D5.2 – Risk Assessment Plan

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Abstract:	The risk assessment plan shows how potential risks are assessed and mitigated in order to avoid any negative influence on the Safe4RAIL-2 project objectives. The interrelated risk assessment plan – risk identification, handling and monitoring – will be established.
Keywords:	Risk assessment, risk identification, risk monitoring, risk mitigation

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Executive Summary

The Safe4RAIL-2 risk assessment plan describes how the project contemplates to manage risks, intends to predict risks, estimates impact and defines mitigation measures. It outlines the management components, the approach and tools used. In order to be aware of the central project activities in relation to the project timeline, the critical path of Safe4RAIL-2 has been defined. Within the project, the iterative and interrelated steps of risk identification, risk analysis and monitoring as well as risk handling are accompanied by easy-to-use tools, clear responsibilities and efficient communication channels towards effective risk management. As the Safe4RAIL-2 consortium is aware of the swift changing environment it is contributing to, risks are regularly monitored, mitigation plans updated and actions taken, if necessary.

This document outlines the risk assessment procedure established within Safe4RAIL-2 based on scientific theoretical background. The detailed risk assessment on work package level was performed on a regular basis.

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Chapter 1 Introduction

"Avoiding rocks on the road to success" [1] - following this guiding principle, the Safe4RAIL-2 consortium has established an effective project risk management strategy to avoid tripping over rocks on the road to successfully reach the planned project outcomes or go even beyond.

Our research and innovation action project Safe4RAIL-2 (Safe architecture for Robust distributed Application Integration in roLling stock 2) is looking at ways of utilizing wireless (5G), interoperable, on-board communication as well as universal integration of the Train Control and Monitoring System (TCMS). Developing and dealing with such an ambitious and highly innovative project, only *"innovation, fused with an agile, sophisticated approach to risk management, can create a powerful, value-driving partnership".* [2]

According to the ISO 31000 standard on risk management, a **risk** can be defined as an "*effect of uncertainty*" towards parts of objectives. An effect is described as a positive or negative deviation from the expected work-plan. Every step towards the project objectives has an element of risk that needs to be managed. In the context of risk management, **uncertainty** exists whenever the knowledge or understanding of an event, consequence, or likelihood is inadequate or incomplete. **Risk management** describes a coordinated set of activities and methods, which supports the control of risks that may affect the project's ability to achieve part of its objectives. The project risk management process is meant to form part of the project management routine at all stages of the project lifecycle. [3]

In order to raise awareness for the central project activities and as a starting point for risk management, a critical path has been defined, which is described in Chapter 2. Failing to follow a structured project risk management process for projects in a self-disciplined manner would quickly lead to project failure [1]. Therefore, within Safe4RAIL-2 a clear structured process of risk identification, risk monitoring & analysis and risk handling has been established (see Chapter 3). This process already started with the risk identification during the proposal preparation phase, continued in all process steps within the first year of the project and will accompany Safe4RAIL-2 throughout the project's lifetime. In order to settle this process as a vital one, communication as well as easy risk assessment tools turned out to be critical factors. Chapter 4 displays the practical risk assessment of the project including an evaluation of probability and severity as well as mitigation plans for defined risks. Chapter 5 is concluding and summarizing the way Safe4RAIL-2 is dealing with risk management and how it will be continued.

Chapter 2 Critical Path of the Project

The critical path of Safe4RAIL-2 has been defined in order to be aware of the central project activities. The critical path determines the targeted time to complete the project and the critical activities, which might be able to threaten the project objectives. The items of the critical path are mostly reflected by project milestones, presenting central and critical achievements during the project lifetime.

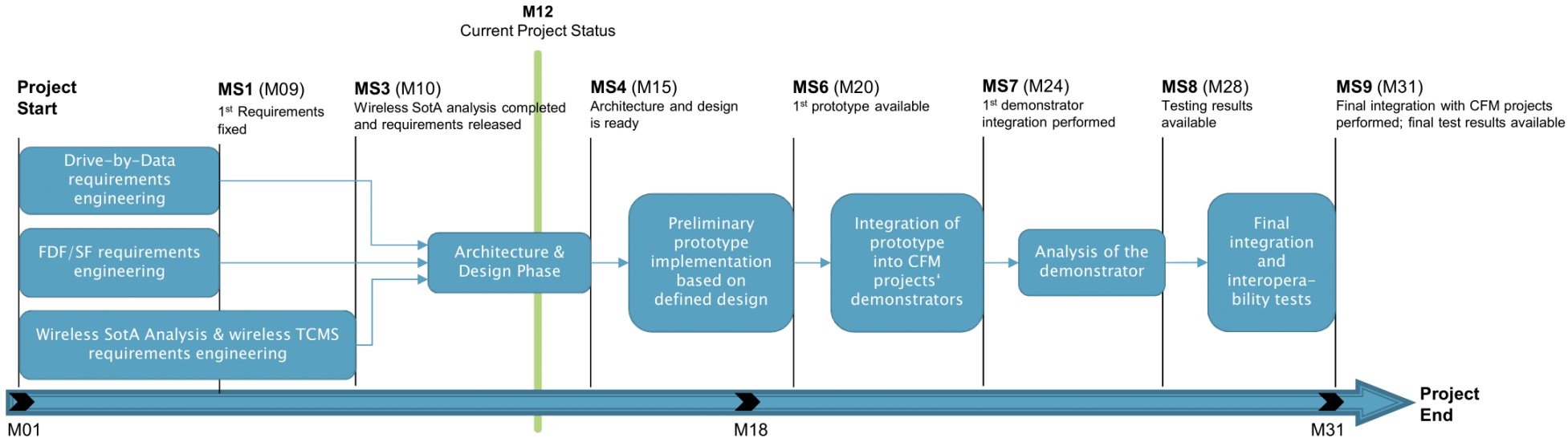

Figure 1: Critical Path

Chapter 3 Risk Management Procedure

This chapter is focussing on the risk management procedure that systematically applies management policies, processes and practices on project activities.

Within Safe4RAIL-2 we basically established a risk management framework including three major strides, which are correlating and interacting continually:

- Risk identification (Section 3.1)
- Risk analysis & monitoring (Section 3.2)
- Risk handling (Section 3.3)

The risk management process needed to be aligned with the project objectives and might be adjusted if required due to changes in the research objectives. The risk management procedure has been established around the routine project work and is accompanying the project through its lifetime. Figure 2 indicates that project stakeholders (JU/EC, related projects, suppliers etc.) and the project environment (regulations, duties, etc.) form the outermost layer, are influencing causes of risks, which may impact the project collaboration with the project objectives in the centre of attention.

