27th IPMA World Congress

Toward project and program management paradigm in the space of complexity: a case study of mega and complex oil and gas development and infrastructure projects

Hiroshi Tanaka *

Japan Advanced Institute of Science and Technology, 1-1, Asahi-dai, Nomi-shi, Ishikawa-ken, 923-1211, Japan

Abstract

The author published his research paper at 26th International Project Management Association World Congress in which he argued that the monodukuri industry, or broadly hard systems project industry, is being affected either positively or negatively by a variety of complexity categorized by P.E.S.T.L.E. (political, economic, social, technological, legal and environmental) factors and proposed a conceptual model of an enterprise viability system reinforced by meta program management. This paper is based on the author’s continuing meta program management research and contextual analysis of the project industry, traces how the typical events discussed under each of the PESTLE factor categories have behaved thereafter to confirm the validity of impact descriptions, and presents a case analysis of current mega oil and gas development and complex infrastructure projects for dominant characteristics of project operations. Then new thoughts of project and program management in the space of complexity of the project industry are proposed as the first step to build a new management paradigm, which has been qualitatively induced by the cases under study and are deriving from existing research results on complex projects.

The new thoughts include meta program management to balance multi objectives; knowledge and stakeholder integration to create complex projects; finance planning and structuring as an essential ingredient of materializing complex projects; management of extreme projects; and contingent risk management.

Keywords: Project industry; complex projects; meta program management; knowledge integration; new paradigm of project management

© 2014 The Authors. Published by Elsevier Ltd.
Selection and peer-review under responsibility of the IPMA.

* Pr. Hiroshi Tanaka Tel.:+81-42-734-7358; fax:+81-42-734-7358.
E-mail address: hirojpmf@wta.att.ne.jp
1. Research background and framework

While we are experiencing a slowdown in project investments in the mature economies caused by the global economic recession and the tight-rope operation of the European Monetary System, investments in oil and gas development by multi-national oil companies and major national oil companies, and in social infrastructures by governments and private funds, in the emerging and developing economies, are steadily increasing according to the World Development Indicators database (World Bank, 2013), the report of the World Economic Forum 2012 on strategic infrastructure (World Economic Forum, 2012), the infrastructure development report of the Asian Development Bank (Asian Development Bank, 2009) and the annual reports of the multinational oil companies. It is noted as we observe in Section 3 of this paper that financial and physical sizes, as well as complexity, of oil and gas and infrastructure development projects have been upscaling exponentially over the past five years or so.

However, project management research has not caught up with this rapid development of the project industry, or the industry related to social infrastructure and natural resources development due to a time lag usually occurring between the state of the projects and scientific research based on data or a lack of researchers having live knowledge of the industry. This fact has motivated the author to initiate developing a conceptual framework to fill the knowledge gap on project and program management paradigm on contemporary complex projects. This paper is based on the author’s qualitative analysis of the state of the project industry dealing with recent major-sized complex projects which are reported in economic newspapers, journals and public or business firms’ websites; and contextual interpretation of the dimensions and characteristics of those projects, by using the author’s 42-year experience in the engineering-procurement-construction (EPC) industry for oil, natural gas and infrastructure projects, his recent research on meta program management, and related recent research on project complexity by others.

The research step is as follows:
1.) Continuing monitoring of the complexity events listed in the author’s 2012 paper (Tanaka, 2013) for the verification of impact analysis,
2.) Review on typical ongoing mega oil and gas and infrastructure projects for multiple project objectives, unique features and complexity factors, and extraction of dominant characteristics of project operations,
3.) Literature review on project management research on complex projects, and
4.) Deriving new thoughts on program management that should be applied to major-sized and complex energy and infrastructure development projects as the first step to build a new management paradigm.

Considering that despite the professional and academic demarcation between a project and a program, as most industry branches do not use the term “program” even if a major-sized project as described so is actually or virtually a program according to the professional definition, both complex projects and programs are hereafter referred to solely as “projects” with an adjective “complex”, but management of these projects is referred to as “program management” as managing complex projects should be distinguished from project management focusing on delivery which is mostly based on positivist management processes and operational techniques.

