railway domain.

The exploitation is supported by the active dissemination activities that demonstrate the quality and applicability of project results. Broad presence and industrial uptake of the SAFE4RAIL results strengthens the market base for the industrial partners and is therefore an important factor in the exploitation of the project's results.

All partners in the project are committed to participate in the development of the common exploitation strategy. The partners have provided information on their previous experience and their current business strategies to facilitate the exploitation activities planned. The plan is based on the high-level exploitation plans and the identified market and business opportunities, including a proposal for exploitation metrics of success.

The underlying exploitation plans have been refined, detailed and further developed during the project frame. Due to the public nature of this deliverable and the confidential nature of the individual exploitation plans, the sketched updated exploitation plans are not included in the deliverable but in the Periodic Report.

In conjunction to this common Safe4RAIL exploitation strategy and in line with the Shift2Rail targets, partners are encouraged to achieve their individual exploitation plans in relation to the project outcomes, also after the project end.

3.2 Methodology

The updated exploitation approach targets the definition of essential elements of the partners' business model. This can be interpreted as a blueprint for a strategy to be implemented through their organizational structures and processes using Safe4RAIL's results. What we have collected from partners from the beginning to the end of the project is the description of their model and their hypotheses, which have been captured in what is called "The Business Model Canvas sheet" [1].

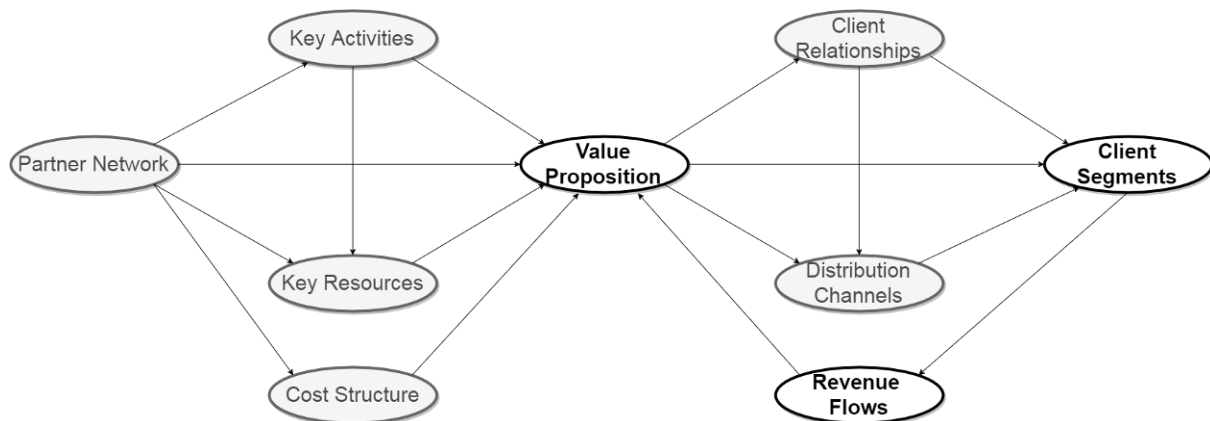


Figure 12: The relation between the nine elements in the Business Model Canvas (adopted from [1])

The nine elements and their relationship are depicted in Figure 12. Despite the model describes nine blocks of information that cover all areas of a business. The partners provide a brief description of three of these blocks that are relevant in particular for new technology development and improvement, which are the following:

- *Value Propositions*: products and services that can create value solving a problem or satisfying a need for each customer segment.
- *Customer Segments*: the different groups of people or organizations that partners aim to reach and their different and common needs.
- *Revenue Streams*: the cash generated from each customer segment; revenue model and pricing tactics.