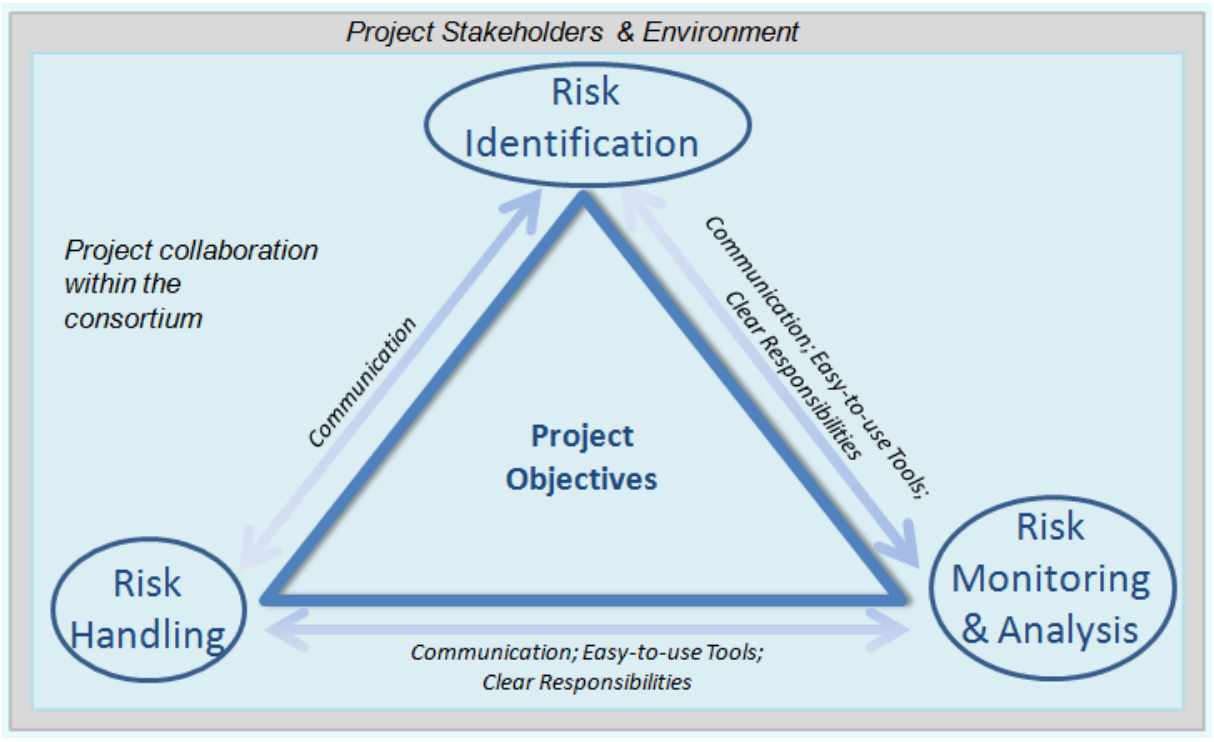

Figure 2: Risk Management Procedure

Taking into consideration all factors external to the project, channels to allow the efficient implementation of the three major steps in the shown risk management procedure, needed to be established. On the one hand, a clear structure for communicating risks including clear responsibilities are required and need to be assured with all partners. On the other hand, it has to be easy for the partners to perform risk management by themselves through easy-to-use tools.

How the above-mentioned tools and steps have been integrated into the project and how they will support to mitigate negative consequences for the project will be described within the following subchapters.

3.1 Risk identification

"Risk identification is a process that is used to recognize, find, and describe the risks that could affect the achievement of objectives."[3]

The target of risk identification is being aware of possible risk sources in addition to the events and circumstances that could affect the achievement of objectives. Further, it includes the identification of possible causes and consequences.

The identification of risks started already during the proposal phase. When developing the idea for an innovative technological advancement, it needs to be formed in a way that creates the most value at an acceptable level of risk. For the identification of risks in such a highly innovative field it is necessary to have experts, who understand on the one hand the technical challenge and its impact and have on the other hand deep insights of the industrial and market needs. The Safe4RAIL-2 consortium unifies all these know-hows in its consortium and is therefore, capable of identifying the risks for the innovative action pursued within Safe4RAIL-2.

Risk identification has not terminated after the proposal preparation phase, but it is rather a continuous process of attaching awareness for potential risks. To address this awareness best, the consortium defined the WP leaders as risk managers for their WPs. The WP leader is an expert in the field, his or her WP is concentrating on and therefore, the most capable person to identify risks. On project level, the technical lead and coordinator (IKL) along with the administrative support (TEC), pay close attention to the identification of potential risks. This is done by means of Interim Management Reports, regular progress telcos and face-2-face meetings. This structure and distribution of responsibilities allows the continuous identification of new risks and encourages the discussion of potential risks within telcos, face-to-face meetings and the WPs themselves.

The risk table shown in Table 1 allows all partners to add new risks at any time. Additionally, the coordinator and administrative support ask partners to pay special consideration on risks on a regular basis within the Interim Management Reports (IMR), which are filled in by the project partners on a half-year basis.

3.2 Risk Analysis & Monitoring

"Risk analysis is a process that is used to understand the nature, sources, and causes of the risks that have been identified and to estimate the level of risk. It is also used to study impacts and consequences and to examine the controls that currently exist. To monitor means to supervise and to continually check and critically observe - it means to determine the current status." [3]

The process of risk analysis and monitoring is iterative, which means that the risks are evaluated, mitigation measures are re-considered and updated, if necessary, as well as the progress, are monitored on a regular basis. Interim Management Reports (described in Section 3.2.2) serve as main tool for regular analysis and monitoring.

Before setting up the structure and requesting inputs from the project partners, we faced the challenge of making our risks measurable and tangible. While a merely quantitative approach is not applicable due to the high degree of innovation, a pure qualitative approach would be hard to evaluate. Therefore, a mixture of quantitative and qualitative elements has been chosen and is described in the following Section 3.2.1.

3.2.1 Quantitative and qualitative approaches to risk analysis

"Qualitative Risk Analysis assesses the priority of identified risks using their probability of occurrence, the corresponding impact as well as other factors such as the time frame and risk

tolerance. When using quantitative analysis, the risk level can be estimated by using statistical analysis and calculations combining severity and probability." [3]

While qualitative risk analysis is performed for all project risks, quantitative risk analysis has a more limited use within the Safe4RAIL-2 project, based on the type of project risks, and the limited availability of data to conduct a quantitative analysis.

The WP leaders are asked to indicate probability and severity of the stated risks, which have been identified in the previous step.

Probability describes the relative likelihood that a risk will eventuate. It can be defined, determined, measured objectively or subjectively and can be expressed either qualitatively or quantitatively.[3] The probability may be dependent on various factors like the project environment, consortium characteristics, external effects, technological breakthroughs etc. For the evaluation of the Safe4RAIL-2 project risks the following classifications were defined:

- **Low -** Below *<30%>* probability of occurrence
- **Medium -** Between *<30%>* and *<70%>* probability of occurrence
- **High -** More than *<70%>* probability of occurrence

Severity defines the effects and consequences a project may face in case of risk occurrence. The severity may be influenced by various risk triggers arising from the project environment, consortium characteristics, external effects, technological breakthroughs etc. and may affect the technological and financial performance as well as the schedule of the project. [3]

- **Marginal -** Risk has relatively little impact on the project's technological and financial performance as well as the schedule
- **Critical -** Risk has the potential to impact the project's technological and financial performance as well as the schedule
- **Catastrophic -** Risk has the potential to greatly impact the project's technological and financial performance as well as the schedule

Classifying risks with the indicated scale, allows the appraisal of any action that might be needed. The qualitative analysis further includes the assessment if the risk is (still) relevant (yes/no), if the risk did materialise as well an as update of the risk. This is needed as basis for the decision if any measures need to be taken in a further step. The description of the current risk status also supports the deeper understanding and specification of the risk. At this point quantitative elements step into. The detailed assessment of the risk may include explanations of further effort requests, additional expenses, etc. needed to deal with the risk consequences, which makes it quantitatively measurable.

The practical implementation of the qualitative and quantitative analysis within the Safe4RAIL-2 project can be found in Chapter 4.

