THE FMEA EXPLOITATION IN SUPPLY CHAIN RESILIENCE EVALUATION

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Abstract

FMEA method is well known as a tool used especially within the automotive industry. Its purpose is to review risk and increase reliability of product and/or process. At the present time, highly efficient and safe supply chain becomes to be an essential presumption for the smooth running of any production in each industry and also for delivering products produced by industry operations to customers. Following text describes capabilities to use FMEA as a next step in our research related to the subject of supply chain resilience.

Keywords: supply chain resilience, FMEA, cycle time, 3PL, risk

1. INTRODUCTION

The nowadays world is much faster, changing and hazardous. The risk is daily fact of every industrial operation including to operation of supply chain. Every activity that a supply chain conducts has inherent risk that an unexpected disruption can occur. The global reach of supply chains, shorter product life cycles, and increasing customer requirements have made businesses aware that supply chain disruptions can cause undesirable operational and financial impact [1]. For all segments of the supply chain is crucial to avoid high risk situations with the aim to ensure and continuously increase its resilience.

A Failure Mode and Effect Analyses (FMEA) is a system reliability and safety review technique created in the 1960s as part of the U.S. Minuteman rocket program to find and mitigate unanticipated design problems. A rather simple technique, the failure modes of each component in a given system are listed in a table, and the effect of that failure is postulated and documented. The method is systematic, effective, and detailed, although sometimes called time-consuming and repetitive [2].

Although there was done plenty of work on the academic field the practice requires user friendly and easy to use tools which could assist to supply chain management in implementation the risk assessment and actions plans through effective and efficient way [3].

An ambition of the following text is to provide evidence that the FMEA tool can be used in the process of Supply Chain Resilience evaluation and improvement.

The text is split into chapters: Definitions, FMEA General, Supply Chain Resilience, Example of FMEA use to improve particular part of Supply Chain.

2. DEFINITIONS

As understanding basic terminology is of the utmost importance terms such as Risk, Control, Supply Chain Resilience etc. are explained and followed by the definition FMEA.

The term logistics encompasses Materials Management & Distribution. Supply Chain comprises Suppliers & Logistics & Customers [4]. The characteristics of each supply chain are as follows (modified on the basis of [5]):

- Supply chain is a complete process the aim of which is to provide products and services to ultimate consumers.

- Supply chain includes all logistic operations, from sourcing to distribution.
- The scope of supply chain activities comprises production and distribution.
- Supply chain management extends beyond the boundaries of individual organizations in order to plan and control processes in other organizations.
- Supply chain allows the implementation of individual goals of an organization.
- Supply chain elements include suppliers, production equipment, warehouses, carriers, consumers and customers.
- The flows among these elements can be divided into information, material and financial.

Supply Chain Resilience means:

- The ability to return to its original state or move to a new more desirable state after being disturbed [7].
- The adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function [1].

Definitions related to the FMEA:

Asset means everything what has value which can be reduced by impact of threat. Threat is occurrence, power, activity, person which may have an influence for safety and may cause damage or loss. Risk for those purposes means mutual influence of Asset and Threat. FMEA (Failure Mode and Effect Analyses) is an analytical method used for reduction of the defect in production. Measure is the act or process of ascertaining the quality or quantity of some activity or product. Control means measure to regulate or check impact of deviation.

3. ABOUT FMEA

FMEA as a tool to manage risk of defects in production was firstly used by the NASA in early 1960´s. In 1980´s it was adopted by Ford Motor Co. engineering and in the 90´s by the Automotive Industry Action Group [7]. Method is primarily used within production industry (product FMEA). FMEA process approach can be successfully used to test process / solution design by service delivery companies. The FMEA is a quality tool that allows the user to examine the process from the viewpoint of its potential for failure (what could go wrong in the process) and plan for its control through service process or product design requirements. The potential for failure is designed out of the process before it reaches the customer [8].

Principle of the approach is to split process into segments and appraise them from potential failure mode and potential effect of failure point of view by the team of experts. When both above factors are defined than team rates the severity of them. Next step is to disclose and term potential cause of failure and to assess occurrence and detection. Product of severity, occurrence and detection is termed rating priority number (RPN) and it provide to the team importance of the issue.

