University of Wollongong

Research Online

Faculty of Engineering and Information Sciences - Papers: Part A

Faculty of Engineering and Information Sciences

1-1-2014

An Architecture Framework Modification Supporting the Acquisition Stakeholders

Farid Shirvani
University of Wollongong, fs936@uowmail.edu.au

Mahmoud Efatmaneshnik
University of Wollongong, m.efatmaneshnik@adfa.edu.au

Allan P. Campbell
University of Wollongong, pcampbel@uow.edu.au

Follow this and additional works at: https://ro.uow.edu.au/eispapers

 Part of the Engineering Commons, and the Science and Technology Studies Commons

Recommended Citation

Shirvani, Farid; Efatmaneshnik, Mahmoud; and Campbell, Allan P., "An Architecture Framework Modification Supporting the Acquisition Stakeholders" (2014). *Faculty of Engineering and Information Sciences - Papers: Part A*. 6473.
https://ro.uow.edu.au/eispapers/6473

Research Online is the open access institutional repository for the University of Wollongong. For further information contact the UOW Library: research-pubs@uow.edu.au

An Architecture Framework Modification Supporting the Acquisition Stakeholders

Abstract

Architectural modeling is gaining support for urban system development to help governments, local agencies and large enterprises acquire, maintain and develop complex infrastructure. This paper proposes a modification to TRAK (The Rail Architecture frameworK) to make it more suitable for acquisition of the general class of urban infrastructure systems. In this paper four of the main system stakeholders, namely acquirer, developer, investor and regulator are chosen and their concerns are identified. In order to identify the gaps, the procurement viewpoints of TRAK are investigated and analyzed to show their inefficiencies in expressing acquisition scenarios and addressing the concerns of those stakeholders. The first main gap is the lack of requirement traceability as there is no viewpoints showing the flow of requirements from acquirer to developers. Also, there is no customized requirement for investor and regulator who have concerns beyond the direct infrastructure system level. As a response to those gaps, four viewpoints are created by using a mixture of TRAK elements. Some new elements are added to TRAK as the existing elements are not enough for creating three of the viewpoints. Finally, the viewpoints are implemented to create a view showing the parts of the architecture which are of concern to those stakeholders. A SysML requirement diagram is used to implement the first two viewpoints as it supports the requirement traceability.

Keywords

acquisition, supporting, modification, stakeholders, framework, architecture

Disciplines

Engineering | Science and Technology Studies

Publication Details

Shirvani, F., Efatmaneshnik, M. & Campbell, A. P. (2014). An Architecture Framework Modification Supporting the Acquisition Stakeholders. Systems Engineering Test and Evaluation (SETE) (pp. 1-11).

This conference paper is available at Research Online: https://ro.uow.edu.au/eispapers/6473

An Architecture Framework Modification Supporting the Acquisition Stakeholders

Farid Shirvani, Mahmoud Efatmaneshnik, Peter Campbell

SMART Infrastructure Facility, University of Wollongong,

Farids@uow.edu.au

ABSTRACT

Architectural modeling is gaining support for urban system development to help governments, local agencies and large enterprises acquire, maintain and develop complex infrastructure. This paper proposes a modification to TRAK (The Rail Architecture frameworK) to make it more suitable for acquisition of the general class of urban infrastructure systems. In this paper four of the main system stakeholders, namely acquirer, developer, investor and regulator are chosen and their concerns are identified. In order to identify the gaps, the procurement viewpoints of TRAK are investigated and analyzed to show their inefficiencies in expressing acquisition scenarios and addressing the concerns of those stakeholders. The first main gap is the lack of requirement traceability as there is no viewpoints showing the flow of requirements from acquirer to developers. Also, there is no customized requirement for investor and regulator who have concerns beyond the direct infrastructure system level. As a response to those gaps, four viewpoints are created by using a mixture of TRAK elements. Some new elements are added to TRAK as the existing elements are not enough for creating three of the viewpoints. Finally, the viewpoints are implemented to create a view showing the parts of the architecture which are of concern to those stakeholders. A SysML requirement diagram is used to implement the first two viewpoints as it supports the requirement traceability.

INTRODUCTION

Traditionally infrastructure systems are procured by engaging the appropriate engineering organizations to deliver such systems. However urban Infrastructures are gaining high level of complexity, and there is a need to create and maintain these complex systems according with improved tools for managing this complexity and for dealing with the proliferation of standards that must be met. This is necessitating a system acquisition approach (in the common meaning of the term in the defense industry) for the procurement of the systems, which in turn is increasing the demand on the part of urban systems stakeholders to employ systems engineering tools and methodologies. The Defense Acquisition University (DAU) (2011) defines acquisition as the conceptualization, initiation, design, development, test, contracting, production, deployment, logistics support, modification, and disposal of weapons and other systems, supplies, or services (including construction) to satisfy DoD needs, intended for use in or in support of military missions. Acquisition is a much wider concept than procurement, covering the whole life cycle of acquired systems. This change the working view of system acquisition is also taking place in Transport for New South Wales, a statutory authority of the local Government of New South Wales, Australia. At this organization a new effort has begun to employ systems engineering tools to govern widespread adoption of rail standards, design innovation and design efficiency in rail industry in NSW (ASA 2013).