3.2.2 Interim Management Reports

Interim Management Reports (IMR) serve as continuous internal quality control and risk monitoring and assessment tool. IMRs have been established by the administrative support TEC, in order to ensure that the work progress and the efforts spent are reasonable and in line with the expectations. It also supports the early recognition of deviations and potential risks for the project. In order to use the IMRs also as preparation for the Periodic Reports, the partners update dissemination and exploitation activities as well, which also implies the continuous update of the

project website and social media accounts. The structure of the IMR includes reports on the following key points:

- Explanation of the work carried out by the beneficiaries and overview of the progress including use of resources and deviations;
- Dissemination, Exploitation, Standardization and Cooperation activities;
- Risk Assessment;

The structure proved to be effective in various projects and turned out as an easy management tool accepted by all project partners. The IMR requests partner inputs after each quarter. It is collected and compiled by TEC. The cumulative outcome gives an overview to all partners about ongoing project issues and makes them aware of potential upcoming challenges.

Further, the IMR allows a check if the partners' work is performed as planned in the DoA. This also minimizes the risk of underperforming partners, deviations in terms of efforts and allows early detection of potential delays. Furthermore, regular progress telephone conferences give an update on the WP status and the partners' work, which allows the assessment and identification of further risks and timely corrective actions if needed.

The effort reported (PMs/partner/WP) in the IMR is collected in a cumulative table over the quarters, which generates diagrams for a swift and easy understanding of over- and under spending of resources per partner as well as on WP level. In this way the critical key indicators in terms of efforts are presented at one glance and possible actions can be taken in due course.

Risk assessment includes the evaluation of the already stated risks according to the current status of the project by the WP leaders as well as the additions of unforeseen or potentially upcoming risks. Those inputs were included into the overall risk map and due to the evaluation, it will then be decided if it is necessary to request measures (risk handling – Section 3.3) or to iteratively continue with the analysis and monitoring process.

3.3 Risk Handling

The process of risk handling starts, once a risk is assessed as likely to occur (medium/high) and has an impact/severity (critical/catastrophic) on the project. At this point a WP leader correlates with the technical leader and the coordinator to define

- if counter-steering measures need to be taken, and
- which project level (project bodies) will be appropriate to deal with the risk.

Basically, the WP leader correlates with the technical leader and the coordinator regarding the risk which occurred or is expected to occur. If it has no major impact on the project and appropriate actions can be taken by the WP leader, the risk will be handled at this level. In case a risk is expected to create major impact on the project, the Executive Board (EB) or the General Assembly (GA) will be involved. In case of substantial risks or major delays, the coordinator also informs the Project Officer and provides a brief assessment of the situation.

Therefore, the structure of the project bodies and the clear definition of responsibilities for each project body, defined during the proposal phase, have been proven and allow clear and swift communication of risks. Below an overview of the defined project bodies and their field of responsibility can be found.

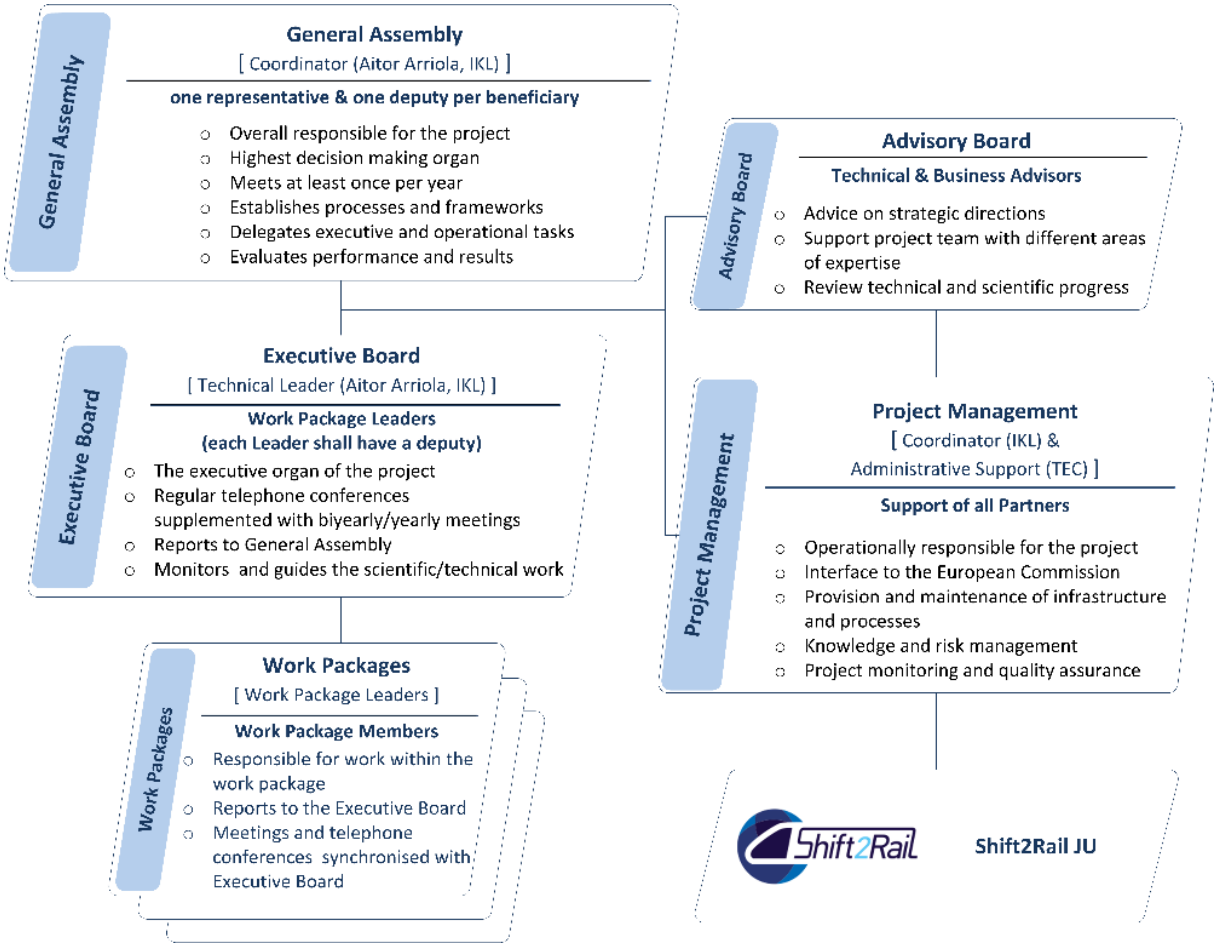

Figure 3: Project Bodies in Safe4RAIL-2

The governing culture of Safe4RAIL-2 is based on democracy, co-determination and clear leadership. Each body operates on separate levels and has its own area of responsibility and decision-making power. Based on the expected impact of a risk, the coordinator will assemble the EB or GA in a telephone conference to discuss counter-steering measures. For risks that affect the overall strategy, and may threaten part of the project outcomes, the GA, as the highest decision-making body will deal with this risk. Risks causing minor delays or minor changes in the work plan will be handled by the EB.

The GA and EB members are experts in their fields and therefore, capable of estimating the effects of the risks as well as of countermeasures. The responsible body discusses if the already proposed mitigation plan is still suitable or if other actions need to be taken or are more suitable to the risk occurred. The decision regarding the countermeasures will be taken according to the voting rules defined in the Consortium Agreement (based on MCARD model). Basically, the WP leader will be in charge of appropriate realization of the defined risk mitigation measures. All applied measures, arising challenges or chances will be documented in the risk table.

Beside the decision-making bodies in the Safe4RAIL-2 structure, an Advisory Board supports the consortium with an external, unprejudiced view. This can also be seen as a risk minimizer as it makes sure that the project outcomes will meet the market expectations and do not fail to meet substantial market-specific needs.