No.	Name of factor	Name of sub factor	Potential Mode of capability loss/Describtion	Severity rate (SR) 1 - 10	Potential cause of capability reduction	Occurrence rate (OR) 1 - 10	Detection rate (DR) 1 - 10	Rating priority number (RPN)	Preventive measures	Responsibility	SR	OR	DR	RPN

Fig. 1 General FMEA Form

All rating related information are recorded into form (see **Fig. 1**) and when the investigated subject is reassessed completely the team sets the prevention action (measure) to reduce total *RPN*:

$$RPN = SR * OR * DR \quad (1)$$

For use of FMEA it is crucial to define content of scale for each factor (*SR*, *OR* and *DR*) to ensure harmonization of rating process. The most common scales are:

- For *SR*: No Impact - Low Impact w/o influence on functionality - Medium Impact with "cosmetic" influence on functionality/design - High Impact with limitation of functionality of some important - Critical Impact with loss of full of major functionality.
- For *OR*: From Remote (less than 1 failure pm) through Moderate (about 12 500 failures pm) to very high (more than 500 000 failures pm).
- For *DR*: From certain (will be detected) through moderate (may be detected) to impossible (will not be detected).

When reassessing the complete table some of special sequences importance has to be considered also (e.g. when *OR* = very high (10) and *SR* = low impact (1) and *DR* = certain (1)). For this sequence the planning and realization of preventive measure is required also. After implementation of preventive measures whole assessment process has to be revised with the aim to ensure effectiveness of them.

4. SUPPLY CHAIN RESILIENCE

The Resilience of Supply Chain is condition of its vulnerability measures robustness and strength of its capability [3], [9]. While vulnerability factors are potential risks for Supply Chain Resilience, its capability can be risk in case of any threats and advantage in case of strengths for Supply Chain Resilience (see **Fig. 2** and **Fig. 3**). Both (vulnerability and capability factors can be considered as a part of process and evaluated with the approach similar as it is for process FMEA (see **Fig. 1**).

