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Concept of Operations of Procurement Engineering Management Support System

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Abstract : A software support system, called procurement engineering management support system (PeMSS), is currently under development through a joint research project. The procurement-related scenarios considered in this research is as follow: an EPC (Engineering, Procurement and Construction) company receives an EPC project contract and starts the project to deliver the agreed system to the acquirer. In order to acquire the required equipments that the EPC company does not produce by itself, it eventually interacts with subcontractors, also called vendors. The EPC company responsibilities during the procurement activities are twofold. First, the EPC company has to guarantee that it has ordered the equipment, through issuing Purchase Order (PO), based on the requirements stated in the contract. Second, the EPC company has to verify that the received equipment designs, called Vendor Print (VP), meet the specifications in the PO, before finally acquiring the equipments. During our survey study, we discovered that EPC company takes a lot of time and effort to create PO and verify VP, mainly because these activities are performed manually by the responsible engineers. Therefore, we intent to support the above activities by developing a support system to the legacy procurement system that can trace the requirements from the contract to the PO and VP, among other functionalities. At the time of the writing of this paper, PeMMS is still under-development, thus, in this paper we focus on presenting the development steps of PeMMS using systems engineering theory and introducing the PO creation function. Wholly, PeMSS attempts to reduce the time and effort of engineers on the procurements activities while also increasing the quality of the procurement outcomes.

Key Words : Procurement engineering, EPC, e-procurement, software platform, project contract.

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1. Introduction

Engineering, Procurement and Construction (EPC) companies play important roles in bridging the research advancement ideas into reality as they bring new system to realization. EPC companies are project-based companies, and the projects also called EPC projects where they contribute to the national economic development. However, EPC projects are often have detrimental performance, increased cost (decreased profit), and delayed completion time [1].

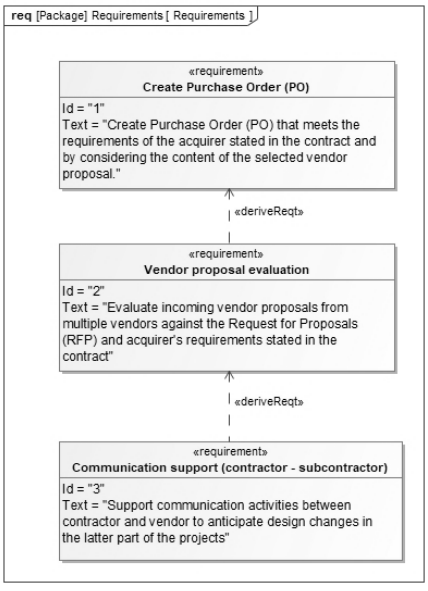
A survey presented that EPC projects often perform lower than planned or perceived [2]. It showed that 69% of the projects, recognized by their performers, have low profit margin, where average profit margin is about 3.75%. Also 64% of the projects have schedule delay, which may leads to unexpected cost increase and probably quality degradation (equipments being idle outdoor for too long may aged). In regard on the project's value, about 70% of the projects were reported to have procurement costs to be at least 30% of the project value or more. The procurement costs, compared to overall procurement, are mainly for major equipment procurement (average 36%).

An EPC project has three main activities, that is Engineering/design, Procurement and Construction activities. Compared to engineering and construction activities, the procurement activities are often overlooked. Engineering are often perceived as the idea sources and construction as idea realization. However, procurement activities are as important because for every designs produced during engineering activities, at some point, the engineers will need to purchase the equipment, whether as a whole (package) or sub-parts to be assembled.

Another reason of procurement being often less considered is because it's activities are inherently simple. It includes available budget, purchase requests, and vendors. However, as the project's complexity increases, various advanced processes are required, such as sourcing, contracting, on-site materiels management, and so on. Effective procurement activities may lead to project cost/time reduction as well as better quality.