“Model based systems engineering (MBSE)” and “System modeling (by SysML)” are commonly used together and often misinterpreted alternatively in the literature and are assumed to be equivalent.

MBSE is the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases. The aforementioned definitions imply that building a model of a system is not solely enough to realize the MBSE as it is not just a model "of" the system, but it is a model "about" the system. So, not only the system of interest should be modeled, but also all other processes and entities that play a role in the existence of system during its lifecycle have to be modeled too, including those needed to design, finance and build it. System stakeholders such as acquirer, designer, constructor, operator, etc. are the main entities here. Every stakeholder has its concerns about the system, so they are the sources of system requirements at this level. Thus, developing a model which expresses the information flow between stakeholders and the system as well as among the stakeholders themselves will lead to a more transparent understanding of the system development and will facilitate engineering and delivering the system.

System architecture provides a common understanding of the system domain and allows for addressing different concerns about the system by describing the domain from a variety of viewpoints. The viewpoints are defined by the architecture framework that covers the whole domain from enterprise goals and capabilities, to operational activities, system functions, and its structure. The architecture has to be implemented by an Architecture Description Language (ADL). There are a variety of ADLs in use such as Acme, Darwin, and Wright, UML, SysML, AADL and ArchiMate. Acme, Darwin and Wright are developed by academia, the latter two have strong semantics that enable machine-assisted formal verification but have weak tool support (Payne et al. 2010). Semantically weaker ADLs such as Acme, AADL (both used in academia) and UML, SysML (which enjoy wide industry adoption) have extensive tool supports (Payne et al. 2010). With regard to different concerns, suitable viewpoints have to be developed that fetch the relevant information from the architecture.

For viability of urban infrastructure project design and build, the most critical linkages between stakeholders appear at the contracting stage, when the system acquirer passes the user requirements to the contractors; then the contracted project development team sends back the system design documents after elicitation of system requirements and designing the system and its components, including proposed changes and exceptions. It is very crucial to have suitable viewpoints at this sensitive stage that address the concerns about the overall acquisition of the system. In this paper we aim at identifying and defining new concerns about system acquisition processes which are overlooked in a candidate architecture framework, namely TRAK (The rail Architecture Framework) (Plum 2012). Consequently, new viewpoints are proposed to address those concerns.

First, an introduction to TRAK is provided which explains the main viewpoints and how they are mapped to the system development lifecycle. Then the deficiencies of procurement viewpoints of TRAK are investigated. Finally, the new needs for acquisition viewpoints rather than procurement ones are defined and their respective viewpoints are introduced.

HOW DOES TRAK WORK?

Introduction to TRAK

TRAK (Plum 2012), appears to be the only architecture framework (so far) specifically designed for an infrastructure system, which provides the means to create the architecture of an urban enterprise. Briefly, it provides five what it calls Perspectives to describe the enterprise (Figure 1). It starts from describing the enterprise in terms of its goals and the enduring capabilities that are required to support the goals in the Enterprise Perspective. The Concept Perspective describes the solution-free (logical) view of what is needed in response to the capabilities required by the enterprise in the Enterprise Perspective. This perspective is often used for describing or defining the user requirements for the system of interest. The Procurement Perspective then defines the procurement activities necessary to procure the solution to realize the operational activities which satisfy the user requirements. The Solution Perspective covers the parts of 'systems' whether human or machine, their exchanges and protocols. It also describes how resources, organizations and equipment are organized and governed. Note that there can be many solutions to the problem described in the Concept Perspective. The management perspective provides ways of defining the scope and findings of the architectural task, structuring the approach and modeling. It also provides ways of describing the requirements and

normative standards that apply (Plum 2012).

Figure 1. TRAK perspectives

Each Perspective consists of different viewpoints and each viewpoint consists of some tuples (architectural elements often called stereotypes that are linked together by connectors). The viewpoints are used to address a concern about a part of the enterprise domain. For instance, Figure 2 shows an example of the Enterprise viewpoint number 2 (EVp-02) namely Capability Hierarchy viewpoint which is a part of the Enterprise perspective. The concerns that this viewpoint addresses are:

- What are the enduring capabilities the enterprise requires?
- How is capability measured?

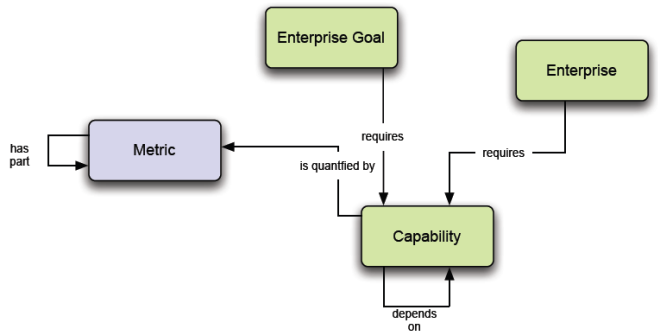

Figure 2. EVp-02 Capability Hierarchy

Stereotypes are the low level ontological objects of TRAK metamodel. There are four stereotypes used in this viewpoint called 'Enterprise', 'Enterprise Goal', 'Capability' and 'Metric'. There are 32 stereotypes in TRAK that contribute in making 21 viewpoints. The collection of all these viewpoints creates the TRAK metamodel which is an ontology that describes and regulates the use of the TRAK architecture framework. The views are instantiations of viewpoints that represent a part of the real world. So, an architecture is created by a collection of views that are instantiated from some chosen viewpoint (not necessarily all the available viewpoints need be used).

