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Are project management standards ignoring the characteristics and needs of different types of projects?

Usually a standard is understood as a norm or requirement. As such it can help us to evaluate the quality of operations, and, to develop the current processes further. For projects and their management a standard can also work as a common framework for unified operations and practices over organizational limits and even over national boundaries.

On the other hand standards and standardization have their limits and shortcomings. Standards present almost without an exception a consensual understanding and wisdom. They can thus be too much based on past experiences and knowledge. Standardization as a process has often an idiosyncrasy by trying to harmonize and homogenize the object in question. There is a danger that this anchors thinking and solutions in a way which can hinder the development of the profession itself.

International and national project management standards are instances where we can see kind of characteristics of standards discussed above. Harmonization and homogenization have produced elegant definitions of a project and the processes how the projects can be managed. On the other hand the knowledge captured in these standards should explain also how management requirements change or can change between projects of different scale and complexity. It is acknowledged widely that different projects needs different project management solutions but the project management standards are almost completely failing to include this rather fundamental principle.

Typologies of Projects are the theme of this Project Perspectives issue. By this we are approaching research results and knowledge to cover different types of projects, their categories and relating project management solutions. Our profession is all the time expanding to cover projects of different disciplines, projects of varying scale, projects of varying degree of complexity and furthermore projects of varying roles within the involved stakeholders. These are examples of dimensions which can be used for categorizing projects. To embrace this diverse world of projects successfully it seems that we need a new kind of standardization paradigm. This paradigm should move clearly towards inclusion of knowledge and solutions that can successfully explain the wide variety of different projects and link those to their particular management solutions. Otherwise the linkage from a generic standard to the actual practice can be almost completely missing. It is our main message that the developers of international and national project management standards should put attention on project typologies and how these could help to explain the world of different management solutions.

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A Global System For Categorizing Projects

Most organizations recognize that the projects they fund and execute fall within different categories, but the discipline of project management has not fully recognized that these different types of projects often exhibit different life cycle models and require different methods of governance: prioritizing, authorizing, planning, executing and controlling. In spite of this de facto categorization of projects by practitioners, no systematic method or system exists for identifying the several basic categories of projects, and the many variations in the key characteristics that can exist within those categories. This paper summarizes some of the research done to date on this subject, briefly discusses the need for and uses of an agreed project categorization system, and proposes a first approach to establishing a number of broad categories based on the products or end results being produced by the projects.

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The Need For Project Categorization

Projects and Project Management

The project management literature, including much research, deals with project management in a general sense, but only a few publications to date examine the projects themselves: the common denominators for the discipline of project management. How are these various types of projects the same, and how are they different? Which aspects of project management can be standardized for ***all*** projects, versus those aspects that can be standardized only for specific project categories?

Why Categorize Projects?

Crawford et al (2004) concluded that all organizations that have large numbers of projects must and do categorize them, although the categories are not always immediately visible. This pervasive ***de facto*** categorization is often taken for granted: "That's the way we always do it."

The basic question here is not whether projects should be categorized, but

- How can they best be categorized for practical purposes?

Two closely related questions are:

- What are the purposes of project categorization?
- What criteria or project attributes are best used to categorize projects?

Crawford et al (2004) state that it is dysfunctional to try to categorize projects without knowing what purpose will be served by the categorization.

"The categorization of projects is beneficial and useful to organizations, but it needs to be practically and not theoretically oriented. Focus groups confirmed that there are intended and unintended consequences of that need to be considered in development of classification systems, such as loss of autonomy, creation of barriers and silos and effects of visibility or invisibility due to inclusion or exclusion from a classification system." (Crawford et al 2002.)

Categorization versus Classification

Some dictionaries use these terms interchangeably, but to avoid potential semantic confusion the term ***categorization*** is used consistently in this paper to identify a set of items with similar characteristics or properties. An item may be placed in more than one category; in other words, categories are not mutually exclusive. A class is often used more rigorously to denote a set of items that can only be placed within a given class; classes are therefore mutually exclusive, when used in this sense. We will use this term here to classify projects within categories using specific classification criteria.

Categorization Criteria

Several authors have identified the many characteristics and attributes of projects that could conceivably be used as criteria to categorize projects. These are summarized by Crawford et al (2004) with this list:

Attributes of projects

- Application area or product
- Stage of life-cycle
- Grouped or single
- Strategic importance
- Strategic driver
- Geography
- Scope
- Timing
- Uncertainty
- Risk
- Complexity
- Customer
- Ownership
- Contractual

Any of these, or any combination of them, could be used to categorize a group of projects, depending on the purpose at hand. Perhaps the reason that little progress has been made to date in developing an agreed overall categorization system is the existence of this wide variety of project attributes and their various combinations.

Four Possible Categorization Methods

Youker (1999) provides a very useful discussion of the alternative ways to categorize projects for practical purposes:

There are four basic ways in which we can set up a classification system of projects:

1) geographical location
2) industrial sector (Standard Industrial Classification System)
3) stage of the project life cycle, and
4) product of the project (construction of a building or development of a new product).

The most important and the most useful breakdown is by type of product or deliverable that the project is producing, such as building a building, developing a new product, developing a new computer software program, or performing a maintenance turnaround or outage on a chemical plant or electric generating station.

Defining The Purposes Of Categorizing Projects

Strategic Project Management

The most effective method of categorizing projects for strategic management purposes will not be the same as the best categorization method for operational project management purposes. These strategic purposes include:

- Project selection: Determining which potential projects are to be funded and executed.
- Prioritize selected projects: Determining the relative importance of selected projects to assist in allocating scarce resources.
- Define Portfolios: Determining the most effective way of grouping projects within specifically defined project portfolios.
- Manage project portfolios: Designing, implementing, and operating the project portfolio management process of the organization.
- Allocate resources to portfolios and projects within portfolios: Deciding the best deployment of money and other limited resources across all project portfolios and among the projects within each portfolio.
- Other: No doubt other strategic PM uses can be identified.

Operational Project Management

This area of use focuses on the specific practices, systems and methods of authorizing, planning, and controlling projects and multi-project programs. The method used for categorizing projects for these purposes will no doubt be very different from those used for strategic and other purposes. These operational PM purposes include:

- Select/assign project managers: Matching the background and experience of available project managers with specific projects is greatly facilitated when the projects are appropriately categorized.
- Design/select best project life-cycle models: Determining which of the many currently used project life-cycle models is best for each project demands that each project must be identified within a defined project category.
- Select/improve project planning, scheduling, executing, and controlling methods: The 'best practice' for each of these basic PM functions varies considerably for different project categories.
- Select/develop PM software applications: The strengths and weaknesses of currently available PM software application packages will vary according to the specific project category. One package that is very strong in the procurement area, important to the 'facilities design/ procure/construct' category, may not be very useful to a project in the 'software new product development' category, for example.
- Build knowledge base of best practices: As indicated above, what is 'best practice' within one project category is not necessarily the 'best practice' in another category.
- Improve risk management methods: At a general level risk management is very much the same across all project categories. However, as one moves into the details significant differences in the sources of risk and methods for mitigating them emerge.
- Evaluate organizational PM maturity: It is obvious from an examination of the PM literature that there are great differences in the basic maturity of the PM discipline itself when one compares one basic project category with another. The maturity of any organization will likewise vary considerably between one category and another. To assign an overall maturity rating to any organization without specifying which project category is involved has little practical significance. See current research in this area at http://www.maturityresearch.com/#.
- Link success and failure factors: The factors that are important to success or failure in one project category are, in many cases, very different from those in another project category.
- Select tools and approach: The PM 'toolbox' is very large and varied. No-one will try to apply each and every PM tool, technique, 'best practice,' method, or system to each and every project for which they hold responsibility.
- Other: Additional purposes and uses of effective project categorization can surely be identified.

Project Management Education, Training, and Certification

PM education, training, and certification is a very big business throughout the world. However, many of the courses and programs are ineffective in actually developing and certifying skilled project managers for specific types or categories of projects. Use of practical project categorization methods in this area include:

- Improve/focus educational and training courses: It is obvious that, if the arguments given above are valid, more specific educational and training courses for defined project categories will result in the wider use of 'best practices' developed for those categories.
- Develop specialized case studies: Case studies related to each of the agreed project categories will be more

effective in the focused educational and training courses and programs.
- Organize speaker tracks at congresses: One of the major problems for participants in large congresses on PM is how to choose which speaker track to attend. With tracks focused on specific project categories, this problem will be reduced significantly.
- Develop specialized certification of project managers: The most popular current PM certification programs (PMI and IPMA) purport to certify individuals in some aspects of PM without regard for any specific project categories.
- Develop specialized certification of PM support positions: Certification of project estimators and schedulers, as examples, for large engineering design and construction projects will require proof of very different knowledge, skills and capabilities than the equivalent support positions in research and development, new product development, or software development projects.
- Develop PM career paths for individuals: Career planning and development of PM career paths differ widely for many of the basic project categories that can be identified.
- Other: Certainly there will be other purposes and uses related to people development of a systematic definition of project categories.

Prioritizing Purposes and Uses

Each organization will benefit from examining the various purposes and uses that are important to them, and determining which purposes are the most important for their strategic growth. Then they can determine which of the several methods of categorization make the most sense within their political, business and economic environment.

Rather than elaborating and making the list of purposes and uses longer and more complex, it is recommended that efforts be directed to consolidating and simplifying them as much as possible.

Characteristics Of A Practical Project Categorization System

Hierarchical and Multi-Dimensional

A practical system for project categorization must be both hierarchical and multi-dimensional. The resulting categories must be based on the same hierarchical approach used in systematically defining a project, as in developing a project/work breakdown structure (P/WBS):

Category levels	
1	Major category
2	Sub-category 2
3	Sub-category 3
4	Sub-category 4

Recommended Categories and Sub-Categories

Eleven recommended basic project categories are listed in Table 1, plus a twelfth category for all others, oriented primarily to products of the projects. Projects within each of these specific categories have very similar life cycle phases and utilize similar authorizing, planning, budgeting, scheduling, monitoring and controlling procedures and tools throughout their life cycles no matter where in the world they are located. Subcategories are also identified within most of these basic categories. In most cases there will be differences—in some cases significant—between the project life cycle management process for the basic category and at least some of its subcategories. Additional major categories may also be required to assure that all conceivable projects of significance to the international PM community are included.

Not Mutually Exclusive or Rigorously Consistent

It should be noted that these categories are not necessarily mutually exclusive: many projects will include aspects of two or more categories. For example, most communications systems projects include at least the adaptation of information system software. Many facilities projects also include communication systems, and vice versa. In such cases the project probably should be classified in the more dominant category, or—if justified by their size, complexity, or risk—defined as two or more projects (of different categories) within a program, with each project having a different life cycle definition.

Classifying Projects Within Categories and Sub-Categories

A wide range of projects within each project category or sub-category exists in large organizations. It is desirable for purposes of the proposed system to further classify projects within categories or sub-categories using some of the attributes identified by Crawford et al (2004) cited earlier, or some of the following classifying characteristics:

Project Size

Project size can be measured in several dimensions: amount of money or other scarce resources (skilled people, facilities, other), scope, and geography are the most tangible and obvious. Larger projects in any of these dimensions usually carry greater risks, of course.

Major and Minor Projects Within a Category

It is useful to identify at least two classes of projects within each category. The distinction between these major and minor classes will be noted in the following definitions:

Major Projects are those whose large size, great complexity and/or high risk require:
- Designation of an executive Project Sponsor.
- Assignment of a full-time Project (or Program) Manager;
- The full application of the project management process specified for the particular project category for major projects (all specified forms, approvals, plans, schedules, budgets, controls, reports, frequent project review meetings, with substantial levels of detail in each.)

Minor Projects are those whose size, simplicity and low risk allow:
- One project manager to manage two or more minor projects simultaneously;
- Less than the full application of the complete project management process for the project category (selected basic forms, approvals, plans, schedules, budgets, controls, reports, less frequent project review meetings, with less detail required in each.)
- No formal assignment of an executive Project Sponsor.

Project Categories Each having similar life cycle phases and a unique project management process	**Examples**
1. Aerospace/Defense Projects	
1.1 Defense systems	New weapon system; major system upgrade.
1.2 Space	Satellite development/launch; space station mod.
1.3 Military operations	Task force invasion
2. Business & Organization Change Projects	
2.1 Acquisition/Merger	Acquire and integrate competing company.
2.2 Management process improvement	Major improvement in project management.
2.3 New business venture	Form and launch new company.
2.4 Organization re-structuring	Consolidate divisions and downsize company.
2.5 Legal proceeding	Major litigation case.
3. Communication Systems Project	
3.1 Network communications systems	Microwave communications network.
3.2 Switching communications systems	3rd generation wireless communication system.
4. Event Projects	
4.1 International events	2004 Summer Olympics; 2006 World Cup Match.
4.2 National events	2005 U. S. Super Bowl; 2004 Political Conventions.
5. Facilities Projects	
5.1 Facility decommissioning	Closure of nuclear power station.
5.2 Facility demolition	Demolition of high rise building.
5.3 Facility maintenance and modification	Process plant maintenance turnaround.
5.4 Facility design/procurement/construction	Conversion of plant for new products/markets.
Civil	Flood control dam; highway interchange.
Energy	New gas-fired power generation plant; pipeline.
Environmental	Chemical waste cleanup.
High rise	40 story office building.
Industrial	New manufacturing plant.
Commercial	New shopping center; office building.
Residential	New housing sub-division.
Ships	New tanker, container, or passenger ship
6. Information Systems (Software) Projects	New project management information system. (Information system hardware is considered to be in the product development category.)
7. International Development Projects	
7.1 Agriculture/rural development	**People and process intensive projects**
7.2 Education	in developing countries funded by The World Bank, regional development
7.3 Health	banks, US AID, UNIDO, other UN, and government agencies; and
7.4 Nutrition	
7.5 Population	
7.6 Small-scale enterprise	**Capital/civil works intensive projects**
7.7 **Infrastructure**: energy (oil, gas, coal, power generation and distribution), industrial, telecommunications, transportation, urbanization, water supply and sewage, irrigation)	often somewhat different from 5. *Facility Projects* as they may include, as part of the project, creating an organizational entity to operate and maintain the facility, and lending agencies impose their project life cycle and reporting requirements.
8. Media & Entertainment Projects	
8.1 Motion picture	New motion picture (film or digital).
8.2 TV segment	New TV episode.
8.2 Live play or music event	New opera premiere.
9. Product and Service Development Projects	
9.1 Information technology hardware	New desk-top computer.
9.2 Industrial product/process	New earth-moving machine.
9.3 Consumer product/process	New automobile, new food product.
9.4 Pharmaceutical product/process	New cholesterol-lowering drug.
9.5 Service (financial, other)	New life insurance/annuity offering.
10. Research and Development Projects	
10.1 Environmental	Measure changes in the ozone layer.
10.2 Industrial	How to reduce pollutant emission.
10.3 Economic development	Determine best crop for sub-Sahara Africa.
10.4 Medical	Test new treatment for breast cancer.
10.5 Scientific	Determine the possibility of life on Mars.
11. Healthcare Projects	Major surgical procedure.
12. Other Categories?	

Table 1. Recommended project categories/sub-categories, with each category (or subcategory) having similar project life cycle phases and one unique process management process [Archibald 2003, Fig. 2.3, p.35 – with addition of Category 11.]

1 Different project categories require different governance, management, planning, scheduling and control practices.

2 Each project category and many sub-categories differ

3 A globally agreed project categorization system is urgently needed

4 Application of "One-Size-Fits-All" PM methods causes many project failures

Project Complexity

The complexity of a project is indicated by the:

- Diversity inherent in the project objectives and scope;
- Number of different internal and external organizations involved, which is usually an indication of the number of required specialized skills;
- Sources of technology; and/or
- Sources of funding.

"Mega" Projects

"Mega" Projects or Programs are extremely large, complex projects (usually programs, in fact) that are so unique in their size, scope, risk and duration that they require specially designed organizational arrangements (usually joint ventures, often including both private companies and governmental agencies.) As these are broken down into their component elements it is usually practical to identify a number of major and minor projects within one or more categories that comprise the mega project/program.

"Commercial or Delivery" Versus "Transformational" Projects

It is important to differentiate between commercial (or standard, somewhat repetitive) projects and transformational projects (and prgrams) that create strategically important changes to the organization, which are often enterprises within the enterprise and include both projects and on-going operations.

Project Life Cycles: Searching For Common Processes

Within each project category and sub-category we must identify the commonly used models for project life cycle phases and decision points. These will form the basis for identification of common management processes within each life cycle phase.

Defining Project Life Cycles

The purposes of designing and documenting the overall project life cycle process for each project category are to:

- Enable all concerned with creating, planning and executing projects to understand the process to be followed during the life of the project.
- Capture the best experience within the organization so that the life cycle process can be improved continually and duplicated on future projects.
- Enable all the project roles and responsibilities and the project planning, estimating, scheduling, monitoring and control methods and tools to be appropriately related to the overall project life cycle management process.

Life Cycle Phases and Decision Points

There is general agreement that the four broad, generic project phases are (common alternative terms are shown in parentheses):

- Concept (initiation, identification, selection.)
- Definition (feasibility, development, demonstration, design prototype, quantification.)
- Execution (implementation, realization, production and deployment, design/construct/ commission, installation and test.)
- Closeout (termination, including post-completion evaluation.)

However, these generic life cycle phases are so broad and the titles so generic that they are of little value in documenting the life cycle process so that it can be widely understood, reproduced, and continually improved. What is needed is the definition of perhaps five to ten basic phases for each project category, usually with several sub-phases defined within each basic phase, together with an appropriate number of decision points (approval, go/kill, go/hold) in each.

Conclusions

1. Different project categories require different governance, management, planning, scheduling and control practices.

2. Each project category and many sub-categories differ in:
   - Maturity of related PM methods and practices
   - How PM methods of planning, authorizing, scheduling, contracting, and controlling the work are adapted and applied
   - Most effective life cycle models
   - Degree of uncertainty: technology, funding, environmental, political, other
   - How the project manager role is assigned and conducted
   - Experience and technical knowledge needed by the project manager
   - Plus others....

3. A globally agreed project categorization system is urgently needed and will have many practical uses:
   - Selecting the best PM methodologies and life cycle models
   - Defining project management systems and developing systematic methodologies for their creation
   - Tailoring education and training curricula, materials, and case studies
   - Developing specialized PM software applications
   - Certifying project managers and PM support specialists
   - Others:

4. Application of "One-Size-Fits-All" PM methods causes many project failures
   - "Best practices" must be identified for each agreed project category
   - In the absence of agreed categories, the wrong PM methods are often applied
   - This is a root cause for many project failures.

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The difference between

Different Types of Projects

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As the Project Management profession moves into working on many different types of projects we are going to have to move to a new level in the project management body of knowledge and develop extensions that define the differences in requirements and approach for different kinds of projects such as construction, new product development, and information systems. This paper attempts start to define the unique characteristics of different types of projects as well as establish a typology or taxonomy of different kinds of projects. The classification is based on the product or deliverable of a project. A list of characteristics is developed that defines the difference between projects such as:

- Degree of uncertainty and risk (construction vs new product development)
- Level of sophistication of workers (construction, vs information systems)
- Level of detail in plans (days or hours for maintenance vs months for research)
- Degree of new technology involved (research vs administrative projects)
- Degree of time pressure (maintenance or big event vs construction)

The paper then defines the essential characteristics of the basic differences between types of projects and outlines how the project management approach must vary for each different type of project. This will serve as a start toward developing one dimension of the needed extensions for the body of knowledge (BOK). A project management professional must know something about different types of projects and how the project management approach must differ for different types of projects. Filling out this taxonomy must be a high priority for the profession. Hopefully the profession can work together to share knowledge and come up with an agreed typology.

Introduction

How should we categorize different types of projects? The dictionary defines **typology** as the study of types as in systematic classification. It defines **taxonomy** as the science, laws, or principles of **classification**. It defines classification as the systematic grouping into categories by shared characteristics or traits. The project management profession needs a classification system for different types of projects so that we may communicate effectively across the entire world. There are many different potential purposes for a system of classification. One useful objective for a list of different types of projects is to segment the market for marketing purposes. Another is to define the different management approaches needed for different projects. The system of classification might change based on the purpose. Another purpose would be to select the right project manager based on the requirements of a specific project.

Other research

Shenhar and Wideman in several papers have proposed a system of classification based on three variables of (1) Degree of uncertainty at initiation; (2) Complexity based on degree of interconnectedness and (3) Pace based on the need for speed in the available time frame for the project. In a second paper they added the dimension of an intellectual product (white collar) versus a craft product (blue collar). These papers present several very useful analyses but they do not give us a complete list of different types of projects nor do they define all the differences between the different type projects. Archibald has carried this much further in several papers as listed in the References.

This is an updated and edited version of a paper originally presented in the Project Management Institute 1999 conference at Philadelphia, Pa. Edited 2002 for Max Wide-man's Web Site.

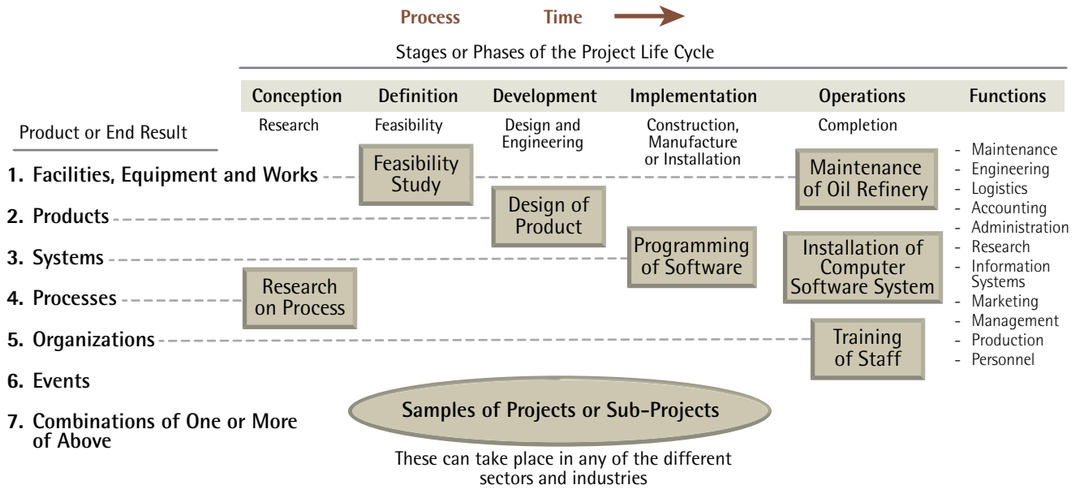

Figure 1. Basic categories for project categorization.

Alternative parameters for categorizing projects

There are a four basic ways in which we can set up a classification system of projects as follows: (1) geographical location, (2) industrial sector (Standard Industrial Classification System, (3) stage of the project life cycle (See Figure 1) and (4) product of the project (construction of a building or development of a new product). The most important and the most useful breakdown is by type of product or deliverable that the project is producing such as building a building, developing a new product, developing new computer software program or performing a maintenance turnaround or outage on a chemical plant or electric generating station. Each of these types of projects has more in common with other similar projects producing the same type of product than with other types of projects. Conversely there is much less commonality between different types of projects in the same industrial sector or company. For example there is much more commonality between projects for developing a new software system in a construction company and a bank than there is between three projects in the same bank for constructing a new building, developing a new product and developing a new computer software system. Figure 1 presents a list of products of projects with a slightly different result based on Russ Archibald's approach. Please note in Figure 1 that a phase of the project life cycle like Feasibility Study is a project in its self and very different from a later phase like construction. Please also note on Figure 1 that projects have to also be related many times to the business function in the organization.

Major Types of Projects Based on Product of Project

Here is a list of nine different types of projects based on the product they produce. The profession should think of other products of projects not listed here and come up with an agreed list. I have combined some like Defense/Aerospace within New Product. They could be separated.

Type of Project		**Product of Project** (Examples)
1.	Administrative	installing a new accounting system
2.	Construction	a building or a road
3.	Computer Software Development	a new computer program
4.	Design of Plans	architectural or engineering plans
5.	Equipment or System Installation	a telephone system or a IT system
6.	Event or Relocation	Olympiads or a move into a new building
7.	Maintenance of Process Industries	petro-chemical plant or electric generating station
8.	New Product Development	a new drug or aerospace/defense product
9.	Research	a feasibility study or investigating a chemical
10.	Other (International Development Projects)	?

Table 1. Different types of projects based on the product they produce.

1.	Stability of scope	H M L High-medium-low
2.	Degree of uncertainty or risk	H M L
3.	Type of worker	Craft (blue collar) vs. Knowledge workers (white collar}
4.	Importance of time (Pace)	H M L
5.	Importance of cost	H M L
6.	Level of new technology	H M L
7.	Series of projects or one of a kind	Series or one off
8.	External contract or internal work	External or internal
9.	Level of detail in plans	H M L

Table 2. Parameters for project classification.

Major variables or parameters or attributes

The following is a list of different characteristics that relate to different projects. It was developed by analyzing the nature of the nine different types of projects. It also draws on previous work as listed in the references.

Common characteristics of the major types of projects

Lets now look at the attributes or characteristics that are common to each of the nine basic types of projects.

1. **Administrative**: Administrative projects involve intellectual workers. The scope may change as the project proceeds.
2. **Construction**: Construction is a contract business where the scope is laid out in detail before the project starts and the level of risk is small. The workers are all most entirely craft or blue collar. In most cases time pressures are moderate and cost is a very important variable. The processes of construction are well known and the foremen very experienced.
3. **Computer Software Development**: Software projects are notorious for having the scope change radically during the project. Often they are pushing the state of the art which introduces high risk. Programmers are famous for individualistic behavior.
4. **Design of Plans**: The design of any kind of plan is an intellectual endeavor. By the nature of the exploratory nature of design the scope may not be well defined at the beginning because the client may not have yet decided just what they want. Quality is of a higher priority than either time or cost.
5. **Equipment or System Installation**: Scope is well defined and speed is essential. Risk should be low if the project was well planned.
6. **Event**: This is a one of a kind project where scope may change during the project and uncertainty is high. Time is critical to meet a specific date. It is probably a complex project. The Olympics or a relocation to a new building are examples.
7. **Maintenance of Process Industries**: Turnarounds and outages are short perhaps nine week projects in which down time can cost as much as a million dollars per day and speed is critical. Uncertainty is high because the scope is not fully known until the plant is disassembled. A large number of different craft workers are involved. They are often worked with three shifts per day and plans are detailed in hours.
8. **New Product Development**: Developing a new product is a risky business. By definition you are pushing the state of the art. Time to market is much more important than cost of the project. Quality is also critical and the scope may change up or down during the project.
9. **Research**: Research projects are usually long term where quality takes precedence over time. It is an intellectual process where scope may not be defined at all in the beginning.

