MASTERS OF BUSINESS ADMINISTRATION

PROJECT MANAGEMENT

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Session 2 Handout

Session 2- 5:00 pm to 9:00 pm	
5:00 pm to 5:50 pm	Project Methodologies • PMI-PMBok Recap • Prince 2 • Agile vs Waterfall
5:50 pm to 6:00 pm	**Coffee/Tea- Break**
6:00 pm to 6:50 pm	Project Charter • Purpose • Project Charter Template
6:50 pm to 7:00 pm	**Coffee/Tea- Break**
7:00 pm to 7:50 pm	Stakeholder Management • Identification of Stakeholders • Stakeholder Analysis • Stakeholder Involvement
7:50 pm to 8:00 pm	**Coffee/Tea- Break**
8:00 pm to 8:50 pm	Project Risk Management • Risk Identification • Risk Analysis and Mitigation • Risk Register Template
8:50 pm to 9:00 pm	Look at the Assignment • Understanding the Requirements • Initial Report Structure

PRINCE2® in one thousand words

Andy Murray, lead author of PRINCE2 (2009) and Director of Outperform UK Ltd

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AXELOS GLOBAL BEST PRACTICE

Outperform making strategy reality

White Paper
September 2011

Contents

1 What is PRINCE2®?

PRINCE2 is a non-proprietary method used extensively in more than 150 countries around the world, and its take-up grows daily. It is widely considered as the leading method in project management, with in excess of 20,000 organizations already benefiting from its pioneering and trusted approach. This is largely due to the fact that PRINCE2 is truly generic: it can be applied to any project regardless of scale, type, organization, geography or culture.

PRINCE2 comprises a set of principles, a set of control themes, a process lifecycle and guidance on matching the method to the project's environment (see Figure 1).

PRINCE2 provides a process model for managing a project. This consists of a set of activities that are required to direct, manage and deliver a project.

2 Benefits of PRINCE2

PRINCE2 provides the following benefits:

- PRINCE2 can be applied to any type of project
- It provides a common vocabulary and approach
- PRINCE2 integrates easily with industry-specific models
- The product focus clarifies for all parties what the project will deliver to agreed quality standards
- PRINCE2 applies 'management by exception' providing efficient use of senior management time
- It ensures a focus on the continuing viability of the project
- There are scores of accredited training and consultancy organizations operating worldwide, which can supply expert support for PRINCE2 projects or for organizations planning to adopt PRINCE2
- It provides explicit definitions of roles and responsibilities so that everyone understands what is expected of them and what to expect of others.

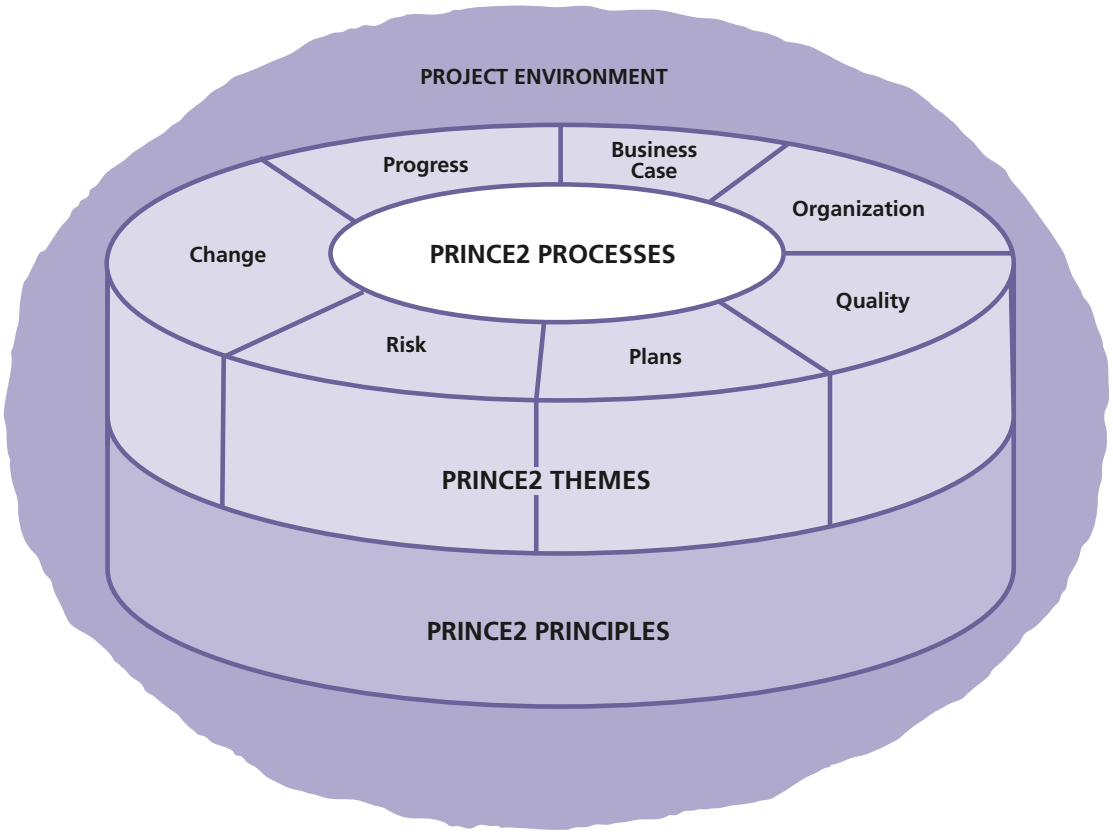

Figure 1 Structure of PRINCE2

3 Principles

The PRINCE2 principles are the guiding obligations for good practice that a project should follow if it is using PRINCE2. These are derived from lessons, both good and bad, that have affected project success.

The principles provide a framework of good practice for those people involved in a project – ensuring that the method is not applied in an overly prescriptive way or in name only, but applied in a way sufficient to contribute to the success of the project.

Principle	Definition
Continued business justification	A PRINCE2 project has continued business justification
Learn from experience	PRINCE2 project teams learn from previous experience (lessons are sought, recorded and acted upon throughout the life of the project)
Defined roles and responsibilities	A PRINCE2 project has defined and agreed roles and responsibilities with an organizational structure that engages the business, user and supplier stakeholder interests
Manage by stages	A PRINCE2 project is planned, monitored and controlled on a stage-by-stage basis
Manage by exception	A PRINCE2 project has defined tolerances for each project objective to establish limits of delegated authority
Focus on products	A PRINCE2 project focuses on the definition and delivery of products, in particular their quality requirements
Tailor to suit the project environment	PRINCE2 is tailored to suit the project's size, environment, complexity, importance, capability and risk

4 Themes

The PRINCE2 themes are those aspects of project management that need to be addressed continually throughout the project lifecycle (i.e. not once only). They provide guidance on how the process should be performed. For example, numerous processes in PRINCE2 involve creating or approving plans and explanatory guidance on this can be found in the plans theme.

The set of PRINCE2 themes describes:

- How baselines for benefits, risks, scope, quality, cost and time are established (in the Business Case, quality and plans themes)
- How the project management team monitors and controls the work as the project progresses (in the progress, quality, change and risk themes).

The organization theme supports the other themes with a structure of roles and responsibilities with clear paths for delegation and escalation.

Theme	Questions answered by the theme
Business Case	Why?
Organization	Who?
Quality	What?
Plans	How? How much? When?
Risk	What if?
Change	What's the impact?
Progress	Where are we now? Where are we going? Should we carry on?

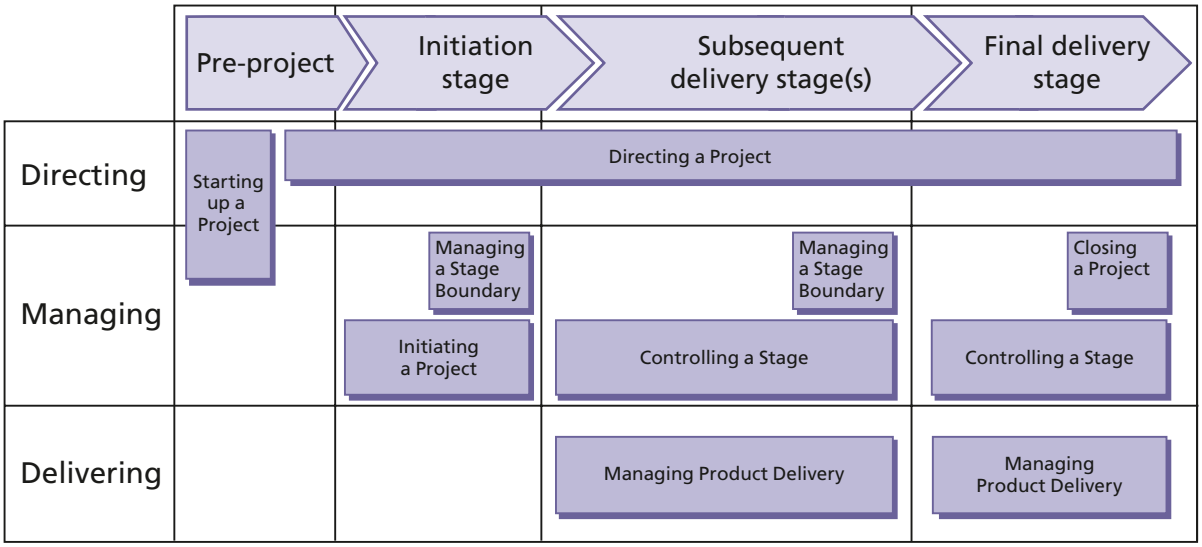

Figure 2 PRINCE2 process model

5 Processes

PRINCE2 provides a process model for managing a project. This consists of a set of activities that are required to direct, manage and deliver a project.

Starting up a Project: Covers the pre-project activities required to commission the project and to gain commitment from corporate or programme management to invest in project initiation by answering the question: 'Do we have a viable and worthwhile project?'

Directing a Project: Describes the Project Board's activities in exercising overall project control. The activities focus on the decision making necessary for Project Board members to fulfil their accountabilities successfully while delegating the day-to-day management of the project to the Project Manager.

Initiating a Project: Describes the activities the Project Manager must lead in order to establish the project on a sound foundation. Every PRINCE2 project has an initiation stage. The key deliverable from this stage is the Project Initiation Documentation, which includes an overall Project Plan and defines baselines for the six project performance targets of time, cost, quality, scope, risk and benefits.

Managing a Stage Boundary: Describes the activities the Project Manager must undertake to provide the Project Board with sufficient information to enable it to review the success of the current stage, approve the next Stage Plan, review the updated Project Plan and confirm continued business justification and acceptability of the risks.

Controlling a Stage: Describes how the Project Manager manages the project execution/delivery activity during a stage, and reports progress and exceptions to the Project Board.

Managing Product Delivery: Addresses the Team Manager's role in supervising the detailed work of creating the project's products and provides the link between the Project Manager and the teams undertaking the project work.

Closing a Project: Describes the closure activity towards the end of the final stage of the project. The Project Manager leads the process which provides for an orderly decommissioning, including any remaining project acceptance and handover requirements.

6 The project environment

It is a PRINCE2 principle that the method must be tailored to suit the particular project context.

Tailoring refers to the measures taken to apply the method properly to an individual project, ensuring that the amount of governance, planning and control is appropriate – neither too burdensome for a simple project nor too informal for a large or complex project.

The adoption of PRINCE2 across an organization is known as embedding.

Embedding (done by the organization to adopt PRINCE2)	Tailoring (done by the project management team to adapt the method to the context of a specific project)
Focus on: ● Process responsibilities ● Scaling rules/guidance (e.g. score card) ● Standards (templates, definitions) ● Training and development ● Integration with business processes ● Tools ● Process assurance.	Focus on: ● Adapting the themes (through the strategies and controls) ● Incorporating specific terms/language ● Revising the Product Descriptions for the management products ● Revising the role descriptions for the PRINCE2 project roles ● Adjusting the processes to match the above.

References

Managing Successful Projects with PRINCE2®, TSO, 2009 edition.

Directing Successful Projects with PRINCE2®, TSO, 2009 edition.

The Executive Guide to Directing Projects: Within a PRINCE2® and MSP® environment, TSO, 2009.

About the author

Andy Murray is a chartered director and a registered consultant in PRINCE2, having worked in the field of projects and programmes for over 15 years. Andy was an early adopter of PRINCE2 (in 1997) and has been helping organizations in numerous countries implement and gain value from PRINCE2 ever since.

Andy is the co-author of the PRINCE2 Maturity Model guide and in April 2007 was appointed as lead author for the update to PRINCE2.

He was formerly on the executive committee of the Best Practice User Group and in 2008 received a special merit award for individual contribution to best practice methods.

In 2010 Andy was listed in the *Daily Telegraph*'s annual project management review as one of the most influential people in project management.

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How PRINCE2 Can Complement PMBOK and Your PMP

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Impact Strategies LLC

Abstract

PMBOK is the recognized (de facto) standard of project management knowledge. In the UK and Europe, PRINCE2 is the project management methodology of choice, and is required by the UK government for all projects it commissions. This paper will provide an overview of the PRINCE2 method and examine the similarities and differences between PMBOK and PRINCE2. Finally, it will suggest how these two project management approaches relate to and can complement each other, and how the PRINCE2 approach can provide added value to a PMBOK knowledge base.

About PRINCE2

PRINCE2 (short for "PRojects IN Controlled Environments") is the de facto standard in the UK. It was developed for and is used extensively by the UK government, and is widely used in the private sector, in the UK and internationally. PRINCE2 is in the public domain, offering non-proprietary best-practice guidance on project management. Anyone may use this methodology, and the manual describing PRINCE2 can be purchased through online booksellers, as well as through the UK government website, http://www.ogc.gov.uk/prince. PRINCE2 is supported by a rigorous accreditation process, including accreditation of training organizations, trainers, practitioners and consultants. (The accrediting body is the APM Group, www.apmgroup.co.uk; their website lists approved training organizations, consultants and practitioners.)

PRINCE2 is a Process-based, structured methodology that highlights how eight particular Components, when understood and effectively addressed, can additionally reduce risks in all types of projects. While PRINCE2 is based in the same ground as the PMBOK, it spotlights a number of areas to concretize PMBOK, and answers the question "how do I apply these concepts in my projects?"

The Structure of PRINCE2

PRINCE2 does not claim to be as comprehensive as the PMBOK. PRINCE2 is based on the principles of the PMBOK, as any project management methodology must be. PRINCE2 extracts and focuses on the elements ("components") which it identifies as being crucial to the successful assessment and completion of a project. It constructs a process to tie those elements together to reduce overall project risk, and provides techniques to support them. While "The Guide to the PMBOK" offers a loose, general approach to integrating the Knowledge Areas, PRINCE2 suggests an effective way to organize them. In essence PRINCE2 says: "using *these* elements in *this* way is the most effective way to *reduce project risk* and *maintain quality* within the project."

PRINCE2 components and processes are consistent with the PMBOK, but PRINCE2 does not include all the knowledge areas and details specified in the PMBOK. PRINCE2 focuses on critical areas, so a project manager still needs to draw on the full depth and range of the PMBOK and other sources to complete project management work. The intention of PRINCE2 is to organize and supplement project management knowledge. It assumes that those learning and working with this methodology have a level of experience that enables them to fill in the details that PRINCE2 omits. In PRINCE2 the scale and content of its Processes, Components and Techniques should be adapted to the size and nature of the project.

PRINCE2 Components

PRINCE2 is comprised of 8 elements, or "components". They are: Business Case, Organization, Plans, Controls, Management of Risk, Quality in a Project Environment, Configuration Management, and Change Control. They roughly map against the PMBOK Areas of Knowledge as follows:

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PMBOK Knowledge Area	Comparable PRINCE2 Components
Integration	Combined Processes and Components, Change Control
Scope, Time, Cost	Plans, Business Case
Quality	Quality, Configuration Management
Risk	Risk
Communications	Controls
Human Resources	Organization (limited)
Procurement	Not Covered

Exhibit 1 – Comparison of PMBOK Areas of Knowledge and PRINCE2 Components

These components are not as comprehensively defined as the Areas of Knowledge. For example, PRINCE2 covers PMBOK's Time and Cost Management within its discussion of Plans — but only insofar as the development of time and cost information is necessary at the relevant plan level. The following summarizes the PRINCE2 components:

Business Case: The existence of a viable Business Case is the main control condition for a PRINCE2 project. The Business Case is verified by the Project Board *before* a project begins and at *every* major decision point throughout the project. The project should be stopped if the viability of the Business Case disappears for any reason.

Organization: Since the Project Manager often has to direct staff who report to another management structure, some senior management oversight organization is needed to assure that those diverse resources are committed to the project. In addition, viability decisions need to made by management with an *investment* in the project, and an *accountability* for delivering it through the Project Manager. In PRINCE2 this oversight is the *Project Board*.

Plans: Plans are the backbone of the management information system required for any project, and require the approval and commitment of the appropriate levels of the project organization. The "Plans" component emphasizes the core concepts of planning; the major steps are highlighted in the process model, in "Planning."

Controls: Control is about decision making: its purpose is to ensure that the project (a) is generating the required products which meet defined Acceptance Criteria; (b) is being carried out to schedule and in accordance with its resource and cost plans; and (c) remains viable against its Business Case.

Management of Risk: As project work is inherently less predictable than non-project work, management of the risks is an essential part of project management. To contain risks during the project, they must be managed in a disciplined manner, through risk analysis and risk management (as in the PMBOK).

Quality in a Project Environment: Quality management ensures that the quality expected by the customer is achieved through a quality system (similar to the PMBOK). Quality requirements of the project's deliverables are based in *Product Descriptions*, prepared by the Project Manager and approved by the Project Board.

Configuration Management: Configuration Management gives the project management team control over the project's assets (the products that it develops), and is vital to any quality system. It provides mechanisms for tracking and controlling the project's deliverables, and a system for tracking project Issues.

Change Control: Controlling scope change means assessing the impact of potential changes, their importance, cost, impact on the Business Case, and a decision by management on whether or not to include them.

None of the above components will be alien to a user of the PMBOK —PRINCE2 simply highlights these elements as being central to project success, often under-addressed by project managers. The PRINCE2 methodology organizes these components into a process model, recognizing that *flow and relationship* are critical to successful use of concepts identified in the components (and Knowledge Areas).

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PRINCE2 Process Overview

PRINCE2 Stages

To provide the appropriate decision gates at the right level of the project, PRINCE2 projects are broken down into Stages, much like the Phases of the PMBOK process model. PRINCE2 calls for decisions about the project *as a whole* to be made prior to looking at any developmental work. PRINCE2 differentiates the start up, planning and close for the *overall* Project ("Starting a Project," "Initiating a Project" and "Closing a Project") from the activities to start up and close down *each of the Stages* ("Managing Stage Boundaries").

The actual Executing and Controlling of the developmental work (from Feasibility or Requirements onward) shows up at the *Stage* level, through "Controlling a Stage" and "Managing Product Delivery." Project oversight (by the Project Board) occurs *throughout* the project through "Directing a Project." "Planning" is a generalized process that is accessed at all levels of the project, as needed.

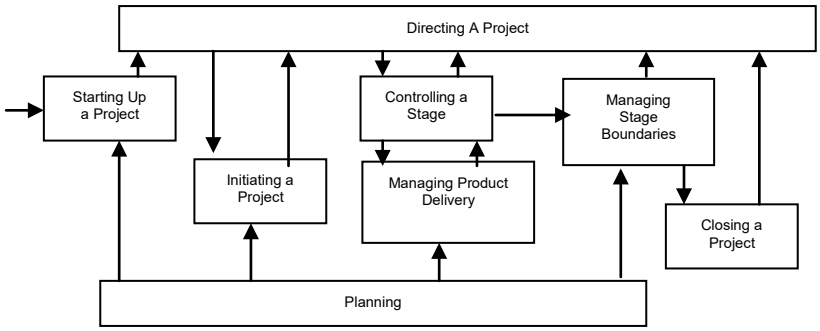

Exhibit 2 – PRINCE2 Process Model

The PRINCE2 Processes (refer to Exhibit 2 for the context of each process.)

"Starting Up a Project" enables a controlled start to the project. It occurs once in the project life cycle, providing the groundwork for project management and oversight, and viability evaluation. This process creates the Project Board, and ensures that resource requirements are understood and committed to the first Stage, "Initiating a Project".

"Directing a Project" operates throughout the project, and defines the responsibilities of the Project Board in its oversight of the project. Like its location in the process model diagram, it sits *above* and interacts with many of the other processes. It provides the mechanisms for authorizing the project, approving continuity at the completion of each Stage, and closure of the project (all based on the Business Case). "Directing a Project" is the framework for supplying input to the project manager, receiving requests from the project manager for information and assistance, and making decisions. This is the only process in which the Project Board is active (other than "Starting Up a Project," when the Board is first formed). All other processes are guided by the Project and Team Managers.

"Initiating a Project" occurs once in the project life cycle. It lays out the view of how the *overall* project is to be managed, and sets it down in a "contract" called the Project Initiation Document (PID). The intention of the PID is to provide a common understanding of the critical elements of the project (similar to the results from PMBOK's Planning process). "Initiating a Project" also calls for resource commitment by the Project Board to the first developmental Stage of the project.

"Planning" is the common process for several other processes in PRINCE2. Plans are produced by identifying the project's required deliverables, the activities and resources necessary to create them, and the management and quality requirements – all at a level consistent with the control requirements identified in the PID. Use of a common module highlights the concept of a consistent, coherent approach to all planning.

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"Controlling a Stage" provides guidance to the Project Manager in managing the project on a day-to-day basis. It includes: work authorization and receipt of work; issue and change management; status collection, analysis and reporting; viability consideration; corrective action; and escalation of concerns to the Project Board and other resources. "Controlling a Stage" is iterative, and is repeated for each developmental Stage of the project.

"Managing Product Delivery" is part of PRINCE2's work authorization system. It is the mechanism for the performers of technical work (teams, individuals and contractors) to agree on work to be performed, report on progress, complete the work, and return it. It occurs as frequently as work packages are authorized.

"Managing Stage Boundaries" manages the transition from the completion of one work Stage to the commencement of the next Stage. It includes assurance that work defined in the Stage has been completed as defined, provides information to the Project Board to assess the ongoing viability of the project (done in "Directing a Project"), develops plans for and obtains authorization for the next Stage of work, and records lessons learned.

"Closing a Project" is the mechanism to transition the project back to the organization. It closes out the project, whether closure is precipitated by completion of the work, or premature termination. In either event, "Closing" picks up lessons learned and project experiences for organizational records. For completed work, its goal is to ensure that (a) the work has been completed to the Customer's and Management's satisfaction, (b) all expected products have been handed over and accepted by the Customer, and (c) arrangements for the support and operation of project products are in place.

PRINCE2 does not have "core" and "facilitating" processes; all components and processes are integrated into a *single* flow, which clarifies the relationships among all of them.

The Strengths of PRINCE2

PRINCE2 has a number of impressive and useful features that distinguish it from other project management methodologies. Its strength lies in its common-sense approach. Each of the following features supplements what the PMBOK provides — through a very specific focus, or by offering a perspective beyond the PMBOK.

Organization and the Project Board

Perhaps the most significant of PRINCE2's features is the concept of the Project Board. PMBOK refers to a 'project sponsor' in general terms, and suggests the role the sponsor should be playing in supporting the project. PRINCE2 is more specific — it calls for a *Project Board* to provide oversight and support in a clearly delineated way. (While PRINCE2 does not *require* the use of any particular feature — such as a Project Board — it does spell out the most robust way to apply that feature, in a manner that would do most to reduce overall risk to the project.)

In most projects, "authority" (the control of resources) is separated from "accountability" (consequences of success or failure): senior management has authority (but often not held accountable for success or failure of the project), while the project manager is held accountable (with insufficient authority over the resources to ensure completion of work). PRINCE2 calls for an accountable Project Board to *own* the project, helping to ensure their commitment to getting the work completed. At the same time, the Project Board grants authority to the Project Manger by explicitly committing resources as the project progresses. The PMBOK suggests this will happen under *certain* organizational structures; PRINCE2 believes it can be implemented in *most* environments.

PRINCE2 proposes management oversight from those who are in the best position to make decisions about project viability. The Project Board is based in representation from the *Business* (speaking for how the project will benefit the organization *as a whole*), the *User* (for value and usability of the project on a functional level) and the *Supplier* (for those who will deliver the solution). These are the roles that can assure the availability of resources (if they are at the proper organizational level), *and are the kind and level of resource that a project manager needs* to resolve issues that arise during a project. Supporting the project manager is part of the Board's role — giving the project manager access to and authority in the parts of the organization needed to ensure success.

The process model calls for the Board to be identified early on, in "Starting Up a Project". PRINCE2 understands that if a Project Board cannot be assembled to represent the above interests (Business, User, Supplier), it is unlikely that there is sufficient support for the project to succeed. (This is an example of how PRINCE2 ties together *what* has to be done with *why* with *when* it should be done to be most effective.)

Business Case-based decision-making

The Business Case (focusing on the *entire* scope of change to the business that is affected by the project) is a PRINCE2 component, but its importance cannot be overemphasized. Responsibility for the Business Case belongs to the Project Board *and* the Project Manager. The Project Board creates and *owns* the Business Case; the Project Manager *provides the information* that enables the Project Board to evaluate it and also ensures that the Business Case is considered in project decisions. PRINCE2 drives home the notion of explicit go/no-go decisions — *based on the Business Case* — in the start-up and initiation of the project, and at the end of each Stage (see Exhibit 3).

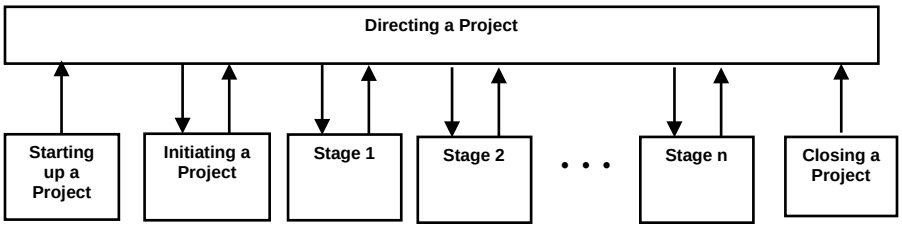

Exhibit 3 – Business Case Review (in "Directing a Project") by the Project Board

Product-Based Planning

The initial element of PRINCE2's Product Based Planning technique — the Product Breakdown Structure — echoes PMBOK's Work Breakdown Structure in identifying the constituent parts of the project deliverables. PRINCE2 continues the logic of focusing on deliverables (since *they* are the goal of the project, *not* the activities), by providing an additional step to this technique: explicating those deliverables through *Product Descriptions*. PRINCE2 calls for a Product Description (for each product/deliverable for which it is needed), comprising these important characteristics: why it is being created; what it is made up of; the source of materials and the tasks needed to create it; what it should look like when it is done; the resources and skills needed to create it; the criteria for accepting it; and how we will make sure that it meets its criteria.

These traits shape and clarify expectations, and help assure the right product will be created the *first* time around, not shaped by afterthoughts. These elements together also serve as a baseline reference for *changes* to the Product. The thoroughness of PRINCE2's Product Descriptions vigorously supplements the PMBOK's approach. This emphasis on Product Descriptions helps ensure that a sound and agreed basis is established for scope management, earned value management, and quality management. Product Descriptions provide clarity for time and resource estimates, and risk management, and they are the core of Work Packages.

Issue Management

One core principle of quality management is that important information should not get lost; PRINCE2 also reminds us that management of Issues is critical to any quality system. PMBOK makes reference to the existence of issues that *need* to be managed, but no mechanism or approach for managing them. PRINCE2 recommends the use of a Log showing details of each Issue: description, evaluation, decisions about it and status. For the "when" of Issue management, PRINCE2 particularly recommends identifying, updating and reviewing Issues during the execution process ("Controlling a Stage") and at the completion of each Stage ("Managing Stage Boundaries"). No project methodology could qualify for "maturity" without an Issue Management process in place.

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Work Packages

The Work Package is the *definitional* element of PRINCE2's work authorization system: the packet of information relevant to the creation of one or more deliverables (products). It contains one or more Product Descriptions as the core of the work to be performed. PRINCE2's Work Package also details any constraints on production such as time and cost, interfaces and confirmation (between the Project Manager and the resource slated to deliver the Work Package) that the work can be done within those constraints. Work Package contents may go further, providing: risk information; suggested (or required) tools, techniques or standards to do the work; how work is to be reviewed, checked and approved; how work is to be returned; and how issues, problems and status are to be handled and reported. The Work Package becomes a mini-PID (Project Initiation Document), conveying the project's requirements to performers of the work. As with other PRINCE2 tools, this product will vary in content and in degree of formality — ranging from verbal directives to formal written instructions for contractors. The recommended content provides a more comprehensive description of the work to be done than the PMBOK, along with the mechanism to ensure that completed work will meet expectations on all levels. (PRINCE2 also links the Work Package into its relevant processes: "Controlling a Stage" manages Work Packages from the Project Manager's side; "Managing Product Delivery" handles them from the side of those performing the work.)

Exception Management

In PRINCE2, the process for handling exception situations is defined before execution, in the PID. The Project Board is not designed to micro-manage, but they will have a greater level of comfort with the Project Manager if agreement is made in advance as to where the Project Manager's discretion lies. PRINCE2 provides for interactive communication: "Taking Corrective Action" and "Escalating Project Issues" from the Project Manager's side ("Controlling a Stage") , and "Giving Ad hoc Direction" from the Project Board's side ("Directing a Project"). The Project Board sets performance thresholds through the concept of "Tolerance," which grants the Project Manager discretion to execute work within agreed time and costs limits. Tolerance is set when planning the overall project ("Initiating a Project") and for each Stage of the project ("Managing Stage Boundaries"); the Project Manager monitors against Tolerance while "Controlling a Stage."

Change Control and Configuration Management

Both of these features are identified as components — PRINCE2's way of saying "many people overlook these because they seem complicated, but they can be straightforward and have significant value in reducing project risk." PRINCE2 makes both of these understandable, in what they are and how to use them. PRINCE2 ties them together: Change Control explains and demonstrates how to manage change requests, while Configuration Management manages the cataloging, tracking and actual changing of the deliverable.

The basic Change Control technique can be used as-is for the simplest of projects, or enhanced to use in a complex environment. Configuration Management does more than manage the change. It provides specific techniques to control project deliverables, including suggested Configuration records and the recommendation to use a Configuration Librarian. What is important is that Change Control and Configuration Management are *required* parts of any complete (ISO9001-certified) quality management system. As PRINCE2 is consistent with ISO9001, they have been included and integrated with the rest of PRINCE2.

