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professionals at all levels SKILLFUL**

**Deliverable D4.3**

**Risk Assessment and SWOT**



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## Abbreviations

Abbreviation	Meaning
WP	Work package
FMEA	Failure Mode and Effects Analysis
SWOT	Strengths, Weaknesses, Opportunities and Threats
VET	Vocational Education and Training
CVET	Continuous Vocational Education and Training
GMPs	Good Manufacturing Practices
PSM	Process Safety Management Act
FDA	Food & Drug Administration
S	Risk Severity
O	Risk Occurrence Probability
D	Risk Detectability
R	Risk Recoverability
RN	Risk Number
WtP	Willingness to Pay

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## Executive Summary

This report constitutes the Deliverable 4.3 of SKILLFUL project, part of the WP4 (Definition of competences, profiles and training provision business scenarios).

The current Deliverable provides a structured approach for the identification of the risks of SKILLFUL outcomes, using a modified extended Failure Mode and Effects Analysis (FMEA). Even if many risk assessment methodologies exist, in SKILLFUL we choose to use the extended FMEA methodology, and adapt it according to the needs and the nature of the project, since it allows us to identify risks for the overall SKILLFUL outcomes and to cluster them in categories, capturing all the dimensions of their probable impact. Using extended FMEA methodology allows us to identify risks that are related to technical, legal, organisational and behavioural issues related either directly to the project's outcomes, as well as indirectly to its stakeholders, while also prioritise them according to their probability, detectability, occurrence probability and severity.

In SKILLFUL risk analysis, **17 risks** were identified in total for all SKILLFUL outcomes and processes. From these 17 risks 3 were defined as legal, 1 as organisational, 11 as technical and 2 as behavioural. Moreover, none was ranked as insignificant, slightly significant or extremely severe. 8 have been ranked as of moderate significance and 9 as severe.

Moreover, in this Deliverable, a SWOT analysis is included, which is a useful technique for understanding the **S**trengths and **W**eaknesses of the project and its outcomes, and for identifying both the open **O**pportunities and the **T**hreats that is probable to be faced during the project and after its completion.

## 1 Introduction to the SKILLFUL project and first results

SKILLFUL is a Research and Innovation action of the European Commission started in September 2016 and lasting for 3 years. The project is working on performing a structured foresight into the vocational and academic qualifications in the Transportation sector of the future, in order to propose training schemes and their supportive business models that could ideally be adopted European-wide, to enhance employability and sustainable industrial development in the transportation sector in Europe. In this respect, it means to cover the first element of “Graduate employability” in the future Transportation sector.

SKILLFUL project looks closely at the needs of the European transportation system, which is a rapidly developing and changing sector, which struggles to develop, attract and retain appropriate staff. The project meticulously analyses emerging trends in future transport and a comprehensive analysis on their impact is also undertaken, covering -amongst other aspects- the impact of automation, the impact of electrification (i.e. on required skills of technical maintenance and service staff), the greening of transport (i.e. on skills of relevant indicators monitoring personnel) and services personalisation, as well as Mobility as a Service businesses (i.e. in relation to relevant new mobile applications development and/or business models set-up). For all the above trends employability is strongly connected to future transport job requirements for all transportation modes and for multimodal chains (which by themselves constitute a key transport of the future trend), and for all levels/types of workers (blue collar, white collar, managers, operators, researchers, etc.).

A number of novel training schemes has been proposed within SKILLFUL, a number of which will be evaluated in real life training and education facilities at Universities, VET/CVET Institutes, etc., as well as on-the-job training environments; to determine their usefulness, usability and in order to assess their impact on employability. Thus, the schemes Piloted in WP5 only constitute a sub-set of those proposed in WP3 and are there to validate the project’s overall concept and to offer a first exemplary nucleus of novel training courses for the Transport sector of the future. Moreover, the competences of trainers and trainees is being defined as well as the design of new profiles of teams devoted to facilitating the transfer of knowledge through innovative ideas/methods and the introduction of novel concepts of business roles to facilitate the training process (i.e. “knowledge aggregators”, “training certifiers” and “training promoters”).

Now, at this stage of the project, the proposed solutions of the project will undergo a thorough assessment of risks and barriers for implementation using the extended Failure Modes and Effects Analysis (FMEA) methodology adopted and modified properly, in order to fit the needs of SKILLFUL project. Relevant risks and barriers have been identified during this process by a group of experts representing all stakeholders sourced from the project Consortium. The methodology, as well as the results of the SKILLFUL risk assessment and SWOT analysis are reported within this document.

This work will be repeated after the Pilots of WP5 (at Month 31), as an a posteriori, analysis to assess the success of the proposed mitigation strategies, as well as re-access the identified risks (add new ones or delete the ones that did not surface).