Chapter 4 Managing Safe4RAIL-2 Risks

This chapter illustrates the implementation of the previously described risk tools into the Safe4RAIL-2 project structure. It presents the defined risks, shows the development of the risks based on probability & severity/impact estimations at several evaluations and tries to assess the current status of the risk. As the WP leaders are the main responsible persons for the risks of their WPs, this section is built up on WP level.

As described in detail in Section 3.2, a probability/severity analysis is used to qualitatively evaluate the risk status. The scale for probability has been defined as low, medium or high. The scale for severity/impact has been defined as marginal, critical and catastrophic. The scale for probability and severity/impact is described in the table below.

	Low	**Medium**	**High**
Probability	Less than *<30%>* probability of occurrence	Between *<30%>* and *<70%>* probability of occurrence	More than *<70%>* probability of occurrence
	Marginal	**Critical**	**Catastrophic**
Severity/Impact	Risk has relatively little impact the projects technological and financial performance as well as the schedule	Risk has the potential to impact the projects technological and financial performance as well as the schedule	Risk has the potential to greatly impact the projects technological and financial performance as well as the schedule

Table 1: Probability/severity matrix

Risks with a high level of probability and/or severity are monitored very closely. They are subject to review within monthly progress telcos. Furthermore, the project management team is in contact with the WP leader in order to monitor the development of such risks.

The detailed risk assessment on WP level was performed four times during the first project year (on quarterly basis). So far four risks in WP5 identified prior to the project start materialised and three new risks in WP3 have been identified during the first project year. The detailed risk assessment per work package is depicted in the following subsection (Section 4.1 - 4.5).

We will proceed with the risk assessment on WP level on a quarterly basis throughout the project lifetime. In order to support the WP leaders to perform the risk assessment and to help them fill in the complex risk assessment template, TEC illustrated the risk assessment process shown in Figure 4. According to the given answers the WP leads have to fill in different questions.

For example:

- If the risk materialised the WP leads have to fill in also the questions: **h)** Explain the reason why it materialised? & **i)** What are the consequences? & **j)** What are the corrective actions & updated mitigation measures?
- If the risk did not materialise the WP leads do not have to fill in these further questions.

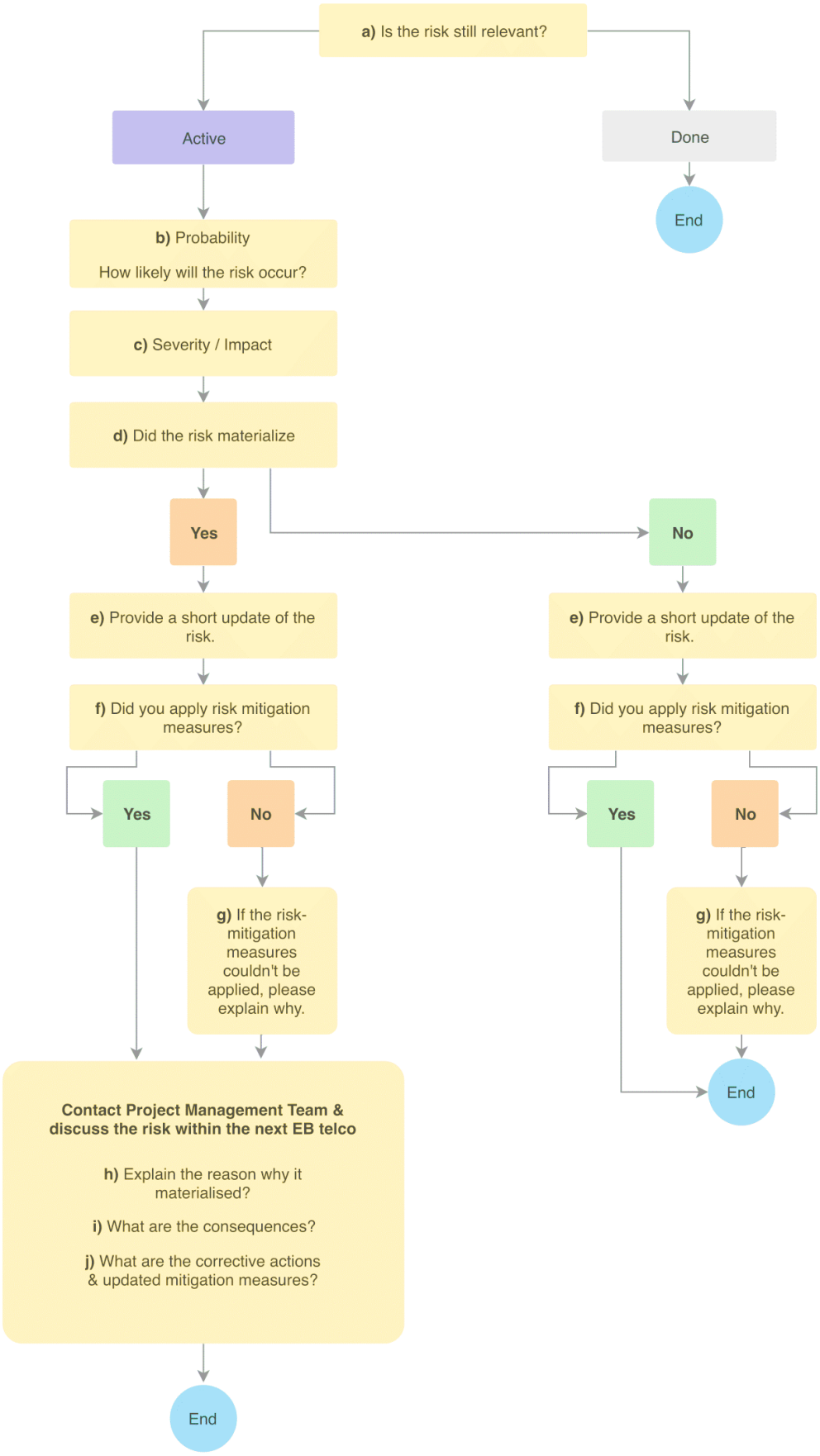

Figure 4: Safe4RAIL-2 Risk Assessment Process

In the following sub-chapters, the risk assessment of each WP will be described shortly. As mentioned before, due to the fact that this deliverable is a public report, a detailed risk assessment report will be available in the first periodic report of the Safe4RAIL-2 project (after M18).

4.1 WP1 TSN-based Drive-by-Data

Duration: M01-M31; WP Lead: TTT

In WP1 there are six pre-defined risks listed. Except from the risk *#4* and *#6*, there have been no adaptations of probability or severity level and no additional risk has been identified. Almost all risks have critical severity, except *#2*, which is categorized with highest level of severity. In total, three out of six risks have a medium/high probability while the highest severity level, which makes them so-called critical risks.

