Research paper

Using a Risk Breakdown Structure in project management

Received: 13th March, 2003

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Abstract
Risk identification often produces nothing more than a long list of risks, which can be hard to understand or manage. The list can be prioritised to determine which risks should be addressed first, but this does not provide any insight into the structure of risk on the project. Traditional qualitative assessment cannot indicate those areas of the project which require special attention, or expose recurring themes, concentrations of risk, or 'hot-spots' of risk exposure. The best way to deal with a large amount of data is to structure the information to aid comprehension. For risk management, this can be achieved with a Risk Breakdown Structure (RBS) — a hierarchical structuring of risks on the project. The RBS can assist in understanding the distribution of risk on a project or across a business, aiding effective risk management. Just as the Work Breakdown Structure (WBS) is an important tool for projects because it scopes and defines the work, so the RBS can be an invaluable aid in understanding risk. The WBS forms the basis for many aspects of the project management process; similarly, the RBS can be used to structure and guide the risk management process. This paper presents the concept of the RBS, and gives a number of examples drawn from different project types and industries. Although not necessarily based in FM, the concepts and experience can be applied to any project. The benefits of using the RBS are then outlined, including as an aid for risk identification or risk assessment, comparison of projects, providing a framework for cross-project risk reporting,

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and structuring lessons to be learned for future projects. This paper shows how to use the RBS to gain these benefits.

Keywords:
risk management, Risk Breakdown Structure, RBS, WBS, project, structure

INTRODUCING THE RISK BREAKDOWN STRUCTURE

Sources of uncertainty

All projects and businesses are subject to the effects of uncertainty, arising from a multiplicity of sources, including technical, management, environmental, commercial etc. Sources of risk can be external to the project or organisation (such as market risk, or the actions of competitors, suppliers or regulators), or internal (arising from people, processes, procedures, organisational culture etc). Risk management has been recognised as an important management approach to dealing with the inevitable uncertainty, aiming to minimise threats and maximise opportunities while maintaining a focus on achievement of objectives.[1] A number of standard processes exist to provide guidance to businesses wishing to implement risk management,[2–8] and there is considerable convergence on the elements required for the effective management of risk.[9] Recent developments indicate how the standard risk process can be applied to the management of opportunity alongside threat.[10]

The risk management process aims to identify and assess risks in order to enable them to be understood clearly and managed effectively. The key step linking the identification/assessment of risks with their management is understanding. This is, however, the area where the manager or risk practitioner gets least help from current guidelines or practice standards. There are many commonly used techniques for risk identification (see for example Project Management Institute, 2000[11]). These identification techniques, however, tend to produce an unstructured list of risks which often does not directly assist the manager in knowing where to focus risk management attention. Qualitative assessment can help to prioritise identified risks by estimating probability and impacts, exposing the most significant risks, but this deals with risks one at a time and does not consider possible patterns of risk exposure, and so also does not provide an overall understanding of the risk faced by the project or business as a whole.

In order to understand which areas might require special attention, and whether there are any recurring risk themes, or concentrations of risk, it would be helpful if there was a simple way of describing the structure of risk exposure.

The need for structure

In any situation where a great deal of data are produced, structuring is an essential strategy to ensure that the necessary information is generated and understood. The most obvious demonstration of the value of structuring within project management is the Work Breakdown Structure (WBS), which is recognised as a major tool for the project manager, because it provides a means of

structuring the work to be done to accomplish project objectives. The Project Management Institute defines a WBS as 'a deliverable-oriented grouping of project elements that organises and defines the total work scope of the project. Each descending level represents an increasingly detailed definition of the project work.'[12,13] The aim of the WBS is to present project work in hierarchical, manageable and definable packages to provide a basis for project planning, communication, reporting and accountability.