Here, the definition of complex projects borrows that of “Complex Project Management Competency Standards Ver. 4.1” and P2M (PMAJ, 2007). Complex projects are highly strategic, emergent and adaptive systems comprising either a major-sized project or a program that are characterized by an embodied holistic entrepreneurial mission; high-profile project modeling as a holistic project mission entrains high uncertainty in scope definition, hence scalability, while adapting to changing environments; recursiveness as they mobilize a variety of stakeholders having multiple objectives, enabling means (technology, etc.), and financing options; and nonlinear feedback loops.

2. Behaviors of complexity events in the project industry

Tanaka (Tanaka, 2013) listed typical complexity events in the world that are affecting the monodukuri industry by categorized P.E.S.T.L.E. (political, economic, social, technological, legal and environmental) factors, nature of the respective events’ complexity and their implication to the industry. The monodukuri industry was defined as the industry of manufacturing and systems environment integration. For analysis purposes of this paper, the first
element of the definition, manufacturing, is dropped, and the industry of systems environment integration is reworded as the project industry. The listed complexity events, relevant to the project industry, have further been monitored as summarized below based on a variety of media reports -- only news reported by plural media are depended on -- to confirm relevancy of the analysis; the code within a parenthesis indicates the pertinent category of the PESTLE factors.

New state leaders in France, Russia, China (P): The new state heads of France, Russia, China and Japan (Japan not listed in the 2012 paper) have all announced and are committed to positive infrastructure project export policies: France, under state leadership, is stepping up its systems export to the emerging and developing economies and promoting ties with Japan in infrastructure exports with its early results including Mitsubishi Heavy Industry-AREVA joint venture (with GDF Suez)’s securing the US$ 20 billion contract for Turnkey’s No. 2 Nuclear Power Plant in Synop on the Black Sea, announced in May 2013, and TECHNIP-JGC Corporation consortium’s award of Yamal LNG Export Terminal on the Russian Arctic Sea which is estimated to cost US$10 billion, announced in April 2013; Russia is committing the Arctic zone oil and gas development, Russian Far East development among other major project investments; China has promised additional development packages to African countries during New President Xi Jinping’s official visit to the African countries in April 2013; Japan is stepping up packaged infrastructure exports to emerging and developing economies and participating in Russian natural gas developments, which all in all will boost the project industry - Prime Minister Abe himself is performing top state sales of Japanese infrastructure and high technology.

Iranian sanction (P): The previously one of the most active oil and natural gas project markets in the world, of Iran, is totally frozen due to the political and economic sanction to the country.

Arab Spring (P): Foreign project investments are further being stalled in the countries concerned and a backlash of the Arab Spring has been manifested in some project scenarios.

Myanmar “early” spring (P): Both Western and Asian project interests, viz. investors, developers and contractors, are lining up in Myanmar eyeing for a new infrastructure development market planned to grow fast.

Persistent worldwide economic recession (E), EURO crisis (E), Escalating presence of BRICS, ASEAN (E), Aggressive resources hunt by emerging economies (E): The current primary marketing focus of the infrastructure project industry based in EU and Asia is on the BRICS and ASEAN countries, which in turn are hunting natural resources in part of BRICS (Russia, Brazil), African and Central Asian countries.

Remarkable shortage of infrastructure in fast growing countries (E): The countries in Asia (Southeast, South and Central Asias) fast-growing in economy entertain evenly serious shortage of infrastructure to support the rapid increase of population and urban development, which fact has prompted the respective governments to formulate specific infrastructure augmentation plans. The high hurdle to the implementation of the government plans is finance gaps or infrastructure needs which cannot be financed by public sector -- refer to paragraph 4.3 of this paper.