In this paper, among the procurement tasks, we focused on the creation of purchase orders (PO) that marks purchase decision with a certain vendor. We present this issue as the main requirement from the stakeholder and derived two requirements (complete requirement derivation is omitted) as shown in Figure 1. The derived requirements are:

1. Vendor proposal evaluation: proposals from multiple vendors are evaluated to select the most suitable vendor and PO should be



[Figure 1] Requirements derivation

addresses to the selected vendor by considering the vendor's proposal content,

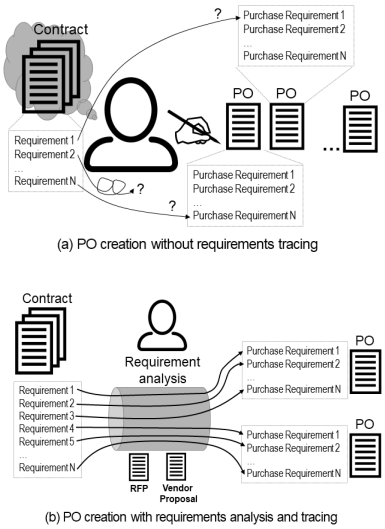
2. Communication support: communication between EPC company (as contractor) and vendors (as subcontractors) during procurement activities is facilitated to reduce future design changes, which can be costly in terms of cost and time.

2. Procurement engineering management support system (PeMMS)

2.1 Purchase Order (PO) creation with requirements tracing

During user survey, we found out that POs are not created in a systematic manner. The engineers rely on personal experience, ad hoc discussion, and referencing manually with standards/references during PO creation. The underlying requirement is that the engineers have to match the requirements in the contract to the proposal submitted by the selected vendor to create POs (illustrated in Figure 2(a)). Using this method, there is lack traceability between the requirement source (contract) to the POs, which may lead to purchase confusion and errors.

In the proposed PeMMS, we encourage requirements tracing between the information items, those are: contract (requirements source) – RFP – proposals from vendors – POs (illustrated in Figure 2(b)). During these processes, further requirements analysis may be performed, such as derivation, task/function mapping, categorization, prioritisation, criteria setting, etc. [3].



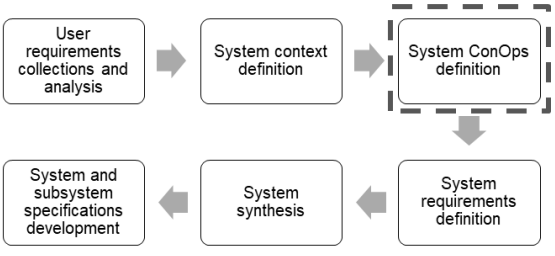
[Figure 2] Requirements tracing in creating PO

2.2 PeMMS development steps

PeMMS supports the procurement activities of EPC projects. We assume that there is an underlying procurement system already applied by EPC performers, in which PeMMS acts as an add-on to that legacy system (interface design also considered important in PeMMS functions). Currently, we focused on adding the requirements tracing into POs creation. PeMMS development steps, as shown in Figure 3, follow the systems engineering (SE) principles. During the writing of this paper, PeMMS is still under-development, namely in the step of "System requirements definition", thus in this paper, we present the System ConOps.

2.3 PeMMS context

First of all, we define the procurement activities



[Figure 3] PeMMS development steps

covered in this paper. Mainly from the result of user requirements collection, we identify the common/traditional procurement activities as follows. Procurement activities start when procurement department receives a purchase request from engineering department. Depending on the purchase scale, procurement department may produce a request for proposal (RFP) and publish it to vendors. Vendors submit their bid/proposal and procurement department together with engineering department evaluate the proposals and select a suitable vendor. The procurement department then produce a purchase order (PO) addressed to the selected vendor. The vendor respond with equipment design blueprints, also called vendor prints (VPs). Engineering department may request changes on these VPs, if any, in which the vendor updated them. When VPs is agreed, the vendor proceed with manufacturing and shipping the equipments, in which the procurement activities end. Sometimes, during the equipments manufacturing or shipping, design changes may occur.

From the identified procurement activities, in PeMMS, we plan to add a function prior to the purchase requests from the engineering department, namely: after the contract is uploaded to PeMMS, it should be able to identify the technical and non-technical requirements from the contract. The procurement tasks considered in PeMMS is presented in Table 1 and Figure 4.