In the same way, risk data can be organised and structured, to provide a standard presentation of risks which facilitates understanding, communication and management. Several attempts have been made previously to organise various aspects of risk, mostly concentrating on the sources from which risk arises. Most of these, however, are simple linear lists of potential sources of risk, providing a set of headings under which risks can be arranged (sometimes called a risk taxonomy). Examples include a generic risk taxonomy,[14] and specific versions for construction projects,[15] large projects,[16] and international development projects,[17] as well as lists of risk categories or risk types in international standards and guidelines.[18–21]

A simple list of risk sources does not provide the richness of the WBS, since it only presents a single level of organisation. A better solution to the structuring problem for risk management would be to adopt the full hierarchical approach used in the WBS, with as many levels as are required to provide the necessary understanding of risk exposure to allow effective management. Such a hierarchical structure of risk sources should be known as a Risk Breakdown Structure (RBS). Following the pattern of the WBS definition above, the RBS has been defined as 'A source-oriented grouping of risks that organises and defines the total risk exposure of the project or business. Each descending level represents an increasingly detailed definition of sources of risk.'[22] The RBS is therefore a hierarchical structure of potential risk sources. The value of the WBS lies in its ability to scope and define the work to be done on the project; similarly, the RBS can be an invaluable aid to understanding the risks faced by the project or business. Just as the WBS forms the basis for many aspects of the project management process, so the RBS can be used to structure and guide the risk management process.[23] Forthcoming updates to risk management guidelines are starting to include the RBS as a key concept (for example, Project Management Institute 2004[24]).

Defining the RBS

EXAMPLES OF RBS STRUCTURES

Some authors and practitioners have gone further in structuring risk than simply listing types of risk faced by a project. These have produced hierarchical structures under various names to describe sources of risk, or risk categories or types, though these are usually focused on a particular project type or application area. Examples include the 'risk taxonomy' for software development projects from the Software Engineering Institute,[25] a 'risk identification list' for

Table 1: RBS for software development (after Dorofee *et al.*[29])

Level 0	Level 1	Level 2	Level 3
Project risk	Product engineering	Requirements	Stability
			Completeness
			Feasibility
			etc.
		Design	Functionality
			Interfaces
			Testability
			etc.
		Code & unit test	Feasibility
			Testing
			Coding/implementation
			etc.
		Integration test	Environment
			Product
			System
			etc.
		Engineering specialities	Maintainability
			Reliability
			Security
			etc.
	Development environment	Development process	Formality
			Process control
			Product control
			etc.
		Development system	Capacity
			Reliability
			System support
			etc.
		Management process	Planning
			Project organisation
			Management experience
			etc.
		Management methods	Monitoring
			Configuration management
			Quality assurance
			etc.
		Work environment	Cooperation
			Communication
			Morale
			etc.
	Program constraints	Resources	Staff
			Budget
			Facilities
			etc.
		Contract	Type of contract
			Restrictions
			Dependencies
			etc.
		Program interfaces	Customer
			Subcontractors
			Corporate management
			etc.

an extra high voltage transmission line construction project,[26] a 'risk identification breakdown structure' for construction projects,[27] and a 'risk-based taxonomy' for large engineering projects.[28] Each of these structures contains three or four hierarchical levels to describe the types of risk faced by the project in question, and so could in fact be described as RBSs. Tables 1 and 2 present two of these examples.

A more general approach was taken in the Universal Risk

Table 2: RBS for construction design (after Chapman[30])

Level 0	Level 1	Level 2	Level 3
Project risk	Environment	Statutory	Planning approval delay
			Legislation changes
			Ecological constraints
			etc.
	Industry	Market	Increase in competition
			Change in demand
			Cost/availability of raw materials
			etc.
	Client	Client team	Client representative fails to perform duties
			No single point of contact
			Client team responsibilities ill-defined
			etc.
		PM team	Inadequate project management controls
			Incorrect balance of resources & expertise
			PM team responsibilities ill-defined
			etc.
		Targets	Project objectives ill-defined
			Project objectives changed mid-design
			Conflict between primary & secondary objectives
			etc.
		Funding	Late requirement for cost savings
			Inadequate project funding
			Funds availability does not meet cashflow forecasts
			etc.
		Tactics	Brief changes not confirmed in writing
			Change control procedure not accepted
			Unable to comply with design sign-off dates
			etc.
	Project	Team	Poor team communication
			Changes in core team
			Inadequate number of staff
			etc.
		Tactics	Cost control
			Time control
			Quality control
			Change control
		Task	Site
			Design

