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H. Tanaka
Honorary Professor, Doctor of Project Management
S. Bushuyev
Professor, Head of Project Management

Kiev National University of Construction & Architecture, Kiev

INNOVATIVE DEVELOPMENT AND META PROGRAM MANAGEMENT OF A NEW GENERATION OF MEGA PROJECTS IN THE OIL & GAS AND INFRASTRUCTURE SECTORS

This paper is based on the authors' continuing foundation research on creation and management of innovative projects and programs and the concept of meta program management; is concerned with contextual analysis of the contemporary project industry with respects to complex dimensions and salient characteristics of new generations of projects; and proposes a framework of development strategy and meta program management of such projects.

Keywords: Innovative projects and programs, new generation of mega projects; meta program management, energy and infrastructure projects, knowledge system of P2M

Розглянуто інноваційні проекти та програми в рамках нової методології управління комплексними проектами на основі системи знань P2M. Застосовано модель факторного аналізу для створення проектів високого рівня складності.

Ключові слова: інноваційні проекти і програми, нове покоління мега проектів, управління мета програмами, енергетичні та інфраструктурні проекти, система знань P2M

Рассматриваются инновационные проекты и программы в рамках новой методологии управления комплексными проектами на основе системы знаний P2M. Применяется модель факторного анализа для создания проектов высокого уровня сложности.

Ключевые слова: инновационные проекты и программы, новое поколение мега проектов, управление мета программами, энергетические и инфраструктурные проекты, система знаний P2M

Research Background and Framework

While we are experiencing a slowdown in project investments in the mature economies such as EU 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 up-scaling 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 authors 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 first authors' 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'

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websites; and contextual interpretation of the dimensions and characteristics of those projects, by using the first author's 42-year experience in the engineering-procurement-construction (EPC) industry for oil, natural gas and infrastructure projects, the second author's 45 years of experience in the practice and scientific research on construction and innovation program management and, the authors' recent research on meta program management as well as innovation program management, and related recent research on project complexity by others.

The research step is as follows:

1) Foundation research on innovation program management at Kiev National University of Construction and Architecture Project and Program Management Department (Azarov,N, Yaroshnko F., Bushuyev, S., 2012; Yaroshenko F., Bushuyev S., Tanaka, H. 2011)

2) Continuing monitoring of the complexity events in the project industry listed in the first author's 2012 paper (Tanaka, 2013a) for the verification of impact analysis,

3) 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,

4) Literature review on project management research on complex projects, and

5) 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", 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, including complex programs, 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.*

Changing Landscape of Major-sized Oil and Gas and Infrastructure Projects

Traditional construction projects in the oil and gas and infrastructure sectors forms a proven application area of project management in which:

- Construction technology, in all the projects in these sectors, and plant engineering (integration of chemical, mechanical, electrical, instrumentation and civil and architectural engineering) are well established;
- Modern project management processes for single projects can readily be utilized;
- There exist bidding procedures of similar philosophy, from the standpoint of transparency, for selecting a prime contractor, and;
- Project delivery methods such as construction management (CM) by owner body or its Engineer + specialty trade contracting; design-build (DB), EPC (engineering-procurement-construction) + project management, are established (Tanaka, 2006).

Hence, success of projects could be secured by the utilization of proper technology and construction project management methods by way of qualified engineers and project managers.

Over the past five years until 2013, however, the landscape of the construction projects is seeing a new scenario characterized by 1) complex project development in coping with changing P.E.S.T.L.E (political, economic, social, technological, legal and environmental) factors facing the project market, 2) innovative profiling and development of project scheme, 3) requirement for innovative finance engineering, and 4) meta program management approach.

The scenario trend 1) is discussed following, and trends 2), 3) and 4) are discussed in Sections 3. and 4.

Tanaka (Tanaka, 2013a.) listed typical complexity events in the world that are affecting the *monodukuri* industry by categorized P.E.S.T.L.E. 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 re-worded 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 (Tanaka, 2013b).

New state leaders in France, Russia, China, and Japan (P)

The new state heads of France, Russia, China and Japan 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 and is consistently following up on this national drive.

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 Shinzo 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 not only socio-political situations but in also 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 4.5 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.

Dimensions and Characteristic New Profiles of Current 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.

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 Ichsys 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. Anadarco 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.

