An Ontology of Megaprojects

Full Paper

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Abstract

Megaprojects are symbolic milestones of human history. From the Great Pyramid of Giza and the Great Wall of China to the Hoover Dam and the Manhattan Project, history is marked by an array of megaprojects. Some megaprojects are born out of necessity while others showcase power and status of individuals, groups, or countries. Most megaprojects are one-of-a-kind endeavors to which traditional project management principles are neither applicable nor suitable, rendering the holistic study of megaprojects especially difficult. Regardless of the recent uptick in research on megaprojects there is no systemic framework that can help systematically assess and guide megaprojects and megaproject research. In the absence of such a framework there is a significant risk of bias in planning the projects and the topics researched. In this paper, we present an ontology of megaprojects and discuss how it can help analyze individual megaprojects and synthesize the corpus of megaproject research.

Keywords

Megaprojects, project management, ontology, ontological meta-analysis.

Introduction

Megaprojects are symbolic milestones of human history. From the Great Pyramid of Giza and the Great Wall of China to the Hoover Dam and the Manhattan Project, the history is decorated with an impressive array of megaprojects. “Megaprojects are large-scale, complex ventures that… take many years to develop and build, involve multiple public and private stakeholders, are transformational, and impact millions of people.” (Flyvbjerg 2014, p.6) Some megaprojects such as the Manhattan Project which was instrumental in bringing the World War II to an end have profound impact on the global scale while others such as Boston ‘Big Dig’ or Central Artery/Tunnel Project (CA/T) (Haynes 2002) have localized impact notwithstanding their hefty price tags. Some megaprojects are born out of necessity (Boyce 1990) while many are “privileged particles of the development process” (Hirschman 2015). Megaprojects more often than not are symbols of political power (Van Der Westhuizen 2007) or display of prestige and status of powerful individuals, groups, or countries. Regardless of size and purpose, most megaprojects are one-of-a-kind endeavors where traditional project management principles are not applicable or suitable (Flyvbjerg 2014), rendering the holistic study of megaprojects difficult.

Research on megaprojects has been around for some time. Figure 1 shows the number of papers with the terms ‘megaproject’ or ‘mega-project’ in the title, abstract, or keywords published yearly in scholarly journals, conferences, and books indexed in Scopus. It indicates that megaproject research has gained traction in the last decade or so following an uptick circa 2002, continuing to grow through 2014. (Note: The 2015 data may be incomplete.) Most of scholarly research on megaprojects however primarily focus on detailed case studies of individual or related megaprojects while a few others focus on institutionalizing best practices in megaproject management into standard management models and theories (Garel 2013). It reflects the difficulty in studying megaprojects as Haynes (2002) aptly states, “little is generally known about the inner workings of these mammoth undertakings.” (p.63) Some classic megaprojects include Channel Tunnel Project (Anguera 2006; Sargent 1988), Hoover Dam (Kwak et al. 2014), Denver International Airport (Szyliowicz and Goetz 1995), and Boston ‘Big Dig’ (Greiman 2013); this by no means is an exhaustive list. Some studies discuss the details of megaprojects along certain dimensions; for example, “five tiers of rich descriptors”—history and purpose, context, project structure, funding, and performance measures—that constitutes the megaproject framework proposed by Haynes (2002). Such frameworks without a doubt facilitate the understanding of the inner workings of

megaprojects. They however fail to provide a systemic approach to study and understand the 'big picture' of megaprojects.