Table 2: Risk Evaluation Form WP1

Risk Evaluation Form WP1				Current assessment of risk						
Risk Nr.	Responsible Partne	Description of risk	Proposed risk-mitigation measures	Date of last evaluation	a) Is the risk relevant?	b) Probability How likely will the risk occur?	c) Severity/Impact	d) Did the risk materialise? (Yes/No)	e) Please provide a short update of the risk: (e.g.: What has happened? Why is it (not) relevant at the moment? etc.)	f) Did you apply risk mitigation measures? (Yes/No)
#1	TTT	Clock synchronisation not precise enough or not robustness enough	Technical measures include the selection of robust clock sources (e.g. best of class GNSS devices). Furthermore, the implementation of graceful degradation mechanisms that support the robust switchover from a synchronous to an asynchronous system state are part of the system design For the wireless part, the size of the synchronized cluster will be reduced to match the required synchronization precision and	Q1	YES	Low	Critical	NO	The requirements and technical concepts explicitly take robustness of the clock synchronisation into account.	YES
				Q2	Yes	Low	Critical	NO	No update	YES
				Q3	YES	Low	Critical	NO	The design concepts of the clock synchronization has be analyzed as well the integration the concepts into the standard ieee802.1as-rev.	YES
				Q4	YES	Low	Critical	NO	The intermediate clock synchronization has been implemented, and ongoing work to developed the final concepts as well as testes in the comings months.	YES

Risk Evaluation Form WP1				Current assessment of risk						
Risk Nr.	Responsible Partne	Description of risk	Proposed risk-mitigation measures	Date of last evaluation	a) Is the risk relevant?	b) Probability How likely will the risk occur?	c) Severity/Impact	d) Did the risk materialise? (Yes/No)	e) Please provide a short update of the risk: (e.g.: What has happened? Why is it (not) relevant at the moment? etc.)	f) Did you apply risk mitigation measures? (Yes/No)
#2	TTT	Network end-to-end latency too high	Selection of technical measures and configuration parameters to reduce the constraints on specific heavily loaded devices. The use of additional mechanisms such as cut-through mechanisms for faster frame-forwarding must be analyzed.	Q1	YES	Low	Catastrophic	NO	Risk was taken into accoutnt in the requirements phase. It must be further evaluated at design/implementation time.	YES
				Q2	Yes	Low	Catastrophic	NO	Design phase ongoing, no re-evaluation of risk possible yet.	YES
				Q3	YES	Low	Catastrophic	NO	Preparation of several joint workshops and specific teleconferences for clarification and planning	YES
				Q4	YES	Low	Catastrophic	NO	No update	YES
#3	TTT	Interoperability between ETBN not working correctly	Specification of interoperability targets early on in the project. Close cooperation between the two ETBN providers in the project to minimize the interoperability risk.	Q1	YES	Medium	Critical	NO	Close cooperation between partners, with technical interaction on a near-daily basis. Clear requirements specification reduces the risk but must continue to be assessed for relevance.	YES
				Q2	Yes	Medium	Critical	NO	Requirements are closed. Integration workshops between ETBN providers are planned at M11, M13 and M15 (for first release).	YES
				Q3		Medium	Critical	NO	The concept design for the inauguration has been discusses with CTA-2 in several meeting.	YES
				Q4		Medium	Critical	NO	The first inauguration test plan takes place with the successfully result. Next Integration workshops between ETBN providers is plan in M15 (for first release).	YES

Risk Evaluation Form WP1				Current assessment of risk						
Risk Nr.	Responsible Partne	Description of risk	Proposed risk-mitigation measures	Date of last evaluation	a) Is the risk relevant?	b) Probability How likely will the risk occur?	c) Severity/Impact	d) Did the risk materialise? (Yes/No)	e) Please provide a short update of the risk: (e.g.: What has happened? Why is it (not) relevant at the moment? etc.)	f) Did you apply risk mitigation measures? (Yes/No)
#4	TTT	FDF specification too late or incomplete, FDF integration not functioning properly	Strong basis for the specification exists from the existing documentation in Safe4RAIL and CONNECTA. Prioritize the implementation by stability of the specification and importance of the functionality.	Q1	YES	Medium	Catastrophic	NO	Interaction between FDF and DBD is a critical element. Responsibilities at the moment not 100% clear between WPs 1 and 3 as well as CTA2. A F2F workshop is planned in March to mitigate this risk.	YES
				Q2	YES	Low	Critical	NO	Based on the requirements definition, a more clear separation fo concerns could be achieved which reduces the risk probability and impact.	YES
				Q3	YES	Low	Critical	NO	Preparation of specific teleconferences for clarification and planning between the WP! ,WP3 and CTA-2.	YES
				Q4	YES	Low	Critical	NO	Integration workshops between WP1 and WP3 planned at M15.	YES
#5	TTT	Long chain of network components fails due to delivery of one of the network components	The multi-vendor strategy of Safe4RAIL-2 enables the replacement of faulty or late components with components from one of the other partners. Technical mechanisms based on 802.1Qci can be implemented to support deterministic behaviour to use of standard Ethernet components	Q1	YES	Medium	Critical	NO	All partners are fully committed to the project work, reducing the risk of late delivery. Other mitigation strategies remain the same.	YES
				Q2	YES	Medium	Critical	NO	No update	YES
				Q3	YES	Medium	Critical	NO	Preparation of joint integration workshop and specific teleconferences for clarification and planning	YES
				Q4	YES	Medium	Critical	NO	A released plan is specified for each partner and synchronized with each others	YES
#6	TTT	ECSP functionality not feasible or Safety layer SDTv4 specification too late or incomplete	Initial review of the requirements and specification of the design will reveal any open topics in the upgraded functionality. Close cooperation between the WP1 partners and the CFM project enables the rapid resolution of open items.	Q1	YES	Medium	Critical	NO	In requirements assessment, we managed to reduce to SDTv2 for large part of inauguration. Only the validation is a SIL4 function. SDTv4 is not directly a S4R risk anymore, but rather a CTA risk now.	YES
				Q2	YES	Medium	Critical	NO	No update	YES
				Q3	YES	Medium	Critical	NO	The SDTv2 and SDTv4 has been analyzed and discussed with CTA-2. Both standards are similarity and no difficulty for implemented anyone of the standard.	YES
				Q4	YES	High	Critical	NO	The source code for the SDTv4 still not received from CTA-2	YES

4.2 WP2 Future Wireless TCMS

Duration: M01-M31; WP Lead: EUR

In WP2, there are three pre-defined risks listed. Three major risks have been identified, one of which, risk #1 did materialize. Risk #1 was classified a medium in probability but in catastrophic in severity, as lacking synchronization for the LTE equipment would not make any communication possible. Risk mitigation has been applied and different hardware have been purchased, which provided the right quality of synchronization signals. This risk later no longer materialized. The next two risks, Risk #7 and #8 have been initially classified as medium in probability and critical in severity. Risk mitigations have been applied to both during the LTE equipment design, which so far led to no risk materialization. During the continuous risk evaluation, Risk #8 saw its probability increased to 'high' due to a new potential risk identified during the requirement identification. Risk mitigation has been applied and the risk has been reduced to 'medium' since.

Table 3: Risk Evaluation Form WP2

Risk Evaluation Form WP2				Current assessment of risk							ONLY if the risk materialised		
Risk Nr.	Responsible Partner	Description of risk	Proposed risk-mitigation measures	Date of last evaluation	a) Is the risk relevant?	b) Probability How likely will the risk occur?	c) Severity/Impact	d) Did the risk materialise? (Yes/No)	e) Please provide a short update of the risk: (e.g.: What has happened? , Why is it (not) relevant at the moment?, etc.)	f) Did you apply risk mitigation measures? (Yes/No)	h) Explain the reason why it materalised	i) What are the consequences? Delay of Dxy, delay of task xy, shift of resources, impact on other WPs, etc.	j) What are the corrective actions & updated mitigation measures?
#1	EUR	Clock synchronisation not precise enough or not robustness enough.	Technical measures include the selection of robust clock sources (e.g. best of class GNSS devices). Furthermore, the implementation of graceful degradation mechanisms that support the robust switchover from a synchronous to an asynchronous system state are part of the system design For the wireless part, the size of the synchronized cluster will be reduced to match the required synchronization precision and robustness.	Q1	YES	Medium	Catastrophic	YES	initial hardware did not match the required synchronization. Purchased different hardware (octoclock instead of GPS devices). Clock sync is OK	YES	External GPSD (cheaper) do not provide an exact discipline to 10Mhz by hardware, but is tweaked by signal processing. This creates a minor oscilliation around the 10Mhz synch, which is not tolerated by the ETTUS USRP boards.	It delayed the test by about 2 months; only minor cost impact; no impact on WPs, as the prototype is due only in M20.	We purchased different hardware directly from ETTUS to guarantee the compatibility.
				Q2	NO								
				Q3	NO								
				Q4	NO								