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$23B	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 Development Program	Russia	US$110	2025	Modernization of the Siberian railroad systems, ports and other trade facilities, city infrastructures; industrial estates; energy development; multi objectives, multi investors, remote projects	8
[Project 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	9
[Project j.] Masdar City Project	UAE-Abu Dhabi	US$18B	2020 -2025 (ongoing)	Futuristic eco-smart city to test the country's future growth and diversification strategy; race against evolving technology	10
[Project 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	11
[Project l.] Turkish No. 2 Nuclar Power Plant	Turkey	US$20B	2023 (first train) (under project preparation)	Japanese/French consortium supported by the two governments to build the first plant of 3rd generation PWR reactor nuclear power plant. The project to provide a total nuclear fuel cycle and required technology transfer to Turkey	12

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 Abbdulah 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=2575a4665b2ae1869fc22bb73c1bb8aa

10. Project brief http://www.designbuild-network.com/projects/mibc/

11. Project home http://masdarcity.ae/en/

12. Program home http://en.tswstc.gov.cn/news_detail/newsId=6d95ed4a-b72c-4573-b7c0-0bd56add0a4e.html

13. Nikkei Shinbun and other international economic media May 4~10, 2013

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

Salient characteristics of these mega projects that augment complexity include the following elements which are not quite common in the traditional construction projects.

Requirement of huge investment costs

All of the projects referenced in Section 3 above are worth multi-billion US dollars or even exceed ten billion $ which per se present a significant source of great risk and mandate innovative finance engineering and risk management.

Multi objectives entertained by the programs/projects

All major-sized construction projects are developed to entertain a mission embracing multiple high-tier objectives such as:

- Boosting national economy as trigger of accelerated growth
- Enhancing national prestige or image
- Providing trunk infrastructure which are not existing or in short supply
- Creating eminent future values
- Up-scaling new or alternative technology, or introducing critical development technology vital for national growth
- Investment returns
- Gaining advantageous positions among competitors, e.g. within the same industry, among competing countries

This mandate of meeting multiple higher objectives requires complex program management.

Political implications

As all of the major-sized natural resources development and infrastructure program/projects occupy a high-profile position in the political scenario of one country or more, programs/projects need right response to political expectations or pressures.

Multi owners and investors from multi countries

The formation, or lining-up, of multi owners and investors from multi countries for a single program or its component projects is required to meet an enormous fund requirement or to combine source technologies and expertise to compose a complex program or a project.

Multi contractors and suppliers/vendors from multi countries

Due to their investment huge sizes sand strategic positions, the programs and projects should 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.

Likewise, multi vendors from multi countries are mobilized under the prime contractor joint venture to realize technologically right and most economical sources.

As a result major sized programs/project would see tens of thousands workforces from multi countries to meet a required quality and quantity of skilled construction workforces. For instance

Compounding emerging technologies

As in eco-smart community development programs, most of mega programs mandate races against technological advancement, hence, scope definition should allow for evolution of the program configuration and stand ready for trade-offs between new but yet unstable technology and program delivery target and budget.

Uncertainty associated with project implementation over an extended period of time

In addition to technological uncertainty mentioned in 3.6, as programs usually span over an extended time of period, e.g. from four to six years for a single program or ten years or longer on a series of regional development programs, changes in PESTLE factors and resultant scalability (upward or downward) or risk of project cancellation after project start due to changes in expected market or some grave changes in assumptions on which a program was judged viable.

Logistic challenges

Programs and projects being increasingly located at remote sites, extreme sites such as the Arctic Sea, deep-waters, and in territories challenges regarding security, pose untraditional challenges to logistics and demand innovative solutions such as adaptation of program/project schedule to cope with harsh climate seasons, modular construction, etc.

Unparalleled environmental risk

Programs and projects located at extreme or remote sites cannot escape from risk of affecting natural habitat. The experience of oil spills in the sea, offshore Alaska and the Gulf of Mexico by multinational oil companies which have seriously damaged the environment and requiring the owners.

Commercial operation and service phase being part of a program

Most of major infrastructure programs discussed here include non-traditional element of the commercial operation and associated services such as maintenance as part of the program itself where prime contractor joint venture or consortium, or a or investor contractually undertakes such unconventional services; these expanded services occur as owner bodies, most often government enterprises, have no or substantially insufficient experience in operating new types of infrastructure, or the program implementation scheme is based on the public-private partnership (PPP) or build-operate-transfer (BOT) system. Another reason for this expanded scope is the recent contracting trend of developing countries letting contractors compete for the major utility (typically nuclear power plants) or mass transportation (such as bullet trains) program as a package deal including additional services such as these commercial operation, technology transfer, local human skill development and social development.