Mapping TRAK to the system life cycle

Figure 3 shows the main TRAK viewpoint's relations to a system life cycle -i.e. how they can be mapped into the stages of system life cycle. The vertical axis represents the levels from Enterprise to System Definition and the horizontal axis indicates the lifecycle stages. Having the architecture of an enterprise enables all the stakeholders to have a common understanding of each other's role in the enterprise. Most of the TRAK viewpoints are defined in the scope of one perspective; for instance CVp-01, CVp-03, CVp-05 and CVp-06 are the viewpoints of Concept perspective which are all defined in that scope. However, there exist some viewpoints that are defined in the scope of two different perspectives; in fact we have identified that they are linkages between TRAK perspectives. As some of these viewpoints are used in the newly proposed viewpoints, it is worth to name and explain them here:

- CVp-04 Concept Activity to Capability Mapping:

This viewpoint describes how the concept activities relate to the enterprise needed capabilities, so it is a linkage between enterprise perspective and operational concept perspective. The main role of this viewpoint is to elicit the concept activities needed to support the required capabilities. Also, the capabilities required by an enterprise that aren't supported by any concept activity can be identified by this viewpoint. This viewpoint is employed in developing the newly created "Acquirer viewpoint".

- SVp-05 Solution Function to Concept Activity Mapping:

This maps the solution functions (SV-04) back up to the logical concept activities (defined in the CV-05). The viewpoint realizes whether the solution functions meet all of the concept activities and if there is any unwanted solution functionality. So this viewpoint can be used by the system developer to validate the system and assure the right system is being developed. This viewpoint links the Concept perspective to the Solution Perspective and is used in developing the new viewpoint "Developer viewpoint".

- SVp-03 Solution Resource Interaction to Function Mapping:

This viewpoint maps resource interactions to functions for justification and completeness. That is it shows if the system resources and their interactions are providing the required functionality. So this viewpoint can be used in verifying the system to make sure it is being developed right. This is the reason why this viewpoint is mapped to the validation stage of the system lifecycle.

- EVp-03 Capability Phasing:

An Enterprise has a start and finish date and therefore when a capability is tied to an enterprise this defines a period for which that capability is required. Similarly, a system can realize a capability when delivered or removed by a project activity. The EVp-03 can be used to show the capabilities needed, the capabilities realized (via the solution and procurement perspectives) or contrast the two to determine Capability gaps. So, this viewpoint is using stereotypes of three perspectives: Enterprise, Solution and Procurement.