The Business Model Canvas is graphically depicted similar to Figure 13:

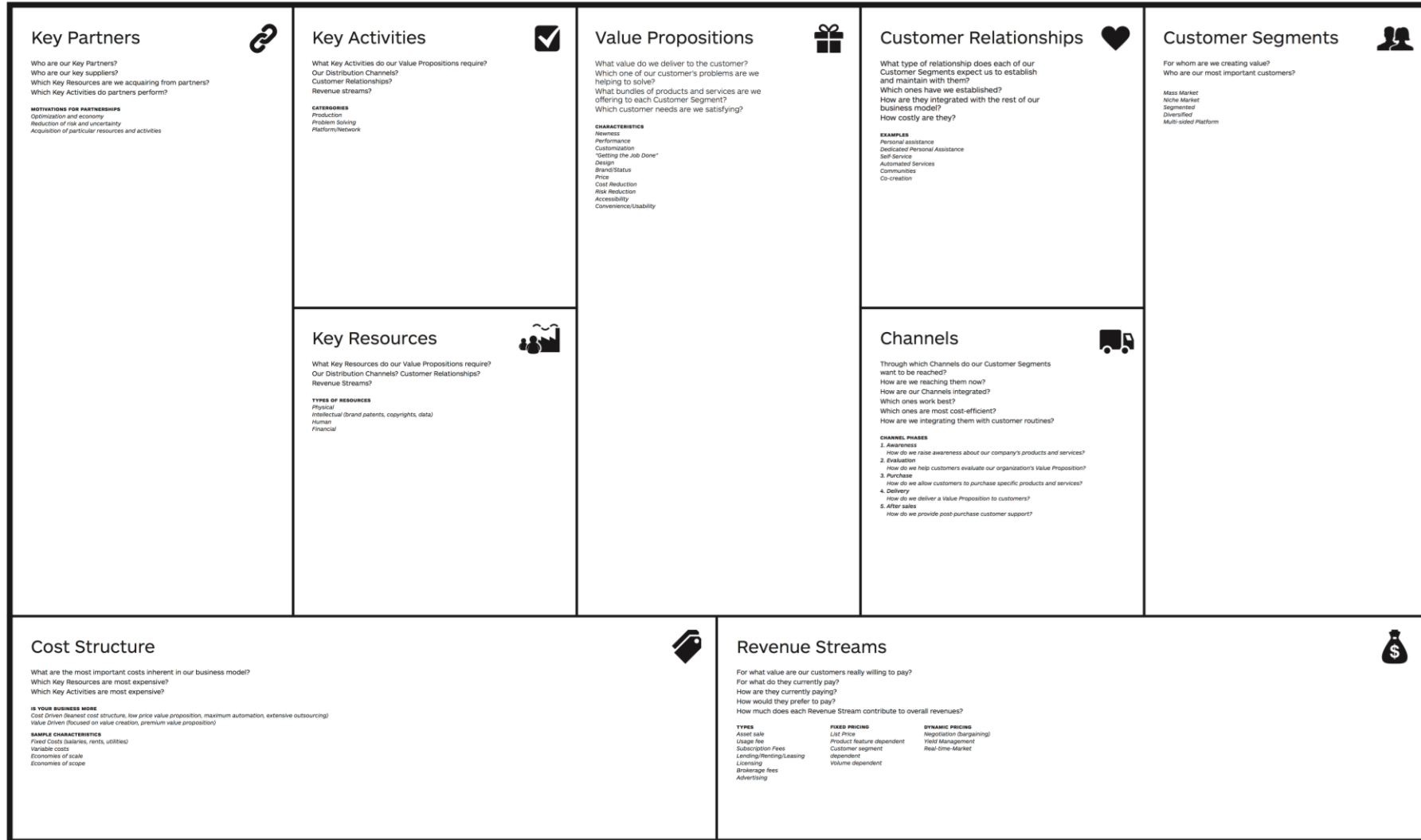


Figure 13: Business Model Canvas [2]







The individual approach to exploitation plans of partners involved in the project through the mentioned Business Model Canvas (BMC) sheet, with a short description of the blocks described above, are contained in the next project's Periodic Report.

3.3 Metrics and KPIs for exploitation

Exploitation activities in the project are tracked according to specified Key Performance Indicators (KPIs) related to exploitation. In the second year of the project, the achievement of these KPIs and actual targets for a Research and Innovation Action has been our goal.

3.3.1 Exploitation KPIs and target values

The following KPIs were defined in the first year of the project for the Safe4RAIL exploitation activities. They have now been revised for the second year to indicate their achievements. The KPIs achievements are marked according to the action and contingency map upon KPI satisfaction or dissatisfaction presented in the deliverable D5.2.