## 2 The extended FMEA methodology

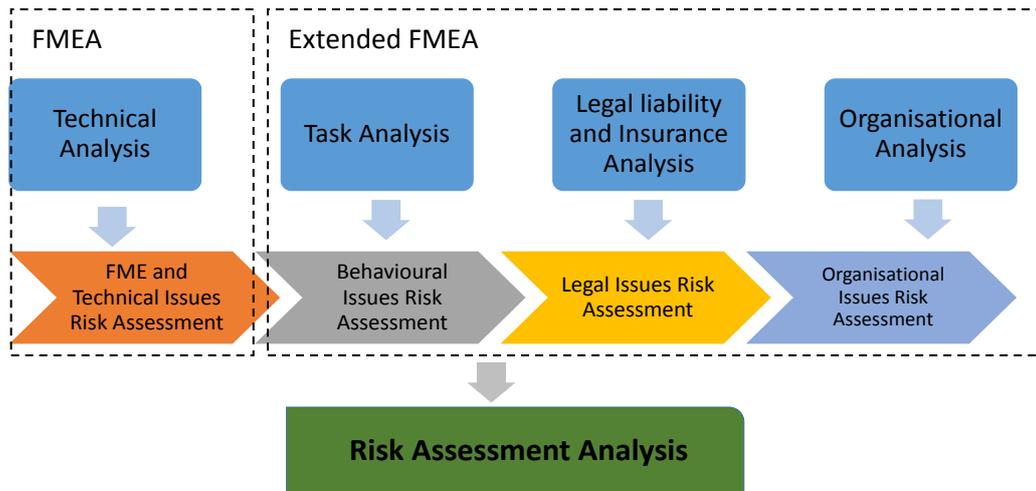
Failure Mode and Effects Analysis (FMEA) is a methodology designed to:

- Identify potential failure modes for a product or process.
- Assess the risk associated with those failure modes and prioritise issues for corrective action.
- Identify and carry out corrective actions to address the most serious concerns.

The FMEA procedure is a tool that has been adapted in many different ways for many different purposes. It can contribute to improved designs for **products and processes**, resulting in higher reliability, better quality, increased safety, enhanced customer satisfaction and reduced costs. The tool can also be used to establish and optimise maintenance plans for repairable systems and/ or contribute to control plans and other quality assurance procedures. It provides a knowledge base of failure mode and corrective action information that can be used as a resource in future troubleshooting efforts and as a training tool for new engineers. In addition, a FMEA is often required to comply with safety and quality requirements, such as ISO 9001, Six Sigma, FDA Good Manufacturing Practices (GMPs), Process Safety Management Act (PSM), etc.

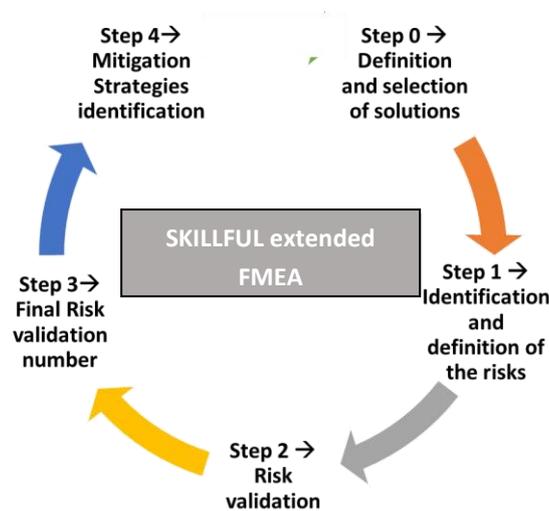
In SKILLFUL the **extended FMEA** has been used that has been developed at ADVISORS project (Bekiaris and Stevens, 2005). The findings, solutions and processes developed in SKILLFUL project has undergone a thorough assessment of risks and barriers for their implementation using the extended FMEA methodology adopted, in order to fit the needs of SKILLFUL project. Relevant risks and barriers have been identified and the initial risks and barriers assessment tables together with the mitigation strategies for the most important ones, will assist on the adoption of SKILLFUL outcomes, from the transportation and education sectors in the short, medium and long term future (2020, 2030 and 2050 respectively).

The **extended FMEA** methodology is based on the classical FMEA methodology, which includes the indicators of *hazard consequence severity*, *occurrence probability*, *detectability* and *recoverability*, and extends it, covering not only technical risk, as done in classical FMEA methodology, but including also *behavioural*, *legal and organisational – related* ones. For the overall SKILLFUL outcomes, risks are first identified and the level of risk is assessed by considering the number of characteristics, as explained in detail in Section 4 for each risk type (technical, behavioural, legal and organisational). The significance of a risk, overall, depends both on its consequences and the probability of its occurrence, but also on how easily the developing risk can be detected. The overall process proposed for the extended FMEA methodology for a specific solution, is summarised in Figure 1.



**Figure 1: Extended FMEA (proposed by Bekiaris and Stevens 2005)**

In general, a risk assessment consists of an analysis of the (i.e. the identification of potential hazards and some estimation of their magnitude) and an evaluation of the tolerability of that risk in its anticipated context. The steps that follow for the calculation of the risk within the **extended FMEA methodology** as applied in SKILLFUL project are depicted in Figure 2. These are similar to the process within the original FMEA.



**Figure 2: FMEA methodology steps.**

In the next chapter, the **extended FMEA methodology** implemented in SKILLFUL, is being described, step by step, as it has been realised in the project in the context of Task 4.5 of WP4. Additionally, all the parameters used in the **extended FMEA methodology** analysis are being explained and a reference table for each parameter that helps in understanding the meaning of such parameters and the criteria utilised for the value assignment, is also included.