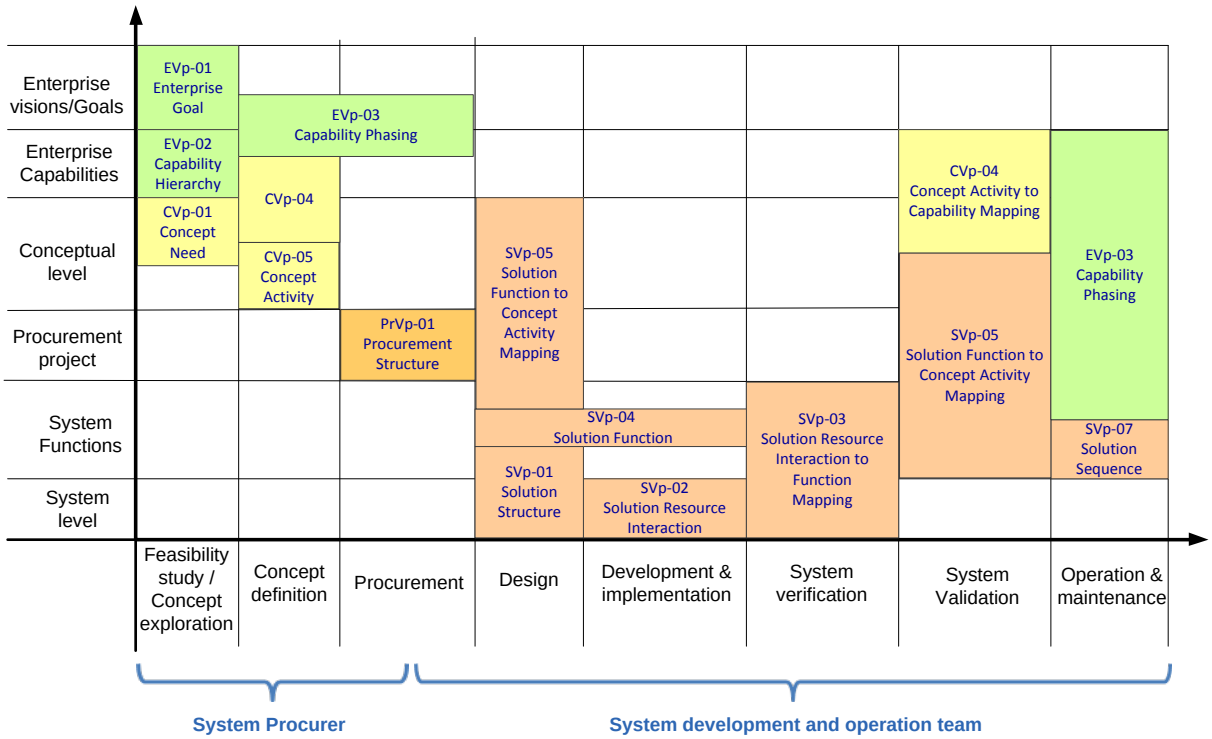

Figure 3. TRAK viewpoints to system lifecycle mapping

IDENTIFIED GAPS

The TRAK metamodel and its stereotypes have been designed in a way which is generic enough to be capable of presenting a large variety of possible scenarios in the system procurement domain. However, not all the potential power of TRAK is exploited through using a mixture of stereotypes to address the main concerns of project stakeholders. The focus of TRAK is on expressing the system procurer's goals and requirements and then representing the solution which is provided by the system developer through a procurement project to satisfy those requirements. The procurement perspective is defined relatively simply as it only looks at the project as a mean of procuring a system. It shows the organization (procurer) governing the project (PrVp-01), the scheduling and timelines of different

projects in procuring a system (PrVp-02), and indicates the systems being procured through each procurement activity (PrVp-03). In fact, the TRAK is mainly created based on the system procurer and developer point of view, so other stakeholders of the system development are overlooked. Moreover, there is no viewpoint that clearly shows the user requirement defined by the procurer and the system requirements elicited from them by the system developers. Consequently, some new viewpoints are needed to address the concerns of other stakeholders in addition to the procurer and developer; and some other new viewpoints to realize the requirement traceability.

In this paper, we describe converting the TRAK representation from a procurement one to a system development one which can be called "acquisition"1. So, from this point onwards in the paper system procurer is called "acquirer". In order to clearly represent the gaps between the procurement perspective and the new viewpoints which fill them, those gaps are listed separately:

- As mentioned above, TRAK focuses on the goals, capabilities and requirements of the acquirer, so there are sufficient viewpoints for showing those concepts. However, the traceability of the requirements is very crucial during the acquisition process and is not well embedded in TRAK viewpoints. The stereotype "Requirement" can be linked to all TRAK elements by a "traces to" link, but there is no specific view point for representing how the goals and capabilities of the acquirer are translated into requirements and how they flow into the acquisition project. As a response to this traceability gap a new viewpoint is created which is customized for the "acquirer" and is referred to as "Acquirer viewpoint".

- The concept perspective is directly connected to the solution perspective (by SVp-05). There is no viewpoint showing how the system functions are defined in response to the user requirements and how the system requirements are elicited from the defined functions. Having such a viewpoint enables us to create a traceable requirement repository which can be used by the system developers. So, the new viewpoint created for filling this gap is called "Developer viewpoint".

- The procurement perspective is focused on the Acquirer and Solution provider as the main stakeholders. Although the stereotypes 'Organization' and 'Enterprise' can be instantiated to represent any kind of stakeholder, the rational connections do not make room for a stakeholders like a Financing Organization or a Regulator, which are other types of stakeholders likely to be present in a modern infrastructure project. In order to show how this gap can be filled, two overlooked stakeholders namely "investor" and "regulator" are chosen and two viewpoints called "investor viewpoint" and "regulator viewpoint" are created to address their concerns.

NEW VIEWPOINTS

As mentioned in the introduction about TRAK, the viewpoints are created to address the concerns of stakeholders by providing them with the relevant information which is in particular tuples of the architecture. In this section we have chosen four of the main stakeholders who play major roles in system acquisition namely acquirer, developer (designer and constructor), investor and regulator. For each of them a new viewpoint by using TRAK stereotypes is customized to address their concerns which are quite varied from each other. Then a sample of that viewpoint is implemented, which is called view, to illustrate how a suitable view can address the main concerns of each of these stakeholders in a consistent way. It has to be mentioned that we needed to create new stereotypes (both elements and connections) to be able to develop some of the viewpoints.

Acquirer

The main concerns of the system acquirer are as follows:

- What are the enterprise goals and what capabilities are required to achieve those goals?

- How the goals and capabilities are translated into the form of high level requirements?

- What are the concept activities that define the system concept and refine the requirements produced by the needed capabilities?

- What are the requirements derived from the concept activities? These requirements will be passed to the system developers and are called "user requirements".