KPI	Description	Target	Achieved
 E1	Exchange with railway OEMs and suppliers	≥ 6	At least 16 meetings and technical workshops with joint participation of S4R and CTA partners were held.
 E2	Organisation/participation in exploitation-oriented events	≥ 3	5 : 2 self-organized conferences, 2 AB Meetings, Safe4RAIL at several booths at the InnoTrans fair.
 E3	New patent application	≥ 1	1 patent application related to graceful degradation in the network (TTT)
 E4	New start-up or spinoff company created	optional	No. It was decided not to be a viable strategy at this stage.
 E5	Total investments mobilised via debt financing and Venture Capital investments	optional	No. Loans and VC were not envisaged at this stage. A further round of research activities will be required (planned for e.g. Safe4RAIL-2 project) to increase maturity of the technology.
 E6	New product developments around Safe4RAIL or integration in existing products / product developments	≥ 1 per industrial partner	All industrial partners (except one) have succeeded in advancing product development based on the Safe4RAIL results, as well as an

KPI	Description	Target	Achieved
			<p>academic partner that has focused on new methods:</p> <p>TTT: Yes, see BMC. In addition to railway, re-spin of technology concepts in other domains.</p> <p>IKL: No</p> <p>NEW: Yes, see BMC</p> <p>UNI: Yes, see BMC.</p> <p>IAV: No, see BMC.</p> <p>IFS: Yes.</p> <p>TEC: Yes, see BMC.</p> <p>ELE: Yes, see BMC.</p> <p>NIER: No.</p> <p>TUV: Yes, see BMC.</p>
■ E7	Contribution to standards or creation of new standards	≥ 1	<p>1 umbrella standard (with at least 4 substandards, i.e. the -2-3, -3-4, -2-5, -2-6) influenced by project.</p> <p>Initial results presented to IEC61375 working groups on T2G and DbD.</p>
■ E8	Personnel or in-house trainings on Safe4RAIL topics and/or outcomes	optional	<p>IKL plans to include from M25 to M27</p> <p>NEW: 1</p> <p>TTT: 2</p>
■ E9	Integration of Safe4RAIL context in academic teaching and education activities	≥ 1 per academic partner	4 doctoral dissertations, inclusion of communication emulator in lecture's lab by SIE
■ E10	Follow-up research project or activities formulated and submitted	≥ 1 (total)	<p>Safe4RAIL-2</p> <p>EmulRadio4Rail (IFS)</p>

Table 4: Exploitation KPIs

It can be concluded that all KPIs have been achieved, with one KPI overachieving on the interaction with the railway industry. In other words, the project results are very promising with regards to exploitation. There is a clear roadmap for the maturation of the project results and the future uptake by the railway industry.

The individual Business Model Canvas' per partner can be found in the 2nd periodic report.

Chapter 4 Standardisation

4.1 Introduction

Harmonization and standardization are important ways to facilitate the adoption of technology, especially in niche markets where volumes are low and investment costs are high. This is exactly the case in the railway domain for safety-related embedded systems. Further factors are the ongoing harmonization of the national technical and safety regulations in the railway domain. Decisions from the past have resulted in non-interoperable, proprietary, country- and vendor-specific solutions. For new technologies, a different, European approach is followed in which interoperability and standardization are key requirements for any new technology in order to avoid future complexity. On the other hand, standardization itself does not come for free and requires all actors to work together to come to suitable standards that can be implemented in a cost-effective way.

In Safe4RAIL, standardization is one of the six key objectives, as announced in the Description of Action: “OBJ 6: Contribution to standards”, with two specific measures of success that are defined alongside the objective:

Measures of success to OBJ 6

- Recommendations and requirements are compliant to the basic safety and security requirements given by the established safety and security standards. A compliance argument is provided for all recommendations and requirements.
- Recommendations and requirements extend the established standards assuring safety and security. A safety & security argument for individual extensions and additions is provided.

This chapter highlights the activities planned and already undertaken with respect to standardization of the results in accordance with the objective of the project.