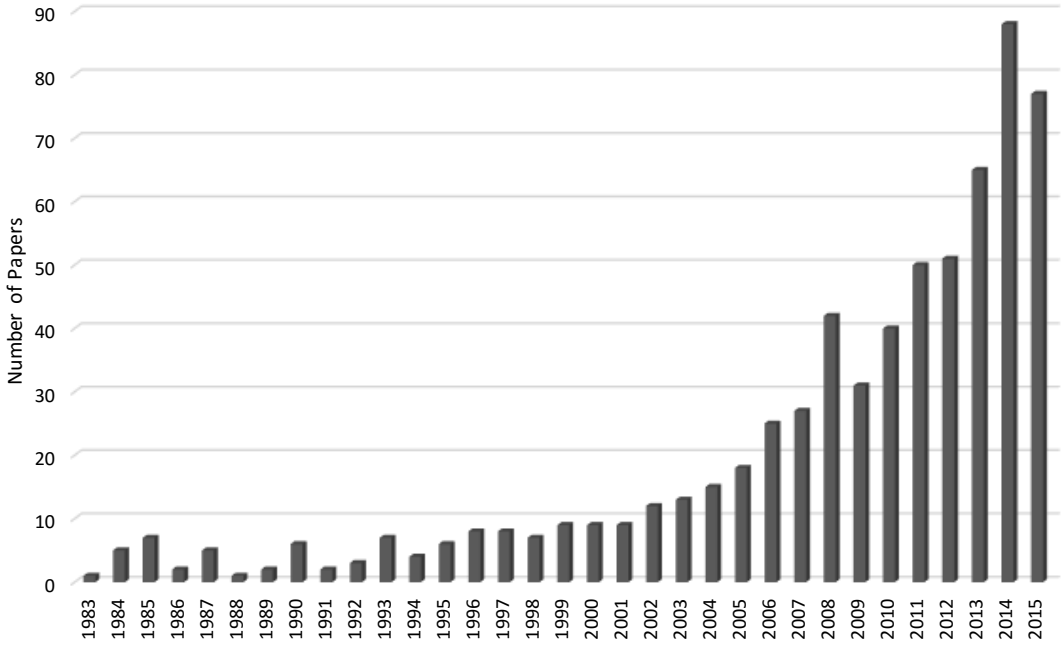

Figure 1 Scholarly Megaproject Research Between 1983 and 2015 (Source: Scopus)

> "The potential benefits of building the right projects in the right manner are enormous and are only matched by the potential waste from building the wrong projects, or building projects erroneously.... Never has systematic and valid knowledge about megaprojects therefore been more important to inform policy, practice, and public debate in this highly costly area of business and government." (Flyvbjerg 2014, p.8)

A systemic framework can help systematically assess and guide the megaproject research. In the absence of such a framework there is a significant risk of bias in the topics researched. Some topics may be heavily emphasized because they are (a) important, (b) in fashion, or (c) convenient for research. On the other hand, some topics may be lightly emphasized because they are (a) unimportant, (b) not in fashion, or (c) inconvenient for research. In addition, there may be topics which have been simply overlooked or are infeasible. These biases can help and hinder the advancement of the domain (Ramaprasad and Syn 2014c). They can result in what is often called the 'herd effect', doing more of the same thing. These consequences could rapidly advance the domain if the research topics are appropriate; they can also significantly retard the domain if the topics are inappropriate.

In this paper, we present an ontology of megaprojects. We describe the deconstruction of the domain into its logical components. We then discuss how the ontology can be applied to (a) the documents about a megaproject to understand its anatomy, and (b) the extent literature on megaprojects to visualize the landscape of research in megaprojects. Last, we conclude with a strong (Ramaprasad and Syn 2014c) agenda for future research in the domain as well as about the domain.

An Ontology of Megaprojects

The ontology represents our conceptualization of the domain (Gruber 2008). It is an "explicit specification of [our] conceptualization," (Gruber 1995, p. 908) and can be used to systematize the description of a complex domain (Cimino 2006). The ontology organizes the terminologies and taxonomies of the domain. "Our acceptance of [the] ontology is... similar in principle to our acceptance of a scientific theory, say a system of physics; we adopt, at least insofar as we are reasonable, the simplest conceptual scheme into which the disordered fragments of raw experience can be fitted and arranged." (Quine 1961, p. 16) The ontology of megaprojects is shown in Figure 2. It organizes the terminologies and

taxonomies of megaprojects. It describes the building blocks of a megaproject in simple but holistic presentation.

Stakeholder		**Temporality**		**Translation**		**Scope**		**Sublime**	
Architects	**[']**	*A priori*	**[+]**	Visualization	**[of]**	Global	**[+]**	Aesthetic	**[megaproject]**
Builders		*Ex ante*		Conceptualization		National		Economic	
Citizens		*In praesenti*		Implementation		Regional		Egotistic	
Communities		*Ex post*		Completion		Local		Moral	
Funders		*A posteriori*		Abandonment				Political	
Governments				Assessment				Scientific	
Historians								Social	
Politicians								Technological	
Visionaries									

Figure 2 Ontology of Megaprojects

The challenge is to construct an ontology which is a logical, parsimonious, and complete description of megaprojects. It has to be logical in the deconstruction of the domain, and parsimonious yet complete in the representation of the domain. It has to be simple yet descriptive of the combinatorial complexity of the domain. It has to be a closed description of megaprojects in its entirety yet adaptable to changes in the domain.