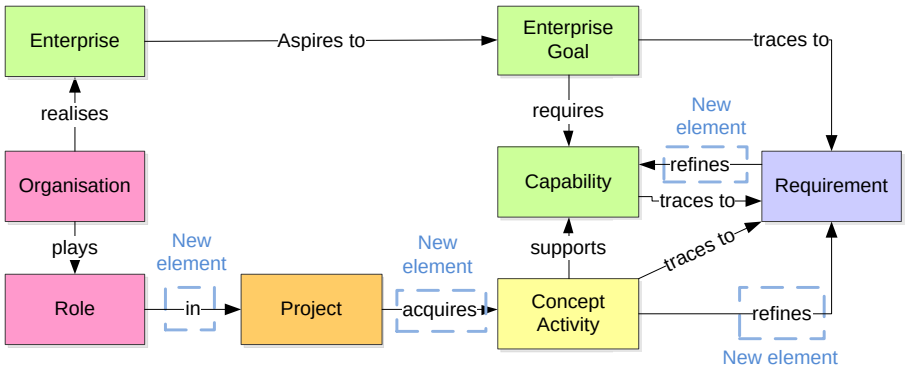

Figure 4. Customized viewpoint for Acquirer

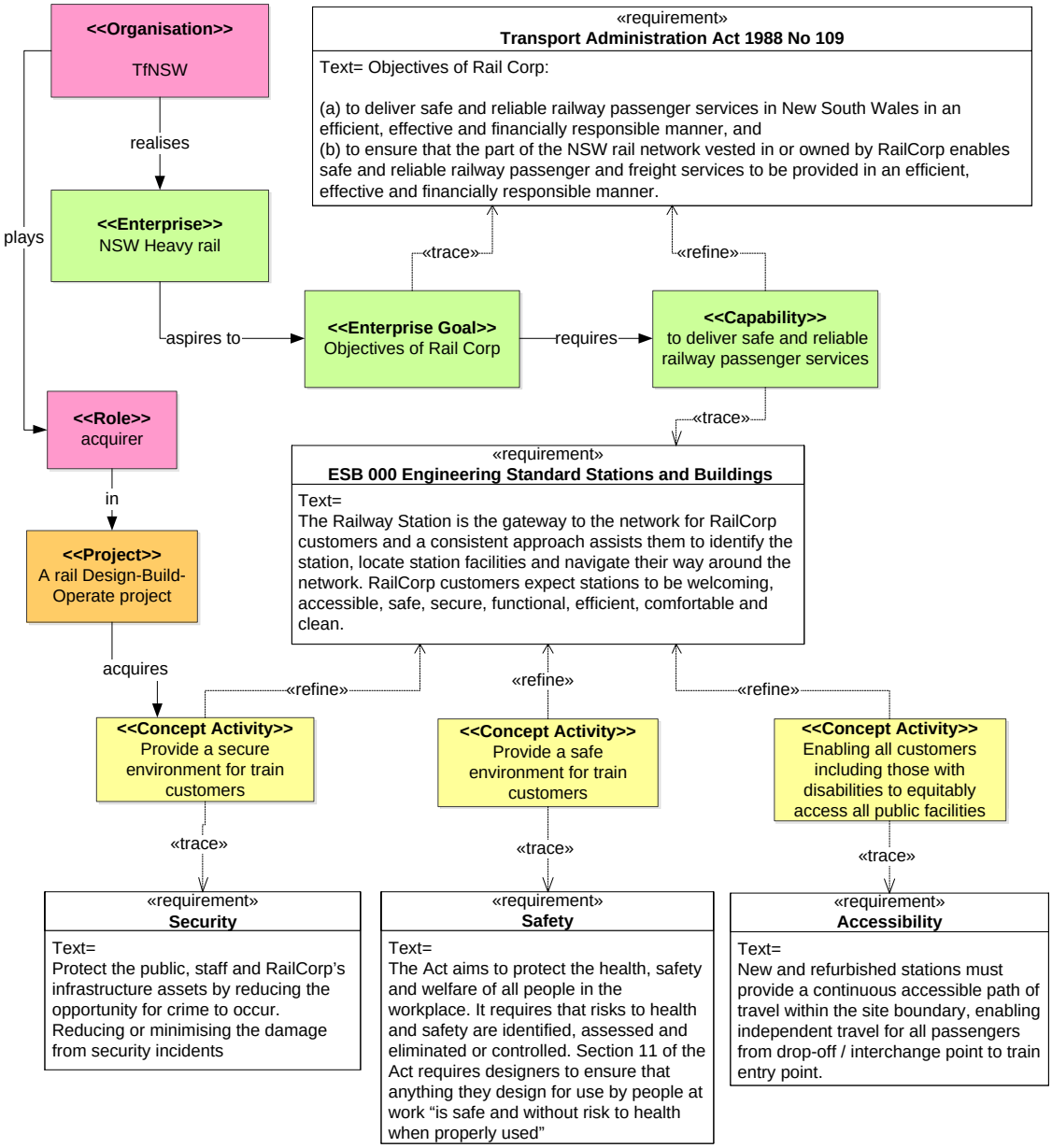

Figure 5. Acquirer view – generating user requirements

The viewpoint addressing these concerns is shown in Figure 4. As this viewpoint is mainly created for the purpose of requirement traceability we used a SysML requirement diagram (OMG 2006) to implement it. Consequently, the connection "refines" is added to the TRAK to make it capable of

presenting the refine connection which is one of the five connections types of the SysML requirements diagram. Also, two more connections called “in” and “acquires” are added for showing the “Role in Project” and “Project acquires Concept activity” tuples. Figure 5 shows the acquirer view which is the implementation of the viewpoint for a rail case. In this example Transport for NSW (TfNSW) plays the role of acquirer in a given design-build-operate project. This view shows how a capability is defined to refine the TfNSW goals and the requirement to which it is traced. Also, the concept activities and the requirements generated by them are expressed.

