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System support engineering application: a refinery case

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Abstract. Modern refineries are complex, very high in value and production. They are expected to function for years to come, with ability to handle the change in technology and feed quality. The aging of a refinery and continues increase of vendors and contractors numbers forces the refinery's operation management to design a support system which can capture these changes. Furthermore, an accurate performance measurement and risk evaluation processes are highly needed. Therefore, this paper explores the nature of the support system design for a refinery. The research work explores the operation support system from a range of perspectives, interviewing managers from across the refinery organization. The factors contributing to complexity of a support system are described in context is presented which clusters them into several key areas. It is proposed that this framework may then be used as a tool for analysis and management of support system. The paper will conclude with discussion of potential application of the framework and opportunities for future work.

Keywords: System Support engineering, refinery, performance, complexity, support system management.

Introduction

Modern refineries are complex, very high in value and production [1]. They are expected to function for years to come, with ability to handle the change in technology and feed quality. Refinery stakeholders are demanding more value out of their asset by ensuring sustainability in operation. These include availability, readiness, extended operation and other value schemes. Literatures show that complex engineering industry is proposing the whole systems approach to satisfy customer's needs. Support systems have to focus on links, interactions and the alignments of the elements [2]. As the refinery stakeholders intend (in some cases have) to outsource the support service and activities, the service provider will take significant part of the risk of sustaining capabilities of the refinery for the duration of the service contract [3-9]. In other phrase, the performance of the refinery will relay or directly affected by service of support provider(s). It is to the interest of the refinery owners (operator) that the refinery does perform as they wish. Hence, the relationship between the support service stakeholders should be clearly drawn and understood in regard to the implication and the nature of performing together to get the most out of the system.

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The aging of a refinery and change in feed quality (crude oil) will lead to continues increase of number of contractors and processing units. This increase forces the refinery's operation management to design a support system which can capture these changes. Furthermore, an accurate performance measurement and risk evaluation processes are highly needed to be developed in alliance with the support system development.

Therefore, this paper explores the nature of the support system design for a refinery. The research work explores the operation support system from a range of perspectives, interviewing managers from across the refinery organization. The factors contributing to complexity of a support system are described in context is presented which clusters them into several key areas. It is proposed that this framework may then be used as a tool for analysis and management of support system. The paper will conclude with discussion of potential application of the framework and opportunities for future work.

1. The case studied refinery

Refining process is simply producing petroleum products and by-products by treating Crude Oil [10, 11] through three key processes: Distillation, Conversion and Clean-up. Petroleum refinery is an industrial process plant where crude oil is processed [12] into products such as petroleum naphtha, gasoline, diesel fuel, asphalt base, heating oil, kerosene, and liquefied petroleum gas [13, 14].

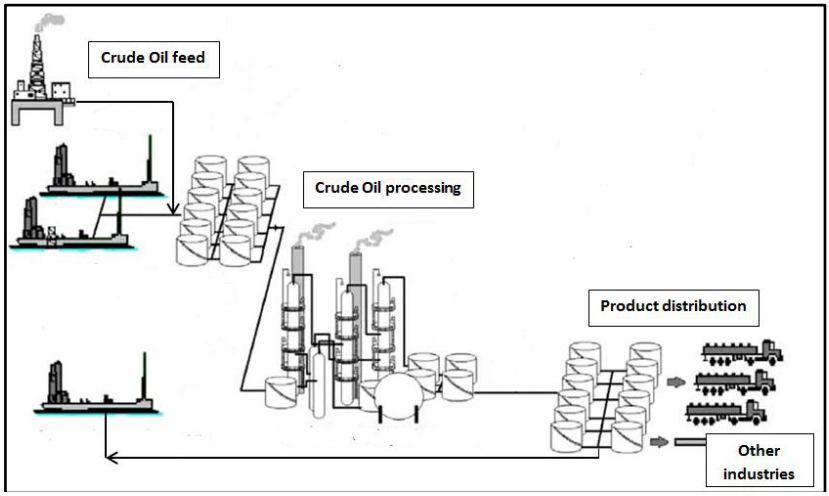

Figure 1: A general layout of a refinery

Sohar refinery is owned and operated by Oman Oil Refineries and Petroleum Industries Company (ORPIC). ORPIC Created from the integration of three companies[15] :

1. Oman Refineries and Petrochemicals Company LLC (ORPC)
2. Aromatics Oman LLC (AOL)
3. Oman Polypropylene (OPP)

ORPIC is one of Oman's largest companies and is one of the rapidly growing businesses in the Middle East's oil industry. It employs more than 1,600 employees [16]. Sohar refinery is a combination of three major complexes:

1) On-Site Process Units

Units where all chemical reaction occurs

2) Utilities Facilities
   - Power Plant, Electricity Receiving and Distribution System.
   - Sea Water Intake Station
   - Water system.
   - Steam and Condensate system.
   - Fuel Gas and Natural Gas System.
   - Instrument Air and Plant Air system.
   - Nitrogen System.
   - Chemicals Preparation and Injection Facilities
3) Offsite Facilities [17]
   - Feedstock & Slops Tankage
   - Product Tankage
   - Marine Loading
   - Truck Loading
   - Waste Water Treating System
   - Sulfur Granulation
   - Bagging System
   - Others