The megaprojects ontology is constructed by logically deconstructing the domain into its dimensions and elements. It is an iterative process which is explained in greater detail in Ramaprasad and Syn (2014a) and Ramaprasad and Syn (2014b). The ontological meta-analysis and synthesis is a new method of analyzing and synthesizing domain knowledge (Ramaprasad and Syn 2015; Tate et al. 2015). It is especially suitable for studying complex, ill-structured domains. It can be used to develop an ontology that will elucidate the domain and serve as a roadmap.

We deconstruct the conceptualization, implementation, and delivery of megaprojects into five main dimensions: (a) stakeholders in the megaproject, (b) temporality of the stakeholders' perspective, (c) translation or stages of development of the megaproject, (d) scope of the megaproject, and (e) sublime or purpose of the megaproject. The underlying argument is that megaprojects are a synthesis of sublimations of multiple stakeholders which may vary in scope; the sublimations happen over a period of time during which an imagined idea is translated into reality and assessed. This argument can be expressed as:

Megaproject = f (Stakeholder + Temporality + Translation + Scope + Sublime)

Stakeholder involvement is critical in megaprojects (Morris and Geraldi 2011). There can be many types of stakeholders in a megaproject (Anguera 2006; Sykes 1998). They can be from public and/or private sector. Many megaprojects are joint venture between public and private sectors. Some have to contend with a network of stakeholders (Rocheleau 2015). The important roles of Governments and Politicians in megaprojects are well documented (Flyvbjerg 2005). Needless to say, Funders reserve the right to make or break any megaproject. Support from Communities and Citizens is also well recognized to have significant influence on the fortune of megaprojects. Other stakeholders such as Visionaries, Architects, engineers or Builders play various important roles. Last but not the least, Historians who chronicle megaprojects create everlasting testimonies of success and failure of megaprojects.

Stakeholder ⊂ [Architects, Builders, Citizens, Communities, Funders, Governments, Historians, Politicians, Visionaries]

The taxonomy of stakeholders is presented in alphabetical order for convenience. The above taxonomy covers the most common stakeholders; some of them may be excluded if necessary, or others may be added too.

Megaprojects take many years to plan as well as complete. Most have far-reaching and long-lasting effects (Mitrofanova et al. 2015). Some may even have unintended benefits after the completion. The perspective on a project may shift considerably over time. Even a small change in perspective can significantly alter the course of a megaproject. Hence, it is imperative to study the temporality of megaprojects.

Temporality ⊂ [*A priori*, *Ex ante*, *In praesenti*, *Ex post*, *A posteriori*]

The taxonomy of temporality is ordinal. The actual time-scale, and hence the period associated with each element, will vary between projects. The time-scale may be in years, decades, or even centuries. Moreover, because of the large timescale a megaproject may be simultaneously in many temporalities.

The translation of megaprojects has to be in stages which move from the abstract to the real—from thought to action. Some studies break down megaprojects into a) conceptual phase, b) planning, execution, and construction phase, and 3) close out phase for detailed analysis—for example, Kwak et al. (2014). Such schemes tend to consider assessment and feedback an afterthought following the linear thinking of traditional project management discipline. We posit that the translation should include feedback to direct or redirect the trajectory of the megaproject.

> Translation ⊂ [Visualization, Conceptualization, Implementation, Completion, Abandonment, Assessment]

The taxonomy of translation is roughly ordinal but with iteration among the elements. Visualization will likely to precede Conceptualization, Conceptualization will likely precede Implementation, and so on. Sometimes, some steps may be skipped. Further, all megaprojects may not be completed; some may be abandoned. Hence, both possibilities have been included. Again, as with temporality, because of the scale and scope of megaprojects, a megaproject may be simultaneously in many translation phases.

The scope of a megaproject will likely affect the scale of the project as well as the definition of the stakeholders. A local megaproject may have fewer groups of stakeholders and be much smaller than a national or global megaproject. Some local megaprojects such as Boston 'Big Dig' however can be extraordinarily outsized. Yet, the balance of power of the stakeholders of local megaprojects can be vastly different from broader scope megaprojects. It is evident in the emphasis on community support and involvement (Greiman 2013).

> Scope ⊂ [Global, National, Regional, Local]

The taxonomy of scope is ordinal. Each subsequent element is a subset of the prior element. A global megaproject is likely to be far larger than a local megaproject.