Developer

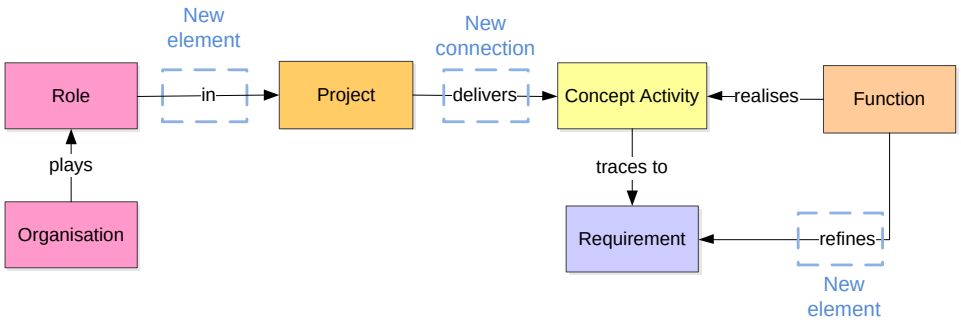

Figure 6. Developer viewpoint

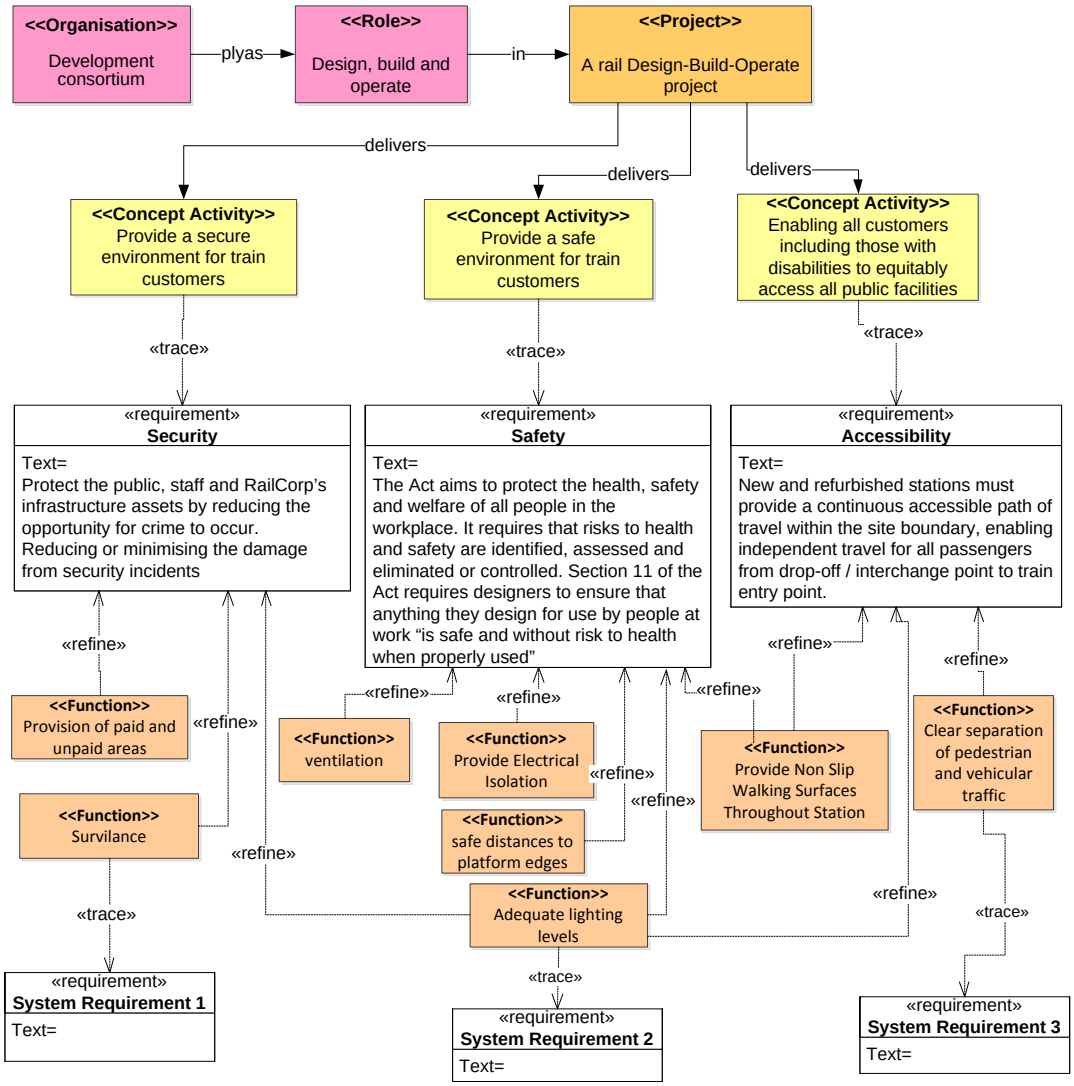

Figure 7. Developer view – tracing user requirements to system requirements

The developer viewpoint is customized to address the concerns of the system development team which are as follows:

- What are the concept activities required by the system acquirer and the requirements generated from them?
- What system functions should be defined to realize those concept activities?
- What are the system requirements generated by the defined functions?

This viewpoint is shown in Figure 6. The connections “delivers” and “refines” are added to TRAK to show the “Project delivers Concept activity” and “Function refines Requirement”. Similar to the acquirer viewpoint, which will be working in conjunction with this viewpoint, the view is implemented by the SysML requirement diagram and is illustrated in Figure 7. In this representation the system development consortium is the organization that plays the roles of designer, constructor and operator of the project which is supposed to deliver the required concept activities defined in the previous view. The functions and generated system requirements are also shown in this view.