Quality Reviews

The PMBOK spends extensive time on quality control, and numerous tools and techniques for accomplishing it. They are largely geared towards a physical product environment. Virtually all internal project deliverables (those needed to manage the project itself) and many of the intermediate and client-centered deliverables, however, are text- or graphics-oriented (reports, web sites, specifications, etc). PRINCE2 provides an excellent, tested technique for doing quality control on such products — the Quality Review. It lays out the steps and resources needed to assess the conformance of such deliverables, using Product Descriptions as the basis for evaluation. Techniques like this, to provide guidance on handling this challenging quality situation, are difficult to find. This technique can be lifted as a whole and used in *any* project environment (a capability shared by many aspects of PRINCE2).

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ISO9000 and Project Maturity Models

Many organizations have become focused on bringing their project management up through maturity models (such as OPM3, Capability Maturity Model, and others). At the same time, they find themselves believing they have to invent a new methodology that will provide the backbone for the project management dimension of this undertaking. PRINCE2 was constructed to be in conformance with ISO9001 requirements from its inception, so it becomes a valuable reference — or *core* — for the development of the project management aspect required by *all* these maturity models. *Its "open" (non-fee) availability means companies do not have to make huge capital investments to build a methodology from scratch, or buy one (often very costly) from a vendor.*

Combining the Best of PMBOK and PRINCE2

PRINCE2 is not meant to stand on its own and needs experience and the depth of PMBOK to fill it out, so it makes most sense to study the PMBOK and get a PMP first. But after Project Managers receive their PMPs, they often ask "Where do I start? How do I put all of this together to actually *run* a project?" PRINCE2 becomes useful at this point, because it can shape and direct that knowledge. Here are several approaches to getting value out of PRINCE2. PRINCE2 was designed in an integrated manner, so a project manager can get the most out of it when it is used in its entirety. But there are elements of PRINCE2 that can be lifted and applied directly in *any* project environment. Neither of these approaches requires deviating from a "PMP" or "PMBOK" environment.

Use it for its unique approaches and insights into project management. Read the PRINCE2 manual, or read the manual and take a PRINCE2 course. Get a grasp of how the "package" as a whole works. Focus on the elements that can be most easily transplanted into your current environment. The most straightforward elements are: Product Descriptions, Change Control, Issue Management, Quality Reviews and Work Packages (all discussed under "The Strengths of PRINCE2"). None of these require "permission" from authorities outside the project, so they are easily implemented by the Project Manager. They can even be used by project teams or in sub-projects. As these approaches and techniques become accepted by stakeholders and others on the project, consider using other aspects of PRINCE2. Because of PRINCE2's integrated approach, if you use most of PRINCE2's approach to a specific piece in the first round, you can add features in almost a plug-and-play manner. Features like Project Boards can be powerful when implemented, but require greater buy-in and commitment from stakeholders to succeed — so put these off until greater interest is shown by management.

Use it as the proven, low-cost basis for your company's methodology. Get to know PRINCE2 and consider using it as the core of your company's new project management approach — perhaps along the lines of "PMBOK and PRINCE2 – Together". Suggest it to management, selling it through its credibility wherever it has been implemented (internationally), and its open (no-fee) availability. Remind management that, when used in an integrated manner, it will support your company's fulfillment of any future "maturity" plans. Propose that a small group create a prototype project management methodology built around PRINCE2, to build understanding and to plan out how to integrate it into your organization's environment. (You can do research on how PRINCE2 has been used via the website of the accrediting body, the APM Group [www.apmgroup.co.uk]. They also have case studies on how to implement it.) Your core group should consider getting themselves accredited in PRINCE2, so you are all sure your team understands how to use it most effectively. (You will also become the Project Office/ resource team for all future work under PRINCE2.) Remember that you will need to bring big chunks of the PMBOK into this methodology to make it complete, so while you're learning about PRINCE2, think forward towards how you will combine the two. PRINCE2 doesn't have to be used "as-is" — though following "pure" PRINCE2 will help ensure that your company will meet later "maturity" accreditation requirements.

By using the PMBOK and PRINCE2 together you are taking advantage of the two most respected project management approaches in the world today, and are getting the best of both!

The author can be contacted at jay.siegelaub@impstrat.com.

Agile project management with Scrum

CONFERENCE PAPER **Agile**, **SCRUM** **22 October 2011**

Sliger, Michele

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Abstract

Scrum is one of the agile methodologies designed to guide teams in the iterative and incremental delivery of a product. Often referred to as “an agile project management framework,” its focus is on the use of an empirical process that allows teams to respond rapidly, efficiently, and effectively to change. Traditional project management methods fix requirements in an effort to control time and cost; Scrum on the other hand, fixes time and cost in an effort to control requirements. This is done using time boxes, collaborative ceremonies, a prioritized product backlog, and frequent feedback cycles. The involvement of the business throughout the project is critical as Scrum relies heavily on the collaboration between the team and the customer or customer representative to create the right product in a lean fashion. This paper provides an overview of Scrum and its use in project management.

What is Scrum?

We should first be clear on what Scrum is not. There is a common misconception that Agile is Scrum. While Scrum is indeed agile, it is not the sole method of implementing agile principles. Scrum is simply one of many agile approaches to product development. Other methods include Extreme Programming (XP), Crystal, Feature Driven Development, DSDM Atern, and so on. All of these methods adhere to the Agile Manifesto and its associated principles. A helpful metaphor would be to think of Agile as being ice cream, while Scrum, XP, Crystal, etc., are all simply different flavors, like chocolate, strawberry, vanilla. They are all agile, they are all good, and many can be used in combination.

Simply put, Scrum is an agile method of iterative and incremental product delivery that uses frequent feedback and collaborative decision making.

History

Scrum is based on a 1986 paper written by Hirotaka Takeuchi and Ikujiro Nonaka for the Harvard Business Review titled “The New New Product Development Game.” In this paper, the authors used the sport of rugby as a metaphor to describe the benefits of self-organizing teams in innovative product development and delivery. Jeff Sutherland, Ken Schwaber, and Mike Beedle took the ideas from this paper, including the metaphor, and applied it to their field of software development. They called their new method Scrum, after the rugby term that describes how teams form a circle and go for the ball to get it back into play again. They first applied this method at Easel Corporation in 1993. Schwaber and Beedle wrote about their experiences in their book Agile Software Development with Scrum in 2002, followed by Schwaber's book Agile Project Management with Scrum in 2004, which included the work Schwaber had done with Primavera.

The Scrum Framework

Schwaber refers to Scrum as a framework and not a methodology. This is primarily due to the connotations around the word methodology, which many infer as prescriptive in nature. By contrast, Scrum simply provides a structure for delivery, but does not tell you how to do specific practices, leaving that to the team to determine. Exhibit 1 shows the basic Scrum framework.

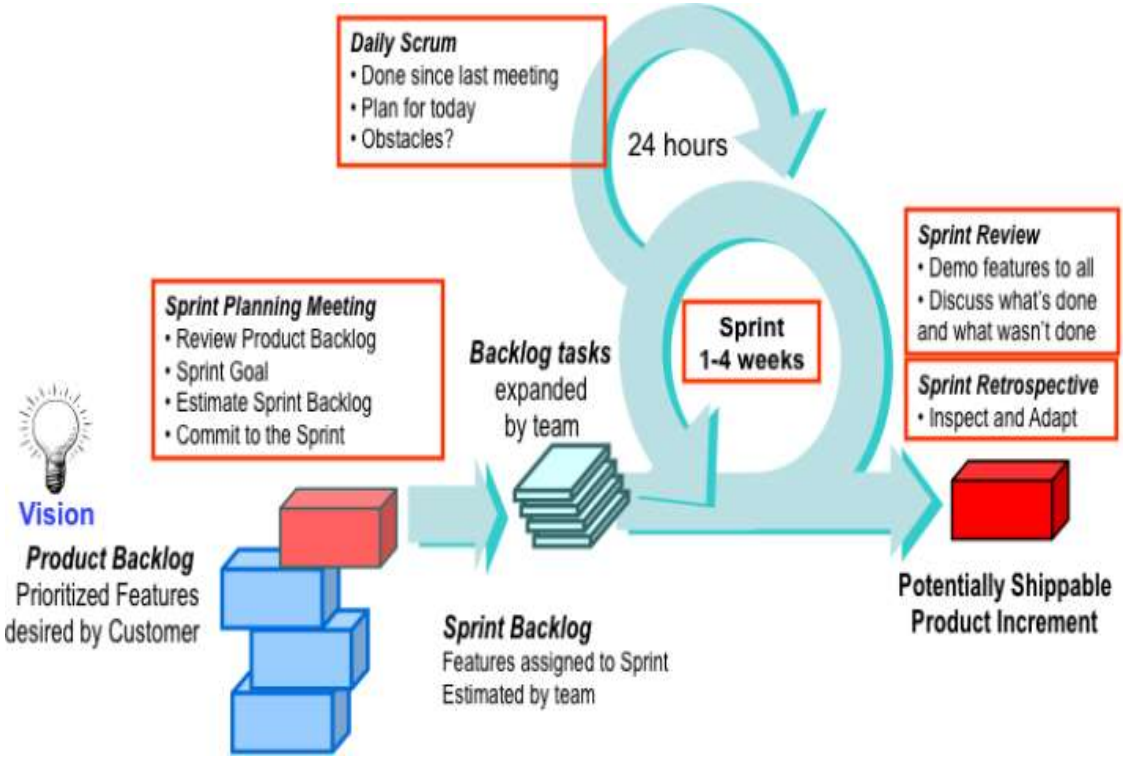

Exhibit 1. The Original Scrum Framework

The project begins with a clear vision provided by the business, and a set of product features in order of importance. These features are part of the product backlog, which is maintained by the customer or customer representative referred to as the Product Owner. A time box commonly referred to as an iteration or sprint, is the set amount of time that the team has to complete the features selected. Sprints are generally from one to four weeks in length, and that length is maintained throughout the life of the project so as to establish a cadence. The team selects items from the product backlog that it believes can be completed in the sprint, and creates a sprint backlog consisting of the features and tasks as part of the sprint-planning meeting.

Once the team has committed to a sprint backlog, the task work begins. During this time in the sprint, the team is protected from interruptions and allowed to focus on meeting the sprint goal. No changes to the sprint backlog are allowed; however, the product backlog can be changed in preparation for the next sprint.

During the sprint, the team checks in daily with each other in the form of a 15-minute meeting known as a scrum. The team stands in a circle and each member states what they did yesterday, what they plan to do today, and what is getting in their way.

At the end of the sprint, the team demos the work they have completed to the stakeholders and gathers feedback that will affect what they work on in

the next sprint. They also hold a retrospective to learn how to improve. This meeting is critical, as its focus is on the three pillars of Scrum: transparency, inspection, and adaptation.

Roles and Responsibilities

There are only three roles in Scrum: the ScrumMaster, the Product Owner, and the Team.

The ScrumMaster is the keeper of the process, the advocate for the team, and the protector of the team. They remove obstacles, facilitate team communication, mediate discussions within the team and negotiate with those external to the team. Above all, they exist in service to the team.

The Product Owner represents the voice of the customer and has the authority to make decisions about the product. This person owns the product backlog and is responsible for communicating the vision to the team, and defining and prioritizing backlog items. The Product Owner works with the team on a daily basis to answer questions and provide product guidance.

The Team consists of seven plus or minus two people who are jointly responsible for the delivery of the product. They own the estimates, make task commitments, and report daily status to each other in the daily scrum. They are self-organizing, meaning that structure appears without explicit intervention from the outside. In other words, the team owns how it chooses to build product features—the team owns the “how,” while the Product Owner owns the “what.”

The Application of Scrum

Scrum is applied by following a set of ceremonies, or meetings. Required Scrum ceremonies include the sprint planning meeting, the daily scrum, the sprint review and the sprint retrospective. Working in time boxes called sprints is also required. Release planning meetings are optional and allow for the planning and forecasting of groups of sprints.

Sprint Planning Meeting

The sprint-planning meeting is held on the first day of every sprint. The ScrumMaster, Product Owner, and Team are all in attendance. The Product Owner presents the set of features he or she would like to see completed in the sprint (the “what”) then the team determines the tasks needed to implement these features (the “how”). Work estimates are reviewed to see if the team has the time to complete all the features

requested in the sprint. If so, the team commits to the sprint. If not, the lower priority features go back into the product backlog, until the workload for the sprint is small enough to obtain the team's commitment.

Tracking Progress

Once the sprint-planning meeting is complete and the team has made a commitment, the team begins to track its progress using highly visible information radiators. These radiators include the burndown chart and the task board.

The task board is used by the team to track the progress of the tasks for each feature. The minimum columns used are To Do, Doing, and Done. Teams will have their daily scrum meeting at the task board, and move items across the board when stating what they did yesterday, what they plan to do today, and what obstacles they are grappling with. See Exhibit 2 for an example task board for a software development project.

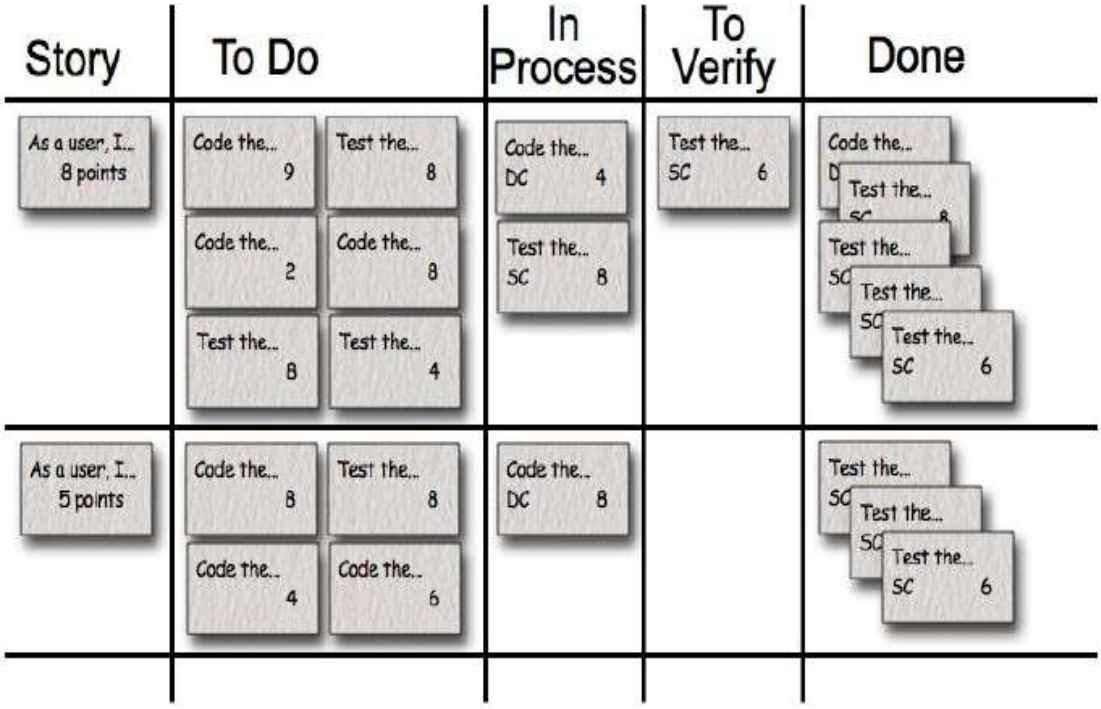

Exhibit 2. Scrum Task Board Example (Graphic courtesy of Mountain Goat Software. All rights reserved.)

The burndown chart shows the trend line of the amount of work left to do in the sprint. The x-axis is the number of days in the sprint, and the y-axis is the number of hours for all the tasks that were defined in the sprint-planning meeting. Over the days of the sprint, the line indicating the amount of work left to do should trend down to zero by the last day of the sprint. See Exhibit 3 for a sprint burndown chart example.

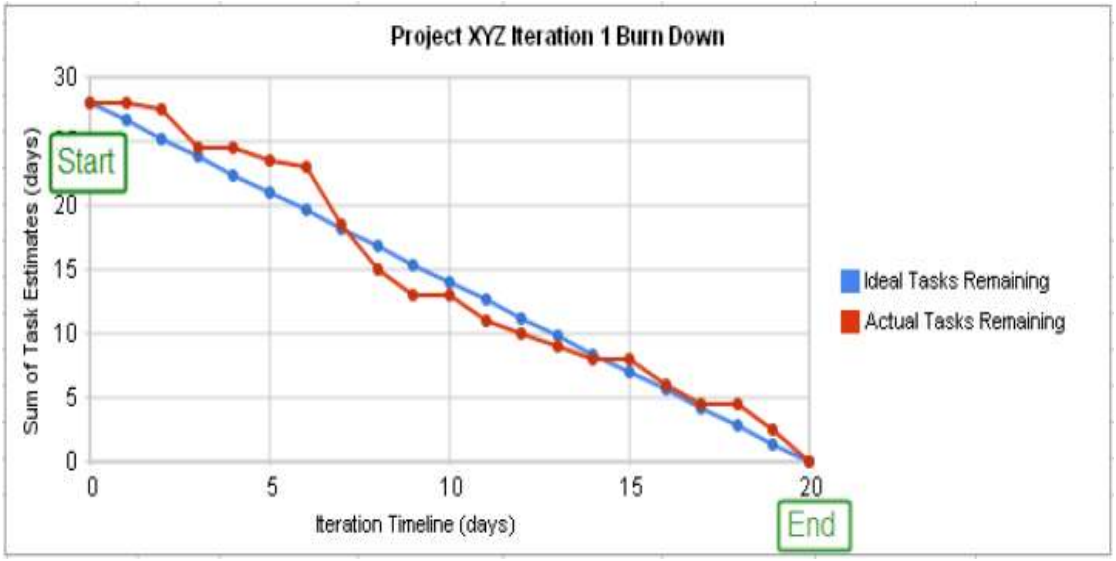

Exhibit 3. Sprint Burndown Chart Example

Sprint progress is tracked using the burndown chart, the task board, and the daily scrum. In combination, these three things can provide a clear picture of what's being worked on, what's completed, what's still to be done, whether or not it will be completed in time, and what might be preventing the team from meeting its sprint and/or release goal.

Sprint Review

At the end of the sprint, the team invites stakeholders to a sprint review meeting where the features that were completed in the sprint are demo'd and feedback is requested. The Product Owner keeps track of the feedback and incorporates it as needed into the product backlog.

Once the review is complete, the team (without the stakeholders) conducts a retrospective to determine what they did well that they wish to continue doing, what they struggled with, and what recommendations they have for change going forward. An action plan is created and these items are implemented over the course of the next sprint, and reviewed for efficacy in the next sprint retrospective.

Release Planning

Release Planning is also part of Scrum, and is a way to do long-term planning for a time box that consists of multiple sprints. This is often done quarterly, and the results of the quarter do not have to be a release to the customer, but may simply be an internal release to confirm system integration and validation. Exhibit 4 shows how release planning fits in with the rest of the Scrum framework.

The entire team attends the release-planning meeting, where the Product Owner presents the features she/he would like to see completed in the quarter. The team does not task out these features however, but instead provides gross level estimates to determine what features can be done in what sprint, and how many of these features can be completed by the end of the quarter. Release planning can be feature-driven (how many sprints will it take to complete this set of features?), time-driven (how many features can we expect to have completed by this deadline?) or cost-driven (given this budget, what does our schedule look like and what features will we have done before we run out of money?).

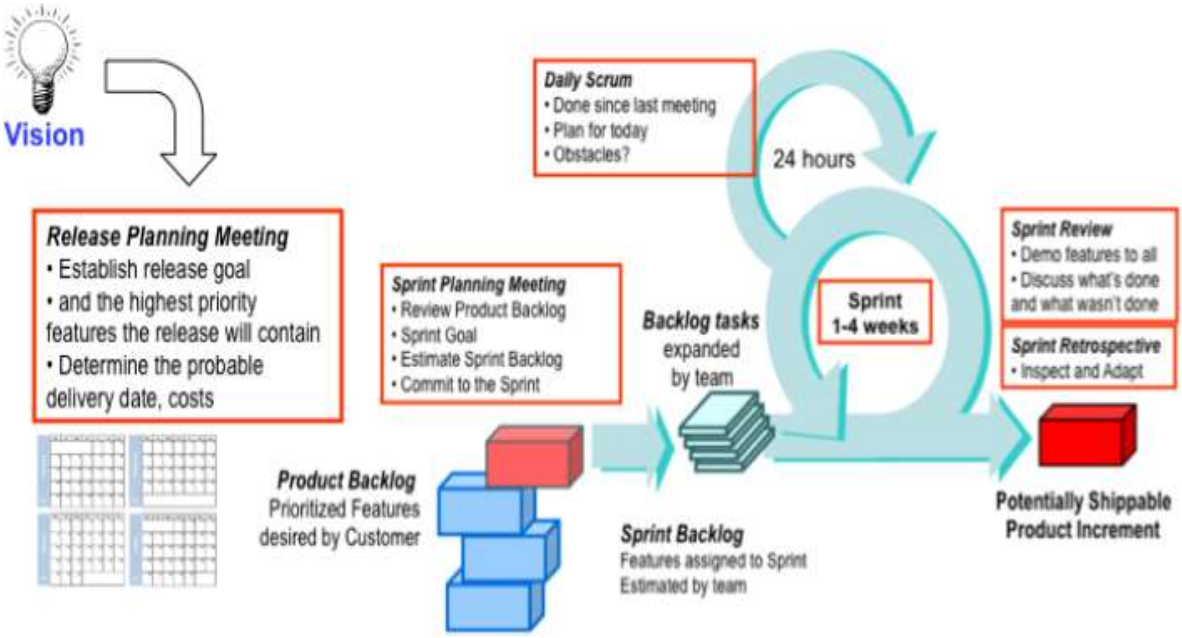

Exhibit 4. Release Planning in Scrum

Some Scrum Examples

Scrum is common in software development projects and myriad examples can be found through simple Google research. What is less obvious is the use of Scrum in non-software projects, so a few of these examples are cited in the following.

Writing a Book Using Scrum

My colleague Stacia Viscardi and I used Scrum to manage our book project. Our product backlog consisted of the chapters we wanted to write for The Software Project Manager's Bridge to Agility, in priority order based on client inquiries. For example, because we seemed to get a lot of questions about scope management and very few regarding procurement,

the chapter on scope was at the top of the backlog, while the procurement chapter was near the bottom.

We held a release-planning meeting and moved the backlog items onto flip chart pages that represented our sprints, which were one month in length. At the beginning of each sprint, we held a call to talk about the chapters we would be writing, set goals and expectations, and commit. During the sprint, we checked in with each other several times a week. As we completed chapters in the sprint we would exchange them to get feedback, and then incorporate that feedback into the final copy. Our sprint reviews consisted of a final review of the chapters, and any additional changes ended up in the product backlog to be planned in the next sprint.

As it was just the two of us, we rotated roles and responsibilities. For one section of the book, I was dubbed the Product Owner, and I had final feature authority. For other sections, Stacia had this role. Our ScrumMaster was our editor, even though he did not realize it. He still performed the ScrumMaster responsibilities, however, he reminded us of our deadlines, removed obstacles for us, and gave us the assistance and tools we needed to do our jobs.

And it's not just us using Scrum to write books. Lonely Planet uses Scrum in their travel guide development, “Prior to Scrum, the development of a book was very sequential and required many handoffs and took a long a time to get a book out from conception to publication. Now they involve all players needed to put a book together (writers, graphic artists, desktop publishing, marketing, editors etc) and incrementally develop the book chapter by chapter following the Scrum framework” (Scrum for Non-Software Projects, 2010).

Using Scrum in a Venture Capital Company

Jeff Sutherland is a Senior Advisor at Openview Venture Partners, a venture capital company based in Boston, MA. In 2010, he wrote a paper for the Hawaii International Conference on Systems Science titled Organizational Transformation with Scrum: How a Venture Capital Group Gets Twice as Much Done With Half the Work that describes how Openview uses Scrum in the management of its portfolio.

Openview teams use Scrum in projects “in management, sales, marketing, finance, and customer support for portfolio companies,” as well as pushing Scrum out to their portfolio companies (Sutherland, 2010, p. 1). In one example of Scrum use, the Labs team use one-week sprints to execute operational value-add projects for their portfolio companies, perform due diligence, and institutionalize their value-add capabilities.

When the Labs team initially implemented Scrum, the increased visibility into projects underway made them realize that several of the projects were actually low-value. As a result, they cut 30 percent of their projects, which made room for more high-value projects and allowed them to focus on and finish these projects. In fact, this clarity of focus and the limit of the amount of work in progress in a sprint helped the team to become more productive, as projects no longer dragged out over long periods of time because too many were being worked simultaneously. The team has already doubled their productivity and is "on their way to the second doubling of productivity" as they continue to adapt (Sutherland, 2010, p. 8).

Scrum in Church

Rev. Arline Sutherland works as an interim pastor for the Unitarian Universalist church. She is also the wife of Jeff Sutherland, one of the co-creators of Scrum. In a 2009 paper for the Agile2009 Conference titled Scrum in Church: Saving the World One Team at a Time, Rev. Sutherland described her experiences using Scrum in churches in Massachusetts, Connecticut, Florida, Delaware, and Virginia.

Scrum is primarily used by office staff and volunteers to both "keep the engine running" and in "new initiatives" (Sutherland, 2009, p. 3). Projects under various programming areas such as pastoral care, children and youth, membership development, social justice, music, facilities, finances and fund raising were managed using Scrum.

Several adaptations were made in each instance to accommodate the needs of the team members and the constraints of their environment. For example, it was impossible to hold daily in-person stand-ups with more than half the team holding down day jobs. So Skype was used since "the largest demographic using Skype are grandparents, (and) even older less technologically sophisticated members are often skilled users" (Sutherland, 2009, p.4).

It is worth noting that Sutherland discovered "that each and every time Scrum is introduced into a system it has to be adapted" (Sutherland, 2009, p. 4). Originally discouraged that her implementations of Scrum never seemed to match the ideal of "real Scrum," she quickly realized that the benefits of genuine adaptive change included the adaptation of Scrum itself.

What Happened To…?

Because this is only a short overview of Scrum, it is expected that the reader may leave with several unanswered questions. In this section, we

will look at the top three questions most often asked by those new to agile and Scrum, then leave you with some final words on where to find more information.

What Happened to Gantt Charts and Other Documentation?

Gantt charts are not typically used on Scrum projects. Burndown charts (both sprint burndowns and release burndowns), task boards, backlogs, sprint plans, release plans, and other metrics charts are used instead to communicate progress, status, and forecasts. A variety of agile project management tools exist to provide this type of dashboard reporting, including plug-ins for Microsoft Project.

The only artifacts Scrum requires are the product backlog, sprint backlog, release burndown, and sprint burndown. All other forms of documentation are left up to the team to decide. The agile rule of thumb is that if the artifact adds value and the customer is willing to pay for it, then the artifact should be created. Artifacts created because “it's on the checklist” or “we’ve always done this” are items that should be considered for elimination. Documents required for governance issues (audits, accounting, etc.) must still be created, but often can be streamlined.

What Happened to the Project Manager?

The project manager often becomes the ScrumMaster. This is not always the case and there are many different transformation permutations. For example, a project manager who has been serving as a domain or subject matter expert might be better positioned as the Product Owner. Or a project manager heading up a team of 50+ people may remain in that role and focus on overall project tasks such as procurement and contract negotiation, while the Scrum teams on the project (remember, a Scrum team is 7 +/- 2 people, so a 50-person project will be made up of 6-10 Scrum teams) each have their own ScrumMaster. In this scenario the project manager assists the ScrumMasters in coordinating, strategizing, and removing roadblocks.

What Happened to Using Detailed Tasks and Task Estimates to Generate Projections?

Traditional estimating and planning uses a bottom-up method, where all requirements must be fully defined, with tasks then created and estimated based on this fixed scope. Agile estimating and planning instead uses a top-down method to forecast. Gross level estimating at the feature level is often done using a technique called planning poker, with estimates given in

points using the Fibonacci sequence. Teams determine their velocity in points, i.e. how many points on average can the team complete in a sprint. Cost per point is determined by calculating the loaded salaries of the team for period x, then dividing that by the number of points completed in period x. Once you have your team's average velocity and a gross-estimated product backlog, you can forecast project milestones and completion dates, as well as the cost per point and thus forecast project cost.

One paragraph cannot do this topic justice, as entire books have been written on this topic. An excellent book with practical advice on how to do estimating using planning poker and forecasting using velocity and points is Agile Estimating and Planning by Mike Cohn.

Final Words

Scrum is an agile project management framework that helps teams to deliver valued products iteratively and incrementally, while continually inspecting and adapting the process. Project Management Institute members will find they can implement Scrum and still be in keeping with the A Guide to the Project Management Body of Knowledge (PMBOK® Guide)—Fourth Edition, as both advocate a plan-do-check-act approach to project management.

This was a short overview of Scrum, and as such did not address many additional areas of interest such as product roadmaps, estimating using points, user stories, story maps, and so forth. These agile practices are often used in conjunction with Scrum, as are other methodologies, such as Kanban and XP. Additional resources on these topics are available online, many for free. A comprehensive reading list can be found at http://www.scrumsense.com/resources/books for those interested in more in depth learning.

References

Cohn, M. (2006). Agile estimating and planning. Upper Saddle River, NJ: Pearson Education, Inc.

Project Management Institute. (2008). A guide to the project management body of knowledge (PMBOK® Guide) (4th ed.). Newtown Square, PA: Project Management Institute.

Schwaber, K. (2004). Agile project management with Scrum. Redmond, WA: Microsoft Press.

Schwaber, K., & Beedle, M. (2001). Agile software development using Scrum. Upper Saddle River, NJ: Prentice Hall.

Scrum for Non-Software Projects. (2010). Retrieved from http://groups.google.com/group/scrumalliance/browse_thread/thread/cd0691005d55ed3b

Sutherland, A., Sutherland, J., & Hegarty, C. (2009, August). Scrum in church: Saving the world one team at a time. Paper presented at Agile2009 Conference, Chicago, IL, USA.

Sutherland, J., & Altman, I. (2010, January). Organizational transformation with Scrum: How a venture capital group gets twice as much done with half the work. Paper presented at the Hawaii International Conference on Systems Science, Koloa, Kauai, Hawaii, USA.

Takeuchi, H., & Nonaka, I. (1986, January-February). The new new product development game. Harvard Business Review, [Reprint 86116].

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The charter

selling your project

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Introduction

The charter is a project's best marketing tool. It is created at the very start of the project, when the selling of the project's goals and ideas needs to begin. It is an ideal place to document the relationships between the project and the organizational strategy. Yet the charter is one of the least talked about deliverables in project management. Scheduling and communication have generated far more attention.

Too many project managers accept a limited role in the framing of the charter. The project manager does not need to write the charter, but the project manager has a role in the process. The project manager needs to demand an adequate charter, and be prepared to create one for the sponsor, if the sponsor does not provide it on his or her own.