Project undertaken jointly by the Risk Management Specific Interest Group of the Project Management Institute (PMI Risk SIG) and the Risk Management Working Group of the International Council On Systems Engineering (INCOSE RMWG), who produced a structured list of 'universal risk areas' which might apply to any type of project in any sector of industrial, government or commercial activity.[31] This structure can also be represented as a RBS, as summarised in Table 3.

Specific RBS for project types

This author has also produced specific RBS structures for consultancy clients in various industries with different project types, including defence software development, energy supply, pharmaceutical vaccine development, construction management, general engineering, and telecommunications. Examples are presented in Tables 4–6.

Each of these RBS structures is different, reflecting the range of possible sources of risk exposure for projects in various sectors and industries. It is therefore necessary for any organisation wishing to use the RBS as an aid to its risk management to develop its own

Table 3: RBS for generic projects (after Hall and Hulett[32])

Level 0	Level 1	Level 2	Level 3
Project risk	Management	Corporate	History/experience/culture
			Organisational stability
			Financial
			etc.
		Customer & stakeholder	History/experience/culture
			Contractual
			Requirements definition & stability
			etc.
	External	Natural environment	Physical environment
			Facilities/site
			Local services
			etc.
		Cultural	Political
			Legal/regulatory
			Interest groups
			etc.
		Economic	Labour market
			Labour conditions
			Financial market
			etc.
	Technology	Requirements	Scope uncertainty
			Conditions of use
			Complexity
			etc.
		Performance	Technology maturity
			Technology limits
			etc.
		Application	Organisational experience
			Personnel skill sets and experience
			Physical resources
			etc.

tailored RBS. The more generic versions mentioned above might be used as a starting point, but these are unlikely to include the full scope of possible risks to every project, so they must be modified accordingly. An organisation may wish to produce a single generic RBS covering all its projects, or there may be several different RBS structures applying to particular project types. Large projects may require their own specific RBS.

HOW TO USE THE RISK BREAKDOWN STRUCTURE

Once an organisation or project has defined its RBS, it can be used in a variety of ways. Some of these facilitate the risk management process on a particular project, while others are relevant across projects. The main uses and benefits of the RBS are outlined in the following paragraphs.

Risk identification aid

RBS as prompt list

The upper levels of the RBS can be used as a prompt list to ensure complete coverage during the risk identification phase. This is accomplished by using the RBS to structure whichever risk

Table 4: RBS for energy supplier

Level 0	Level 1	Level 2	Level 3
Project risk	Technical	Requirement specification	Specification may be inadequately defined
			Change control procedures may be unclear
			etc.
		Technology	Technology may become obsolete
			Capability may not be available
			etc.
		Complexity and interfaces	Complex design may unduly affect future maintenance
			Interface complexity of project may be unacceptable
			etc.
		Performance	Criteria for acceptable performance may not be defined
			Equipment may not be fit for purpose
			etc.
		Reliability	May be unable to meet reliability requirements
			Unsuitable modifications may affect reliability
			etc.
		Quality	Available materials may be of insufficient quality
			QA procedures and standards may be inadequate
			etc.
		Safety	Safety may not be considered in design
			Employees without correct knowledge to work safely
			etc.
		Security	Fire may cause delay or additional cost
			Equipment may be stolen or vandalised
			etc.
	Management	Strategy	Company strategy could change
			Project strategy may be ill-defined
			etc.
		Organisation	Projects objectives may conflict within organisation
			Organisation may change project objectives
			etc.
		Project management	Project planning may be inadequate
			Inaccurate estimates may cause overspends
			etc.
		Resources	Unplanned loss of manpower (sickness or resignation)
			May be unable to obtain competent staff
			etc.
		Communication	Unclear communication may cause work omissions
			Inadequate communication channels may be available
			etc.
		Information	Sub-contractors may lack the required knowledge
			Irrelevant information may cause information overload
			etc.
		Health, Safety and Environment	May not communicate HS&E Regulations to employees
			May be unable to meet environmental regulations
			etc.
	Commercial	Contractual	Contract specifications may be poor
			Contract T&Cs may be inappropriate
			etc.
		Financial	Interest rate fluctuations may occur
			Cashflow may not be acceptable
			etc.
		Regulatory	Possible change of requirements by Regulator
			May not comply with existing regulations
			etc.
		Consents	Delay may occur in receiving consent
			Consent achieved may be heavily qualified/conditioned
			etc.
		Reputation	Unplanned outages may occur affecting reputation
			May damage reputation causing share value to fall
			etc.