Required Project Management Approach

Lets now look at the different approaches that are necessary to manage each of the nine basic types of projects.

1. **Administrative**: Teambuilding and refinement of objectives are important on administrative projects where some or all of the team may be part timers.
2. **Construction**: Construction projects generally run smoothly since the staff are all experienced and know their jobs. Control of labor hours and cost control is important for the contractor on lump sum type contracts.
3. **Computer Software Development**: Tight project control is necessary on software projects in which other factors may be quite loose. The Project Manger needs to be ready to adapt to changing requirements from the client.
4. **Design of Plans**: Because the scope and activities necessary for development of plans may be fuzzy it is all the more important to have a detailed Project Management System to adapt to changes as they occur.
5. **Equipment or System Installation**: This is a case of thinking through all contingencies ahead of time and being sure that all involved are heading in the right direction.
6. **Event**: Detailed planning and good teambuilding are important in these complex projects where timing is critical.
7. **Maintenance of Process Industries**: With hundreds of workers involved in three shifts per day where a reduction of one day can be worth a million dollars, detailed planning and control is essential.
8. **New Product Development**: The business of managing a diverse group of various technical specialists in a matrix organization to meet quality and time objectives on a complex project is demanding. Good project management is necessary.
9. **Research**: Project Management can be relaxed on long lead-time research projects but it is all the more essential to set goals and to measure progress against those goals.

Other variables common to all types of projects (secondary factors)

The following factors are important in projects but are not specific to any one of our list of project types. They could relate to any of the types. These factors could be used in other classifications of projects.

1. Size
2. Duration (Length of time)
3. Industrial sector
4. Geographical location
5. Number of workers involved
6. Cost (large, medium or small)
7. Complexity
8. Urgency
9. Organizational design

Conclusions and Recommendations

The most useful classification of types of projects is by the product of the project. This paper presented a list of nine different types, which should be expanded as more persons contribute ideas. The profession should adopt this breakdown as a basic segmentation of the Project Management business and use it in a number of different ways including organizing the breakout of tracks at annual conferences. The list of projects and their different attributes (Figure 1) needs to be worked on and agreed upon. The interest groups for each of these types of projects should expand the sketchy descriptions in this paper of the nature of their projects and required approaches. Another dimension of a taxonomy not mentioned in this paper is the list of subjects or topics of the practice of Project Management similar to the BOK.

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A Contribution to Developing a

Complex Project Management BOK

This paper proposes a project typology focused on system of systems (SoS) projects, which are recognised as complex in a hierarchy of simple, complicated, and complex. Three types of complex systems are proposed: traditional SoS projects, such as defence or air transport, in which a developing project incorporates an existing independent asset; SoS projects which address wicked problems and hence require use of soft system methods to determine stakeholders, boundaries and a solution process; and, integration of assets, such as states or enterprises into an encompassing system. Context, leadership style and personality types suitable for each are proposed. Some tools are referenced. Soft system methods to explore solutions to wicked problems are outlined.

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This is an updated and edited version of a paper that was first time published in the proceedings of IPMA 2011 World Congress.

Introduction

While traditional projects have had available various bodies of knowledge to assist planing and execution, including the PMBOK® Guide (PMI 2008), IPMA's Competence Baseline, ISO 21500, APM (2006), PRINCE2TM (2009) and the Japanese P2M (PMAJ 2004), complex projects do not yet have a BOK to guide their development. This has been under development since September 2009 by several dozen contributing authors and reviewers, carefully chosen from the Systems engineering field including many members of the International Council on Systems Engineering (INCOSE).

There are many relevant research papers to assist practitioners and researchers and these include Gorod, Sauser and Boardman, 2008, Sauser, Boardman & Gorod, 2009, Keating et al, (2003), Firesmith (2010), Bar-Yam (2003, 2004), and White (2010, 2009, 2008), and other references in this paper. Furthermore, all of these bodies of knowledge have a reductionist flavour and none explicitly recognise SoS projects. Furthermore, even more complex projects than the 'traditional' SoSs, such as addressing terrorism, international disputes, and climate change, which require a soft system methodology to identify stakeholders, boundaries and possible solutions, are not addressed in a BOK. This seems remarkable since there is an International Journal of System of Systems Engineering (IJSE).

This paper recognised a hierarchy of Simple, Complicated and Complex among projects and explores three types of complex projects, these being:

- Traditional SoS projects in which there is inclusion of an existing system into a new project, the existing system being independent and autonomous (Type A complexity);
- SoS projects which require systems thinking to determine stakeholders, project boundaries, and soft systems methods of Checkland or Systems Dynamics to develop a potential solution (Type B);
- Integration of independent assets into a larger system (for example a corporation or a food supply) into a system in order to reduce waste (Type C).

The approach for the complicated project (reductionist) does not assume the project elements have autonomy and independence. It assumes suppliers are locked into a relationship with the deliverer via contracts, and that employees are locked in by conditions of employment. This is in contrast to the case where contributors have autonomy and independence, for example selling jet engines, in which case the behaviour of competitors and customers cannot be predicted.

Some aspects of the relationship between Simple, Complicated and Complex projects are shown in Fig 1. Note that Simple projects are shown as a rectangle, indicating relatively fixed boundaries and scope whereas complicated projects are shown as circle, indicating fairly fixed boundaries and scope. Complex projects are indicated as a cloud, portraying unclear and varying boundaries. Management effort is indicated but this still needs much further research.

Understanding System of Systems projects

It is now recognised that a new form of projects has emerged, these being system of systems (SoS), which are complex projects (Types A-C). There is no satisfactory definition of complexity. Ashby (1956) pointed out that complex systems were self organising. They are unpredictable and uncontrollable and cannot be described in any complete manner. However, there are a number of texts focusing on system of systems as applied to projects. Jamshidi (2009), Aiguier et al (2010), and Braha et al (2006) are a few. There are many research studies and papers with a number of annual conferences in a number of countries based on system of systems.

Lane and Valerdi (2010) define a SoS as 'a very large system using a framework for architecture to integrate constituent elements, [which] exhibits emergent behaviour, with constituents systems: [they are] independently developed and managed, [with] new or existing systems in various stages of development/evolution, [they may] may include a significant number of COTS products, and their own purpose, and, can dynamically come and go from the SOS'.

Norman and Kuras (2006:209) provide an example of a SoS in which this independence and autonomy is described. The Air and Space Operations Centre (AOC) of the US, which provides tools to plan, task, and monitor all the operations in Afghanistan and Iraq, is composed of 80 elements of infrastructure including communication balance, application, servers, and databases. The systems:

- Don't share a common conceptual basis;
- Aren't build for the same purpose, or used within specific AOC workflows;
- Share and acquisition environment which pushes them to be stand-alone;
- Have no common control or management;
- Don't share a common funding which can be directed to problems as required;
- Have many customers in which the AOC is not only one;
- Evolve at different rates subject to different pressures and needs;

SoSs have been further described as having:

1. Operational Independence of the Individual Systems.
2. Managerial Independence of the Individual Systems
3. Geographic Distribution
4. Emergent behavior
5. Evolutionary Development (Morganwalp and Sage 2003:88).

In the authors' view the issue of inclusion of autonomous and independent systems is a crucial aspect because this requires significantly different methods of management. Heylighen (2002) points out that complex projects are self organising.

Categorisation of simple, complicated and complex projects

Categorisation processes

Addressing SoSs is assisted by developing granularity in describing complexity. Snowden and Boone (2007) take-up the classification of systems into categories of simple, complicated, complex and chaotic. This is used by Glouberman and Zimmerman (2002) as well in the classification of health care systems. Tools for distinguishing complicated from complex are provided by Cotsaftis (2007). The test to identify whether it is complicated or complex is: Identify whether the system can be explained by reduction (ie are there equations, or obvious hierarchic relationships between the system and its components)?

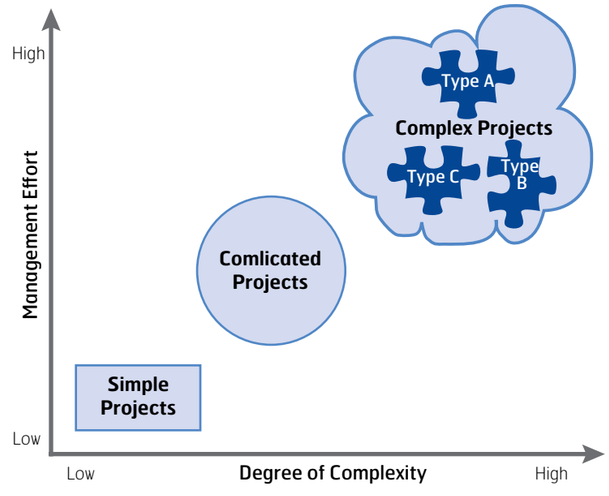

Figure 1. Degree of complexity for Simple, Complicated and Complex projects

Complicated and complex projects are separated by the following test:

1. Identify the degrees of freedom in the system (the number of variables or aspects free to vary);
2. Decide if it is simple or complicated – how many degrees of freedom are there;
3. Check the number of control tools and do these match the degrees of freedom?

If the number of control tools is less than the number of degrees of freedom, the system is complex (Type A, B or C.)

In reasonably 'traditional' SoS projects the goal in integrating the systems is to integrate the legacy system into the SoS (Norman and Kuras 2006). Such as approach is labelled Complex system Type A. Examples are:

- Glouberman & Zimmerman (2002) for healthcare;
- De Lauentis for transport (Jamshidi 2009:520-541);
- Thisen and Herder for infrastructure (Jamshidi 2009:257-274);
- Bhasin and Hayden space exploration (Jamshidi 2009:317-347);
- Korba and Hiskens for electrical power systems (Jamshidi 2009:385-408);
- Dahman for Defence (Jamshidi 2009:218-231);
- Wilber for airline (Jamshidi 2009: 232-256).

Some more detailed examples of SoSs include:

New York Cabs The SoS is the overall cab service (Sauser, Boardman and Gorod 2009:207). Each operator conforms to each of the first four elements noted in section 2. The overall cab service maintains its integrity; if one of the cabs exercise their autonomy by choosing not to participate in the service at a particular time the overall service is maintained by others stepping in to take its place.

Electricity power systems An integrated electric power supply system is a more complex example of a SoS. Each generator and distributor has the autonomy to be part of the system of systems or not, and if one or more drop out at a particular time, the system still performs, due to the load being transferred to those who remain in (Korba and Hiskens, 2009).

Airports These are somewhat similar to integrated power system as one airline dropping out will have minimal effect on the operation of the airport (Delaurentis and Fry 2008).

Defence 'Most defence domain examples of SoS have a centralised authority and a clear chain of command. The constituent systems in a defence SoS have independence – an air vehicle and a ground vehicle can operate without direct linkage to each other, or without requiring explicit instructions for every move – but strategic SoS decisions are made at high level' (Moffat 2003.

Points made by DeRosa et al (2008) enable us to realise why complex projects cannot be managed as reductionist based projects, analysed by using reductionist principles, because traditional projects have assumptions of:

- **Closed systems assumption** – the assumption that the system is insulated from changes and disturbances outside the system;
- **Superpositionality** – the assumption that we can decompose requirements down to definable components and deal wit these in relative isolation; when we assemble them the whole will equal the sum of the parts;
- **Central or hierarchical control assumption** - Traditional projects assume central control which is exercised through a contract between the principal and the general contractor and subsequently further contracts between the general contractor and subcontractors In contrast, the complexity of enterprise systems overwhelms the ability of any one authority to control the whole (DeRosa et al (2008:3);
- **Linear causality assumption** - this assumption interprets enterprise behaviour as resulting from separable and linear chains of causes and effects (eg value chain, kill chain, etc). But in real complex systems causation and influence are networked, creating a web of positive and negative feedback loops that together govern overall behaviour.

De Rosa et al (2008) comment that interdependence implies that reduction by decomposition cannot work, because the behaviours of each component depends on the behaviours of the others. Writing from a military background, they add four further elements to the list of aspects of complexity:

1. The situation cannot be unambiguously bounded since there are always significant interactions with elements of the wider context, and some of these may be changing at a rate comparable to that of the situation itself
2. Both the situation and the wider context contain entities (people, groups, systems) which act in their own interest and react to support or oppose every intervention in the problem, in ways that cannot be precisely predicted (eg counter-insurgency warfare, global business operations, web applications).
3. Most seriously, the number of possible "solutions" grows at least exponentially with the number of entities in the situation creating a huge possibility space which cannot be pre-stated or analysed in any compact way (eg assets-to-tasks problem, software assurance, system design)'.

DeRosa et al (2008) pick up the issues of a difference between complicated and complex, pointing out that the root of the word complicated means to fold whereas the root of the word complex means to weave. Snowden and Boone echo this distinction (2007).

SoS tools

Some tools suitable for use on Type A SoSs are:

- Systemigram (Boardman and Sauser, 2008)
- Incremental commitment (Boehm and Lane 2007, 2009);
- Architecture (Dagli and Kilicay-Ergin (2009);
- Modularity and the Design Structure Matrix (Baldwin and Clark 2004:6).
- Governance (Morris, Place & Smith, 2006).

The world's major problems or projects

There is a further aspect which leads to the conclusion that complex projects require a different approach to traditional projects. Projects such as terrorism, international disputes, the European debt crisis and control of illicit drugs, can be seen as wicked or messy problems and thus require a systems thinking approach (Jackson, 2003). This systems thinking approach initially distinguishes them from SoS Type A and we call this Type B.

Bar-Yam (2003) sees complex projects as:

- Those which have interdependent parts; therefore one cannot identify the system behaviour by just considering the parts separately;
- Furthermore, there is an interplay of behaviour and multiple scales, and between this system and its environment (Korba & Hiskens, 2009).

Some examples of interactive behaviours challenging the management of SOS are noted by Bar-Yam include:

- Military operations in Iraq and Afghanistan: if the army does this, will the insurgents do X or Y, and what will the general population do?
- Reducing their harmful effects of climate change (if a carbon tax is imposed how will oil producers, and public users react? Will users of oil, use less and what effect will it have on overseas suppliers?

Bar –Yam (2003:5) also points out that the military and intelligence communities have realise the benefits of networked and distributed control and information systems. However he comments that the traditional reductionist approach fails when dealing with such systems. He is supported by Snowden and Boone (2007) and DeRosa et al (2008).

Furthermore, Bar-Yam reports very significant losses, amounting to multi-billions of dollars through treating complex projects as traditional command and control systems (Bar-Yam 2004:224). Bar-Yam's work is supported by Mihm and Loch (2006), De Rosa et al (2008) and White (2009).

Jackson on complex tasks

Complexity is defined by Jackson as a number of interconnected issues, with lack of clarity about purposes, conflict, uncertainty about the environment and social constraints (Jackson, 2003:137). This will be discussed further as Type B Complexity.

Approaches to dealing with Type B Complexity are primarily the need to identify stakeholders, definition of boundaries and use of Checkland's Soft Systems Methods to solve problems

Identification of stakeholders and addressing uncooperative stakeholders

Strategic assumptions surface testing (SAST) is useful for assisting to define relevant stakeholders for a complex project stop for principles are highlighted by Mason and Mitroff (1981):

- Participative based on the belief that different stakeholders should be involved;
- Integrative based on the belief that different options offered by the participative and adversarial principles must eventually be brought together again in a higher order synthesis;
- Integrative based on the belief that different options offered by the participative and adversarial principles must eventually be brought together in a higher order synthesis;
- Managerial mind supporting based on the belief that managers exposed to different assumptions that highlight the complex nature or with the problem will gain deeper insight into the difficulties facing an organisation (Jackson 2003:142).

The first method of the process addresses:

- How are the assumptions of the groups different?
- Which stakeholders feature most strongly in giving rise to the significant assumptions made by each group?
- Do groups rate assumptions differently (e.g. as to their importance for the success of the strategy)?
- What assumptions of other groups does each group find the most troubling with respect to its own proposals (Jackson 2003:144)?

The stakeholder groups need to be as broadly based as possible. Rosenhead (1987) and Jackson (2003:136) contributes that the characteristics should include or recognise:

- A satisficing with rather than optimising rationale;
- Acceptance of conflict of goals;
- Different objectives measured in their own terms;
- The employment of transparent methods that clarify conflict and facilitate negotiation;
- The use of analysis to support judgement with no aspiration to replace it;
- The treatment of human elements as active subjects;
- Problem formulation on the basis of a bottom up process;
- Decisions taken as far down the hierarchy as there is expertise to resolve them;
- The acceptance of uncertainty as an inherent characteristic of the future and a consequential emphasis on keeping options open.

The second method incorporates assumptions specification and assumptions rating in which case assumptions are categorised on the basis of least certain to most certain and least important of most important, thus allowing the more likely assumptions to be accepted

Clarification of boundaries of a complex system

Critical System Heuristics (CSH) focuses on identifying the boundaries of a complex system. It recognises that in trying to grasp the whole system we invariably fall short and produce limited accounts and sub-optimal decisions based on particular pre-suppositions (Jackson 2003:214).

Ulrich identified twelve boundary questions in the 'ought' mode:

1. Who ought the client (beneficiary) of the system be?
2. What ought the purpose of the system be?
3. What ought the system's measure of success be?
4. Who ought the decision maker be? (ie have power to change the System's measures of success)
5. What components (resources and constraints) of the system ought to be controlled by the decision taker?
6. What resources and conditions ought to be part of the systems environment (ie NOT to be controlled by the system's decision taker)?
7. Who ought to be involved as designer of the system?
8. What kind of expertise ought to flow into the design of the system?
9. Who ought to be the guarantor of the system (ie where ought the designer seek the guarantee that the design will be implemented and will prove successful, as judged by the system's measure of success)?
10. Who ought to belong to the witness representing the concerns of the citizens that will or might be affected by the design of the System (ie who among those affected should be involved)?
11. To what degree and in what way ought the affected be given the chance of emancipation from the premises and promises of the involved?
12. On what worldview of either the involved or the affected ought system's designed be based? (Jackson 2003:219).

Development of a solution

Checkland's (1981) basic process to address wicked problems is to use the seven step approach, which is called a soft system methodology (SSM), shown in figure 2.

Van Haperen (2002) has developed a methodology that enables coherent development and definition of user requirements. Traditional system development and engineering methods no longer suffice and more qualitative methods and techniques need to be embraced. An evolutionary relationship exists between the methodologies and techniques used to define requirements, to design and develop the system and to assess its effectiveness. Wilson (1990) highlights that organisations, rather than dealing with 'how' to solve a problem, firstly should concern themselves with determining 'what the problem is'. Worm (2001) highlights that 'adequate performance in complex, high risk, tactical operations requires support by highly capable management'. Measuring performance, developing systems and conducting operational testing that cope with such complex conditions are a challenge.

Hence, Complex Type B projects, dealing with issues such as terrorism, managing climate change, addressing illegal drugs, disputes between countries which are traditional enemies, and others, require very different methods, primarily including the use of systems thinking methods, especially Checkland's Soft Systems Methods (SSM), to identify a potential solution (Jackson, 2003).

The first step is to understand the concept of different perspectives that are possible to draw out of the rich picture. The SSM process of

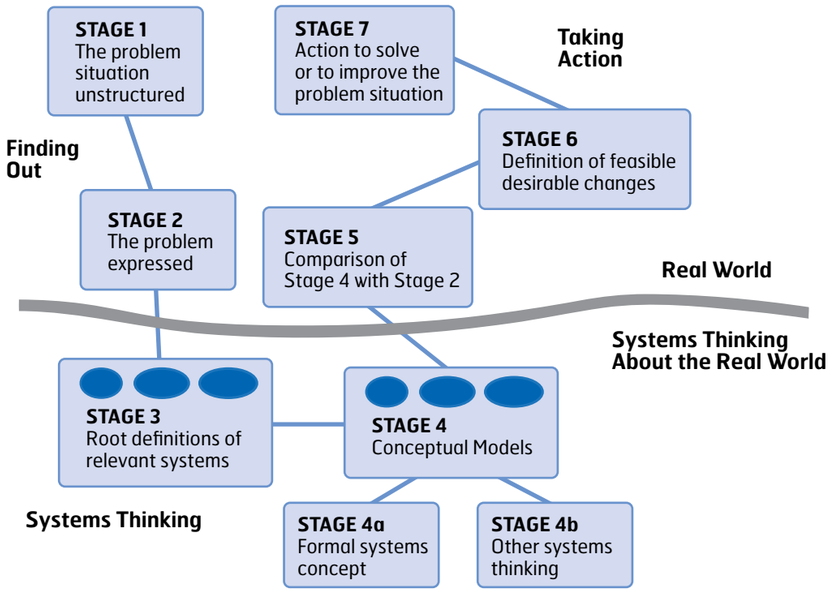

Figure 2. Checkland's soft systems approach.

using CATWOE standing for Customers, Actors, Transformation process, Weltanschauung or World View, the Owner to whom the "system" is answerable and the Environment that influences but does not control the system, all provide a tight process necessary for the breadth of vision required to see integration of systems possibilities.

Checkland's approach of developing multiple CATWOEs (possibly 10-20), and comparing them for additional perceptions, contributes to development of a solution.

Bergvall-Kareborn (2002) suggests the perspectives of ethical, judicial, aesthetic, economic, social, lingual, historic, logical, physical, faith, love, harmony, frugality, social intercourse, symbolic representation, energy, vitality, and motion among others. Will (2012) points out that the roles in the CATWOE or BATWOVE will differ depending on the perspective taken (Will also comments that the CATWOE approach can be amended to replaced C with two concepts; B for Beneficiaries, and V for Victims producing BATWOVE). Exploring each of perspectives suggested by Bergvall-Kareborn (2002) may not be appropriate – other perspectives may be more relevant to the systems being integrated. However, it is the recognition of the results from each and the comparison of these which provides the power of the method.

System Dynamics (SD) could be used as an alternative to SSM in developing a solution (Jackson 2003:65).

Integration of systems such as enterprises, states and supply chains (Type C)

Korsten and Seider (2010) discuss the issue that many enterprises and entities could benefit by their integration to a higher level system. They reported that lack of efficiency in integration of enterprises into a system is costing the world $15 trillion pa in which they estimate that $4 trillion pa could be saved.

A clear-cut example of savings with regard to water management occurs as rivers pass through state and national boundaries. First users of the water often take more than their share of the water leaving inadequate supplies for downstream states (Elfithre, 2006).

Another example is the integration of road jurisdictions between adjacent states and countries thus allowing integration of speed limits, emergency and maintenance services, and other aspects, over multiple jurisdictions hence producing increased average speed and thus reduced energy costs.

A further example is integration of health care services. Reid et al (2005) propose that a four level approach be used to address the integration of systems in health care, the levels being the Patient, the Care Team, the Organisation and the Political and Economic Environment. They assert that real time monitoring of patients would save costs and lives.

It is possible to categorise projects into four types

Tools to deal with Type C complexity

Type C complexity is the integration of enterprises operating for similar purposes into an overall system at a higher level. Examples of these include:

- Rivers passing through different state jurisdictions;
- Different medical services available to a patient such as general practitioner, specialist medical services, hospitalised services, patient records, medical practitioner associations, medical guilds, and others;
- Integration of organisations in a supply chain;

On the issue of river systems integration Ferreya and Beard (2005) outline practical insights for protecting groundwater in rural areas of Ontario.

Governments, in recognising both the challenges and benefits of multi-organisational integration, can provide both legislation and taxation benefits to force and encourage enterprise integration Li (1964).

Other examples include transport systems integration between rail, bus, ferry, motor vehicles on roads and use of bicycles. Examples of rail, bus and ferry coordination include integration of timetables to reduce waiting time at exchange points, use of an integrated ticket system, supply of bicycles by the city at railways stations.

Air-traffic management and integration occurs at airports however the integration of control systems is a system of systems issue.

Comparison of projects

Based on this approach a comparison of projects is shown in Table 1.

Can PMBOK be used on complex projects?

In the end the task of the project is to clarify the boundaries and objectives of the project and develop a solution which can be produced using traditional methods such as the Project Management Body of Knowledge, or another BOK, and systems engineering principles. However, it is only after a solution is developed using soft system principles that be Type B and C projects can be delivered.

Some tools are suggested to assist project management.

Conclusions

It can be seen that it is possible to categorise projects into four types, these being simple, complicated, which can be developed in a reductionist manner, and a third type being complex projects, which can be broken up into three different types, Type A being a SoS such as defence, which include autonomous and independent systems, which are addressed by integration of independent system into the larger system of systems; and Type B which requires a soft system approach to define stakeholders, establish boundaries and develop a solution. Type B projects use Checkland's soft system methods, or system dynamics, before a solution is developed in a similar manner to Type A projects. A third type of complexity, Type C is the integration of autonomous and independent assets, such as an enterprise or a state in a federation (for rivers or road systems) into a larger system, in order to reduce wastage and increase benefits.

Some tools are suggested to assist project management. Finally once a solution has been developed the project can then resort to traditional project management techniques for development and implementation.