Some project managers fail to get an adequate charter because they do not recognize the key components of a charter. A charter should be simple, straightforward, and short, but it must contain certain key elements. Once the basic components of a charter are clear, it is possible to give it a central role in the organization. The charter has a critical influence on any application of organizational strategy, organizational project maturity, program management, and portfolio management.

The charter has grown in importance and visibility in recent years. The third edition of A Guide to the Project Management Body of Knowledge (PMBOK® Guide) added a new process “Develop Project Charter,” making it a more visible deliverable than in the 2000 edition. That document remains an exception, though, with many program and portfolio management experts giving little attention to this vital project management

step. There is an opportunity for more integration of the charter into enterprise-wide approaches to project management.

What Is a Charter?

The PMBOK® Guide, 3dEdition defines a project charter as “a document issued by the project initiator or sponsor that formally authorizes the existence of a project, and provides the project manager with the authority to apply organizational resources to project activities.” (PMI, 2004, 368) The key word in this definition is “authority.” It authorizes both the project and the project manager.
The PMBOK® Guide lists specific information that the charter should provide, either directly or by reference, including:

- Requirements
- Business needs
- Summary schedule
- Assumptions and constraints
- Business case, including return on investment

This list is normative, providing guidance on what a charter “should” provide. A document can still be a charter, even if it omits one of more of the information items on the list. If a return-on-investment (ROI) calculation were truly required for a project charter, then few projects could be said to have a charter; experts still argue over whether an ROI calculation is meaningful for regulatory or mandated projects and many IT projects lack ROI analysis.

Some project managers may be misled by the word “document” in the definition and by the specific list of information in PMBOK. They fear that they do not have a project charter unless they have a specific document formatted with certain headings. PMBOK® Guide does not mandate the use of any specific document format, and project charters can take many forms. Often the charter appears in the form of a free-form e-mail or memo.

The definition itself gives the critical questions that determine, “Does a project have a charter?” These questions are:

- Does the sponsor know the project exists, and does the sponsor agree that it should exist? (authorize existence)
- Does the sponsor know who the project manager is and does he or she support that person's leadership of the project? (authorize the project manager)

- Has the sponsor given the project manager authority over money, people, and other organizational resources, in order to accomplish that project? (authority to apply resources)
- Has the sponsor ever written an e-mail, written a memo, spoken at a meeting (preferably a meeting with documented minutes) indicating, even implicitly, a "Yes" answer to the questions above?

A "yes" answer to these questions means that the project has a charter. Restated this way, it is clear that all successful projects must at some point have been chartered. If a project were not chartered, the project manager would likely be fired for insubordination if he or she expended any time, money, or other resources on it. In most organizations, it is not possible to make progress without authorization from someone.

Common Misconceptions about Charters

The term "project charter" is often misunderstood. Less-experienced project managers often believe that it must be a very formal document. The word "charter" is used in English to describe executed contracts or deeds, often founding papers for cities, educational institutions, or even governmental bodies. Traditionally a charter is a formal, legal document. Traditional charters can be quite short and simple, but few people think of them that way.
A project charter is quite different. Typically it is not prepared by lawyers and a project charter might not carry any legal weight. The project charter is authorizing a temporary endeavor, not an educational institution, not a state, and not a country's constitutional government.

Due to these misunderstandings, many project managers actually have a charter and do not recognize it. They offer many reasons to explain why they do not have a charter or cannot develop one:

- "There is no one document that provides the authority, the project name, the business needs, and the project manager's name!"
- "We have a document with all the right information, but the sponsor did not write it."
- "My boss just told me to do it. Then he e-mailed me all the documents I need to get started. I have no charter."
- "We are not through the requirements-gathering phase, so how can we possibly have a charter yet? We do not know what the requirements are."
- "We typically develop our charter after several weeks of research into the project. It meets all the PMBOK definitions for a charter, and it includes quite

a lot of detail about the project requirements. Schedules and budget rarely slip much from the ones authorized in the charter."

Not Always One Document

A project charter does not need to be contained in a single document. Ideally, one document will authorize the effort and include references to other documents that show business need, milestone schedule, and other key information. If authority has been provided, and the sponsor has approved project-related documents that include all of that information, then that collection of documents effectively forms the charter. Even if they do not explicitly cross-reference each other, the collection of documents can be considered a charter.

In many companies that perform project work on behalf of clients, the work order may serve as a key component of the project charter. In these companies, the work order gives specific people authority over organizational resources.

The signature of a customer at the bottom conveys authority from the customer-side, and the counter-signature of an officer of the consultancy makes the agreement binding on the consultant-side. Work orders often provide short explanations of the scope of the work, or they refer to more detailed specifications. Work orders can serve as a self-contained project charter or a component of a charter.

Not Written by the Sponsor

Sponsors are often senior executives with little time. Expecting them to write and deliver a complete project charter may be impossible for even a project-oriented organization. Senior executives often employ speech writers and ghost authors when crafting important messages. The project manager should be prepared to serve in a similar role, drafting or even writing the final copy for the charter. The sponsor must authorize it, not write it. Depending on the company, authorization may be delivered by a formal signature, a formal chartering ceremony, or simply a reply e-mail saying, "I agree. Proceed."

For projects that are sponsored by a committee or a group of people, it is particularly impractical to have the sponsors author the charter. Typically the project manager or one of the sponsors will write the document and the others will approve it.

"My Boss Just Told Me To Do It"

It is common when the project manager's direct manager authorizes the project, for the project manager to feel that there is no charter. In all likelihood the project manager has the strongest charter that anyone could ask for. When a manager tells a subordinate to start a project, the lines of control and authority are clear. The initial assignment may be informal and undocumented, but the manager will typically reinforce that charter in writing and verbally on a regular basis through status reports, formal meetings, and informal discussions. Normal day-to-day work will lead to some documentation of the assignment. The manager will usually issue a written statement at some point making clear that the project has been authorized. When the manager provides documents about the desired results, the manager is documenting requirements, business needs, and other parts of the project charter. This document trail is the project charter.

Some managers rarely create documents about assignments, though. Project managers who work for these managers should consider writing a brief e-mail or note confirming the conversation that started the project. The note might begin, “As we discussed earlier today…” and follow with notes from the conversation and a summary of key documents the manager provided. This note does not need to take a special form. Using free-form text it can fill all the requirements of a project charter.

Some project-management experts might argue that the manager needs to at least confirm in writing, “Yes, I agree,” for that note to be a charter. Documentation makes it stronger and is highly recommended, but a project can be successfully chartered, executed, and completed even without that documentation. An orally-communicated charter is still a charter. If the project manager honestly got the assignment and the authorization of resources, even verbally, the project should be considered chartered.

“We Are Not Done With Requirements”

In order to issue a charter at the very start of a project, the charter's author must create it based on only partial information.
The PMBOK® Guide recommends including “requirements,” “schedule,” and “budget,” but it will be impossible to give detailed versions of any of these pieces of information at the very start. Instead, prepare the charter based on the limited information available at the time.

By necessity, the charter will give a far shorter explanation of requirements than would follow a detailed requirements analysis. Information Technology project managers particularly suffer from misconceptions on the term “requirements.” There has been a long history of complaints that IT projects under-deliver, so softwaredevelopment experts urge IT professionals to understand requirements completely and in detail before doing any design or coding. IT project managers should not use that advice as justification to

avoid documenting an early statement of business needs and requirements. A good charter can contain high-level requirements statements; those statements may in fact help to guide and focus a detailed requirements-gathering phase.

When people say, “We are not done with requirements,” often that is a sign that the initial charter must be one with a small scope. The charter might only authorize an effort to gather the detailed requirements. This charter would then answer questions about how the requirements must be gathered, what their business purpose is, and so on. This charter could remain completely silent on questions of what will ultimately be delivered.

It is possible that requirements may be completely unknown, and a charter for the full scope of the project is impossible. It is always possible to define some basic requirements and business needs for the earliest phase of the effort. Perhaps a research and development effort might begin with a project charter that defines the business need and requirements around a marketplace challenge and the need to find solutions to it. Future phases of the project could revise the project charter to include more concrete, more specific requirements.

Detailed Project Charters

A member of the Project Management Institute (PMI®) Financial Services Special Interest Group (SIG) discussion group posted a sample charter template that contained 32 headings and sub-headings, and could be up to twenty-five pages in length (Cuffe, 2004). In many organizations, this document would be considered a detailed project plan, sufficient for the full and complete budget and schedule commitment for the project. A document of this form might be necessary, but it could not be the original charter for the effort. It could be the charter for a second phase of the project, but not the first. Too much time and effort is required to prepare such a plan. In the classic cycle of “Initiate-Plan-Execute-Control-Close,” the document would have required substantial investment in planning and perhaps early execution.

The charter is created at the Initiation phase, before significant resources are assigned. An early project charter should typically be short, perhaps a few pages in length. They can be as short as a part of a single page, so long as they clearly provide authority to the project and project manager.

Longer, heavily structured documents are often critical to organizational and project success. These documents will replace the short, early charter as the governing document for the project team. This evolution is natural and should be encouraged. The charter is best understood, though, in its

simplest form, when it turns an idea in someone's head into an authorized project. Master both the long and short forms of this important document.

One Project, Many Charters

A typical project will have many charters. A good project manager needs to understand the scope of the current charter and look ahead to establish the charter for the upcoming phases of a project. According to PMBOK® Guide each phase of a project goes through the initiation processes, and each has a charter (PMI, 2004, 82). Many project managers struggle to identify their initial charter, as discussed above. Identifying the charter for each phase of their project is even more difficult, because it is usually even more subtle.

Hierarchy of Charters

Some projects will move from phase to phase without any ceremony or celebration. The customer or sponsor might have little understanding of the phases, so it is difficult to see how he or she could authorize the charter for each phase. Without the authorization of the sponsor, it does not seem that there could be a charter for a given phase.

The sponsor has given the project manager authority over the internal project activities, including the movement from one phase to the next. Because the sponsor granted the project manager with authority for the overall project, the project manager can be the authorizing agent for each phase within the project.

When the project manager defines the work breakdown structure (WBS), he or she defines the organization of the work and the phases of the work. Usually each phase or deliverable has a definition that includes a business need. Some deliverables might be technical, with little obvious tie to the business needs listed in the original project charter. The project manager explains the business need of each phase or deliverable through the WBS and other project documents. When the project manager authorizes work on the first task in a phase or deliverable, he or she is essentially delivering a charter for that phase or deliverable. He or she is authorizing the start of the phase with the work-order. The WBS and related project documents provide the business justification and other elements of a charter.

Authority in a project has a hierarchy. The project manager typically gets authority from the sponsor. The project manager may then authorize work within the scope of the sponsor-provided authority. Some projects might contain team leads, sub-project managers, and other people to whom the project manager grants authority. In some cases these leads and managers will issue charters of their own.

When the Sponsor Must Re-Charter

In other projects, the sponsor may use the beginning or end of a phase as an opportunity to authorize the project again. The initial charter may have limited scope or limited definition. For instance, in a research and development effort, the initial charter might only authorize investigation and research up to a certain dollar budget. Before that budget ceiling is hit and before the project moves into development, the project manager must get a new charter from the sponsor. Without a new charter, the project would be unauthorized.

The updated project charters may appear very different than the initial project charter. They may include detailed work-plans, budgets, lists of specific deliverables, and other items. These updated charters may be many pages, and include all the elements of a detailed project plan. Sometimes the development of the plan for the subsequent phase is one of the final deliverables of a project phase. These updated charters may include all the components of a detailed project plan.

Sometimes unforeseen events make a project's charter irrelevant. Often the project team will get authorization for gradual changes to keep the work relevant, and the charter may grow increasingly stale. For these projects, the change requests may have become the new charter for the project. The project manager may find it helpful to ask the sponsor to approve a revised charter officially. Having a new charter can help to

- Focus team efforts around a single documented vision
- Improve team morale by recognizing the project changes officially
- Improve access to organizational resources by confirming executive support for the project

When and whether to seek a new charter, will depend on the specific circumstances and policies of the organization.

The Charter and Organizational Strategy

Many project managers aspire to contribute to organizational strategy, but few have a voice in it. Project managers long to be involved in the earliest decisions regarding their projects. Many want to help shape the strategy that drives the organization to launch projects. By creating and negotiating a charter the project manager has a chance to work at a strategic level in the organization. He or she can be visible to strategic thinkers in the organization. A great charter joins strategy to execution. The charter can make sure that the project's relationship to organizational strategy is clear.

A charter is ideal for critically examining whether a project truly supports organizational strategy. The project is new, so investment is low. If the project is not truly aligned with organizational strategy, the charter is the best chance to stop that project before resources are wasted. If project managers consistently stopped misaligned projects before they started, there would be far fewer failed projects.

The charter is short but should contain the business needs or goals. Details of implementation are not known yet. Organizational strategy operates on exactly this level — business needs and goals, without implementation details. People can quickly compare a project charter to a vision statement, a business plan, or a strategy document and determine if the two are compatible. The charter provides a very pure expression of the business intent. Drafting the charter is a unique opportunity to align the project clearly with overall business goals.

Getting Your Organization Started With Charters

Some project managers complain about executives starting projects without understanding what it takes to get them done. They wish that these executives would talk to the project managers before launching these projects, to get feedback on how to do them right.

The truth is that these executives do talk to the project managers.

They talk to project managers when they make assignments. They talk to the project managers when they authorize the project. They talk to the project managers when they provide the project charter. Many project managers are not prepared to take advantage of these brief opportunities to have a voice in organizational strategy.

The best chance to have strategic input is at the start of the project assignment. When approached with a new assignment, the project manager has a responsibility to ask for certain information and for clear authority. Merely asking clarifying questions about the assignment begins a subtle negotiation over the nature of the project and the scope of the authority being provided. Negotiating for a solid project charter from the start will position the project manager as a strategic thinker in the organization. Negotiating changes to the charter later will reinforce that position.

The project manager should immediately ask critical questions at the time of project assignment. If the relationship of the project to organizational strategy is unclear, the time to ask is during the assignment. If the relationship is clear, the charter is a vehicle to document those assumptions clearly and to get confirmation from the sponsor that the

assumption is correct. If the project is already underway when a project manager is assigned, reconfirming the existing charter or writing a new one is a great way for the new project manager to establish credibility.

The project manager also needs a definition of the boundaries of his or her authority. The form of that definition will vary by organization, but the project manager shows maturity by asking these questions early. A charter is a statement of authority and support from the sponsor. A professional project manager will demand a clear charter before starting work and especially before asking team members to act on his or her behalf.

The Project Manager as Charter Author (or at least ghostwriter)

Leaving the authoring of the charter in someone else's hands is essentially leaving the promotion, the marketing, and the direction of the project in someone else's hands. The best sponsors will perform those roles well, but not all do. Too many project managers despair because their project sponsors will not write down a charter in a clear form. The definition of the charter does not include any mention of who writes it, just who “issues” it. Project managers can draft the charter themselves, and then ask for approval of it. It is essential that a person with sufficient authority approve the charter and stand by it; it does not matter at all who writes it.

In some cases, the project sponsor may be unwilling or unable to approve the draft charter. Sponsors may ask for change after change, or may refuse to approve. Unwillingness to approve a document is a sign of misunderstanding, lack of support, or worse. A professional project manager should stop work until the situation is resolved. Proceeding on a project without any authorization and definition is a recipe for disaster.

The Charter, Organizational Process Maturity, Program Management and Portfolio Management

The charter provides a unique opportunity to improve organizational maturity, because it provides an opportunity to

- Decide whether to proceed;
- Consider organizational goals and strategy;
- Control the authorization and deployment of organizational assets.
  By setting standard processes and controls for the authorization of new projects, organizations have an opportunity to improve their project management processes dramatically. Because one of the core functions of portfolio and program management is to control the start-up of projects,

establishing standards for project charters can benefit these disciplines as well.

Establishing Consistent Processes to Charter Projects

There have been volumes written about implementing program or portfolio management processes, yet relatively little about processes for chartering a project. I believe that chartering projects that has more impact on the overall program or portfolio performance than any other project management process. Controlling which projects start, when they start, and what business needs they address brings a huge benefit to the organization. These processes have the potential to avoid waste on unsupported or misdirected projects. Because the charter happens at the very start of a project, the potential savings are 100% of the project budget and schedule; there is no better possible savings for a failed project.

Because the charter is simple, the processes to authorize and approve a charter can be simple as well. At Mitsui Sumitomo Insurance Group, USA (MSIG USA), we have a template, called the “Opportunity Document.” The document is two or three pages in length when completed. The appropriate “Chief Officer” signs off on the opportunity. A Strategic Planning Office Manager and a Chief Planning Officer administer the whole process and help people through it. They recommend a sponsor and project manager. A committee of five senior officers of the firm, including the President and CEO, review the proposal. The committee approves it, rejects it, or asks for changes. Once it is approved this opportunity document serves as an iron-clad charter for the effort. The project manager has the blessing of the top officers of the firm, and their decision is captured in the minutes for the meeting. Not all the projects in the company finish successfully, but all projects in the company are authorized. The process is documented in a three-page procedure. The procedure and the template are available to everyone in the firm through the company intranet. Projects have gone from idea to authorized project in as few as seven calendar days; the time could be cut to one or two days in an emergency. To date, the approval process has never delayed the start of a project. Once the idea was fully understood, the approval was always received before a team could be freed from other assignments.

This process helps MSIG USA ensure that management has authorized any major effort. By capturing objectives, high-level estimates of size, and interdependencies in a short document, the project teams have a reference whenever they are uncertain of the scope of their authority. Other organizations could adopt a similar procedure. Some organizations have more levels of authority, perhaps based on budget size or work-hours, but

the basic principles of the review and approval can be simple. Most importantly, the process can be short.

Potential Area for Further Organizational Maturity Study

Organizational Project Management Maturity Model (OPM3®) includes several questions about project, program and portfolio "initiation" in its basic assessment tool (PMI, 2003, 76-85) and makes charters a key element of these initiation processes (PMI 2003, 130, 150). Introductory books on project management often make reference to the charter. Typical portfolio and program management approaches focus on project selection methods and other ways to analyze the content of a project portfolio. It remains to be seen whether the upcoming Program and Portfolio Management standards from PMI will embrace the project charter as a key vehicle for shaping and controlling programs and portfolios.

Project charters are an area for potential research and development. PMI has focused in recent years on linking project management to business results; the authorization and start-up of a project is one of the best opportunities to join project management to core decisions about business results. I recommend other authors and researchers to investigate this topic more fully.

References

Cuffe, Don. (2004, Feb 6). Project Charter Template. PMI FSSIG Knowledge Center On-Line Discussion Group. Retrieved on 7/4/2005 from http://finance.groups.yahoo.com/group/PMIFSSIG/message/711 (URL only accessible to PMI FSSIG members)

Project Management Institute. (2000) A guide to the project management body of knowledge (PMBOK®) (2000 ed.). Newtown Square, PA: Project Management Institute.

Project Management Institute. (2004) A guide to the project management body of knowledge (PMBOK®) (Third ed.). Newtown Square, PA: Project Management Institute.

Project Management Institute. (2003) Organizational project management maturity model (OPM3®): Knowledge Foundation. Newtown Square, PA: Project Management Institute.

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Stakeholder management

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Abstract

Projects do not exist in isolation. Even if there is a defined brief, budget, programme and scope of work the project is still subject to external influences. The project exists within a 'political' environment, populated by all those who have a particular stake or interest in the outcome of the project. This political environment and the expectations of stakeholders represent significant risk to a project. It is unlikely that the requirements of all stakeholders will coincide and they will seek to influence the project in order to meet their own requirements. Pressure from stakeholders generates change and change increases the complexity of the management task, jeopardising cost and programme certainty. However if the views of project stakeholders are not addressed and if stakeholders are not involved in the development of the project, then the project is unlikely to deliver optimum value for all involved. It is important that project managers strike the right balance between stakeholder involvement and isolation of the project from external influence in order to achieve delivery on cost and time but also to maximise benefit for the client and his stakeholders.

Background and General Principles

Stakeholders are those who have a stake or an interest in a project or strategy undertaken by a company or an organisation, they will be affected in some way be the project and so have an interest in influencing it. They may benefit from the project and so will be supportive and positive about it; conversely, the project may damage their interests or they may perceive it will have a negative outcome for them so they will seek to stop it or, at the very least, project it in a bad light.

In construction projects stakeholders can include:

- Users of a building
- Funders
- Neighbours
- Regulatory bodies
- General public

It generally falls to the client to manage project stakeholders. In order to do this the client needs to reconcile the differing stakeholder requirements and pass clear direction to the project manager. Where briefing information is late, where answers to questions are delayed or where sign off of the design at different stages is a lengthy process this is probably because the client representative is liasing with the different project stakeholders in order to gain their agreement.

The term multiheaded client is often used to describe organisations where the decisions are not made by one individual but by a group. Some projects are the result of a joint venture between

different organisations or development partners. This is common in the public sector, for example transport projects. For public projects or projects within large private organisations it is often the case that there are numerous internal stakeholders as well as external ones.

Stakeholder influence is often felt most keenly in the early stages of the project. The project is flexible at this stage and can be changed and stakeholders are generally aware of this. Once it starts to progress, it takes on a momentum and a power of its own and the cost of stopping it or altering its direction becomes high. Stakeholder influence often drops off markedly when construction starts, but will increase again as handover nears. Project managers should continue to manage stakeholder expectations to ensure that the completed building meets the needs of stakeholders as well as possible and is favourably accepted.

Some client's are better at managing stakeholder influence than others, and some stakeholders are easier to manage than others. On a sizeable, publicly funded project it is easy to identify 40 – 50 stakeholder groups all with different involvement, requirements, levels of power to influence the project and levels of interest in doing so. This is a very complex situation to manage.

Internal and External Stakeholders

Internal Stakeholders

There are broadly two groups of project stakeholders, those internal and those external to the client organisation. The type most usually recognised are the external stakeholders, however the management of internal stakeholders is often more problematic. In construction projects it is often difficult to identify who actually is the client, there may be a nominated single point of contact but this person is not really the 'client' just the representative of the client organisation. Very often it is the case that this person has the responsibility of juggling a whole range of different requirements within the client organisation and as a result they will be subject to many influences which will may well affect the project as change. Within the client organisation there will be a whole range of individuals with very different 'stakes' in the project, unless the nominated client representative takes a very strong line they will succeed in influencing the course of the project.

The client organisation is made up of a whole range of individuals with differing wants and needs who make up a 'multiheaded' client. In these situations the decision-making process becomes complex. Questions cannot be answered directly by the nominated client single point of contact. That single point of contact must negotiate with the various other stakeholders within the client organisation in order to get an answer.

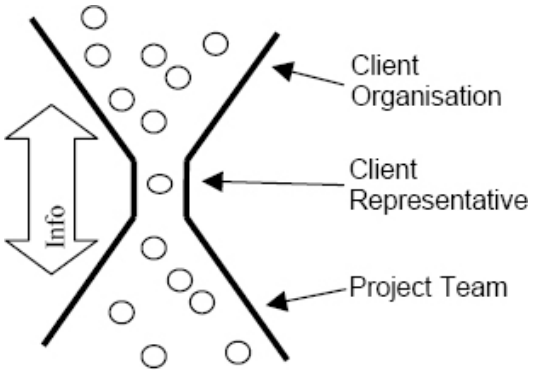

Exhibit 1 Generally all project information passes from the various members of the client organisation via the client representative and vice versa. The client representative acts as a filter.

There is a school of thinking that states that organisations do not have goals, it is the individuals within the organisation that use the organisation to further their own differing personal goals. By extension of this, the individuals use the projects the organisation undertakes to achieve their own ends. If we consider this - Do you go to work to help your company achieve every bullet point of its mission statement? Or do you get the 7am train every morning to earn money, gain experience, improve your CV, work on interesting projects, grow your department, build your empire, gain promotion and be part of the team? The same applies to the people in your client's organisation.

It is hardly surprising that when you are building to meet the diverse goals of your multiheaded client, it is difficult to find the right solution that satisfies the goals of most of those individuals and prevents those who do not get exactly what they want from obstructing the project.

Internal stakeholders could be anyone within the organisation. Most commonly, they are the eventual users of the project, but they could also be the heads of marketing, IT or human resources, other employees, trade unions and so on. All have a stake in the project and all can affect it, directly or by influence.

External Stakeholders

External stakeholders are the individuals or organisations who are not part of the client organisation but nevertheless have an interest in the project. They are perhaps the stakeholder groups most readily recognised. For publicly funded projects the number of stakeholders who can be identified is high. These generally consist of:

- Funders, whether this be a government department, grant provider or private sector partner.
- Users, whether these be passengers for a transport project or visitors for a museum.
- Regulatory authorities. Most commonly the planning authorities, but also specialist regulatory authorities for example those involved in rail projects.
- Those affected, who may be neighbours or those working or living nearby.
- The press and media are another significant group who can greatly influence perception of the project and its perceived, and in some cases actual, success.

It is relatively easy to identify forty individual stakeholder groups for a significant public project, although private sector projects tend to have slightly fewer. One of the key problems with stakeholder management is the sheer number of people involved and the fact that their levels of power and interest differ markedly.

Management of the stakeholder environment is a highly complex management task.

Stakeholder Analysis

Stakeholder analysis can be used to understand the stakeholder environment and to prioritise management resources. It can be undertaken as follows:-

- The first step is to identify stakeholders, you can't manage them if you don't know who they are, list them out. This exercise will need to involve all members of the team.
- Next decide on the level of power and interest each individual stakeholder has to influence the project. This is not a precise art, the assessment can only be based on the perceptions of

the team, but it is important that you consider 'interest' from their point of view not yours, a large organisation, for example a key grant provider, may be of great interest to the project but is the project of great interest to the grant provider? If the project does not happen they can just fund something else. You then plot the stakeholders on a matrix.

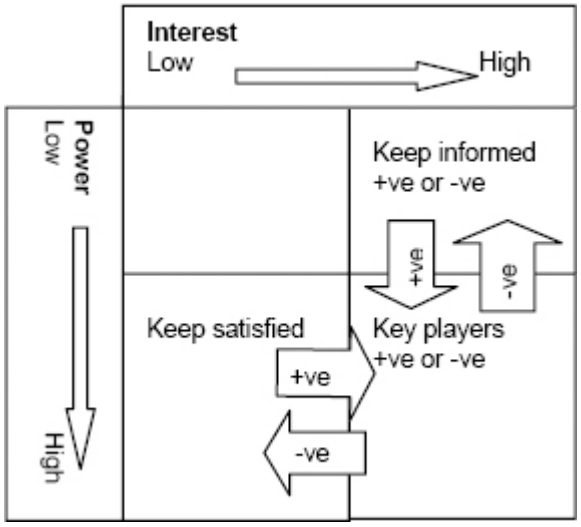

Exhibit 2 The stakeholder analysis matrix offers a way of grouping stakeholders to enable us to better understand them.

- You will then need to define whether the individual stakeholder groups are broadly positive or negative about the project. You will probably find that those with a high level of interest, on the right of the matrix are either strongly supportive or otherwise, this is not surprising as their interest is high and so they have an opinion. Those on the left may have no strongly formed views.

This completes the basic analysis, you should then use the analysis to form the basic management and communication strategy for the project.

Active Management of Stakeholders

The basic requirement is to manage the project so that positive stakeholders are in the bottom right hand corner and negative stakeholders are out of that corner. You need to remember that the matrix is dynamic, changes of individual within stakeholder organisations or changes to your project will be reflected in the matrix. The following are some ideas for strategies that you or the client may wish to adopt to deal with the various groups.

High Power, High Interest

If they are positive provide them with information to maintain their support, look after them well they are important, let them know that. Don't ignore them just because they are not causing you any problems at the moment. Involve them in your project, make them part of your project steering group (if they are not already), involve them in decisions, use them to lobby other groups and make sure they voice their support. Those with high power and interest, who are negative are a big problem and you need to put effort into dealing with them. Use other positive stakeholders to lobby them and hopefully change their views, attempt to counter any negative influence they may have on other groups, reduce their power if the means exists to do this. They may also respond to bargaining. Find out what is important to them, help them out, buy their favour. Some also respond to information and interest.

Management strategies

Positive

- Provide information to maintain their support
- Consult with them prior to taking project decisions
- Meet with them regularly
- Consult with them, involve them and seek to build their confidence in the project and the team
- Encourage them to act as advocates for the project
- Nurture them, look after them, they are critically important to you and to the project

Negative

- Attempt to develop their support and change their view by ensuring they fully understand the project and the benefits it will deliver. Their resistance maybe due to lack of information or understanding.
- Attempt to build their confidence in you and in the team.
- Find out what is important to them, if you can help them out or minimise negative impact on them they may be more helpful.
- Demonstrate that you are doing your best to limit adverse effects on them.
- Counter any negative influence they may have on others.

High Power, Low interest

The high power, low interest group are the unexploded bombs – their interest is low, at the moment. However if the project alters or the individuals change their interest may suddenly increase and they will use their power to influence the project.

Management strategies

- Maintain a careful watching brief, make sure that changes to the project or changes within the stakeholder organisation do not suddenly increase the level of negative interest.
- Find out what is important to these groups and make sure that the project does not adversely affect this. If the project is likely to have a positive effect for them make sure they are aware.
- Beware of other negative stakeholders passing information to this group to encourage them to oppose the project.

High Interest, Low Power.

If they are positive they are strong allies – treat them well, provide them with information, involve them, use them to lobby other groups. If they are negative, they will probably deluge you with e-mails and phone calls, you need to ensure that you don't spend too much time on them.

Management strategies

Positive

- Maintain their enthusiasm and interest in the project, they are good allies to have.
- Provide them with information, invite them to presentations, involve them as much as resources allow. This can be done fairly cheaply through a project website, newsletter or open presentations.
- Seek their input and opinion if you can, they will be flattered by this, but ensure that you do not get too many opinions.

Negative

- This is a group that you will probably know all too well, because of their high level of interest they will probably deluge you (or your client) with e-mails and other correspondence. You need to be sure that you do not spend too much time on them, remember their power is low.
- You may need to get the project sponsor or client representative to take a firm line with them they can use a lot of time and resource.

Low Power, Low Interest

Make sure you don't spend too much time on them but if they are supportive provide them with information and be nice to them, their position or view may change in the future

Management strategies

- Ensure they receive the project newsletter, have access to a project website or are invited to presentations.

Conclusions

Like all management models, the key benefit of stakeholder analysis is that it helps bring understanding to a complex situation and therefore helps project managers and teams to manage and communicate with stakeholders in the most effective way, enabling hem to concentrate resources where maximum benefit will be derived and informing communications planning for the project. The benefits are very much in the discipline of having undertaken the process. However stakeholder analysis is only a tool that helps the project manager and the team identify the management actions necessary. It is perhaps most easily applicable to the management of external stakeholders and a useful output of stakeholder analysis is a project communications plan which will help the team define and understand which stakeholders they need to communicate with and how. A typical format for a project communications plan is given below, the output of the stakeholder analysis exercise can be used to help define the recommended approach and action plan. On a large project this helps define clarity of communication routes and ensure consistency.