Table 5: RBS for pharmaceutical projects (vaccine development)

Level 0	Level 1	Level 2
Project risk	Regulatory	Approvals
		Filing
	Process	Expression
		Fermentation
		Downstream
		Formulation
		Analytics
		Stability
		Scaling up
	Pre-clinical	Immune response
		Immunoassays
		Animal models
	Clinical	Clinical study development plan
		Read-outs
		Target population
		Reactogenicity
		Medical
	Marketing	Costs
		Competition
		Commercial
		Market assessment
	Management	Team
		Core technologies
		Collaboration
		Strategic fit
		Intellectual Property
		Organisation
		Milestones

identification method is being used. For example, a risk identification workshop or brainstorm might work through the various elements of the RBS, perhaps at the first or second levels, encouraging participants to identify risks under each of the RBS areas. Similarly, the RBS major areas can be used to structure risk identification interviews, providing an agenda for discussion between the facilitator and interviewees.

RBS as checklist

A risk identification checklist can also be developed based on the RBS, by taking each of the lowest RBS levels and identifying a number of generic risks in each area based on previous experience. Future projects can then determine whether each generic risk applies, answering 'Yes', 'No', 'Don't know' or 'Not applicable'.

In addition, the RBS can be used to structure lists of risks identified by other methods, by mapping identified risks into the lowest levels of the RBS. This reveals possible gaps or blind spots in risk identification, and exposes any double counting or duplication. It can determine whether the risk identification method has considered all potential sources of risk, and indicate whether additional risk identification activity is required.

Ensuring complete risk identification

Using the RBS to structure the risk identification task provides assurance that all common sources of risk to the project objectives have been explored, assuming that the RBS is complete. The danger that this assumption is incorrect can easily be overcome by

Table 6: RBS for engineering (contracting organisation)

Level 0	Level 1	Level 2
Project risk	Technical	Scope definition
		Requirements definition
		Technical processes
		Technical interfaces
		Technology
		Performance
		Reliability
		Safety and security
		Test and acceptance
	Management	Project management
		Organisation
		Resourcing
		Communication
		Information
		Health, Safety and Environment
		Reputation
	Commercial	Contractual T&Cs
		Financing
		Liabilities and warranties
		Payment terms
	Commercial	Suspension and termination
		Internal procurement
		Subcontracts
		Applicable law
		Partnering
		Legislation
		Regulatory
		Exchange rates
		Site/facilities
		Competition
	External	Weather
		Political
		Country
		Pressure groups
		Force majeure

including a short additional risk identification effort for 'Other risks' not covered by the RBS.

Risk assessment

Assessing risk hot-spots

Identified risks can be categorised by their source by allocating them to the various elements of the RBS. This then allows areas of concentration of risk within the RBS to be identified, indicating which are the most significant sources of risk to the project. This can be determined by simply counting how many risks are in each RBS area. A simple total number of risks can be misleading, however, since it fails to take account of the relative severity of risks. Thus, one RBS area might contain many risks which are of minor severity, whereas another might include fewer major risks. A better measure of risk concentration within the RBS is therefore a 'risk score' of some sort, based on the scale or size of each individual risk. A common method is the P–I score, where numerical scores are associated with rankings of probability (P) or impact (I), then multiplied to give a combined value reflecting both

factors. The risk management chapter of the Project Management Body of Knowledge (PMBoK) describes one such scoring scheme based on probability and impact.[33] Concentration of risks within the RBS areas can then be assessed by comparing the total 'risk score' for those risks within each area. This is likely to give a more meaningful perspective than a simple total count of risks, indicating which RBS areas are giving rise to more risk to the project.