4.2 Standards addressed by Safe4RAIL

The relevant standards can be classified in two different areas that are of relevance to the project:

1. **Technical standards**, which can be split in generic and railway-specific technical standards.
 - a. Generic technical standards - this relates to e.g. Ethernet standards described in IEEE802.3. new technological insights may trigger updates of such standards, especially where participants on Safe4RAIL are directly involved. These standards are typically optional for use in the railway domain, and can be selected or not depending on their technical merits and efficacy.
 - b. Railway-specific technical standards – this relates to domain-specific standards that are defined by and for the railway industry. An example of such a standard is the IEC61375 for electronic railway equipment for the Train Communication Network (TCN).
2. **Safety and Security standards** – this relates to railway safety standards which are normative standards that are actively enforced by authorities and must be adhered to.

Standards are defined targeting the prevention of dangerous system failures and safety of human life, both due to unintended failure (safety) and intended failure (security). As an example CENELEC EN 50126 targets the Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) of railway applications.

Both technical and safety/security related standards are important for the success of the Safe4RAIL project. However, they are important in different ways due to the way they affect the development of the rolling stock, on two different grounds:

Normative vs. descriptive standards: The technical standards are descriptive. As such they target mainly the interoperability and serve as a means to reduce cost (either immediately or in the future). Safety and security standards are normative, non-negotiable and must be adhered to.

Stakeholder dynamics: The technical standards are largely shaped and defined by industrial parties and as such more susceptible to change in case of better technical alternatives. The major drivers for change are financial/effort-wise or feature-wise improvement of the capabilities offered by the technology, as well as interoperability reasons pushed for by specific stakeholders (e.g. operators). Safety norms are changed on the merits of safety and require proof to and approval of authorities. Subsequently, although all standards are slow, safety norms are particularly conservative and react with certain delay on technological changes to ensure that unintended pitfalls are avoided at all times and safety is guaranteed.

4.3 Methodology

It is well-known that standardization is an activity that typically stretches over many years or even decades. At the same time, the project is working on results that will be suitable for standardization rather by the end of the project than by its beginning. As such, it is not feasible to expect conclusion of new standards with Safe4RAIL results directly in the context of the project.

The goal of the standardization activities described in this chapter is, due to these long lead-times, a different one, i.e.

- a) to ensure compatibility with existing safety and security standards without the need for changes to these standards,
- b) to integrate project technical results to the respective technical standardization bodies on a per-partner basis,
- c) to invite and discuss with members of standardization bodies regarding the update window according to the lifecycle of such standards in which new contributions can be brought to the table,
- d) to present recommendations for updates to the relevant railway standards.

Phases

The standardization methodology followed in Safe4RAIL is set up in three phases:

Phase 1 – Survey of relevant standards and standardization groups

Phase 2 – Detailed analysis of those standards with regards to compatibility and alignment with Safe4RAIL concepts

Phase 3 – Recommendation for changes towards these standards:

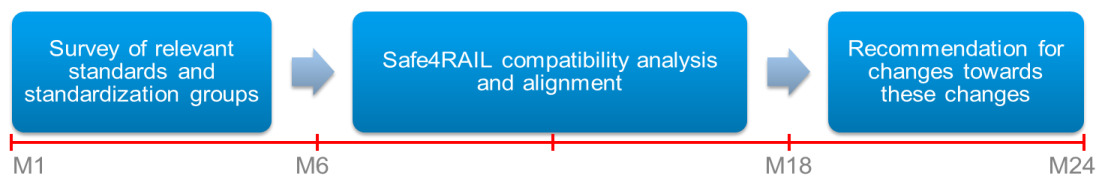


Figure 14: Phases of Standardization

4.4 Survey of relevant standards and standardization groups

In the first phase, the survey of relevant standards and standardization groups was performed which was documented in the deliverable D5.2. This deliverable D5.3 addresses the next steps of the methodology explained above where the alignment of the standards with the Safe4RAIL concepts and recommendations for changes are included.

4.5 Safety and Security Standards

4.5.1 *EN 50126 - Railway Applications - The Specification And Demonstration Of Reliability, Availability, Maintainability And Safety (RAMS)*

Next generation TCMS platform will be able to integrate all critical and non-critical functions relevant for train operation, including functional, performance, safety, security, availability and integrity requirements. The EN 50126 should take into account the integration of the critical functions (SIL4) such as traction control, brake control and signaling and the non-safety-critical functions in one single platform. Strong encapsulation features and guaranteed non-interference are crucial for this “mixed-criticality” platform.