Commercialization of shale natural gas production (T): The success in the commercialization of shale gas production in the U.S.A. has drastically changed the long-range scenario of fossil fuel supply in the world; led the U.S.A. to one of the top positions in the natural gas reserve and production; and increased the competitiveness of the U.S. manufacturing industries. Its effect of pulling down the world prices of natural gas has affected Russian supply of natural gas to EU and pushed the country to accelerate sanctions of four mega-sized liquefied natural gas (LNG) production projects in Russia.

3. Dimensions and characteristics of mega and complex projects

To elucidate the sizes and unique complexity dimensions at a glance, typical mega projects in progress in the oil & gas and infrastructure sectors is given in Table 1. The information sources are shown in the footnote. The table indicates the commonly used title of the project with a project ID code, host country of the project, estimated investment value of the project, planned completion time, project features inviting complexity and information source reference to the footnotes. As seen, most use the title of projects, and not programs, though they are programs according to the definition of the project management discipline.
Table 1. Typical recent mega and complex energy development and infrastructure projects in the world

| Project Name                                      | Host Country  | Planned investment amount (B: billion) | Planned completion          | Project features                                                                                                                                                                                                 | Data Source |
|--------------------------------------------------|---------------|----------------------------------------|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| [Project a.]
Pearl GTL Project                               | Qatar         | US$18 to 19B                           | 2013 (production started in 2011) | The world’s largest natural gas to liquids (GTL) production complex to produce alternative high-value petroleum products; joint venture of Shell and Qatar Government; program management contract; 10+ prime contract packages, 56 thousand project personnel from 60+ countries; excellent project performance and governance; viability of alternative energy solutions established | 1           |
| [Project b.]
Ichthys LNG Project                              | Australia     | US$34B (Phase I)                       | 2016 (ongoing)              | 8.5 million tons/year LNG production and export (onshore/offshore); multi investors, multi contractors; remote site; own source of LNG for Japan with nuclear power plants shutdown | 2           |
| [Project c.]
Vladivostok LNG Project                           | Russia        | US$36B                                 | 2018 (investment decided by Gazprom) | 15 million tons/year LNG production and export (offshore/offshore facilities); multi investors, multi contractors; remote site; Russia to increase LNG export | 3           |
| [Project d.]
Cabo Delgado LNG Project                          | Mozambique    | US$10 to 15B                           | 2018 (investment decided: under front-end design) | 10 million tons/year LNG production and export (onshore/offshore); multi investors (US-Japan) joint venture, multi contractors; remote site | 4           |
| [Project e.]
Delhi-Mumbai Industrial Corridor Project          | India         | US$90B                                 | Phased (ongoing)           | Accelerated national economic development; India-Japan government-to-government strategic partnership program; debottlenecking trunk export traffic systems with a high-speed freight train network & associated infrastructure development; industrial clusters; flagship eco-smart cities; multi objectives, multi-layer state program and multi stakeholders | 5           |
| [Project f.]
Russian Arctic Oil and Gas Development Program    | Russia        | US$500 to 700B                         | 2020 (partially ongoing)   | Arctic oil and gas fields development (100 billion tons oil equivalent of potential resources); racing against ice-breaking offshore oil & gas development technology; two base-load LNG production complexes, associated infrastructures; extreme projects at super-remote sites | 6           |
| [Project g.]
King Abdullah Economic City                        | Saudi Arabia  | US$30 to 86 billion                    | 2020                      | Futuristic mega city with a seaport, high speed railway, industrial valley, central business district, residential areas, educational zone, resorts; multi objectives, multi investors, multi owners, multi developers | 7           |
| [Project h.]
Russian Far East Region Overall                    | Russia        | US$110                                 | 2025                      | Modernization of the Siberian railroad systems, ports and other trade facilities, city infrastructures; industrial estates; energy | 8           |
| Project Code | Project Name                              | Country | US$ (Estimated) | Years     | Description                                                                 |
|-------------|-------------------------------------------|---------|----------------|-----------|-----------------------------------------------------------------------------|
| i.          | Moscow International Business Center Project | Russia   | US$40B         | 2018      | Urban infrastructure for the New City - new traffic systems, eco energy, city water/waste management systems; national prestige; multi developers, multi owners, multi finance sources |
| j.          | Masdar City Project                       | UAE-Abu Dhabi | US$18B        | 2020-2025 | Futuristic eco-smart city to test the country’s future growth and diversification strategy; race against evolving technology |
| k.          | Tangshan Smart City Project               | China    | US$800B       | 2025-ongoing | Futuristic eco-smart community including an industrial valley; establishing a leading model to demonstrate national prestige |