COMMUNICATIONS PLAN					
No	**Stakeholder**	**Reason consultation / communication**	**Likely stance on project**	**Recommended approach and action plan**	**Owner**
Ref	*Organisation or individuals*	*Reason we need to communicate with them. For example to gain their approval.*	*Supportive or otherwise. Whether they have a specific interest in the project.*	*Who needs to talk to who, what information needs to be provided. Who is responsible for doing this.*	*Person responsible*

Exhibit 3 Communications Plan

Management of internal stakeholders is, if anything, more complex because internal stakeholders are generally closer to the issues and will be affected to a greater degree. If we are to avoid large scale change to the project as it progresses it is important that we ensure that it is set up right in the first place with the right types of involvement and consultation. The important thing is to get the wider internal stakeholder group involved as early as possible. Involve them in the detail of the briefing process, present the initial designs to them, and take their comments seriously. Everyone must get a chance to learn about the project, have their say, hear about what others think, learn about the complexities and limitations of the project and the opportunities it presents. Not everyone will get exactly what he or she wants, but they are more likely to accept what they do get if they know why a particular decision was made and if they feel they played a part in making that decision. This is a time consuming process but it is important because it will smooth the path for the later stages of the project and it is the best way to ensure that the project optimises benefit for the client organisation. For example there may be the opportunity to streamline the project by sharing facilities rather than by satisfying individual wish lists and broader consultation will lead to better project briefing. These processes allow you to tap into the knowledge, skills and creativity of a wider range of individuals.

The process obviously needs control, but communication should occur as freely as possible, and decisions made should be communicated to the wider group as efficiently as possible. It is important to avoid the very simple and limiting communication routes described in Exhibit 1.

Free communication between designers and users, certainly in the early stages, allows the designers to build a better understanding for what they are designing and allows users the opportunity to learn about what is achievable and what is not. The sort of communication route described in Figure 1 may well simplify the project management task and maximise the chances of delivering the project to cost and time but it is unlikely to assist in the delivery of the best project to meet the needs of the organisation as well as possible.

Where a range of departments within an organisation are affected by a particular project we need to give careful thought to how communication is managed. The project team is set up as a temporary team, who will probably move on after the project is finished, other departments in the organisation know that they will have to live with the results. We need to ensure that the project is suitably integrated with the overall development of the organisation. A project team that works in isolation may well deliver a project on budget and time as there has been little client led change but it is unlikely that they will deliver the project that the organisation actually requires. It is important that information about the project, that will affect the whole organisation, is cascaded out. One mechanism is to nominate project representatives in each of the departments affected who maintain communication.

It is important that we remember that when we build, we are building not just for a single individual but also for a wide group of people who will have to live with the building when the project team has moved on. Rather than complaining that we cannot get clear decisions out of the client, we need to try to understand the range of needs to be satisfied and achieve an optimal balance. Project managers will probably always be judged on whether or not they delivered the project to time and budget and the more they need to involve project stakeholders in the process the greater the risk to time and budget but if we are to deliver projects that meet the long term needs of organisations we need to involve and meet the needs of the organisations stakeholders and we can only do this through active stakeholder management.

Reference

Johnson, G. & Scholes, K. (2002) Exploring Corporate Strategy. UK:Prentice Hall

Risk analysis and management

a vital key to effective project management

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Abstract

Risk Analysis and Management is a key project management practice to ensure that the least number of surprises occur while your project is underway. While we can never predict the future with certainty, we can apply a simple and streamlined risk management process to predict the uncertainties in the projects and minimize the occurrence or impact of these uncertainties. This improves the chance of successful project completion and reduces the consequences of those risks.

This paper presents the structured Risk Management process followed at Nokia Siemens Networks that helps avoid crisis situations and incorporate learning from past mistakes. It highlights that effective and early risk identification and management secures the achievement of project objectives, leading to reduced rework costs.

Introduction

Project team members at various levels identify and handle risks in different flavours. However, this will be ineffective without a structured risk management framework, as this leads to:

- Incomplete impact evaluation, leading to loss of:

- Knowledge of the overall impact on the project objectives, like scope, time, cost, and quality
- Identification of secondary or new risks arising from the already identified risks

- Lack of transparency and a communication gap within and outside the team

Thus, it is very important for any project organization to set up an effective risk management framework. Instituting such a practice as a project team culture ensures:

- Conscious and focused risk identification and management
- Project progress as desired, with the least amount of deviations or surprise, and in line with project and organizational objectives
- Early and effective communication of project issues to organization and project stakeholders
- An effective team building tool, as team buy-in and acceptance is assured

Exhibit 1 shows that risk management is an iterative process and each facet of risk management should be planned and followed during each phase of the project.

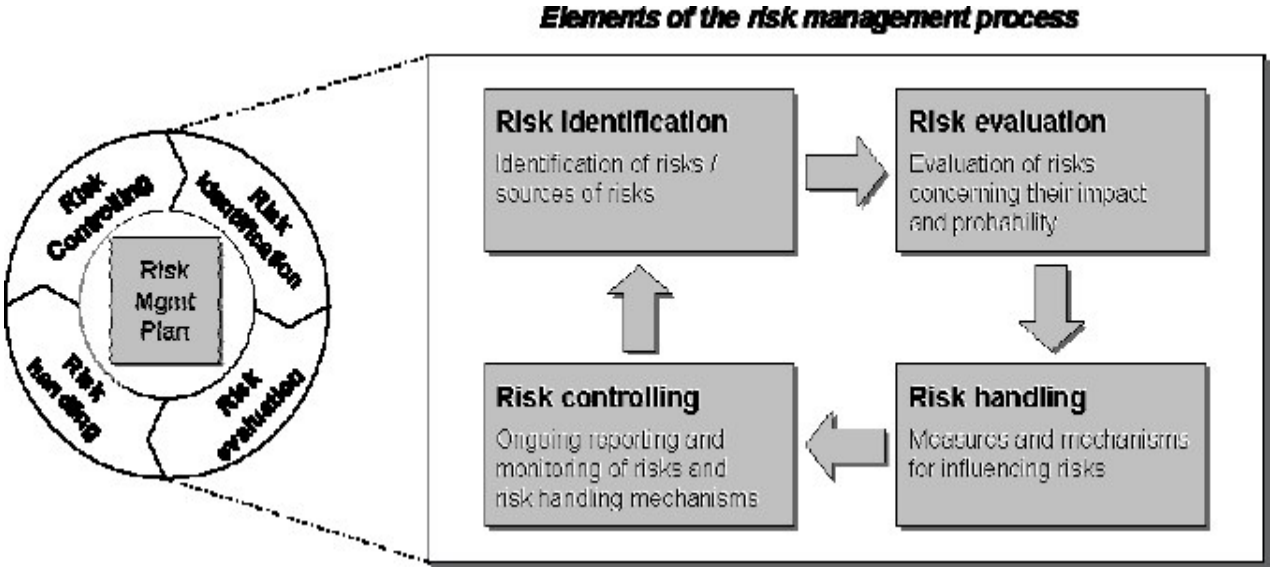

Exhibit 1 – Risk Management Process

The risk management framework followed at Nokia Siemens Networks provides guidelines for:

- Continuous risk identification
- Risk evaluation
- Risk mitigation and contingency measure definition

- Risk monitoring and control
- Risk identification efficiency measurement

The risk management framework also provides templates and tools, such as:

- A risk register for each project to track the risks and issues identified
- A risk checklist, which is a guideline to identify risks based on the project life cycle phases
- A risk repository, which is all the risks identified across projects so far

Risk Management Framework

Risk Management Plan

The organization-mandated risk management framework is reviewed and tailored to define the project risk management plan when the project is initiated. The risk management plan includes these definitions and guidelines:

- List of possible risk sources and categories
- Impact and probability matrix
- Risk reduction and action plan
- Contingency plan
- Risk threshold and metrics

Risk Identification

Risks are to be identified and dealt with as early as possible in the project. Risk identification is done throughout the project life cycle, with special emphasis during the key milestones.

Risk identification is one of the key topics in the regular project status and reporting meetings. Some risks may be readily apparent to the project team—known risks; others will take more rigor to uncover, but are still predictable.

The medium for recording all identified risks throughout the project is the risk register, which is stored in the central project server.

The following tools and guidelines are used to identify risks in a structured and disciplined way, which ensures that no significant potential risk is overlooked.

1. Risk Sources

Risk Source	Description
Risk repository	The risk repository is the history data containing the list of risks identified for completed projects. The risk repository can be used to arrive at a list of potential risks for the project. This risk repository can also be filtered based on risk sources, categories, and projects.
Checklist analysis	The risk identification checklist is a questionnaire that helps identify gaps and potential risks. It is developed based on experience and project type.
Expert judgement	Risk identification is also done by brainstorming with or interviewing experienced project participants, stakeholders, and subject matter experts.
Project status	The project status includes project status meeting reports, status reports, progress reports, and quality reports. These reports provide the current project progress, issues faced, and threshold violations. These provide insight into the status of the project and potential new risks.

Exhibit 2 – Risk Sources

2. Risk Category

Risk category provides a list of areas that are prone to risk events. The organization recommends high-level, standard categories, which have to be extended based on the project type.

Risk Category	Extended categories
Technical	Requirements, Technology, Interfaces, Performance, Quality, etc.
External	Customer, Contract, Market, Supplier, etc.
Organizational	Project Dependencies, Logistics, Resources, Budget, etc.
Project Management	Planning, Schedule, Estimation, Controlling, Communication, etc.

Exhibit 3 – Organization-Provided Standard Risk Categories

Risk Analysis

Risk analysis involves examining how project outcomes and objectives might change due to the impact of the risk event.

Once the risks are identified, they are analysed to identify the qualitative and quantitative impact of the risk on the project so that appropriate steps can be taken to mitigate them. The following guidelines are used to analyse risks.

3. Probability of Risk Occurrence

a. High probability – (80 % ≤ x ≤ 100%)
b. Medium-high probability – (60 % ≤ x < 80%)
c. Medium-Low probability – (30 % ≤ x < 60%)
d. Low probability (0 % < x < 30%)

4. Risk Impact

a. High – Catastrophic (Rating A – 100)
b. Medium – Critical (Rating B – 50)
c. Low – Marginal (Rating C – 10)

As a guideline for Impact Classification the following matrix is used:

Project Objective	C Rating 10	B Rating 50	A Rating 100
Cost	Cost increase > 0 % or > 0 €	Cost increase 5 - 10% or > 50.000 €.	Cost increase > 10 % or > 100.000 €.
Schedule	overall project schedule delay > 0 days	overall project schedule delay > 1 week	overall project schedule delay > 2 weeks *
Scope	Scope decrease barely noticeable	Minor areas of scope are affected	Major areas of scope are affected; scope reduction unacceptable to the client
Quality	Quality reduction barely noticeable	Quality reduction does not affect vital functionality	Quality reduction requires client approval

Exhibit 4 – Impact classification guideline

The score represents bottom thresholds for the classification of risks assuming “normal” conditions. An upgrade of the score to the next or even next + 1 level is necessary, if the risk is impacted by critical factors such as:

- How important the specific customer is

- Whether the project is critical for the further development of the relationship with the customer
- The risk is already in the focus of the customer
- Specific penalties for deviations from project targets are agreed in the contract with the customer

5. Risk Exposure

Risk Exposure or Risk Score is the value determined by multiplying the Impact Rating with Risk Probability as shown in Exhibit 5.

		Probability			
		1 = high (80% ≤ x ≤ 100%)	2 = medium high (60% ≤ x < 80%)	3 = medium low (30% ≤ x < 60%)	4 = low (0% < x < 30%)
Impact	A=high (Rating 100)	(Exposure – Very High) (Score 100)	(Exposure – Very High) (Score 80)	(Exposure – High) (Score 60)	(Exposure – Moderate) (Score 30)
	B=medium (Rating 50)	(Exposure – High) (Score 50)	(Exposure – Moderate) (Score 40)	(Exposure – Moderate) (Score 30)	(Exposure – Low) (Score 15)
	C=low (Rating 10)	(Exposure – Low) (Score 10)	(Exposure – Low) (Score 8)	(Exposure – Low) (Score 6)	(Exposure – Low) (Score 3)

Exhibit 5 – Impact-Probability Matrix

The colours represent the urgency of risk response planning and determine reporting levels.

6. Risk Occurrence Timeframe

The timeframe in which this risk will have an impact is identified. This is classified into one of the following:

Timeframe	Description
Near	Now- until one month
Mid	next 2-6 months
Far	>6 months

Exhibit 6 – Risk occurrence timeframe

In addition to classifying risks according to the above guidelines, it is also necessary to describe the impact on cost, schedule, scope, and quality in as much detail as possible based on the nature of the risk.

7. Risk Classification Examples:

Risk event	Probability	Impact rating	Score
The hardware will be delivered 10 days late, leading to an overall project delay of 10 days in a project that is of minor importance to the customer	100%	B (50)	50
The hardware will be delivered 10 days late, leading to an overall project delay of 10 days. Delivery on time is important to the customer. High penalties for each day of delayed delivery are agreed.	100%	B (50)	50, but because of special circumstances is upgraded to 100
The acceptance test scope of work is not confirmed by the customer by integration test completion. From experience, it may be expected that the customer will require a certain number of additional test cases, leading to schedule delay and additional costs.	70%	B (50), because a risk of 6% cost increase and 10 days project schedule delay are expected	40
At C130 the customer has confirmed half the features described in the R-Spec, but informs Nokia Siemens Networks that the other half, as well as some additional requirements, are still under discussion. The final scope of the project is therefore very unclear. Major changes are to be expected.	80%	A (100), because a risk of more than 10% cost increase and more than 2 weeks project schedule delay, as well as major changes in scope, are expected	100

Exhibit 7 – Risk Classification Examples

Risk Response Planning

There may not be quick solutions to reduce or eliminate all the risks facing a project. Some risks may need to be managed and reduced strategically over longer periods. Therefore, action plans should be worked out to reduce these risks. These action plans should include:

- Risk description with risk assessment
- Description of the action to reduce the risk
- Owner of the risk action
- Committed completion date of the risk action

All risk action plans should be allotted to the person identified to carry out the action plan.

1. Risk Response Plans

For each risk, a risk response must be documented in the risk register in agreement with the stakeholders. This should be ensured by the project manager.

Risk response plans are aimed at the following targets:

1. Eliminating the risk
2. Lowering the probability of risk occurrence
3. Lowering the impact of the risk on the project objectives

Risk response plans usually impact time and costs. It is therefore mandatory that the time and cost for the defined response plan are calculated as precisely as possible. This also assists in selecting a response plan from the alternatives, and in verifying whether the response plan is costlier or has more impact on one of the project objectives than the risk itself.

After successfully implementing a set of response plans, the score of a risk could be lowered in consultation with the stakeholders.

Examples:

Risk event	Risk Response
Schedule delay to be expected if the hardware is delivered late.	Agree on penalties with the hardware supplier for delayed delivery. • Evaluate ways to shorten the timeline for onsite activities like installation, commissioning, etc. • Shorten the acceptance phase by reducing acceptance test cases or inviting the customer to a joint system test before customer release.
Time, cost, and scope deviation to be expected if requirements not final at project kick-off.	• Make sure that the requirements specification has been internally reviewed by all concerned parties and is internally agreed as complete and feasible. • Inform the customer about the latest possible date for input into the final version of the requirements specification and about the version that is to be used as basis for the development if no further input is available until then. • Open a claim against the customer. • Agree with the customer that all issues not clarified until project kick-off will be treated as change requests with possible impacts on time and cost.

Exhibit 8 – Risk response - Examples

2. Risk Triggers

For each risk a trigger must be documented in the risk register. The trigger identifies the risk symptoms or warning signs. It indicates that a risk has occurred or is about to occur. The risk trigger also gives an indication of when a certain risk is expected to occur.

Examples:

Risk Event	Risk Trigger
Schedule delay to be expected if the hardware is delivered late.	Confirmed hardware delivery dates not available at project initiation.
Time, cost, and scope deviation to be expected if requirements will not be final at project kick-off.	R-Spec is not ready for customer review 1 week before project kick off.

Exhibit 9 – Risk Trigger Examples

3. Risk Ownership

The ground rule is that responsibility for managing all risks in the project lies with the project manager.

Based on this ground rule a Risk Owner (who is not necessarily the project manager) must be determined and named in the Risk Register. The Risk Owner is normally the one who can best monitor the risk trigger, but can also be the one who can best drive the defined countermeasures. The Risk Owner is responsible for immediately reporting any changes in the risk trigger status and for driving the defined countermeasures.

Examples:

Risk event	Risk owner
Schedule delay to be expected if the hardware is delivered late.	Technical Order Manager and Service Account Manager
Time, cost, and scope deviation to be expected if requirements will not be final at project kick-off.	Project Manager
Overall project schedule delay to be expected if customer release will not be reached in time.	System Test leader

Exhibit 10 – Risk Owner Examples

Risk Monitoring and Control

Risk monitoring and control includes:

- Identifying new risks and planning for them
- Keeping track of existing risks to check if:
  - Reassessment of risks is necessary
  - Any of risk conditions have been triggered
  - Monitor any risks that could become more critical over time
  - Tackle the remaining risks that require a longer-term, planned, and managed approach with risk action plans
- Risk reclassification

  For the risks that cannot be closed, the criticality has to go down over a period of time due to implementing the action plan. If this is not the case then the action plan might not be effective and should be re-examined.

- Risk reporting

  The risk register is continuously updated, from risk identification through risk response planning and status update during risk monitoring and control. This project risk register is the primary risk reporting tool and is available in the central project server, which is accessible to all stakeholders.

Risk monitoring and controlling or risk review is an iterative process that uses progress status reports and deliverable status to monitor and control risks. This is enabled by various status reports, such as quality reports, progress reports, follow-up reports, and so forth.

Risk Reviews are a mandatory item of milestone meetings and/or regular project meetings, but they can also be executed during separately planned risk review meetings. These risk reviews must be held regularly. The frequency could also be determined based on the overall risk level of a project.

Risk Threshold

The risk priorities have to be set to direct focus where it is most critical. The risks with the highest risk exposure rating are the highest priority.

Risks with Exposure Low can be dropped from the mitigation plans, but may need to be revisited later in the project.

The organizational mandate is that if the projects have at least one “Very High” risk or more than 3 “High” risks, guidance should be sought from management and stakeholders, as the project may be at high risk of failure. This is the recommended risk threshold. Projects can customize the threshold based on project needs.

Risk Efficiency measurement

Risk Metrics

The efficiency of risk analysis and management is measured by capturing the following metrics during project closure. The analysis results are used to decipher lessons learned, which is updated in the organization's lessons learned database.

- Number of risks that occurred / Number of risks that were identified
- Was the impact of the risks as severe as originally thought?
- How many risks recurred?
- How do the actual problems and issues faced in a project differ from the anticipated risks?

Risk Audit

This is an independent expert analysis of risks, with recommendations to enhance maturity or effectiveness of risk management in the organization. This evaluates:

- How good are we at identifying risk?
- Exhaustiveness and granularity of risks identified
- Effectiveness of mitigation or contingency plan
- Linkage of project risks to organizational risks

This is not a “process adherence” audit, but an aid to enhance the quality of risk identification and risk analysis. This is also used as a forum to benchmark and identify good practices of risk management among various projects in the organization.

The risk audit is done by a group of independent domain or technical experts through documentation review and interviews. The key deliverables of this risk audit are:

- Customized checklist to evaluate the risks of a project
- Identify areas of importance for risk analysis for a project (risk taxonomy)
- Risk radar – risk-prone areas of the product group
- Potential additional risks identified based on the review
- Top 10 risks in the organization from key projects, which requires management attention

Conclusion

Risk management is becoming the most challenging aspect of managing software projects. While we can never predict the future with certainty, we can apply a simple and streamlined risk management process to predict the uncertainties in the projects and minimize the occurrence or impact of these uncertainties.

Risk management not only helps in avoiding crisis situations but also aids in remembering and learning from past mistakes. This improves the chance of successful project completion and reduces the consequences of those risks.

This certainly is not the end of the journey for us on the effective risk management. It is a constant learning process to be able to constantly improve our practices to increase our process efficiency.

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Transforming project risk management into project uncertainty management

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Abstract

This paper argues that all current project risk management processes induce a restricted focus on the management of project uncertainty. In part this is because the term 'risk' encourages a threat perspective. In part this is because the term 'risk' has become associated with 'events' rather than more general sources of significant uncertainty. The paper discusses the reasons for this view, and argues that a focus on 'uncertainty' rather than risk could enhance project risk management, providing an important difference in perspective, including, but not limited to, an enhanced focus on opportunity management. The paper outlines how project risk management processes might be modified to facilitate an uncertainty management perspective.

Keywords: Risk management; Uncertainty management; Opportunity management

1. Introduction

This paper suggests that project risk management (PRM) processes as currently operated have a limited focus which restricts the contribution to improving project management practice and hence project performance. The authors argue that a broader perspective concerned with managing uncertainty is needed.

A recent paper by Green [1] makes a related argument, although his characterisation of project risk management as '*primarily concerned with quantitative techniques*' is inappropriately narrow, and we do not agree with his recommendation. Green's concern is that established techniques of risk management pay too little attention to uncertainty associated with stakeholder interactions, and the uncertainties that '*characterise the strategic interface between construction projects and client organisations*'. Green argues for the use of Friend and Hickling's 'Strategic Choice' approach [2] to project uncertainty, which seeks to aid decision making processes by conceptualising three types of uncertainty related to the working environment, guiding values, and related decisions. The present authors are sympathetic to Green's concerns. Further, as a generic framework the Strategic Choice approach is certainly capable of useful deployment in a project management context. However, as a generic process Strategic Choice lacks focus on project management issues. Rather than pursue this approach to enhance the management of uncertainty in projects, the present authors argue for transforming existing PRM processes into Project Uncertainty Management. Strategic Choice can be used within this framework as appropriate. This will facilitate and extend the benefits of what is currently PRM. However, it will also help direct attention towards areas of project related uncertainty and associated management issues that are not addressed in current PRM processes.

The authors have been moving towards this position over a number of years, in the light of issues that have arisen in consultancy work, conceptual development of existing techniques, and reactions of project managers to presentations on the subject. Nevertheless, the arguments and proposals presented here have not been widely tested. They are offered here to stimulate debate and to encourage empirical testing.

The arguments presented here begin by considering how use of the term 'risk' induces a restricted focus on the management of project uncertainty. The middle part

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of the paper identifies some basic kinds of uncertainty that need to be addressed in projects. The final part outlines how PRM processes could be modified to avoid inducing a restricted focus and to address a wider set of sources of uncertainty.

2. Problems with the term 'risk'

In dictionary definition terms 'risk' means: "*hazard, chance of bad consequences, loss, exposure to chance of injury or loss* " (Concise Oxford Dictionary). Such definitions illustrate one problem with the term 'risk'—its ambiguous use as a synonym of probability or chance in relation to an event or outcome, the nature of an outcome, or its cause. In an entertaining and well referenced paper, entitled "Against risk", Dowie [3] argues persuasively for abandoning use of the term 'risk' altogether. "*It is simply not needed*". Dowie argues that the term 'risk' is

> an obstacle to improved decision and policy making. Its multiple and ambiguous usages persistently jeopardize the separation of the tasks of identifying and evaluating relevant evidence on the one hand, and eliciting and processing necessary value judgements on the other.
> (The term) 'risk' contaminates all discussions of probability because of the implicit value judgement/s that the term always brings with it, just as it contaminates all discussions of value assessment because of the implicit probability judgement/s that it contains [3].

The present authors are inclined to disagree with Dowie about abandoning use of the term 'risk' completely, but we are very sympathetic to his concerns.

One of our concerns relates to the association of the term 'risk' with adversity, implying that project risks are potential adverse effects on project performance, and that sources of risk are 'things that might go wrong', or threats to the project. With this association, PRM would seem to be about identifying and managing threats to project performance. As is widely recognised, this view of PRM is restrictive because it fails to consider the management of opportunities, in the sense of 'potential welcome effects on project performance'.

In any given decision situation both threats and opportunities are usually involved, and both should be managed. A focus on one should never be allowed to eliminate concern for the other. Moreover, opportunities and threats can sometimes be treated separately, but they are seldom independent, just as two sides of the same coin can be examined at one at a time, but they are not independent when it comes to tossing the coin. Courses of action are often available which reduce or neutralise potential threats, and simultaneously offer opportunities for positive improvements in performance. It is rarely advisable to concentrate on reducing threats without considering associated opportunities, just as it is inadvisable to pursue opportunities without regard for the associated threats.

Recognising this, guides published by the US Project Management Institute (PMI) and the UK Association for Project Management (APM) have adopted a broad view of risk. Their definitions of risk are very similar, as follows:

> *Risk—an uncertain event or condition that, if it occurs, has a positive or negative effect on a project objective* [4, p127].
> *Risk— an uncertain event or set of circumstances that, should it occur, will have an effect on the achievement of the project's objectives* [5], (p 16).

These definitions encompass welcome 'up-side' as well as unwelcome 'down-side' effects. In spite of this, there is still a tendency for practitioners to think of risk in largely down-side, threat terms (a tendency which the authors are not always able to resist), and PRM as primarily threat management. For example, Table 1 lists references in the PMI guide [4] to risk in down side, threat terms which include: illustrative examples of risks as threats, terminology, descriptions of risk responses, and the use of probability impact matrices. The preponderance of such references suggests at least an emphasis, if not a pre-occupation, with threats rather than opportunities. This emphasis might reflect a difficulty in throwing off the commonly understood meaning of 'risk'.

Another of our concerns is the focus on 'events' or 'circumstances' which these definitions suggest. We suggest it is important to take uncertainty about anything that matters as the starting point of uncertainty management, defining uncertainty in the simple 'lack of certainty' sense.

3. Uncertainty management

To emphasise the desirability of a balanced approach to opportunity and threat management, the term 'uncertainty management' is increasingly used in preference to the more established terms 'risk management' and 'opportunity management'. However, uncertainty management involves rather more than the combination of risk management and opportunity management. Uncertainty management is not just about managing perceived threats, opportunities and their implications. It is about identifying and managing all the many sources of uncertainty which give rise to and shape our perceptions of threats and opportunities. It implies exploring and understanding the origins of project uncertainty before seeking to manage it, with no preconceptions

about what is desirable or undesirable. Key concerns are understanding where and why uncertainty is important in a given project context, and where it is not. This is a significant change in emphasis compared with most PRM processes.

4. The scope of uncertainty

The scope for uncertainty in any project is considerable, and most project management activities are concerned with managing uncertainty from the earliest 'Conception' stage to the final 'Support' stage of the project life cycle (PLC) [6], clarifying what can be done, deciding what is to be done, and ensuring that it gets done. Uncertainty in the plain English sense of 'lack of certainty' is in part about 'variability' in relation to performance measures like cost, duration, or 'quality'. It is also about 'ambiguity' associated with lack of clarity because of the behaviour of relevant project players, lack of data, lack of detail, lack of structure to consider issues, working and framing assumptions being used to consider the issues, known and unknown sources of bias, and ignorance about how much effort it is worth expending to clarify the situation.

In a project context these aspects of uncertainty can be present throughout the PLC, but they are particularly evident in the conceive, design, plan and allocate stages [6]. Here these aspects of uncertainty contribute to uncertainty in five areas: the variability associated with estimates of project parameters, the basis of estimates of project parameters, design and logistics, objectives and priorities, and relationships between project parties. All these areas of uncertainty are important, but generally items become more fundamentally important to project performance as we go down the list. Potential for variability is the dominant issue at the top of the list, but ambiguity rather than variability becomes the more dominant underlying issue towards the bottom of the list. Uncertainty about variability associated with estimates involves the other four areas, each of them involving dependencies on later areas in this list.

4.1. Variability associated with estimates

An obvious area of uncertainty is the size of project parameters such as time, cost, and quality related to particular activities. For example, we may not know how much time and effort will be required to complete a particular activity. The causes of this uncertainty might include one or more of the following:

- lack of a clear specification of what is required;
- novelty, lack or experience of this particular activity;
- complexity in terms of the number of influencing factors and inter-dependencies between these factors;
- limited analysis of the processes involved in the activity;
- possible occurrence of particular events or conditions which could have some (uncertain) effect on the activity.

Table 1
Illustrations of a threat perspective

Examples of a focus on risks as threats
Risk categories largely threat orientated using terms like 'poor' allocation/use, 'inadequate', 'lack of', 'interruption', 'conflicts', *force majeure* (11.2.1.3).
Rating impacts for a risk (Figure 11.2), most table entries expressed in threat terms.
Individual illustrative examples all threat based (11.2.3.2/3, 11.5.2.3/4, 11.5.3.4).

Terminology
Risk described in terms of *severity* (11.3.3.2, 11.5).
The term 'impact' is linked with *severity of effect* (11.3.2.2).
High impact risks considered undesirable: non linear scales "reflecting the organisation's desire to *avoid* high-impact risks" (11.3.2.2, Figure 11.2).

Description of types of risk response (11.5.2)
Responses categorised as avoidance, transference, mitigation, acceptance:
Avoidance: "is changing the project plan to *eliminate* the risk or condition or to *protect* the project objectives from its impact. Although the project team *can never eliminate all risk events*, some specific risks may be avoided.
Transference: "does not *eliminate* it (risk)"; "nearly always involves payment of a risk *premium* to the party taking on the risk".
Mitigation: "seeks to *reduce* the probability and/or consequences of an *adverse* risk event to an acceptable threshold. Taking early action to *reduce* the probability of a risk's occurring or its impact on the project is more effective than trying to *repair* the consequences after it has occurred."; "...may take the form of...action that will *reduce* the *problem*".

Use of probability impact matrices (11.3.2.2)
PIMs require an ordinal or cardinal scale "to determine whether a risk is considered *low, moderate or high*". This treats risks purely as threats, since a ranking of opportunities and threats would require a more complex approach.

Extracted from [4], paragraph numbers shown in parentheses.

Only the last of these items really relates to specific events or conditions as referred to in the earlier definitions of a 'risk'. The other sources of uncertainty arise from a lack of understanding of what is involved and as such, are less obviously described as threats or opportunities.

4.2. Uncertainty about the basis of estimates

An important area of uncertainty relates to the basis for estimates produced by project parties [4], (p. 11.3.1.5). For example, it is often necessary to rely on subjective estimates for probabilities in the absence of sufficient relevant statistical data for determining probabilities 'objectively'. The basis for such subjective judgments may be unclear, but articulating them at least makes these estimates available for scrutiny and comparison with other estimates. Uncertainty about the basis of estimates may depend on who produced them, what form they are in, why, how and when they were produced, from what resources and experience base, and the extent of any bias in estimates.

