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Types of Risk in a System Engineering Environment and Software Tools for Risk Analysis

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Abstract

Every day, companies are exposed to various types of risk. They can be connected to property, liability of third parties, staff or decisions; risk is the usual companion in every business and with direct influence on result. In the paper different types and categories of risks are explained in a great detail. The essential aspects and characteristics of risks are systematically described and discussed. For better decision making the introduction of the software tool RISK is shown and argumented.

Keywords: uncertainty; risk; decision making; organisation; software tools; risk analysis

1. Introduction

Risk is the potential of loss resulting from a given action, activity and/or inaction. Usually we have a choice having an influence on the outcome. Exact definition of risk is given within ISO 31000 family of standards. Risk is defined by two characteristics of a possible negative future event: probability of occurrence (whether something will happen) and consequences of occurrence (how catastrophic if it happens). If the probability of occurrence is not known then one has uncertainty and the risk is undefined.

The computerization of the workplace and the levels of IT dependency that now exist means the risks associated with the failure of IT systems owe one of the most potent sources of operational risk within any organization (see Fig. 1 for development risk). Globalization, too, has added new risks, especially those associated with pollution, the environment and the exploitation of workforces [1].

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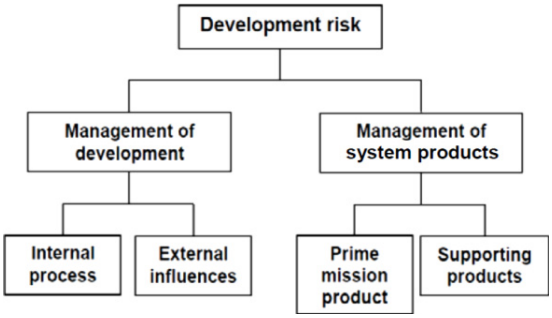


Fig. 1. Risk hierarchy (in development).

People are always on the frontline and in the background of events. Human factor is a kind of a driving force or essential matter in our thinking, decision making and acting. The person is expected to be economical, and humane, but his nature also allows the fulfillment of different drives in business decisions [2].

Systems engineering management related risks could be related to the system products or to the process of developing the system [3].

Risk management in quickly changing environment is a requirement, for it contributes to reaching strategic advantages of a company [4].

2. Risks

Risk can be defined as the combination of the probability of an event and its consequences. In all types of undertaking, there is the potential for events and consequences that constitute opportunities for benefit (upside) or threats to success (downside). For the systems is very important to recognize different type of risks and evaluate them [5].

2.1. Type of risks

Risks related to the system development generally are traceable to achieving life cycle customer requirements.

Product risks include both end product risks that relate to the basic performance and cost of the system and to enabling products that relate to the products that produce, maintain, support, test, train and dispose of the system.

Risks relating to the management of the development effort can be technical management risk or risk caused by external influences [6].

Risks dealing with the internal technical management include those associated with schedules, resources, work flow, on time deliverables, availability of appropriate personnel, potential bottlenecks, critical path operations and the like [7].

Risks dealing with external influences include resource availability, higher authority delegation, level of program visibility, regulatory requirements and the like.

2.2. Categories of risks

Strategic risk – this is associated with those risks that can affect the strategic direction and survival of the organization. Factors that play into this category include the macroeconomic risks created by the fiscal policies of central and federal governments, as well as the impacts of disruptive technologies, such as the Internet. Such risks are also associated with poor business decisions and direction setting and extend to such things as mergers and acquisitions. It is well known, for example, that mergers and acquisitions are notorious for failing, with up to 80 % never realizing the benefits expected of them. Considering the amount of money invested in such ventures, the very fact that so many fail suggests poor risk management [8].

Business / financial risk – this covers those risks that can affect the business in terms of its general financial viability. It includes risks associated with the market in which the organization operates (market risk), as well as the ability to finance growth through loans (credit risk). These risks are generally well understood, with a large number of financial instruments and techniques available to the risk manager [9].

Program and project risk – this is the risk that a major change initiative could fail or the benefits expected of it might not materialize. With an increasing use of projects and programs to drive through change within organizations, this type of risk is often closely associated with strategic risk, as failure can have significant impacts on the organization. Moreover, with the increasing complexity of organizations, managing this type of risk is fast becoming an essential skill [10].