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Complexity Type	Context	Leadership Style	Tools	Choice of staff	Project Example
Simple	A local and small project.	Top down	Scope development, WBS, Scheduling	Likes clear instructions	Repair of ship, Building a house, Managing a marketing campaign
Complicated and reductionist	Cause and effect relationships discoverable but not immediately apparent, Expert diagnosis required, More than one right answer possible, Known unknowns, Fact-based management	Top down	Tools for simple projects PLUS, PMBOK or IPMA ICB PLUS systems engineering tools for technology based projects	Likes clear instructions	Design and produce a jet engine
Complex Type A	Flux and unpredictability, No right answers, emergent instructive patterns, Unknown unknowns, Many competing ideas, A need for creative and innovative ideas, Pattern-based leadership	Top down Sense, analyse and respond, Create panels of experts, Listen to conflicting ideas	Balancing internal context with external environment, Architecture development, Requirements management, Incremental commitment, Addressing unk unks, Developing modularity, Systemigram, Managing governance, Identifying patterns	Abstract reasoning, Business acumen, Comfortable with ambiguity, Emotional Intelligence, Systems thinking, Understanding perspectives Helmsman (2010)	Integration of healthcare systems, Airport traffic management , Infrastructure integration, Space exploration, Electrical power systems integration, Defence system integration, Commercial airline development.
Complex Type B	A wicked problem	Probe, sense and respond, Create environments and experiments that allow patterns to emerge, Increase levels of interaction and communication, Use methods that can help generate ideas, Open up discussion as through large group methods, Encourage dissent and diversity, and manage starting conditions and monitor for emergence (Snowden & Boon 2007)	Type A tools but preceded by: - SAST - CSH - SSM - SD	Abstract reasoning, Business acumen, Comfortable with ambiguity, Emotional Intelligence, Systems thinking, Understanding perspectives Helmsman (2010)	Managing terrorism in Afghanistan, Managing multi-national integration for climate change, Managing international disputes., Solving the illicit drug problem.
Complex Type C	An attempt to reduce wastage	Not clear yet	Not clear yet	Business acumen, not territorial, opportunity focused	Integrating road and river systems between states Distributing food from rich countries to poor Integrating transport systems.

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Eyes Wide Shut:

Expanding the view of portfolio management

This conceptual paper examines our existing world-view portfolio is defined the management of that portfolios from that of project and new product development portfolios to other portfolios that exist in an organisation, such as the asset portfolio, resource portfolio and ideas portfolio. Portfolios do not exist in isolation in an organisational context, but instead overlap and interact. This paper argues that there is a need to move another step higher, and examine the relationships between portfolios of projects and related activities across an organisation in order to optimise outcomes across the organisation. We propose the need for 'enterprise portfolio management' and suggest that this approach has the potential to improve organisational efficiency, and in the longer term could be a source of competitive advantage.

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Introduction

Project portfolio management (PPM) is an emerging aspect of business management that promotes and facilitates a holistic perspective to optimise benefits across the project portfolio. The goals of PPM are to align projects with strategy, maintain a balance of project types, and ensure that the project portfolio fits with resource capability so that the organization can sustain the maximum value from project investments (Cooper, Edgett, & Kleinschmidt, 2001; Kendall & Rollins, 2003). Some of the initial PPM concepts have their theoretical underpinnings in business finance (Markowitz, 1952; McFarlan, 1981; Kendall & Rollins, 2003) and the evolution of PPM appraoches have been heavily influenced by field of product development (Cooper, Edgett, & Kleinschmidt, 1999; Killen C. P., 2008; Killen, Hunt, & Kleinschmidt, 2008).

The rise of PPM follows decades of improvements in project management skills and capabilities and may be considered the biggest leap in project management since the development of PERT or CPM (Levine, 2005). As the field of project management has matured, attention has shifted to multi-project management systems as a way to improve project success rates. It is no longer enough to 'do things right' with effective project management capabilities; it is also important to 'do the right things' using a portfolio-level perspective (Cooper, Edgett, & Kleinschmidt, 2001).

This conceptual paper suggests that we extend our world view from a rather myopic perspective whereby once a portfolio is defined the management of that portfolio occurs in an isolated matter. We argue that there is a need to move another step higher, and examine the relationships between portfolios of projects and related activities across an organisation in order to optimise outcomes. We use the term 'enterprise portfolio management' for this higher level capability and propose that organisations will benefit by understanding and managing the relationships between project portfolios and other organisational portfolios such as the asset portfolio, the resource portfolio and the ideas portfolio (see for example: Buttrick, 2000; Cooper R. G., 2005; Krebs, 2009; Larsson, 2007; Center for Business Practices, 2005). This paper asserts that these portfolios do not exist in isolation in an organisational context, but instead overlap and interact. By examining each portfolio, and in particular the linkages and interfaces between each portfolio, we suggest organisational-wide communication and coordination improvements can be made. As such, this 'enterprise portfolio management' has the potential to improve organisational efficiency, and in the longer term could be a source of competitive advantage.

Organisational Context

The Project Management Institute (PMI) (2008) suggests that in any organisation, work can be identified as either project-based or operations-based. These two domains are presented as quite separate, with management methods and techniques for each domain having a different focus and approach. Turner and Muller (2003) suggest that 'operations' within an organisation are designed for the management of routine in stable environments. The focus here is efficiency and incremental change as small continuous improvements are applied. Projects on the other hand are vehicles that support more radical change and operate at their optimum in dynamic environments (Turner and Muller, 2003).

Research on organisations has shown that the extension of project concepts into the operational functions of organisations is lacking, and mechanisms for sharing and resolving conflicts are seldom in place (Turner and Muller, 2003). Shenhar and Dvir (2004) suggest that this is due to project management being a relatively new organisational concept and as such top managers treat projects as separate entities that sit outside the regular functional structure. However, when 'projects' and 'operations' are viewed as separate entities, the potential for resource contention and conflict is created, forcing both 'operations' and 'projects' areas within the organisation to compete for priority amongst the pool or shared resources (Engwall & Jerbrandt, 2002). The project-level resource priority conflicts are also highlighted at the project portfolio level.

In the simplest sense, a 'portfolio' is really nothing more than a collection or a grouping of objects. In the art world, an artist's portfolio may contain a set of drawings, sketches, paintings or photographs. In the business and management world, a portfolio is a defined as sets of entities or opportunities to be managed. Most often the portfolio management approaches are applied to project portfolios – these can contain a mix of project types, or can be a set of a particular type of project such as IT projects or new product development (NPD) projects, with each discrete portfolio usually operating within a functional element of an organisation. For example, the projects portfolio might sit in an operations division, and a NPD portfolio might exist in an engineering or research and development division, as highlighted in Figure 1.

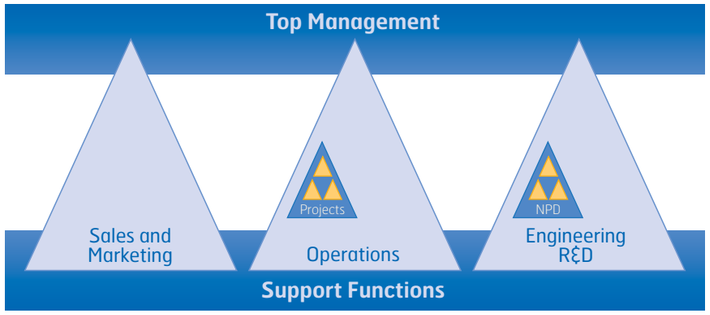

Figure 1. Existing World View of Portfolios

While portfolio management concepts are most commonly applied to the management of project portfolios in organisations, there are many other opportunities to apply portfolio management approaches to other sets of entities. Portfolio management concepts and approaches are being developed, applied and tailored to a wide range of project-focused areas including the information technology, and product development sectors (Killen, 2008; Buttrick, 2000; Center for Business Practices, 2005; Dye & Pennypacker, 2000; Kendall & Rollins, 2003; Office of Government Commerce, 2009; Morris & Jamieson, 2004; Milosevic & Srivannaboon, 2006). In a limited fashion portfolio management concepts are also being applied to other some areas such as financial investments and corporate strategy (for example, the BCG matrix (Mikkola, 2001), however many other areas have yet to apply portfolio management concepts. This may be partly due to the fact that PPM literature is fragmented and most remains somewhat isolated from mainstream business, management or strategy literature. This situation inhibits the transfer of knowledge across the application areas and many practices developed for the project portfolio context have not been effectively transferred and adjusted for application in other portfolio contexts. By rethinking the definition of an organisational 'portfolio', new opportunities may be identified.

Potentially, the portfolio concept and portfolio management tools and techniques could be extended to and adopted by a much broader selection of organisational functions: the organisation's pool of resources, assets or ideas are but some of these collections.

The Project Portfolio

The project portfolio has been defined as '...a collection of projects and/or programs ... and other work, that are grouped together to facilitate effective management of that work to meet strategic business needs' (PMI, 2008 p4). Project Portfolio Management (PPM) involves identifying, prioritising, authorising, managing and controlling the component projects and programs and the associated risks, resources and priorities (PMI, 2008). The focus of PPM is ensure efficient use of a common and shared pool of scarce resources (International Project Management Association, 2008) and to ensure that the organisation's strategic objectives are achieved (Office of Government Commerce, 2009).

Traditionally PPM discourse has focussed on the project portfolio as the primary unit of study. Whilst there have been significant developments in organisational studies at the project level, developments in organisational theory and associated studies still appear to be somewhat limited in their coverage and scope at the portfolio level. Project portfolios have found a home at the functional level in organisations, particularly in IT (McFarlan, 1981; Weill & Broadbent, 1998) where the portfolio consists of IT specific projects; and NPD (Cooper, Edgett, & Kleinschmidt, 1999), where the portfolio consists of new product development projects. Although the PMI (2008) definition of the project portfolio refers to 'other work', there has been little or no discussion that identifies what form the 'other work' takes, and portfolio management concepts are not evident in the management of 'operations'. Likewise there is only limited adoption of portfolio management concepts at the strategic business unit or corporate strategy levels in an organisation.

Each organisation will have a unique set of possible portfolios of entities that could benefit from portfolio management approaches. In addition to the commonly defined project

portfolios described above, an organisation could, for example, manage resources, assets or ideas from a portfolio perspective. Other types of organisational portfolios are also possible, however for this discussion, the resource, asset and ideas portfolio concepts will be discussed individually followed by a discussion of the linkages between the portfolios.

We will start by examining the resource portfolio.

The Resource Portfolio

An organisation's resources include all assets, capabilities, organisational processes, firm attributes, information and knowledge controlled by an organisation to conceive and implement strategies that improve its efficiency and effectiveness (Barney, 1991). Extending this concept, Krebs (2009) suggests the notion of a resource portfolio, drawing the link between cross-organisational resource management and portfolio management approaches, with resource portfolio management being focussed on managing the common pool of 'talent' in the organisation ensuring there is an available pool of resources to work on both current and future projects across the organisation.

Whilst the idea of resource management and forecasting is not a new concept in project management (for example, see Cleland & Ireland (2007) or Shenhar & Dvir (2004) or project portfolio management more broadly (Mikkola, 2001), the idea of a resource portfolio (as distinct from Barney's (1991) resource-based view of the firm) remains somewhat poorly examined, with much of the discourse examining only human resources.

Traditionally, as part of a regular ongoing business process, both operational managers (for business as usual activity) and project managers (for project activity) forecast and define their financial and human resource requirements for projects, programs and other work (PMI, 2008), taking into account the specific features, aspects of capabilities of such resources. Taking a resource portfolio view, short, mid-term and long-term resource forecasts can be used to determine the desired future level of resources, across the organisation. These forecasts take into account not only periods of normal operations but also for peak periods of demand, based on project and operational work that has been prioritised and strategically-linked. When combined, an organisational-wide resource demand profile can be developed.

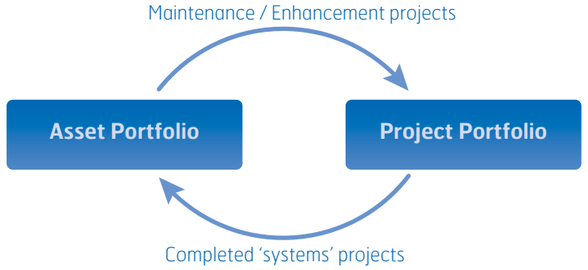

Figure 2. Two-way interaction between project and asset portfolios

These resource demands are fulfilled through the allocation of resources from the portfolio resource pool to both projects and other operational activities based on these logical forecasts (Kendall & Rollins, 2003; Engwall & Jerbrandt, 2002).

Once the resource supply and demand forecast has been developed, decisions can be made as to whether portfolio workload is to be limited to the available resource supply, or whether additional resources are required to cover the deficit. Plans can then be made to develop or acquire the required types and level of human resources can be put in place, balancing supply and demand (Turner & Cochrane, 1994). Potentially, project portfolio selection techniques and models can be used for resource prioritisation and selection. This approach would enable the alignment of resources to the organisation's strategies and prioritises so they are allocated to the business-critical projects and activities, rather than to a large number of small, low profile projects or low priority operational activities (Engwall & Jerbrandt, 2002). By using an enterprise portfolio management approach, resource prioritisation and planning can be done effectively across the entire resource pool, including but not limited to the project portfolio resource pool.

Let us now examine the Asset Portfolio.

The Asset Portfolio

Traditionally, assets have been viewed as systems, buildings, equipment or other physical assets, practices and processes (American Association of Cost Engineers, 2006). Extending the traditional view, an asset portfolio would also be comprised of knowledge-based components, such as the pool of an organisations intellectual property. The asset portfolio is not an isolated entity, but interfaces with other portfolios in the organisation. Krebs (2009) suggests a linear single relation exists from the project portfolio to the asset portfolio; however, we propose that the interaction is two-way (see Figure 2). Not only do projects produce physical assets (as deliverables or capabilities delivered by the project), but assets in their own right also generate a series of projects, by way of maintenance and enhancement activities required to ensure the asset continues to function and perform as designed. The assets may also serve to support or enhance the project portfolio outcomes.

These asset maintenance and enhancement activities draw upon the organisational resource pool. Assets, such as a building plant or system, malfunction from time to time and require unplanned, emergency maintenance to be performed. While many of the expected activities and the required resources will be planned through an Asset Maintenance Plan, these unplanned activities have the potential to drain the resource portfolio and may draw resources away from other priority activities, jeopardising the ability of the organisation to achieve their strategic objectives (Engwall & Jerbrandt, 2002).

The ideas portfolio will now be examined.

The Ideas Portfolio

The existence of an Idea Portfolio draws on the concept of ideation and the 'fuzzy-front end' (Larsson, 2007) that is examined extensively in new product development literature (see Cooper, 2005). The idea portfolio is a systematic approach to transforming ideas into businesses opportunities by enriching the right ideas to maturation from the multitude of initial concepts. This approach helps organisations stimulate idea generation and choose which products to fund, given limited investment availability and limited resources (Cooper et at, 1999).

Much of the NPD literature suggests that ideas form the 'fuzzy-front end' of the new product development lifecycle, however, ideas and the ideation occurs in a wide range of project environments. For example, new ideas are regularly generated for process, service delivery or operational improvements. Rather than using an ideas portfolio that feeds only into the new product development portfolio and then into the project portfolio (Figure 2), there may be organisational benefits of a more holistic definition of an ideas portfolio that includes product, service and process ideas. Alternatively an organisation may manage several ideas portfolios (one for each area), however delineating types of ideas is becoming increasingly difficult due to the blurring of the boundary between products, services and processes (Crandall & Crandall, 2008; Howells & Tehther, 2004). Therefore we suggest that there may be benefits in implementing a holistic ideas portfolio that collects all types of ideas and interacts with other organisational portfolios so that each idea has the opportunity to be considered, prioritised, selected and actioned within the relevant domain.

Figure 3. Portfolio Interfaces (after Larsson 2007)

Portfolio Interactions

Through their Project Portfolio Management Maturity Benchmarking survey, the Center for Business Practices (2005) discovered that more than one third of respondents also practiced product portfolio management, asset portfolio management and application portfolio management, with the prevalence increasing as the organisation's project portfolio management maturity increases.

Definitions and findings of this nature suggest that there is an opportunity to manage the inter-relatedness between the varying types of portfolios that exist in the organisation. The prevalence of environments where project portfolios co-exist with other types of portfolios supports a move to manage portfolios in a more holistic sense and not limit our thinking to just the project portfolio or the new product development portfolio.

Not only must we examine the life span from project inception to project closure, but we must also examine a project's interaction with other types of portfolios due to the linkages and interdependencies of the project, asset, resource, idea and other portfolios that occur across the organisation. By taking this broader perspective of portfolios and their management we can extend our world-view with higher-level vision. The shift in emphasis to an 'enterprise portfolio management' approach can improve the linkages and transfer of knowledge between portfolios.

Unless all portfolios are managed in an integrated manner, cross-portfolio impacts can occur, resulting in mis-alignment between overarching organisational priorities and individual portfolio priorities (Figure 4). An integrated approach is required to ensure a consistent and common set of priorities across all organisational resources, assets and projects. Such an approach is suggested to recognise the cross-organisational impacts of unplanned projects and activities and to facilitate the ability to adapt to evolving or changing priorities that may shift in relation to environmental, political or other influences.

Figure 4. Conflicting Portfolio Priorities

Enterprise Portfolio Management

The proposed holistic portfolio approach (Figure 5), links multiple organisational portfolios and focuses on ensuring that each portfolio maintains alignment with overarching organisational priorities. The approach operates at a pan-organisational level and within the context of the external environment, reflecting the dynamic nature of decision-making in response to environmental shifts.

The proposed approach illustrates how organisational priorities flow through to a range of organisational portfolios, such as the idea portfolio, NPD portfolio, project portfolio, resource portfolio and asset portfolio. These organisational priorities and the portfolios are not singular, linear or static, but are linked and dynamic in nature.

Figure 5. Enterprise Portfolio Management

Interactions between portfolios are central to organisational processes. For example, in the idea portfolio raw ideas are conceived and pass through an idea screen (Cooper, 2005). Viable ideas are prioritised and flagged for development at which point they flow from the idea portfolio to the relevant portfolio such as the NPD portfolio (after Larsson (2007) and Cooper (2005)) or the IT project portfolio. Through the new product development or IT project processes, additional ideas may be conceived and may pass back into the Idea Portfolio for screening. The idea portfolio, the NPD portfolio and the IT project portfolio all consume organisational resources (from the resource portfolio). These portfolios also interact with the asset portfolio (after Krebs (2009) and Larsson (2007)). Projects (in the project portfolio) develop and create assets (in the asset portfolio), which over time are maintained and enhanced, not only to ensure these assets continue to operate and perform as designed, but to also generate ongoing benefit to the organisation. The projects that develop, create, maintain and enhance individual assets consume resources (from the resource portfolio) and as such interact with the resource portfolio. The management of these linkages and interactions creates a high-level challenge. The traditional wisdom has suggested that projects be prioritised, however, project priorities may not align with resource priorities. If the resource portfolio lens is used to examine the situation, a different set of priorities and organisational strategies may become apparent. If the relative priorities amongst the various portfolios are not consistent with each other, or with the overarching organisational priorities, contention may occur.

Currently the project portfolio management discourse is relatively insular and focuses on a small subset of the larger organisation in which it operates. This limits the degree of top management vision and support. Unless a corporate level approach is taken to ensure all portfolio priorities are consistent, the organisation may not achieve its desired or stated objectives. By taking a pan-organisational 'enterprise portfolio management' approach, portfolio management concepts can be extended into the mainstream management domain and tailored to each environment to aid in the implementation of business unit-level strategy.

Conclusion

The introduction of the portfolio concept in the finance, new product development and information technology sectors brought with it a shift in thinking, a perspective which has been further extended in this paper to the asset, resource and ideas portfolios. From the early development of portfolio concepts in the new product development discipline, portfolio management has evolved to include a range of tools and techniques particularly in relation to project selection, prioritisation and balancing. Existing project portfolio tools and techniques help organisations to identify, select and manage an optimum set of projects in order to achieve the organisation's strategic outcomes, yet, such concepts are not regularly applied to the management of an asset portfolio or resource portfolio.

We assert that portfolios of investments, projects, resources or assets should not be managed in an isolated manner. It is only when organisational priorities are linked across all portfolios that contention can be removed and optimal outcomes can be achieved. The inter-relatedness between each portfolio is critical and must be taken into account during portfolio re-balancing across and within each portfolio.

This conceptual paper aims to stimulate discussion on the application of PPM concepts to a wider range of organisational areas and on the management of cross-portfolio linkages. Our aim is to identify and promote developments that facilitate integration across multiple portfolios and to evolve the model over time to provide a practical framework that may assist managers to improve organisational performance and bridge the gaps between 'projects' and 'operations'.

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Methods and Tools of

Success Driven Project Management

Advanced project management methodology called Success Driven Project Management integrates scope, time, cost and risk management suggesting reliable tools for project planning and performance management. After brief step by step instructions on SDPM application we will discuss risk simulation approaches that may be used for setting reliable project targets, their strong and weak sides. SDPM suggests to use optimistic estimates for creating working plans and manage project time and cost buffers. In SDPM project buffer is the difference between target and scheduled values. During project execution buffer penetrations are estimated by analyzing success probability trends. Since success probability depends not only on project performance but also on changes in the project environment success probability trends are perfect integrated performance indicators. Negative trends require considering corrective actions. SDPM has some common features with Critical Chain project management but there also many differences that will be discussed.

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This is an updated and edited version of a paper that was first time published in the proceedings of IPMA 2011 World Congress.

Introduction

Success Driven Project Management (SDPM) is project management and performance analysis methodology developed in Russia in 90-s and since then successfully used in many projects, programs, and organizations in Russia, East Europe and Brazil. SDPM is supported by Russian PM software Spider Project but its basic approaches can be used with other PM software tools.

SDPM methodology has some common features with Critical Chain approaches to project management but there are also many differences discussed in this paper.

SDPM Methodology Steps

Step 1 – Define integrated project success criterion

With multiple success criteria decision making is complicated – increasing one of them we may decrease another. There is a need for some weighting factor that may be used for decision making. It is necessary to be able to measure overall benefits of projects and portfolios, to be able to compare options and to select the best management decisions. We suggest to set one integrated criterion of the project/portfolio success or failure.

One of the potential approaches is to use money for measurement of everything. For example, defining the cost of one day for project acceleration and delay we will be able to estimate if it is profitable to pay more for faster performance and if project performance was successful if its finish was late but certain amount of money was saved.

Step 2 - Create optimistic project schedule model

Optimistic model is based on optimistic estimates of all project parameters and includes only most probable (with 90% probability or larger) risk events.

This model will be used for setting performance targets for project workforce. It is clear that optimistic targets will not be achieved but in any case performance targets shall not include contingency reserves or they will be lost (Parkinson Law).

Step 3 - Simulate risks and set reliable targets for project management team

Project management team shall have time and cost buffers for managing project risks and uncertainties. Project or phase buffer is a difference between target value and the value for the same parameter in the optimistic schedule.

Targets shall be set using risk simulation. These targets shall have reasonable probabilities to be met (usually in 70-80% probability range).

Project and phase targets and buffers may be created not only for integrated project success criterion but also for other parameters like project cost and duration, they can be set for the project as a whole and for certain project phases. Probabilities to meet project/phase targets are called success probabilities.

Step 4 - Set project sponsor targets

Management reserves for unknown unknowns are usually created basing on past performance data. When these data are missing or not reliable project sponsor targets are set using the same risk simulation model but with higher probability to be achieved (usually in 90-95% probability range).

So project has a set of targets – tight targets for project team, reasonable targets for project management team that include sufficient contingency reserves, and more comfortable targets for project sponsor that include additional management reserves.

Step 5 - Estimate buffer penetrations

It is natural that project will be late to optimistic schedule and project/phase buffers will be penetrated in the process of project execution. It is necessary to be able to estimate if these buffers are still sufficient and if project performance was better or worse than expected. The natural way for estimating buffer penetrations is calculation of current probabilities to meet the targets. If these new probabilities are higher than initial, project performance was better than expected though success probabilities depend not only on internal factors. If project performance was perfect but new risks were identified, success probability may become lower because initial contingency reserves did not cover these new risks.

Step 6 - Analyze success probability trends

Current success probabilities show project status but project status information is not sufficient for decision making. Decision making shall be based on the analysis of project trends.

If the probability to meet project target is rising then project buffer was consumed slower than expected, in other case project buffer was consumed too fast and project success is endangered. Management decisions shall be based on the trend analysis. Even if current status is good (success probability is high) but the trend is negative corrective actions shall be considered.

Success probability trends are the best integrated performance indicators – they take into account project risks, they depend not only on performance results but also on the project environment changes.

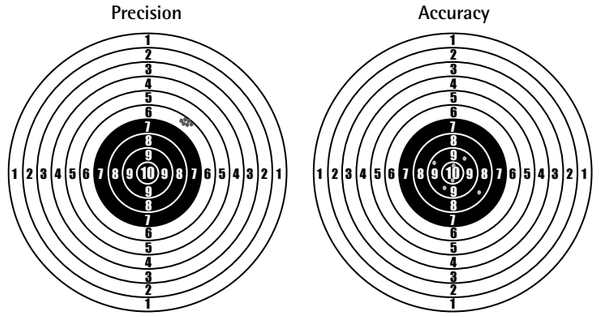


Figure 1. Accuracy and Precision

Setting project targets with risk simulation

Traditional approach to risk simulation utilizes Monte Carlo simulation. Proper Monte Carlo simulation requires a lot of time. Usually necessary time is not available and people are satisfied if the results are "good enough".

We prefer 3 scenarios approaches for the reasons explained further.

Let's look at the difference between accuracy and precision. Accuracy means that the measured values are close to the true value. Precision means the values of repeated measurements are clustered and have little scatter.

Monte Carlo means Accuracy but lack of Precision. Precision may be achieved by very large number of iterations but for large projects with limited resources the time needed is too large.

Three scenarios means Precision but lack of Accuracy. A bias in estimating success probability is systematic.

The choice depends on management approach. Our approach may be called "Management by Trends". Applying Trend Analysis we rely on data precision.