Additional assessment insights

Categorising risks according to the RBS provides a number of additional insights into the assessment of risk exposure on the project, which would not be available from a simple list of risks, even if the list were prioritised. These include:

— understanding the type of risk exposure on the project
— exposing the most significant sources of risk to the project
— revealing root causes of risk, via affinity analysis
— indicating areas of dependency or correlation between risks
— focusing risk response development on high-risk areas
— allowing generic responses to be developed for root causes or dependent groups of risks.

Comparison of projects or tenders

Risk exposure on different projects or competing tenders can be directly compared since the RBS presents a common framework. The RBS allows risks identified on each project or tender to be structured in the same way, permitting direct comparison. In the case of tender evaluation, risks can be identified for competing tenders and then structured using a common RBS. Instead of trying to compare unstructured lists of risks for each tender, the amount and types of risk associated with each option are presented in a consistent format, allowing the relative risk exposure to be considered when the preferred tender is being selected. Similarly, the risk exposure of individual projects within a related programme or portfolio can be compared using a common RBS to allow them to be prioritised or ranked on the basis of their associated risk exposure, or to permit construction of a risk-balanced portfolio.

Tender evaluation

Risk balanced portfolio

Risk reporting

The RBS can be used to roll-up risk information on an individual project to a higher level for reporting to senior management, as well as drilling down into the detail required to report on project team actions. Reports to senior management may include total numbers of risks or total risk score in each higher-level RBS area, perhaps with metrics or trend analysis presented graphically. Project teams can also be notified of risks within their part of the project by selecting relevant RBS areas for each team member.

Multi-level reporting

The RBS can also be used to provide cross-project or multi-project reports to senior management, since it provides a consistent language for risk reporting, removing or reducing the potential for misunderstanding or ambiguity between projects. Risks within the

same RBS area can be directly compared across projects, since it means the same for all projects. This can be further enhanced by using an RBS-based numbering scheme to identify risks.

Lessons learned for future projects

One of the most difficult tasks in the post-project review is to structure the information so that it can be referenced and used by future projects. Many organisations lose the benefits of such reviews, since the information is not held in an accessible format.

Common framework for lessons learned

The RBS can provide a common format for analysing risk-related information from each post-project review. An RBS-based analysis will reveal risks which occur frequently, allowing generic risks to be identified and recorded for future reference, together with effective responses. If routine analysis of post-project reviews indicates that a particular risk is occurring repeatedly, then preventative responses can be developed and implemented. Risk identification checklists can also be updated and maintained to include common or generic risks exposed by an RBS-based analysis of post-project review data.

CONCLUSION

Successful and effective risk management requires a clear understanding of the risks faced by the project and business. This involves more than simply listing identified risks and characterising them by their probability of occurrence and impact on objectives. The large amount of risk data produced during the risk process must be structured to aid its comprehension and interpretation, and to allow it to be used as a basis for action. A hierarchical RBS framework similar to the WBS provides a number of benefits, by decomposing potential sources of risk into layers of increasing detail. The RBS is a powerful aid to risk identification, assessment and reporting, and the ability to roll-up or drill-down to the appropriate level provides new insights into overall risk exposure. A common language and terminology facilitates cross-project reporting and lessons learned. The RBS has the potential to become the most valuable single tool in assisting the manager to understand and manage risks to the project or business. The approach outlined in this paper shows how to use the RBS to gain these benefits.

Benefits of RBS

ACKNOWLEDGMENTS

A previous version of this paper was presented to the 2002 Project Management Institute Annual Seminars & Symposium.[34]

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