Data source:
1. Shell global Pearl GTL website http://www.shell.com/global/aboutshell/our-strategy/major-projects-2/pearl.html, Hydrocarbons – technology website http://www.hydrocarbons-technology.com/projects/pearl/
2. INPEX Ichthys LNG Project website http://www.inpex.co.jp/english/ichthys/index.html, http://gateway.icn.org.au/project/451/ichthys-lng-project
3. Gazprom project website http://www.gazprom.com/press/news/2013/april/article160730/
4. Anadarko website http://www.anadarko.com/Investor/Pages/NewsReleases/NewsReleases.aspx?release-id=1769213
5. DMIC Project home page http://delhimumbaiindustrialcorridor.com/
6. Is Russia ready for Arctic challenges, Petroleum Intelligence Weekly 29/03/2013 issue http://www.energyintel.com/Pages/About_PIW_Datasource.aspx
7. Offshore oil and gas development in Russian Arctic zones http://gasoilpress.com/dgir/dgir_detailed_work.php?DGIR_ELEMENT_ID=280&WORK_ELEMENT_ID=5565
8. King Abdullah Economic City home http://www.kingabdullahcity.com/
9. Moscow Approves New Funding to Develop Far Eastern Regions http://www.jamestown.org/single/?no_cache=1&tx_ttnews%5Btt_news%5D=40726&tx_ttnews%5BbackPid%5D=381&cHash=2575a465b2ae18609c22b7b3c1bb8a8
10. Project brief http://www.designbuild-network.com/projects/mibc/
11. Program home http://en.tswstc.gov.cn/news_detail/newsId=6d95ed4a-b72c-4573-b7c0-0bd56add0a4e.html

Note: some estimated project costs are taken from parallel news sources

Salient characteristics of these mega projects that augment complexity include (the codes within parentheses refer to the corresponding project codes in the table):

- **Requirements of huge investment costs** which per se present a significant source of great risk and mandate innovative finance engineering and risk management (project a. through k.)
- **Multi objectives** entertained by the projects, e.g. all or most of, enhancing national prestige, creating eminent future values, up-scaling new or alternative technology, investment return (project a. through k.)
- **Multi owners and investors** from multi countries required to meet an enormous fund requirement or to combine source technologies and expertise to compose a complex project (project a. through k.)
- **Multi contractors** from multi countries to reap on combined benefits and to hedge risks inherent in awarding a prime contract to a single contractor as well as to couple export credits provided by multiple countries as tied to top-tier contractors of the countries (project a. through k.)
- **Multi vendors** from multi countries to realize technologically right and most economical sources (project a. through k.)
- **Tens of thousands workforces** from multi countries to meet a required quality and quantity of skilled construction workforces (project a. through k.)
- **Compounding emerging technologies** as in eco-smart community development that mandates races against technological advancement (project e. through k.)
- **Uncertainty associated with project implementation** over an extended period of time, such as changes in PESTLE factors and resultant scalability (upward or downward) or risk of project cancellation after project start (project a. through k.)
- **Logistic challenges**, especially on mega projects at remote sites (project a. through k.)
4. New thoughts of project and program management toward a new management paradigm

Based on the analysis of the characteristics of the mega and complex projects reviewed above, new thoughts of (project and) program management are proposed by the author. These new thoughts are preliminary and should evolve with further feedbacks from these mega projects to eventually build a new adaptive management paradigm.