Risk Evaluation Form WP2				Current assessment of risk						
Risk Nr.	Responsible Partner	Description of risk	Proposed risk-mitigation measures	Date of last evaluation	a) Is the risk relevant?	b) Probability How likely will the risk occur?	c) Severity/Impact	d) Did the risk materialise? (Yes/No)	e) Please provide a short update of the risk: (e.g.: What has happened? , Why is it (not) relevant at the moment?, etc.)	f) Did you apply risk mitigation measures? (Yes/No)
#7	EUR	LTE equipment not ready in time for integration in demonstrators or not interoperable	The LTE equipment consists of software and commercial hardware boards. The LTE equipment will be developed in iterations, with a first version with reduced functionalities available shortly after the project kick-off. The LTE equipment only needs software upgrade once installed. An early assessment of 3GPP LTE functions required for interoperability will be conducted. If 3GPP functions required for interoperability are missing, they will be added to OAI. In case it is not possible, we will reduce the set of interoperable functionalities.	Q1	YES	Medium	Critical	NO	An early prototype will reduced capabilities will be tested at an early stage	YES
				Q2	YES	Low	Critical	NO	All hardware equipment have been identified, corresponding to the set of requirements for the prototype.	YES
				Q3	YES	Low	Critical	NO	First prototype for D2D communications is operational	YES
				Q4	YES	Medium	Critical	NO	An overlay module needs to be added to support the extra functions (mesh group discovery, group communications). To avoid delay, OAI will rely on D2D mode 1/2, which supports most of it). Remaining to develop: Mesh support	YES
#8	EUR	LTE equipment do not meet specifications	An early assessment of the hardware/software specifications, as well as review of the capabilities of various hardware boards at a very early stage of the project. If the assessment missed anything, we will shift effort to develop simple prototypes with reduced specifications but providing necessary functionality.	Q1	YES	Medium	Critical	NO	From CTA-2 requirements, and OAI flexible configuration, the appropriate LTE-V2/D2D mode1/2 or 3/4 will be selected regarless o the state of standard. Would such aspect occur, S4R2 would bring this to 3GPP to evolve the standard	YES
				Q2	YES	High	Critical	NO	From CTA-2 requirements, L2 multihop routing has been identified. L2 multi-hop routing in 3GPP does not exist in the current specification. The complexity will be assessed, but as an alternative, L3 multi-hop routing will be proposed, including tunneling of L2 packets for transparent L2 networking.	YES
				Q3	YES	Low	Critical	NO	First functional tests of D2D communications have been carried out	YES
				Q4	YES	Medium	Critical	NO	LTE-V2X does not support service discovery and group communication; To support it for demonstrator, OAI will rely on mode 1/2 and develop the V2X mode 3/4 in separate streams;	YES

4.3 WP3 Functional Distribution Framework and Simulation Framework

Duration: M01-M31; WP Lead: IKL

In WP3 there have been two pre-defined risks, which have been extended to five during the continuous risk assessment. There have been adaptations of probability and severity level in three risks (*#9*, *#10* and *A2*). All risks have at least critical severity. In total, two out of five risks have a medium/high probability while medium/high severity, hence there are marked as critical risks.

Table 4: Risk Evaluation Form WP3

Risk Evaluation Form WP3				Current assessment of risk						
Risk Nr.	Responsible Partne	Description of risk	Proposed risk-mitigation measures	Date of last evaluation	a) Is the risk relevant?	b) Probability How likely will the risk occur?	c) Severity/Impact	d) Did the risk materialise? (Yes/No)	e) Please provide a short update of the risk: (e.g.: What has happened? Why is it (not) relevant at the moment? etc.)	f) Did you apply risk mitigation measures? (Yes/No)
#9	IKL	Delay to achieve the integration of the HVAC function in the FDF	Close contact with CONNECTA-2 and stablishement of roadmaps to ease dependency: TRDP, OPC-UA, SDTv4 integration...	Q1	YES	Low	Critical	NO	CONNECTA-2 Task 1.2 on the extension of FDF and SF specifications will end on M15, which was unexpected when the proposal was written.	YES
				Q2	YES	Medium	Critical	NO	Preparation of several joint workshops (FDF integration, FDF API, TRDP integration workshop etc.) and specific teleconferences for clarification and planning.	YES
				Q3	YES	High	Critical	NO	The definition of the FDF API has been delayed considerably. The workshops have show to be fruitful and have allowed to make progress on the API definition which now appears to be close to finalization. Further workshops have already been planned on the short term for Regional Demo and will be planned for the Urban Demo.	YES
				Q4	YES	High	Critical	NO	First Regional Demo Integration Workshop has been held. Two more Regional Demo Integration Workshops are planned before end of year. Urban Demo workshop to be planned. Meeting between Ikerlan and CAF regarding Integrity FDF has ben held. Ongoing development work in CAF on Integrity FDF API Wrapper.	YES

Risk Evaluation Form WP3				Current assessment of risk						
Risk Nr.	Responsible Partne	Description of risk	Proposed risk-mitigation measures	Date of last evaluation	a) Is the risk relevant?	b) Probability How likely will the risk occur?	c) Severity/Impact	d) Did the risk materialise? (Yes/No)	e) Please provide a short update of the risk: (e.g.: What has happened? Why is it (not) relevant at the moment? etc.)	f) Did you apply risk mitigation measures? (Yes/No)
#10	IKL	Delayed integration of the HVAC function in the Simulation Framework	Close contact with CONNECTA-2 and stablishement of roadmaps to ease dependency. LIEB will provide a HVAC sample model for the regional demonstrator.	Q1	YES	Low	Critical	NO	CONNECTA-2 Task 1.2 on the extension of FDF and SF specifications will end on M15, which was unexpected when the proposal was written.	YES
				Q2	YES	Low	Critical	NO	Preparation of joint integration workshop and specific teleconferences for clarification and planning	YES
				Q3	YES	Medium	Critical	NO	For the Urban Demo the solution is mature since extensive documentation has been provided by the partners. For the Regional Demo the success will mostly depend on the adoption of a common solution for BT and SIE SFs.	YES
				Q4	YES	High	Critical	NO	Open Issue regarding use of Linux or Windows for Simulation Models. Meeting has been held but the issue still is not resolved. If no agreement can be achieved the backup solution is that Bombardier prepares its own simplified Simulation Model for Linux.	YES
A1	IKL	Delay to have the implementations of FDF and SF ready for integration.	The design of roadmaps to set some priorities during the preparation/development of given components of the FDF/SFs has been agreed, with the aim to diminish the dependency and avoid blocking.	Q1	YES	Low	Catastrophic	NO	The roadmap will be crated jointly with CONNECTA-2 after Task 3.1 is closed.	YES
				Q2	YES	Low	Catastrophic	NO	A concrete set of open items has been defined to improve the collaboration between CONNECTA-2 and Safe4RAIL-2. WP3 is holding weekly telcos for a constant and deep monitoring.	YES
				Q3	YES	Low	Catastrophic	NO	A concrete set of open items has been defined to improve the collaboration between CONNECTA-2 and Safe4RAIL-2. WP3 is holding weekly telcos for a constant and deep monitoring.	YES
				Q4	YES	Low	Catastrophic	NO	First Regional Demo Integration Workshop has been held. Two more Regional Demo Integration Workshops are planned before end of year. Urban Demo workshop to be planned. Meeting between Ikerlan and CAF regarding Integrity FDF has ben held. Ongoing development work in CAF on Integrity FDF API Wrapper.	YES