Deriving from the project results, there will be no proposed changes to the EN 50126. In contrast, the technology has been developed to be completely compatible to the requirements derived from the standard and to demonstrate the RAMS capabilities.

4.5.2 *EN 50128 - Railway Applications - Communication, Signalling And Processing Systems Software For Railway Control And Protection Systems*

The EN 50128 specifies the method and process of the software development to meet the technical requirements of safety critical systems. In the Safe4RAIL concepts, safety requirements are addressed and the safety measures are defined under the guide of this standard. EN 50128 also takes the software development methodology into account, i.e., a specific software component originates from a generic base that is specifically configured. The Safe4RAIL Functional Distribution Framework (FDF) is designed to be generic and portable between different hardware platforms. While in the development of the FDF demonstrator, the generic software components of the FDF are developed and they are configured to reside on different platforms (PikeOS, INTEGRITY and AUTOSAR). The demonstrated FDF use cases (BMS application and Rogue application) are also executed on the FDF instance, in order to show that the FDF is capable to host safety critical TCMS application through preventing fault propagation between different applications of different safety critical levels.

From the view point of the work done in WP2, there is no specific recommendation for changes regarding this standard.

4.5.3 EN 50129 - Railway Applications - Communication, Signalling And Processing Systems - Safety Related Electronic Systems For Signalling

One of the Safe4RAIL aims is to provide a reconfigurable embedded platform that supports modularity and characterize the railway's interfaces in both temporal and logical domains. Those goals provide assurance of the fitness of the technical concept to support the *modular certification of distributed integrated modular railway architectures* according to EN 50129. EN 50129 provides the framework for the implementation of the corresponding electronic system. Safe4RAIL concepts are directly compatible with the standard in its current formulation.

No recommendation for changing the standard is proposed.

4.5.4 EN 50159 - Railway Applications - Communication, Signalling And Processing Systems - Safety-Related Communication In Transmission Systems

The EN50159 defines key principles for safety-related communications, potential sources of errors and mitigation measures. The sources of error have been analysed and defense mechanisms in line with the standard have been defined in the DbD concept. Safe4RAIL concepts are directly compatible with the standard in its current formulation.

No recommendation for changing the standard is proposed.

4.5.5 EN 50657 - Railway Applications - Rolling Stock Applications - Software On Board Of Rolling Stock, Excluding Railway Control And Protection Applications

In line with the EN 50128, the EN 50657 specifies the process and technical requirements for the development of software for programmable electronic systems for use in rolling stock applications. In the Safe4RAIL concepts, a common software to offer an execution environment for rolling stock applications which ensures an strict time/space partitioning and acts as an abstraction layer for Hardware and protocols is developed under the guide of this standard. EN 50657 also takes the software development methodology into account, i.e., a specific software component originates from a generic base that is specifically configured. The Safe4RAIL Functional Distribution Framework (FDF) is designed to be generic and portable between different hardware platforms. While in the development of the FDF demonstrator, the generic software components of the FDF are developed and they are configured to reside on different platforms (PikeOS, INTEGRITY and AUTOSAR). The demonstrated FDF use cases (BMS application and Rogue application) are also executed on the FDF instance, in order to show that the FDF is capable to host safety critical and non-critical TCMS applications side by side by guaranteeing the non-interference between them.

4.5.6 IEC 62443 - Cybersecurity

As cybersecurity has become an important topic also in the field of railway systems, particularly because it influences safety components, it has to be taken into account in new developments and research and innovation projects.

Since there is no international normative document available dealing with the application of cybersecurity in railway systems, the developers and researchers have been looking for support in their security task in existing applicable standards. One example of such a standard was IEC 62443 series addressing cybersecurity in Industrial Automation Control Systems (IACS).