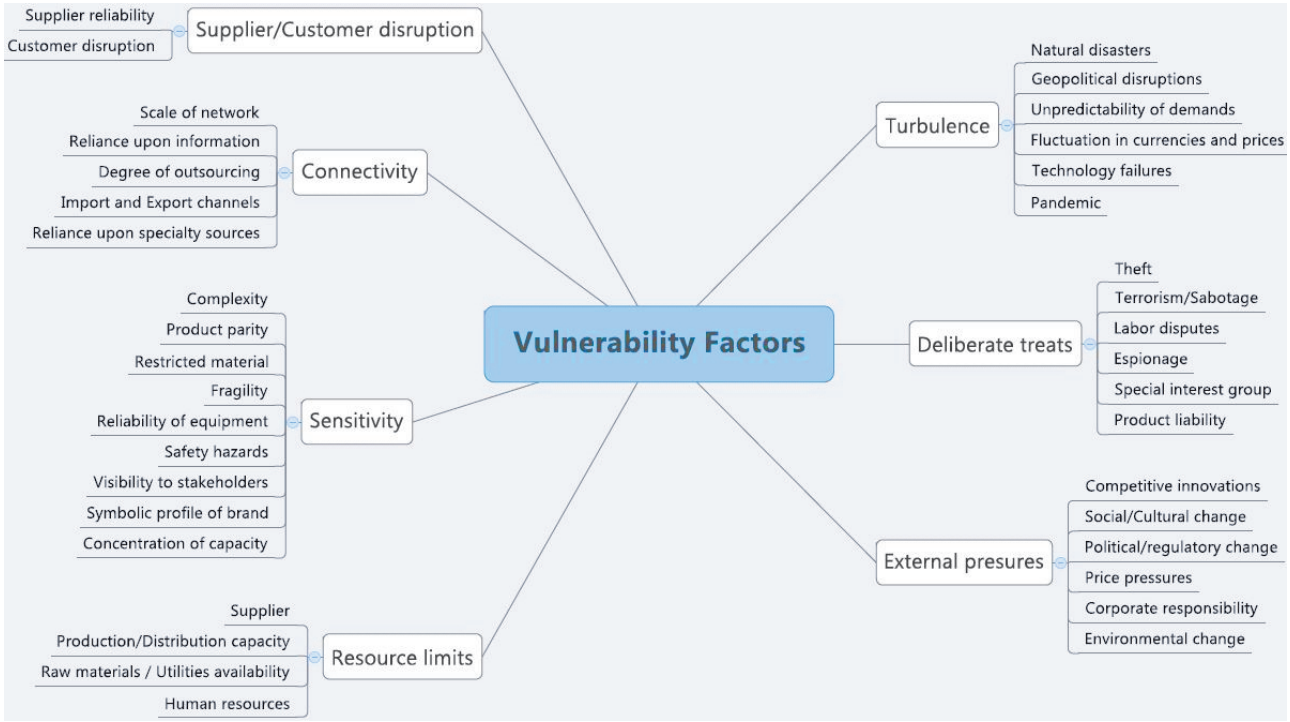

Fig. 2 Supply Chain Vulnerability Factors (freely by [9])