Risk Evaluation Form WP3				Current assessment of risk						
Risk Nr.	Responsible Partne	Description of risk	Proposed risk-mitigation measures	Date of last evaluation	a) Is the risk relevant?	b) Probability How likely will the risk occur?	c) Severity/Impact	d) Did the risk materialise? (Yes/No)	e) Please provide a short update of the risk: (e.g.: What has happened? Why is it (not) relevant at the moment? etc.)	f) Did you apply risk mitigation measures? (Yes/No)
A2	IKL	Unability of implementing two different solutions for SF SIL on Regional demo	A deadline for the decission on the protocols was requested by Safe4RAIL-2 WP3. This deadline is end of M05.	Q2	YES	Medium	Critical	NO	BT and SIE will try to reach an agreement to work on a common solution, then will contact LIEB.	YES
				Q3	YES	Low	Critical	NO	BT and SIE has reached an agreement on a common solution based on FMI standart. LIEB is checking viability of the solution and regular meetings are beeing held.	YES
				Q4	YES	Low	Critical	NO	BT and SIE has reached an agreement on a common solution based on FMI standart. LIEB is checking viability of the solution and regular meetings are beeing held.	YES
A3	IKL	Delay in the availability of the TSN Hardware (Moxa Switches and TTT PCIe card) for the correct	Close contact with Safe4RAIL-2 WP1 through teleconferences and monitoring of the state by means of the OIL.	Q3	YES	Low	Critical	NO	WP1 plans with an internal release by M15, after which interoperability testing needs to be performed between the devices from the different manufacturers.	YES
				Q4	YES	Low	Critical	NO	TTTech will provide prototypes of the PCIe Network Cards.	YES

4.4 WP4 Dissemination, Communication, Exploitation and Standardisation

Duration: M01-M31; WP Lead: TEC

In WP4 there are five pre-defined risks. Only in risk *#11*, there have been adaptations of probability level. In WP4, no additional risk has been identified. All three actually relevant risks have critical severity. In total, only one out of five risks has a medium probability and critical severity, hence the so-called critical risk is risk *#11*. Besides that, risk #14 and #15 were not assessed within the first year of Safe4RAIL-2, since they were not relevant so far.

Table 5: Risk Evaluation Form WP4

Risk Evaluation Form WP4				Current assessment of risk						
Risk Nr.	Responsible Partne	Description of risk	Proposed risk-mitigation measures	Date of last evaluation	a) Is the risk relevant?	b) Probability How likely will the risk occur?	c) Severity/Impact	d) Did the risk materialise? (Yes/No)	e) Please provide a short update of the risk: (e.g.: What has happened? Why is it (not) relevant at the moment? etc.)	f) Did you apply risk mitigation measures? (Yes/No)
#11	TEC	Low number of dissemination activities	Advise partners to create scientific and operational community. Use additional channels for dissemination, participate in dissemination activities including all consortium members	Q1	YES	Low	Critical	NO	advised partners on dissemination activities, created list for an overview on dissemination/cimmunication activities as well as for scientific publication and their research data	YES
				Q2	YES	Low	Critical	NO	TEC and IKL is reminding the partners during each PWT to take care of the dissemination activities	YES
				Q3	YES	Medium	Critical	NO	TEC and IKL took care of reminding partners to provide dissemination plans per beneficiary in order to inform JU as well. Regular updates on the dissemination acitvities list will be forced	YES
				Q4	YES	Medium	Critical	NO	Industry partners are aware of their responsibility to disseminate the project on industrial events. All partner are kept reminded on providing news on dissemination (past and future).	YES

Risk Evaluation Form WP4				Current assessment of risk						
Risk Nr.	Responsible Partne	Description of risk	Proposed risk-mitigation measures	Date of last evaluation	a) Is the risk relevant?	b) Probability How likely will the risk occur?	c) Severity/Impact	d) Did the risk materialise? (Yes/No)	e) Please provide a short update of the risk: (e.g.: What has happened? Why is it (not) relevant at the moment? etc.)	f) Did you apply risk mitigation measures? (Yes/No)
#12	TEC	IPR conflicts between partners or between groups of partners	Early detection of the issue through close and good contacts, frequent meetings and a clear and unambiguous legal framework (e.g. CA). The coordinator, being a fully independent entity, has acted successfully as IPR mediator between Industry, Research, and Universities before.	Q1	YES	Low	Critical	NO	Kick-Off Meeting took place for first F2F discussions, further physical meetings being planned. Regular telephone conferences taking place as well. Furthermore, legal framework, respectively the Consortium Agreement was established and signed.	YES
				Q2	YES	Low	Critical	NO	CA, GA and COLA established	YES
				Q3	YES	Low	Critical	NO	No conflicts or an early stage of conflicts occurred	YES
				Q4	YES	Low	Critical	NO	No conflicts or an early stage of conflicts occurred	YES
#13	TEC	Dissemination / Communication / Exploitation is out of plan	The Task Leader monitors the dissemination/ exploitation activities and will react immediately. The dissemination and exploitation plans are clearly structured and provide a flexible tool to monitor the activities. The WP meetings will find workarounds.	Q1	YES	Low	Critical	NO	According to DoA (part B) section 2.2 measures to maximise impact, we are taking care of phase I "Awareness creation" dissemination activitites	YES
				Q2	YES	Low	Critical	NO		YES
				Q3	YES	Low	Critical	NO	At the moment, we are in-line with our pre-defined dissemination plan and will follow the plan further	YES
				Q4	YES	Low	Critical	NO	The number of dissemination is lower than expected (as stated in risk #11). Partners are aware of disseminate the projects on appropriate events. Furhtermore, we are in the preparation phase on the mid-term conference to present mid-term results to stakeholders and interested public. Exploitation plan is in-line with our pre-defined plan.	YES
#14	TEC	Insufficient adoption of the project results by any of the relevant	Marketing campaigns targeted to each stakeholder group and incentives for early adopters will help achieve critical mass.	Q1	NO				Risk is not relevant/applicable yet. This risk will be assessed in a later stage again.	
				Q2	NO					
				Q3	NO					
				Q4	NO					
#15	TEC	Weak acceptance of project results by relevant agencies and organisations	Safe4RAIL-2 will involve these organisations actively during the design and implementation of the Safe4RAIL-2 tools and methodology.	Q1	NO				Risk is not relevant/applicable yet. This risk will be assessed in a later stage again.	
				Q2	NO					
				Q3	NO					
				Q4	NO					

4.5 WP5 Project, Risk and Innovation Management

Duration: M01-M31; WP Lead: IKL

In WP5 there are four pre-defined risks. One risk (risk *#18*) materialised so far and was successfully mitigated. There have been no adaptations of probability or severity level and no additional risk has been identified. All risks have critical severity. In total, all four risks have a medium probability and critical severity, which makes them counting to the critical risks as well.