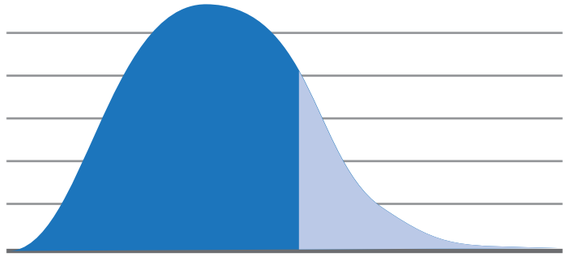
We think that trends supply management with most valuable information on project performance. Trend analysis helps to discover performance problems ASAP and to apply corrective actions if necessary.

It is the main reason why 3 scenarios approach may be selected. It is fast, simple and has sufficient precision though probability estimates are not accurate.

The quality of initial data for project risk simulation is never good enough but Monte Carlo risk simulation creates an impression of accuracy that is actually dangerous for project managers. In any case we need Optimistic schedule and budget for project performance management. We need to understand what happens with success probability during project performance and so we need data precision.

Three scenarios approach to Risk Simulation includes following steps:

- A project planner obtains three estimates (optimistic, most probable and pessimistic) for all initial project data (activity durations and volumes of work, resource productivity,



The area under the probability curve to the left of the target value determines the probability to meet the target.

P=S(blue)/S(whole)

Target dates of most projects usually are predefined. They may be set not only for the whole project but also for its major phases.

Figure 2. Setting Reliable Target

calendars, costs, etc.) and creates optimistic, most probable and pessimistic scenarios of project performance.

- Risk events are selected and ranked using the usual approach to risk qualitative analysis. Usually we recommend to include risk events with the probability exceeding 90% in the optimistic scenario, exceeding 50% in the most probable scenario, and all selected risks in the pessimistic scenario. Most probable and pessimistic project scenarios may contain additional activities and costs due to corresponding risk events and may employ additional resources and different calendars.
- As the result project planner obtains three expected finish dates, costs and material consumptions for all project phases and the project as a whole. They are used to rebuild probability curves for the dates, costs and material requirements.
- If probability curve is known then required probability to meet project target defines the target that shall be set.

In Spider Project software that supports 3 scenarios approach probability curves are predefined and depend on the total number of project activities and the number of activities belonging to the critical path. The same software also suggests Monte Carlo simulation option that may be used for determining probability curves using the same data. But larger accuracy does not add much to SDPM method though requires much more calculation time for achieving required data precision.

Project planning includes determining how to organize project/program execution to be able to meet required target dates with the reasonable probability. Probabilities to meet approved project targets we call Success Probabilities. These targets may be set not only for project success criterion but for all project parameters that will be controlled (profit, expenses, duration, material consumption).

Lev	Name	Duration, Days	Start [Buffer]	Finish [Buffer]	Total Cost [Remaining]	Total Cost [Buffer]
1	**Software Selection**	20.73	0.24	9.27	28 169.54	13 300.76
2	**Project Management**	20.73	0.24	9.27	4 506.23	2 026.46
2	**Requirements and Market**	9.00	0.24	5.00	11 208.00	6 936.32
3	**Requirements Development**	7.50	0.24	5.00	8 744.00	5 480.84
	Technical Requirements	1.50	0.24	0.74	924.00	518.43
	Functional Requirements	4.00	0.49	1.48	2 816.00	1 184.99
	Selection Criteria	1.00	3.50	3.50	1 760.00	
	Expertise	1.00	3.50	3.50	1 000.00	298.50
	Requirements Revision		3.50	4.50		2 221.86
	Request For Proposal	1.50	4.50	5.00	2 244.00	1 259.05
3	**Market Research**	4.00	1.50	5.00	2 464.00	1 455.48
	Software Market Analysis	3.00	1.50	3.50	1 848.00	1 331.83
	Vendor List	1.00	3.50	3.50	616.00	123.65
	Send RFP		5.00	5.00		
2	**Analysis and Choice**	11.23	7.00	9.27	12 455.31	4 337.98
3	**Proposal Analysis**	4.96	7.00	8.04	4 306.03	1 358.45
	Receiving Proposals		7.00	7.00		
	Specification Analysis	1.14	10.44	10.55	800.02	109.66
	Supply Conditions (cost, time) Analysis	0.25	10.55	10.61	176.00	68.17
	Demo (Evaluation) Versions Analysis	4.46	7.00	7.54	2 750.01	599.62
	Creating Short List	0.50	7.54	8.04	660.00	580.99
3	**Information Check-up**	2.50	8.04	8.54	3 515.56	1 106.41
	Check References	2.50	8.04	8.54	2 660.00	995.57
	Check Support	1.39	9.54	9.65	855.56	110.84
3	**Negotiations and Choice**	3.77	8.54	9.27	4 553.73	1 873.13
	Demonstrations	1.85	8.54	8.68	2 037.06	364.24
	Negotiations	1.67	8.68	9.02	1 966.67	583.11
	Choice	0.25	9.02	9.27	550.00	925.78

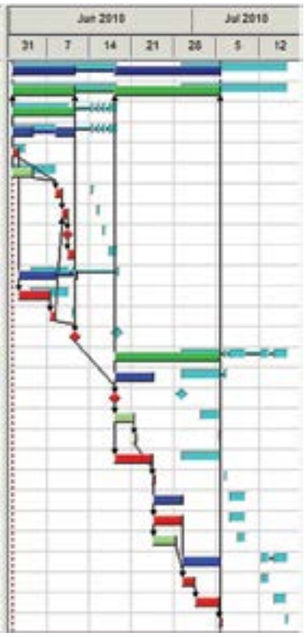


Figure 3. Critical Schedule

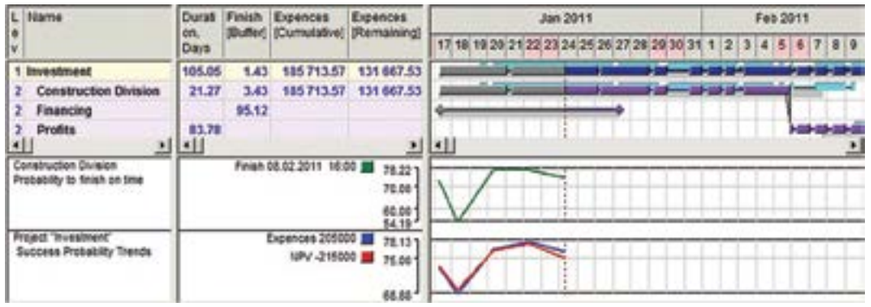


Figure 4. Success Probability Trends

Project buffers and Critical schedule

Target dates do not belong to any schedule. Usually they are between most probable and pessimistic dates. A set of target dates and costs for project phases (analogue of milestone schedule) is the real project baseline. But baseline schedule does not exist! It means that application of usual project performance measurement approaches (like Earned Value Analysis) is complicated. Without certain schedule and cost baselines it is impossible to calculate Planned and Earned Value. If we select some schedule (Optimistic or Most Probable) as the project management baseline the values of Performance Indices that are lower than 1 do not mean that project performance is worse than expected.

We recommend to use optimistic schedule for setting tasks for project work force and manage project contingency reserves. The schedule that is calculated backward from the target dates with most probable estimates of activity durations we call Critical schedule.

The difference between start and finish dates in current and critical schedules we call start and finish time buffers (contingency reserves). The difference between project (phase) cost that has defined probability to be met and optimistic cost of the same project (phase) we call cost buffer.

Time, cost and material buffers show contingency reserves not only for a project as a whole but also for any activity in the optimistic project schedule.

Project Performance Management

Project/Program/Portfolio planners shall keep performance archives to be able to get trends of project/program/portfolio parameters.

We recommend to manage projects and portfolios basing on the analysis of performance trends:

- If some project is 5 days ahead of the baseline but one week ago it was 8 days and one month ago 20 days ahead of the baseline then some corrective action shall be considered.
- If the project is behind the schedule but the distance become smaller then project team improved project performance process and corrective actions are not necessary.

So trend analysis shows short term performance results and helps to make timely management decisions. Project management team usually analyses trends of main project parameters like duration, cost, and profit.

Earned Value Analysis is another method that is used for estimating program/project performance. But this method shall be used very carefully and only in combination with other methods because:

- the real situation may be distorted,
- project managers are motivated to do expensive jobs ASAP and low cost jobs ALAP,
- it does not consider if activities that were performed were critical or not,
- it does not consider project risks.

We consider success probability trends as the really integrated project performance indicators.

Success probabilities may change due to:

- Performance results
- Scope changes
- Cost changes
- Risk changes
- Resource changes

Thus success probability trends reflect not only project performance results but also what happens around the project.

Success probability is a measure of buffer penetration. If in the middle of the project half of the project buffer was consumed it does not mean that the project is performed as expected. If most risks were behind then success probability will become higher and it will tell us that project buffer consumption was lower than expected, if success probability went down then buffer consumption is too high and it is necessary to consider corrective actions.

Success probability trends may be used as the only information about project performance at the top management level because this information is sufficient for performance estimation and decision making.

We call Management by Trends methodology *Success Driven Project Management*.

Success probabilities depend on project performance, scope changes, risk changes.

Success Driven Project Management and Critical Chain Project Management

Both SDPM and CCPM suggest to set tight schedule for project work force and create and manage project time buffer. Both methods suggest to prioritize projects managing project portfolios. But there are also many differences described below.

Working Schedule

CCPM suggests to use 50% probability estimates for Critical Chain schedule development. But using 50% probable estimates means that activity duration estimates still include some reserves and these reserves will be lost due to Parkinson Law.

SDPM suggests to use optimistic estimates in the schedule that is used for project workforce management.

Project Buffers

CCPM suggests to estimate excessive contingency reserves that people added to most probable activity duration estimates, take them away, summarize and put in a dummy activity that is called Project Buffer and follows the last activity of the Critical Chain.

SDPM uses risk simulation for setting reliable targets and project time buffer is the difference between project optimistic and target finish dates. Project time buffer does not belong to any chain.

Besides, SDPM suggests to set targets for project costs, materials, and integrated success criterion. Cost Buffers, Material Buffers and Project Success Criterion Buffer are managed together with Time Buffers.

Critical Chain Protection

CCPM suggests to create feeding buffers on activity paths that precede Critical Chain activities to protect Critical Chain. CCPM proposes that Critical Chain shall never change.

SDPM does not protect any chain – project schedule is regularly recalculated and risks analyzed. Change of Resource Critical Path during project execution is usual. Besides Resource Critical Paths in optimistic, most probable and pessimistic schedules may be different.

Portfolio Planning

CCPM suggests to "pipeline" projects in the portfolio (to perform them one after another) to avoid multitasking.

SDPM suggests almost the same – always apply priorities to the portfolio projects when calculating portfolio schedule. But if resources are available they may be used in the projects with lower priorities. Besides there are special cases when multitasking is useful.

Buffer Penetration Estimation

CCPM does not suggest reliable quantitative methods for analyzing buffer penetrations. Suggested methods are qualitative. Dividing buffer into three zones (green, yellow, red) is one of them. Entering yellow zone means an alert, red zone penetration requires considering corrective actions.

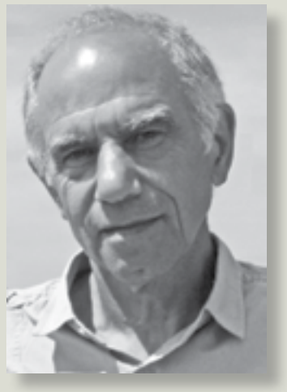
SDPM estimates buffer penetrations by success probability trends. If the trend is negative then project buffer is consumed faster than expected. If in the middle of the project execution project buffer is half consumed it may mean excellent performance if most risks are behind and poor performance if most risks are ahead.

Conclusions

Success Driven Project Management is powerful methodology that provides project managers with reliable tools for integrated scope, time, cost and risk management. It includes risk planning and simulation for setting reliable project targets and selecting optimistic estimates for creating working schedules and budgets. The differences between target and scheduled finish dates, between target and optimistic project cost are called time and cost buffers.

SDPM estimates buffer penetration by calculating probabilities to meet set targets (success probabilities) and analyzing their trends. Negative trends show that buffer penetrations are larger than expected and corrective actions shall be considered.

Success probabilities depend on project performance, scope changes, risk changes. Success probability trends are perfect project performance indicators that supply management with reliable integrative estimates of project performance.



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Spider Project Team is Global Registered Education Provider PMI®, and the developer of Spider Project – professional PM software that is used in 29 countries.

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Project Management Methodologies:

An Invitation for Research

Having existed for millennia, project management has attracted increasing research interest in the last three decades. In this time the details leading to project success have been researched extensively. Surprisingly little attention has been paid to the popular practice of establishing and employing structured collections of project management processes and best practices, usually in an attempt to enhance project effectiveness and increase the chances of project success, typically known as project management methodologies. This paper provides a review of extant research, identifies central emphases, and proposes a definition of the concept. Research aiming to improve the understanding of project management methodologies is crucial for practitioners as well as researchers operating in the field of project management: In addition to increasing the chances of project success and enhancing project effectiveness, an improved understanding of project management methodologies is likely to provide clues towards a formal theory of project management.

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Introduction

Project management has become increasingly recognized since the 1950s through global endeavours connected to the Apollo space program, the Concorde aircraft, the English Channel tunnel and the Sydney Opera House (Morris & Hough, 1987; Morris 1994; Packendorff, 1995, Bredillet, 2007). Many practical works, such as the PMBOK Guide (PMI, 2008) and the PRINCE2 (OGC, 2005), and research papers have been published to identify the factors leading to project success, and the issues to avoid in order to elude project failure. Concurrently many organizations have been collecting project management processes and best practices and compiling them into structured collections known as project management methodologies. It appears these collections have, up to date, received very limited research: Papers mentioning project management methodologies usually leave the concept undefined, and logics, structures, dimensions, contents, as well as results without attention. This may be due to the concept being considered too trivial, or the unintentional boundary which appears to exist between the practical and the theoretical fields of project management. This is startling considering the practical reasons, and the rich empirical data project management methodologies offer for project management research.

This paper aims to increase interest in project management methodologies by reviewing extant research, identifying central emphases, and proposing a definition of the concept.

This paper describes an analysis of published research covering or relating to project management methodologies through questions *How much published project management methodology research exists? What emphases, if any, does this research have? Is it possible to propose a definition of the concept based on these materials? This paper is a part of a greater research endeavour into project management methodologies, theory of project management, and the connection between the two.*

This paper comprises three main sections: The first one provides a review of extant research covering or relating to project management methodologies, the second one identifies the central emphases, and the third one proposes a definition of the concept.

Method

The research method applied can be best described as a form of discourse analysis, focusing on extant papers covering or relating to project management methodologies, published in the English language in top-rated peer-reviewed research journals such as *International Journal of Project Management, Project Management Journal,* and *International Journal of Managing Projects in Business*. Discourse analysis, a method for examining language, is employed as it is well suited for scrutinizing texts on management study, and widely applied when studying management issues including professional and organizational identities, strategic sensemaking and institutional logics (The editors, 2010).

Results

Review of extant research relating to project management methodologies

Packendorff (1995) notes project management methodologies, such as PRINCE, have been set up by the public sector, such as government agencies, to control project budget, schedule and quality disasters. Laufer et al. (1996) identify principles project managers use in turbulent projects: Adjusting the project management methodology according to extant circumstances is mentioned as a key component towards project success. Conroy and Soltan (1997) find contemporary project management tools unable to provide sufficient decision-making and conflict-handling support, and devise a project management methodology for assisting project managers with multi-disciplinary challenges. Clarke (1999) finds structured project management methodologies a potential way to achieve significantly improved benefits from projects. White and Fortune (2002) analyse project practitioners' experiences, and report PRINCE(2) the most common methodology.

Crawford et al. (2003) describe government encouragement for employing formal project management methodologies, developed in a 'hard' project context, in an effort to increase project effectiveness, and develop a 'soft' system project management approach for integrating soft systems methods into project management methodologies. Investigating determinants for project manager communication, Müller (2003) refers to project management methodologies as credible collections of project management best practices. Pennypacker and Grant (2003) note organizations often implement project management processes as well as integrated support processes to prepare project staff for implementing projects effectively: "In general, companies should be working to establish all project management processes as organizational standards. This ... requires the development of formal, documented standards that are applied throughout the company ..." (p 9).

Investigating the role project management standards and methodologies play in achieving effective workplace performance, Crawford (2005) discovers no significant relationship between generally available methodologies, in their entirety, and senior management perception of workplace performance and effectiveness. Milosevic and Patanakul (2005) assert project management standardization should be started with *tools, leadership skills,* and *processes* as these best support project success: While project management standardization is identified as having a positive correlation with project success, Milosevic and Patanakul draw attention to the point of inflection beyond which standardization is unlikely to provide further benefits. Milosevic and Patanakul propose contingency approach for standardizing project management, finding a single standard unlikely to fit all projects.

Cicmil et al. (2006) propose a new research approach for improved understanding of project practitioner experience, finding project management methodology "... universally applicable as a neat and orderly solution to implementing complex organisational initiatives" (p 681). Cicmil et al. recognize complexity, uncertainty, and schedule constraints as the main reasons for project overruns, and note the *agile* and lean aspects often integrated into IT project management methodologies. Cicmil and Hodgson (2006) note project management methodologies, such as PRINCE, enable public sector control budget, time schedule and quality, and the Packendorff (1995) finding practitioners only tend to employ the most basic project management methodologies, and frequently in ways and under circumstances for which they were never intended. Cicmil and Hodgson conclude "It becomes obvious that, frequently, the very principles of effective, structured project management methodology are simultaneously its major causes of failure" (p 116).

Crawford (2006) investigates organizational project management capability, and finds *project management methodology* a recurring subject. Crawford describes a case organization realizing methodology variances between different sites: The drive for all sites to employ the same methodology faces resistance and feelings some processes are unreasonable for certain projects and project managers: "A sense of tension between desire for corporate control and standardization and corporate pressure for performance, allied with project management reluctance to follow process, emerges from the text" (p 81).

Jaafari (2007) focuses on the health of large projects and programs on their way to their targets, noting *sick* endeavours with no systemic approach proceed in a disorganized way, whereas *healthy* endeavours with systemic structures, such as project management

methodologies and standards, proceed in an organized manner. Hobbs and Aubry (2007) report statements such as "A PMO is an entity that develops and implements a standardized project management methodology" (p 80) common, as 76% of the focal 500 PMOs are involved in the development and implementation of project management methodologies. Hobbs and Aubry further report such a methodology, including the tools, techniques and methods, "... constitutes a coherent set of functions that reinforce one another" (p 82).

Crawford and Pollack (2007) study the generic nature of project management knowledge and practice, and note project management standards are employed in the creation of project management methodologies assuming a positive relationship exists between such standards and effective workplace performance. Crawford and Pollack remind project management guides are written on a general level, and assuming projects are alike, provide guidance to most of the projects most of the time. Crawford and Pollack conclude "... future standards development should address the needs of different industries and application areas, and any development of global standards for project management needs to recognize the potential variation in how project management is practiced and thought about in different countries" (p 95). Believing earned value management is an effective project management methodology, Marshall (2007) investigates its role towards project success. This belief is not widely agreed to, as individual tools and techniques are usually considered methods as opposed to methodologies (Hobbs and Aubry, 2007).

Hobbs et al. (2008) note the dilemma between the drive to standardize processes and the need for project management flexibility. Studying centralised project management office contribution to virtual project team success, Curlee (2008) identifies organizational processes as critical project management methodology components. Pons (2008) finds stage-gate type project management methodologies suitable for managing uncertainty in product development projects, and notes the argument some researchers make against project management methods in new product development, as well as the requests for more trial-and-error development, empathy, and co-operation.

Hällgren and Maaninen-Olsson (2009) advise against blind use of the PMBOK Guide (PMI, 2008) for reaching project targets: "The access to different tools and methods creates an illusion of the project as being planned and executed in a controllable manner. However, although the planning and the use of formal tools and methods are used, there will always be deviations that need to be managed" [sic] (p 55). Nogeste (2008) mentions Australian Department of Justice requirement for projects to be managed with PRINCE2, the standard approach in public UK projects. Hurt and Thomas (2009) describe combining PMBOK Guide (PMI, 2008) process approach and industry best practices, and achieving a methodology benefitting junior and senior project managers as well as contractors. Hurt and Thomas assert there is a point of inflection, beyond which the methodology benefits will not justify further development. Cicmil et al. (2009) note local organizations expecting international funding need "... to demonstrate the use of a systematic, documented, and disciplined management approach according to donors' preferred project management standards and methodologies" (p 92). Crawford and Helm (2009) note organizations employing PRINCE2 (OGC, 2005) or PMBOK Guide (PMI, 2008) as methodology foundation report improved staff morals and satisfaction despite some reports the methodology is overly work-intensive, time-consuming and bureaucratic, especially for small projects. Crawford and Helm recognize project management methodologies "... streamlining processes and assisting time-constrained staff in doing their work, and in all cases there was recognition, however reluctant, of the accountability and transparency that the systems provided ..." (p 85).

Cooke-Davies et al. (2009) support the hypothesis the degree of fit between organization strategy and project management system enhances available benefits, and agree with Shenhar and Dvir (1996) claim project management should be adapted to organizational backgrounds and circumstances. Cooke-Davies et al. criticize 'blind' use of project management standards and methodologies, as lack of fit between methodology and organizational backgrounds and circumstances is reason enough for project failure: "The underlying hypothesis of this perspective is that project success is related to choice of the 'right' management approach related to specific project characteristics" (p 110). Mengel et al. (2009) acknowledge a PMBOK Guide (PMI, 2008) inspired project management methodology, including a comprehensive stage-gate model, process descriptions and templates, and emphasize the satisfaction stakeholders receive from projects implementing management consistently and according to organizational best practices. At the same time less demanding projects may find a comprehensive methodology and documentation requirements overkill. Lechler and Cohen (2009) report widely varying levels of formality between project management methodologies in focal organizations, as well as fluctuating percentages of projects which actually follow the methodologies.

McHugh and Hogan (2010) report client demand for a recognized methodology, ensuring best practices, enhanced recruitment, and contracting possibilities the main drivers for an internationally-recognized methodology, and mention the PMBOK Guide (PMI, 2008) and PRINCE2 (OGC, 2005) as the internationally-recognized methodologies most organizations appear to be building on. Turner et al. (2010) report small and medium-sized project-based firms need to have "... a 'lite' version of project management" (p 755). Aubry et al. (2010) identify three project management methodology related PMO characteristics: "Homegrown or brought in from outside", "Use is compulsory or discretionary" and "Degree to which methods are actually followed" (p 770). Aubry et al. refer to Thomas and Mullaly (2008) finding "... a 'fit' should exist with the organizational context" (p 776) and organizational project management. Artto et al. (2011) investigate project management office role in innovation front end, and refer to the Hill (2008) list of PMO tasks, the first one being ".... practice management, including the subtasks of project management methodology, project tools, standards and metrics, and project knowledge management ..." (p 413).

Emphases in extant research relating to project management methodologies

Several emphases emerge from extant research of project management methodologies:

- Ability to enhance project effectiveness and increase chances of project success: Project management methodology ability to enhance project effectiveness and increase chances of project success comes up, in one way or another, in all focal papers: A very positive overall perception surrounds the concept. The comments by Crawford (2005) and Crawford and Pollack (2007), which might first appear to criticize the concept, relate, upon a closer inspection, to existing assumptions and lack of published research.
- Standardization vs. flexibility: Project management standardization, optimum level of standardization, and standardization versus flexibility are described by most writers, including Clarke (1999), Crawford et al. (2003), Pennypacker and Grant (2003), Crawford (2005), Milosevic and Patanakul (2005), Cicmil and Hodgson (2006), Crawford (2006), Crawford and Pollack (2007), Hobbs and Aubry (2007), Curlee (2008), Pons (2008), Crawford and Helm (2009), Hobbs et al. (2008), Hurt and Thomas (2009), Lechler and Cohen (2009), Aubry et al. (2010), McHugh and Hogan (2010), Smith and Winter (2010), Turner et al. (2010) and Artto et al. (2011).
- Internal vs. external methodology: Employing an internally or an externally developed project management methodology is described by Cicmil et al. (2009), Crawford and Helm (2009), Hurt and Thomas (2009), Aubry et al. (2010) and McHugh and Hogan (2010).
- Voluntary vs. involuntary use: Voluntary and involuntary methodology use is described by Conroy and Soltan, (1997), Clarke (1999), Cicmil and Hodgson (2006), Pons (2008), Hurt and Thomas (2009) and Mengel et al. (2009).
- Organizational fit and contingencies: The need for the methodology to fit relevant backgrounds and circumstances, and for the project staff to optimize the fit by applying it as necessary is described by Laufer et al. (1996), Milosevic and Patanakul (2005), Crawford and Pollack (2007), Hobbs et al. (2008), Thomas and Mullaly (2008), Cicmil et al. (2009), Cooke-Davies et al. (2009), Aubry et al. (2010) and Artto et al. (2011).
- Point of inflection: A point beyond which methodology benefits fail to justify further development is noted by Milosevic and Patanakul (2005) and Hurt and Thomas (2009).
- Light methodology: A scaled-down, less-demanding methodology is appropriate for organizations with small and less complex projects according to Turner et al. (2010).
- Coherence of functions: The methodology comprising "a coherent set of functions that reinforce one another" is mentioned by Hobbs and Aubry (2007) (p 82).

Definition of the concept of project management methodology

Employing one or more means, project management methodologies target enhancing project effectiveness and increasing the chances of project success through systematic applying of standardized processes and best practices. PMBOK Guide (PMI, 2008), the most referred-to publication in the extant project management methodology research, interestingly states "This standard is a guide rather than a methodology" (p 4). Drawing on extant research and the PMBOK Guide, I am tempted to propose a definition of the concept:

Project Management Methodology:
A system of recognized project management processes and practices, targeting to enhance project effectiveness and increase chances of project success, applied in a coherent and coordinated way to obtain benefits not available from employing them individually. Project management methodologies may include logics, structures, tools, techniques and methods outside the discrete processes in the methodology.