Sublimes are the aspirations of stakeholders of megaprojects (Flyvbjerg 2014). The term sublime was first introduced to megaprojects by Frick (2008). Beyond the four sublimes—Technological, Political, Economic, and Aesthetic—we can also include four more sublimes: Egotistic, Moral, Scientific, and Social. Some megaprojects may be aspired by more than one sublime. For example, the flood control megaproject in Bangladesh was likely aspired by Political as well as Moral sublimes (Boyce 1990). Four additional sublimes will enable a better understanding of megaprojects' aspirations.

> Sublime ⊂ [Aesthetic, Economic, Egotistic, Moral, Political, Scientific, Social, Technological]

The taxonomy is presented in alphabetical order for convenience. It will be ordinal if presented in the priority order of the sublime. Thus in a technological megaproject, Technological sublime may be listed first, Scientific next, Economic third, and so on. The Egotistic sublime may not (or sometimes may) find a place in such a project.

Validity of the Ontology of Megaprojects

The 'big picture' portrayed by the ontology will be only as good as the validity of the ontology itself. The validity of the ontology will determine the strength of the interpretations derived from the ontology-based analysis. The ontology is logically constructed but grounded in the theory and practice of the domain. The dimensions are logically specified, not empirically generated. They are deduced from the definition and nature of megaprojects. The dimensions and taxonomies are grounded in existing literature on megaprojects and related disciplines. In contrast to our method, an ontology may be induced from the corpus of a domain. Automated ontology extraction tools based on linguistic extraction techniques such as Part of Speech (POS) tagging and Natural Language processing (NLP) (Alani et al. 2003) can help develop comprehensive and detailed (with reference to the corpus) OWL-based ontologies (W3C 2012), thesauruses of hierarchically arranged terms, and other ISO-based ontology exchange standards (Ahmad and Gillam 2005). The automated tools are designed for standardizing terminologies (Burton-Jones et al. 2005; Evermann and Fang 2010; Staab et al. 2004), as for example in medicine, but not to deduce

semantically meaningful logical components of a domain as we seek to do. The automated tools cannot yet formulate an ontology which is (a) parsimonious as the one we propose, and (b) organized such that the domain components can be concatenated to form natural language sentences.

The logical construction minimizes the errors of omission and commission. For example, the Translation dimension compels the researchers to explicitly consider the full lifecycle of megaprojects including Assessment, and feedback cycle associated with it (Ramaprasad 1983). Continuous feedback can alleviate the significant fixes that "often takes place at great and unexpected cost to those stakeholders who were not aware of what was going on" (Flyvbjerg 2014, p.12). On the other hand, pure grounded approaches are liable to significant errors of omission. An unobserved or unrealized attribute is unlikely to emerge from the grounded data.

Past studies have identified methods for validating ontologies (Burton-Jones et al. 2005; Evermann and Fang 2010; Staab et al. 2004). These methods however are mostly suitable for formal ontologies that represent concepts using the triples of subject, predicate, and object to facilitate machine learning. Our ontology on the other hand aims to facilitate human understanding of megaprojects. We construct the ontology from major dimensions of megaprojects; each dimension represents a corresponding taxonomy that incorporates the terminology of the domain. It is less formal than computer scientists', more parsimonious than medical terminologists', and more pragmatic than philosophers'. It is practical, not meta-physical. It is a domain ontology that "helps identify the semantic categories that are involved in understanding discourse in that domain." (Chandrasekaran et al. 1999, p.23) We draw upon the traditional constructs of validity commonly used in social sciences (Brennan et al. 2011; Horn and Lee 1989) to justify the face, content, semantic, and systemic validity of the ontology of megaprojects.

The megaprojects ontology is a structured natural language representation of the core logic of megaprojects found in literature. The core dimensions are extracted from the logical components of megaprojects and the corresponding taxonomies from relevant domains such as project management. The validity of the ontology borrows from that of the underlying domain. The ontology and its components should be meaningful and make sense 'on its face value' to experts and novices alike who are familiar with the underlying domains. Thus, the face validity of the ontology is high.

The components derived from the ontology are expressed in natural English sentences. Each component is a concatenation of elements across dimensions. Each dimension represents a taxonomy of a respective domain. Hence, each component is semantically meaningful to users, irrespective of its instantiation. As such, it is easy for a user to (a) recognize the instantiations of a component in research or practice, and (b) envisage the potential instantiations of a component in research and practice. Since each component may be instantiated in many ways, its manifestations may vary by context. Moreover, the users can derive these components from the ontology, translate between the ontology-based statement and its instantiation(s), and judge their meaningfulness. Thus, the semantic validity of the ontology is high.