### 3 SKILLFUL risk analysis methodology

#### 3.1 SKILLFUL template

For the realisation of the extended FMEA methodology a template (see Table 1) has been filled in from all the expert partners. Each cell of the table is related to the steps of the methodology as indicated in the table that follows. The individual steps are explained in the following Sections.

**Table 1: Risks assessment methodology template**

Risk type* (select one)	Problem short description*	Relevant WP/ Activity	S*	O*	D*	R*	Risk	Problem severity	Mitigation strategy*	Mitigation possibility
<input type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.										

#### 3.2 Step 1: Identification and definition of risks

The first thing we had to realise in the SKILLFUL risk identification, was to recognise the areas of the project where the risks can occur.

Based on various criteria (i.e. significance of solution and/or of SKILLFUL process, education and training system readiness, society readiness, technical aspects of pilots realisation, etc.), partners that have expertise within different areas of the education and research transportation fields, were asked to identify and prioritise risks stemming from different SKILLFUL steps, based on their expertise. Each one of the risks that emerged from this selection, have been defined as technical, legal, organisational or behavioural.

#### 3.3 Step 2: validation

For each one of the risk types (technical, behavioural, legal and organisational) a specific validation has been made. In the following sections it is explained in detail how the ranking of each type of risk has been done.

**Table 2: Extended risks assessment methodology template, Step 2.**

Risk type* (select one)	Problem short description*	Relevant WP/ Activity	S*	O*	D*	R*	Risk	Problem severity	Mitigation strategy*	Mitigation possibility
<input type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.										



### 3.3.1 Risk Severity (S)

#### 3.3.1.1 Technical Risks Analysis

Technical assessment considers technical (hardware and software) failures or to risks that are related to the technical maturity of the solution. In general, technical issues will be barriers to SKILLFUL pilots if one or more of the following applies:

1. A technical solution or part of it, is not available, needs further investigation, or is highly complicated.
2. Cost of the technical solution or part of it would be prohibitive.
3. The benefits gained from the functionality of the solution are uncertain.

The severity levels (S) for technical failure are described below.

**Table 3: Definition of unmitigated severity levels for technical risks.**

Severity of unmitigated risk of issue now	Rate	Definition
Extremely severe	9-10	The failure could put user safety at risk.
Severe	7-8	The failure implies total loss of the solution availability causing major user's dissatisfaction.
Moderate	5-6	Failure implies the partial loss of the solutions' function causing user's dissatisfaction.
Slight	3-4	The failure implies slight dissatisfaction to the user.
Insignificant	1-2	The failure does not imply perceptible effects to the system function and to the user's satisfaction.

Mitigation strategies could involve implementing one of the alternative provisions identified in the FMEA, or restricting the scope or function of the solution.

#### 3.3.1.2 Behavioural Risks Analysis

Behavioural risks are connected with the behaviours of users and organisations that have a negative impact on the society and the SKILLFUL outcomes. To apply the extended FMEA methodology to user and society behaviours for significant issues that are likely to affect solution deployment should be summarised and assessed here. In general, human error issues will be a barrier for SKILLFUL outcomes evaluation and/or adoption if one or more of the following applies:

1. A change to human behaviour (reduced human error) is required before the solution can be fully deployed.
2. The expected cost (training, design changes, time availability) of the deployment of the solution is significant.
3. The benefits gained from changed human behaviour due to the deployment of the solution are uncertain.

The severity levels (S) for behavioural risk are described below.

**Table 4: Definition of unmitigated severity levels for behavioural risks.**

Severity of unmitigated risk of issue now	Rate	Definition
Extremely severe	9-10	The user error in operating the solution could lead to an incident worseness (i.e. safety effects).
Severe	7-8	User behavioural error may abort the solution's benefits (i.e. safety effects due to changes in ways of acquiring info).
Moderate	5-6	User's behavioural changes may significantly reduce the positive effects of the solution.
Slight	3-4	User's behavioural changes may somehow influence the positive effects of the solution.
Insignificant	1-2	User's behaviour is not expected to reduce the solution's benefits significantly, or may even further enhance them.

Note that Table 4 (and subsequent tables) develops their broad risk categorisations – “severe”, “moderate” etc. – to allow a broad strategic overview of risk even though the nature of the risk can arise in different ways. This means that classification of risk severity is a process that requires the application of experts' judgement.

**3.3.1.3 Legal Risks Analysis**

Significant legal issues that are likely to affect SKILLFUL outcome evaluation and/or are summarised and assessed. In general, legal issues will be a barrier to module deployment if one, or more, of the following applies:

1. A change to existing law is required before the module can be fully deployed.
2. The expected legal cost of deployment (including fees and damages) is significant.
3. There is uncertainty about where large potential liabilities will fall.

The severity levels (S) for liability failure are described below.

**Table 5: Definition of unmitigated severity levels for legal risks.**

Severity of unmitigated risk of issue now	Rate	Definition
Extremely severe	9-10	Are there laws in each country that do not allow the solution to be implemented?
Severe	7-8	New laws are required for solution's implementation and no relevant work has been performed yet.
Moderate	5-6	New laws are required for solution's implementation and work required has already been performed.
Slight	3-4	New laws are required for solution's implementation but consensus on them exist.
Insignificant	1-2	No new laws are required for implementation.

