Enterprise Cost/Benefit Risk Analysis Using FMEA

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INTRODUCTION

A large body of knowledge covering enterprise integration architectures, modelling, and methodologies (EIAM&M) has been developed covering various types of enterprises. Most viewpoints have been either static or cycle based, with the major drivers being design and implementation of computer integrated manufacturing (CIM) plant and major engineering projects including virtual enterprises (Bernus & Nemes, 1996, p. 377-450; Whitman & Huff, 1997; Williams, Rathwell, & Li, 2001).

While a focus on interoperability and an agreed ontology is essential to the success of EIAM&M in these types of industry, there is a lack of uptake in many other enterprises (Whitman, 1999; Whitman & Huff, 2001).

Practical observation in consulting shows the major requirement of service- and knowledge-based industries is financial and economic efficiency, rather than interoperability as in a CIM plant. To meet these practical needs, an enterprise architect or modeller requires a set of financial and economic metrics to help judge whether an existing or proposed architecture is optimal. One major area requiring optimization is that of cost benefit based risk analysis & management.

Reference frameworks such as GERAM (ISO/IS 15704:2000), the Zachman Framework (Zachman, 1987), CIMOSA (CEN ENV 40003), PERA (Williams, Rathwell, & Li, 2001), etc., do not intrinsically highlight or provide suitable dynamic or time varying economic or financial metrics, or views that can be used for risk assessment or mitigation. These must be "bolted on" by adding extra dimensions to the frameworks. In the case of GERAM and PERA, there is no intrinsic time dimension, other than the overall life cycle. In the case of Zachman, the top level matrix has a time dimension, but no suitable statistically based risk/cost dimensions.

Practical consulting experience has shown that management of business risks require the addition of dynamic, cost based risk mitigation views and management methodologies, comprising a mix of:

- Market research and awareness
- Strategic analysis
- Threat analysis
- Cost benefit decision making
- Financial engineering
- Use of quantifiable statistical analysis across all of these areas

One metric that has been found to be useful as a practical enterprise management tool in these areas is the mapping of failure mode effects analysis (FMEA) and related techniques to the enterprise's financial and business operational areas.

The literature shows extensive use of these methodologies in engineering and safety (Goddard, 1993; McDermott, Mikulak, & Beauregard, 1996; Onodera, 1997), extensions into software engineering (Banerjee, 1995; Reifer, 1979), as well as recent applications in medical areas (DeRosier et al., 2002; Krouwer, 2004). However there does not appear to be much literature covering the practical application of FMEA for commercial risk mitigation in enterprise modelling for business process and enterprise structure design and validation.

A particular advantage of FMEA techniques is the ability to provide quantitative assessment and management of enterprise wide risks. They may also be used to assess and validate proposed enterprise changes or designs.

This article presents the practical extension and re-mapping of the classical engineering and safety based FMEA and failure mode risk analysis (FMRA) to generate suitable cost benefit metrics for financial or economic risk assessment and mitigation across either stand alone, networked, or virtual enterprises.

BACKGROUND

FMEA & FMRA Overview

Originating in engineering design, failure mode and effects analysis (FMEA), failure mode risk analysis (FMRA), failure tree analysis, and failure modes, effects, and criticality analysis (FMECA) are methodologies designed to identify potential failure modes for a product or process; to assess the risk associated with those failure modes; to rank the issues in terms of importance, and to identify and carry out corrective actions to address the most serious concerns first.

See *The basics of FMEA* (McDermott et al., 1996) for a comprehensive treatment of this subject. The following is a typical high-level description of the methodology.

FMEA is an analytical technique, which explores the effects of failures or malfunctions of individual components or processes in a system (i.e., "If this part/component/process fails, in this manner, what will be the result?"

Although the purpose, terminology, and other details can vary according to the type of system, the basic methodology is similar for all types of systems.

First, the system under consideration must be defined so that system boundaries are established. Then the essential questions are:

- Whether and how each component/process/part can fail?
- What might cause these modes of failure?
- What will the effects be if the failures did occur?
- How serious are these effects?

The level of risk is determined by:

Risk = probability of failure x severity of effects

where severity might be categorized as:

Category	Severity	Comment
1	Minor	Functional failure of part of machine or process--no potential for damage to the system or injury
2	Critical	Failure will probably occur without major damage to system or serious injury
3	Major	Major damage to system and/or potential serious injury to personnel
4	Catastrophic	Failure causes complete system loss and/or potential for fatal injury

And failure probability might be categorized as:

Level	Quantitative Probability	Qualitative Probability	Comment
A	10^{-1}	Frequent	Likely to occur frequently
B	10^{-2}	Probable	Likely to occur several times in the life of an item
C	10^{-3}	Occasional	Likely to occur sometime in the life of an item
D	10^{-4}	Remote	Unlikely to occur but possible
E	10^{-5}	Improbable	So unlikely that occurrence may not be experienced
F	10^{-6}	None	The probability of 10^{-6} is generally taken to be the level for "zero risk"

It is preferable to use quantitative figures if they are available, both for severity of effects and failure probabilities. In many cases, this is possible, particularly if previous operational statistics are available. However, qualitative analysis is still useful and will assist in risk minimization and management in any case.

A failure mode risk analysis assessment may then be prepared based on the FMEA and summarized by management as a list with high probability/high severity items [A4] at the top to low probability/low severity items [F1] at the bottom.

Items are then actioned, or risk mitigation steps taken, from the top of the list downward, as resources (funds, staff, time, material, etc.) permit. It is also possible for management to decide not to continue below a certain level on the list, as the costs would outweigh any benefits.

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