4.1. Meta program management to balance multi objectives

To manage mega and complex projects with numerous interactions of complexity factors, we need program management beyond program management as traditional project management and program management founded on positivist management approaches and operational techniques, e.g. for project governance, cannot deal with projects characterized by multi objectives and multi layers of stakeholders with specific interests which are not always well aligned each other, progressing technology, uncertain project environment and, all in all, scalability as projects pursue evolving definitions. All of the above-listed projects have many of such complexity profiles as a degree of disorder, uncertainty, non-linearity, irregularity, instability, requirement for innovative and highly creative thoughts, multiplicity, scalability, recursiveness, requirement for management by praxis (and not by process), requirement for heuristic logic, directional complexity such as unshared goals and paths and temporal complexity such as results from unanticipated environmental impact (Tanaka, 2013). Bredillet (Bredillet, 2008). states that project management needs to be understood as a complex discipline because it aims to deal with complex, uncertain, ambiguous reality. In mathematics, since Ashby (Ashby, 1958) and the law of requisite variety, it is well known that to control a complex system with n dimensions, you need an n+1 dimensional system. The available control variety must be equal to or greater than the disturbance variety for control to be possible. The author regards the following three methodologies as basis of developing a meta program management framework.

Complex Project Manager Competency Standards Ver. 4.1 (International Centre for Complex Project Management, 2012) provides valuable insights into complex projects by stating these standards move away from traditional philosophies, approaches and languages, which cannot adequately describe complex projects; instead these standards use a Systems Thinking philosophical approach and methodology. The standard views provide insights from multiple perspectives, that together provide holistic understanding of the project management of complexity, stresses using multiple views and behaviors suited to complex sets of interactions arising from cognitive and emotional responses to dynamic conditions.

Tanaka (Tanaka, 2013; Burkov, et al. 2011) defines meta program management as a meta framework of program management beyond the traditional program management and is for organizations’ strategy implementation to apply their organizational resources and capabilities for attaining major capital investments or carrying out major innovation initiatives for enhanced organizational value and/or any form of transformation while responding flexibly to changes in the ecosystem. This concept of meta program management reflects the meta-method, or “MAP - Management and Analysis of Projects” - aiming at providing effective and efficient structure and process for acting and learning in various complex, uncertain and ambiguous managerial situations of projects, programs and portfolios (Bredillet, 2008), and embraces program visioning and conceptualization founded on a holistic mission carrying multi objectives; planning and modeling; structuring; implementation; and the exploitation of program products, as against the traditional program management which means managing a collection of projects that are organically combined with each other and hence could better be managed in a combined form. This category of meta program management should serve as a development and planning framework for complex projects in which a project is seen as a politico-socio-techno-economic system (Bredillet) as reviewed in Section 3 above, and project modeling is not straight forward and must pursue series of simulations based on a holistic program mission coming from an organization or jointed organizations’ strategy to craft unique and significant future values and to cope with changing PESTLE factors. It is observed that Tanaka’s meta program management
model is active in the Japanese project industry which is participating in projects a. to f. and h. to k. of the above project table, in such aspects as (Burkov et al., 2011):  
- Engineering driven projects that require ingenuity to a varying degree,  
- Continuous project development by combining diverse technology, engineering disciplines, management methods and finance engineering in dialectic environment,  
- Heavy use of “ba” theory (Nonaka, 1991) where program/project participants and other key stakeholders contribute to collaborative knowledge and hence value creation through modeling, practicing, learning and feeding back, and,  
- Use of conventions for front-end planning of a program/project in unique environment

Morey (Morey, 2011) refers to meta-program management as a new approach to drive momentum and achieve coordinated outcomes across large complex public infrastructure programs, from his experience in managing a complex alley of public infrastructure program in South East Queensland, Australia. He defines meta program management as “a centrally sponsored group of programs and projects that are delivered by a number of discrete self-governing organizations, and centrally coordinated to achieve outcomes that are of strategic importance”. This meta-program management model should find its utmost value in a cluster of government development programs under a holistic, strategic growth policy of a certain country or region/state.