The committee CLC/TC 9X “Electrical and electronic applications for railways” was entrusted with the preparation of the document specifying requirements as well as recommendations for applying cybersecurity within the railway domain. The working group WG26 should submit the first draft of the document of TS (Technical Specification) level named “Railway applications – Cybersecurity” by the end of 2018. The scope of this technical specification expressing also the relation of the document to IEC 62443 standard is given below (extracted from the working draft of the document).

“This document provides to the railway operators, system integrators and product suppliers, with guidance and specifications on how cybersecurity will be managed in the context of the EN 50126-1 RAMS lifecycle process. This document aims at the implementation of a consistent approach to the management of the security of the railway systems. This document can also be applied to the security assurance of systems and components/equipment developed independently of EN 50126-1:2017.

This document applies to Communications, Signalling and Processing domain, to Rolling Stock and to Fixed Installations domains.

The aim of this technical specification is to ensure that the RAMS characteristics of railway systems / subsystems / equipment cannot be reduced, lost or compromised in the case of intentional attacks.

The security models, the concepts and the risk assessment process described in this document are based on or derived from IEC 62443 series standards. In particular, this document is consistent with the application of security management requirements contained within the IEC 62443-2-1.”

The railway security standard currently under preparation is expected to consider all specifics of railway systems regarding cybersecurity. Hence, there is no need to suggest any changes to the IEC 62443 at this moment.

4.5.7 ISO/IEC 15408 - Common Criteria for Information Technology Security Evaluation

Regarding cybersecurity the railway systems will follow the railway security standard named “Railway applications – Cybersecurity”, which is currently under preparation (see previous section for details). The railway system shall be able to integrate, as COTS elements, independently developed and for security certified components based on requirements given in other standards, e.g. ISO/IEC 15408. According to this standard a number of Protection Profiles (PP) facilitating the handling security aspects of components have been elaborated. For instance, operating systems INTEGRITY and PikeOS, which can be used in the Integrated Modular Platform (IMP) designed in Safe4Rail, have been certified against Separation Kernel PP. Other type of devices used in railway systems that could be certified according to IEC 15408 are network devices, for which a number of PPs exist.

The railway security standard currently under preparation is expected to consider all specifics of railway systems regarding cybersecurity. Hence, there is no need to suggest any changes in this document with respect to the ISO/IEC 15408.

4.6 Technical Standards

4.6.1 IEC 61375 - General

SAFE4RAIL addressed various architectures and topologies. Based on that a reference architecture for the next generation of the TCMS is presented. This architecture provides

- I. highly available and highly reliable integrated platform in order to serve the TCMS functionality.
- II. Integration of all critical and non-critical functions relevant for train operation, including functional, performance, safety, security, availability and integrity requirements.
- III. independent design, testing, V&V and certification/homologation of functions.
- IV. guarantee timing and performance of all critical functions, based on system integration configuration.
- V. reconfiguration management system that is robust and easy to maintain to allow for redeployment of functions and changes in train configuration.

Changes related to Drive-by-Data are also explicitly described in the deliverable D1.7 (chapter 6.4) [4]. The core standard in which these aspects are addressed are the various substandards associated to the IEC 61375 in the following sections of this deliverables.

4.6.2 IEC 61375-2-3 - Communication Profile

Suggested changes/extensions to IEC61375-2-3 Annex A, B and C:

There are a number of changes that relate to the changes in the Drive-by-Data aspects of the project that require minor to medium changes to the communication profile/TRDP and the use of the improved safety protection layer SDTv4. This concerns specifically the Annexes A, B and C in line with the following points:

- A.2 Lower Layers: Changes referring to TSN shall be noted, e.g. no Message Data over TSN
- A.6 Process Data: Constraints for communication patterns (TSN supports 'Push' only, no 'Pull'). The reduced TRDP header will only be used for TRDP over TSN, and will only be used with the push-pattern.
- A.6.5 PD-PDU: Add description of reduced header (see WP1 D1.9 Chapter 6: Chapter 6 Data Transmission Concept [5])
- B.x – Safe Data Transmission: Add SDTv4 mechanisms
- C.4.2.5 Telegram Configuration (ExchgPar): Add optional attribute "type" with values "source", "sink" and "source-sink" to telegram tag definition to remove ambiguity for multicast destination
- C.4.2.5.6 SDTv2 Parameters: Either add SDTv4 parameters or define an alternative tag.
- C.6.1 General (com-parameter): Additional optional attributes 'vlan', 'priority' and 'tsn' to configure the TRDP stack to use TSN.