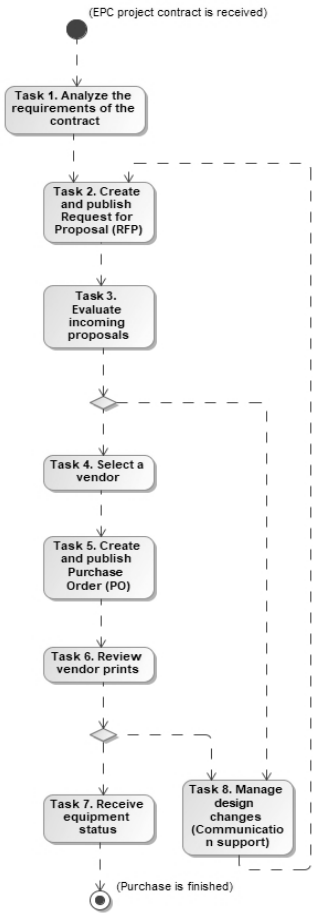
From the above procurement activities, in this paper, we focus on "Create and publish Purchase Order (PO)". The reasons of selecting this activity are as follows:

During our survey, it is agreed that PO creation is an important activity because it

<Table 1> Procurement activities considered in PeMMS

No	PeMMS task	Requirement type*
1	Analyze the requirements of the contract	N/A
2	Create and publish Request for Proposal (RFP)	N/A
3	Evaluate incoming proposals	Derived
4	Select a vendor	N/A
5	Create and publish Purchase Order (PO)	Main
6	Review vendor prints (VP)	N/A
7	Receive equipment status	N/A
8	Manage design changes (Communication support)	Derived

* the requirements considered in this paper, not the requirements in the contract.



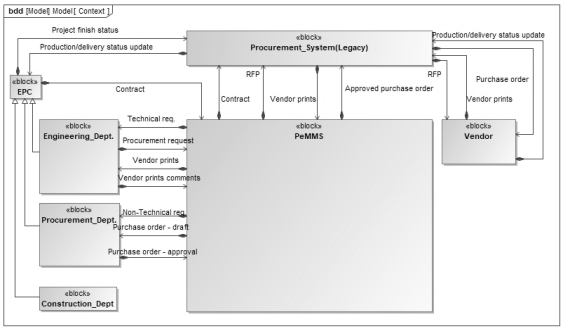
[Figure 4] Procurement tasks

marks purchase decision with a certain vendor. After PO is published, it might take a lot of effort, if not impossible, to change vendors or to cancel the purchase.

- The PO creation is time-consuming since the engineers have to check the information items one-by-one manually against the desired quality (standards).
- The engineers also have to trace the PO to the requirements in the contract and plan a verification activity for the to-be-received equipment.
- The PO creation is not included in the common/legacy procurement system.
- Project's risks may be traced back to PO [4]. Thus PO creation is a risky activity.

PeMMS is an electronic procurement system [4, 5] that works as an add-on to a legacy procurement that is implemented in the EPC company. The e-procurement method has higher data integrity compared to document-based procurement method. Also, e- procurement improves the performance of supply chain [7].

As shown in Figure 5, PeMMS context involves the legacy procurement systems and the users. The users are the engineering, procurement, and construction department, and the vendor. The vendor can only interacts with the legacy procurement system while the other users can interact with both legacy procurement system and the PeMMS. All of the users provide input data to the systems and respond to the results from the systems. PeMMS interacts with the legacy procurement system in processing these information: contract, RFP, vendor prints, and approved PO.

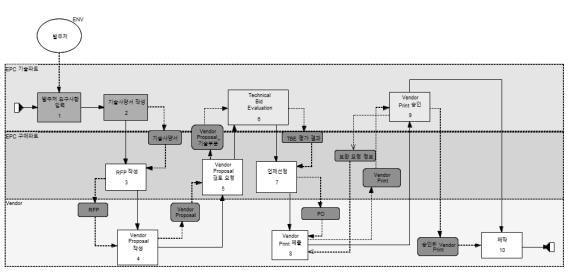


[Figure 5] PeMMS context

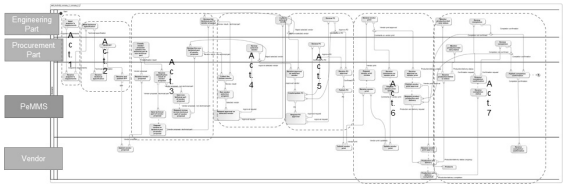
2.4 PeMMS Concept of Operations (ConOps)

The initial concept of operations (ConOps) of PeMMS is developed by referencing to the literature and by interviewing EPC companies, which shown in Figure 6 (initial ConOps). In Figure 6, three users are presented, as follows: the technical part of EPC (renamed to engineering department), the purchase part of EPC (renamed to procurement department), and Vendor. Notice that the PeMMS is not presented in this initial ConOps. The initial ConOps shown in Figure 6 simply serves as a comparison between the initial ConOps and the detailed ConOps. The information listed in this figure is obsolete.