Investor

The investors financially support the project to get benefit from the revenues produced by the system operation. So, they do not have any main concern about the system itself, but they are interested in the revenue generated by the project and the costs that they have to pay for in different stages of system development and operation. So their concern can be written as:

- What are the costs and incomes associated with each project activity?

Two elements called “Cost” and “Income” are added to TRAK to create this viewpoint which is shown in Figure 8.

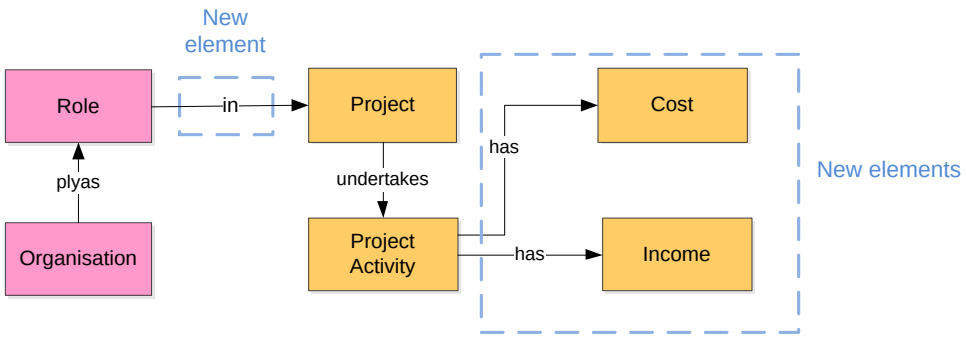

Figure 8. Investor viewpoint

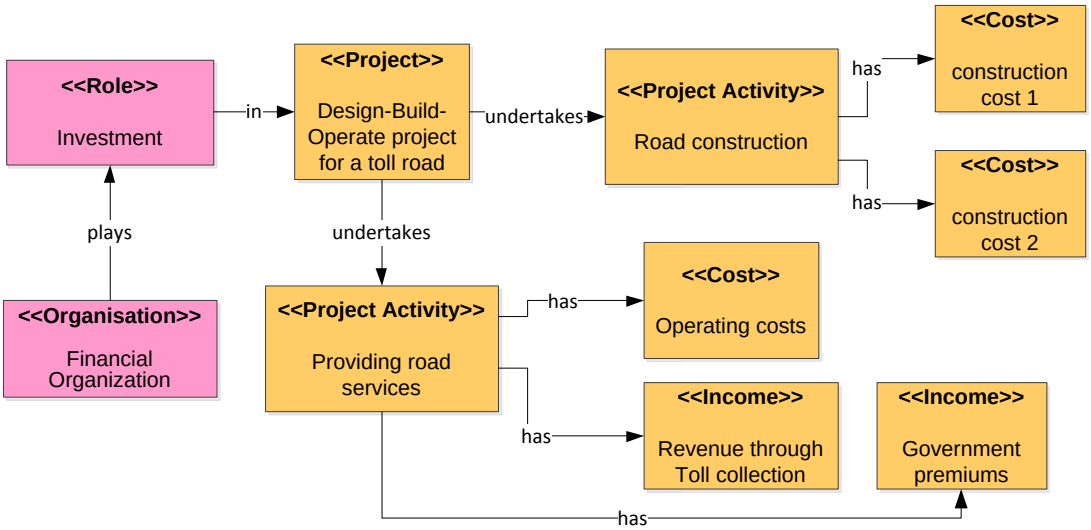

Figure 9. Investor view

The view is implemented to show a financial organization which plays the role of investor in a toll road project. There are some costs associated with the construction and operation of the road. The income sources in this project are tolls collected from the customers and the premium paid by the government in case of toll collection being insufficient to cover agreed returns. Figure 9 illustrates this view.

Regulator

There exist standards, acts and regulations which must be followed by the project team during the system development and operation. These standards are usually defined by federal and state government and are enforced under supervision of regulatory agencies. The concerns of the regulators are:

- What standards and acts are applicable to this project?
- Which standard should be applied to which project activity?

The regulator viewpoint aims at illustrating the applicable standards to a project, the organization issuing those standards and the connection of them to different project activities. This viewpoint and the sample view implemented by that are shown in Figure 10 and 11 respectively.

Figure 10. Regulator viewpoint

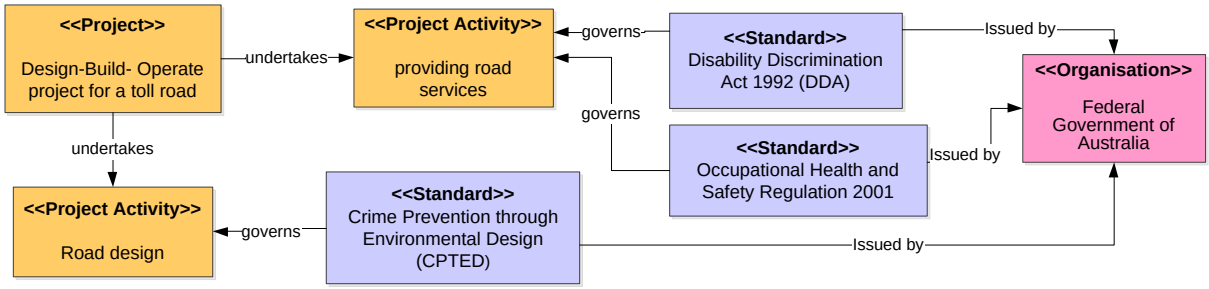

Figure 11. Regulator view – Showing a few of the many possible regulations

It should be mentioned that there are many standards applicable to the project phases including design, construction, operation and maintenance. Figure 11 shows just a few of possible standards (of the over 900 that we know exist).