4.6.3 IEC 61375-2-5 - Ethernet Train Backbone

Suggested changes:

The Ethernet Train Backbone standard as defined in IEC 61375-2-5 will be extended with the following main aspects (as described in detail in Safe4RAIL D1.7 [4]):

- Topology with two independent lines, with implications for link aggregation and removed the need for a bypass function on the ETBNs
- Clock synchronisation
- Scheduled communication
- Redundant communication
- Filtering and policing based on time-aware features
- Configuration aspects

It is planned to recommend this communication architecture to the standardization authority in the next update cycle of the standard.

4.6.4 IEC 61375-2-6 - Train2Ground

The draft standard IEC 61375-2-6 was essential for the work on the Train-to-Ground Test Environment (T2G TE) in S4R WP3. The goal was to provide means for the validation of T2G communication implemented according to this standard. The work has been done in a close cooperation with the CONNECTA project partners (Bombardier, Siemens, CAF, Alstom). They have implemented a Mobile Communication Gateway (MCG) in accordance with the standard, UniControls (S4R participant) has implemented a Ground Communication Gateway (GCG). After the implementation phase, validation tests have been performed between three different implementations of the MCG and the GCG using the T2G Test Environment.

During all phases of the work (analysis, design, implementation, validation and testing) many issues in the IEC 61375-2-6 standard have been identified, such as:

- ambiguities in definitions and requirements
- inconsistencies throughout the text
- undefined behaviour of the components involved in the communication in certain situations (particularly handling of error situations)
- errors in the definition of the content of some telegrams

These technical issues have been passed as comments on the draft standard, which was in the final voting stage, in a standard way, i.e. by means of National Committees. As generally no comments of technical character used to be accepted in that stage the identified issues remain unresolved.

To summarize, the current version of the standard does not sufficiently support individual developers of T2G communication to achieve interoperable solutions. Therefore, we suggest the revision of the standard in the nearest possible time.

4.6.5 IEC 61375-3-4 - ECN / Ethernet Consist network

IEC61375-3-4 demands a minimum cycle time for Process Data telegrams of 20ms. This should be reduced to 1ms to reflect advanced TSN capabilities of the NG-TCN.

Capabilities for clock synchronisation, redundancy management, scheduled data transmission and ingress and egress policing may be included on the Ethernet Consist Network as well.

4.6.6 SAE 6802 - TTEthernet

After analysis of the TTEthernet environment as described in D1.1 [3], it was decided that the technology will not be used in the project proof-of-concepts. No recommendations for further standardization will be made in the context of the project.

4.6.7 IEEE 802.3 - Ethernet

The IEEE 802.3 Ethernet standard is considered as a given, robust and existing platform. The concepts proposed are completely compatible to the standard. No recommendations for further standardization will be made.

4.6.8 IEEE 802.1 - Local Area Networks

The IEEE 802.1 LAN standard is currently directly impacted by the work on Time-Sensitive Networking. The TSN sub-standards (e.g. 802.1CB, 802.1AS-rev, 802.1Qci) have further developed during the course of the project. With TTEch as a contributing member to these new sub-standards, contributions have been made in the discussion on the further shaping of these technologies to ensure future interoperability.

4.6.9 ARINC 664 Part 7 - Avionics Full Duplex Switched Ethernet (AFDX)

After analysis of the AFDX environment as described in D1.1, it was decided that the technology will not be used in the project proof-of-concepts. No recommendations for further standardization will be made in the context of the project.

4.6.10 TRDP - Train Real-time Data Protocol

See changes for IEC61375-2-3 (section 4.6.2)

4.6.11 DIN VDE V 0831-104 - Electric signalling systems for railways - Part 104: IT Security Guideline based on IEC 62443

The intention of this DIN standard in the relation to EN 50129 is to contribute to the future integration of all aspects of IT-security to the Technical Safety Report. It could serve as an “adapter” which integrates the IT-security according to IEC 62443 into functional safety according EN 50129. The EN 50159 as well as DIN VDE 0831-102, which deal with safety-related communication, are also the parts of this integration framework. It is directly relevant

for the Safe4RAIL work which ensures compatibility, but no recommendations for changes to this standard will be made in the context of the project, it is rather taken “as is”.