Adjustment for bias in estimates is especially difficult. Bias may be conscious or unconscious, pessimistic or optimistic, and clues if not data, may be available or not. Deliberate pessimistic bias to "protect" estimates may be systemically induced by previous management practice of arbitrarily cutting back all estimates provided from members of the project team. This is an implicit admission that management is uncertain about the status of estimates. If this cycle of padding and cutting back of estimates goes unchecked, then the uncertainty in subsequent estimates is amplified and may become considerable. This uncertainty is further compounded if related activities are not well defined, relatively novel, or complex, or there has been limited opportunity to develop a high quality estimate (as in many competitive tendering situations, for example).

A particularly important source of uncertainty is the nature of assumptions underpinning estimates. The need to note assumptions about resources choices and methods of working is well understood if not always fully operationalised (see for example: [4], (p. 11.2.2.4). However, estimates may also be conditional on the assumed non-occurrence of "*force majeure*" events, and possible changes in project context and scope. The effects of such events and possible changes may be difficult to quantify, even when they are identified. This gives rise to the characterisation of such events and possible changes as either 'known unknowns' where they are identifiable at least in qualitative terms, and 'unknown unknowns' when they are unspecified events or possible changes.

Estimates ought to be clear about the extent to which they have been adjusted to allow for factors in the above categories. Failure to make or identify such adjustments, and the rationale for them, introduces additional uncertainty about assumed prevailing conditions. However, further uncertainty typically exists about what levels of adjustment to estimates are appropriate for different project parties. For example, to what extent should one party worry about allowing for *force majeure* events? If a client company out-sources a particular task to a contractor, the contractor's view of what adjustment to cost estimates is appropriate to cover *force majeure* will be rather different from the client's view. The set of *force majeures* that could impact on each party may be different, or the parties may have different perceptions of with whom the consequences of a given *force majeure* will finally rest.

The problem of uncertainty about the conditions underpinning estimates is even greater in respect of estimates of the probability of an event occurring. A large proportion of those using probabilistic analysis in projects often fail to get to grips with the conditional nature of probabilities and associated measures used for decision making and control.

4.3. Uncertainty about design and logistics

In the conception stage of the PLC the nature of the project deliverable and the process for producing it are fundamental uncertainties. In principle, much of this uncertainty is removed in pre-execution stages of the PLC by attempting to specify what is to be done, how, when, and by whom, at what cost. In practice, a significant amount of this uncertainty may remain unresolved through much of the PLC. The nature of design and logistics assumptions and associated uncertainty may drive some of the uncertainty about the basis of estimates.

4.4. Uncertainty about objectives and priorities

An aim of improving project performance presupposes clarity about project objectives and the relative priorities between objectives and acceptable trade-offs. Attempting project management or risk management when this clarity is lacking is like attempting to build a tower on wet sand. The implications of uncertainty related to the nature of objectives and relative priorities need to be managed as much as uncertainty about what is achievable. It is perhaps indicative of a perceived failure of conventional risk management and project management to address objectives and trade-offs that the concept of 'Value Management' has been introduced to encompass this [7].

Morris and Hough [8] argue for the importance of setting clear objectives and performance criteria which reflect the requirements of various parties, including stakeholders who are not always recognised as players (regulatory authorities, future customers, for example).

The different project objectives held by interested parties, and any inter-dependencies between different objectives need to be appreciated.

The nature of objectives and priorities assumptions and associated uncertainty may drive some of the uncertainty about the basis of estimates and the amount of variability estimated. For example, if the relative priorities of time, cost and performance are not clear, the associated uncertainty for all three will be larger than it would be if clear priorities were determined.

4.5. Uncertainty about fundamental relationships between project parties

A pervasive source of uncertainty is the multiplicity of people, business units, and organisations involved in a project. The relationships between the various parties may be complex, and may, or may not, involve formal contracts. The involvement of multiple parties in a project introduces uncertainty arising from ambiguity in respect of [9]:

- specification of responsibilities;
- perceptions of roles and responsibilities;
- communication across interfaces;
- the capability of parties;
- contractual conditions and their effects; and
- mechanisms for coordination and control.

Included here can be ambiguity about roles and responsibilities for bearing and managing project related uncertainty. This ambiguity ought to be systematically addressed in any project, not just those involving formal contracts between different organisations. Contractor organisations are often more aware of this source of ambiguity than their clients, although the full scope of the risks and opportunities that this ambiguity generates for each party in any contract (via claims, for example) may not always be fully appreciated until rather late in the day. For example, interpretations of risk apportionment implied by standard contract clauses may differ between contracting parties [10,11].

The nature of assumptions about contractual relationships and associated uncertainty may drive uncertainty about objectives and priorities with further knock-on effects. For example, if a 'fair weather partnership' cracks when the going gets tough, everything else comes apart, and lost opportunities may be the biggest casualty.

5. Towards uncertainty management

Efficient and effective project management requires appropriate management of all the sources of uncertainty outlined in the previous section. PRM processes which adopt a focus on threats will not address many of these sources of uncertainty. A comprehensive PRM process concerned with threats and opportunities will do better, but will still tend to be focussed on uncertain events or circumstances. This does not facilitate consideration of aspects of variability which are driven by underlying ambiguity. To address uncertainty in both variability and ambiguity terms, we need to modify and augment existing PRM processes and adopt a more explicit focus on uncertainty management. An obvious first step is to consider the usefulness of terminology involving the word 'risk' and various threat orientated terms. Other steps involve modifications to PRM processes to address the various sources of uncertainty outlined in the previous section.

5.1. Revise terminology

Present use of the term 'risk' is ambiguous. Best practice regards risk as encompassing both threat and opportunity, but guidance on PRM is frequently couched in threat management terms, and in common parlance risk is more usually synonymous with threat. More fundamentally, widely followed guidance is defined in terms of 'events' or 'circumstances'. An obvious first step towards uncertainty management is to remove this ambiguity by using the term 'uncertainty' in the everyday sense of 'lack of certainty' as a starting point. A less obvious second step is to associate 'downside risk' with the *implications* of significant 'threats', or unwelcome consequences, and 'upside risk' with the *implications* of significant 'opportunities' to welcome consequences. Consideration of significant threats and opportunities then becomes part of uncertainty management. Risk becomes 'the implications of significant uncertainty about the level of project performance achievable', a useful clarification consistent with everyday usage if not identical to dictionary definitions. This is the definition adopted in Chapman and Ward [6], (p. 7) because it clarifies the core pursuit of 'risk efficiency'.

Replacing 'risk' with 'uncertainty' as a starting point could significantly broaden thought processes in 'risk identification' which becomes '*uncertainty* identification'. In particular, a process involving '*uncertainty* identification' (rather than 'risk identification'), would draw attention in a natural way to items 3, 4, and 5 in Table 2: uncertainty about design and logistics, uncertainty about project objectives and priorities, and uncertainty about fundamental relationships between project parties.

Additionally an '*uncertainty* identification' process would induce identification of a wider set of responses for managing a particular source of uncertainty. For example, a 'risk identification' process, focussing on potential threats, might highlight 'unavailability of a key resource', prompting possible responses such as 're-schedule activities', 'obtain additional resource'. However,

an exercise seeking to identify sources of *uncertainty* encourages a more open ended, neutral description of factors, which facilitates a less constrained consideration of response options. Thus instead of the risk 'unavailability of a key resource', an exercise identifying sources of uncertainty would express this as 'uncertainty about availability of a key resource', prompting questions about all factors influencing availability, essential characteristics of the resource, and the possibility of excess as well as shortage of the resource. In particular, how to make good use of excess resource has to become an issue.

After simple substitution of 'uncertainty' for 'risk' in all terminology, an additional step would be to modify wording in PRM guidelines wherever this associates risk (uncertainty) with threat. For example, in Table 1, the risk response of 'mitigation' is described as *reduction* of probability and/or consequences of an 'adverse risk' [4]. Taking an uncertainty perspective, Chapman and Ward [6], refer to the generic response of 'mitigation' as impact *modification* (rather than impact *reduction*), and the generic response of 'prevention' as *changing* the probability of occurrence (rather than *reducing* it). Decisions about the transfer of *risk* would become decisions about the transfer of significant *uncertainty*, the upside and the downside. Not only would this terminology induce a more considered view of the wisdom of risk (threat) transfer, it would also stimulate consideration of wider implications of transfer strategies. Table 3 gives further examples drawing on terms included in Table 1.

An important further benefit of this terminology is the way it encourages an iterative approach with an initial focus on the question 'does it look like uncertainty matters, or can uncertainty be safely ignored, in some areas if not in total?' Where it may matter or if it may matter, further iterations can then address whether or not associated risk needs to be managed, the depth of understanding warranted, and the detail of the uncertainty management strategy. The perceived risk may change as the understanding of uncertainty develops.

A further important benefit of this terminology is a shift in emphasis without a need to throw away the useful terms 'risk' and 'risk management', and a re-emphasised focus on 'risk efficiency'. Their meaning changes only very slightly in terms of APM and PMI terminology, not at all in terms of closely related and widely adopted terminology [6]. Critically important, in these (revised) terms we need to move our focus from the product to the process. 'Uncertainty management' is the process which is the focus of our attention. 'Risk management' is one of the products. Other products included are enhanced communication, more focus on project objectives, more focus on value analysis issues, and a range of other widely appreciated spin-offs which are valuable in their own right.

Table 2
Types of uncertainty

1. Variability associated with estimates
2. Uncertainty about the basis of estimates
3. Uncertainty about design and logistics
4. Uncertainty about objectives and priorities
5. Uncertainty about fundamental relationships between project parties

Table 3
Uncertainty Management terminology

Risk management	Uncertainty management
a downside risk	a threat (giving rise to downside risk)
an upside risk	an opportunity (giving rise to upside risk)
a risk (upside or downside)	a source of uncertainty
a (possible) source of risk	a source of uncertainty
a problem	an issue
an impact	a consequence/effect
a weakness	an issue
a poor allocation	an inappropriate/unclear allocation
inadequate	Inappropriate
avoid risk	resolve uncertainty
mitigate	modify
lack of	shortage or surplus of
major risk	significant uncertainty
absence of	availability of

5.2. Expose and investigate variability

Single point estimates of a particular parameter are of limited value for uncertainty management (and PRM) purposes without some indication of the potential variability in the size of the parameter. Thus a best estimate of the cost of a particular activity is of limited value without some indication of the range or probability distribution of possible costs.

In respect of particular sources of risk, the current widespread use of probability impact matrices to size risks generates unnecessary uncertainty by over-simplifying estimates of impact and associated probability. An alternative, a 'minimalist' approach [12] is to identify explicit ranges not only for estimated impacts, but also for associated probabilities, and to combine these in a way that does not obscure or underestimate potential variability. In the minimalist approach expected values and associated ranges for all quantified sources of uncertainty are presented graphically in a way that displays the contribution of each to the total, clearly indicating what matters and what does not. A first pass display provides a basis for managing subsequent passes of the process in terms of data acquisition to confirm important probability and impact assessments, refinement of response strategies and key decision choices. The first pass is an attempt to size variability reflecting all relevant underlying ambiguity associated with the size of uncertainty about both the impact and probability of risk events occurring, with uncertainty about the size of probabilities often dominating uncertainty about the size of impacts. The approach is deliberately conservative (pessimistic) about variability to counteract natural bias towards ranges that are too narrow, to manage expectations that any subsequent refinement of estimates should indicate less uncertainty rather than discover more, and to avoid dismissing uncertainty which may be significant.

As noted earlier, difficulty in estimating time or effort required to complete a particular activity may arise from a lack of knowledge of what is involved rather than from the uncertain consequences of potential threats or opportunities. Attempting to address this difficulty in conventional PRM terms is not appropriate. What is needed is action to improve knowledge of organisational capabilities and reduce variability in the performance of particular project related tasks. For example, uncertainty about the time and cost needed to complete design or fabrication in a project may not be readily attributable to particular sources of risk, but to variability in efficiency and effectiveness of working practices. An uncertainty management perspective would seek an understanding of why this variability arises, with a view to managing it. This may require going beyond addressing uncertainty associated with a specific project, to trigger studies of operations which provide an input into a range of projects, as illustrated by this example.

5.3. Clarify uncertainty about the basis of estimates

The basis for all estimates needs to be understood, in terms of the quality, reliability and integrity of underlying data [4], (p. 11.3.2.4, 11.3.3.2). As noted earlier, uncertainty about the basis of estimates may depend on who produced them, what form they are in, why, how and when they were produced, and from what resources and experience base. Recording answers to these questions would provide useful guidance on the quality of estimates. This would help counteract bias in estimates, discourage decision making based on inappropriately limited data, and facilitate selective, cost effective development of estimates where appropriate.

Existing PRM processes generally recognise the desirability of recording key assumptions used to generate estimates [4], (p. 11.2.2.4). However, practice could improve in terms of the extent to which assumed conditions are recognised and treated in estimates. For example, if certain conditions do in the event apply, a contractor may avoid the need to allow for the variation in cost arising from the presence of these conditions by appropriate contractual agreement, leaving the client to manage this variation in cost. However, this raises the issue of how such cost variations might be allocated within the client's organisation. Should this variation in cost be incurred by the project manager's budget?, or by higher, programme level or corporate level contingency funds? A key point is that the 'known unknowns', 'unknown unknowns', and bias in estimates referred to earlier may not be controllable or readily sized by the project manager, or even by corporate management. The project manager may not be the appropriate party to be responsible for them, but the organisation at some level has to be. Delineating what uncertainties the project manager is responsible for, and what is the responsibility of programme and corporate management, is an important aspect of uncertainty management. 'Known unknowns', 'unknown unknowns', and bias are inherently difficult to size, but they cannot be ignored for corporate management purposes. This problem is more readily identified with uncertainty management than it is with PRM focussed on the consequences of particular events on a given project's objectives.

5.4. Address uncertainty about fundamental relationships, as well as design and logistics

Careful attention to formal PRM is usually motivated by the large scale use of new and untried technology while executing major projects, where there are likely to be significant threats to achieving objectives. A threat perspective encourages a focus on these initial motivating

factors. However, key performance issues are often unrelated to these motivating factors, but rather are related to sources of ambiguity introduced by the existence of multiple parties and the project management infrastructure. Such issues need to be addressed very early in the project and throughout the PLC, and should be informed by a broad appreciation of the underlying 'root' uncertainties. Chapman and Ward [6] offer a six Ws framework for this purpose based on the following six questions:

1. Who are the parties ultimately involved?
2. What do the parties want to achieve?
3. What is it that each party is interested in?
4. Whichway (how) is each party's work to be done?
5. What resources are required?
6. When does it have to be done?

Understanding the uncertainty associated with each of these basic questions, and the implications of interactions between them, is fundamental to effective identification and management of both threats and opportunities. Use of the six Ws framework from the earliest stages of the PLC could usefully inform development of project design and logistics by clarifying key sources of uncertainty.

5.5. *Address uncertainty about objectives and priorities*

Strategies for managing project uncertainty cannot be divorced from strategies for managing project objectives and associated trade-offs. A key issue is 'do all parties understand their responsibilities and the expectations of other parties in clearly defined terms which link objectives to planned activities?' The six Ws are a core framework for considering the tradeoffs between time, cost and quality, the different tradeoffs for different project stakeholders, and the implications of tradeoffs that change over time. For many projects, objectives and related performance criteria can be refined progressively through the Conceive, Design, Plan and Allocate stages of the PLC [6]. However, in some projects, for example information systems or software development projects, it may not be practicable to ensure that all project objectives are well defined or crystallised prior to the Execute stage. This becomes apparent in previous stages where decisions to continue with the project acknowledge the continued ambiguity about objectives. In this scenario 'control evaluation', undertaken each time a milestone is achieved, ought to include a 'configuration review' of objectives currently achievable with the project [13,14]. If these objectives are unsatisfactory, further Design and Plan effort may be necessary. 'Value management' and related approaches to the formulation of objectives should be regarded as one part of the uncertainty management process [1].

Failure to develop operational measures of performance in a way that allows tradeoffs between performance criteria creates substantial uncertainty which has effects beyond individual projects. Consider for example, tradeoffs in producing in-house design work for a project. If no appropriate incentives exist, the potential for misalignment of objectives between the design department and the project is substantial. Important management questions are: how much is it worth to a project to be able to complete the design faster?; what might the effect on the quality of design be? Uncertainty management could involve design of internal incentive contracts between the design department and project manager to encourage appropriate tradeoffs by the design department. If incentives lead to more efficient working practises involving less multi-tasking, staff morale and staff turnover may improve. This could lead to opportunities associated with easier hiring, a deepening experience base, and qualitative improvements in designs on future projects with cumulative, 'virtuous circle' benefits.

6. Conclusions

Risk management can make an important contribution to effective project management. However, there is some justification for the view that current PRM processes are threat orientated and that this can limit the contribution that PRM makes to improving project performance. Further a threat orientation is not the only concern. Specifically, it is suggested here that a threat and event-based perspective can result in a lack of attention to several important areas of project related uncertainty, including: variability arising from lack of knowledge, the basis of estimates, the treatment of assumptions about operating conditions, and the development of appropriate objectives and associated tradeoffs.

Comprehensive treatment of project uncertainty requires an approach which amounts to modifying and augmenting current PRM processes. A simple but effective starting place involves use of the phrase Project Uncertainty Management instead of Project Risk Management. This would help to shift PRM processes from a threat focus towards a greater concern with understanding and managing all sources of project uncertainty.

Further process modifications would also assist this shift of emphasis, and might include for example:

- More emphasis on recording information in suitable format about the basis for estimates in order to guide subsequent refinement of estimates and analysis.
- More emphasis on understanding 'root' uncertainties facilitated by frameworks such as the six Ws.

- Developing methods for articulating and comparing performance objectives and perceived trade-offs between them.
- More emphasis on quantitative approaches which do not obscure variability, reducing reliance on probability impact matrices and adopting approaches such as the 'minimalist' approach [12].

A weakness in current PRM processes is that they are not readily focussed on sources of operational variability in the performance of organisational activities. An 'uncertainty management' perspective facilitates such a focus and also draws attention to the need to understand and manage variability in organisational activities that have an input into a number of projects.

A similar argument applies to identification and treatment of the conditions ('known unknowns') assumed to prevail when developing estimates. 'Unknown unknowns' and bias need to be allowed for at some level in the organisation, and it is not efficient for these issues to be considered only at project level. Again an uncertainty management perspective highlights the need to address some aspects of project related uncertainty outside of particular project contexts, as part of managing the project infrastructure, taking a programme or corporate view.

Finally, an uncertainty management approach should facilitate integration with project management earlier in the PLC than a threat orientated PRM process. The need to explore and understand uncertainty (and avoid a largely pessimistic threat orientated perspective) is greatest in the earliest stages of the PLC, during conception when uncertainty is at its greatest. An uncertainty management perspective more naturally focuses attention on this stage of the project than threat orientated PRM. Comprehensive project uncertainty management should operate as an important extension of conventional project development, with the potential to influence project design and base plans on a routine basis, occasionally influencing very basic issues like the nature of project stakeholders and their objectives.

References

[1] Green SD. Towards an integrated script for risk and value management. Project management 2001;7(1):52–8.
[2] Friend JK, Hickling A. Planning under pressure: the strategic choice approach. 2nd ed. UK: Butterworth-Heineman, 1997.
[3] Dowie J. Against risk. Risk Decision and Policy 1999;4(1):57–73.
[4] Project Management Institute. A guide to the project management body of knowledge, 2000 edition. USA: Project Management Institute, 2000.
[5] Simon P, Hillson D, Newland K, editors, Project risk analysis and management (PRAM) guide. UK: The Association for Project Management, 1997.
[6] Chapman C, Ward S. Project risk management: processes, techniques and insights. UK: John Wiley, 1997.
[7] Kelly J, Male S. Value management in design and construction: the economic management of projects. UK: E & FN Spon, 1993.
[8] Morris PWG, Hough GH. The anatomy of major projects. UK: John Wiley, 1987.
[9] Ward S. Requirements for an effective project risk management process. Project Management Journal September 1999:37–43.
[10] Hartman F, Snelgrove P. Risk allocation in lump sum contracts—concept of latent dispute. Journal of Construction Engineering and Management September 1996:291–6.
[11] Hartman F, Snelgrove P, Ashrafi R. Effective wording to improve risk allocation in lump sum contracts. Journal of Construction Engineering and Management December 1997:379–87.
[12] Chapman CB, Ward S. Estimation and evaluation of uncertainty: a minimalist, first pass approach. International Journal of Project Management 2000;18:369–83.
[13] Turner JR. The handbook of project based management: improving processes for achieving your strategic objectives. US: McGraw-Hill, 1992.
[14] Turner JR, Cochrane RA. Goals and methods matrix: coping with projects with ill-defined goals and/or methods of achieving them. International Journal of Project Management 1993;11:93–102.

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Selecting risk response strategies considering project risk interdependence

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Abstract

In risk response analysis, risks are often assumed independently. In fact, however, risks in a project mutually affect and the independent risk seldom exists in reality. This paper provides an approach to quantitatively measure the risk interdependence. Based on the analysis of the risk interdependence, we construct an optimization model for selecting risk response strategies considering the expected risk loss, risk interdependence and its two directions. Further, the effects of the risk interdependence on risk response can be investigated. There are two major findings by the analysis of the case project. First, the expected utility would be more sensitive to the risk interdependence itself than to the directions of it. Second, the insufficient attention paid to or neglect of the risk interdependence would lower the expected utility and increase the implementation cost.

Keywords: Project risk management; Risk interdependence; Risk response strategy; Optimization; Expected utility

1. Introduction

Projects are, by nature, exposed to multiple risks in practice. If the risks are not dealt with effectively in the process of project management, the poor performance with increasing cost and time delays will appear. Therefore, project risk management (PRM) is an important topic for practitioners and academic scholars. In general, PRM consists of three phases (Buchan, 1994): risk identification, risk assessment and risk response. Risk identification is the process of recognizing and documenting associated risks. Risk assessment is the process of evaluating project risks according to their characteristics such as the probability and impact. Risk response refers to developing, selecting and implementing strategies in order to reduce risk exposure. The risk response plays a proactive role in mitigating the negative impact of project risks (Miller and Lessard, 2001). Appropriate risk response strategies must be selected to reduce global risk exposure in project implementation once the risks have been identified and analyzed (Zou et al., 2007). Therefore, the risk response analysis can be regarded as an important issue in PRM (Ben-David and Raz, 2001).

In risk response analysis, risks are often assumed independently and then analyzed according to their individual characteristics in response strategy selection (Fan et al., 2008; Seyedhoseini et al., 2009). In fact, however, project risks are not always independent (Adner, 2006; Kwan and Leung, 2011), and risks in a project mutually affect (Ren, 1994). This leads to the need to consider risk interdependences as a part of risk analysis (Ackermann et al., 2007). The interdependences, as one of important elements of defining project complexity (Baccarini, 1996), make projects are becoming increasingly complex (Loch and Terwiesch, 1998; Archer and Ghasemzadeh, 1999; Williams, 1999). With the growing complexity of projects, more and more issues in decision-making about the prioritization of risks and development of the strategies may arise (Marle et al., 2013). Thus, it can be said that if the risk interdependences can be correctly analyzed, the project managers will be able to make more effective risk response decisions (Kwan and Leung, 2011).

In this paper, we firstly provide an approach to measuring risk interdependence. The approach avoids the need to moderate divergences in evaluations of different experts or test the consistency of the evaluation results. Further, we propose an optimization model considering the risk interdependence and its

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two directions for selecting risk response strategies. On the basis of these, we can investigate the effects of the risk interdependence on the decisions about project risk response. The computation results and discussions through a case study show that the expected utility is more sensitive to the risk interdependence itself than to the directions of it. Moreover, more attention paid to the risk interdependence can increase the expected utility and reduce the implementation cost. The numerical and analytical results indicate that, in practical PRM, it is important to understand the interdependences between project risks.

The remaining of this paper starts from reviewing the previous studies related to the risk interdependence and project risk response. Then it moves to an introduction of the formulae and properties of the strength of risk interdependence. Subsequently, we propose an optimization model for selecting risk response strategies considering the risk interdependence. Thereafter, the application of the proposed methodology to an engineering project is illustrated and related results and discussions are here reported. Conclusions and perspectives appear in the last section.

2. Literature review

2.1. Relevant literature on risk interdependence

Project execution is always accompanied by risks and the studies on project risks and risk interdependence have always been the topics of concern in academia and practice. Some scholars study on the project risk interdependence from qualitative perspectives. Badenhorst and Eloff (1994) consider the risk dependence as one of the risk factors in the process of IT risk management. Adner (2006) points out that the success of a company's growth strategy hinges on the assessment of the ecosystem's risks of the company. And the ecosystem is characterized by three fundamental types of risks: initiative risks, interdependence risks and integration risks. Ackermann et al. (2007) develop the 'Risk Filter' which is a tool to evaluate risks in projects considering the interaction between risks as a part of risk analysis. The 'Risk Filter' has been used on many projects since its introduction. Kwan and Leung (2011) propose methods to estimate risks by taking account of risk dependence effects, and risk response strategies focusing on risk dependences should also be developed. Correa-Henaoa et al. (2013) describe a methodology for risk management in electricity infrastructures considering interdependences between the infrastructure assets. Cavallo and Ireland (2014) advocate the need for disaster preparedness strategies using a networked approach which can deal with interdependent risk factors. Besides, in the context of project portfolios, Keisler and Linkov (2010) describe what makes a set of risks worth considering as a portfolio. And they further point out that the ignorance of important risk interdependences can lead to underestimating the remaining portfolio risks or overlooking ways to eliminate more risks with a fixed budget, or otherwise getting the wrong answer. Teller (2013) points out that project risk management alone is insufficient in the context of project portfolios, and it is necessary to understand the interdependences and cross-portfolio risks within the project portfolio. An empirical investigation is also applied to show that it is necessary and important to understand the interdependences between projects and their risks for project portfolio success (Teller and Kock, 2013). Pajares and López (2014) argue that new methodologies should be developed in order to deal with project-portfolio interactions in terms of risk, schedule or cash-flow.

In addition, there are approaches quantitatively assessing risk interdependences, which can be mainly classified into the following categories: the Monte Carlo simulation approach, the nature language assessment approach, the matrix-based approach and the Delphi-based approach. The Monte Carlo simulation approach is mainly used to establish interdependence among different project risks (Rao and Grobler, 1995; Touran and Wiser, 1992). However, some major shortcomings have been mentioned (Wirba et al., 1996): the linear correlation is assumed to establish interdependences between random variables, but the linear correlation does not completely account for the interdependencies; it is not always practical to estimate the correlation because of the lack of readily available data, and the correlations are best used in situations where the necessary relationships must be developed empirically while this is hardly ever the case in risk analysis. To overcome these shortcomings, linguistic variables are used to assess the interdependence (Wirba et al., 1996). In the assessment process, linguistic variables have to be transformed into fuzzy numbers because the algorithms are designed to handle the mathematics of fuzzy set operations. After the computation, the obtained fuzzy numbers need to be transformed into linguistic variables once again since the results are difficult to understand. It can be seen that there are loss of information in the transformation. In recent years, the approach based on Design Structure Matrix (DSM) (Steward, 1981) which represents relations and dependences among objects, is developed (Fang and Marle, 2012; Fang et al., 2012, 2013; Marle and Vidal, 2011; Marle et al., 2013). The core of the approach is to capture and represent project risk interdependences by building up matrices. The approach mainly includes two steps. First, a binary matrix representing the existence of potential interdependence between each pair of risks is built. Secondly, the binary matrix is transformed into a numerical one to assess the strength of risk interdependence, in which a Likert scale using expert judgments or the Analytic Hierarchy Process (AHP) (Satty, 1980) is used. The last approach is based on the Delphi technique (Linstone and Turoff, 1975). In the approach (Aloini et al., 2012a, 2012b), questionnaire respondents are asked to assess the strength of interdependence among the risks. Then the experts' judgments are elaborated in order to define a unique map of relationships and the process is reiterated until a consensus is reached although it takes time to reach the consensus.

The above approaches have made significant contributions to risk interdependence analysis. However, from quantitative perspectives, there are some limitations in the existing approaches. For example, 0 and 1 are used to indicate whether the interdependence exists between two risks in the matrix-based approach and Delphi-based approach. This could lead to underestimation for relatively weak interdependence and overestimation for relatively strong interdependence. And it would be somewhat unrealistic that the complex risk interdependence is assigned either a numerical

value in the matrix-based approach and Delphi-based approach or a linguistic variable in the nature language assessment approach. In addition, since different experts may get outcomes with differences in the process of assessment and they would rarely move far from their initial views, it could be difficult or even impossible to moderate this kind of confusion and divergence. In this paper, we try to propose an approach which can quantitatively measure the risk interdependence without the need to moderate the divergences in evaluations of different experts or test the consistency of the evaluation results.

2.2. Relevant literature on project risk response

It can be seen that some scholars have paid attention to the portfolio selection of risk response strategies from different perspectives (Hatefi and Seyedhoseini, 2012). The approaches involved in the existing studies can be mainly classified into four categories (Zhang and Fan, 2014): the zonal-based approach, the trade-off approach, the WBS-based approach and the optimization-model approach. Among the above methods, most closely related to this work is the stream of literature on the optimization-model approach. Therefore, the brief descriptions and comments on these optimization-model approaches will be given as follows.

Ben-David and Raz (2001) firstly put forward an optimization model aiming to minimize the sum of expected risk loss and risk response cost for obtaining the optimal risk response strategies. The main contribution of this work is in demonstrating that a practical and common problem can be treated with mathematical models. The above work is extended considering the interactions among risk response strategies as model constraints in (Ben-David et al., 2002). Kayis et al. (2007) develop a risk response selection model which minimizes the difference between the upper bound mitigation cost/risk ratio and the mitigation cost/risk ratio generated from the project within the limited budget. Fan et al. (2008) construct a mathematical model for selecting risk response strategies based on the analysis of the relationship between risk response strategies and relevant project characteristics. The model is to minimize the sum of risk-prevention and risk-adaptation costs under the acceptable risk level. Fang et al. (2013) construct a mathematical model to solve the risk response strategy selection problem. In the model, the budget requirement, response effect and risk response cost are considered in the objective function. And, two parameters are introduced into the objectives: one is to balance the tradeoff between the budget and response effect, and the other is to reflect the project manager's degree of aversion to budget overruns. Besides the risk response cost, budget constraints, and expected risk loss considered in the above studies, project time and project quality are included in the following models. Nik et al. (2011) propose a multi-objective model to determine the optimum set of risk response strategies. In the model, risk response cost, expected time loss and expected quality loss are respectively minimized as three objectives, and the three objectives are changed into a single one by assigning the weight to each objective. Zhang and Fan (2014) propose a WBS-based integrated mathematical programming model aiming to maximize the estimated risk response effects which considers project cost, project schedule, project quality and the trade-offs among them simultaneously.