### 3.3.1.4 Organisational Risks Analysis

The regulatory pressures for improved risk assessment and reporting on internal control is of high importance before implementing a specific solution, since organisational risks like accounting failures, frauds, internal control breaches, and governance failures may occur.

It is necessary to relate the attributes of the SKILLFUL outcomes, to the actors involved in their design, evaluation and use. Application of the extended risks assessment methodology in this area is difficult but organisational issues can be subject to analysis by management and political consultants by considering actors, roles and responsibilities, processes and communications. Problems can occur when there is a lack of communication and reporting structures between actors.

The severity levels (S) for Organisational risks are described below.

**Table 6: Definition of unmitigated severity levels for organisational risks.**

Severity of unmitigated risk of issue now	Rate	Definition
Extremely severe	9-10	Wide and different organisational framework is needed, that is completely missing (i.e. new services).
Severe	7-8	Organisational framework adaptation is needed (some initial actions have been taken on this domain).
Moderate	5-6	Organisational framework adaptation is needed which has already started being realised.
Slight	3-4	There is a need for limited and easily realised organisational changes.
Insignificant	1-2	There is no need at all for organisational changes.

### 3.3.2 Risk Occurrence Probability (O)

The **Occurrence Probability (O)** is the probability that all the risk causes related to the risk modes described in the analysis can occur. This is often a qualitative index especially when new technologies are concerned because of the few reliability data available.

**Table 7 : Occurrence indicator scale of risk analysis methodology**

Occurrence Probability (O)	Technical issue	Behavioural issue	Legal issue	Organisational issue
9 – 10 (HIGH)	It is certain that some failures will sometimes occur.	It is certain that some behavioural effects will occur (by the users).	It is certain that some legal problems will occur.	It is certain that there will be a need for organisational restructuring.
6 - 7 – 8 (MEDIUM)	A failure could occasionally occur.	Some behavioural effects could occasionally occur.	Some legal problems could occasionally occur.	A need for organisational restructuring could occasionally occur (depending on the needs of the solution that will arise).

Occurrence Probability (O)	Technical issue	Behavioural issue	Legal issue	Organisational issue
3 - 4 - 5 (SLIGHT)	There is only a slight probability that an error/failure will occur.	There is only a slight probability that some behavioural effects will occur.	There is only a slight probability that some legal problems will occur.	There is only a slight probability that a need for organisational restructuring will occur.
1 - 2 (IMPROBABLE)	It is unlikely that a fault will occur.	It is unlikely that some behavioural effects will occur.	It is unlikely that some legal problems will occur.	It is unlikely that a need for organisational restructuring will occur.

### 3.3.3 Risk Detectability (D)

Detectability (D) is the probability to detect the occurrence of a risk mode identified in Step 1 of the methodology. Detection of a developing risk is an important aspect of overall risk management, as early detection is a prerequisite for the application of mitigation strategies. In the technical, and to some extent behavioural, domains, detection can be facilitated by additional sensors and processing. In the legal and organisational domains surveys, monitoring and feedback are important tools.

Detectability is assigned a value between 1 and 10 (1 means that it is always perfectly detectable and 10 that it is always undetectable).

**Table 8 : Detectability indicator scale of risk analysis methodology.**

Detectability (D)	Technical issue	Behavioural issue	Legal issues	Organisational issue
9 - 10 (IMPROBABLE)	It is impossible or improbable that a problematic area will be detected.	It is impossible or improbable that a user's behavioural effect will be detected.	It is impossible or improbable that a legal problem will be detected.	It is impossible or improbable that an organisational problem will be detected.
7 - 8 (SLIGHT)	The problematic area is detected only in particular cases.	The user's behavioural effect is detected only in particular cases.	The legal problem is detected only in particular cases.	The organisational problem is detected only in particular cases.
5 - 6 (MODERATE)	It is probable that the problem will be detected (depending on the situation).	It is probable that the user's behavioural effect will be detected.	It is probable that the legal problem will be detected.	It is probable that the organisational problem will be detected.
3 - 4 (HIGH)	It is very probable that a problem will be detected.	It is very probable that the user's behavioural effect will be detected.	It is very probable that the legal problem will be detected.	It is very probable that the organisational problem will be detected.
1 - 2 (VERY HIGH)	It is certain that a problem will be detected.	It is certain that the user's behavioural effect will be detected.	It is certain that the legal problem will be detected.	It is certain that the organisational problem will be detected.

### 3.3.4 Risk Recoverability (R)

Recoverability (R) is an efficacy index of the possible recovery action performed by the risk management procedures implemented in the Scenario. It estimates the ability of the solution to tolerate the risk. The effectiveness is valued in terms of recoverability which is assigned a value between 1 and 10 (10 represents not recoverable and 1 always perfectly recoverable).