Strategy and Management of the New Type of the Mega Energy and Infrastructure Projects

Based on the analysis of the characteristics of the mega and complex projects reviewed above, a set of required strategy and management of such new types of mega projects are proposed by the authors.

Strategic project marketing

Because of the strategic nature, complexity, novelty and significant impact on national or major corporations' development entertained by the projects and programs discussed in this paper, development lead time should be considerably longer than ordinary programs or projects.

While the implementation phase-detailed planning, engineering, procurement, construction and implementation program management – is contracted through public bidding to ensure transparency as strong government interests are usually involved in these programs, as a general rule, the pre-contracting phase is highly important for discriminating marketing for the seller side. For instance, formation of a consortium team representing an export country combining best companies of the disciplines involved, export country's head or senior minister's top sales toward a host country, pre-arranging attractive finance arrangements are common strategic marketing activities.

Fruits of these pre-contract marketing efforts would include a sole-source contract or added soft value (not based on the monetary value of the bid prices) reflected as a considerable plus in the overall bid evaluation by the owner.

Joint venture or consortium approach.

The prime contractors' joint venture form (Joint Venture) and consortium form (Consortium) have been used frequently on major-sized construction and engineering projects in Europe, Japan, South East Asia and the Middle East.

Both forms are similar in the structure that more than two contractors form a prime contracting body toward the owner but have the following difference (Tanaka, 2007):

Joint Venture:

A prime contractors' joint venture contracting organization is one of the alliance schemes of two or more contractors, and it is employed widely for large-sized projects, mostly in excess of United States dollars 300 million in EPC or Design-Build contract amounts. While the term "JV" means an incorporated joint venture company in many industries, in the engineering and construction industry, it refers to an unincorporated joint project organization that shares a single or significantly common fund and project performance liabilities as well as bears joint project execution responsibility to the owner. An exception is that on very large projects, partner contractors may found a specific corporation in a neutral country for the sole sake of "one shot" execution of a particular project.

Consortium:

Another similar but different collaboration format among contractors is a consortium. For this scheme, a clear split of work for each partner contractor is defined within a consortium and consortium partners are individually responsible for the defined scopes, within a consortium. In other words, the consortium scheme can be employed only if clear splits of work can be defined prior to the initiation of the project.

The rationale for joint venture or consortium contract forms on both the owner side and the contractor side are given as follows (Tanaka, 2013c).

On the owner side, megaproject characteristics which have the following profiles favor a JV approach in prime contracting in EPC or design-builds to secure higher assurance of project completion and reduce risk or contractor low performance:

- Investment costs exceeding US$1billion and
- High project complexity
- Long duration (usually over 5 years)
- High level of uncertainties (i.e. unknown-unknown: technical, social, etc.)
- Significant challenge to the stakeholders
- A significant stretch on the corporate resources
- The project to generate socio-economic and political interest in the host country
- Substantial direct and indirect impacts on the environment, socio-economy/socio-politics of the local community

On the contractor side, the JV or consortium approach is preferred in the following aspects:

- Added assurance for timely project completion demanded by owner

- Reaping combined strengths of EPC partners in such areas of securing ECA (export credit agency) financing packages from plural countries; providing sets of unique knowledge from among multiple contractor companies; leveraging with another contractor's differentiating experience and expertise in particular plant technology, host countries or particular owner companies; allowing wider staffing opportunities of quality project team key members and general intellectual resources; building enhanced worldwide procurement network
- Risk sharing and mitigation among plural contractor companies
- Enhancing business capacity by way of higher constant chances of major contract awards and entering new markets by way of leveraging on competitors
- Opportunities on global business training for young engineers

Meta program management

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, 2013a, Tanaka 2013b).

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.