Among the above literature, the methods for selecting project risk response strategies assume that the risks are independent, apart from one presented in Fang et al. (2013). Fang et al. (2013) propose a framework for risk response strategy selection considering the risk interactions, and the DSM method mentioned above is applied to identify the risk interactions. In their work, however, the effect of the risk interactions on the project risk response decisions is not analyzed, which produces a space guiding us to make deep thinking and conduct a further study in this aspect. In this study, we will try to fill this gap by proposing an optimization model for selecting risk response strategies and further analyze the effects of the risk interdependence on decisions about project risk response.

3. Methodology

In this section, we firstly provide an approach to measuring risk interdependence, in which the evaluations on the risk interdependence by all experts can be regarded as a discrete random variable with probability distribution and then the strength of risk interdependence can be measured by comparing the random variables. The approach avoids the need to moderate divergences in evaluations of different experts or test the consistency of the evaluation results. Further, we construct an optimization model for selecting risk response strategies considering the risk interdependence and its two directions. One direction of the risk interdependence refers to the situation that the risk takes precedence over other risks, and the other direction refers to the situation that other risks take precedence over this risk. The above work can lay the foundation for analyzing the effects of the risk interdependence on the decisions about project risk response in the next section.

3.1. Risk interdependence analysis

Risk identification, usually the first step for project risk analysis, is the process of determining risk events which could affect project objectives negatively or positively (PMI, 2008). Our study directly uses the set of risk events $R=\{R_1,\ldots,R_n\}$ previously identified by the project manager (PM) and his or her team, in which R_j is the jth risk event, $j=1,\ldots,n$. A risk event has two substantial attributes; these are the probability of occurrence and the impact, and the expected loss of the risk event can be defined as the product of the probability and the impact (Kwan and Leung, 2011). Here, we assume that the risks have been identified and analyzed, and the results of risk identification and risk analysis can directly serve as inputs for risk response analysis.

The risk interdependence is defined as the existence of a possible precedence relationship between two risks R_i and R_j (Fang et al., 2012; Marle et al., 2013). The analysis of the risk interdependence is performed on a direct link that means that there is no intermediary risk between the two risks (Fang et al.,

2012). For example, when there is interdependence between risks *R1* and *R3* because *R1* is linked to *R2* and *R2* is linked to *R3*, this kind of interdependence is called indirect and it is not necessary to formalize interdependence between risks *R1* and *R3*. On the contrary, the interdependence between *R1* and *R3* is replaced by two direct interdependences, i.e., *R1* and *R2*, and *R2* and *R3*. In addition, the effect of the risk interdependence refers to an effect of one risk on the other risk arising from the direct interdependence. Specifically, there are two kinds of effects of risk interdependences considered in the paper which are unfavorable effects and favorable effects. The unfavorable effect will increase the expected loss by increasing the probability and/or the impact of the other risk, while the favorable effect will reduce the expected loss by lowering the probability and/or the impact of the other risk.

The experts with expertise and experience are generally invited for analyzing the risk interdependences since every new project is essentially unique with no previous data on it. The experts are firstly required to judge if there exist the risk interdependences between any two risks, and determine that the risk interdependences are favorable or unfavorable. Next, the strength of the risk interdependences needs evaluating. In practice, the experts often evaluate the strength of risk interdependence using phrases such as "*slightly weak*" or "*very strong*" for this kind of evaluation information is in the form of human language which can be naturally and easily expressed. For quantitative analysis of the risk interdependence, let $E=\{E_1,\ldots,E_l\}$ be a set of experts and $S=\{s_0,s_1,\ldots,s_T\}$ be a finite and totally ordered discrete linguistic term set with odd cardinalities in which $s_i>s_j$ ($s_i,s_j\in S$) iff $i>j$ (Bordogna et al., 1997). The linguistic term s_0 can also be regarded that almost no interdependent relationship exists between the two risks. Each expert gives evaluations on interdependent relationship from R_i to R_j using the linguistic scale, where $R_i,\ R_j\in R$. The evaluation on the interdependence from R_i to R_j by expert E_k is denoted as x_{ij}^k, which satisfies $x_{ij}^k\in S$, $i,j=1,\ldots,n$, $i\neq j$, and $k=1,\ldots,l$. Further, the evaluations on the interdependence from R_i to R_j by all the experts can be denoted as X_{ij}. The vector X_{ij} can be regarded as a discrete random variable with probability distribution $f_{ij}(x)$, where $\sum_{x=s_0}^{s_T} f_{ij}(x)=1$. A brief example below can make this easier to understand.

Example 1. Suppose that five experts are invited to analyze the risk interdependences with respect to three risks (R1, R2, R3) using a linguistic seven-term scale, i.e., $S=\{s_0=$ Very Weak (VW), $s_1=$ Weak (W), $s_2=$ Slightly Weak (SW), $s_3=$ Medium (M), $s_4=$ Slightly Strong (SS), $s_5=$ Strong (S), $s_6=$ Very Strong (VS)$\}$. By analyzing the three risks, the experts determine that there exist risk interdependences between risks R1 and R2, and the effect of R1 on R2 is favorable and that of R2 on R1 is unfavorable. From the evaluations on the interdependence from R1 to R2, it can be generalized that the evaluation VW is provided by three experts, W by one expert, and SW by one expert. Similarly, the evaluations on the interdependence from R2 to R1 are: VW is provided by two experts, SW by one expert, M by one expert, and SS by one expert. Thus, the probability density functions $f_{12}(x)$ and $f_{21}(x)$ can be obtained as follows, respectively.

$$f_{12}(x)=\begin{cases}3/5, & x_{12}=VW\\ 1/5, & x_{12}=W\\ 1/5, & x_{12}=SW\\ 0, & x_{12}=M\\ 0, & x_{12}=SS\\ 0, & x_{12}=S\\ 0, & x_{12}=VS\end{cases},\quad f_{21}(x)=\begin{cases}2/5, & x=VW\\ 0, & x=W\\ 1/5, & x=SW\\ 1/5, & x=M\\ 1/5, & x=SS\\ 0, & x=S\\ 0, & x=VS\end{cases}.\ \square$$

In practice, the interdependent relationship between risks is complex; meanwhile it is probable that the evaluations are divergent due to experts from multiple departments with different expertise and previous experience. More specifically, the evaluations in reverse direction between R_i and R_j may probably exist, i.e., the evaluations from R_j to R_i. Thus, we need to know which risk should be prioritized and the relative importance of each risk in project risk response. For this purpose, the strength of risk interdependence of R_i over R_j (or R_j over R_i) needs to be measured.

The strength of risk interdependence can be known by calculating the probabilities of $X_{ij}>X_{ji}$ and $X_{ij}<X_{ji}$. From the above analysis, it can be seen that X_{ij} and X_{ji} can be regarded as two independent discrete random variables, that is to say, there is no inherent relation between the evaluations from R_i to R_j and those from R_j to R_i. Further, the probability distributions of X_{ij} and X_{ji} are denoted as $f_{ij}(x)$ and $f_{ji}(x)$, respectively, where $\sum_{x=s_0}^{s_T} f_{ij}(x)=1$ and $\sum_{x=s_0}^{s_T} f_{ji}(x)=1$. Let x_{ij} and x_{ji} be outcomes of X_{ij} and X_{ji}, respectively. Here, event $x_{ij}=x_{ji}$ can be regarded as a situation where events $x_{ij}>x_{ji}$ and $x_{ij}<x_{ji}$ occur with the same probability simultaneously, i.e., in the situation of $x_{ij}=x_{ji}$, the probability that events $x_{ij}>x_{ji}$ and $x_{ij}<x_{ji}$ occur is 0.5. Based on the above analysis, we give Definition 1, and Properties 1 and 2 (Liu et al., 2011).

Definition 1. Let X_{ij} and X_{ji} be two independent discrete random variables with probability distributions $f_{ij}(x)$ and $f_{ji}(x)$, respectively, where $\sum_{x=s_0}^{s_T} f_{ij}(x)=1$ and $\sum_{x=s_0}^{s_T} f_{ji}(x)=1$. Then the strength of risk interdependence denoted as D_{ij} is given by

$$D_{ij}=\sum_{x_{ij}=s_0}^{s_T}\sum_{x_{ji}=s_0}^{x_{ij}} f_{ij}(x_{ij})f_{ji}(x_{ji})-0.5\sum_{x_{ij}=s_0}^{s_T} f_{ij}(x_{ij})f_{ji}(x_{ij}),\qquad(1)$$

and accordingly, the strength of risk interdependence denoted as D_{ji} is given by

$$D_{ji}=\sum_{x_{ij}=s_0}^{s_T}\sum_{x_{ji}=x_{ij}}^{s_T} f_{ij}(x_{ij})f_{ji}(x_{ji})-0.5\sum_{x_{ij}=s_0}^{s_T} f_{ij}(x_{ij})f_{ji}(x_{ij}).\qquad(2)$$

The strength of the risk interdependence in the above equations can be regarded as the probability that the possible outcome of one random variable is greater than the other. Thus, the following properties can be easily found.

Property 1. $D_{ij}+D_{ji}=1$.

Property 2. $0\le D_{ij}\le 1$ and $0\le D_{ji}\le 1$.

The following example can be used to show how to calculate the strength of risk interdependence.

Example 2. Using the probability density functions $f_{12}(x)$ and $f_{21}(x)$ obtained in Example 1, the strength of risk interdependence of R1 over R2 (denoted as D_{12}) can be calculated by Eq. (1) as follows.

$$D_{12}=\frac{3}{5}\times\frac{2}{5}+\frac{1}{5}\times\frac{2}{5}+\frac{1}{5}\times\left(\frac{1}{5}+\frac{2}{5}\right)-0.5\times\frac{3}{5}\times\frac{2}{5}-0.5\times\frac{1}{5}\times\frac{1}{5}=0.3.$$

Similarly, the strength of risk interdependence of *R2* over *R1* (denoted as D_{21}) can be calculated by Eq. (2), and $D_{21}=0.7$. □

Further, let D_j be the strength of risk interdependence of risk R_j when risk R_j takes precedence over other risks, and D_j can be defined as

$$D_j=\eta\frac{1}{\left|\tau_j^-\right|}\sum_{\substack{i=1\\R_i\in\tau_j^-}}^{n}D_{ji}+(1-\eta)\frac{1}{\left|\tau_j^+\right|}\sum_{\substack{i=1\\R_i\in\tau_j^+}}^{n}D_{ji},\tag{3}$$

where $0\le D_j\le 1$, and the parameter η denotes the importance degree of the unfavorable risk interdependence relative to the favorable risk interdependence which satisfies $\eta\in[0,1]$. The set τ_j^- is composed of all the risks which risk R_j takes precedence over and the effects of the risk interdependences are unfavorable, and $|\tau_j^-|$ denotes the number of elements in the set τ_j^-. Similarly, the set τ_j^+ is composed of all the risks that risk R_j takes precedence over and the effects of the risk interdependences are favorable, and $|\tau_j^+|$ denotes the number of elements in the set τ_j^+. The set τ_j^- or τ_j^+ can be the empty set $\varnothing$ if there are no unfavorable or favorable risk interdependences with respect to risk R_j. And accordingly, let $\overline{D}_j$ be the strength of risk interdependence of risk R_j when other risks take precedence over risk R_j, and $\overline{D}_j$ can be defined as.

$$\overline{D}_j=\gamma\frac{1}{\left|\upsilon_j^-\right|}\sum_{\substack{i=1\\R_i\in\upsilon_j^-}}^{n}D_{ij}+(1-\gamma)\frac{1}{\left|\upsilon_j^+\right|}\sum_{\substack{i=1\\R_i\in\upsilon_j^+}}^{n}D_{ij}.\tag{4}$$

where $0\le\overline{D}_j\le 1$, and the parameter γ denotes the importance degree of the unfavorable risk interdependence relative to the favorable one which satisfies $\gamma\in[0,1]$. The set υ_j^- is composed of all the risks that take precedence over risk R_j and the effects of the risk interdependences are unfavorable, and $|\upsilon_j^-|$ denotes the number of elements in the set υ_j^-. Similarly, the set υ_j^+ is composed of all the risks that take precedence over risk R_j and the effects of the risk interdependences are favorable, and $|\upsilon_j^+|$ denotes the number of elements in the set υ_j^+. The set υ_j^- or υ_j^+ can be the empty set $\varnothing$ if there are no unfavorable or favorable risk interdependences with respect to risk R_j.

Example 3. It is assumed that there also exist risk interdependences between risks R2 and R3 in Example 1, and the effect of R2 on R3 and that of R3 on R2 are both unfavorable. Thus, the strength of risk interdependences D_{23} and D_{32} can be calculated by Eqs. (1) and (2), respectively, and the calculation results are $D_{23}=0.8$ and $D_{32}=0.2$. Taking risk R2 for instance, D_2 and $\overline{D}_2$ can be obtained below by Eqs. (3) and (4), respectively.

$$D_2=\eta\frac{1}{2}(D_{21}+D_{23})=\eta\cdot 0.75,\overline{D}_2=\gamma D_{32}+(1-\gamma)D_{12}$$
$$=\gamma\cdot 0.2+(1-\gamma)\cdot 0.3.\ \square$$

3.2. Risk response analysis

3.2.1. Constructing the optimization model

For the convenience of quantitative analysis, the notations are firstly given below. Let b_j be the expected loss of the risk event R_j, and the expected loss b_j is the product of the likelihood of occurrence and severity of the impact of R_j. In order to mitigate the expected loss of each risk, candidate risk response strategies must be proposed and selected to cope with the risks in the project implementation. When the response strategies are formulated, the cost of implementing each strategy and the risk response effect after implementing the strategies need to be estimated. Let $A=\{A_1,\ldots,A_m\}$ be the set of candidate risk response strategies and c_h be the cost of implementing risk response strategy A_h, $h=1,\ldots,m$. Let a_{hj} be the estimated risk response effect (i.e., reduced expected loss of the risk event) after implementing risk response strategy A_h to cope with risk event R_j. The budget is the most basic guarantee for the PM to complete risk response tasks successfully, and let B be the budget for implementing risk response strategies.

Thus, an optimization model for selecting risk response strategies is constructed considering risk interdependence as follows.

$$V(y)=E[U(y)]=\sum_{h=1}^{m}\sum_{j=1}^{n}w_jU\left(y_{hj}\right),\tag{5}$$

$$\text{s.t.}\quad\sum_{h=1}^{m}\left(c_h\max_j y_{hj}\right)\le B,\tag{6}$$

$$y_{hj}\in\{0,1\}.\tag{7}$$

where y_{hj} is the binary integer decision variable, and y_{hj} is equal to 1 if risk response strategy A_h is implemented for risk event R_j and otherwise y_{hj} is equal to 0. In the model, objective function (5) aims at maximizing the PM's expected utility. Constraint (6) ensures that the cost of implementing risk response strategies meets the budget requirement, and "$\max_j$" in constraint (6) can guarantee that the cost of implementing each risk response strategy cannot be counted more than once. Constraint (7) is a binary mode indicator.

In the following, the utility function $U(y_{hj})$ and weighting function w_j in the objective function (5) will be explained in detail, respectively.

3.2.2. Determining the utility function

In the above model, the optimization goal is to maximize the PM's expected utility. The PM's risk attitude is supposed to be risk aversion in this paper and a concave utility function is used since the concavity of the utility function may imply that the PM is risk averse. In project risk management, the PM needs to take measures to cope with the risks. The risks in projects that the PM intends to deal with, unlike those in gambling and lottery, are generally negative and manageable (March and Shapira, 1987), and the PM expects to gain benefits from implementing risk response strategies. Thus, the individual generally appears to be risk averse in the situation that possible outcomes of risky actions are generally good (Kahneman and Tversky, 1979) except for special cases. In some special cases, the PM's risk attitude may not be risk averse, for instance, the organization or project is "failing", the manager's own position or job is threatened (MacCrimmon and Wehrung, 1986). Among the concave utility functions, exponential utility can "satisfactorily treat a wide range of individual and corporate risk preference" (Howard, 1988), and indeed exponential utility is commonly used in decision analysis (Tsetlin and Winkler, 2005). Therefore, the exponential utility function which exhibits constant absolute risk aversion is used in this paper.

Thus, the utility function $U(y_{hj})$ in the objective function (5) can be expressed as follows.

$$U\left(y_{hj}\right) = 1-e^{-\alpha\left(y_{hj}a_{hj}\right)}, \tag{8}$$

where $U(y_{hj})$ denotes the subjective assessment of the risk response effect $y_{hj}a_{hj}$. The parameter α is the coefficient of absolute risk aversion. In the light of a rule of thumb (Howard, 1988), the risk tolerance (the reciprocal of absolute risk aversion) tends to be about one-sixth of equity. Without loss of generality, $U(y_{hj})$ equals 0 at the zero point of $y_{hj}a_{hj}$, and $U(y_{hj})$ approaches 1 as $y_{hj}a_{hj}\to\infty$.

3.2.3. Defining the weighting function

The weighting function w_j denotes the severity of risk R_j, and satisfies $w_j\in(0,1)$. In this paper, it is assumed that the severity of risk is related to two attributes: the strength of risk interdependence and expected loss of the risk. In the risk interdependence, two directions of the risk interdependence are both considered, i.e., the strength D_j when the risk R_j takes precedence over other risks and strength $\overline{D}_j$ when other risks take precedence over the risk R_j. Thus, the weighting function w_j can be expressed as follows.

$$w_j = \lambda\left(\theta D_j + (1-\theta)\overline{D}_j\right) + (1-\lambda)\frac{b_j}{\sum_{j=1}^{n} b_j}, \tag{9}$$

where the parameter λ denotes the importance degree of the risk interdependence relative to the normalized expected loss, and satisfies $\lambda\in[0,1]$, and the parameter θ denotes the importance degree of the strength D_j, and satisfies $\theta\in[0,1]$. Besides, $\frac{b_j}{\sum_{j=1}^{n} b_j}$ is the normalized expected loss since the expected loss and strength of risk interdependence are incommensurate.

Based on the above analysis, a research framework for project risk response decisions considering the risk interdependence is shown in Fig. 1.

4. Case study

In this section, we will show a substation renovation engineering project to illustrate the proposed approach to solving the problem of risk response strategy selection considering the risk interdependence. And we try to investigate the impact of the risk interdependence on the expected utility, costs of implementing strategies and risk response strategy selection.

4.1. Problem description and analysis

The substation was put into operation in 1996. Since the substation had been running for 18 years, the aging equipments made maintenance costs increasing and security risks more and more serious. Thus, the equipment reform and substation renovation become necessary and urgent. In the initial phase of the substation renovation project, an expert panel is established to evaluate project risks and risk interdependences. The expert panel includes fourteen experts, in which two experts on PRM, two experts on safety and quality management, two experts on substation maintenance, two experts on relay protection, two experts on high voltage electrical testing, one expert on vehicle management, one expert on contract management, one expert on electrical design, and one expert on civil design. By conducting a thorough analysis of the project and a brainstorming session, critical risk events are identified. Then, expected losses of the identified risks are estimated based on historical data and the experts' experiences and judgments. The project risks and expected losses of them in monetary form are shown in Table 1.

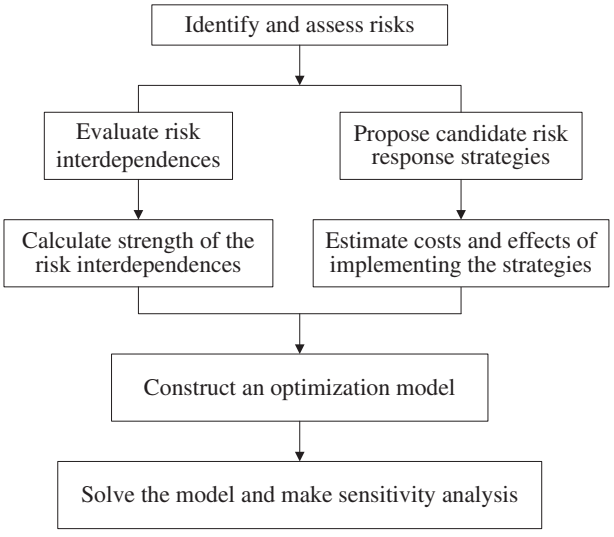

Fig. 1. Research framework.

Table 1
Project risk list.

Risk (R_j)	Expected loss (k$) ($b_j$)
Unqualified installation or construction craft (R_1)	665.04
Inferior quality of the goods and materials (R_2)	432.96
Substandard concrete construction (R_3)	181.08
Potential risk on traffic safety (R_4)	103.48
Delay in equipment delivery to the site (R_5)	264.36
Manpower shortage in the construction peak (R_6)	4.09
Accidentally touching the charged interval (R_7)	18.83
Special weather during the construction (R_8)	984
Disqualification of parameter debugging in the relay protection (R_9)	602.64
Personnel electric shock and injury (R_{10})	21.52
Misuse of new materials, new craft and new technology (R_{11})	32.96
Insufficient power supplies for major international conferences or events (R_{12})	22.44
Incompetent technical personnel when facing complex cases (R_{13})	132.24
Construction funds not in place timely (R_{14})	63.12
Bad inspection of the construction site (R_{15})	678
Unsuitable construction technology scheme (R_{16})	1140
Omissions and mistakes in the design drawing (R_{17})	670.56

Table 2
Candidate project risk response strategies.

Proposed candidate risk response strategy (A_h)	Cost (k$) ($c_h$)
Reserving safety stock (A_1)	188.28
Signing a carriage contract with the logistics company with good credit standing (A_2)	78.42
Tracking the orders (A_3)	9.41
Developing contingency plans for labor shortage (A_4)	1.88
Making security cards (A_5)	0.94
Installing anti-misoperation devices (A_6)	0.38
Communicating with relevant departments (A_7)	0.14
Making the scheduling plan (A_8)	0.56
Hiring experienced site engineers (A_9)	244.8
Strengthening supervision of project quality (A_{10})	9.6
Taking preventive measures (A_{11})	12
Formulating emergency response plan (A_{12})	6
Improving the traffic safety management rules and regulations (A_{13})	5.76
Purchasing insurance (A_{14})	28.14
Setting up traffic safety facilities (A_{15})	25.8
Establishing safety incident emergency handling procedures (A_{16})	0.42
Enhancing safety awareness of construction site personnel by safety training (A_{17})	0.14
Providing PPE and the required training for its use (A_{18})	0.94
Installing leakage protectors (A_{19})	8.47
Establishing technical disclosure system (A_{20})	4.7
Doing well on-job training (A_{21})	6.24
Employing experienced practitioners (A_{22})	7.2
Developing financing channels (A_{23})	6.72
Reviewing and adjusting the scheme in time (A_{24})	36
Signing the supervision contract (A_{25})	306
Strengthening supervision and inspection (A_{26})	14.4
Taking remedial actions (A_{27})	18
Cooperating with large designing institute with strength (A_{28})	60

Further, the risk interdependent relationships between the risks are basically confirmed based on the analysis and discussion by the experts, and the effects of the risk interdependences are determined to be unfavorable. Then, each expert is asked to give evaluations on the interdependent relationships between the risks using a linguistic seven-term scale, i.e., $S=\{s_0=$ Very Weak (VW), $s_1=$ Weak (W), $s_2=$ Slightly Weak (SW), $s_3=$ Fair (F), $s_4=$ Slightly Strong (SS), $s_5=$ Strong (S), $s_6=$ Very Strong (VS)$\}$. Thus, the strength of risk interdependence D_{ij} can be calculated using Eq. (1), and through Properties 1 and 2, we can know the value of D_{ji}. The project risk network based on the analysis of the strength of risk interdependence is built as shown in Fig. 2. Next, the strength of risk interdependences D_j and $\overline{D}_j$ can be obtained using Eqs. (3) and (4) when the values of parameters η in Eq. (3) and γ in Eq. (4) are determined.

On the basis of the analysis of the risk events and risk interdependences, the expert panel discusses and proposes 28 candidate risk response strategies according to their experiences

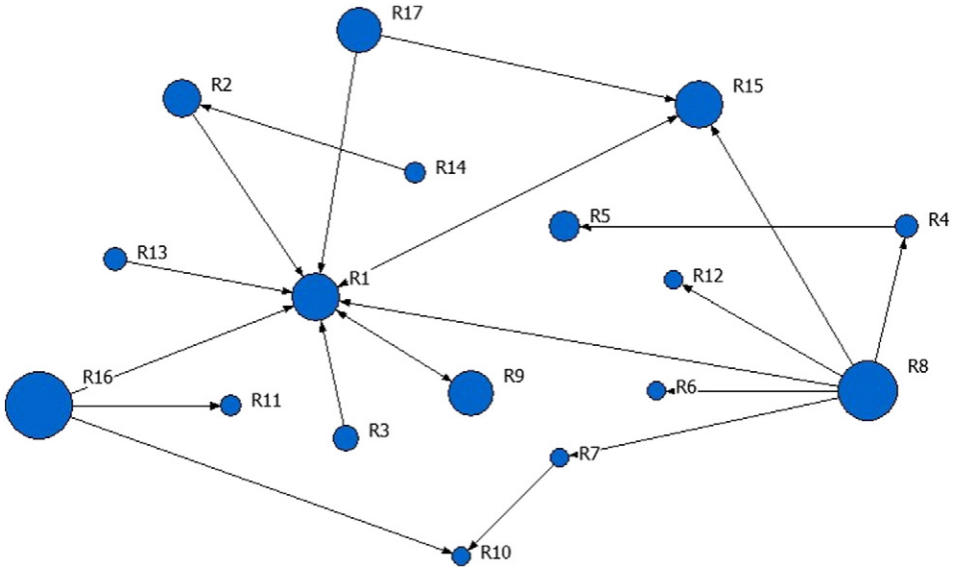

Fig. 2. Project risk network.

in similar projects or risk events before. The total budget or cost for implementing the strategies is no more than $420K, and the parameter α is the reciprocal of one-sixth of the budget, i.e., $\alpha = 0.015$. Thus, Table 2 lists candidate risk response strategies and their estimated implementation costs. Furthermore, the estimated risk response effects after implementing the strategies in monetary form (K$) based on the analysis of the risks and strategies are shown in Fig. 3. Lingo 14.0 is available and hence is used to solve the model. The results obtained by solving the given model as the parameters vary are presented in the following part.

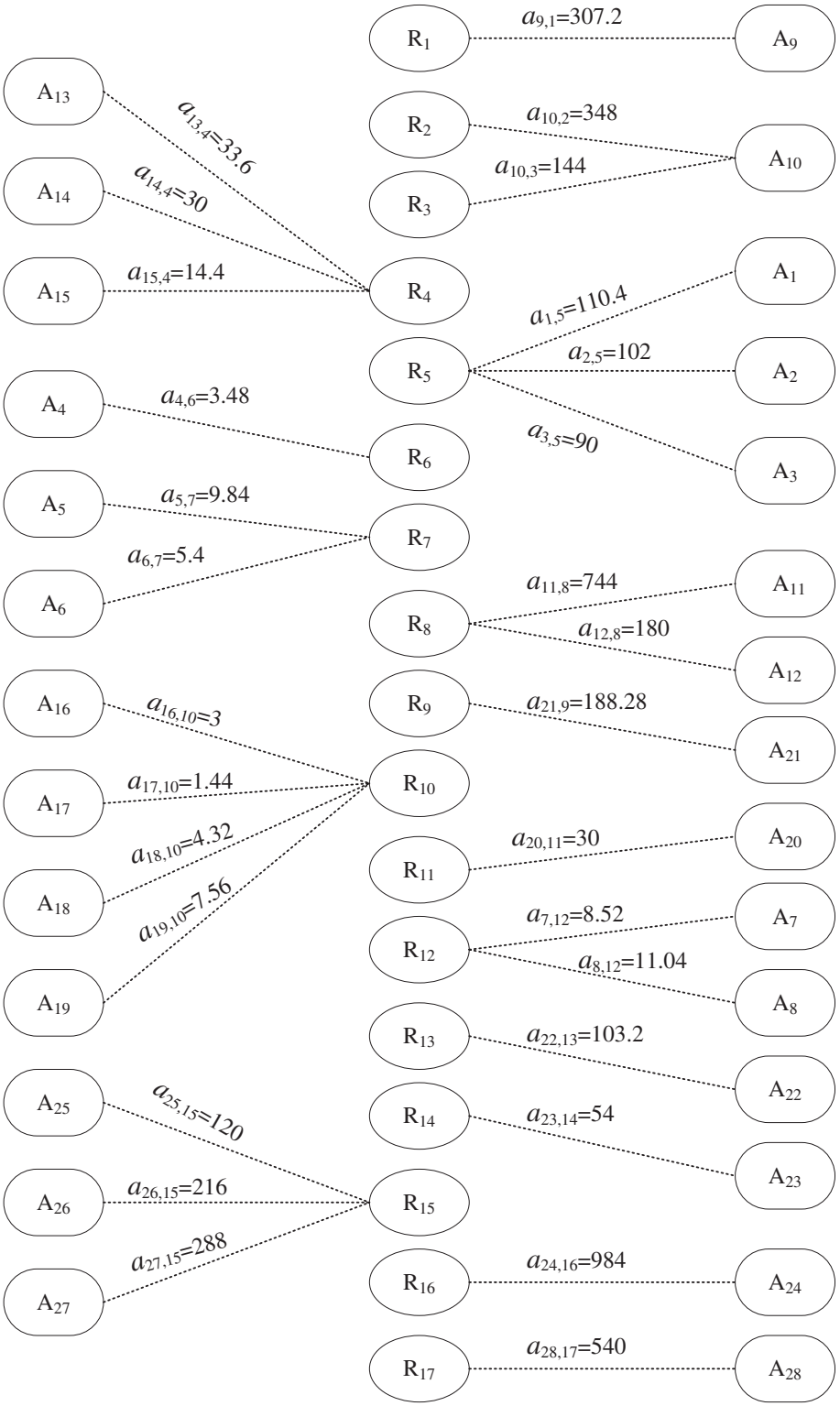

Fig. 3. Risk response effects.

4.2. Computational results and sensitivity analysis

In order to obtain the solutions to the model, we suppose that parameter η in Eq. (3) equals 1 since the effects of the risk interdependences in the project are unfavorable. Similarly, we suppose that parameter γ in Eq. (4) is equal to 1. Because different attentions paid to the risk interdependence and its directions can make the expected utility and the solution to the model different, the sensitivity analysis is performed as follows to elucidate the impact of parameter changes in λ and θ, respectively, on the robustness of the risk response effects.