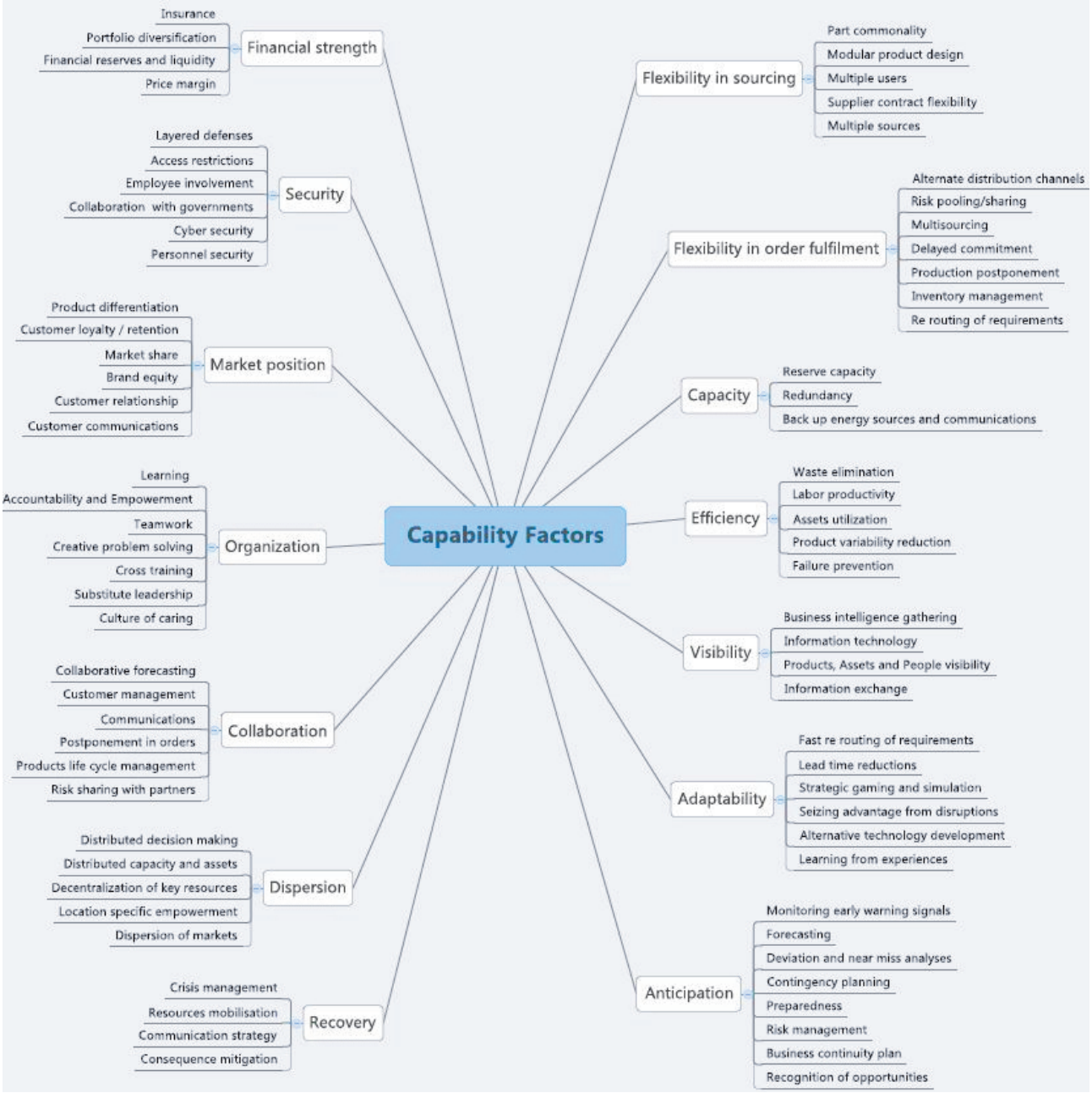

Fig. 3 Supply Chain Capability Factors (freely by [9])

5. FMEA APPROACH TO EVALUATE AND IMPROVE SUPPLY CHAIN RESILIENCE

We have made an attempt to use modified FMEA for evaluation of particular part of Supply Chain to get closer to practice.

5.1. Description of the case

3PL provider has started to implement new solution design of warehousing and transportation services for one of the biggest automotive industry suppliers on the traffic lane from EU to Balkans production. The service process consists of:

- Partial loads import from EU sub suppliers to one warehouse at Germany in the case that call off is not for full truck volume.

- Full truck loads operation from sub suppliers to the Balkans for the case that call off for material is equal to full truck volume.
- Material consolidation to full truck loads at the warehouse.
- Full truck operation from the cross dock warehouse to the Balkans based on the call off from Balkans' production plant.

The 3PL company before implementation of the processes (during tender process - process of solution design) has managed FMEA with the objective to assess its capability, eliminate risk and prove robust resilience of Supply Chain set up.

5.2. Description of the process

The whole process of FMEA implementation is possible to describe in following steps (see **Fig. 4**):

- Establish the team from experts for various areas of 3PL logistics operation, if possible involve representatives of customer.
- Slightly revise the form and if needed smarten up.
- Agree on the scale for *SR*, *OR* and *DR* factors. Calibrate the team.
- Start to review every of Capability / Vulnerability sub factors.
- Assess as result of consensus severity rate.
- By team discussion disclose and define potential Capability reduction / Vulnerability boosting modes. Define circumstances in which before described may happen.
- Assess as the result of team consensus *OR* and *DR*.
- Calculate *RPN*.
- When having all sub factors assessed select all results you have agreed to action (usually above 125). Do not forget to check special sequences of assessment (see chapter 3.).
- Set the measures and re-assess after implementation.

No.	Name of factor	Name of sub factor	Potential Mode of capability loss/Describtion	Severity rate (SR) 1 - 10	Potential cause of capability reduction	Occurrence rate (OR) 1 - 10	Detection rate (DR) 1 - 10	Rating priority number (RPN)	Preventive measures	Responsibility	SR	OR	DR	RPN
4.1	Efficiency	Waste elimination	Possible CO2 foot print due to use of Balcanees transporters with less than Euro5 Engine trucks	6	Limited database of transport companies. Lack of cooperation entrz audit.	7	2	84	> Database of transport companies > Regular audit of subcontractors	Herr Staring Herr Nowak	6	2	2	24
4.2	Efficiency	Labor productivity	Staff in th warehouse does not achieve described productivity	7	Staff does not have any feedback about productivity during cross dock	6	4	168	> Instalation of displays at the warehouse	Herr Wrede	7	4	2	56
4.3	Efficiency	Assets Utilization	Low utilization of the trucks	6	The WMS does not calculate utilization of the loads	8	6	288	> Apply in WMS module to fold up material with the aim to achieve best utilization of trucks	Herr Matyke	6	2	2	24
4.4	Efficiency	Products Variability						0						
4.5	Efficiency	Failure prevention						0						

Fig. 4 Sample of FMEA Capability of Supply Chain Resilience assessment

CONCLUSION AND FURTHER RESEARCH

The results we have obtained confirm that the FMEA can be successfully used for assessment and control of Supply Chain Resilience improvement process. Based on the results coming from our previous activity - assessment of Supply Chain Resilience perception in various industries [10] we may continue on deployment of FMEA method use within operation of the Supply Chain together with modified QFD / Resilience House [3].

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