Operational risk – this is a wide-ranging category of risk that includes the failure of any aspect of a business's operations. This includes management failure, system and software failure, human error, process inefficiencies and procedural failures. Although comparatively new, it is recognized as being an important part of an overall risk management framework.

Technological risk – this is different from operational risk in that it is associated with bringing new technology products to market and introducing new technology (and IT systems) into the organizational setting, both of which are high risk ventures [11].

2.3. Another risk categorisation

Technical risk: Design incomplete, environmental analysis incomplete or in error, unexpected geotechnical issues, change requests because of errors, inaccurate assumptions on technical issues in planning stage, surveys late and / or surveys in error, materials / geotechnical / foundation in error, structural designs incomplete or in error, hazardous waste site analysis incomplete or in error, need for design exceptions, consultant design not up to department standards, context sensitive solutions, fact sheet requirements (exceptions to standards).

External Risks: Landowners unwilling to sell priorities change on existing program, inconsistent cost, time, scope and quality objectives, local communities pose objections, funding changes for fiscal year, political factors change, stakeholders request late changes, new stakeholders emerge and demand new work, influential stakeholders request additional needs to serve their own commercial purposes, threat of lawsuits, stakeholders choose time and / or cost over quality.

Environmental Risks: Permits or agency actions delayed or take longer than expected, new information required for permits, environmental regulations change, water quality regulation changes, reviewing agency requires higher-level review than assumed, lack of specialized staff (biology, anthropology, archaeology etc.) historic site, endangered species, wetlands present, controversy on environmental grounds expected, project in the coastal zone, project on a scenic highway, project near a wild and scenic river, project in a floodplain or a regulatory floodway, quality at the program and plan level, water quality issues, negative community impacts expected, hazardous waste preliminary site investigation required, growth inducement issues, cumulative impact issues, pressure to compress the environmental schedule.

Organizational Risks: Inexperienced staff assigned, losing critical staff at crucial point of the project, insufficient time to plan, unanticipated project manager workload, internal "red tape" causes delay getting approvals, decisions, functional units not available, overloaded, lack of understanding of complex internal funding procedures, not enough time to plan, priorities change on existing program, new priority project inserted into program, inconsistent cost, time, scope and quality objectives [12].

Project Management Risks: Project purpose and need is poorly defined, project scope definition is poor or incomplete, project scope, schedule, objectives, cost and deliverables are not clearly defined or understood, no control over staff priorities, too many projects, consultant or contractor delays, estimating and / or scheduling errors, unplanned work that must be accommodated, communication breakdown with project team, pressure to deliver project on an accelerated schedule, lack of coordination / communication, lack of upper management support, change in key staffing throughout the project, inexperienced workforce / inadequate staff / resource availability, local agency issues, public awareness/support, agreements [13, 14].

Right of Way Risks: Utility relocation may not happen in time, freeway agreements, railroad involvement,

objections to right of way appraisal takes more time and / or money.

Construction Risks: Inaccurate contract time estimates, permit work windows, utility, surveys, buried man-made objects / unidentified hazardous waste.

Regulatory Risks: Water quality regulations change, new permits or new information required, reviewing agency requires higher-level review than assumed [15].

3. Decision making and software tools for risk analysis

Making the right decision means performing risk analysis. Risk analysis is systematic use of available information to determine how often specified events may occur and the magnitude of their consequences. The goal of any of these methods is to help the decision-maker choose a course of action, given a better understanding of the possible outcomes that could occur. By exploring the full space of possible outcomes for a given situation, a good risk analysis can both identify pitfalls and uncover new opportunities. Risk analysis can be performed qualitatively or quantitatively. Qualitative risk analysis generally involves assessing a situation by instinct or filling and is characterized by descriptive statements. Quantitative risk analysis attempts to assign numeric values to risks, either by using empirical data or by quantifying qualitative assessments. We will focus on quantitative risk analysis.