Based on the initial ConOps, we developed a detailed ConOps by adding the system point of view and defining the information items exchanged between users and system. The detailed ConOps is shown in Figure 7 with the



[Figure 6] PeMMS initial ConOps



[Figure 7] PeMMS detailed ConOps (Higher-resolution figure is presented in Appendix)

procurement activities (Table 1) number marked on it. However, in this stage of ConOps development, we have not defined (and it is not compulsory to define) the abstraction level of the information items. We intent to define the information items abstraction level, such as document-level, sentence-level, data-level etc, when we develop OpsCon (Operational Concept) as our solution. So far, we planned to proceed with the sentence-level information items.

Explanations about the activities in Figure 7 is explained in details based on the activities, as follows:

Activity 1. Analyze the requirements of the contract.

This activity is a new concept in PeMMS in terms of that it was not considered in the legacy procurement system. In this activity, engineering department inputs the requirements in the contract into PeMMS. PeMMS either accepts those requirement statements or extract the requirements from the uploaded contract documents by itself. In the latter case, PeMMS needs to recognize the content type to categorize each sentence to be a requirement or not a requirement. Considering advanced techniques, PeMMS might be able to categorized requirements further to be technical requirement and non-technical requirements and so on.

Activity 2. Create and publish RFP

The engineering department analyzes the requirements in the contract and creates technical specifications for the equipment that needs to be purchased. PeMMS stores the technical specifications and notifies the procurement department about the purchase request from the engineering department. Procurement department prepares the RFP based on the technical specifications and adds the non-technical limitations such as proposals acceptance duration, equipment cost and delivery time. PeMMS stores and publishes the RFP to the vendors. In order to publish the RFP, vendors information should be saved in PeMMS. A possible advancement in this scenario is PeMMS may prepare draft RFP from the technical specifications and request approval/comments from the procurement department.

Activity 3. Evaluate incoming proposals

PeMMS accepts proposals from vendors during the acceptance duration and notifies the procurement department, that divides the content into technical and non-technical part and inputs the classification results back to PeMMS. PeMMS saves both parts separately and requests review about the technical part to engineering department and the non- technical part to procurement department. Both departments input their review result to PeMMS. This scenario can be enhanced by allowing PeMMS to classify the content of vendor proposals by itself. In this case, PeMMS needs content recognition function. Alternatively, PeMMS might provide electronic proposal input system, where the technical and non-technical parts are divided and PeMMS requires the vendors to input the respective information

correctly separately. Moreover, to assist the review process, PeMMS might perform initial evaluation by comparing the content of vendor proposals to the RFP and present the comparison results to engineering and procurement department.

Activity 4. Select a vendor

From the technical and non-technical part review results, PeMMS can run vendor selection algorithm given data are provided beforehand. Examples of vendor selection criteria are: vendor's facilities, vendor's workers condition, vendor's current work load, previous purchase history involving the vendor, vendor's licenses and patents, etc. PeMMS requests approval for the selected vendor to engineering department and procurement department. When both departments approve the selected vendor, this activity is finished. If departments do not approve, then either the vendor selection algorithm is executed again with different parameters or activity 3 is performed again. However, in the case that the data for vendor selection algorithm is not provided, then algorithm cannot be executed and engineering and procurement departments should discuss and select the vendor manually and input the selection result to PeMMS.

Activity 5. Create and publish PO

PeMMS creates a PO addressed to the approved selected vendors. In order to be able to create a PO, PeMMS have to know the standard PO template for every equipment to be purchased. Referring to PO template, PeMMS fills in the content from the selected vendor proposal and the comments from engineering and procurement department, if any. PeMMS requests for PO approval to engineering and procurement department. When approval is obtained, PeMMS publishes the PO to the selected vendor and publishes proposal rejection notification to other vendors, if any. PeMMS also requests for vendor prints (VP) to the selected vendor. A possible advancement in this scenario is to provide information to the engineering department during the PO review. We had explain in the previous section about the problems occurred in PO creation. PeMMS might help by providing the necessary information, such as the requirements in the contract, the codes and standards of the equipment, etc.