4.2. Knowledge and stakeholder integration to create complex projects

In project management as a complex integrative field (Bredillet, 2004), knowledge-based management is crucial. Bredillet relates meta management in project context to the effect that respectful on the various project management perspectives in presence, while providing an integrative ontological and epistemological framework the meta approach is about designing a contextual structure that:

- Provides a privileged place for project (and program) managers, project team members and stakeholders to act and learn,
- Facilitates this praxis through a specific meta-method, one of the underlying paradigms being that there is a co-evolution between the subject/actor and his or her environment (praxeological epistemology) and,
- Enables to generate a specific convention (configuration of order) and some kind of stability to cope with uncertainty and ambiguity.

Integration of multiple elements of knowledge held by multiple stakeholders can be illustrated in Fig 1. with reference to Kosaka’s three dimensional, knowledge fusion space model (Kosaka, 2010).

![Fig. 1. Meta program management space as a platform of knowledge integration](image-url)
A meta program management space serves as a platform of knowledge and stakeholder integration. Knowledge elements required to realize a program design based on a holistic program mission, characterized by resonance to PESTLE trends, are integrated on a program modeling space called a mission-profiling platform. Knowledge structuring and integration is performed as a function of a.) existing knowledge elements and identified new knowledge required to meet the program design, b.) stakeholders possessing enabling means, including knowledge elements, funds (financing abilities) and management capabilities, c.) financing options, and d.) program delivery alternatives such as front-end engineering (FEED) rolled over to engineering, procurement and construction (EPC), design-build-own and public-private-partnership (PPP). On major-sized, complex projects, knowledge spiral (Nonaka, 1991) is realized through a program mental space as a platform of shared context in motion for collaborative knowledge and value creation (Burkov et al., 2011).

4.3. Finance planning and structuring as an essential ingredient of materializing major-sized projects

No projects are materialized without funds procured for a particular project. For instance, according to Asian Development Bank, in Asian countries alone (except Japan), the total required investment amount for infrastructures, including those for energy, telecommunications, transportation, water and other social services, planned by relevant governments, amounts to US$10 trillion or 5 to 6% of GDP in 2020, as drastically increased from US$4 trillion in 2010; however, finance gaps, or infrastructure needs which cannot be financed by the public sector, of US$750 billion per year, are anticipated during the 2010-2020 period (Asian Development Bank, 2009).

Except for “P2M - Project and Program Management for Enterprise Innovation Japan (Project Management Association of Japan, 2007), no chapter or section is dedicated to finance planning for projects/programs in the project management and program management standards used globally. Program managers of complex projects need fundamental knowledge of finance and involvement in finance scheme planning although professional transactions of finance are conducted by finance specialists. The knowledge in question include that on alternatives of financing for projects, e.g., combining direct project investments by owners of component projects; official export credit(s) by export credit agency (ies), including syndicated loans; government development funds; project finance; public-private-partnership (PPP) as well as on structuring multi-source financing packages. Also, financing scheme development in relation to risk-based project investment decision is an essential ingredient of new program management paradigm.

4.4. Management of extreme projects

There emerges an increasing number of mega resources development projects involving extreme project implementation conditions at remote locations such as oil and gas field development in deep seas, oil sands and shale oil development at remote sites such as deep North Canada and Siberian basins, and oil and gas development in the Arctic zone. These extreme projects require unconventional degrees of care and measures to protect human safety in rough project execution environment, habitat and other natural environment and built facilities; prepare against attack by natural perils as well as mandate heavy planning and problem solving of project logistics. Continuing feedback of related experience is needed to build a body of knowledge of managing extreme projects as part of meta program management.