**Table 9 : Recoverability indicator scale of risk analysis methodology.**

Recoverability (R)	Technical issue	Behavioural issue	Legal issues	Organisational issue
9 – 10 (NULL)	No recovery action is provided.	System is inflexible to user’s behavioural effects.	System is either accepted or rejected by the legal framework.	System requires a fixed organisational environment to operate.
6 - 7 – 8 (LOW)	The user is only advised on the failure.	Behavioural effects are taken into account by the solution.	System may be slightly adapted to meet legal restrictions.	System requires a fixed organisational framework with limited adaptations.
3 - 4 – 5 (HIGH)	Effective recovery action is provided.	System customisation might compensate for user’s behavioural effects.	System encompasses different versions to meet particular legal demands.	System may operate within various organisational frameworks.
1 – 2 (TOTAL)	The failure effect is completely avoided by the recovery action.	System does not allow user’s behavioural effects.	System is easily reconfigurable to meet legal demands.	System does not require organisational changes.

### 3.4 Step 3- Final risk validation number

After the risk classification in each of the four domains, an overall relative indication of risk may be useful and for this reason the extended FMEA calculates a risk number (RN) for each risk identified, using the following formula:

$$\text{Risk Number} = S * O * \left[ \frac{D + R}{2} \right]$$

This calculation is applied to each risk area (technical, behavioural, etc.) to generate a risk number. The results of this equation may vary from 0 to 1000 depending on the validity of the risk each failure mode has. Normally, organisations select a pre-defined range for the RN, i.e. above 500 in the 0-1000 scale for which risks a mitigation strategy should be implemented. This is done in order to optimise use of resources and minimise cost.

The results of the risk number can be translated using the following table, which has been established by the FMEA methodology.

**Table 10 : Results of the Risk number.**

Overall risk factor	Overall severity	Mitigation possibility
513-1000	I- Extremely severe	Very High
217-512	II- Severe	High
65-216	III - Moderate	Medium
9-64	IV - Slight	Low
1-8	V - Insignificant	Improbable

The overall Risk Number helps in evaluating the most critical risks. A critical risk mode is a risk which is very dangerous in their effects, which occurs rather often, is not detected by the internal diagnosis and there is no recovery action performed over its effects.

**Table 11: Extended risks assessment methodology template, Step 3.**

Risk type* (select one)	Problem short description*	Relevant WP/ Activity	S*	O*	D*	R*	Risk	Problem severity	Mitigation strategy*	Mitigation possibility
<input type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.										

### 3.5 Step 4- Mitigation strategies identification

The issues that have been identified as risks have been further analysed to determine the possibility of mitigating strategies. Risk reduction is an iterative process involving dependencies between the different issues. In terms of mitigation strategies, risk can be reduced in a number of generic ways:

1. reducing the probability of the hazard occurring;
2. increasing failure detection speed and probability;
3. reducing the magnitude (severity) of the consequences of the potential hazard;
4. protecting against the risk - mitigating strategies to compensate for a failure (e.g. back-ups).

One advantage of this approach is its consistency between the different domains (Technical, Legal, Organisational and Behavioural).

The mitigation strategies will be presented in the column of Step 4 in the extended FMEA template (see Table 12).

**Table 12: Extended risks assessment methodology template, Step 4.**

Risk type* (select one)	Problem short description*	Relevant WP/ Activity	S*	O*	D*	R*	Risk	Problem severity	Mitigation strategy*	Mitigation possibility
<input type="checkbox"/> Technical										



Risk type* (select one)	Problem short description*	Relevant WP/ Activity	S*	O*	D*	R*	Risk	Problem severity	Mitigation strategy*	Mitigation possibility
<input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.										



## 4 Application of the extended FMEA in SKILLFUL outcomes

### 4.1 Introduction

In the following table, the results of the extended FMEA executed for the selected SKILLFUL outcomes are presented. All the selected risks are presented, while also their S, O, D, R rates their Risk Numbers and their planned mitigation strategies are presented.

**Table 13: SKILLFUL risk analysis**

Risk type* (select one)	Problem short description *	Relevant WP/ Activity	S*	O*	D*	R*	RN	Problem severity	Mitigation strategy*
<input type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input checked="" type="checkbox"/> Organis.	The European Master course does not collect the necessary credits to be recognised as such.	A3.6	8	9	2	8	360	Severe	Within SKILLFUL only the overall curriculum is specified and a few courses are taught as proof of concept.
<input type="checkbox"/> Technical <input checked="" type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.	Risk of non-compliance with safety regulations in cases where the health of the trainee may be in danger	WP5	8	2	3	6	72	Moderate	Increase security measures during training and the awareness of trainees.
<input type="checkbox"/> Technical <input checked="" type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.	Overconfidence of trainees due to their training.	WP5	6	6	6	8	252	Severe	The training and knowledge limitations should be clearly described to the trainees and linked to any kind of relevant certification they might get after the training
<input checked="" type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.	Insufficient expertise and time to develop and deliver the modules.	WP3	7	6	6	4	210	Moderate	Partners are experts in relevant areas. In case this happens with modules, these will be replaced by others.
<input checked="" type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal	The Pilot site has not the necessary trainers to teach the planned module	WP4/ WP5	8	8	2	5	224	Severe	Trainers will be transferred from the course developer.