3.1. RISK software tool

RISK is the risk analysis add-in for Microsoft Excel. As an add-in, RISK becomes seamlessly integrated with the user's spreadsheet, adding risk analysis to existing models. Working with RISK is as easy as working in Excel. Explorer-style lists, tabbed reports, toolbars and handy right-click menus make navigating RISK simple. RISK uses a technique known as Monte Carlo simulation to allow the user to take all possible outcomes into account (Fig. 2). The user needs to replace uncertain values in existing spreadsheet model with RISK probability distribution functions. In the software only selected (mainly continuous) probability distribution functions are available. The power of Monte Carlo simulation lies in the distributions of possible outcomes it creates (Fig. 3a). Simply by running a simulation, RISK takes the spreadsheet model from representing just one possible outcome to representing thousands of possible outcomes [16].

RISK provides a wide range of graphing options for presenting the results. The user can create histograms, cumulative curves, area and line graphs all with an intuitive toolbar and right-mouse clicks. Overlay graphs for comparison of several results on one graph or summary graphs that display risk over a range of time or across outputs, can be created. Quick Reports (Fig. 3b) include cumulative graphs, Tornado charts for sensitivity analysis, histograms, and summary statistics. RISK provides the user with Sensitivity and Scenario Analyses to determine which factors cause risk in the model.

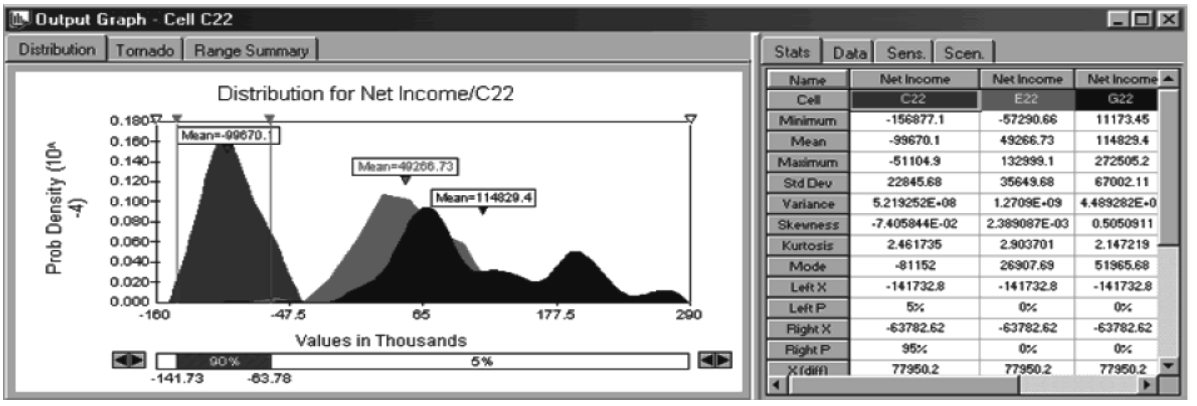


Fig. 2. Example of output graph in RISK application.