Table 6: Risk Evaluation Form WP5

Risk Evaluation Form WP5				Current assessment of risk						
Risk Nr.	Responsible Partner	Description of risk	Proposed risk-mitigation measures	Date of last evaluation	a) Is the risk relevant?	b) Probability How likely will the risk occur?	c) Severity/Impact	d) Did the risk materialise? (Yes/No)	e) Please provide a short update of the risk: (e.g.: What has happened? Why is it (not) relevant at the moment? etc.)	f) Did you apply risk mitigation measures? (Yes/No)
#16	IKL	Underperforming/ Overperforming partners	Close contact between WP leaders, technical leader and coordinator, short feedback loops and personal contacts (regular Executive Board telcos, physical meetings, etc.). Continuous internal quality/progress control (IMR).	Q1	YES	Medium	Critical	NO	Up to now regular telcos are being held between partners in all WPs.	YES
				Q2	YES	Medium	Critical	NO	Up to now all partners are performing as expected.	YES
				Q3	YES	Medium	Critical	NO	Up to now all partners are performing as expected.	YES
				Q4	YES	Medium	Critical	NO	Up to now all partners are performing as expected.	YES

Risk Evaluation Form WP5				Current assessment of risk						
Risk Nr.	Responsible Partner	Description of risk	Proposed risk-mitigation measures	Date of last evaluation	a) Is the risk relevant?	b) Probability How likely will the risk occur?	c) Severity/Impact	d) Did the risk materialise? (Yes/No)	e) Please provide a short update of the risk: (e.g.: What has happened? Why is it (not) relevant at the moment? etc.)	f) Did you apply risk mitigation measures? (Yes/No)
#17	IKL	Conflicts between partners (technically and administrative)	Conflict management through close and good contacts, frequent meeting (regular Executive Board telcos/meetings, General Assembly meeting, etc.)	Q1	YES	Medium	Critical	NO	At the moment partners are working at specification level, no technical or administrative conflicts have arisen so far.	YES
				Q2	YES	Medium	Critical	NO	At the moment partners are working at specification level, no technical or administrative conflicts have arisen so far.	YES
				Q3	YES	Medium	Critical	NO	At the moment partners are working at specification level, no technical or administrative conflicts have arisen so far.	YES
				Q4	YES	Medium	Critical	NO	Partners are working at design level. No technical or administrative conflicts have arisen so far.	YES

Risk Evaluation Form WP5				Current assessment of risk							ONLY if the risk materialised		
Risk Nr.	Responsible Partner	Description of risk	Proposed risk-mitigation measures	Date of last evaluation	a) Is the risk relevant?	b) Probability How likely will the risk occur?	c) Severity/Impact	d) Did the risk materialise? (Yes/No)	e) Please provide a short update of the risk: (e.g.: What has happened? Why is it (not) relevant at the moment? etc.)	f) Did you apply risk mitigation measures? (Yes/No)	h) Explain the reason why it materalised	i) What are the consequences? Delay of Dxy, delay of task xy, shift of resources, impact on other WPs, etc.	j) What are the corrective actions & updated mitigation measures?
#18	IKL	RTD efforts are not reaching technical targets	Technical leader is present in all technical meetings and holds the expertise, involvement of additional experts if necessary. Continuous internal quality/progress control (IMR).	Q1	YES	Medium	Critical	YES	Inputs from CONNECTA-2 for closing Safe4RAIL-2 requirements are coming slower than expected.	YES	Safe4RAIL-2 had a slow start and Inputs from CONNECTA-2 are coming slower than expected.	* D1.1 delayed 2 months. No impact on subsequent tasks. * D2.1 (preliminary version) delayed 1 month. No impact on subsequent tasks. * D3.1 delayed 3 months. End of Task T3.2 delayed 2 months.	Additional telcos and meetings have been scheduled with CONNECTA-2 to speed up the collection of requirements.
				Q2	YES	Medium	Critical	YES	The definition of requirements has been delayed.	YES	Slow ramp-up on the start of the project and extensive interaction with CONNECTA-2.	* Additional 2-month delay in D3.1. * Delay in subcontractor assignment for T2.3 (wireless inauguration).	* Submission of an interim version of D3.1 to CONNECTA-2, and scheduling additional F2F meetings for requirement definition. * MOXA will review the first draft of the wireless inauguration procedure provided by CONNECTA-2 to accelerate the closure of procedure and subcontractor assignment.
				Q3	YES	Medium	Critical	YES	The definition of wireless inauguration procedure has been delayed.	YES	Internal definition within CONNECTA-2.	* Delay in subcontractor assignment for T2.3 (wireless inauguration).	* Involvement of MOXA as reviewer for the wireless inauguration procedure to accelerate the closure of procedure and subcontractor assignment.
				Q4	YES	Medium	Critical	YES	* Releases of deliverables D2.1 and D3.1 has been delayed due to a delayed requirement definition. * T2.3 is being delayed, as more details are needed on the definition of the wireless inauguration process.	YES	Requirement definition has taken longer than expected.	* Delay in subcontractor assignment for T2.3 (wireless inauguration).	* Several meetings, workshops and telcos have been organized to close requirements and complete deliverables D2.1 and D3.1. * Further meetings with CONNECTA-2 have been schedule to detail the wireless inauguration procedure and its implementation requirements.

Risk Evaluation Form WP5				Current assessment of risk						
Risk Nr.	Responsible Partner	Description of risk	Proposed risk-mitigation measures	Date of last evaluation	a) Is the risk relevant?	b) Probability How likely will the risk occur?	c) Severity/Impact	d) Did the risk materialise? (Yes/No)	e) Please provide a short update of the risk: (e.g.: What has happened? Why is it (not) relevant at the moment? etc.)	f) Did you apply risk mitigation measures? (Yes/No)
#19	IKL	IPR conflicts between partners or between groups of partners	Early detection of the issue through close and frequent meetings and a clear and unambiguous legal framework (e.g. CA). The CA will include also clauses regulating the rules of confidentiality among members of the consortium and also external parties which may be granted access to Safe4RAIL-2 IPR. Transferring of background and foreground will be subject to requirements established on the GA and the CA.	Q1	YES	Medium	Critical	NO	At the moment partners are working at specification level, no IPR conflicts have arisen so far.	YES
				Q2	YES	Medium	Critical	NO	At the moment partners are working at specification level, no IPR conflicts have arisen so far.	YES
				Q3	YES	Medium	Critical	NO	At the moment partners are working at specification level, no IPR conflicts have arisen so far.	YES
				Q4	YES	Medium	Critical	NO	Partners have started working at design level. No IPR conflicts have arisen so far.	YES

Chapter 5 Conclusion

The described risk management approach indicates how the Safe4RAIL-2 consortium is and will avoid potential pitfalls and roadblocks on the road to success. Based on theoretical inputs, as described in Chapter 3, the Safe4RAIL-2 risk management tends to professionally identify, analyse, monitor and handle highly innovative project risks. The consortium has been very effective when monitoring the project risks. As a result of continuous risk monitoring, partners identified three new risks, whereby several might negatively affect the project if not handled carefully. Overall, the current level of risks indicates appropriate mitigation measures as well as close attention of all partners.

Risk Assessment is a process, which will last throughout the lifetime of the Safe4RAIL-2 project. Updates and assessments will be regularly performed by the consortium and reported within the Periodic Reports.

List of Abbreviations

Table 7: List of Abbreviations

Abbreviation	Translation
DoA	Description of Action
EB	Executive Board
EC	European Commission
GA	General Assembly
IMR	Interim Management Report
ISO	International Organization for Standardization
JU	Joint Undertaking
MS	Milestone
PM	Person Months
TCMS	Train Control and Monitoring System
TSN	Time-Sensitive Network
WP	Work Package

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