Risk type* (select one)	Problem short description *	Relevant WP/ Activity	S*	O*	D*	R*	RN	Problem severity	Mitigation strategy*
<input type="checkbox"/> Organis.									
<input checked="" type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.	The Pilot site has not the necessary training infrastructure/ equipment (i.e. simulator, web-proctoring tool, etc.)	WP4/ WP5	9	6	2	7	243	Severe	Should rent it or use another Partner ones remotely. If necessary, transfer training to another site.
<input checked="" type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.	Can't find trainees with the necessary skills for a course	WP4/ WP5	8	7	2	7	252	Severe	Some trainee requirements could be relaxed or overall number of trainees to be reduced.
<input checked="" type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.	Not enough interest from trainees	WP5	8	5	2	6	160	Moderate	All Pilot sites have big enough trainee pools to counterbalance this
<input checked="" type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.	Training impacted by trainer/ trainee drop-offs	WP5	8	5	2	7	180	Moderate	Replacement list will be kept for both. However, if it happens at mid-term, there will not be possible for new trainees to join the course.
<input checked="" type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.	Several trainees do not take the final exams	WP5	8	5	5	8	260	Severe	Results will be based on questionnaires and qualified assessment.
<input checked="" type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.	Course is found not to be adequate/ interesting	WP3	8	3	8	8	192	Moderate	Unlikely to happen due to the expertise of Partners. If this occurs, the course will be abandoned and resources will be transferred to other courses. To recognise such possibility, internal evaluation is taking place before the



Risk type* (select one)	Problem short description *	Relevant WP/ Activity	S*	O*	D*	R*	RN	Problem severity	Mitigation strategy*
									piloting of each course.
<input checked="" type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.	Lack of sufficient models to support economically relevant training after the end of the project.	WP3/ WP4	8	5	2	7	180	Moderate	Several alternative business models will be analysed and proposed. Initial interest from the training stakeholders and industrial interest looks promising.
<input checked="" type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.	Low WtP on project's results for sustainable exploitation.	WP6	7	5	2	6	140	Moderate	Several modules could be offered for free or used by the developing organisations for self-training; thus, gaining competitive advantage over competition.
<input checked="" type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input type="checkbox"/> Legal <input type="checkbox"/> Organis.	Proof of concept is successful but generating all the required new content and training systems suffers from the curse of dimensionality and lack of funds and mechanisms.	WP6	8	7	5	7	336	Severe	That is why the relevant business models of WP4 are being developed. The pressing industrial needs for new skills will eventually lead to the required resources.
<input type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input checked="" type="checkbox"/> Legal <input type="checkbox"/> Organis.	Training outcome not able to be connected with official University/ vocational courses and certification/ accreditation schemes during the project.	WP3/ WP5	6	8	2	8	240	Severe	Such training is seen as proof of concept and provided free of cost to the trainees. If successful, it will be adapted/ integrated to national/ official schemes gradually after the end of the project.
<input type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input checked="" type="checkbox"/> Legal <input type="checkbox"/> Organis	Data protection problems (i.e. data leakage) during the implementation of the Pilots	WP5	9	2	9	9	162	Moderate	A pilot responsible is named at each site. They are the only ones that know the names of the trainees and protects the collected data. Anonymisation and security mechanisms are in place in all sites. However, collected data are generally not security critical.



Risk type* (select one)	Problem short description *	Relevant WP/ Activity	S*	O*	D*	R*	RN	Problem severity	Mitigation strategy*
<input type="checkbox"/> Technical <input type="checkbox"/> Behavioural <input checked="" type="checkbox"/> Legal <input type="checkbox"/> Organis.	Differences in legal requirements between countries	WP5	8	9	2	8	360	Severe	Legal requirements have been checked in each Pilot site beforehand. However, if any unexpected barriers arise, the curriculum will be adapted or the Pilot will be transferred to another country.

## 5 SKILLFUL risk analysis discussion

### 5.1 Summary and statistics

During the SKILLFUL risk analysis, 17 risks were identified in total, related to the training courses developed in within the SKILLFUL project and all project's relevant outcomes.

From these 17 risks 3 were defined as legal, 1 as organisational, 11 as technical and 2 as behavioural. As depicted at the following chart, we can see that the technical risks are the ones that appears the most.



**Figure 3: Types of SKILLFUL risks**

Furthermore, from these 17 risks identified by the Consortium experts, none was ranked as insignificant, slightly significant or extremely severe. 8 have been ranked as of moderate significance and 9 as severe. Mitigation strategies were provided from the experts for all risks. These mitigation strategies will be taken into account during the evaluation of the SKILLFUL training courses (of the SKILLFUL Pilot phase), as well as during the overall project.

As mentioned before, this work will be repeated after the Pilots of WP5 (at Month 31), as an a posteriori, analysis to assess the success of the proposed mitigation strategies, as well as re-access the identified risks (add new ones or delete the ones that did not surface).

The risk analysis of SKILLFUL took approximately 3 months to be completed. During this period, partners with different expertise and backgrounds have participated and provided with extremely helpful feedback, ideas and concerns.