Activity 6. Review vendor prints (VP)

PeMMS accepts VP from the vendor inputs and request for comments to the engineering department. Because the content is mainly technical, the procurement department does not need to review the VP. If engineering department requests for VP updates, then PeMMS forwards the request to the vendor and accepts updated VP. When engineering department approves the VP, PeMMS notifies this result to the vendor and requests for product production and delivery status input. PeMMS might be enhanced to support the VP reviews by providing historical or similar VP for comparison. Also PeMMS might provide requirements tracing from the vendor proposal to the submitted VP.

Activity 7. Receive equipment status

PeMMS receives production and delivery status from vendor and notifies engineering and procurement department. Both monitor the delivery status and check the actual delivery on the construction site. When vendor inputs

delivery completion status, PeMMS requests for completion confirmation to engineering and procurement department. It might also be requested to construction department. If completion confirmation is not obtained from both departments, then PeMMS continues to request for product delivery. When completion confirmation is obtained, PeMMS notifies the vendor and closes current project.

Activity 8. Manage design changes (Communication support)

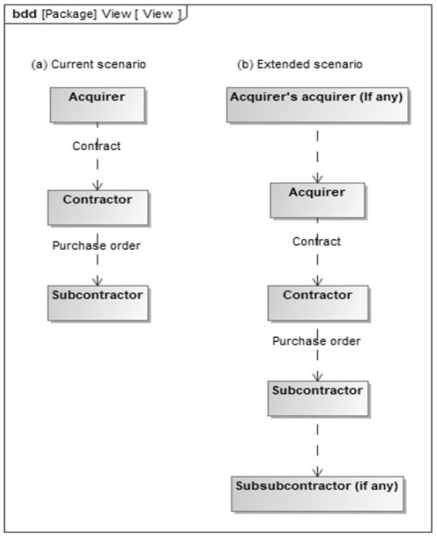
This activity is not explicitly shown in the detailed ConOps because it occurs during other activities. Currently, we consider two events of communication between the contractor and subcontractors. First communication event is during the technical specifications writing. The engineering department may communicate with the vendors to get insights about the equipment current technology status and supply status. Second communication event is during the VP reviews. The engineering department's request for VP updates, thus triggering design changes, might be reduced if engineering department and vendor negotiate on the changes beforehand. PeMMS should support this communication by providing communication platform and saved the communication history.

3. Discussion

In this section, we discuss some of the ways to enhance and add value to PeMMS.

3.1 Extended scenario

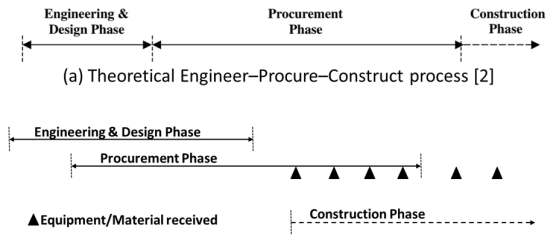
The above discussed procurement activities are seen in the viewpoint of the EPC company as a contractor, with the considered scenario of a contractor receiving a contract from an acquirer and produce POs to multiple vendors/subcontractors. This scenario can be extended to consider the whole cycle of EPC project. In other words, considering the viewpoint of the vendors/subcontractors. they can further produce POs to subsubcontractors, and in the viewpoint of the contractor, it may produce proposals to compete with other contractors on other EPC projects. PeMMS should be developed by also considering the extended scenario. Figure 8 illustrates the current scenario and extended scenario.



[Figure 8] Comparison of current and extended scenario

3.2 Procurement timing

In EPC projects one can assume that the engineering, procurement, and construction activities occurs in series, as shown in Figure 9 (a). However, it is almost impossible due to the time limitations and design changes must be anticipated. It is commonly agreed that procurement starts during engineering activities, called strategic procurement [8], as illustrated



[Figure 9] Theoretical and actual EPC process

in Figure 9 (b), where the procurement phase starts early and in parallel with the engineering phase in order to prepare the material in the fields on time for the construction phase, as some procurement process may take a long time to process.

There are two main documents/information items that mark the procurement activities: 1) Request for Proposal (RFP) marks the decision to purchase some equipments and 2) Purchase Order to marks the decision of procurement with a specific vendor. Thus, the question of how complete is the design for the procurement to start has to be considered. A study stated that the level of design completeness affect the opportunity for innovation (low completeness), technical bid simplicity and possibility of higher change requests (high completeness) [9]. However, it stated that 30% of the design should be completed for the RFP to be published, where various cases are allowed considering the project complexity and other measures. The PeMMS should have the option of supporting various levels of design completeness.