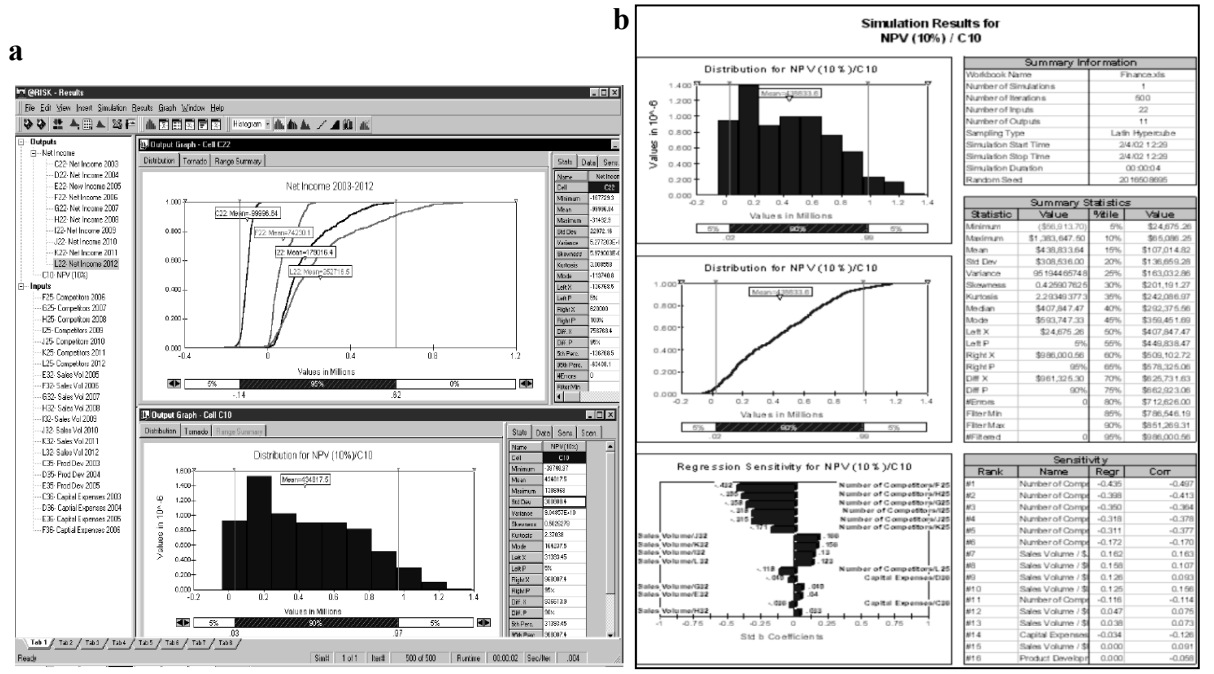


Fig. 3. (a) Presentation of all possible outcomes; (b) Quick Reports in RISK.

3.2. RISK for Project

Any project involves many risks. Projects can go over budget, deadlines can be missed, and money can be lost. RISK for Project seamlessly integrates with Project, adding a new toolbar and new functions. The user needs to replace values or fields in any tasks or resources with RISK probability distribution functions. RISK recalculates the project several times, using random values from the RISK functions and recording the outputs. The result is a distribution of possible outcomes and the probabilities that these values will occur. Simulations in RISK for Project can include multiple projects.

RISK for Project displays user's risk simulation results fully integrated with – and in the same format as – Project's native Gantt charts. New bars indicate the range of possible values for uncertain variables, and display sensitivity and critical index information (Fig. 4).

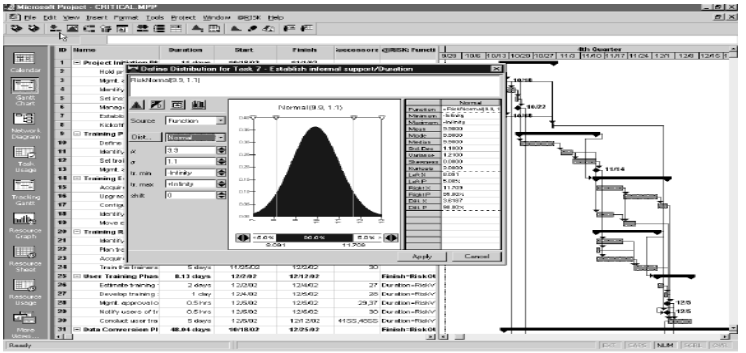
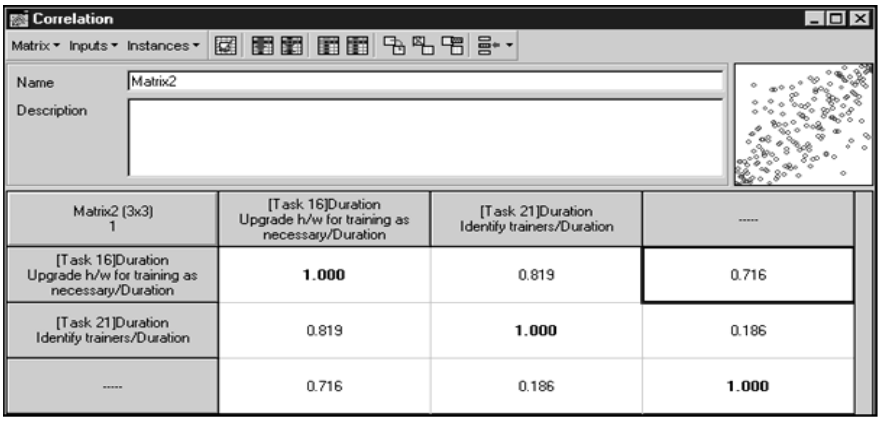


Fig. 4. A pop-up Define Distribution Window over the project model.