DISCUSSION

As shown in figure 4 and figure 6, the requirements originate in the enterprise level and then are translated into more detailed requirements in concept, function and system levels. The Acquirer and Developer viewpoints act as a two part connected channel that carries the requirements from the point of origin to the lower levels of system development team. These two viewpoints are attached in the concept level which means that the requirements of Acquirer (user requirements) are sent to the Developer in the form of system concept, not system specifications (system level requirements). Having the user requirement at concept level provides the developers with more room for innovation in design and construction as they do not follow the prescriptive requirements, but they respond to the performance requirements in a way to satisfy them by the least costs and usage of resources.

The architecture, regardless of the entity it describes, is an integrated network of information which expresses a design concept as a whole. The viewpoints are defined at the architecture framework level to filter the information according to what is needed to be shown out of the architecture. Data visibility and access levels to the information is a matter of care in every organization, so, in order to practically use such architectures some sort of access permission levels have to be defined on the architecture to control the visibility of information to different individuals within an organization and also to different

organizations that are mutually using the architecture. As the architecture is a live model and is expected to be updated regularly, the read and write permissions have to be defined to assure the authorized modifications.

CONCLUSION

Architecture frameworks are able to provide an understanding of the structure of an enterprise. The use of different views of the enterprise architecture gives the stakeholders a common understanding of each other's role in that enterprise. Stakeholders are the source of system requirements during the system development lifecycle as they have their concerns about the system. The main goal of a systems engineering approach and the model based version of that (MBSE) is to manage the system life cycle considering all the concerns and assuring that they are addressed and can be traceable to one another. This aim is achieved by defining viewpoints which provide particular information to the stakeholders to address their concerns.

TRAK was chosen as a candidate architecture framework for analysis in this paper; because it is the only such framework specifically tailored for infrastructure systems and has been specifically use for an urban system (rail). An acquisition of a proposed rail system prompted the proposed modification of the TRAK architecture description framework.

The system acquisition stage was investigated in this study. System acquirer, system developer, investor and regulator are the main stakeholders who deal with or have vested interest in system and user requirements. On this basis, four new viewpoints for the TRAK architecture are defined as for use in this ongoing work. These viewpoints will be contributing to creating pieces of architecture which reflects suitable information about the expanded procurement stage, which is called acquisition in this paper. The views, which are the instantiated state of the viewpoints, have been implemented to show the parts of architecture created by those viewpoints. SysML diagrams were used to implement the views as it can express the requirements traceability clearly.

REFERENCES

Asset Standard Authority (ASA). http://www.transport.nsw.gov.au/asa

Object Management Group (OMG), 2006, Systems Modeling Language version 1.0, Available from www.omgsysml.org. [Accessed July 2006].

Payne, R., and Fitzgerald, J. "Evaluation of architectural frameworks supporting contract-based specification," *Computing Science*) 2010.

Plum, N. "TRAK Enterprise Architecture Framework. http://trak.sourceforge.net/implementations.html," 2012.

Systems Engineering Fundamentals Defense Acquisition University Press, 2011.

BIOGRAPHY

1. Farid Shirvani is a PhD student in SMART infrastructure facility, University of Wollongong under supervision of Professor Campbell since 2012. His research interest is assessment and application of MBSE methodologies and tools in complex systems domain. He holds an MS in Information and Communication Technology with major in Enterprise Networking from University of Wollongong, Australia in 2011. His previous research field was design and development of a Decision Support System for diabetic complications
2. Mahmoud Efatmaneshnik has a PhD in Engineering Management of Complex Systems from University of New South Wales, Australia (2009), ME in Industrial Management (2004) and BE of Aerospace (1999). He has researched complex engineered systems characteristics for many years and has made significant contribution in the field. His priority research focus has been toward addressing management of the coupling between product/system, process and

organization complexities. He has several years of experience in modeling complexity, robustness, resilience of engineered systems and organizational coherence. He has authored or co-authored more than 35 journals, book chapters and conference papers mostly in systems engineering, trade-space analysis, flexibility, adaptability, complexity, robustness and reliability engineering. He has hands on experience with integrated navigation system for a civil automated guidance systems. His research interests are modeling and simulation of complexity, collaborative design of large-scale and complex systems, design decision support system for self-organizing adaptable problem solving, complexity measures of engineered systems, system resilience, flexibility.

3. Professor Campbell is Professor of Systems Modelling and Simulation and Research Leader in the Defence and Systems Institute (DASI) at the University of South Australia since 2004. DASI has a focus on up-skilling government and the defence industry in complex systems engineering and systems integration. From October 2010 he has held a parallel appointment as Professor of Infrastructure Systems, SMART Infrastructure Facility, University of Wollongong. His interests include agent based modelling for the development of decision support systems, and scenario analyses of complex systems, and model based Systems Engineering. Prior to joining the University of South Australia, he was at Argonne National Laboratory where he was engaged in similar modelling and simulation work.