The ontology shown in Figure 1 is a complete closed description of megaprojects. Its dimensions and elements are well-founded in bodies of knowledge of respective domains. They are logical, inclusive, and yet parsimonious. It encapsulates all possible components of megaprojects regardless of whether they have been articulated in bodies of knowledge or instantiated in research or practice. Its systemic validity is high.

Discussion

The proposed ontology is a lens to study the anatomy of megaprojects. For a complex domain like megaprojects, there may be other lenses to study the same and each can be encapsulated by a different ontology. They will provide different perspectives. We will discuss the present one in detail.

We have discussed the individual dimensions (columns) and elements of the ontology while describing the construction of the ontology. Multiple elements of a dimension may coexist independently but may also interact with each other in a megaproject. Thus, many stakeholders, temporalities, translations, scopes, and sublimes may coexist and interact with each other. Knowing the independent and interacting elements is critical to envisioning and implementing megaprojects. The ontology can help systematically study and manage the elements' independence and interactions. In the following we discuss how the ontology can be used to systematically study the interaction of: (a) elements within a dimension, (b)

elements across two dimensions, and (c) elements across multiple dimensions, to understand the anatomy of a megaproject at different levels of granularity and complexity.

Combinations within a Dimension

All possible first-order interactions among the elements of a dimension can be mapped into a table of the dimension with itself. Such a mapping can reveal strong interactions (both constructive and obstructive), weak ones, absent ones, and unexpected ones among the elements. It can also highlight the direction of the interaction—one-way (*a* to *b* OR *b* to *a*), and two-way (*a* to *b* AND *b* to *a*). In the following we will discuss some possible insights from such a mapping of each dimension.

Stakeholders act individually and in coalitions. Mapping the interactions among the stakeholders can provide insights into the forces that can help or hinder a megaproject. For example, the architects, builders and politicians may be part of a coalition supporting a megaproject while the citizens, communities, and historians may be opposed to it. The ontology can also help obtain deeper insights into the motivations of the stakeholders and stakeholder-coalitions (Rocheleau 2015). In the above example, the first group may be driven by a national perspective and economic, egotistic, and political sublimes whereas the latter group may be driven by a local perspective and aesthetic, moral, and social sublimes. Their temporality and translation concerns may also be different. The former's attention may be on the challenge of *a priori* visualization and conceptualization; the latter's on the risk of *a posteriori* completion or abandonment.

The temporalities of a megaproject may converge and conflict—among the stakeholders, during different phases of translation. Further, the scope and the sublimes may shift with time. A regional pilot project may be upgraded to a national project because of its successful performance in the initial phases, and for the same reason political and egotistic sublimes associated with a project may be substituted by economic and social sublimes. Since megaprojects by definition stretch over a long period, these temporal changes could be substantial. Moreover, the same projects may exist simultaneously in many temporalities. Stakeholders in the proximity of completed phases may view it *ex post* and *a posteriori* (Fahri et al. 2015), whereas those in the midst may view it *in praesenti*, and those yet to be affected may view it *a priori* and *ex ante*. A temporality matrix, like the stakeholder matrix describe earlier, can help understand and manage the complex feedforward and feedback loops in the project. These loops can be used to manage the stakeholders' perceptions of scope and sublime during the different phases of translation.

It is very unlikely that a megaproject will remain unchanged through all its phases of translation, from visualization to completion/abandonment and subsequent assessment. It is very likely to evolve—both incrementally and radically. The phases of translation are iterative, especially in a megaproject. As with its temporality, a megaproject is likely to be in multiple phases of translation simultaneously. Thus, lessons from implementation and completion of one phase can lead to revisualization and reconceptualization in the remaining phases. The revisualization and reconceptualization may affect assessment of completed phases and the future ones. A matrix of translation phases can be used to map and manage the feedback and feedforward learning and planning loops between the phases.

A national megaproject may have a large local impact or no local impact at all—for example, the polio eradication project in India. By the same token, a local megaproject may have no national impact or a very large national impact—for example, a local dam which may affect a nationally endangered fish species. Thus, even if a megaproject is defined primarily as being global, national, regional, or local it is likely to have secondary and tertiary effects at other levels. These effects can ripple further into other levels. A secondary local effect, for example the submersion of a historical religious site due to the construction of a dam, may ripple into a national political issue. A Scope x Scope matrix can be used to map the secondary, tertiary, and subsequent effects. It can help minimize the chances of devastating (to the megaproject's sublime) unintended consequences.