Fig. 4 shows that the expected utility is sensitive to the variation of the parameter λ. Fig. 5 shows that the expected utility is sensitive to the variation of the parameter θ, and the sensitivity becomes more obvious as the value of λ gradually increases. By contrast, the slopes of the straight lines in Fig. 4 are greater than those of the lines in Fig. 5. From Fig. 6, it can be seen that the cost for implementing risk response strategies or the solution to the model is robust when λ and θ are, respectively, more than or equal to 0.04 and 0.3. The optimum solution to the model is $y_{1,5}=0$,$y_{9,1}=0$, $y_{25,15}=0$ and the other decision variables equal 1, respectively. Thus, the selected strategies are all the candidate strategies except A_1, A_9 and A_{25}, and the cost for implementing these strategies is \$285.237K and the maximum expected utility of 8.33 will be obtained. When λ and θ are, respectively, less than or equal to 0.03 and 0.3, the robustness is not good. For example, when λ and θ are, respectively, equal to 0.02 and 0.9, the cost for implementing risk response strategies increases to \$360.827K but the maximum expected utility decreases to 1.288. When λ and θ are, respectively, equal to 0.03 and 0, the solution to the model is $y_{9,1}=1$, $y_{10,2}=1$, $y_{10,3}=1$, $y_{13,4}=1$, $y_{11,8}=1$, $y_{12,8}=1$, $y_{21,9}=1$, $y_{22,13}=1$, $y_{26,15}=1$, $y_{27,15}=1$, $y_{24,16}=1$, $y_{28,17}=1$ and the other decision variables equal 0, respectively. Thus, the maximum expected utility decreases to 1.291 while the cost for implementing risk response strategies increases to \$360.827K.

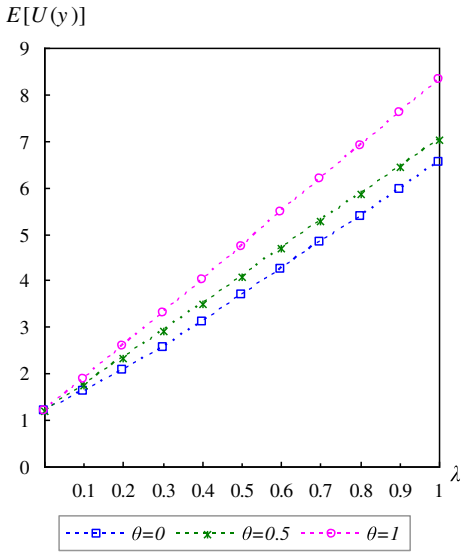

Fig. 4. The expected utility with different θ.

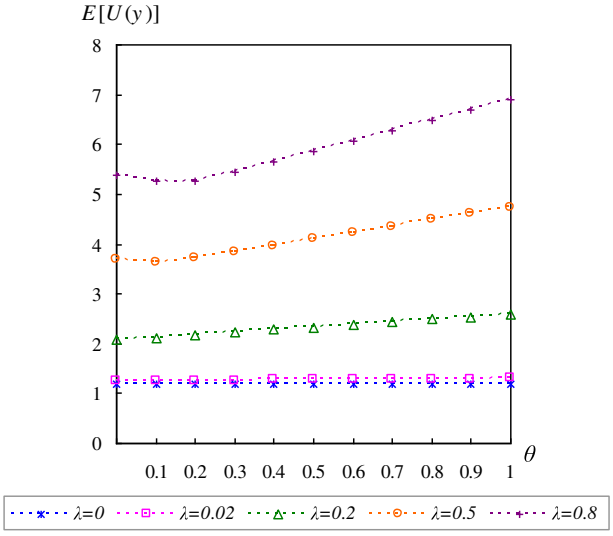

Fig. 5. The expected utility with different λ.

And the selected strategies are A_9, A_{10}, A_{11}, A_{12}, A_{13}, A_{21}, A_{22}, A_{26}, A_{27}, A_{24}, and A_{28}. This solution to the model is not feasible since risks R_7 and R_{14} are not coped with directly or indirectly.

In summary, as shown in Figs. 4 and 5, the expected utility is more sensitive to the variation of the parameter λ than to the variation of the parameter θ on the whole. It means that the PM should first put emphasis on the interdependent relationship and then the directions of the interdependence in PRM for achieving greater expected utility. Fig. 6 shows that the solution to the model is robust when the value of λ is not particularly small. It also implies that more attention paid to the risk interdependence can lower the cost of implementing the risk response strategies.

4.3. Feedback and discussion

In order to carry out more effective project risk management, a feedback session was conducted to allow the PM and his team to review the computation results. During a two-hour session, we collected feedback through careful recording of the participants' reactions, responses, questions, and discussions. Participants' feedback on three main topics is presented below.

(1) The interpretation of the risk interdependence. The confusions and queries came primarily from the risk network (Fig. 2) and calculation of the risk interdependences. Some participants felt confused about the sizes of the circles in Fig. 2. Specifically, at first sight, the participants were very likely to consider that the larger circle indicated the higher level of the risk interdependence. In face of such misunderstanding, the researchers explained to the participants that the circle represents the risk and the size of the circle is related to the expected loss of the risk. The larger the size of the circle is, the higher the expected loss of the risk will be. The interdependent relationship is represented by the line and the direction of the interdependence is represented by the arrow. In addition, some participants also questioned the

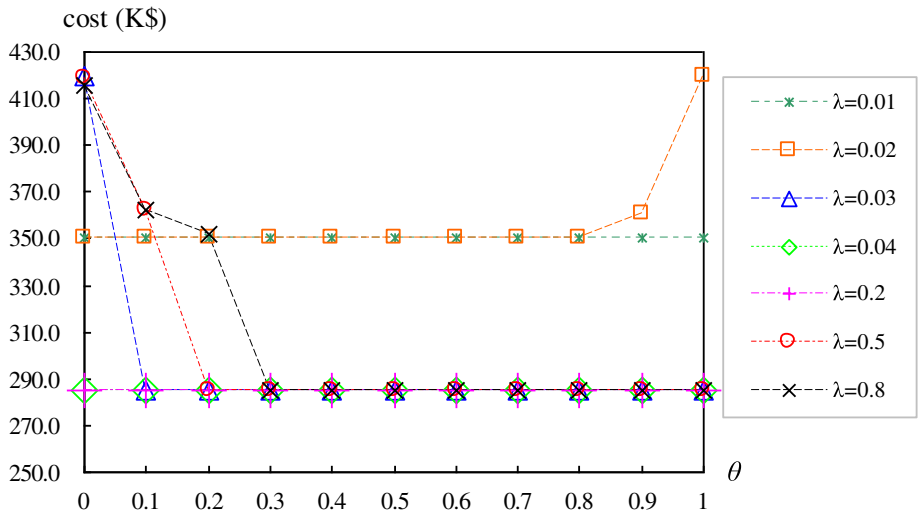

Fig. 6. The implementation cost with different λ.

calculation of the strength of the risk interdependence. For example, one participant said, "*I've noticed that in the network, some risk is intertwined with several other risks, but there're only two numerical values available with respect to the risk. How do you obtain the values?*" With regard to this question, the researchers explained in detail the calculation principle and process. The approach considers two directions of each risk interdependence. One direction of the risk interdependence refers to the situation that the risk takes precedence over other risks, and the other direction refers to the situation that other risks take precedence over this risk. The strength of the risk interdependence can be obtained by aggregating the experts' opinions in both directions, respectively. Through effective communication, the participants finally showed appreciation for our efforts. Some participants acknowledged that the phenomena of the risk interdependence do exist, but they did not consider the interdependence when they dealt with the risks in practice. According to the collected feedback, we noticed that one participant was quite impressed by the work. "*This network shows us the relationship between the risks intuitively. Besides, the network and the calculated strength of the risk dependence make me easily find out major risks so as to avoid greater loss*", said one participant.

(2) The effects of the risk interdependence. The participants agreed that most PMs are risk-averse in project risk management, and they approved that the risk response strategies obtained by solving the optimization model are necessary and feasible. However, they questioned that many selected strategies could also be implemented without consideration of the risk interdependence. With regard to this question, the researchers gave the relatively detailed explanation of the results shown in Figs. 4, 5 and 6. As shown in Figs. 4 and 5, the PM should put emphasis on the risk interdependence and the directions of the interdependence in PRM for achieving greater expected utility. Further, more attention paid to the risk interdependence can lower the cost of implementing the risk response strategies as shown in Fig. 6. The participants finally acknowledged that the model indeed can provide a quantitative decision support for their practical work, and expressed their opinions respectively. For instance, one participant said, "*The strategies A_{14}, A_{19} and A_{20} are indispensable for coping with the corresponding risks, but they don't get selected by solving the model when the attention to the risk interdependence is insufficient.*"

(3) The implementation of the method. With regard to the implementation of the approach, there are three main questions from the participants. The first question is how to calculate the strength of the risk interdependence since the equations look a bit complicated. The second one is how to solve the optimization model. The last one is whether the research results are applicable to all projects. With respect to the first two questions, the researchers explained that the simple program and commercial solver are easily available to them. The researchers also suggested that a decision support system (DSS) should be developed for project risk response. With respect to the last question, the researchers explained that similar conclusions were obtained from the study of one engineering project and one IT project previously. However, it is not sure whether the research results are applicable to all projects since the general conclusions from analytical solutions still need to be obtained in future studies.

5. Conclusions and perspectives

With the growing complexity of projects, phenomena of the risk interdependence become more universal. In this study, an approach to measuring risk interdependence is given, and then an optimization model considering the risk interdependence and its two directions for selecting risk response strategies is constructed. The computation results of the model as the parameters vary

show that the risk interdependence has significant effects on decisions on risk response. The contributions of this paper are discussed as follows.

In the proposed methodology, the approach to calculating the strength of risk interdependence is firstly given. The approach for measuring the risk interdependence avoids the need to moderate divergences in evaluations of different experts or test the consistency of the evaluation results. For selecting risk response strategies and further investigating the effects of the risk interdependence on the decisions about project risk response, an integer programming model is constructed. In the model, we consider the expected risk loss, risk interdependence and its two directions by defining the weighting function. The computation results obtained by solving the given model through a case project demonstrate the necessity of the consideration of the risk interdependence in risk response analysis in pursuit of individual utility and organizational benefits maximization. Furthermore, it can be found that each risk response strategy can cope with multiple risk events, and on the other hand each risk event can be considered through several risk response strategies.

The management implication for practitioners in PRM is that the PM should first attach great importance to the risk interdependence and then put more emphasis on the risks that take precedence over others in the project system. The insufficient attention paid to or neglect of the risk interdependence would lower the expected utility, increase the implementation cost and even affect the overall benefits from project risk management.

The limitation of the study is that the results are obtained from the case project. It would be better to sum up the general conclusions on the impact of the risk interdependence on project risk response decisions, which needs to be studied with greater depth in the next step. Besides, the PM's risk attitude is assumed to be risk aversion and the exponential utility function is used in this paper. Although it is true in most situations from the perspective of behavior analysis, as previously mentioned, the PM's risk attitude may not be risk averse in some special cases. Therefore, in the situations of different risk attitudes and utility functions, the conclusions need to be further verified. In addition, it is worth considering whether the effects of a risk on all the other risks are favorable when the risk could affect the project objectives positively. It can be seen that, from the existing studies, the effects of a risk which could affect the project objectives negatively on the other risk are generally unfavorable. However, in actual projects, it is still common that the positive risks are not adequately managed, let alone their interdependent relationships with other risks. Therefore, more empirical field work is needed to study the positive risks and their interdependences.

In general, we believe that this work provides an important building block for project risk response decisions. The simplicity and computational ease of the proposed approach to measuring the risk interdependence make it promising for practical application to improve the effectiveness of project risk management. It is expected that the proposed methodology can be applicable to a wide set of engineering projects for risk management.

Conflict of interest

The author declares that there is no conflict of interest.

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References

Ackermann, F., Eden, C., Williams, T., Howick, S., 2007. Systemic risk assessment: a case study. J. Oper. Res. Soc. 58, 39–51.

Adner, R., 2006. Match your innovation strategy to your innovation ecosystem. Harv. Bus. Rev. 1–11 (April).

Aloini, D., Dulmin, R., Mininno, V., 2012a. Modelling and assessing ERP project risks: a Petri Net approach. Eur. J. Oper. Res. 220, 484–495.

Aloini, D., Dulmin, R., Mininno, V., 2012b. Risk assessment in ERP projects. Inf. Syst. 37, 183–199.

Archer, N.P., Ghasemzadeh, F., 1999. An integrated framework for project portfolio selection. Int. J. Proj. Manag. 17, 207–216.

Baccarini, D., 1996. The concept of project complexity—a review. Int. J. Proj. Manag. 14, 201–204.

Badenhorst, K.P., Eloff, J.H.P., 1994. TOPM: a formal approach to the optimization of information technology risk management. Comput. Secur. 13, 411–435.

Ben-David, I., Raz, T., 2001. An integrated approach for risk response development in project planning. J. Oper. Res. Soc. 52, 14–25.

Ben-David, I., Rabinowitz, G., Raz, T., 2002. Economic Optimization of Project Risk Management Efforts. The Israel Institute of Business Research.

Bordogna, G., Fedrizzi, M., Pasi, G., 1997. A linguistic modelling of consensus in group decision making based on OWA operators. IEEE Trans. Syst. Man Cybern. Part A Syst. Humans 27, 126–133.

Buchan, D.H., 1994. Risk analysis—some practical suggestions. Cost Eng. 36, 29–34.

Cavallo, A., Ireland, V., 2014. Preparing for complex interdependent risks: a system of systems approach to building disaster resilience. Int. J. Disaster Risk Reduction 9, 181–193.

Correa-Henaoa, G.J., Yusta, J.M., Lacal-Arántegui, R., 2013. Using interconnected risk maps to assess the threats faced by electricity infrastructures. Int. J. Crit. Infrastruct. Prot. 6, 197–216.

Fan, M., Lin, N.-P., Sheu, C., 2008. Choosing a project risk-handling strategy: an analytical model. Int. J. Prod. Econ. 112, 700–713.

Fang, C., Marle, F., 2012. A simulation-based risk network model for decision support in project risk management. Decis. Support. Syst. 52, 635–644.

Fang, C., Marle, F., Xie, M., Zio, E., 2013. An integrated framework for risk response planning under resource constraints in large engineering projects. IEEE Trans. Eng. Manag 60, 627–639.

Fang, C., Marle, F., Zio, E.J.B., 2012. Network theory-based analysis of risk interactions in large engineering projects. Reliab. Eng. Syst. Saf. 106, 1–10.

Hatefi, M.A., Seyedhoseini, S.M., 2012. Comparative review on the tools and techniques for assessment and selection of the project risk response actions (RRA). Int. J. Inf. Technol. Project Manage. 3, 60–78.

Howard, R.A., 1988. Decision analysis: practice and promise. Manag. Sci. 34, 679–695.

Kahneman, D., Tversky, A., 1979. Prospect theory: an analysis of decision under risk. Econometrica 47, 263–291.

Kayis, B., Arndt, G., Zhou, M., Amornsawadwatana, S., 2007. A risk mitigation methodology for new product and process design in concurrent engineering projects. Ann. CIRP 56, 167–170.

Keisler, J.M., Linkov, I.I., 2010. Managing a Portfolio of Risks, Wiley Encyclopedia of Operations Research and Management Science. John Wiley & Sons, Inc., pp. 1–24.

Kwan, T., Leung, H., 2011. A risk management methodology for project risk dependencies. IEEE Trans. Softw. Eng. 37, 635–648.

Linstone, H.A., Turoff, M., 1975. Delphi Method: Techniques and Applications. Addison-Wesley.

Liu, Y., Fan, Z.-F., Zhang, Y., 2011. A method for stochastic multiple criteria decision making based on dominance degrees. Inf. Sci. 181, 4139–4153.

Loch, C.H., Terwiesch, C., 1998. Communication and uncertainty in concurrent engineering. Manag. Sci. 44, 1032–1048.

MacCrimmon, K.R., Wehrung, D.A., 1986. Taking Risks: The Management of Uncertainty. Free Press, New York.

March, J.G., Shapira, Z., 1987. Managerial perspectives on risk and risk taking. Manag. Sci. 33, 1404–1418.

Marle, F., Vidal, L., 2011. Project risk management processes: improving coordination using a clustering approach. Res. Eng. Des. 22, 189–206.

Marle, F., Vidal, L., Bocquet, J., 2013. Interactions-based risk clustering methodologies and algorithms for complex project management. Int. J. Prod. Econ. 142, 225–234.

Miller, R., Lessard, D., 2001. Understanding and managing risks in large engineering projects. Int. J. Proj. Manag. 19, 437–443.

Nik, E.R., Zegordi, S.H., Nazari, A., 2011. A multi-objective optimization and fuzzy prioritization approach for project risk responses selection, Industrial Engineering and Engineering Management (IEEM). 2011 IEEE International Conference on IEEE, Singapore, pp. 888–892.

Pajares, J., López, A., 2014. New methodological approaches to project portfolio management: the role of interactions within projects and portfolios. Procedia Soc. Behav. Sci. 119, 645–652.

PMI, 2008. A Guide to the Project Management Body of Knowledge (PMBOK Guide). fourth ed. Project Management Institution.

Rao, G.N., Grobler, F., 1995. Integrated analysis of cost risk and schedule risk. Comput. Civ. Eng. 2, 1404–1411.

Ren, H., 1994. Risk lifecycle and risk relationships on construction projects. Int. J. Proj. Manag. 12, 68–74.

Satty, T., 1980. The Analytic Hierarchy Process: Planning, Priority Setting. McGraw-Hill.

Seyedhoseini, S.M., Noori, S., Hatefi, M.A., 2009. An integrated methodology for assessment and selection of the project risk response actions. Risk Anal. 29, 752–763.

Steward, D., 1981. The design structure matrix: a method for managing the design of complex systems. IEEE Trans. Eng. Manag. 28, 71–74.

Teller, J., 2013. Portfolio risk management and its contribution to project portfolio success—an investigation of organization, process, and culture. Proj. Manag. J. 44, 36–51.

Teller, J., Kock, A., 2013. An empirical investigation on how portfolio risk management influences project portfolio success. Int. J. Proj. Manag. 31, 817–829.

Touran, A., Wiser, E.P., 1992. Monte Carlo technique with correlated random variables. J. Constr. Eng. Manag. 118, 258–272.

Tsetlin, I., Winkler, R.L., 2005. Risky choices and correlated background risk. Manag. Sci. 51, 1336–1345.

Williams, T.M., 1999. The need for new paradigms for complex projects. Int. J. Proj. Manag. 17, 269–273.

Wirba, E.N., Tah, J.H.M., Howes, R., 1996. Risk interdependencies and natural language computations. Eng. Constr. Archit. Manag. 3, 251–269.

Zhang, Y., Fan, Z.-P., 2014. An optimization method for selecting project risk response strategies. Int. J. Proj. Manag. 32, 412–422.

Zou, P., Zhang, G., Wang, J., 2007. Understanding the key risks in construction projects in China. Int. J. Proj. Manag. 25, 601–614.

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Construction Project Risk Management in Singapore: Resources, Effectiveness, Impact, and Understanding

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Abstract

While previous studies have focused on the need for Project Risk Management (PRM), highlighting its potential benefits, resources invested in PRM have been rarely identified. This study aims to investigate the resource allocation, effectiveness, impact and understanding of construction PRM in Singapore. To achieve the objectives, a questionnaire survey was conducted with professionals and 43 complete questionnaires were returned. The results revealed that higher proportion of costs was invested in PRM than time and labor resources, and that more resources invested would not necessarily lead to a higher level of PRM effectiveness and greater assurance with the achievement of project objectives. Also, the results showed the low-level understanding of PRM in the survey firms and suggested that the overall impact of PRM on project outcomes differed according to levels of understanding. Despite the low-level understanding, all the nine PRM principles and guidelines were significantly agreed. Hence, this study provides a clear picture of PRM in the Singapore construction industry. The findings of this study can help practitioners to better implement PRM and assure the achievement of project outcomes.

Keywords: *resource, effectiveness, impact, project risk management, construction industry, singapore*

1. Introduction

Project Risk Management (PRM) is a critical component of project management as risks that are not well-managed may lead to project failures (Royer, 2000). This, in particular, is a concern to construction projects. A typical construction project may involve all forms of risks such as contractual, financial, operational, political and technical risks. The evanescent nature of the venture, the multitude of players with conflicting personalities and their different understanding of risks, make PRM a daunting task right at the onset. This is compounded by variations in the project such as harsh weather and productivity problems that make PRM a challenging process throughout its lifecycle. It is thus considered "truth" that no single project may be able to eliminate risks completely.

Mills (2001) pointed out that the construction industry had a poor reputation for managing risks, with many projects failing to meet deadlines and cost targets. The potential losses of poor PRM hence range from thousands of dollars (e.g., liquidated damages for small scale projects) to millions or billions of dollars (e.g., project failure). Typical reasons for poor PRM include but are not limited to contractors' lack of information and knowledge, insufficient resources such as money and time, and lack of expertise in risk techniques (Hlaing *et al.*, 2008). On the contrary, well-planned PRM from the initial stages of a project would allow a more credible estimate of the final project costs. Furthermore, Mills (2001) highlighted that PRM can be a form of opportunity management, arguing the earlier it is done, the more potential commercial benefits can be reaped later, which agreed with the double-edged nature of risks (Zou *et al.*, 2007), namely risks can encompass both threats and opportunities (Ward and Chapman, 2003).

While there have been extensive studies on the process of PRM and its consequences, little investigation has been conducted to assess the extent to which PRM is employed in projects, and its impact on project performance. Hence, the objectives of this study are:

(1) To explore the amount of resources invested in PRM and specific types of risk;
(2) To evaluate the effectiveness and impact of PRM on project outcomes and its association with the resource invested;
(3) To investigate the understanding of PRM and the relationship between such an understanding and the overall effectiveness and impact of PRM; and
(4) To examine the agreement to the principles and guidelines for PRM.

The results would highlight the effectiveness of PRM in

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relation to the resources allocated. Also, the recognition of the impact of PRM would assist the industry players to review their current strategy for PRM, principally in the context of Singapore.

2. Background

2.1 Benefits of Project Risk Management

Construction firms should implement PRM because construction businesses are usually plagued with complex and diverse risks (Deng and Low, 2013; Low *et al.*, 2009; Ock and Han, 2010; Zhao *et al.*, 2013) and they mainly depend on construction projects to earn revenue and profits. Previous studies indicated that PRM can bring about a number of benefits. Simister (1994) revealed that the benefits of project risk analysis and management included the formulation of more realistic plans, an increased understanding of the risks in a project, the assessment of contingencies that actually reflected the risks, the increased benefits from more rational risk taking, as well as the identification of the party best able to handle a risk. Also, Mok *et al.* (1997) pointed out that PRM allowed decision makers to confront risks in a more realistic manner and thus improved decision-making. Ali (2000) indicated that in addition to helping projects completed on time and within budget, PRM could develop different scenarios with different impacts, clarify the importance of project risks, and make management aware of possible project outcomes. Pennock and Haimes (2002) found that proper PRM can reap great benefits in terms of reducing technical and programmatic risks. In addition, Mills (2001) believed systematic risk management could produce a series of benefits, including a cost-benefit assessment of risk control actions, removal of unnecessary contingency, clear recognition and acceptance of risk at an early stage to avert risks at the minimum cost, and achievement of realistic cost estimating by itemizing and quantifying risks. Moreover, Hilson (1998) argued that PRM should become fully integrated into both the management of projects and into the organizational culture, and then projects teams can gain full benefits from PRM. Furthermore, Klemetti (2006) proposed a co-operative risk management model and indicated that construction projects can benefit from this model in the form of shorter decision-making, less transaction costs or better allocation of risks to the parties that can best handle them.

To implement PRM properly, reduce losses and obtain the potential benefits, various resources should be invested. In the long run, the benefits can far outweigh the resources invested in PRM. Thus, the resources invested can be justified by the benefits and PRM becomes convincing. However, few studies have investigated the amount of resources invested in construction PRM. Hence, this study attempts to investigate the resources distributed to PRM and the association between these resources and PRM effectiveness and impact on project outcomes.

2.2 Project Risk Management in the Singapore Construction Industry

A few studies have been conducted to investigate PRM in the Singapore construction industry. Chan and Mak (2000) found that the contractors in Singapore were reluctant to perform PRM due to the lack of a systematic method and the perception that PRM was a laborious process without substantial tangible benefits. Thus, Chan and Mak (2000) proposed a systematic PRM method for these contractors to better manage their risks and believed that the advancement in information technology would improve the efficiency in PRM and help demonstrate more benefits. Also, Ali (2000) investigated the application of PRM in preparing construction project cost estimation and capital budgeting and found that the "Estimating using Risk Analysis" method was superior over other traditional methods. Woo and Tee (2001) identified the risks relating to construction project delays in Singapore and found that delayed decisions and decisions based purely on costs made by owners were detrimental to project schedule performance. Moreover, Khan and Narasimhan (2006) focused on the risk analysis techniques and concluded that the application of the Monte-Carlo simulation in modeling project cost and schedule data can produce fairly accurate and realistic results in the Singapore construction industry. However, few studies have focused on PRM effectiveness and impact on project outcomes in the Singapore construction industry. Thus, this study attempts to evaluate the PRM effectiveness and impact, and to examine their relation to the understanding of PRM in Singapore contractors.

3. Methodology and Data Presentation

3.1 Research Design

In order to assess the resource, effectiveness and impact of PRM with regards to the construction projects in Singapore, an understanding of the current scenario and implementation status of the above is vital. A questionnaire survey was performed to study the extent to which PRM was implemented in the Singapore construction industry. In addition, professionals were interviewed to capture a comprehensive picture of the opinions and information from construction companies towards PRM. This would help ascertain solutions to effectively manage the risks identified, thereby encouraging an active risk management culture.

The professionals who participated in the survey and interviews had experience and knowledge relating to PRM. The sampling frame consisted of construction companies identified through the Contractors Registry System (CRS) at the Building and Construction Authority (BCA) website. The pilot study was conducted with four professionals to solicit comments on the readability, comprehensiveness, and accuracy of the questionnaire. Based on their comments, revisions were made to improve the readability and accuracy of the statement and footnotes were added to explain the terminologies used in the questionnaire.

3.2 Data Collection

The finalized questionnaire consisted of three sections. The first section included questions meant to profile the respondents.

Table 1. Profile of Respondents

Occupation	Years of Experience								Total	
	<5		5 to 10		11 to 15		>15			
Project Manager	-		5		5		3		13	30%
Quantity Surveyor	6		1		1		3		11	26%
Architect	-		1		5		1		7	16%
Contract Manager	1		4		1		-		6	14%
Risk Manager	1		2		3		-		6	14%
Total	8	19%	13	30%	15	35%	7	16%	43	100%

More specifically, the information about the occupation and years of working experience of the respondents was included.

The second section included several project-specific questions, which were aimed to solicit the data related to a selected project that they were involved. In this section, the data relating to the value, type and duration of projects that the respondents were engaged in were collected. Additionally, the respondents were asked to indicate the amount of cost, time and labor resources allocated for the formulation of the PRM plan and management of the risks identified. Specifically, in this study, the cost resource for PRM is the money allocated to the activities related to PRM in the project budget; the time resource for PRM is the time (hours) spent on PRM during project construction; and the labor resource for PRM is the individuals directly involved in PRM. The respondents can provide either the exact figures of project resources for PRM or the percentages represented by the resources for PRM among the total project resources. Common risks identified from the literature review and pilot study were listed and the respondents were asked to select no more than three risks that were of priority to their projects. Then, the respondents were requested to indicate the amount of resources that they allocated to manage their three prioritized risks, respectively. Also, the respondents were asked to assess the effectiveness of their PRM according to a five-point Likert scale (1 = very ineffective; 2 = ineffective; 3 = neutral; 4 = effective; and 5 = very effective). Moreover, the impacts of PRM on the project outcomes (i.e. project schedule, cost and quality) were rated according to another five-point scale (1 = very insignificant; 2 = insignificant; 3 = neutral; 4 = significant; and 5 = very significant).

The third section consisted of the questions to investigate the understanding level of PRM within the firms of the respondents in accordance with a five-point scale (1 = very low; 2 = low; 3 = middle; 4 = high; and 5 = very high). Also, nine principles and guidelines of PRM were presented in this section and the respondents were requested to rate their agreement to each one according to another five-point Likert scale (1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; and 5 = strongly agree).

A total of 43 completed questionnaires were returned after which the data in the responses were codified and analyzed using the Statistical Package for Social Sciences (SPSS) 17 software.

3.3 Data Presentation

The two largest groups of respondents who answered the survey were Project Managers and Quantity Surveyors, followed by Architects, Contract Managers and Risk Managers, as summarized in Table 1. 81% of the respondents had at least five years of experience in the construction industry. The wide experience range of the professional experience and expertise made the data reliable.

Table 2. Profile of Projects

Project Characteristics		N	%
Project Type	Residential Buildings	7	16%
	Institutional Buildings	11	26%
	Commercial Buildings	10	23%
	Specialized Industries	5	12%
	Infrastructure & Heavy Construction	10	23%
Project Value (Million)	<$1	3	7%
	$1 - $5	26	60%
	$5 - $10	5	12%
	$10 - $15	6	14%
	$15 - $30	0	0%
	>$30	3	7%
Project Duration (Year)	<1	3	7%
	1-3	10	23%
	3-5	30	70%

Table 2 summarizes the characteristics of projects undertaken by the respondents, with Institutional buildings at the top of the list (26%), followed by Commercial and Infrastructure/Heavy construction (23% for both). In addition, as most projects (86%) were in the range of US$1 to US$15 million, indicating that the size of the projects ranged from small to medium scale, with the exception of a few. It can also be seen that all the projects were completed within a period of five years, with the majority between three and five years (70%).

4. Data Analysis and Discussions

4.1 Project Resources Invested in Project Risk Management

Although the respondents could enter either exact figures or percentages of the project resources invested in PRM, the

Table 3. Project Resources Invested in PRM

Resource	% of Resources Invested in PRM	Response		Mean	SD
		N	%		
Cost	5%	8	19%	9.5%	3.0%
	6%	1	2%		
	7%	2	5%		
	10%	26	60%		
	15%	6	14%		
Time	3%	2	5%	7.0%	2.6%
	5%	23	53%		
	10%	18	42%		
Labor	5%	25	58%	6.6%	2.2%
	6%	4	9%		
	7%	2	5%		
	10%	12	28%		

Table 4. Types of Risks

Type	N	%
Contractual Risk	36	80%
Financial Risk	15	33%
Design Risk	20	44%
Procurement Risk	30	67%
Tender Risk	25	56%
Safety and Health Risk	30	67%
Security Risk	5	11%
Human Resource Risk	1	2%

majority of them provided percentages due to the confidential nature of the projects. Hence, the exact figures were converted to percentages to facilitate data analysis.