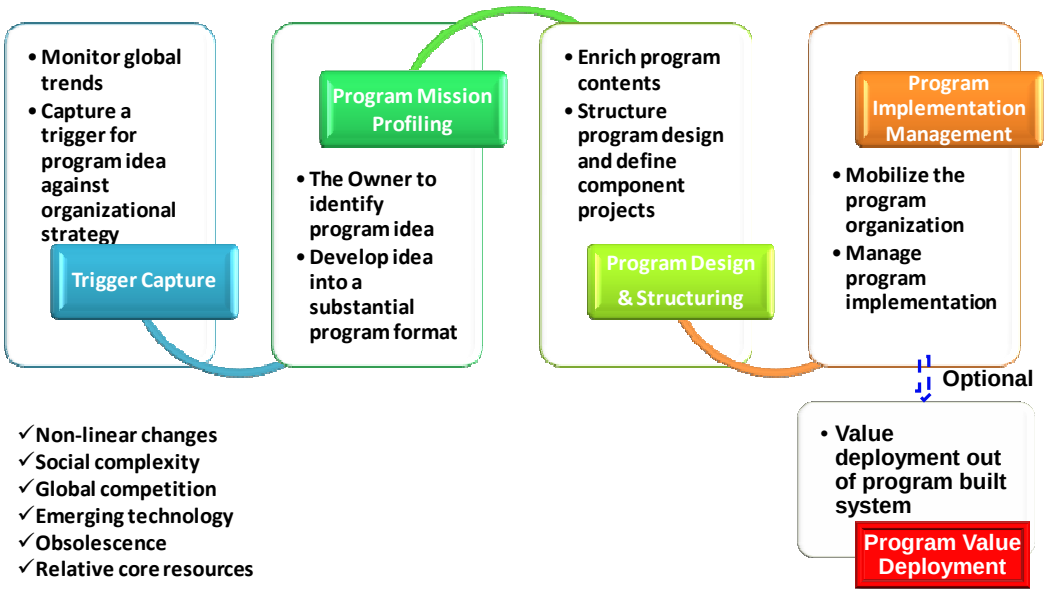

Fig. 1. Meta program management concept

Tanaka (Tanaka, 2013a; 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. A illustrative model of meta program management is given in Figure1.

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 most of the projects above project table (Table 1), in such aspects as (Burkov et al., 2011):

- Engineering driven projects that require ingenium 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

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.

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 Figure 2. with reference to Kosaka's three dimensional, knowledge fusion space model (Kosaka, 2010).

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).

Finance planning and structuring as an essential ingredient of materializing mega 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,

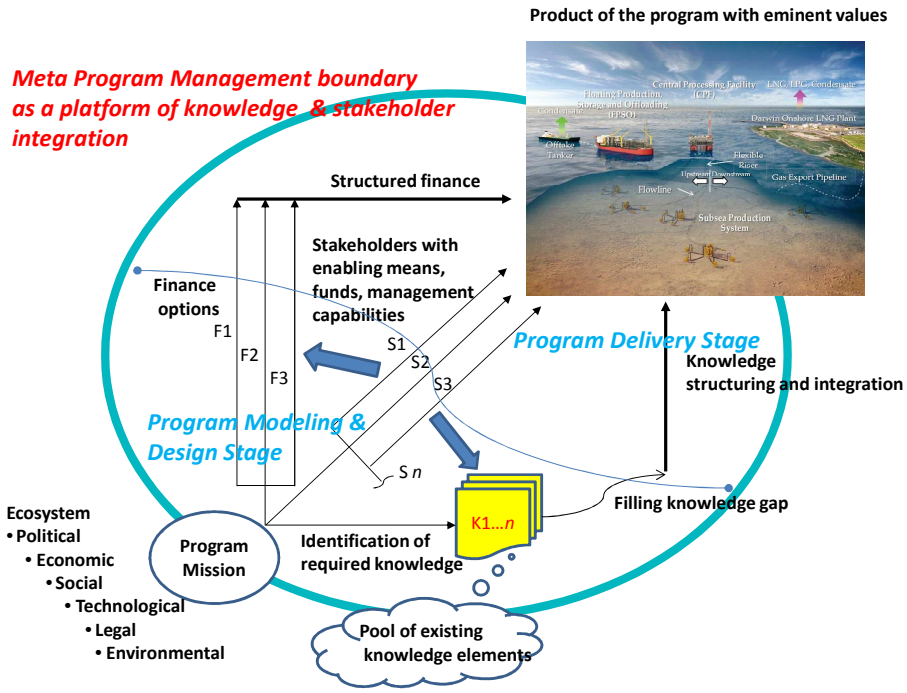

Fig. 2. Meta program management space as a platform of knowledge integration

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.

Risk management as a not as usual approach

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).

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 (first) 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.

Conclusion

This paper expands the existing research on complex project management and 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 framework of strategy and met program management for new generation of complex projects.

The new framework include strategic project marketing; joint venture and consortium approach; , meta program management; knowledge and stakeholder integration to create complex projects; finance planning and structuring as an essential ingredient of materializing complex projects; and risk management as not as usual.

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