3.3 Database and knowledge-based method

In order for PeMMS to support the legacy procurement system more effectively, relevant data should be collected and maintained in the database system [10]. The data may be later used in the knowledge-based processing. For example, for PeMMS to excell on the task of PO creation, these database and knowledge-based method are required:

- Purchase order standard form/template for each type of equipment purchase
- Purchase order standard form/template that match the equipment code & standard
- Purchase order completeness requirements based on the design completeness level
- Previously issued purchase order on the same or similar equipment
- Current and previous contract data
- Vendor's technical and non-technical data, and so on

4. Conclusion

In this paper, we propose to enhance the procurement activities of EPC projects by introducing PeMMS as an add-on to the legacy procurement system. Currently we focus on the Purchase Order (PO) creation of the procurement activities. Procurement department has prepared PO relied heavily on personal experience, internal discussion, and manually referring to the standard documents. This method is time and effort consuming as well as risky from purchase errors that may lead to fail to meet the requirements stated in the contract. Therefore currently we are developing PeMMS to manage the procurement activities in a systematic manner. We are developing PeMMS by tracing the higher level requirements to end of the procurement activities.

Acknowledgment

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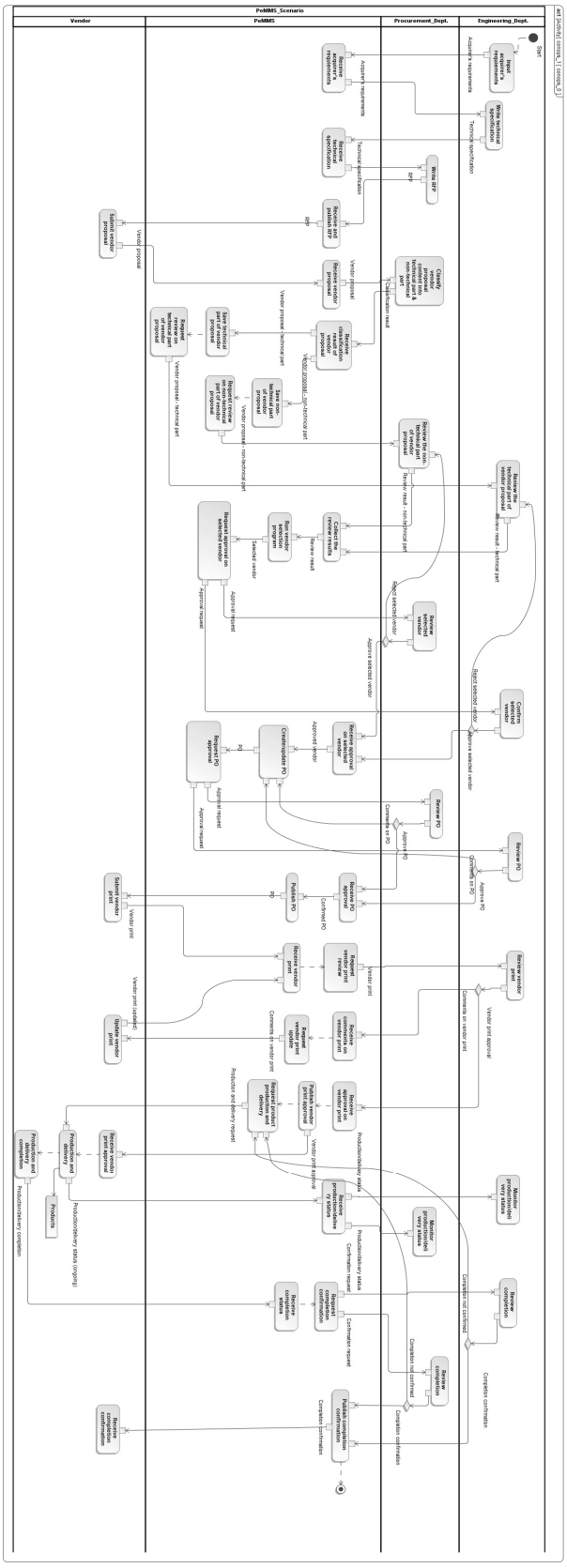

[Appendix] Higher-resolution of Figure 7