4.5. Contingent risk management

The mega and complex projects involve unique and systemic risks, including those not experienced by project and program management to date, and cannot rely on traditional risk models. Traditional risk models perceive risk as primarily objective and identifiable, and utilize primarily reductionist, linear processes such as mathematical and statistical models (Kämpf et al., 2011).

We see a number of research papers, recommended practices and industrial state reports published recently regarding unique risks and risk management in specific situations of complex projects such as value of flexibility in managing uncertainty in oil and gas investments (Begg, 2002); risk management in the Arctic offshore (Kämpf
et al., 2011); offshore oil and gas development in Russian Arctic zones (Nikitin et al, 2006); risk management of shale gas developments and operations (Det Norske Veritas AS, 2013); risk management on (Canadian) oil sands (Canadian Oil Sands, 2012); cross-cultural project management on major-sized global oil and gas plant projects (Tanaka, 2007); global infrastructure investments in times of crisis (Lin, 2012); risk management challenges for complex infrastructure projects (Holmes, 2011); manageability of complex construction engineering projects (Leitejen, 2009); transition from comparative risk assessment to multi-criteria decision analysis and adaptive management in complex environmental policy design (Linkov, 2006); key principles of strategies and principles in leading complex projects (Obelensky, 2013). Of these, the following two research literatures are considered to provide high quality input to a new paradigm of contingent risk management for complex projects.

M. Kämpf and S. Haley of University of Alaska Anchorage, in their paper “Risk Management in the Arctic Offshore: Wicked Problems Require New Paradigms” (Kämpf and Haley, 2011), points out the flaws of traditional risk models for complex projects and examines how various groups with interests in the Arctic offshore define risks. The findings link the wicked problem framework - that of problems that are unstructured, complex, irregular, interactive, adaptive, and novel - and the emerging paradigm of project management of the Second Order, ”PM-2” (Saynisch, 2010). The research synthesizes literature on the topic to offer strategies for navigating wicked problems, provide new variables to deconstruct traditional risk models, and integrate objective and subjective schools of risk analysis.

I. Linkov, et al. conducted a comprehensive research on environmental risk assessment and decision-making strategies over the last several decades (Linkov, et al., 2006) and argued that although comparative risk assessment (CRA) has mainly been used in environmental risk assessment over the decades, as CRA lacks a structured method for arriving at an optimal project alternative, multi-criteria decision analysis (MCDA) provides better-supported techniques for the comparison of project alternatives based on decision matrices, and it also provides structured methods for the incorporation of project stakeholders' opinions in the ranking of alternatives, and that the inherent uncertainty in our ability to predict ecosystem evolution and response to different management policies requires shifting from optimization-based management to an adaptive management paradigm. The author supports this concept of a combination of MCDA and adaptive management as it has applicability to complex energy development and infrastructure projects planned under multiple objectives and often conflicting stakeholder interests and needing highly adaptive management to PESTLE environment which is common to all of the listed case projects.

5. Conclusion

This paper expands the existing research on complex project management and meta program management. It verifies the nature of complexity of major-sized projects in the oil and gas development and infrastructure industry, presents case studies of current global mega projects for identifying discriminant characteristics contributing to unique project complexity and as a result qualitatively proposes new thoughts of project and program management in the complexity space in the related project industry. The new thoughts include meta program management to balance multi objectives; knowledge and stakeholder integration to create complex projects; finance planning and structuring as an essential ingredient of materializing complex projects; management of extreme projects; and contingent risk management, which should be elaborated with continuing feedbacks from the ongoing major-sized projects in study to form a new paradigm of project management.

References

Asian Development Bank (2009). Infrastructure for Seamless Asia. A joint study of the Asian Development Bank and the Asian Development Bank Institute. Manilla: Asian Development Bank

Ashby, R. (1958). Requisite variety and implications for control of complex systems. Cybernetica, (1): pp. 83-99.