Discussion

This study identifies several papers covering or relating to project management methodologies. Surprisingly, none of the focal papers scrutinize the concept, nor define it appropriately when making a reference thereto. It is clear, considering the number of papers mentioning project management methodology *ability to enhance project effectiveness and increase chances of project success*, that adequate project management methodology related research has not been published. It is astonishing to find a concept, which is so popular among project management practitioners, and so widely considered to have the ability to cure many of the most persistent project management problems, to be so scarcely researched. Understanding the author of this paper was unable to identify all relevant papers due to the wide variety of names employed, this situation results most likely from the divide between the practical and the theoretical fields of project management.

A number of secondary emphases emerge from this study. *Standardization vs. flexibility, internal vs. external methodology*, and *voluntary vs. involuntary use* relate to strategies

for increasing methodology effectiveness. *Point of inflection* and *light methodology* relate to optimizing methodology structures and contents on tactical level. The difference between methods and methodologies is defined by *coherence of functions*: Organizations may employ tools, techniques and methods to enhance project work, however, these must be systematic and coherent, be employed in a coordinated way, and reinforce one another in order for the resulting system to be considered a methodology.

Organizational fit and contingencies relates to the concept of contingency theory, according to which organizational structures and ways of working must fit organizational backgrounds and circumstances in order for the organization to operate effectively and succeed. This is exactly what project management methodologies are all about: Even a collection of recognized project management processes and best practices must be applied, as opposed to blindly followed, according to relevant backgrounds and circumstances. It is no surprise contingency theory is recognised as a potent platform for a theory of project management (Bredillet, 2007; Artto and Kujala, 2008; Söderlund, 2010). It is very likely project management methodologies can offer clues for establishing such a theory.

The results of this study indicate insufficient research has been published regarding project management methodologies: Further research is necessary to enhance understanding and increase the employing of this important concept. For practitioners this means increasing project efficiency and chances of project success. For researchers and academics this offers clues for establishing a generally acceptable formal theory of project management.

The main issues which should be considered in future research include:

- Project management methodology logics, structures, dimensions and contents
- The connection between backgrounds and circumstances, methodologies and projects
- The connection between project management methodologies and theory
- The expected and actual benefits of project management methodology usage

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Next generation of

Meeting Tools for Virtual Project Teams

Advanced educational virtual project teams (f.i. www.apicollege.edu.au) work combining two-dimensional (2D) tools like Adobe Connect, Google Group, Yahoo Group, and Skype. But to technologically support virtual teams working on projects like risk assessment, product design and improvement, benchmarking, best practices, or strategy planning, three dimensional (3D!) meeting tools are needed which benefit from technological specifics that only space (3D) provides. This paper analyses the latest 3D-meeting tools (SecondLife, Google Lively, HiPiHi, etc.) and considers benefits and drawbacks. 3D-meeting tools offered by Alpine Executive Centre reveal strengths for: Setting priorities, resource allocation, socializing and other outcomes relevant for virtual project teams having to manage interactive tasks like risk assessment, product improvement, strategy planning etc. Conclusion: Meetings in 3D-virtual worlds have potential to be almost as effective as real world meetings. Drawbacks to virtual meetings can be overcome with the right process, expert facilitation, and special 3D-meeting tools. In handsomely designed virtual 3D-environments networking and socializing can work just as it can in the real world.

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Introduction

Virtual 3D-worlds attract increasingly attention in non-gaming applications. SecondLife, Google Lively, HiPiHi, Alpine Executive Centre are but a few of the over many 3D-products and environments. At the same time, it looks like while many people try out some of these applications, few people return regularly. Why? Because most virtual settings – be it 2D or 3D – still lack a feeling of 'presence', 'place', 'importance' and lack 'viable meeting tools' - which has a negative impact on cohesion, performance and satisfaction. Question is how dispersed project members yet can be effectively supported while working in virtual worlds?

Method

This paper reviews a selection of current literature on doing real work in 2D- and 3D-virtual worlds. Aim is to build an understanding of successful applications of 3D-virtuality, critical success factors and how these environments might evolve – to brighten the future of dispersed project teams.

A selection of reviewed literature

Potential of virtual worlds

A yearly online research conducted by the Universities of Eindhoven/NL and Hong Kong provides insight into virtual teams working on developments (IT, software related fields). This online research produces reports that integrate an Asian, American and European perspective (Rutkowski A., Vogel D., Bemelmans T., & van Genuchten M., 2010). 3D-virtual worlds are going far beyond kinky games or sexy pin ups. The following current research questions illustrate the potential of 3D-virtual worlds: How can dispersed units be better supported via 3D-virtual worlds? How do virtual worlds help to interact with customers in an efficient fashion? Education via virtual worlds flourish- yet how can differing needs of students, instructors and institutions be met? Do challenged populations (paraplegics, certain mental disabilities etc.) find virtual worlds a way of real world compensation? Off-shoring via virtual worlds is a potent component in provision of products and services. How can governments make their country a more appealing off-shoring site? Conclusion: 3D-virtual environments can contribute essentially to values like true collaboration, sustainability and social responsibility.

Acceptance of virtual worlds

To participate in 3D-virtual worlds participants have to beam a 3D-representation of their body, face and talk into the 3D-world. Soon (in 2014?) beaming will be possible either by wearing a tip-to-toe jumpsuit with electrodes or by a personal scanner device which transfers a representation of their body and facial movements into the 3D-world. As a result of the upcoming beaming-technology you and your project team members as well as for example a meeting facilitator can watch your 'alter ego' as you move around in the 3D-environment and interact with other 'alter egos' - participants with also beamed themselves via y tip-to-toe jumpsuit or personal scanner into the 3D-world. At present a 3D-representation via an 'avatar, a do-it-yourself designed virtual human-like looking 3D-object, is available in SecondLife. People who are used to play with puppets or toy soldiers easily adapt to managing their alter ego which they need to exploit 3D environments. Yet in an online survey in 2007 six group support technologies - common online chat like MSN Instant Messaging, SecondLife, Video Conferencing, Forums (blackboard), E-mail - were compared. Participants of the online survey in 2007 still preferred 'common online chat' and felt resentments working via SecondLife platform. Yet "older participants were significantly more pleased" with communicating via SecondLife. This result is attributed to novelty concerning SecondLife and lack of experience with 3D-environments more advanced than SecondLife. Results "indicate that SecondLife in its incarnation in 2007 is likely to need some reincarnation prior to ascent to Nirvana" (Vogel D, Maxwell G., Zhou P., Tian S. & Zang J, 2008, p. 11). Similar to this result virtual project teams today – unfortunately - still stick to working solely with e-mail and common online chat (1D). But educational virtual teams (f.i. www.apicollege.edu.au) work mingling Adobe Connect, Google or Yahoo Group, Skype – all 2D.

User profile

The potential benefits which 3D-virtual worlds offer to many real-life domains such as business, project management and education, attract researchers and practitioners. Yet the values of virtual worlds cannot be realized without a sufficient number (!) of users. Results show that people are willing to install their personal 'avatar' (SecondLife) and enter virtual worlds "because of three types of motivations: Functional, experiential, and social. Comparative analysis by gender, age, education, and experience suggests that (1) female users are more inclined to do shopping, researching, and exploring within virtual worlds, whereas male users are more concerned with using f.i. SecondLife for making money; (2) younger users are more likely to use virtual worlds for entertainment, while older users use it for creating and education; (3) relative to their counterparts, experienced users are more aware of the values of virtual worlds for creating, education, and commerce" (Zhou, Z.; Jin, K.; Vogel, D. & Fang, Y., 2010). Once artificial 'avatars' are overcome and natural beaming-technology (a tip-to-toe jumpsuit with electrodes or personal scanner device which transfers a real (!) representation of body and facial movements into the 3D-world) is available, attraction of entering 3D worlds may increase dramatically especially for virtual project team members.

The effect of space (3D)

Having animated your 'avatar' (soon you will be able to beam your natural 'alter ego') the question now is: How does 3D, i.e. space, provided by virtual worlds affect participants? How are particularly '3D meeting tools' perceived by users? To what extent do users consider the 3D user interface easy to apply and understandable? Research was conducted "to 1st see whether a 3D interface increases the sociability of meeting tools and 2nd to know whether users think that 3D-meeting tools help to 'brainstorm', 'organize ideas' and 'make decisions'. All three meetings tools were tested with participants geographically distributed during virtual meetings. Results show positive effects of space/3D on 'user interface', 'structure of the meeting process' and 'collaboration'. Overall results indicate that providing space/3D is good for 'brainstorming', 'idea organizing' and 'voting'. Personal feedback obtained during the virtual meetings also indicate positive attitude towards '3D-meeting tools'. The participants were receptive of the tools and expressed their interest to use them again for a range of purposes" (Molina Orrego 2008). Question: What kind of 3D-design do the favored meeting tools have? Will they work for virtual project teams too?

Meeting tools in virtual worlds

Based on research results several improvements to the virtual world were implemented. For example additional features of '3D-meeting tools were added. *Three dimensional* (3D) meeting tools benefit from technological specifics that only space (3D) can provide. Following virtual offices, designed in 2010 for dispersed business units and project teams, reveal how 3D-virtual worlds can be exploited for truly collaborative work: Virtual worlds are at their best when they need no further explanation and provide instant understanding and familiarity. Subsequently, screen shots from virtual worlds illustrate how virtual offices providing meeting tools look like.

Figure 1. Due to 3D/space it is obvious what you are invited to do: 'Voting grid tool' lets participants (at present via their 'avatar', soon via their beamed 'alter ego') vote on multiple criteria by standing on the voting platform. Combined voting results are calculated and displayed instantly in real time.

Figure 2. Again due to 3D/space it's obvious what you are invited to do: Participants (at present via their 'avatar', but soon via their beamed 'alter ego') brainstorm with a 3D-meeting tool in a virtual world.

These screen shots show that since 2010 "attendees of virtual project or business meetings have the opportunity to augment the existing co-presence benefits of 3D including voice for presentations and interviews" (Adams, 2010). Adding voice to your 'alter ego' participating in virtual meetings jumps the curve. The latest 3D-meeting tools enhance the feeling of 'co-presence' and 'importance' which virtual worlds once suffered. Finally they provide features that eliminate the negative impacts on 'cohesion', 'performance' and 'satisfaction'.

Practice of project meetings in virtual worlds

Crucial question still is: Does business networking and socializing really work in virtual worlds? In the real world networking and socializing are an important aspect of meetings where participants get to know each other, share information and build trust. Real-world project meeting planners regularly allocate specific times for networking, and participants consider these times useful as well as enjoyable. Virtual meeting services offer similar activities: *Special Occasion & Unique Place*: Applying similar networking activities to the virtual world can work if the participants consider the virtual meeting to be somewhat of a significant occasion. Otherwise virtual networking and socializing is reduced to activities comparable to online group chat. Creating a 'meaningful context' for networking in the virtual world is the key to making project meetings interesting and useful. Taken together with the perception of a 'memorable event' and a 'unique place', networking takes on more relevance and importance. *Co-Presence*: The co-presence (i.e. I'm not alone because I can see other individuals represented by their 'avatar' or 'alter ego') felt by participants in the virtual world contributes to the effectiveness of networking and socializing. Research in progress (de Nobrega K., or Soepnel B., or Mulders R.,) report that for business meetings people today enjoy the 3D-virtual world (f.i. Alpine Executive Centre) more than other meeting platforms, including web-based shared workspaces and video conferencing. Participants entering this 3D-virtual executive centre benefit from the combination of thorough preparation, expert facilitation, appropriate tools and creative meeting processes.

Facilitating virtual project meetings

What are the roles and skills of an expert facilitator? Entering a virtual office equipped with the latest 3D-meetings tools does not by itself make for a successful project meeting. Although collaborating via a virtual environment saves 50% of labor hours and 90% of project time, this is only accomplished when skilled facilitation is provided. The same dynamics that influence 'cohesion', 'performance' and 'satisfaction' in a group can be even more prevalent in a virtual world meeting as it can be a highly interactive experience. It's the facilitator's job to help the group dynamics to become and remain positive throughout the meeting. Therefore superior facilitation skills are required to make appropriate use of 3D meeting tools. According to research (Veil C.C., Saunders S., Hunt A., Kavanagh D. & Van Onna M., 2004) the facilitator should be able to: Conduct meetings with several tools: 'brainstorming', 'idea organizing', 'decision making' a.o.; Reinforce the project manager's objectives concerning the outcome of the meeting; Inform participants precisely about what exactly is going on in the joint working process; Handle expectations and dynamics of large as well as small virtual groups; Identify key issues that arise in a series of project meetings with the same remote project members; Use techniques for exploring issues more in-depth such as pointing out contradictions in arguments or supporting critical reflection on practice; etc.

Experience of project meetings in virtual worlds

Comparative research on collaborating in 3D-virtual worlds is prevalent. Can a project meeting in a virtual world be better than a project meeting in the real world!? Yes, five reasons:

Convenience, Right People, Costs: "Virtual meeting participants can simply take a break from their current tasks and connect with their colleagues no matter where they are and what they are doing. This convenience not only saves a lot of money, it encourages the right people to come to the meeting. In a virtual meeting it is often easier to get all the essential people involved at the same time" (Adams, 2010).

Process, Structure: A common problem with any meeting is a lack of structure, discipline and process. We all hear about meeting agendas not being followed or nonexistent, and of long-winded presentations. Project members often complain of decisions not made, or follow-up that never happens. "Although these complaints are not exclusive to the real world, they are less of a problem in the virtual world because virtual meetings typically require degree of expert facilitation. This assures the likelihood that a feasible structure will be built into the virtual meeting" of the project (Adams, 2010).

Mental Presence: Virtual-world meeting participants may be absent physically, but are more likely to be present mentally, while real-world meeting participants can be present physically but absent mentally. "When someone joins a virtual-world meeting they have to stay engaged to know what's happening. So unlike the real world where a participant can remain silent with something else on their mind, it's difficult to do that in the virtual world, providing the right tools and processes are employed" (Adams, 2010).

Active Engagement: Expert facilitators try to keep participants fully engaged in the meeting process. "By taking advantage of the 3D characteristics of the virtual world the degree of engagement and the feeling of co-presence can be enhanced to levels at least equal to real-world experiences" (Adams, 2010). The paradox is that the more participants can be immersed in the virtual meeting the more actively engaged they will be.

Do the Impossible: In the virtual world you can do things you can't do in the real world. 'Avatars' or 'beamed alter egos' "can interact with each other and with objects, and objects can interact with 'avatars'/'alter egos' and other objects. Imagine in the real world having an idea that you can identify on a physical object, then pass that object with your idea around for others to see and hold. In the virtual world you can sort those ideas physically into a collection of categories arranged so participants can walk around, move, sort, edit and comment on them. You can't do that in the real world. Try to visualize a real world meeting where you express your opinion on issues and see the results of your opinion and those of your colleagues displayed spatially right in front of you, being dynamically updated as discussions continue" (Adams, 2010). This sort of dynamic two-way interaction is not possible in the real-world, neither with a whiteboard nor a flipchart.

Figure 3. How to support the feeling of 'presence' and 'importance': Keep everyone – 'avatar' or soon beamed their 'alter ego' - actively engaged by using spatial (3D) meeting tools.

Discussion

In a global context there is an urgent need to *technologically* support virtual teams working on projects like risk assessment, product design and improvement, benchmarking, best practices, or strategy planning. Technological challenge is to design a virtual world which embodies all that is necessary to actively engage remote participants in a truly collaborative experience by providing a place where real work is done efficiently and affordably. *Three dimensional* (3D) meeting tools benefit from technological specifics that only space (3D) can provide. This includes easiness to walk around in a 'unique meeting place' (3D) via personal representations ('avatar', from 2014 onwards a beamed 'alter ego'). Precondition is effective exploitation of space/3D which provides not only people's 'presence' and 'VIP-feeling' but also instant understanding 'what is going on' in the meeting via the screen. Since 2010 this challenge is met - and also services provided for virtual projects teams.

Yet what are the drawbacks in virtual project meetings? And what are the remedies for remote project teams? According to the objectives from our literature research mentioned above this challenge is at present best met by meeting services offered by *Alpine Executive Centre*. It facilitates highly demanding work sessions of dispersed project teams, however further technological improvements are under construction. Following five issues of concern have to be considered:

Inconvenience – Asynchronous Meetings: It's not always convenient for everyone to login at the same time for a virtual project meeting. In addition to personal work schedules, time-zone differences must be taken into account. Synchronous same-time meetings are the norm when meeting virtually in any medium. However, with the right meeting tools some meetings can be structured to run asynchronously, where participants login at different times, make their contributions, record their votes, etc. and leave. Planning and running asynchronous meetings takes careful preparation and guidance together with well-designed text-capturing tools and a linked database with report producing capabilities.

Figure 4. How to support a feeling of 'place' and 'co-presence': Small groups of' 'avatars' (soon beamed 'alter egos') can choose among differently designed virtual locations for meetings.

Figure 5. An example of a virtual World that can include places and venues for project meetings and their activities.

More Time – Travel Offsets: Accomplishing tasks in a virtual-world project meeting takes longer than a real-world meeting. This is because participants have to simultaneously manage many tasks that are not required in the real world. To keep up with proceedings in a virtual meeting, participants have to: Make their own contributions, read the contributions of others, listen to public and private conversations (voice), read public and private text messages, and manage their own voice and camera view. However, it's worth noting that time differentials are appreciably offset when you consider the amount of travel time that is eliminated from everyone's schedule".

Limited Topics – One Subject: It is more difficult to accomplish everything you might like in one virtual project meeting as compared to a real-world project meeting. In the real-world it's somewhat easier to manage several issues at once or change the topic. In a virtual meeting it's better to stick with just one subject for a meeting so remote participants know exactly what is expected of them without issuing additional instructions during the meeting.

Managing Process – Design Scenarios: Process flow in a virtual-world project meeting can be tricky to manage when compared to a real-world project meeting. Drilling down to a decision may involve for example: surfacing issues, identifying causes, proposing solutions, prioritizing solutions, and assigning actions. To deal with drill-down scenarios like this in a virtual project meeting requires careful planning and execution so activities occur in manageable chunks. This is where well-designed meeting tools and expert facilitation play a big part in the success of virtual meetings.

Lost Importance – Point of Reference: One unfortunate drawback of virtual business or project meetings is that these meetings frequently lose their degree of importance and their impact becomes insignificant. Virtual project meetings frequently take on a persona of a temporary or ad hoc event and eventually get lost in a hazy repository of routine business activities. So it is important to promote the virtual project meeting as an 'event remembered', along with the 'venue of choice', a unique place in one's mind.

Conclusion

Since 2010 meeting tools are offered to take advantage of the *three dimensional* potential of virtual worlds - including instant voice messaging via do-it-yourself-made 'avatars'. This is accomplished by supporting the visualization of parallel contributions and by enabling the visualization of the meeting process. By making the 3D-interface of meeting tools understandable and easy to use, it is now possible to increase sociability and the feeling of co-presence, while actively engaging the participants in the meeting process. The space (3D) provided in virtual worlds improve the feeling of meeting at a 'place', where 'everybody can see each other'. The interactive 3D-tools keep activities interesting and fun while helping to drive a manageable process with documented protocols that are instantly available to the dispersed project members. Working in this virtual group each action of a remote project member has a visible contributing effect on the results.

So meetings in virtual world have the potential to be almost as effective as real world meetings. Drawbacks to virtual meetings can be overcome with the right process, expert facilitation, and special 3D-meeting tools. Networking and socializing in handsomely designed 3D-virtual environments ('scenic places' like the Alpes) can work just as it can in the real world." To overcome the constraints of the artificial looks of 'avatars' a beaming-technology is coming up for 2014. It may apply tip-to-toe jumpsuits with electrodes or personal scanner devices which transfers a representation of body and facial movements into the 3D-world. Thus you can beam your natural 'alter ego' into the 3D-world.

Meetings in virtual world have the potential to be almost as effective as real world meetings.

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Future Practitioners of Project Management –

Are We Disciples of Stanley Kubrick or Ridley Scott?

To peer into the future, we need to explore the tracks we have left behind as well as the prism through which we envisage what is yet to come. In this paper, the author examines the nature and historical role of project management, the forces that have defined the role of the project manager in society, and the challenges that lie beyond our immediate horizons. Stanley Kubrick provided images of inspirational projects that future project managers might one day deliver, while Ridley Scott gave us a far bleaker view of the failed legacy of project managers of the future. The author then discusses the challenges facing education and training in the development of future project managers. What are the appropriate attributes? Who are the key players moulding future generations of project managers? What are their visions of our future heroes who may be asked to manage the very existence of the human race?

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Introduction

In this conceptual paper, the author explores one of the key themes of the International Project Management Association (IPMA) Congress – the Future. The project management profession has a longstanding legacy that allows us to reflect on the past what evolutionary patterns have developed, and where they are likely to take us in the future in the context of education and training for future practitioners.

An historical view of project management in human history

Homo Sapiens evolved over approximately two million years in Africa and then undertook an amazing journey over the last one hundred thousand years or so across Asia, Europe, the Americas and Australia (Lahr & Foley, 1998). Motivated by the search for food, and perhaps curiosity, Homo Sapiens ventured out of the security of Africa into an unknown landscape. Evolutionary forces allowed those who managed risk well to survive and procreate and to continue the journey, while those who managed risk badly, perished. Survival strategies were passed on from generation to generation in the form of communal learning as tales, stories and folklore, until more permanent communication strategies such as drawings, hieroglyphics, writing and printing allowed learning and wisdom to be distributed across all social layers.

The availability of resources flowing from the adaptation of technology allowed those with vision and leadership abilities to conceive and orchestrate larger and more complex undertakings. The Chinese and the Egyptians built complex civilisations thousands of years ago, and the Romans spread an empire across Europe and northern Africa. Columbus recognised the patterns of the winds on either side of the equator and risked everything on a project to cross the Atlantic and to forge a new route to the East Indies. His assumptions were correct, although he discovered the West Indies to his surprise – it pays to be flexible in defining key project objectives ("Christopher Columbus," 2011). The outcome of that one project changed the pattern of trade routes across the world forever (Law, 1986).

Do we travel forward to a world envisaged by Stephen Spielberg in 'A.I.' where failed projects in artificial intelligence have changed the landscape of society and blurred the meaning of life and death.

Such undertakings have illustrated the evolution of what we now regard as project management. Key stakeholders have articulated organisational (or national) goals and objectives, allocated responsibility for achieving those objectives to those with leadership and vision, allocated resources to facilitate the required change, developed new technologies to support the mission, identified and managed risk as best they could, and put in place an integrated strategy to see the project through to its conclusion. We are riding on the shoulders of thousands of leaders across the eons who have tested their instincts with little or no framework of knowledge, and either lived to tell the tale for the benefit of others, or disappeared without trace.

The more recent history of project management

Numerous authors (Fondahl, 1987; Snyder & Kline, 1987; Stretton, 1994; Urli & Urli, 2000) have traced the more recent history of project management from its formalisation around the time leading up to World War 2, the development of sophisticated tools for better management of time, risk and costs, and the utilisation of computer technologies for improved performance and communications amongst stakeholders. Concepts such as project, program, portfolio and enterprise project management have raised the profile of project managers in the corporate world significantly to the point where senior job advertisements now commonly require some level of project management skills for executive positions across all sectors. There is an increased tendency towards organisational structures that embed dedicated project managers across organisations or within defined project management offices to secure organisational objectives (Faulkner, 2002; Kwak & Dai, 2000).

Key skill sets have matured over the years from those that reflected a predominantly tools-focused role to one of coordinator and facilitator (Crawford, Pollack, & England, 2006) with an emphasis on relationship management and strategic alignment. The focus has changed from the technical and quantitative processes to those more qualitative skills (Smith, 1999) that are seen as essential to achieve project outcomes. Project managers, who once mainly came from the quantitative sectors of engineering and construction, now come from a much wider range of sectors including business, health, education, science, information systems and research.

What will future projects look like?

What horizons do we adopt when we talk of the future? Using a cinematic perspective, do we look at the near future represented by Stanley Kubrick's '2001: A Space Odyssey' – a calendar date that has been and gone, but a scenario that has yet to pass? HAL has not quite taken over our future as Arthur Clarke might have thought but technology and 'ubiquitous computing' (Lyytinen & Yoo, 2002) continue to dominate the essence of future projects. In '2012' and the 'The Day after Tomorrow' (http://en.wikipedia.org/wiki/The_Day_After_Tomorrow) rapid climate change is the main challenge for future project managers. In 'Blade Runner', Phillip Dick provides a bleak view of the world where massive

projects have allowed those who can afford it to leave planet Earth to live in style and safety, with those who can't inheriting the legacy of a failed social project of multiculturalism where non-human replicants are hunted down by blade runners? Or do we travel forward to a world envisaged by Stephen Spielberg in 'A.I.' where failed projects in artificial intelligence have changed the landscape of society and blurred the meaning of life and death.

What message is there for future project managers in such art forms? Authors of such storylines incorporate sound research into their premise, although artistic licence tends to exaggerate time lines and story outcomes tend to spin out of control for the sake of drama (http://www.msnbc.msn.com/id/5058474/ns/us_news-environment/), but key messages remain. The conflict between the rapid and inequitable consumption of finite resources and societal expectations of increasing standards of living will be a key challenge for projects in the near and distant future. Ethical and moral views on sustainability will place demands on the economic dimensions of future projects, requiring difficult choices and decisions to be made in terms of project evaluation. What is desirable? And what is acceptable, as standards of living will inevitably fall where technology does not find ways to compensate for the diminishing availability of physical resources?

Where will future project managers come from?

Project managers will inevitably be caught in this ethical and social crossfire. Who will be the project managers of the future? Will project managers increasingly emerge from industry on a 'learn as you go' basis, or will the responsibility for the development of future project managers be placed with the tertiary education institutions? Will society demand a new breed of project managers with competence at levels expected of historically recognised professions such as medicine and law? Will society continue to tolerate the extent of project failure that is seen to be commonplace (Pinto & Mantel, 1990)? As educators, do we have a strategy for development of our would-be profession? I contend that at present, we don't. We have disparate views on ways in which skill sets can be developed to the level that should be expected of an aspiring profession. Recognition of professional mastery has historically moved from local guilds to state and national authorities, and more recently to international authorities, and the role of professional bodies should be as advocates of those members of their professions who have earned their place at the table, not competing at commercial levels for training and certification dollars.