Most of the risks defined and analysed are related (as shown in Table 13) with the evaluation of these courses, during the Pilot phase of the SKILLFUL project. However, it is clearly depicted through the mitigation strategies of the analysis that the project partners have taken account of almost all possibilities and have already developed mechanisms to deal with problematic situations that could jeopardise the smooth conduct of the pilot phase.

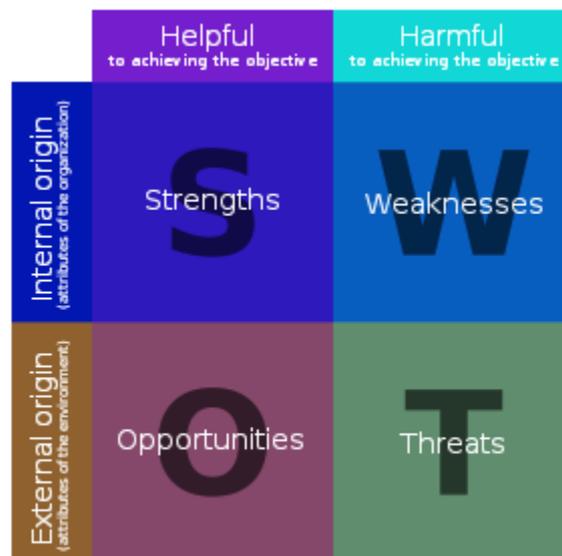
The same applies to dealing with similar situations that may arise after the evaluation of the training courses and modules (i.e. the characterisation of a module as inadequate). However, this possibility has been considered to be low, due to the internal evaluation procedures that has been adapted for the courses, while also due to the high expertise of the partners that have developed the courses.

## 6 SWOT analysis & expected impacts

### 6.1 Methodology

**SWOT Analysis** is a strategic planning method used to evaluate the **Strengths**, **Weaknesses**, **Opportunities**, and **Threats** involved in a project or in a business venture. It involves the specification of the objective of the business venture or project and the identification of the internal and external factors that are favourable and unfavourable towards the achievement of that objective.

- **Strengths:** attributes of the organisation that are helpful for the achievement of the objective.
- **Weaknesses:** attributes of the organisation that are harmful for the achievement the objective.
- **Opportunities:** *external* conditions that are helpful for the achievement of the objective.
- **Threats:** *external* conditions which could do damage to the business's performance.



**Figure 4: Illustrative diagram of SWOT analysis.**

If, on the other hand, the objective seems attainable, the SWOTs are used as inputs to the creative generation of possible strategies, by asking and answering each of the following four questions, many times:

- How can we Use each Strength?
- How can we Improve each Weakness?
- How can we Exploit each Opportunity?
- How can we Mitigate each Threat?

The aim of any SWOT analysis is to identify the key internal and external factors that are important for the achievement of the objective. These come from within the company's unique value chain. SWOT analysis groups key pieces of information into two main categories:

- Internal factors – The *strengths* and *weaknesses* internal to the organisation.
- External factors – The *opportunities* and *threats* presented by the external environment to the organisation.

The internal factors may be viewed as strengths or weaknesses depending upon their impact on the organisation's objectives. What may represent strengths with respect to one objective may be weaknesses for another objective. The factors may include all of the 4P's<sup>1</sup>; as well as personnel, finance, manufacturing capabilities, and so on. The external factors may include macroeconomic matters, technological change, legislation, and socio-cultural changes, as well as changes in the marketplace or competitive position. The results are often presented in the form of a matrix.

SWOT internal issues are sorted into the programme planning categories of:

1. Product (what are we selling?)
2. Process (how are we selling it?)
3. Customer (to whom are we selling it?)
4. Distribution (how does it reach them?)
5. Finance (what are the prices, costs and investments?)
6. Administration (and how do we manage all this?)

By sorting the SWOT issues into the 6 planning categories one can obtain a system which presents a practical way of assimilating the internal and external information about the business unit, delineating short and long term priorities, and allowing an easy way to build the management team which can achieve the objectives of profit growth.

## 6.2 SWOT in SKILLFUL

In Figure 5 below, the SWOT regarding the SKILLFUL project and its procedures and outcomes is presented.

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<sup>1</sup> **Product** - A tangible object or an intangible service that is mass produced or manufactured on a large scale with a specific volume of units. Intangible products are often service based like the tourism industry & the hotel industry. Typical examples of a mass produced tangible object are the motor car and the disposable razor. A less obvious but ubiquitous mass produced service is a computer operating system.

**Price** - The price is the amount a customer pays for the product. It is determined by a number of factors including market share, competition, material costs, product identity and the customer's perceived value of the product. The business may increase or decrease the price of product if other stores have the same product.

**Place** - Place represents the location where a product can be purchased. It is often referred to as the distribution channel. It can include any physical store as well as virtual stores on the Internet.