As shown in Table 3, the surveyed projects invested 5-15% of their costs in PRM, with the majority of projects (N = 26; 60%) having 10% of their project budget dedicated to PRM. On the average, these projects used 9.5% of their budget in PRM. In reality, as some interviewees indicated, there may be no hard-and-fast rule with regards to the amount of budget for PRM and the contextual setting would be more important in the budgeting for PRM.

In terms of time, the mean percentage dedicated to PRM was 7.0%, with 95% of the projects allocating 5% (N = 23; 53%) or 10% (N =18; 42%) of their time to PRM. Some interviewed risk managers highlighted the fact that PRM was an on-going process, and hence it was difficult to put an exact figure with regards to time. Several other professionals concurred, claiming that the time spent varied among the different construction phases. The opinions of the respondents seemed to be in tandem with the view of Flanagan and Norman (1993) that the perhaps assurance for the completion of projects was more important in construction than the amount of time spent in developing PRM strategies during various project phases.

Similar to the time invested, all the projects set aside 5-10% of their labor for PRM while the data distribution indicated that 72% of the projects utilized less than 8% of the project labor for PRM. On the average, the surveyed projects invested 6.6% of their labor in PRM.

Hence, it was found that the mean proportion of the costs invested in PRM was slightly higher than that of the time and labor invested, respectively. Although the amount of resources identified above is worth attention, a couple of interviewees stated that there might be no hard-and-fast rules for investing resources in PRM as the contextual settings of projects were more important to the resource allocation, similar to the conclusion drawn by Wang *et al.* (2004). Also, as Klemetti (2006) indicated, the "soft" method of risk management would benefit construction projects. Tang *et al.* (2006) argued that partnering could play an important role in improving PRM, and would facilitate optimum decision-making to reduce lost opportunities and dealing with project risks. Thus, it can be inferred that just investing resources in PRM would lead to only limited effectiveness of PRM.

4.2 Project Resources Invested in Specific Risks

The major risks expounded by scholars and the respondents in their projects were surveyed. As the list was not meant to be exhaustive the respondents were also encouraged to indicate otherwise. Table 4 summarizes the results.

Contractual risk exhibited the highest frequency (N = 36; 80%). Interviewees revealed that while the contractual framework posed considerable risks, it was still a good mechanism for risk allocation. This was in agreement with Hlaing *et al.* (2008) who pinpointed that flaws in contract documents weighed heavily in the perceptions of PRM of Singapore contractors. Contractual risk was closely followed by procurement risk (N = 30; 67%) and safety and health risk (N = 30; 67%). Procurement risk attracted attention because of the significant changes in construction project delivery methods, which enables clients to allocate more risks to contractors (Hlaing *et al.*, 2008). In addition, safety and health risk was another major concern for the contractors because of the statutory obligations imposed on the stakeholders to mitigate potential occupational hazards and risks. In Singapore, the Workplace Safety and Health Act 2006 has been issued to deal with the relevant safety and health issues.

Moreover, tender, terrorism, design, financial and human resource risk were also considered by the respondents. However, a project manager interviewed indicated that tender risk can overlap with contractual risk, and hence it would be sufficient that resources for the former were set aside for managing the latter. Also, financial and terrorism risks could be more or less mitigated by insuring projects while design risk may be largely left to professionals such as architects or professional engineers to deal with. Interestingly, human resource risk was given the least attention despite the argument that human resource plays a crucial role in determining the success of PRM (Edwards and Bowen, 1998). The Construction 21 (C21) study initiated by the

Table 5. Project Resources Invested in the Management of Specific Risks

Type	% of Cost Invested	Response		Mean	SD	% of Time Invested	Response		Mean	SD	% of Labor Invested	Response		Mean	SD
		N	%				N	%				N	%		
Contractual Risk (N=36)	1%	3	9%	3.8%	1.1%	2%	3	8%	3.1%	1.3%	2%	2	6%	4.2%	1.1%
	2%	12	33%			3%	18	50%			3%	9	25%		
	3%	8	22%			4%	1	3%			4%	9	25%		
	4%	4	11%			5%	13	36%			5%	13	36%		
	5%	9	25%			6%	1	3%			6%	3	8%		
Procurement Risk (N=30)	1%	9	30%	2.2%	1.0%	1%	2	7%	3.4%	1.3%	1%	4	13%	3.0%	1.3%
	2%	9	30%			2%	6	20%			2%	7	23%		
	3%	9	30%			3%	9	30%			3%	8	27%		
	4%	3	10%			4%	5	17%			4%	7	23%		
	-	-	-	-	-	5%	8	26%			5%	3	10%		
	-	-	-	-	-	-	-	-	-	-	6%	1	4%		
Safety and Health Risk (N=30)	1%	9	30%	2.1%	0.8%	1%	11	37%	1.8%	0.7%	1%	4	13%	2.7%	1.2%
	2%	9	30%			2%	15	50%			2%	11	37%		
	3%	12	40%			3%	4	13%			3%	10	33%		
	-	-	-	-	-	-	-	-	-	-	4%	2	7%		
	-	-	-	-	-	-	-	-	-	-	5%	2	7%		
	-	-	-	-	-	-	-	-	-	-	6%	1	3%		

Ministry of Manpower of Singapore had taken note of this aspect. As a result, professional development programs, improvement of curriculum, stricter codes of conduct and licensing to improve standards were introduced. In view of labor skills, similar efforts were initiated. This enrichment of human resource ensuring their self-sufficiency and quality could be a probable cause for the negligence of human resource as risk in Singapore.

Based on the top three risks indicated by the respondents, analysis on the amount of resources invested towards their management was carried out. As summarized in Table 5, on the average, projects devoted approximately 3.8%, 3.1% and 4.2% of resources in terms of cost, time, and labor, respectively, to the management of contractual risk. More specifically, 33% of the respondents spent 2% of costs on contractual risk management, 50% devoted 3% of time to managing this risk, and 36% assigned 5% of labor to dealing with this risk.

In case of procurement risk, on the average, projects set aside 2.2%, 3.4% and 3% of cost, time, and labor resources, respectively. The slightly lower figures than those for contractual risk can perhaps be explained by its close relationship with contractual risk. Contractual framework is a preferred method and an important tool for allocation of procurement risk (CIDB, 2004; Edwards and Bowen, 1998). This may cause more resource allocation to the contractual risk which in broad included some portion of procurement risk.

Safety and health risk should be emphasized because contractors had to comply with the act related to occupational hazards and risks. Hence, PRM cannot afford to overlook such an important area. However, as shown in Table 5, the proportion of the resource allocation for safety and health risk is, on average, 2.1% for cost, 1.8% for time and 2.7% for labor, which is much less an investment than the rest of the two areas. In addition, 40%, 50% and 37% of the respondents invested 3% of costs, 2% of time and 2% of labor in the management of this risk, respectively. Considering that legislations strictly require projects to mitigate potential safety and health risks, the analysis result was of interest and the possible reason may be that potential losses caused by poor management of the aforesaid risks might be greater than those of safety and health risk. However, this could seriously undermine the effectiveness of PRM in the event of accidents. Thus, the work would be forced to stop, leading to project delays, and more troubles might follow in the form of cost escalation and liquidated damages.

Another aspect of significance is the distribution of resources with the type of risk. It can be noted that higher proportion of cost and labor resources were invested in contractual risk management while higher percentage of time was spent on procurement risk management. It can therefore be inferred that resource allocation was highly dependent on the nature of risk. The greater importance attributed to contractual risk supported the higher proportion of cost and labor resources invested, thus partly confirming the result that higher percentage of costs was invested in PRM than time and labor (see Table 3).

4.3 Effectiveness and Impact of Project Risk Management

The respondents were asked to comment on the effectiveness of PRM using a five-point Likert scale (1 = very ineffective and 5 = very effective). The one-sample t-test was performed to test whether the PRM effectiveness and the impact were significant. As summarized in Table 6, the mean score of the overall effectiveness of PRM was 2.98 without significance (p-value = 0.844), suggesting that the overall effectiveness was perceived neutral. Also, the respondents rated the effectiveness in identifying and assessing risks. Although the mean score of 3.19

Table 6. Effectiveness and Impact of PRM

Code	Indicators	Response	1	2	3	4	5	Mean	SD	*p*-value*
OE	Overall Effectiveness	N	-	13	18	12	-	2.98	0.77	0.844
		%	-	30%	42%	28%	-			
EIAR	Effectiveness in Identifying & Assessing Risks	N	-	8	19	16	-	3.19	0.73	0.103
		%	-	19%	44%	37%	-			
OI	Overall Impact on Project Outcomes	N	1	11	20	8	3	3.02	0.91	0.868
		%	2%	26%	46%	19%	7%			
IPS	Impact on Project Schedule	N	-	11	24	8	-	2.93	0.67	0.498
		%	-	25%	56%	19%	-			
IPC	Impact on Project Cost	N	-	12	23	8	-	2.91	0.68	0.377
		%	-	28%	53%	19%	-			
IPQ	Impact on Project Quality	N	-	11	23	9	-	2.95	0.69	0.660
		%	-	26%	53%	21%	-			

*The results of the one-sample t-test (test value = 3.00, two-tailed).

Table 7. Correlation among the Indicators

Indicators	OE	EIAR	OI	IPS	IPC	IPQ	Cost	Time	Labor
OE	1.000								
EIAR	0.430*	1.000							
OI	0.441*	0.421*	1.000						
IPS	0.458*	0.562*	0.549*	1.000					
IPC	0.357*	0.131	0.194	0.402*	1.000				
IPQ	-0.002	0.112	0.191	0.096	0.294	1.000			
Cost	-0.025	-0.112	-0.057	0.174	0.060	0.105	1.000		
Time	-0.024	0.062	0.210	0.191	0.347*	0.093	0.000	1.000	
Labor	-0.384*	-0.172	-0.326*	-0.311*	-0.247	0.128	0.075	0.008	1.000

*Correlation was significant at the 0.05 level (two-tailed).

was larger than 3.00, this lacked statistical significance (*p*-value = 0.103). Thus, the result indicated that the respondents were neutral towards the effectiveness. However, the mean score over 3.00 could indicate that PRM was slightly effective in risk identification and assessment. This result echoed KPMG (2010), which claimed that PRM was effective at least in the areas of risk identification and assessment.

Furthermore, the impacts of PRM on project outcomes were gauged according to another five-point scale (1 = very insignificant and 5 = very significant). In terms of the overall impact, the mean score was 3.02 with the *p*-value of 0.868, indicating that the respondents were neutral towards the question and that PRM was not almighty to affect the construction project outcome significantly. This was also supported by the results from the subsequent survey questions, which investigated the impact of PRM on project schedule, cost and quality. Project schedule, cost and quality are recognized as the most common project objectives, which can be associated with project performance indicators (Ling *et al.*, 2009). The mean scores were 2.93, 2.91 and 2.95, respectively. The one-sample t-test result indicated they were not significantly different from 3.00 (neutral). Thus, the impact of PRM on project schedule, cost, and quality was also neutral.

The Pearson correlation was performed to investigate the association among the six indicators relating to the effectiveness and impact of PRM (see Table 7). The results showed that overall effectiveness of PRM was positively associated with the overall impact on project outcomes ($r = 0.441$). This was probably because the impact of risk managemet on project outcomes could be considered as an element of PRM effectiveness. Similiarly, the overall effectiveness was positively associated with the effectiveness in identifying and assessing risks ($r = 0.430$) because risk identification and assessment are elements of PRM. These two correlations can explain the positive association bewteen the overall impact and the effectiveness in risk identification and assessment ($r = 0.421$). In addition, the impact of PRM on project schedule was positively correlated with the overall effectiveness ($r = 0.458$), the overall impact ($r = 0.549$) and the effectiveness in identifying and assessing risks ($r = 0.562$), respectively. However, the impact on project costs was only positively associated with the overall effectiveness ($r = 0.357$) while the impact on project quality was not correlated with the effectivess and overall impact of PRM. Furthermore, the impact on project costs was positively correlated with that on project schedule ($r = 0.402$), while the impact on project quality was not associated with that on project schedule and costs.

Also, the Pearson correlation was used to examine the association beween the resources invested in PRM and the six indicators

relating to the effectiveness and impact of PRM (see Table 7). It was found that the time invested was only positively associated with the impact on project costs (r = 0.347). This implied that the more time spent on PRM was likely to lead to the better assurance of the project cost objective. In addition, the labor invested for PRM was negatively asscciated with the overall effectiveness (r = -0.384), overall impact (r = -0.326) and impact on project schedule (r = -0.311), respectively. The results suggested that the higher labor invested would result in the lower effectiveness and impact of PRM. Moreover, the costs invested were not significantly associated with any indicator relating to the effectiveness and impact of PRM, indicating that high costs allocated to PRM would not necessarily bring about effectiveness and impact of PRM. This was consistent with the findings of some previous studies. Rahman and Kumaraswamy (2002) believed that the optimal PRM should minimize the total cost of risk to a project and allow all the project parties to jointly manage risks. Kutsch and Hall (2010) indicated that social and cognitive factors, such as the deliberate ignorance of risk-related information, could constrain the effectiveness of project risk manageemnt. Klemetti (2006) also suggeted that the relationships among the project players would influence the effectiveness of PRM. Furthermore, the three types of resources (i.e. costs, time and labor) invested in PRM were not associated with each other as the three correlation coefficients were very close to 0.000, which confirmed the opinions of some interviewees that the contextual settings of projects can significantly affect the resource allocation for PRM.

4.4 Understanding of Project Risk Management

The understanding level of PRM within the firms of the respondents was evaluated according to with a five-point scale (1 = very low and 5 = very high). The mean score of the understanding of PRM within the company of the respondents was 2.44 (see Table 8). The one-sample t-test result suggested that the understanding of PRM was significantly low (p-value = 0.000). As the interviewees reported, the poor understanding of PRM was mainly due to the insufficient knowledge, apathetic attitude and inadequate time for PRM implementation. This seemed to coincide with Hlaing *et al.* (2008), who found that the lack of time was ranked as the first barrier to PRM implementation in the Singapore construction industry. In addition, Ahmed and Azhar (2004) observed a similar lack of time trend in the Florida construction industry. Furthermore, Uher and Toakley (1999) found that the lack of knowledge and inadequate skill were the two most important obstacles to applying PRM to work processes. This signified the reason for neutrality in the assessment of effectiveness of PRM. A positive impact might not be experienced unless the PRM process is applied in a comprehensive manner to the project as a whole.

Table 8. Understanding of PRM

Score	N	%	Mean	SD	p-value
1	12	28	2.44	1.27	0.007*
2	12	28			
3	12	28			
4	2	5			
5	5	11			

*The one-sample t-test result was significant at the 0.05 significance level (two-tailed).

As the firms with higher understanding level of PRM are likely to have the PRM programs with higher overall effectiveness and impact on project outcomes, two hypotheses can be drawn: H_1: The effectiveness of PRM differs according to the different levels of understanding of PRM; and H_2: The overall impact of PRM on project outcomes differs according to the levels of understanding of PRM.

The one-way Analysis of Variance (ANOVA) was conducted to test the hypotheses at the 0.10 significance level (see Table 9). The F value of 1.666 with the p-value of 0.178 indicated that there were not significant differences in the overall effectiveness of PRM among the firms with different levels of understanding of PRM. Thus, H_1 had to be rejected. In addition, the F value of 3.094 with the p-value of 0.027 implied significant differences in the overall impact of PRM on project outcomes among the firms with different levels of understanding of PRM. Thus, H_2 could be accepted. The Tukey test was used as the past hoc test to identify the understanding levels between which the PRM impact on project outcomes significantly differed. Through the multiple comparison shown in Table 9, the Tukey test results suggested that there were significant differences in the overall impact of PRM on project outcomes between the companies with level 1 and level 5 (p-value = 0.011), level 2 and level 5 (0.072), and level 3 and level 5 (p-value = 0.047), respectively. Hence, the firms with very high levels of understanding of PRM could implement PRM with significantly more impact on project outcomes than those with middle, low and very low levels of understanding. In other words, the firms that can better understand PRM would benefit more from PRM.

Table 9. Effectiveness and Impact of PRM by Understanding

Indicators	One-way ANOVA		Post hoc test (Tukey)	
	F	p-value	Comparison	p-value
Overall effectiveness	1.666	0.178	No significant differences	
Overall Impact on Project Outcomes	3.094	0.027*	Level 1 and 2	0.863
			Level 1 and 3	0.947
			Level 1 and 4	0.984
			Level 1 and 5	0.011**
			Level 2 and 3	0.999
			Level 2 and 4	1.000
			Level 2 and 5	0.072**
			Level 3 and 4	1.000
			Level 3 and 5	0.047**
			Level 4 and 5	0.434

*The ANOVA result was significant at the 0.10 significance level (two-tailed).
**The post hoc test results were significant at the 0.10 significance level (two-tailed).

Table 10. Level of Agreement on PRM Principles and Guidelines

Statement	Mean	Rank	*p*-value
Training and education is important for construction professionals to deal with risks effectively.	3.70	7	0.000*
There is no one-size-fit-all risk management program for construction projects.	4.23	1	0.000*
Construction professionals and companies should continuously maintain a health record of risk management data.	3.86	3	0.000*
Technology, especially Information Technology, is important for companies to adopt effective risk management in international projects.	3.51	9	0.000*
Involvement of employees (not only limited to risk management teams) is essential for effective risk management in projects.	3.77	5	0.000*
Forming collaborative partnerships with groups such as subcontractors is important for risk management.	3.58	8	0.000*
Risks and opportunities are two-sides of the same coin.	3.79	4	0.000*
Assessment of risks should be done systematically based on facts and figures, with as little human subjectivity as possible.	3.72	6	0.000*
Risk management should be able to interoperate with other management theories and systems such as Total Quality Management.	4.07	2	0.000*

*The one-sample t-test (test value = 3.00) result was significant at the 0.05 significance level (two-tailed).

4.5 Risk Management Consultancy Firms vs. In-House Experts

Respondents were enquired if they were aware of the existence of risk consultancy firms that could provide training for construction-related risks. The result indicated that 86% of them were unaware while the remaining 14% were unsurprisingly, risk managers themselves. This could be attributed to the following two scenarios: (1) there were too few risk training firms; or (2) PRM was not considered very important. If it was the latter, it would explain the reason for qualitative or expert judgment-types of non-quantitative analysis techniques that have been predominantly used (Thevendran and Mawdesley, 2004; Wiguna and Scott, 2006). These techniques do not require complicated software but rely primarily on human experience, which is a more commercially 'viable' option since it requires less resources (Akintoye and MacLeod, 1997). Since PRM is considered unimportant in the opinions of the respondents, it also explained the rationale behind the tendency towards neutrality as to whether PRM is crucial for the achieving of the corporate objectives.

Closely related to the awareness of risk training firms, 77% of the professionals replied that their company did not have in-house construction risk experts. Supposing that indeed there was a low awareness with regards to risk training firms, then the high response rating for 'no in-house risk experts' should not be surprising since there might not be any relevant training for professionals. The low awareness and lack of PRM expertise were a concern of Edwards and Bowen (1998), who argued that PRM techniques would only offer advantages if the project partakers were knowledgeable and proficient in using them. Thus, it would appear that the quality rather than quantity of human resource for PRM would be able to explain the effectiveness level of PRM. However, this human oriented aspect associated with PRM has rarely been focused on.

4.6 Principles and Guidelines for Project Risk Management Practices

The last question of the survey required respondents to indicate their level of agreement with certain principles and guidelines of PRM (1 = strongly disagree and 5 = strongly agree). The one-sample t-test results suggested that all the nine principles and guidelines were significantly agreed by the respondents (*p*-value = 0.000). As summarized in Table 10, the statement "there is no one-size-fit-all risk management program for construction projects (mean = 4.23)" got the highest level of agreement. This result ecohed the findings of Wang *et al.* (2004). Construction projects are one-off endeavors with unique features such as long period, complicated processes, abominable environment, financial intensity and dynamic organization structures (Zou *et al.*, 2007). Thus, each project tends to involve a unique environment and the PRM appropriate for one project may be inappropriate for another.

The statement with the second highest level of agreement was "risk management should be able to interoperate with other management theories and systems such as Total Quality Management" (mean = 4.07), suggesting that the respondents agreed that PRM should be incorporated into other management processes. This was consistent with the fundamental concept of Enterprise Risk Management (ERM) that risk management should be fully integrated into the business and management processes of an enterprise (Chitakornkijsil, 2010; Sharman, 2002). In addition, such a high level of agreement indicated that ERM would be implemented in the construction industry, which confirmed the forecast of Adibi (2007) that ERM would grow in construction firms.

Another mostly agreed principle was "construction professionals and companies should continuously maintain a healthy record of risk management data" (mean = 3.86), indicating that the respondents agreed that PRM data should be recorded. This was consistent with the ISO31000:2009 (ISO, 2009), which

recommended that the risk management process should be recorded to enable risk management activities to be traceable, thereby providing the foundation for continuous improvement in the overall process.

Althought the statement realitng to the infromation technology was ranked the bottom, it still got a significant level of agreement. Information technology should play a key role in enabling information flow across a project and an enterprise (Dafikpaku, 2011). In most cases, inforamtion technology is not considered as a single source for guaranting successful PRM implementation. Instead, it would function as a tool to increase synergy among the rest of the principles and guidelines.

5. Conclusions

This study explores the amount of resources invested in PRM and specific types of risk, evaluates the effectiveness and impact of PRM on project outcomes and its association with the resource invested, investigates the understanding of PRM and the relationship between such an understanding and the overall effectiveness and impact of PRM, and examines the agreement to the principles and guidelines for PRM. To achieve the objectives, a questionnaire survey was conducted and 43 complete questionnaires were returned. The analysis results implied that most projects set aside a significant portion of project resources for PRM and that higher proportion of costs was invested in PRM than that of time and labor resources, respectively. Also, the results indicated that higher proportion of cost and labor resources were invested in contractual risk management while higher percentage of time was spent on procurement risk management. Thus, the allocation of resources towards depends on the nature of risk. In addition, despite the resources invested, both the overall effectiveness of PRM and the effectiveness of risk identification and assessment were perceived at the neutral level. Similarly, the overall impact of PRM and the impact on three project objectives, i.e. schedule, costs and quality were also neutral. Moreover, the results of the Pearson correlation implied the positve association between the time spent and the impact on project costs and the negative associations between the labor invested and the overall effectiveness, overall impact and impact on project schedule, respectively. However, the costs invested were found not associated with the indicators relating to the effectiveness and impact of PRM. Thus, more resources invested would not necessarily lead to a higher level of PRM effectiveness and greater assurance with the achievement of project objectives. Furthermore, the analysis results indicated the low-level understanding of PRM in Singapore contractors and suggested that the overall impact of PRM on project outcomes differed according to the levels of understanding. Finally, all the nine principles and guidelines presented in the questionnaire survey were significantly agreed, indicating they could be used to guide PRM practices in construciton projects in Singapore.

Although the objectives of this study were achieved, there were some limitations to the conclusions drawn from the results. First, the amount of the resources for PRM and the effectiveness and impact of PRM was estimated based on their experience and subjective judgment because there would not be clear boundaries among the time, cost and labor resources invested and PRM could be integrated into other management and business processes in most cases. As most assessment relating to PRM on experience and subjective judgment (Raz and Michael, 2001; Wiguna and Scott, 2006), the imprecision and subjectivity could be seen as common problems. Second, as the statistical tests were performed with a small sample, cautions should be warranted when the results are interpreted and generalized. Lastly, in some cases, the impact of PRM on project outcomes may be intangible as PRM is conducted to guarantee the achievement of project objectives. This could disturb the perceptions of the respondents on the impact of PRM on project outcomes.

This study provides the industry practitioners with the benchmarks of resource allocation for PRM, predominantly for small-to-medium sized projects. Future studies are recommended to investigate the resource invested in PRM in large-scale projects. Also, as the contextual settings of projects were more influential for resource allocation, it would be interesting to explore how some specific projects invest resources in PRM using in-depth case studies.

References

Adibi, S. (2007). *Industry should embrace risk management tools*, New York Construction News (Retrieved on 12 February, 2011) <http://newyork.construction.com/opinions/bottomline/archive/2007/06.asp>.

Ahmed, S. M., and Azhar, S. (2004). "Risk Management in the Florida Construction Industry." *Proceedings of the 2nd Latin American and Caribbean Conference for Engineering and Technology*, Miami, Florida, USA.

Akintoye, A. S. and MacLeod, M. J. (1997). "Risk analysis and management in construction." *International Journal of Project Management*, Vol. 15, No. 1, pp. 31-38.

Ali, R. (2000). *The application of risk management in infrastructure construction projects*, MSc Thesis, Nanyang Technological University, Singapore.

Chan, F. T. and Mak, Y. C. (2000). *Systematic construction risk management: A case study of chinatown MRT station and clarke quay tunnelling Works*, MSc Thesis, Nanyang Technological University, Singapore.

Chitakornkijsil, P. (2010). "Enterprise risk management." *International Journal of Organizational Innovation*, Vol. 3, No. 2, pp. 309-337.

CIDB (2004). *Managing construction procurement risks*, Construction Industry Development Board, Pretoria.

Dafikpaku, E. (2011). "The strategic implications of enterprise risk management: A framework." *2011 Enterprise Risk Management Symposium*, Chicago, Illinois, USA.

Deng, X. and Low, S. P. (2013). "Understanding the critical variables affecting the level of political risks in international construction projects." *KSCE Journal of Civil Engineering*, KSCE, Vol. 17, No. 5, pp. 895-907.

Edwards, P. J. and Bowen, P. A. (1998). "Risk and risk management in construction: A review and future directions for research." *Engineering*

Construction and Architectural Management, Vol. 5, No. 4, pp. 339-349.

Flanagan, R. and Norman, G. (1993). *Risk management and construction*, Blackwell, Oxford.

Hilson, D. (1998). "Project risk management: Future developments." *International Journal of Project and Business Risk Management*, Vol. 2, No. 2, pp. 1-11.

Hlaing, N. N., Singh, D., Tiong, R. L. K., and Ehrlich, M. (2008). "Perceptions of Singapore construction contractors on construction risk identification." *Journal of Financial Management of Property and Construction*, Vol. 13, No. 2, pp. 85-95.

ISO (2009). *ISO 31000:2009 risk management-principles and guidelines*, International Organization for Standardization, Geneva, Switzerland.

Khan, A. I. and Narasimhan, V. L. (2006). *Study of risk aspects in building construction projects,* MSc Thesis, Nanyang Technological University, Singapore.

Klemetti, A. (2006). *Risk management in construction project networks*, Helsinki University of Technology, Helsinki.

KPMG (2010). *The business case for a risk executive*, KPMG (Retrieved on 11 April, 2011) <http://www.kpmg.com/AU/en/Issues AndInsights/ArticlesPublications/Documents/The-business-case-for-a-risk-executive.pdf>.

Kutsch, E. and Hall, M. (2010). "Deliberate ignorance in project risk management." *International Journal of Project Management*, Vol. 28, No. 3, pp. 245-255.

Ling, F. Y. Y., Low, S. P., Wang, S. Q., and Lim, H. H. (2009). "Key project management practices affecting Singaporean firms' project performance in China." *International Journal of Project Management*, Vol. 27, No. 1, pp. 59-71.

Low, S. P., Liu, J. Y., and He, S. Q. (2009). "External risk management practices of Chinese construction firms in Singapore." *KSCE Journal of Civil Engineering*, KSCE, Vol. 13, No. 2, pp. 85-95.

Mills, A. (2001). "A systematic approach to risk management for construction." *Structural Survey*, Vol. 19, No. 5, pp. 245-252.

Mok, C. K., Tummala, V. M. R., and Leung, H. M. (1997). "Practices, barriers and benefits of risk management process in building services cost estimation." *Construction Management and Economics*, Vol. 15, No. 2, pp. 161-175.

Ock, J.-H. and Han, S.-H. (2010). "Measuring risk-associated activity's duration: A fuzzy set theory application." *KSCE Journal of Civil Engineering*, KSCE, Vol. 14, No. 5, pp. 663-671.

Pennock, M. and Haimes, Y. (2002). "Principles and guidelines for project risk management." *Systems Engineering*, Vol. 5, No. 2, pp. 89-108.

Rahman, M. M. and Kumaraswamy, M. M. (2002). "Risk management trends in the construction industry: Moving towards joint risk management." *Engineering, Construction and Architectural Management*, Vol. 9, No. 2, pp. 131-151.

Raz, T. and Michael, E. (2001). "Use and benefits of tools for project risk management." *International Journal of Project Management*, Vol. 19, No. 1, pp. 9-17.

Royer, P. S. (2000). "Risk management: The undiscovered dimension of project management." *Project Management Journal*, Vol. 31, No. 1, pp. 6-13.

Sharman, R. (2002). "Enterprise risk management-The KPMG approach." *British Journal of Administrative Management*, Vol. 31, pp. 26-28.

Simister, S. J. (1994). "Usage and benefits of project risk analysis and management." *International Journal of Project Management*, Vol. 12, No. 1, pp. 5-8.

Tang, W., Duffield, C., and Young, D. (2006). "Partnering mechanism in construction: An empirical study on the Chinese construction industry." *Journal of Construction Engineering and Management*, Vol. 132, No. 3, pp. 217-229.

Thevendran, V. and Mawdesley, M. J. (2004). "Perception of human risk factors in construction projects: an exploratory study." *International Journal of Project Management*, Vol. 22, No. 2, pp. 131-137.

Uher, T. E. and Toakley, A. R. (1999). "Risk management in the conceptual phase of a project." *International Journal of Project Management*, Vol. 17, No. 3, pp. 161-169.

Wang, S. Q., Dulaimi, M. F., and Aguria, M. Y. (2004). "Risk management framework for construction projects in developing countries." *Construction Management and Economics*, Vol. 22, No. 3, pp. 237-252.

Ward, S. and Chapman, C. (2003). "Transforming project risk management into project uncertainty management." *International Journal of Project Management*, Vol. 21, No. 2, pp. 97-105.

Wiguna, I. P. A. and Scott, S. (2006). "Relating risk to project performance in Indonesian building contracts." *Construction Management and Economics*, Vol. 24, No. 11, pp. 1125-1135.

Woo, K. W. and Tee, H. L. A. (2001). *Delays of construction projects in singapore*. MSc Thesis, Nanyang Technological University, Singapore.

Zhao, X., Hwang, B. G., and Low, S. P. (2013). "Developing fuzzy enterprise risk management maturity model for construction firms." *Journal of Construction Engineering and Management*, Vol. 139, No. 9, pp. 1179-1189.

Zou, P. X. W., Zhang, G., and Wang, J. (2007). "Understanding the key risks in construction projects in China." *International Journal of Project Management*, Vol. 25, No. 6, pp. 601-614.