Project management as a future profession

The rights of project managers to regard themselves as part of a profession have been explored by numerous authors (Barber, 2001, p. 953; Curling, 1998; Mitra, 2001; Turner, 1999; Zwerman, 2000). Project management has often been called the 'accidental' profession (Stretton, 1994) and Turner (1999) has examined the nexus between PM as a profession and the role of professional associations. First-generation professions of medicine, law and philosophy have matured through openness and sharing of ideas. Through such teaching and learning practices, consensus has been achieved in language, terminology, practices, values, and cultures which have become embodied in discrete disciplines and programs of study. 'Second-generation' professions of architecture, engineering, nursing, accounting, etc have tried to model themselves on first-generation professions. Industry-based practices have evolved into theoretical frameworks through research and have now become the domain of universities and recognised undergraduate disciplines of study. There are valid reasons for university involvement in the development of professions, including objectivity, development of evidence-based practices through research, availability of infrastructure and a focus on 'higher learning' skills.

Third-generation professions such as project management have attempted to jump over that stage and bolt on professional 'wings' that allow them to fly with the minimum of training and formal education. Jon Whitty has used a 'peacock' metaphor for project managers on previous occasions (Whitty, 2011) and this may be an apt example of its application – project managers who provide a colourful and noisy show but with little real ability to fly.

An analysis of higher education for medicine reveals a comprehensive pattern of learning, moving from early stages of basic awareness and knowledge of the essentials through to developing skills. The right to practice in more specialised areas of medicine requires greater levels of training and education (Booth, 1995). In project management, we have a fragmentation of training and education. Non-registered training organisations have carved out a sizeable niche providing continuing professional education (CPE) courses. Registered training organisations (RTOs) and the Technical and Further Education (TAFE) sectors offer programs structured around the Australian Qualifications Framework (AQF) (http://www.aqf.edu.au/Portals/0/Documents/Handbook/AQF_Handbook_07.pdf accessed 24 April 2010) and the Australian National Competency Standards for Project Management (NCSPM) (Australian Institute of Project Management, 1996).

The future of project management education

There is limited control of providers of education and training in spite of national quality control authorities in both sectors. There is little consistency across the training models employed by registered training organisations (RTOs), and there is inconsistency and duplication across the university sector in development of project management programs. The new Australian Qualifications Framework (Australian Qualifications Framework Advisory Board, 2011) will not eliminate the confusion due to interpretation of the requirements of graduate (and postgraduate) qualifications and the lack of guidelines on exemptions for work experience as credits into tertiary study.

Competencies that will be the key to future successful projects relate more to generic attributes and 'softer' skills, as these are essential in the articulation of project outcomes to meet the needs of disparate stakeholders. Such project managers will not depend on high levels of skill in the use of traditional tools – they will depend on the management of people. Traditionally, the development of such leaders has been the domain of universities where an emphasis lies on facilitation of skills in leadership of diverse teams, decision-making in 'fuzzy' environments (Tüysüz & Kahraman, 2006), and problem solving in situations of ethical dilemmas.

Established and recent entrants to project management are often unsure whether to seek professional certification or higher education, and the advice they receive is contradictory. Professional bodies appear to promote certification processes as de facto professional qualifications in lieu of formal education. The Australian Institute of Project Management (AIPM) uses the RegPM certification process (http://www.aipm.com.au/html/regpm.cfm) to gain considerable revenue but has always struggled with the conflict between the AQF levels of the certification (levels 4 to 6) which equate to Diploma, Advanced Diploma and Associate Degree, and industry's expectations that highly competent practitioners would have qualifications well above Advanced Diploma level. The irony is that many of the recipients of professional certification already have competencies appropriate to postgraduate qualifications at university level. The Project Management Institute (PMI) promotes their suite of professional certifications (http://www.pmi.org/Certification.aspx) and earns considerable revenue from the program, but the PMI certification has no alignment with any qualifications framework (such as the AQF). In the case of both AIPM and PMI, certification is unrelated to any requirement for membership of that body, which is a significant anomaly.

Will society continue to tolerate the extent of project failure that is seen to be commonplace?

Part of the problem is also created by the lack of a consensus between educators in the tertiary sector. Historically taught at postgraduate level, we now see the creation of undergraduate project management programs in universities (http://www.rmit.edu.au/programs/bp208), producing practitioners who may not have spent any significant amount of time in the workplace. This is offset to some extent by the increasing adoption of 'work integrated learning' (WIL) (Orrell, 2004) in university programs, and this should be expanded significantly to capture workplace experience.

Similar industries are concluding that an undergraduate degree is a clear indicator of an aspiring profession. The Financial Planning Association has recently committed to a minimum entry requirement for professional recognition as a Personal Financial Planner of an appropriate Bachelor's degree (http://www.fpa.asn.au/default.asp?action=article&ID=21638). Educators in the area of project management must put aside their competitive tendencies, and share practices and resources to ensure that future graduates meet the expectations of all stakeholders. Where is the 'International Project Management Education Council' or its equivalent? It does not exist yet but it should. At this stage, the profession of project management has multiple competency frameworks developed by multiple organisations. The AIPM developed the Australian National Competency Standards for Project Management (NCSPM) (http://www.aipm.com.au/html/pcspm.cfm) in the 1990s and these have been revised over the years. The PMI has published the Project

Manager Competency Development (PMCD) Framework, and the Global Alliance for Project Performance Standards (GAPPS) (http://www.globalpmstandards.org/) provides a forum for the creation of performance-based frameworks and standards for project management.

Project managers of the future will find it increasingly more difficult to access education and training due to workplace constraints. Physical attendance at universities and other places of higher learning will become more difficult, creating more demand on the utilisation of technology for access to learning activities. The need will be for more flexible learning opportunities but what is 'flexible' in pedagogical terms (Laurillard & Margetson, 1997; Moran & Myringer, 1999)? The profession of the future will demand quality project management education that is flexible in terms of place and time, and wrapped around a pedagogical framework that is consistent from one institution to another (Todhunter, 2009).

Unfortunately, there is considerable waste and duplication in the development of learning resources, most of which already utilise a common industry framework such as the Guide to the Project Management Body of Knowledge (PMBOK) (Project Management Institute, 2008). Synergies are largely untapped in terms of the multiple cohorts of project management students across the world, who could undertake learning activities in team-based environments that would reflect an authentic project management workplace of the future. There are challenges in such models though, and assessment practices and integrity of the evaluation of the learning outcomes can be difficult to coordinate (Centre for the Study of Higher Education, 2002; James, McInnis, & Devlin, 2002).

Conclusion

This paper commenced with a reflective view of the evolution of project management – the drivers, the practitioners, the stakeholders and the outcomes, with projects progressively contributing to a cumulative body of knowledge. This platform provided the basis for development of project management practices and processes that have become formalised in contemporary methodologies. A view over the horizon has highlighted the changing nature of projects resulting from social and economic pressures and rapid technological advancement. These changes will impact on the profile of future project managers who will come from different backgrounds, have different attributes, demand more extensive education and training, and require different professional skill sets to manage the complexity and scope of future projects. Social and professional expectations will place greater demands on higher education to provide appropriate teaching and learning environments to cater for the needs of our future project managers.

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A Universal Management Mode for Permanent Organizations Based on Management by Projects

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Based on the assumption of regarding "goals, tasks and resources" as three core elements of organizational management and the perspective of "Management by Projects (MBP)", a universal management mode for permanent organizations based on MBP (MBP-mode) is presented through case study and empirical study. This paper establishes a conceptual model for the MBP-mode with project orientation and the highlight of sufficient utilization of management resources and external resources. In accordance with that, a structure of the management system based on MBP for permanent organizations and its basic construction elements is developed by using four-quadrant chart. A compound organizational structure based upon the improved matrix is further developed in this paper. In order to support the implementation of the management system based on MBP, this paper proposes five key mechanisms which focus on dealing with relations among goals, tasks and resources.

This is an updated and edited version of a paper that was first time published in the proceedings of IPMA 2011 World Congress.

Introduction

A project is a temporary organization (Turner, 2006). In project practise, we are aware of the fact that project management usually can not achieve favourable results merely by the temporary organization itself. It calls for a broader management and supporting platform provided by the strategic level or the level of permanent organizations. What's more, tasks (Maylor, 2006) in permanent organizations become projectified to deal with the rapid changing macro and micro environment characterized by diversity and uncertainty. However there is a lack of a project-oriented management system which can dynamically integrate organizational resources to better achieve project goals in permanent organizations so that they can thrive in the uncertain external environment. The MBP-mode presented in this paper is hereby to cope with the questions abovementioned.

Relevant researches have been developing from ideas to specific aspect of organizational project management. Anderson (2003) points out that projects without strategic instruction from permanent organizations usually end up with failure or poor performance. Thiry (2007) proves that there is a collaborative relationship between project management practise and organizational practise in project-based organizations (PBOs). Turner (1999) provides a viewpoint that governance structures and operational control in PBOs should vary according to the difference of projects and then offers different governance models for PBOs (Turner, 2001). Aubry (2007) and Hobbs (2008) present PMOs as part of a network of complex relations that links strategy, project and structures and thus is a point of entry to foundation of organizational project management. Some researchers talked about the effectiveness of programme management and portfolio management in organizational project management (Payne, 1998; Lycett, 2004). Some other researches focus on the role of project management capability in organizational project management (Crawford, 2005; Jugdev, 2007). Above all, it's not hard to observe that researches abovementioned are basically conducted from certain facet of organizational project management or specific field of organizations such as PMOs, PBOs etc, while they don't give out a whole picture to deal with organizational project management. Therefore, this paper intends to develop a systematic management framework (the MBP-mode) for all kinds of permanent organizations.

Research methodology

The MBP-mode is defined as a universal management application system framework in this paper. Experimental Research is applied into the research of such a model which stands upon the methodology "coming from the practice and tested by the practice". The research process lasts for nine years by following certain methodological route (figure 1).

This study intends to build up a universal management mode for permanent organizations from the perspective of MBP (MBP-mode). And thus we firstly categorize permanent organizations from the light of tasks into three types: operation-based (not accounted in this study, since projects have been well acknowledged as an essential part in organizations), hybrid tasks-based and project-based, in order to analyze the commonality among all types of organizations. And then this study conducted several case studies on different type of organizations to answer the two questions: what permanent organizations need to do to support the application of project management methods, and how to establish a comprehensive and efficient management system for project-based organizations. This research then conducted literature study incorporating operation management, organizational project management, PBOs, PMOs, change management, programme management and portfolio management etc to discover the common features of permanent organizations and the theoretical and practical system frame of the MBP-mode. This research further conducted expert interviews with more than 800 business management and project management professionals to receive more professional suggestions to improve the MBP-mode. Empirical study of several R&D institutes and public sectors were then conducted to testify the validity and applicability of the MBP-mode.

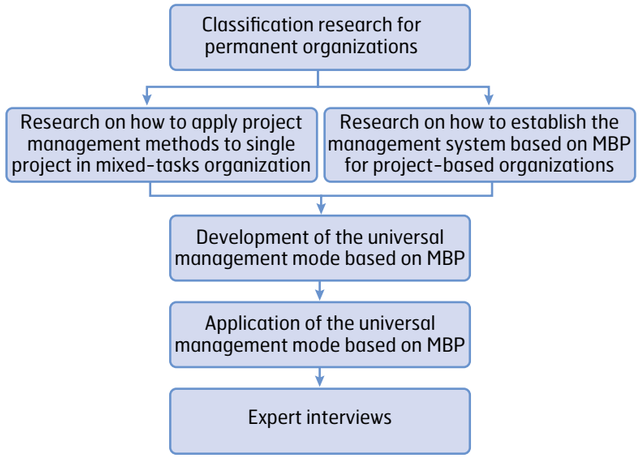

Figure 1. Methodological route for the research of the MBP-mode

Conceptual model

Assumptions are the logic starting point, independent perspective or the fundamental theoretical premises on which some certain theory or method framework is built. Based on the definition of "management" and common characteristics of organizational management, the MBP-mode is developed on basis of the assumptions (A) as follow:

A1: Goals, tasks and resources act as the three core elements of organizational management (see figure. 2.).

A2: The major tasks of organizational management are to obtain and maintain favourable relationships between strategies and tasks, between strategies and resources, as well as between tasks and resources.

A3: There are two types of tasks in a permanent organization: projects and operations. The former is the key of organization development, characterized by a growing proportion of projects in it.

A4: There are two kinds of resources utilized in permanent organizations: internal resources and external resources, and external resources utilization now act as a growing important mean for expanding rapidly, coping with changes and reducing risk. Organizational resources can be separated into two parts: technology resources and management resources, and management resources have become a significant component of the organizational core competitiveness.

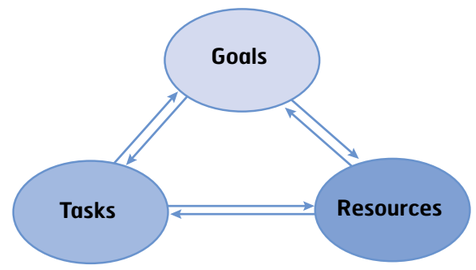

Figure.2. Relationships among three core elements of organizational management

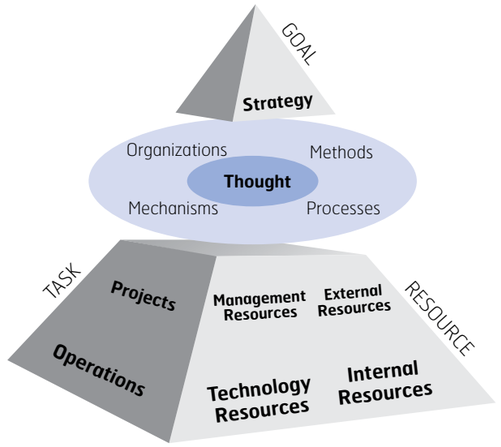

Figure.3. A conceptual model for the MBP-mode

A management mode can be viewed as a system which consists of management thoughts, management organizations, management methods and management tools. In accordance with the assumptions abovementioned, this paper constructs a conceptual model (see figure. 3) of the MBP-mode by understanding the basic characteristics of organizational management elements and the growing concern of strategy and tasks. The conceptual model contains 5 key points (K) as follow:

K1: the management system based on MBP comprises management thoughts, management organizations, management methods, management mechanisms and management process.

K2: a project is defined as a temporary organization, and the thought of MBP acts as the dominant role in permanent organizations.

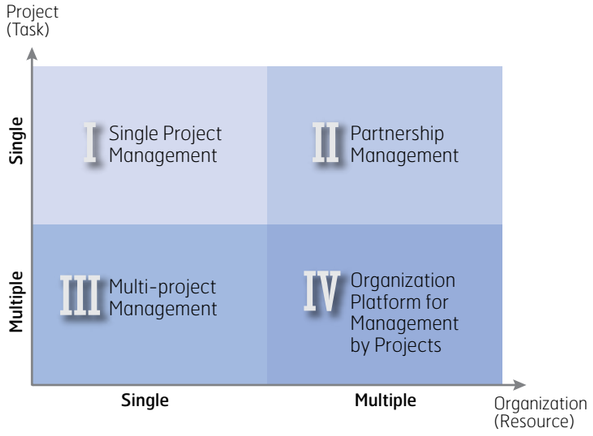

Figure.4. The structure of management system based on MBP for permanent organizations

K3: strategic goals are realized by the implementation of projects, and the management system of permanent organizations is project-centred or project-oriented.

K4: temporary organization units such as project organizations are of great importance to enhance organization flexibility. Permanent organization units and temporary organization units bring out the best in each other.

K5: strategy management and project management, which are merging together, act as the backbones of organizational management in the model. Project management, programme management and portfolio management are the core methods of organizational management.

Management system

A good management system is the guarantee to achieve organizational goals. Based upon the assumptions of three core elements and the thought of MBP, by introducing the form of BCG Matrix which depicts "task" as the vertical axis and "resource" as the horizontal axis, this paper presents the structure of management system based on MBP (figure.4.) with project orientation and the highlight of sufficient utilization of management resources and external resources for permanent organizations.

Such management system incorporates four sub-systems, the basic construction elements of each of which briefly explained on the following:

1. Single project management sub-system
   - Projects with similar characteristics of management can be put into one category, for each of which the corresponding management system is developed. According to the unique characteristics of the specific project, the applicable project management plan can be further formed through refinement of the corresponding management system.
   - Single project management sub-system is project-oriented, which incorporates the control and support from the permanent organizations and all business carried out by temporary organizations. .
2. Multi-projects management sub-system
   - The multi-projects management system can be used within organizations in which two or more projects simultaneously exist. Such management system concerns about the relationship among projects and how to build up the body of project management capability improvement from the perspective of supporting all projects inside the organization.
   - Correlation analysis among projects, multi-projects management mode and methods constitutes the core content of the sub-system.
3. Partnership management sub-system
   - Partnership management sub-system is defined as the one which deals with the issues from stakeholders outside. It concerns how to establish the external resources network in light of strategies, how to maintain a favourable relationship among partners, and how to select appropriate partners and effectively manage the cooperation.
   - Partner relationship management and procurement management are the core of such sub-system.
4. Organization platform for MBP
   - The organization platform for MBP introduces temporary organizations with project orientation to enhance organization flexibility and help realize the strategic goals of permanent organizations.
   - Temporary organizations are the highlights of the Organization platform for MBP of which the relationship between temporary organizations and the permanent organization stands on a key position.

Organization model

Organizations lay a solid foundation to complete tasks by centring on resource allocation. Based upon the thought of MBP, this paper recommends a universal organizational structure for permanent organizations-a compound organizational structure based on the improved matrix (see figure 5) characteristics (C) of which are explained on the following:

C1: Because of the diversity of tasks in permanent organizations, the organizational structure becomes flexible more than a constant single one. Hence, the compound organizational structure based on the matrix organization is presented which can dynamically adjust itself in accordance with the characteristics of tasks.

C2: In light of tasks projectification tendency, temporary organizations units such as projects take up the responsibility of completing tasks, while the permanent organization units such as functional departments and business divisions change into the role of resource providers and managers or act as the inner owners of projects, from which the structure based on the improved matrix is developed.

C3: The organizational structure highlights the share of management resources and the utilization external resources on the strategic level.

C4: A temporary organizational structure concerned about projects and the corresponding construction elements (see figure 6) is presented, which clearly cites out the basic temporary organizational elements of the MBP-mode on the organizational level.

Management mechanisms

Management mechanisms are referred to the static structure and dynamic operation mechanism of the management system, which stand as the core of enhancing management performance. They are in nature the internal relations, functions and operation principles within the management system. Management mechanisms generally contain operation mechanism, dynamic mechanism and constraint mechanism. The implementation of MBP-mode requires key mechanisms (M) in order to reinforce the thought of MBP, which are depicted in the figure below (figure 7):

M1: Project Initiation and Evaluation Mechanism is used to ensure projects goals in consistent with organizational strategic goals, primarily pointed at establishing the scientific and normative projects planning, projects evaluation process as well as projects decision process and methods;

M2: Resource Allocation and Integration Mechanism basically focuses on allocating core resources in accordance with the

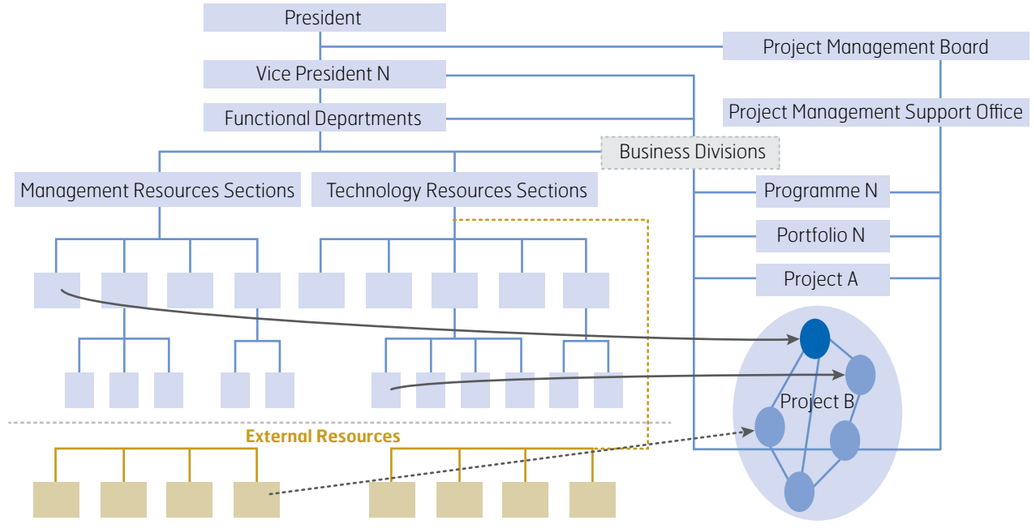

Figure 5. A compound organizational structure based on the improved matrix

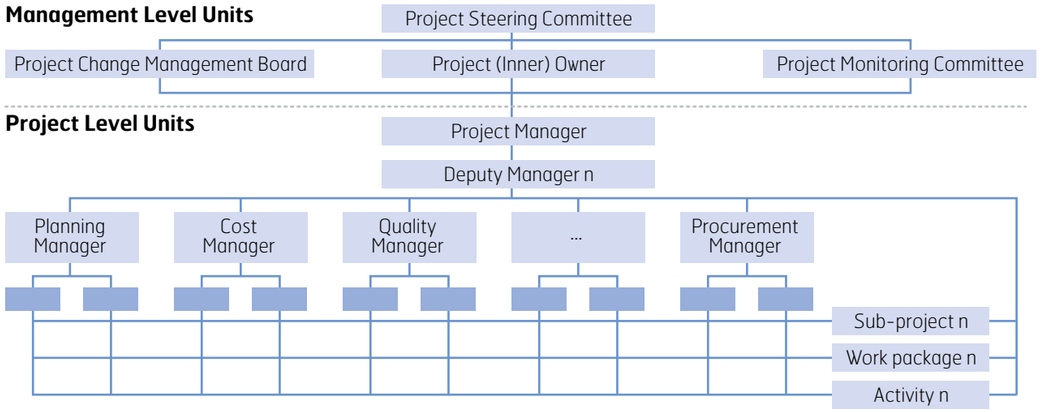

Figure 6. A temporary project organization structure

requirements of strategy development by constructing reliable external resources networks for organizations and integrating internal and external resources to attain the projects goals. Primarily pointed at developing the strategic planning system for organizational resources, the internal resources allocation mechanism and the external resources integration mechanism;

M3: Communication and Knowledge Accumulation Mechanism aims at creating an open, convenient as well as effective environment for information flow and consolidating knowledge accumulation in order to successfully address the relationship between the temporary nature of projects and the requirement over knowledge asset from permanent organizations, primarily pointed at developing the communication mechanism among stakeholders, management information system and knowledge accumulation mechanism;

M4: Performance Appraisal and Motivate Mechanism aims at guiding organizational and individual behaviours and correctly inducing their working motivation through appraisals to sustain or correct their behaviour so that the requirements or strategic goals of both organizations and individuals can be realized. It mainly centres on establishing the corresponding appraisal system and motivation measures to support the implementation of the "MBP" thought;

M5: Project Management Capability Continuous Improvement Mechanism focuses on constantly strengthening Project Management Capability, the core competitiveness of permanent organizations that see the MBP as their leading idea, which mainly aims at developing the Project Management Capability evaluation system and activation mechanism for capability improvement.

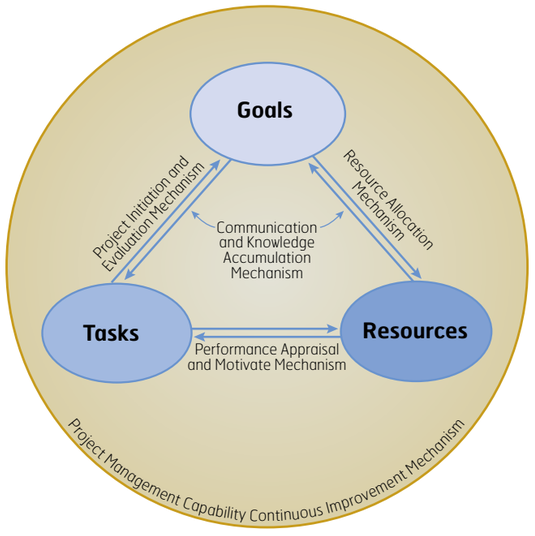

Figure 7. Five key mechanisms and their relationships

The MBP-mode presented in this paper also serves as a reliable reference paradigm for the five mechanisms abovementioned.

Conclusions

On the basis of the assumption of three core elements in organizational management and the perspective of Management by Projects, the MBP-mode is developed through case study and empirical study. It has been attested by practices to be a valuable guideline to build up the management system based on MBP for permanent organizations (particularly project-based organizations and project-oriented organizations) in rapid changing environment. This paper provides project management with a new study perspective which starts on an organizational level. And by introducing the MBP-mode, it brings about a new clue for the study of organizational management.

Dr. Lixiong Ou

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Sustainable Beauty -

achieving sustainability goals by fulfilling materialistic aspirations

Project production involves creation of original goods ranging from engineer-to-order ships and buildings to bespoke clothes and furniture. These goods fulfil the most sophisticated materialistic aspirations for unique goods that make personal statements about their owners. Established perspectives on project production can be found in, for example, International Project Management Journal (e.g. Yang, 2012) and the International Journal of Managing Projects in Business (e.g. Fox, et al., 2009). This paper introduces new perspectives on the environmental and economic potential of project production. These perspectives are possible because of innovative production technologies and new lifecycle strategies.

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Challenges and opportunities in project production

Production challenges

Currently, project production of goods is carried out through the application of craft skills and engineering practices. In particular, smaller goods, such as clothing and jewellery are created for individual customers by bespoke businesses, which use craft practices. Larger goods, such as homes and yachts, are created for individual customers by engineer-to-order (EtO) enterprises involving, for example, building architects or naval architects. In either case, the starting point is the incomplete and imprecise images envisaged by the individual customer in the mind's eye.