The sublime of a megaproject is likely to be a composite of many sublimes interacting with one another. The composite sublimes are neither unitary sublimes nor simple combinations of many sublimes. The interaction among the subliminal elements of a project has to be mapped to manage the composite effectively. Thus, a local megaproject—for example, a national art museum—may be driven primarily by its aesthetic, technological (architectural), and economic sublimes. In understanding the project, it is essential to consider the interaction between these sublimes. An increase in the aesthetic sublime may be

technologically possible but not so economically. Further, an architect may emphasize the aesthetic sublime while the funders are likely to give priority to the economic sublime. These priorities may change temporally (for example, as the true costs become clear) and as the project progresses through the different translation phases.

Combination between Dimensions

In addition to interactions among the elements of a dimension, all possible first-order interactions among the elements of a pair of dimensions can be mapped into a table. Such a mapping can reveal strong interactions (both constructive and obstructive), weak ones, absent ones, and unexpected ones between the elements of the two dimensions. It can also reveal the direction of the interaction—one-way (*a* to *b* OR *b* to *a*), and two-way (*a* to *b* AND *b* to *a*). With the five dimensions of the ontology there are ten possible pairs. In the examples in the previous section we have some possible interactions between many of the dimensions. Here we will summarize the ten possible pairs and the potential insights from them.

1. Stakeholder x Temporality – Variation in and evolution of temporal focuses of stakeholders.
2. Stakeholder x Translation – Variation in and evolution of translational focuses of the stakeholders
3. Stakeholder x Scope – Convergence of and conflicts in the scope of stakeholders
4. Stakeholder x Sublime – Convergence of and conflicts in the subliminal focuses of the stakeholders
5. Temporality x Translation – Progression and retrogression of translational phases with time
6. Temporality x Scope – Progression and retrogression of scope with time
7. Temporality x Sublime – Incremental and radical shifts of subliminal focus with time
8. Translation x Scope – Incremental and radical shifts of scope with translational phases
9. Translation x Sublime – Reframing and reinterpretation of subliminal focus with translational phases
10. Scope x Sublime – Reframing and reinterpretation of subliminal focus with scope

Components of a Megaproject

The dimensions of the ontology are arranged left to right with adjacent words/connectors such that the concatenation of an element from each dimension with adjacent words/connectors creates a natural English sentence illustrating a potential component of management of a megaproject. The components and fragments (incomplete components) define the domain of megaprojects. Some illustrative components are:

- Governments' a priori visualization of national political megaproject. For example, a government's plan to build the tallest statue of a historical political leader.
- Historians' a posteriori assessment of global economic megaproject. For example, historians' assessment of the global war on poverty.

The ontology encapsulates 8,640 (9 x 5 x 6 x 4 x 8) potential organizational components of the conceptualization, implementation, and delivery of megaprojects. It would be laborious and voluminous to enumerate all components of megaprojects. The ontology provides a convenient and concise 'big picture' of megaprojects in a limited space. It helps visualize the combinatorial complexity of the domain.

A component may be instantiated in many different aspects of megaprojects. Consider the first illustrative component above: Governments' a priori visualization of national political megaproject. Instantiations may vary depending on political purpose. Imagining the tallest statue of a historical political leader can be one such instantiation. Envisaging a national monument to commemorate a tragic event can be another instantiation of the same component.

Some components may be instantiated frequently, some infrequently, and some not at all in a megaproject. The frequently instantiated components will constitute the dominant themes, the infrequently instantiated ones the less-dominant themes, and the un-instantiated one the non-dominant themes or potential gaps in the megaproject. The frequency of instantiation of a component may not necessarily indicate its importance, centrality, criticality, or other priority. A dominant theme may simply be a product of convenience or a 'herd effect'; a less-dominant theme may be a product of inexperience or oversight; and a gap may in fact have been overlooked or infeasible.

In summary, the ontology can be used to study the anatomy of megaprojects systemically and systematically. It can be used to study both the research on and the realization (or non-realization) of megaprojects. Mapping the growing research corpus on the topic, highlighted at the beginning of this paper, will highlight its areas of emphasis, lack of emphasis, and oversights. Mapping a megaproject's corpus of documents will highlight the priority of different elements and components in the project. The insights from such mappings can be used to develop a roadmap for future research and practice. In the following we will conclude with a brief description a program of research to follow.