Matrix2 (3x3) 1	[Task 16]Duration Upgrade h/w for training as necessary/Duration	[Task 21]Duration Identify trainers/Duration	-----
[Task 16]Duration Upgrade h/w for training as necessary/Duration	**1.000**	0.819	0.716
[Task 21]Duration Identify trainers/Duration	0.819	**1.000**	0.186
-----	0.716	0.186	**1.000**

Fig. 5. Conditional modelling and contingency planning.

The Professional version of RISK for Project includes a set of branching features that enables the user to build in contingency plans if certain events occur (Fig. 5).

RISK for Project provides the user with Sensitivity and Scenario Analyses to determine the critical factors in the models. Integrated risk results in the Project Gantt chart make interpreting much easier (Fig. 6).

4. Conclusion

Risk is inherent in all activities. It is a normal condition of existence. Risk is the potential for a negative future reality that may or may not happen.

Risk can be defined as the combination of the probability of an event and its consequences. In all types of undertaking, there is the potential for events and consequences that constitute opportunities for benefit (upside) or threats to success (downside).

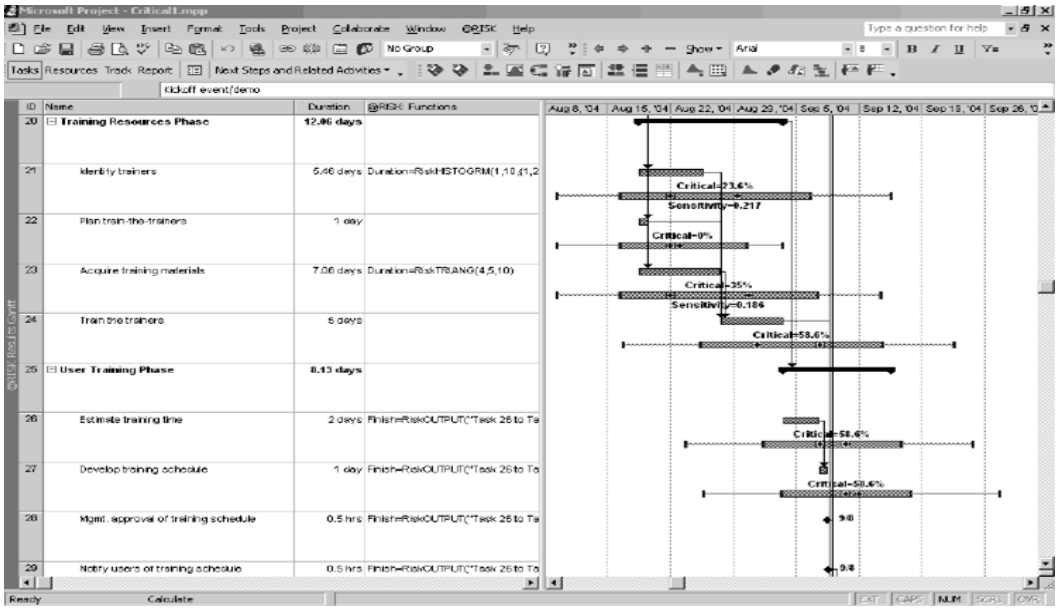


Fig. 6. Integrated risk results in the Project Gantt chart.

Risk is not a problem. It is an understanding of the level of threat due to potential problems. A problem is a consequence that has already occurred. It is very important for that in a time of great uncertainty, in the right time and quickly analyzes the situation with which they arise [17]. That gave us great help computer tools to quickly and professionally support our decisions.

The classification of risks in order to group those with similar risk characteristics is fundamental to any engineering system. In our paper we present and classify the risks which arise in decision making. Later the use of RISK tool is analyzed and discussed.

The basic challenge for future is the creation of unique software tool that would include all in this research used techniques and encompass the entire calculations from the input of required data to the printout of results and drawing of all diagrams and proposed guidelines in decision making. We think that inclusion of artificial intelligence methods and fuzzy logic will be necessary. This will be our main future orientation.

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