A project produced good is first seen in the mind's eye of the individual who imagines its form and function. The good is not seen then as a complete and precise picture. Rather, it is seen as incomplete and imprecise mental images. Thus, when individuals speak of the goods that they envisage – they speak of their dreams. For example, individuals speak of their dream houses, and other goods, which they would have made for themselves if they had enough money.

Typically, the individual customer's requirements are elicited through multiple iterations of dialogues, measurements, sketches, models, etc., which lead to the definition of design information. These multiple iterations lead to a description of an original good that is uniquely meaningful for the individual customer. This is because the design information brings completeness and precision to what the individual customer has previously envisaged as an incomplete and imprecise conceptualization in the mind's eye. As the design information is manufactured a physical good, through multiple iterations of shaping, fitting, and fixing, the individual customer experiences the tangible form of what is first seen in the mind's eye. Thus, bespoke businesses and EtO enterprises do not offer goods. Rather, they offer production services that enable individual customers to realize their personal dreams as original goods, which for them are especially beautiful.

By contrast, companies operating mass production or its derivative, mass customization, pre-design the sub-assemblies of the goods that they offer, and they pre-define all the possible configurations of those sub-assemblies. This pre-design and pre-definition of goods is aligned with what the marketing departments of mass companies define to be the common attributes of millions of consumers. Then, mass companies communicate the range of their goods' forms and functions to consumers through in-store displays, online configurators, etc.

Mass companies reduce the time and cost of creating goods by reducing reliance on human-to-human interactions and human skills. They achieve this through deployment of technologies that depend upon the pre-design of sub-assemblies and the pre-definition of their potential configurations: for example, shaping presses and assembly robotics. The high costs of these mass production technologies are then spread across mass sales. Consider, for example, the locate-to-order practices of mass car production. These involve automotive companies smoothing demand by making common types of family cars to forecast, and then storing those cars until orders are received for them. Subsequently, when a consumer is persuaded to buy one of the stored vehicles, it is located-to-order. Hence, while many cars were painted black at the beginning of the 20th Century; many cars are painted silver at the beginning of the 21st Century, and given other features which mass companies define to be the common denominators among masses of consumers (Agrawal et al., 2002).

By contrast, bespoke businesses and EtO enterprises rely on human skills and human interactions for the multiple iterations of dialogues, measurements, sketches, models, etc., that lead to definition of individual customer's requirements. For example, an individual customer interacting with one or more skilled industrial designers; and then industrial designers interacting with one or more skilled production crafts persons. Subsequently, all of the costs of design and manufacture have to be borne by the price of the one original good that is created. Accordingly, technological innovations are needed that reduce the time and cost of creating goods, but that do not depend upon pre-design of sub-assemblies and the pre-definition of their potential configurations.

Sustainability opportunities

As summarized in Table 1, the differences between project produced goods and mass produced goods are not limited to their design and manufacture. They also include status and longevity. In particular, mass production drives throwaway consumerism by "instilling in the buyer the desire to own something a little newer, a little better, a little sooner than is necessary" (Stevens, 1954).

Throwaway consumerism is driven by mass companies through planned obsolescence: in particular, obsolescence of desirability and obsolescence of function. Obsolescence of desirability is imposed by mass marketing. This tells consumers over and over again that the goods they recently bought are no longer in fashion. Thus, if they want to have self-esteem and social standing, they must replace those out-of-fashion goods with new goods. Hence, these throwaway goods have only extrinsic value for their owners. Obsolescence of function is imposed by introducing alternative types of goods, rather than offering parts, servicing, etc. to improve the functionality of existing goods. Living under the threat of obsolescence, billions of consumers are locked into an unsustainable cycle of buy – throwaway – buy again – throwaway again – and again and again and again.

This throwaway cycle is unsustainable because of the massive quantities of raw materials that are consumed in producing new goods. It is unsustainable because of the millions of tonnes of greenhouse gas emissions are pumped into the Earth's atmosphere through endless cycles of extracting, transporting, and processing. It is unsustainable because of the vast quantities of thrown-away goods that are pushed into landfills, piled onto scrapheaps, and dumped off-shore.

Unlike mass companies, bespoke businesses and engineer-to-order enterprises do not make goods that they intend to be thrown away as soon as possible. Rather, they create treasured possessions that their owners can value for decades. They can even become family heirlooms, and be valued by their owners' subsequent generations. The goods are treasured because they are uniquely meaningful for their owners. This is because beauty is in the eye of the beholder; and their owners first beheld them in their own minds' eye. Then, they had input into every stage of their design and production. Hence, these goods have strong intrinsic value for their owners.

Importantly, project produced goods are a materialistic aspiration for many. This is be-

Characteristic	Project produced goods	Mass produced goods
Concept	Mind's eye of individual customer	Brand holder's marketing department
Design	Multiple iterations of dialogues, measurements, sketches, models	Pre-design of components and pre-definition of their potential configurations
Manufacture	Unique shapings, fittings and fixings	Made-to-forecast and locate-to-order
Status	Treasured possession with intrinsic value	Throwaway good with extrinsic value
Longevity	Life of owner; even future generations	Planned obsolescence

Table 1. Project produced goods compared to mass produced goods

cause many consumers aspire to the lifestyles of the rich and famous as presented in celebrity magazines, etc (Robins, 2010). Yet, the rich and famous are not presented with mass consumer goods. Rather, their wealth enables them to have their own uniquely beautiful treasured possessions. These goods range from original jewellery, clothing and furniture to original boats and buildings, which are created through project production.

Project produced goods that are treasured for decades can make an important contribution to sustainability, because can they make an important contribution to reducing the materials consumption, greenhouse gases, and waste arising from throwaway consumerism. Until recently, however, the time consuming and labour intensive processes involved in the design and manufacture of project produced goods has put them beyond the financial reach of many people. As described in the following paragraphs, this situation is now changing through the introduction of innovative technologies for project production.

Innovative project production technologies

Technological innovations are needed that reduce the time and cost of creating goods, but that do not depend upon pre-design of sub-assemblies and the pre-definition of their potential configurations. Three such innovations are digital data capture technologies, generative computation, and digitally-driven manufacturing equipment.

Digital data capture technologies

Digital data capture technologies include digital pens. These enable rough sketches drawn on paper and other surfaces to be rapidly converted into digital computer models. Other digital data capture technologies include digital photograph cameras and digital video cameras. The data captured with these can be converted into digital computer models through photogrammetry. Another versatile digital data capture technology is low cost scanners. These can be hand-held or table-mounted, and like digital cameras, enable ordinary people to easily make digital descriptions of physical objects as computer models. Together, these technologies enable ordinary people to formulate digital approximations of what they behold in the mind's eye: for example, as roughly drawn adaptations of existing physical goods (Song et al., 2009).

Generative computation

Generative computation can then be applied to the digital computer models that represent rough approximations of what is in the mind's eye. Generative computations can emulate what human designers/engineers do when they draw, erase, modify and/or move shapes such as lines and curves. Generative computation is already widely used in the design of unique buildings. Rough approximations of the form envisaged in the mind's eye, such as physical models shaped from paper, card, etc., are scanned and converted into digital computer models. Generative computation then automates the evolution of an infinite variety of designs from the initial form. The individual customer chooses the particular design that provides the most complete and precise representation of what is been envisaged in the mind's eye.

The Birds Nest Stadium, created in Beijing for the 2008 Summer Olympics, is notable example of the application of generative computation to an initial approximate representation of design intent. As well as generating a unique aesthetic, generative computation yielded a design for the Bird's Nest Stadium that met exacting criteria for production. The setting of criteria for generative computations, such as minimum material usage, can filter the number of design to be viewed by the individual customer to a practical number (Krish, 2011).

Importantly, generative computations can be carried out within brand aesthetics. For example, generative computation has been applied to the aesthetics of famous building architects, such as Frank Lloyd Wright, and famous product brands, such as Harley Davidson (Fox, 2011).

Digitally-driven manufacturing equipment

Generative design computations can be related to optimal combinations of manufacturing machinery and materials (Fox, 2011). Optimal meaning those combinations of manufacturing machinery and materials which can best meet key criteria such as, for example, minimum manufacturing duration. This enables efficient physical production of the designs generated by computations even though each of those designs has its own unique geometries. In particular, generative computations can be linked to digitally-driven production equipment such as multi-axis routers or additive manufacturing object printers. These types of equipment are well-suited to the production of unique geometries which are especially meaningful for the individual customers who first envisage them in the mind's eye. They have been used to produce goods such as unique personal clothing for some years (Fox, 2003). More recently, they have become more reliable and versatile in the production of three dimensional components and goods, which would have previously required dies, moulds, and other types of traditional manufacturing tooling, for their production. Object printers, for example, produce goods of extremely complex geometry by the digital deposition of materials. This involves placing material only and exactly where needed, as directed by the digital data of the design.

Further, digitally-driven manufacturing can enable original goods, and components, of any geometry to have removable micro-electronics, such as sensors, included in them. They can be contained in precisely manufactured compartments which can be opened and closed as necessary: in the same way that, for example, sim cards are held in internet dongles. This can make enable individuals to create their own unique "Internet of Things". This involves physical objects having wireless micro-electronics

Innovation	Reduce reliance on human skills	Reduced human-to-human interactions
Digital data capture	3D data formed automatically rather than by human structuring of 1D data	Reduced iterations of dialogues and , measurements during elicitation
Generative design computation	Automates evolution of an infinite variety of original designs from an initial form	Reduced iterations of sketch / model – feedback – sketch / model – feedback
Digitally-driven manufacturing	Automatic data transfer from design to digitally-driven equipment	Reduced iterations of explanation needed to set-up equipment

Table 2. Innovative technologies for project production

that enable their Internet-based communication: for example, a plant pot being able to send a message to inform that its plant needs to be watered (http://www.botanicalls.com/kits).

Combining technological innovations

As summarized in Table 2, together, digital data capture technologies, generative computation, and digitally-driven manufacturing equipment can radically reduce reliance on human-to-human interactions and human skills in the creation of goods that are first envisaged in the mind's eye of their owners. In doing so, these technologies can enable a fundamental shift from mass production to mass imagineering, and the scaling up of project production businesses.

Inexpensive digital data capture technologies, for example, replace manual measuring practices that employ tape measures, vernier gauges, etc. These traditional measuring practices often involve repeated iterations of fitting – finishing – fitting. This is inevitable because tapes, gauges, etc., are one dimensional (1D) measuring devices (i.e. only linear distance) from which three dimensional (3D) data have to be formulated - both conceptually and numerically. Next, generative computations can be at least as creative as human designers/engineers. However, unlike human designers and engineers, generative computations can work relentlessly across days and nights without a break. Thus, generative computations can generate many new design options that might not have been created by human designers/engineers, using CAD/CAM software, due to human fatigue, lack of time, etc.

Then, digitally-driven manufacturing can enable the production of snap-fit components direct from design data. A snap-fit is a mechanical joint system where part-to-part attachment is accomplished by locating and locking features. Hitherto, snap-fit methods depended upon all parts being designed together when a snap-fit system is being developed. Now, the geometric freedom of digitally-driven manufacturing makes it possible for snap fits to be realized between, for example, new components and existing goods. Importantly, snap-fit connections do not require skill knowledge or hand-tools, this because they just have to be pushed together to establish a tight fit.

Thus, the combination of digital data capture technologies, generative computation, and digitally-driven manufacturing equipment technologies can make the luxury of project produced goods affordable for all. In doing so, as shown in Table 3, innovative technologies can be deployed to address both obsolescence of desirability and obsolescence of function.

New lifecycle strategies for project production

Project production goods that are treasured for decades can make an important contribution to sustainability, because can they make an important contribution to reducing the materials consumption, greenhouse gases, and waste arising from throwaway consumerism. As described in the following paragraphs, sustainability can be further increased by the project production of goods involving the augmenting of standard assemblies and the upcycling of existing goods.

Augmenting standard assemblies

The lifecycle of mass produced functional goods can be extended by augmenting them with uniquely beautiful casings, housings, etc. The company, Bespoke Innovations, for example, makes uniquely beautiful casings, which calls fairings, for standard prosthetics (http://www.bespokeinnovations.com). These fairings are

Characteristic	Mass produced good	Project produced good
Desirability	Obsolescence of desirability is imposed mass marketing	Goods have intrinsic value because they originated in owner's mind's eye
Function	Obsolescence function is imposed by continual introduction of whole new goods	Goods can have removable components to enable improved functionality

Table 3. Addressing the planned obsolescence of throwaway consumerism

	Innovative production technologies	New lifecycle strategies
Beauty	Enable capture and realization of what is seen as beautiful in the mind's eye of the individual customer	The augmenting and/or upcycling of assemblies / products enables each good to have its own original beauty
Sustainability	Goods are thrown away less often because they have intrinsic value and components that can be easily upgraded	Augmenting and upcycling reduces the consumption of raw materials; generation of pollution; and volume of waste.

Table 4. Sustainable beauty from project produced goods

unique to the owner and have a beauty that they treasure, such as a particular geometry which matches their favourite motorcycle.

Many other project produced goods could be created by augmenting standard assemblies such as structural frameworks. Project produced cars, for example, can deploy Body on a Frame structures. These use an internal space frame to carry loads. External non-load bearing panels are attached to the internal frame to keep out wind, rain, etc, and to provide car body shape. Uniquely beautiful panels could be made from, for example, carbon fibre composites, rather than the steels used in mass produced cars. This is because very strong solid equipment is needed to enable the shaping of strong solid materials, such as high strength steel bars and sheets, into strong solid steel car body panels. This equipment includes sets of huge mechanical presses, as well as very large convex and concave moulds. By contrast, manufacturing materials that are not so strong individually, such as liquid resins, or more flexible, such as carbon fibres, do not require such strong or solid equipment for their shaping into strong solid composite car body panels. This opens up possibilities for reducing environment costs from manufacturing while creating car bodies that are more individual to their owners.

In addition to creating more individual body panels, new technologies can be deployed to augment, for example, cars with unique features such as original dashboards, handles, mirrors etc. For example, a type of additive manufacturing called mammoth stereolithography can produce components of more than two meters in width. Such augmenting of components could be widely used to create original goods if mass produced standard goods were made as partially completed shells. These could comprise the necessary physical frameworks and internal mechanisms to ensure their reliable operation. This strategy is already being applied with commercial success by the innovative car company, Local Motors (Mone, 2010).

Upcycling existing goods

The augmenting of project produced components to existing goods can bring about widespread expansion of upcycling. That is the process of converting waste materials into new materials, or converting goods that are considered to be obsolete into valued goods. (Pauli and Hartkemeyer, 1999). Thus far, upcycling has largely involved the conversion of waste materials. The company, TerraCycle, for example, has established partnerships with major brands in order to upcycle waste packaging materials into shopping bags (http://www.terracycle.net).

Now, the augmenting of uniquely beautiful components to existing goods can enable the upcycling of many existing goods which would otherwise be thrown away due to perceived obsolescence. Consider, for example, goods such as business laptops, which are considered obsolete even if they are only a couple of years old. Their functionality may still be more than adequate for home use, but they can be considered to have an obsolete style by the children who could use them at home. Now, the exact geometry and dimensions of the laptop can be captured; designs for additional components can be generated and efficiently manufactured; then the additional components can be quickly snap-fitted onto the laptop to give it a unique style of its own. Most importantly, the unique style was first envisaged in the mind's eye of the child who will use the laptop. Thus, the style of laptop is uniquely beautiful to its user.

Upcycling does not have to be limited to stand-alone goods such as laptops. Consider, the door handles and sink taps that are often replaced when people's grip and vision deteriorate as they become older. Until now, such built-in fittings have had to be replaced in order to make them easier to grip and operate. This has involved trying to find carpenters, plumbers, etc., who have the time to do the work. Then, existing fittings and associated pipework etc., are removed and thrown away. Next, new larger fittings are installed. All of this work is time consuming and labour intensive. Now, however, new snap-fit components can be added to existing handles, taps, etc. These new components can make them more aesthetically pleasing, as well as easier to grip and operate by elderly people. Such components are needed to serve the ever expanding multi-billion commercial market for Assistive Technologies (Bureau of Industry and Security, 2012). A summary of contributions to beauty and sustainability from is provided in Table 4.

New perspectives on project production

A sustainable alternative to mass production

The State of the World Report 2010 contains a grim warning, "Preventing the collapse of human civilization requires nothing less than a wholesale transformation of dominant cultural patterns. This transformation would reject consumerism and establish in its place a new cultural framework centred on sustainability" (Owen, 2010). So far, this type of grim warning has failed to persuade billions of consumers that sustainability is a more attractive option to aspire to than the lifestyles of the rich and famous (Robins, 2010). Indeed, current conceptualizations of sustainability are so unappealing to some that they would prefer to consume what remains of the Earth's resources. Then, attempt to journey to other planets where fresh new resources would be available (Monbiot, 2010)! Compared to doomsday scenarios, the opportunity to have their own project produced goods may be a more attractive option for many.

Beauty is in the eye of the beholder, and project produced goods are first seen in the mind's eye of the individual customer. Then, design information brings completeness and precision to what the individual customer has previously envisaged as an incomplete and imprecise conceptualization in the mind's eye. As the design information is manufactured as a physical good, the individual customer experiences the tangible form of what is first seen in the mind's eye. Thus, individual customers can realize their personal dreams as project produced goods, which for them are especially beautiful. This creation of goods with intrinsic beauty has a very different ethos to throwaway consumerism; which is driven by instilling in the buyer the desire to own something a little newer, a little better, a little sooner than is necessary. Importantly, innovative production technologies can bring the luxury of project produced goods within the financial reach of customers who hitherto have only be able to afford mass produced goods.

A means of achieving sustainable economic growth

Nations that have previously offshored mass production of physical goods are now trying to find ways of rebalancing their economies by revitalizing their manufacturing sectors. However, they cannot simply bring back mass production, because it is now too deeply entrenched in other parts of the world. (The Economist, 2011). These post-industrial economies seek to increase economic growth through creative industries, including project production of original goods (Florida, 2002). However, the recent report from the United Nations, "Decoupling natural resource use and environmental impacts from economic growth", calls for resource consumption to be decoupled from economic growth (UNEP, 2011). Using the new lifecycle strategies of augmenting and upcycling, project production businesses can meet both of these apparently contradictory goals at the same time. This is because they can expand manufacturing activity with less consumption of raw materials and less emission of greenhouse gases.

Overall, innovative production technologies and new lifecycle strategies enable project production now to be seen as a means of achieving sustainability goals by fulfilling materialistic aspirations. This introduces opportunities for the growth of project production businesses and for the growth of post-industrial economies.

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Uncertainty Management in Projects -

A New Perspective

This paper focuses on a Norwegian research project, called "Practical uncertainty management in a project owner's perspective – in short, the PUS-project. The PUS-project had 6 major industrial partners – from public and private sectors. Both qualitative and quantitative methods were associated with this collaborative project work. This paper describes some of the major results produced by the PUS-project. In this regard, this paper touches upon approaches, methods and practices related to managing uncertainty in projects. The PUS-project emphasised on the role of project owner and giving adequate consideration on opportunities, when it comes to managing uncertainty. This emphasis, which is not common in the project world, is discussed in this paper with relevant theories and practical examples. This paper also presents examples from the industry to highlight some of the benefits that the involved organisations obtained in collaboration with the PUS-project – a research project's contribution to create value in the industry.

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Introduction

This paper focuses on a research project called "Practical uncertainty management in a project owner's perspective" – in short, the PUS-project. The purpose of this paper is to describe some major contributions of this research project to create value in the industry and academia.

In order to materialize this purpose, this paper has the following structure: The paper starts with a short description of the PUS-project. A brief description of methodology follows it. Then, some contributions of the PUS-project are described. Firstly, the topic of dealing with opportunities in uncertainty management in projects is discussed. This is one of the significant focus-areas of the PUS-project. And then, examples from the industries are presented to point out some concrete benefits that the involved organisations achieved in collaboration with the PUS-project. Contribution to academia is then briefly described. Finally, concluding remarks wind up the whole discussion.

The PUS-project

The PUS-project (2006-2010) had an ambition of focusing on leadership and culture connected to practical management of uncertainty in major public and private projects. Lot of work was done on the issue of uncertainty analysis both in Norway and abroad, and much of this kind of work was carried out in the early phase ("front end loading") of projects. But, there was less research on the issue of how to manage opportunities and threats in a project's life cycle in a practical manner. Furthermore, there was not much research on what the project owner role should be with respect to management of uncertainty. PUS had an ambition to shed light on the owner's role in uncertainty management throughout the project life cycle. The project had a keen interest in influencing large organisations' thinking patterns and actions associated with identification and management of uncertainty elements in projects.

The PUS-project collaborated with the Research Council of Norway and the Norwegian Centre of Project Management (NSP). The main industrial partners (both from public and private sectors) of the project were:

1. Statoil (an international energy company with operations in 34 countries, headquartered in Norway),
2. Norwegian Directorate of Public Construction and Property Management
3. Telenor (one of the world's largest mobile operators with 33200 employees worldwide, headquartered in Norway)
4. Norwegian Armed Forces
5. Norwegian Public Roads Administration
6. Norwegian National Rail Administration

Apart from these main industrial partners, other Norwegian organisations were also involved in the PUS-project. The project's cost frame was approximately 4 million euro. This frame included spin-off projects and own efforts.

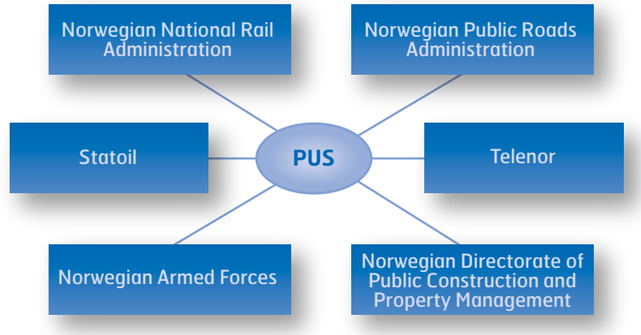

Figure 1. Major industrial partners of the PUS-project

Methodology

Methodology that we mention here is a mode of cooperation that the PUS-project had with its industrial partners. During the cooperation, the PUS-project used both qualitative and quantitative research methods: (1) Questionnaire studies (2) Interviews (3) Document analysis (4) Action research.

During the project, two focus-seminars per year were conducted with the intention of anchoring plans, developing new models, procedures, routines, and transferring experiences between project managers and project owners in the involved organisations.

Focus on opportunities

When it comes to managing uncertainty in projects, there has been more focus on dealing with threats than with opportunities (Ward & Chapman, 2003).

We believe that it is relevant and important to look at opportunities – the positive outcome of uncertainty adequately, because it can generate benefits to projects / organisations.

A project can be seen as a system. The system is basically instable and flexible at the start of the project, and it tries to achieve stability and order by the help of establishing objectives, sub-objectives and plans. This will reduce uncertainty of the system. And, the system becomes gradually more stable and controllable. Though the system becomes more controllable when it goes form the early phase to the execution phase, it becomes more rigid, and the flexibility with respect to changes and adopting new opportunities in later phases of the project therefore tends to diminish.

However, new opportunities can emerge at any time in a dynamic work environment. There can be new internal conditions (such as, higher level of competence, effective resources / work methods) and new external conditions (such as cooperation with new projects in the nearby area, which can lead the project to save money by, for instance, common procurement; new products in the market, which can lead the project to simplify its technical solutions) that the project did not consider when objectives and plans were established.

If these conditions are exploited effectively, then the project can deliver the product / service with the predetermined quality at a lower cost, or quicker than previously expected. Active involvement, knowledge and authority are required from the management in order to materialize the benefits of opportunities.

Here are two examples that can illustrate that opportunities can appear / created during the course of projects:

- Project E18 Ostfold – a road construction project – was assessed by quality assurance procedure (QA2) and given a cost estimation of approximately 163 million euro. When the initial contracts came in, a new analysis showed that the project, with a low probability, would manage to keep itself within the predetermined frame of cost. The analysis showed that the cost forecast was approximately 176 million euro. The project carried out a process with the focus on finding potential opportunities that could reduce cost. In the course of four hour time, opportunities were found and they were used to reduce the cost more than approximately 20 million euro.
- Project R6 – Construction of 3 government buildings – was at the phase of developing keys and lock-systems that could deliver safe and secure solutions. This process originally included among other things, design / project engineering, purchase and installation. But, the project participants found out that there was another project that was going on primarily in connection with key and lock-systems in government buildings. Then, the project R6 cooperated with the other project. This cooperation produced benefit for the R6 project; for instance, reducing cost related to their project engineering activities, and purchasing the key and lock-systems at a cheaper rate.

These examples were obtained in uncertainty analysis sessions in which a researcher from the PUS-project was actively involved (action research). These examples, along with theories (Hillson, 2004; Olsson, R., 2007), point out benefits of having adequate focus on opportunities in managing uncertainty in projects. One of the ways for project managers to deals with opportunities effectively and efficiently is cooperation with their project owners.

In order to discuss this issue, we shall categorise consequences of projects in 3 orders. These consequences reflect different objectives that are associated with the project.

Having a broader view on the consequences of a project

Consequences of a project can be seen in several dimensions; first, second and third order consequences. The first order consequences are the concrete result that the project is intended to produce (for example, constructing a hospital building with respect to time, cost and quality). The second order consequences are the effect of the project's concrete result (for example, applying new knowledge that has been gained by the people and organization(s) that were involved in the project, curing and taking care of sick people). The third order consequences are a larger, social impact (for example, better health care system, wellbeing, new business establishments near the hospital – kiosk, etc.)

Opportunities – 1st, 2nd and 3rd order consequences

Opportunities can be looked at with respect to different levels of consequences (see Figure 2). Opportunities can produce effects and benefits for stakeholders of a project. How an opportunity is viewed is dependent on the stakeholders; for example, a consequence of a project can be seen as positive by a stakeholder, while another stakeholder views the consequence negatively.