Conclusion

The ontology of megaprojects illustrates the 'big picture' of a megaproject. It helps visualize the combinatorial complexity of a megaproject. The ontology can be used as a common, comprehensive framework to map the anatomy of a megaproject and the research on megaprojects. It can also be used to compare and contrast megaprojects. The mapping can be used to generate ontological maps which will clearly illuminate the elements or components of megaprojects which are frequently present, less frequently present, and absent in research and practice.

The mapping of the extent research literature on the topic onto to the ontology will reveal the elements, fragments, and components of the ontology that have been researched heavily ('bright' spots), scantly ('light' spots), and not at all ('blind/blank' spots). We will enlist the extent literature through a systematic search of the online databases such as Scopus and Web of Science. The PRISMA (Liberati et al. 2009) guidelines will be used to select the final articles for mapping. The articles will be mapped onto the ontology using NVivo. The results will be presented as ontological maps of monads and dyads, and clusters of ontology elements. We will explore potential reasons for the differences in emphases, discuss potential corrections, and develop a roadmap for future research.

Similarly, we propose to map megaprojects about which extensive documents are available onto the ontology. The mapping should provide deep insights into the anatomy of megaprojects. It will help compare and contrast megaprojects. It will also help discover gaps between practice and research on megaprojects. The gaps may be of three kinds: (a) significant topics of practice with limited research, (b) significant topics of research with little practice, and (c) overlooked topics in practice in research. Such a gap analysis can improve both research and practice in the future.

The landscape of a domain can change over time with emerging best practices and theories. The ontology-based roadmap can be amended to reflect the changing landscape. New categories and dimensions can be added, obsolete ones discarded, and existing ones modified. Changes can also be introduced by the shifting focus in the domain. The finer levels of dimensions and elements can be added to the ontology to reflect the greater focus on certain dimensions or categories. For example, new stakeholders can be included to reflect their growing importance in a megaproject. On the other hand, sub-categories and sub-dimensions can be collapsed to echo their diminishing importance in the domain. The shifting focus and direction of research and development can be chronicled by analyzing the snapshots of ontological maps over time. The ontology can help visualize the past and present of the domain, and envisage its future.

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Appendix – Glossary

Stakeholder: Stakeholders in a megaproject.
- *Architects*: Architects of a megaproject.
- *Builders*: Builders of a megaproject.
- *Citizens*: Citizens affected by a megaproject.
- *Communities*: Communities affected by a megaproject.
- *Funders:* Individuals/organizations with financial interest in a megaproject.
- *Governments:* Governments with vested interest in a megaproject.
- *Historians*: Historians who chronicle a megaproject.
- *Politicians*: Politicians involved in a megaproject.
- *Visionaries*: Individuals who initiate the idea of a megaproject.

Temporality: Temporality of megaproject translation phases.
- *A priori:* Prior to a translation phase.
- *Ex ante:* Preceding a translation phase.
- *In praesenti*: During a translation phase.
- *Ex post*: Following a translation phase.
- *A posteriori*: After a translation phase.

Translation: Processes or stages of a megaproject.
- *Visualization*: Conceiving or envisioning a megaproject.
- *Conceptualization*: Developing conceptual models of a megaproject.
- *Implementation*: Constructing or implementing a megaproject.
- *Completion*: Finalizing and handing over a megaproject.
- *Abandonment*: Abandoning a megaproject before completion.
- *Assessment*: Assessing or evaluating a megaproject.

Scope: Reach or impact of a megaproject.
- *Global*: A megaproject with a global reach or impact.
- *National*: A megaproject with impact on a country.
- *Regional*: A megaproject with impact on a region.
- *Local:* A megaproject with impact on a local area.

Sublime: Stakeholders' aspiration to initiate or contribute to a megaproject.
- *Aesthetic*: Aspiration to improve the appearance.
- *Economic*: Aspiration to improve economic status.
- *Egotistic*: Aspiration to satisfy self-esteem or self-importance.
- *Moral*: Aspiration triggered by moral obligation to do the right thing.
- *Political*: Aspiration to improve one's political status.
- *Scientific*: Aspiration to make scientific discoveries.
- *Social*: Aspiration to improve one's social status.
- *Technological:* Aspiration to push the technological boundaries.