4.6.12 VDE V 0831-102 - Electric signalling systems for railways - Part 102: Protection profile for technical functions in railway signalling

This standard focuses on the tailoring of the Common Criteria specifically to railway signalling, and is therefore very specific in its use. Nonetheless it provides guidance and information that is accessible for other domains within the railway applications as well. As it is dealing with the transmission of safety-related data it complements the EN 50159 as well as EN 50129 with the aspects of integrity, authenticity and confidentiality. This standard has been analysed in the context of the Safe4RAIL D2.1 [6] and Safe4RAIL D2.3 [7] deliverables but since it is focusing specifically on the signalling application. Since it is not directly adopted in Safe4RAIL nor need it be adapted for Safe4RAIL, no recommendations for changes to this standard will be made in the context of the project.

Chapter 5 Conclusion

Dissemination, standardization and exploitation are three key activities for the whole consortium responsible for the success of the project. In total, three tasks were devoted to dissemination of the project and its results as well as to exploitation and standardization. The target audiences were addressed by a range of different communication channels. In particular, the project website, social media and related communications received considerable attention.

This document represents the update of the last report, namely deliverable D5.2 “Initial report and updates on dissemination, exploitation and standardisation activities”. As reported, the project was disseminated through 44 activities in total. To go into detail, Safe4RAIL was disseminated 22 times by means of press releases and related dissemination activities as well as presented in 22 events including presentations, conferences, exhibitions and workshops by consortium members during the project lifetime. By far the most successful events for disseminating Safe4RAIL, were the Mid-Term and Final Conference. In terms of numbers, our project website attracted a lot of interest during the full duration. To be more accurate, the website was visited almost by 5,000 unique visitors in total. Social media was helpful for dissemination as well. By means of Twitter, our tweets generated more than 30,000 impressions. Thanks to dissemination - performed mostly by the commercial consortium members - the project’s results were diffused targeting either potential stakeholders or the general public.

The exploitation activities helped to improve partner’s competitiveness and paved the way for product innovation. The individual exploitation plans confirm the effectiveness of the research results produced within the project, and the possibility to produce value by taking advantage of the project’s activities. In total, 10 KPIs were pre-defined for exploitation activities, including 3 optional KPIs. 6 out of 7 mandatory KPIs were achieved completely, 1 partially (due to different product development intentions of partners) and 1 out of 3 optional KPIs was also achieved in its entirety.

With regards to standardization, the activities have been targeting international standard bodies focusing on topics and techniques related to security in railway, while aiming at a broader acceptance of the project’s results. As standardization represents the main tool for technology adoption on the market, Safe4RAIL addressed different standards in the domain of safety and security as well as technical-related standards, and in turn, addressed one of its six objectives defined at the beginning of the project.

List of Abbreviations

Table 5: List of Abbreviations

AFDX	Avionics Full Duplex Switched Ethernet
B2B	Business-To-Business
BMC	Business Model Canvas
CMS	Content Management Service
ECN	Ethernet Consist Network
ICT	Information- and Communication Technology
KPI	Key Performance Indicator
OEM	Original Equipment Manufacturer
RAMS	Reliability, Availability, Maintainability and Safety
TCMS	Train Control Monitoring System
TCN	Train Communication Network
TRDP	Train Real-Time Data Protocol
TSN	Time Sensitive Network
WP	Work Package

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- [3] Safe4RAIL D1.1 – Drive-by-Data State-of-the-Art Document
- [4] Safe4RAIL D1.7 - Safety Concept for Ethernet Networks with Recommendations for Regulatory and Standardization Activities
- [5] Safe4RAIL D1.9 - Final Drive-by-Data Concept Design
- [6] Safe4RAIL D2.1 - Report on State-of-the-art of 'functional distribution architecture' frameworks and solutions
- [7] Safe4RAIL D2.3 - Report on 'TCMS framework concept' design, security concepts, and assessment