The first order consequences emerge within the framework of the execution of a project and deliverance of the project's result-objective. (Result-objective focuses on time, cost and quality). Opportunities are in this respect connected to achieving project's result-objective:

- Opportunities in terms of cost: The project can deliver more at the cost that was previously determined, or with the predetermined quality at a lower cost.
- Opportunities in terms of time: The project can deliver a predetermined product / service quicker than planned, without increasing the cost and with the predetermined quality.
- Opportunities in terms of quality: The project can deliver a concept that is better than the one which was originally agreed upon, within the same frame of time and cost. Operational solutions can also be considered here; for example, a project can deliver a product / service according to the predetermined frame of time and cost, and the delivery is more optimal to operate.

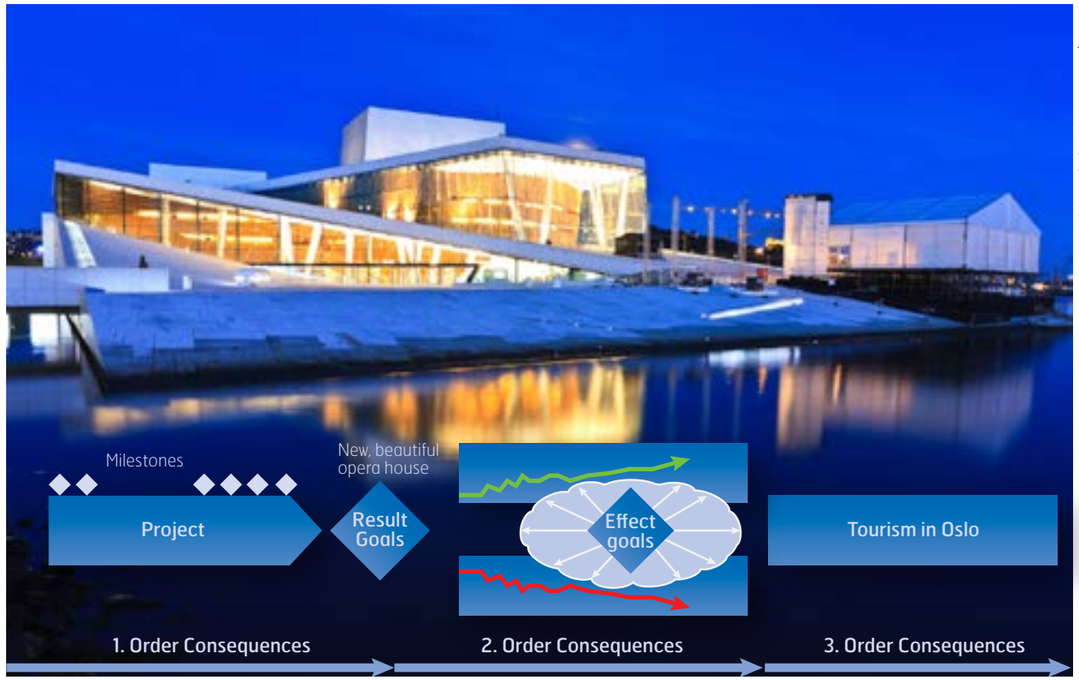

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Figure 2. 1st, 2nd and 3rd order consequences (Johansen, Jermstad & Ekambaram, 2009)

Project	First order consequences (Result-objective)	Second order consequences (Effect-objective)	Third order consequences (Society-objective)
The Opera house, Oslo	- A modern building where opera shows can be arranged.	- Having the possibility to apply the experience that the involved organisations gain in future projects.	- Tourism in Oslo / Norway - Town-development (Bjorvika)
Constructing the highway E6 Ostfold	- New, modern road	- Less accidents - Faster traffic-movement - Shorter queues.	- New firms / businesses; f. ex. gas station, grocery store, restaurant

Table 1. Examples of consequences

The second order consequences are the effects that emerge after the project is completed. These effects include benefits to the organisations that have been involved in the project, i.e., access to new markets and technology, development of new knowledge and competence within the respective organisations.

The third order consequences are broader effects of the project on the society. Opportunities in this regard encompass establishment of new organisations and services as the result of the completion of the project. An example in this regard is a construction project called Snowwhite project in the Finnmark region, Norway. When the construction project was completed and operations were begun, then the surrounding environment / society started to obtain benefited from it; for instance, there were new work opportunity for the local people, day care facilities for children, and schools.

Table 1 shows examples of first, second and third order consequences.

Now, we shall use the description of the 3 orders of consequences (the 3 different objectives that are associated with projects) to illustrates the role of project owner in handling opportunities in projects.

Cooperation between project managers and project owners

It is beneficial to have a broader perspective in managing projects. The broader perspective can be developed by establishing a good cooperation between project managers and project owners – with a strong involvement from project owners.

A project owner has rights to and is responsible for the project. Olsson, Johansen, Langlo, & Torp (2007) say:

> *"The beauty behind the concept of a project owner lies in the fact that a project owner has incentives for weighing costs against benefits for a project. Project owners are therefore expected to strive for project governance aimed at maximising the value from the project."*

The project manager focuses on achieving the result-objective of the project in accordance with the predefined time, cost and quality (1st order consequences), whereas the project owner focuses on ensuring the effect-objective as well as the society objective (2nd and 3rd order consequences).

Project managers and project owners traditionally deal with two types of information; project managers with detailed information (mainly projects' internal conditions – operational), and project owners with general / high level information (mainly, projects' external conditions – tactical and strategic). Establishment of a common understanding by combining and studying these two types of information can lead the involved parties to identify / create opportunities effectively in projects.

However, cooperation between the project owner and the project manager is not always a problem-free affair. The project owner and the project manager can have varying understanding of opportunities: what opportunities are and how one can use them in order to improve result-objective, effect-objective and society-objective.

Though there are challenges with respect to communication and attitudes, companies take certain measures in order to tackle the challenges. A study in the Norwegian telecommunication sector (conducted by the PUS-project) points out that there are training programs in which project owners and project managers learn about their roles, responsibilities and what they expect from each other. After the training programs, project managers seem to notice improvement in project owners' behaviour and in the collaboration. These training programs can be seen as arenas for reflecting on action and making sense of various situations.

Creative thinking

We see that there is a clear connection between creativity / innovation and the topic of opportunities in projects. It can be said that creative and innovative thinking can promote identifying and creating opportunities in projects. In this

Identifying and creating opportunities, materializing them and harvesting the benefits of them can also encourage innovative and creative thinking in organisations

regard, it is relevant to mention what Hillson says (2004, page 256):

> *"[...] techniques designed to stimulate or support creativity and innovation are well suited to encouraging organizations to think positively, see opportunities, and develop strategies to capture benefits."*

Brainstorming, scenario thinking and creation of artificial crises are some of the methods that can be used to promote creative thinking to identify and create opportunities in projects. These methods were applied by the organisations that have been involved in our research study on the topic of uncertainty in projects.

Identifying and creating opportunities, materializing them and harvesting the benefits of them can also encourage innovative and creative thinking in organisations (Ekambaram, Johansen, Jermstad, & Okland, 2010). We believe that the topic of opportunity in projects can contribute to the wider management field. The focus on opportunities can influence creating an organisational culture that promotes innovation and creativity; uncertainty can thus be seen as a potential source of generating opportunities, not as a condition that exclusively deals with threats. The lessons and experiences of how uncertainty is managed in projects can be transferred / transformed in order to make positive effects on wider organisational settings.

Examples from the industry

The Norwegian Directorate of Public Construction and Property Management (Statsbygg), in collaboration with the PUS-project, started its own development project called "Uncertainty management in Statsbygg" – in short, the SUS-project. And, Statsbygg worked closely with the researchers connected to the PUS-project. Through the cooperation with the PUS-project, Statsbygg has become a mature organisation when it comes to dealing with uncertainty effectively and efficiently. And, Statsbygg acknowledges it (PUS-project, 2011).

The SUS-project has 3 phases. They are:

- Studies in the case projects: The were 8 case projects, and methods and tools were tested in them; for example, a matrix for visualizing situations of uncertainty, risk register for monitoring uncertainty and monthly reporting of uncertainty in the case projects.
- Developing the systems – methods and tools: Based on experiences from the case projects, Statsbygg developed methods and tools. New governing documents were created, and a new role called "uncertainty coordinator" was established.
- Implementing the systems: As per October 2010, the tools were used by about 20 projects. Procedures, guidelines, templates and training programs were in use. Statsbygg's school offers courses and training for their employees.

In the beginning of 2011, the SUS-project won Statsbygg's innovation prize. A description that accompanied the prize says that the project has provided documentation of both threats and opportunities over time in projects, including effects and efforts related to them, and that the overview of uncertainty, provided by the documentation, gives both project managers and project owners more confidence in executing their roles in managing uncertainty in projects.

Another industrial example is Telenor (from the private sector). Telenor developed a tool called "Health check" in collaboration with the PUS-project. The tool has 20 questions that can be used to check how project participants experience their work situations. The questions can be used in different phases of a project – as a kind of an early warning system. The tool is now available at the website of the Norwegian Centre of Project Management (http://www.nsp.ntnu.no/) to its members. Telenor indicated its willingness to continue the work, which had been started with the PUS-project, through its "risk-forum" (PUS-project, 2011).

Contribution to academia

The PUS-project contributed to academia too. In this regard, 17 master degree theses and 11 student project theses were produced at the Norwegian University of Science and Technology (NTNU), Trondheim, Norway. Two doctoral theses were also connected to the PUS-project. Eleven journal articles and 22 conference articles were published during the 4 year period.

The academic contribution was in collaboration with the industry.

Concluding remarks

In this paper, we have described some major contributions that the PUS-project made to the industry and academia in Norway.

The PUS-project managed to create a positive culture that can promote effective and efficient uncertainty management in projects. Organisations such as Statsbygg and Telenor acknowledged the development of the positive culture in their organisations through the collaboration with the PUS-project and the need to involve project owner more in managing uncertainty in projects (PUS-project, 2011). The organisations involved in the PUS-project agreed on the relevance and necessity to pay adequate attention on opportunities, when they deal with uncertainties.

Furthermore, the cooperation between the PUS-project and the involved organisations, such as Statsbygg, illustrates how a research project attempted to create value in the industry – an example of collaboration between researchers and practitioners.

Acknowledgement

We sincerely thank Mr. Tor Inge Johansen (Chairman, the PUS-project), Ms. Ragnhild Aalstad (Project Manager, Statsbygg) and Mr. Helge Marheim (Project Manager, Telenor) for their support to the PUS-project and thus to the work related to this paper.

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The rolling wave scheduling problem

solved by the real options approach

This paper presents a methodology for the rolling wave scheduling. The methodology aims to manage the cost and risk of delay of the project by identifying the best schedule using the available information. The literature shows the absence of specific quantitative algorithms for the rolling wave schedule since most of the approaches are merely qualitative. Therefore it is necessary to define and test a new methodology to evaluate the overall alternatives. This new approach first lists all the possible schedules than evaluate each schedule with a real option based optimization model.
The methodology described has been implemented in Matlab, in order to perform the related sensitivity analysis. The results show how this approach is able to reduce both the expected cost and the variance respect to a not real option approach.

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Introduction

This paper presents a model for project re-planning using real options as a tool to value the information available to the Project Manager (PM). Traditional scheduling methods do not consider the possibility to include on the algorithm the information about uncertain events. This paper aims to fill this gap providing, describing and implementing a model able to consider the risks and the costs to hedge them. The application area of the model is the Rolling Wave Scheduling (RWS) i.e. the periodical short-term project rescheduling. The model aims to determine the best schedule based on the available information at the time of evaluation. The model's goal is to hedge the risk of delay through the possible rescheduling of Work Package (WP) and "exercises of options" available for the PM. The model manages the execution risk on the project when it is quantifiable and when actions to reduce the risk considered are available.

Literature review

Even if most of the projects deal with RWS only few authors provides quantitative algorithms. The main contributions are a set of guidelines to implement a well-structured process control project progress. Therefore the methodology presented in this paper relays mainly on the following contributions:

(Russell, 2003) identifies the re-planning as a sequence of steps based on measuring actual cost and schedule and comparing them with the budget values. The correlation between progress and costs is considered at single WP level.

(Ipsilandis, 2007) is focused on the scope of project management developing the concept of *timeboxes*. He analyzes the scheduling of repetitive project with a linear programming model multi-objective. The author proposes an optimization model to minimize an objective function which takes into consideration cost elements regarding the project's duration, the idle time of resources, and the delivery time of the project's units. The interesting aspect is the use of the algorithm in *timeboxes* and mathematical formulation of the problem of linear optimization.

(Georgiannis, Mavridis, Ipsilandis, & Stamelos, 2008) propose, starting from the timeboxes, a scheduling algorithm using interactive real options approach. They identify the problem as a problem of scheduling multi-objective, in which the PM has two options: (1) to stop the project, (2) to continue the project.

Real options derive from financial options, that had a very strong theoretical development since the papers of (Black & Scholes, 1973) and (Merton, 1973).

Such papers detail the theory of options, hedging instruments whose value depends on a certain underlying asset. Options are tools that give the right, not an obligation to perform or not an action (e.g. an investment like building a temporary roof, change a supplier, work on two shifts etc...) at a pre-determined price (strike price). There are several types of options; those used in this model are defined as call options which give their holder the right to buy the underlying security at a specified price.

Among the call options, the specific type of real options used this model is the "deferral option", i.e. it is expected that the PM has the ability to make an investment that can eliminate the negative event considered. The ability to exercise the option is held until the last possible moment, consistent with the theory of *vanilla (European) call options*. In that moment, if the value of this option is greater than the cost of its exercise, the option is exercised (hedging the risk), otherwise the PM take risk of the event.

It is hypothesized that there are means (i.e. options) to avoid the risk and the relative cost. For example, in case of risk of bad weather, it is assumed that it is possible to arrange a temporary roof and its cost. If the risk is a stroke it is possible to cover the risk with a wage rise. There are three main clusters of algorithm to evaluate real options (Dixit & Pindyck, 1994): Black & Scholes Model, Simulation and Binomial Model. The model used in this work is the binomial.

Model description

The "time windows" is the interval of time (some days, or few weeks) of the project analyzed with the method. The method proposed aims to answer to the following research question:

"How can a new updated schedule evaluate the risks in the time windows (and relative counter-measures) in order to increase the value of the project?"

Respect to this research question there are two main points:

1. to assess if the new schedule increases the value (i.e. decreases the expected cost, the cost variability, anticipated the delivery date etc...) respect to the existing one;
2. to evaluate the "options" embedded in the time windows in order to determine if it is worthy to exercise them.

As common in each scheduling problem there are three main assumptions:

1. all the WPs have to be executed;
2. to execute a WP requires a certain amount of resources. The resources available are constrained;
3. if the precedence constrains are respected it is possible to execute any of the WP available.

The final goal of the method is to minimize the "total extra-cost" composed by the following addendum:

- delay cost: for each day after a certain deadline it is necessary to define a fee;
- the cost of exercises the option.

Therefore, comparing different schedules and different possibilities of exercises the options available the method has to return the schedule with the relative options to exercise in order to minimize the delay and exercise cost.

The inputs required are:

- WPs' characteristic: duration, early start, float, resources usage;
- Total resources availability;
- Precedence constraints among WPs;
- Final deadline and delay cost [money/time];
- Risk-free rate (r);
- Risk described by probability and magnitude (number of days);
- WPs jeopardized by the risk;
- Counter-measure to avoid the risk and its cost.

While the output provided are:

- List of options to exercise and options to drop;
- Optimal schedule;
- Total cost of the solution.

Problem Solving

General overview

Figure 1 summarizes the method presented in this section.

Identification of WP

This phase lists the WPs included in the time window considered.

Identification of Feasible Schedules

The method (Matlab based) creates all the possible schedules. From a computation point of view this is the most time consuming step. Since the method creates and evaluates all the possible schedules it could be defined as an "optimal enumerative algorithm".

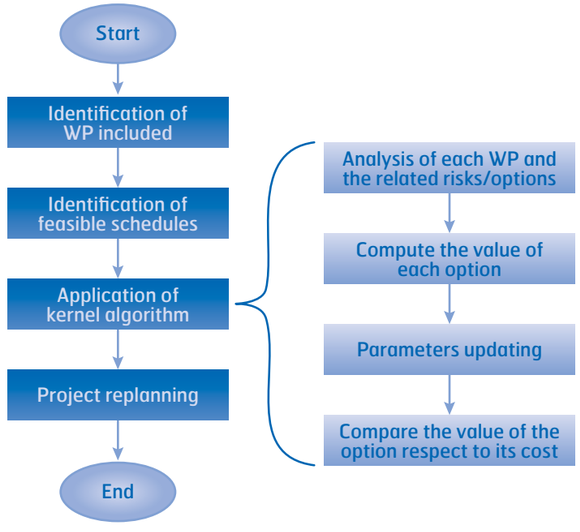

Figure 1. Method

Application of Kernel Algorithm
For each feasible schedule identified in the previous steps the Kernel Algorithm (presented in the next section) evaluate the total cost. This cost, called "Rolling Wave Scheduling Cost (RWSC)" represents the main attribute of each schedule. The schedule with the minimum RWSC is the best schedule.

Project Replaning
The method provides the news schedule with the list of options to exercise

The Kernel Algorithm

The options embedded in a project are considered as "European call options" since can be executed in each moment but has the maximum value at maturity[1]. To use the real option algorithms it is necessary to "translate" the PM parameters in real option parameters:

- The *Option underlying (S_t)*, is the evolution of the delivery date under different scenarios
- The *strike price (X)* is the delivery date at the time now.

The evaluation of each option is divided in four main steps

STEP 1: analysis of each WP and the related risks/options

This steps analysis each WP to assess if it is jeopardized and if there are options available to hedge the risk.

STEP 2: compute the value of each option

The method used to evaluate the option is the binomial tree. The method implies the evolution of both underling value and options value according to positive and negative probabilities i.e. it performs an evaluation for each scenario assessing what happen if the risk occurs or not.

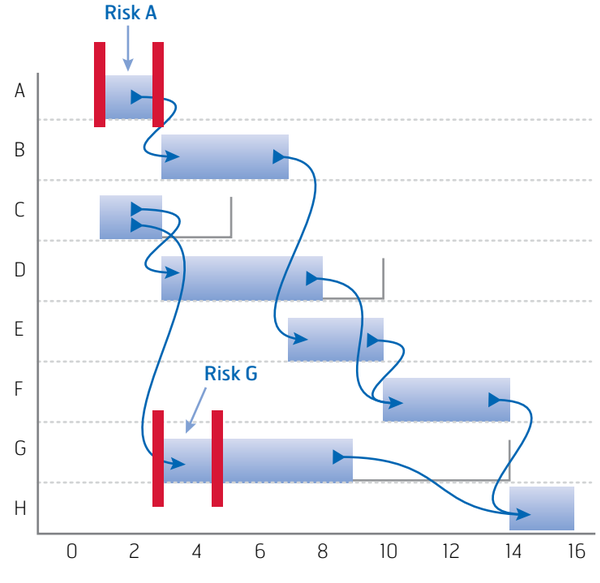

Figure 2. Initial Early Start schedule

The time bucket is one day (or the units of measure used in the project). The underlying tree is defined starting from the S_0 (expected delivery date) at the time now. There are two possible evolutions:

1. A single branch if there are not risks or the risks are neutralized. Without the risk the duration is deterministic
2. A ramification of two branches if the risk can occur or not

As a consequence the underling tree shows the delivery date (*underlying (S_t)*) according to the different paths. It is worth to exercise the option if it provides a positive effect. If building a temporary roof avoids the risk from the bad weather the positive effect is the number of days "saved". This value can be easily computed by subtracting in the final value for each scenario (considering the risk) by the value of a scenario "without risk". The remaining nodes are calculated with a back-forward approach using as *strike price (X) the delivery date at the time now*.

STEP 3: parameters updating

The Kernel algorithm uses three parameters

1. WP state: This indicator considers the "WP float" i.e. compares the duration of work remaining (standard value, risk free) respect to the same value plus the WP float (computed with the CPM, early start). Larger the WP float less valuable is the option since a delay does not increases the duration. A float equal to zero (or negative) implies that each delay will increase the fee to pay.
2. Project state: This indicator considers the "project float" i.e. the float between the duration of the project computed with the CPM, early start and the contractual delivery date.
3. Global state: This indicator merges the two previous indicators and it is used to compute the indicator used in the option valuation.

Since the algorithm is executed at different time it is necessary to update them to perform each evaluation

STEP 4: Compare the value of the option respect to its cost

The first step is to convert the value embedded in the option in monetary terms with the formula

$$\alpha = \textit{option payoff} * \textit{delay} * \textit{Global state}$$

This value is compared with the cost of exercise the option

$$\beta = \alpha - \textit{excercise cost}$$

$$\textit{if} \begin{cases} \beta > 0 \text{ it is worth to excercise the option} \\ \beta > 0 \text{ it is not worth to exercise the option} \end{cases}$$

Now the method can provide the new schedule with the following information:

- The new schedule of each WP
- Which option to exercise

# WP	Float availability	Number of configurations	Number of feasible schedules	Number of optimal schedules	Resolution time [minutes]	Evaluation of optimal schedules time [minutes]	Total time [minutes]
8	9	54	32	12	0,04	0,02	0,06
8	14	648	384	144	0,21	0,02	0,23
8	22	4.536	3.504	1.080	0,90	0,73	1,63
8	22	2.732	864	432	0,76	0,06	0,82
18	16	2.916	1.024	480	3,22	0,12	3,33
18	18	3.724	2.916	972	4,01	0,56	4,57
20	23	17.496	5.568	2088	145,09	6,48	151,57
28	29	223.864	111.486	4.448	250,09	15,15	265,24
35	39	8.503.056	3.785.693	986.632	924,85	79,45	1004,30

Table 1. Time required to solve the problem

The application: results and risk management

This paragraph shows how the algorithm presented in section 4 deals with risk management. The algorithm, developed to minimize the "excepted total cost" can even reduce the variability of the delivery date and therefore is a useful Risk management tool. For example, let's consider the project in figure 2 jeopardized by two risks:

1. Risk A
   - Impacts on activity A
   - Can occur the day 1 (70% probability) and the day 2 (40% probability)
   - Strike price of option A to cover the Risk A: 20.000Euro
2. Risk G
   - Impacts on activity G
   - Can occur the day 2 (80% probability) and the day 3 (70% probability)
   - Strike price of option B to cover the Risk B: 5.000 Euro

Without any countermeasure this project has:

- An earliest delivery date the day 15 (32% probability),
- Mean/expected delivery date the day 16 (39% probability)
- Latest delivery date the day 17 (29% probability);
- The standard deviation is 0,784 days (results obtained with the CIM - Controlled Interval and Memory - or Montecarlo approach).

The model can now perform the analysis:

- There are 32 feasible schedules;
- Among these 32 schedules 12 of them minimize the total rolling wave cost, i.e. have the same minimum cost. The model chooses the early start schedule from the optimal solution.
- The best solution implies the exercising of option A and to delay the activity G without exercise its option. The risk on WP G cannot occur since the WP has been delayed;
- The total cost of this solution is 32.000 (include the overload cost for resources).

The schedule is risk free and lasts 15 days (figure 3). The risk A has been neutralized by exercising the option and activity G has been postponed.

A set of parameters has been investigated in order to assess the time required to the algorithm to solve the problem and usually:

- the optimal schedules are *1/3* of the feasible schedules;
- the time required to generate the feasible schedules is about *8/10* of the total time.

From table 1 it is clear how the computational cost of the algorithm is mainly due to the generation of feasible schedules. This is the main disadvantage of using an enumerative algorithm.

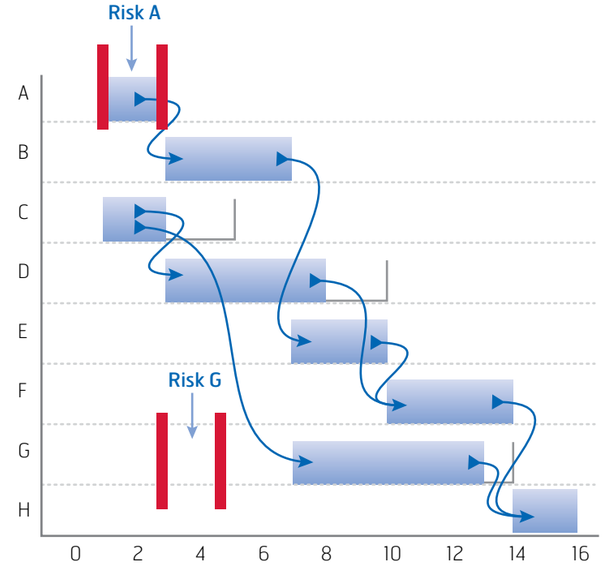

Figure 3. Final Early start schedule

Conclusions

This paper presented a model for the project's rolling wave planning using real options as a tool to exploit the information and the degrees of freedom owned by a PM.

Each day a PM faces many risks and there are options to overcome them. Some options could be free of charge, as rescheduling some not critical activities, other are costly (as building a temporary roof). Therefore a tool is required to identify the optimal schedule with the relative options to exercise. The method presented in this paper aims to support the PM in managing the risk in the RWS. The literature review showed as the real options have the characteristics to become a valuable tool in project re-planning, however it is necessary to shape them according to the specific PM field.

The main assumptions of the model are:

- The underlying was identified in the delivery date of the project, and consequently it was assumed that the PM owns one or more options on its evolution.
- The financial reference option has been identified as a European call option without dividends, in particular a deferral (real) option.

The scheduling algorithm is associated to an optimization model with an appropriate objective function that has to be minimized: the decision variables are measured in monetary terms: cost of option, resources and risk assumed. The model presented allows an efficient and effective risk reduction.

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1 - A European option may be exercised only at the expiry date of the option, i.e. at a single pre-defined point in time. An American option may be exercised at any time before the expiry date. Even if the options are American the algorithm treats the option as European. Let's consider the stroke risk. Until the last moment it is not necessary to give the pay raise since the treat of stroke can be a bluff or can be avoided with other cheaper solution.

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