**Promotion** - Promotion represents all of the communications that a marketer may use in the marketplace. Promotion has four distinct elements - advertising, public relations, word of mouth and point of sale. A certain amount of crossover occurs when promotion uses the four principal elements together, which is common in film promotion. Advertising covers any communication that is paid for, from television and cinema commercials, radio and Internet adverts through print media and billboards. One of the most notable means of promotion today is the Promotional Product, as in useful items distributed to targeted audiences with no obligation attached. This category has grown each year for the past decade while most other forms have suffered. It is the only form of advertising that targets all five senses and has the recipient thanking the giver. Public relations are where the communication is not directly paid for and includes press releases, sponsorship deals, exhibitions, conferences, seminars or trade fairs and events. Word of mouth is any apparently informal communication about the product by ordinary individuals, satisfied customers or people specifically engaged to create word of mouth momentum.



## SKILLFUL SWOT ANALYSIS

### **Strengths**

- Training use cases and curricula well-correlated to actual training needs, emerging of changing jobs, mainstream professions, new training methodologies, well specified trainers and trainees competences.
- Pragmatic training courses, taking into account cost efficient timing, legal and organisational schemes in each country.
- Holistic covering, in good balance, of all transport modes and job/skills types.
- Several business models researched to support sustainability and expansion of developed training schemes.
- Most training courses applied and tested in multiple countries/ training settings; thus of high transferability.
- Good and sound bases of existing vocational and university courses and other initiatives (i.e. Young Researchers Seminars), to base upon the emerging training modules.
- Strong stakeholders' engagement across Europe and beyond.

### **Opportunities**

- Radically and rapidly changing transportation technologies lead to major needs and new workforce skills.
- Major investments underway in transportation technologies, part of which can be used for skills' development.
- Existing and emerging unemployment pressure to generate new skills for professionals and enhance workforce employability.
- European investments to keep production capacity in Europe and balance extra-European production low cost with European added value, enhanced quality and better workforce expertise.
- Common technological evolution across modes (i.e. electrification, automation, shared economy) and all over Europe; leading to a wide market for new skills and promising career mobility options.

### **Weaknesses**

- Due to time and resources limitations the applied courses' Pilots can only be considered as proof of concept (i.e. 3 of the over 10 European Transport Master degree courses can be taught and even those without the full developed content).
- For the same reasons, the Piloted courses constitute only a part of the overall developed and proposed courses and they address –again– only a part of the recognised needs.
- Long-term effects of courses on trainees' skills can't be assessed during the project.
- Unforeseen problems may emerge in Pilot trainings due to the complex training/ educational frameworks; that are affected by external factors (i.e. new training laws in a country or changing vocational business schemes, etc.)

### **Threats**

- Technologies are rapidly changing in transport; thus, the needs for skills may also radically differ from the estimated ones; especially in the medium to long term.
- Some key industries and sectors may import required skills from abroad or transfer production capacity instead of waiting for home market skills to emerge.
- Very slow evolution and conservative nature of University education schemes in Europe; it may require too long periods to incorporate new courses.
- Cost pressure on vocational training sector in Europe may hinder the inclusion of new courses/ schemes.

Figure 5: SKILLFUL SWOT analysis

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## 7 Conclusions

The current Deliverable contains the risk analysis regarding the realisation of the SKILLFUL project, as well as the adaptation of its outcomes. For this analysis, the extended Failure Mode and Effects Analysis (FMEA) approach has been used, in order to identify risks for the overall SKILLFUL outcomes and to cluster them in categories, capturing all the dimensions of their probable impact. Using the extended FMEA methodology has allowed us to identify risks that are related to technical, legal, organisational and behavioural issues related either directly to the project's outcomes, as well as indirectly to its stakeholders, and also prioritise them according to their probability, detectability, occurrence probability and severity.

Within this risk analysis, **17 risks** were identified in total for all SKILLFUL outcomes, from which 3 were defined as legal, 1 as organisational, 11 as technical and 2 as behavioural. All identified risks have been ranked as of moderate significance and as severe. The risks that have arisen for this analysis are mostly related to the following issues:

- Realisation of the evaluation process of the SKILLFUL developed courses (Pilot phase), due to several reasons (i.e. insufficient expertise of trainers, overconfidence of trainees, limited time, lack of necessary infrastructure/ equipment, etc.)
- Acceptance and adoption of the SKILLFUL courses/ modules by the educational and training institutes and organisations.
- WtP on project's results for sustainable exploitation.
- Lack of sufficient models to support economically relevant training after the end of the project.
- Data protection and privacy issues.
- Legal requirements among different countries

Moreover, this document includes a SWOT analysis (Section 6), realised for better understanding of the **S**trengths and **W**eaknesses of the project and its outcomes, and for identifying both the open **O**pportunities and the **T**hreats that will probably need to be addressed throughout the project's realisation but also after its finalisation (Figure 5).

## References

- 1 Bekiaris, E., Stevens, A. (2005), "Common risk assessment methodology for advanced driver assistance systems", *Transport Reviews*, Vol. 25, No. 3, p. 283-292, May 2005.
- 2 EU General Data Protection Regulation (GDPR), available at <https://www.eugdpr.org/>
- 3 SKILLFUL (2018), Deliverable 5.1. Pilot Plans.
- 4 SKILLFUL (2018). Deliverable 3.1. Proposed future training curricula and courses for the Transport sector.
- 5 SKILLFUL (2017). Deliverable 7.2. Ethics and Privacy Protection Manual.
- 6 SKILLFUL (2017). Deliverable 5.2 Data management plan.