Bredillet, C. (2004). P2M - toward a new project & program management paradigm?. Proceedings of International P2M Forum 2004. Tokyo: Project Management Association of Japan.
Bredillet, C. (2008). Learning and Acting in project situations through a meta-method (MAP): a case study: Contextual and situational approach for project management governance in management education. *International Journal of Project Management*. Vol.26 (3): pp.238–250.

Burkov, V., Bushuyev, S., Tanaka, H, Konstantin, K, Sergey,S., Rhyzhkov,S., et al. (2011). The theory of the balanced innovation model. *Project-oriented competitive science intensive enterprises creation and development* (monograph, Russian-English bilingual) pp.71-94. Nikolayev: Ukrainian National University of Shipbuilding named after Admiral Makarov & Torubarov ES (ISBN 978-966-2312-18-8)

Canadian Oil Sands (2012). Canadian Oil Sands Annual Report 2011 - Risk Management pp. 41-47. Canada: Canadian Oils Sands Limited http://www.cdnoilsands.com/files/COS_AR11_FULL.pdf

DET NORSKE VERITAS AS (2013). Risk management of shale gas developments and operations – Recommended Practice DNV-RP-U301: Norway: DET NORSKE VERITAS AS

Holmes, A. (2011). Risk management challenges for complex infra projects. *Infrastructure Journal Supporting Infrastructure Investment*. British Consulting http://www.britishconsulting.com/en/i.journal-aug-2011-risk-management.pdf

International Centre for Complex Project Management (2012). Complex project manager competency standards, version 4.1. Sydney: International Centre for Complex Project Management

Kämpf, M et al. (2011). Risk management in the Arctic offshore: wicked problems require new paradigms. ISER Working Paper 2011.3. UAA University of Alaska Anchorage Institute of Social and Economic Research (ISER)

Kosaka, M. (2010). An approach to knowledge growth models (in Japanese) p.62. Tokyo: Shakaihyoronsha Co., Ltd

Leietjen, M. (2009). Manageability of complex construction engineering projects: *Dealing with uncertainty*. *Second International Symposium on Engineering Systems MIT*. Cambridge, Massachusetts, June 15-17

Linkov, I et al. (2006). From comparative risk assessment to multi-criteria decision analysis and adaptive management: Recent developments and applications. *Environment International* 32 , pp 1072-1093: Elsevier

Lin, J. Y. and Doemeland, D. (2012). Beyond Keynesianism: Global infrastructure investments in times of crisis. Policy Research Working Paper 5940. Washington: The World Bank Development Economics Vice Presidency Office of the Chief Economist

Morey, A (2011). Meta-program management: A new approach to drive momentum and achieve coordinated outcomes across large complex public infrastructure programs. Australia: ARUP http://www.arup.com/_assets/_download/6c639c0f-19bb-316e-400b9def809e45ce.pdf.

Nonaka, I. (1991). The knowledge-creating company. *Harvard Business Review*, 69(NovemberDecember) pp.96-104.

Obelensky, N. (2013). Leading complex projects - key principles and strategy. Australia: International Centre for Complex Project Management

Project Management Association of Japan (2007). P2M – a guide of project and program management for enterprise innovation (2nd English Edition). Tokyo: Project Management Association of Japan

Saynisch, M. (2010). Mastering complexity and changes in projects, economy, and society via project management second order (PM-2). *Project Management Journal*, 41(5), pp. 4-20, Wiley/PMI USA.

Tanaka, H. (2007). Cross-cultural project management on major-sized global oil and gas plant projects. In D. I. Cleland & L.R. Ireland (Eds), *Project manager’s handbook – Applying best practices across global industries* pp.151-165. New York:McGraw-Hill

Tanaka, H. (2013) . A viable system model reinforced by meta program management. *Procedia - Social and Behavioural Sciences Journal*, 74, pp. 135-145: Elsevier

World Bank (2013). World Development Indicators, April 2013. Washington: World Bank:

World Economic Forum (2012). Strategic infrastructure: steps to prioritize and deliver infrastructure effectively and efficiently.*World Economic Forum 2012 reports*. Geneva: Word Economic Forum