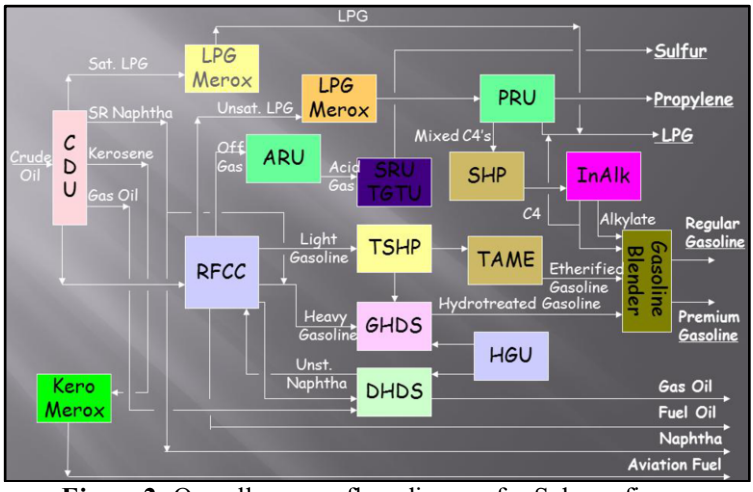

Figure 2: Overall process flow diagram for Sohar refinery

Sohar refinery is the heart of other chemical industries complexes in the Sohar port site, where it is the main supplier of their raw petrochemical materials. Hence, the criticality of the Sohar operative performance significantly rises. Therefore, in order to meet functional demand by the end users, the capability and efficiency of the system should keep increasing [18]. As a result of that, the management of the Sohar refinery needs to measure the performance of the support system to insure operations meets the demands. Performance measurements depend on good operation support data that is

analyzed with sound methods and be translated into information and knowledge allowing decisions to take place. Refinery officials often complain of information overload and difficult to allocate and that they do not have all the relevant information to make sound and well-informed decisions.

To identify what parameters to measure, it is needed to first understand what to change to improve performance and subsequently, identify what are the measuring parameters. After reasonable investigation, data analysis and staff interviews, main challenges were highlighted to be:

- People working behavior and culture understanding and training within organization.
- Process and system integration and harmonization as whole coherent systemic approach.
- Maintaining ongoing performance sustainability and improvement.

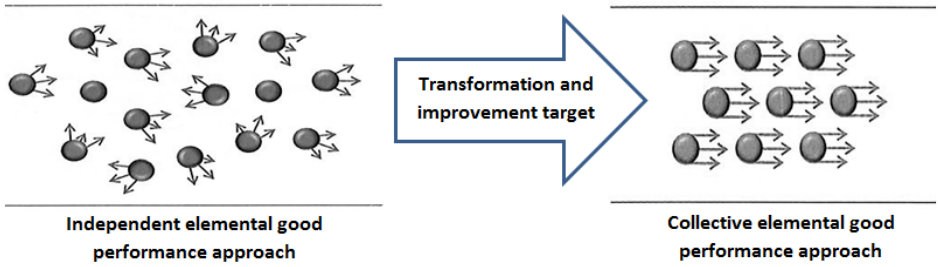

Figure 3: Management view of the targeted operation support system.

This support the indication of a need to develop a structure(s) that practitioners in the refinery can use to help in support system design for operating refinery as a long-term service that maintains optimized performance and achieves the best return on investments. This structure should integrate industry domain knowledge to create and deliver a specific support solution for in-service refinery, as the circumstance requires.

Classical techniques in refinery management involve performance monitoring, process control and fault diagnosis techniques that aim to determine the limit of the unit's service life. Theoretically, replacement should be made at the time when the unit facility is about to fail so that the full service value of the unit can be utilized. However, this is not possible as modern petrochemical processing systems [19] are of increasing complexity and sophistication. Many other factors are governing the operations of the refinery. Most of these factors such as opportunity costs or lost customers are difficult to quantify and measure. Many asset management decisions are made on rules of thumbs rather than using analyzed system performance data. Decisions such as asset replacement, upgrade or system overhaul are in many respects equivalent to a major investment, which is risk sensitive. Therefore, solution centered proposition is needed.

It is proposed that system support concept could be a guide in providing a systematic modeling approach [20]. Therefore, a proposition was made to apply the generic framework of system supports engineering on designing operation system support of the refinery.

2. Concepts of system support engineering (SSE)

SSE concept involves the integration of service and system engineering to design support solutions. It incorporates a core knowledge base, drawing upon principles derived from a wide range of business and engineering disciplines. SSE is "solution centered", delivering output solutions which are a mix of service and product. Service is a dynamic and complex activity. In all services, irrespective of industry sectors or types of customers, services are co-produced with and truly involving consumers. In support solutions, service engineering and system engineering are used together as critical knowledge agents to guide the solution design. Service engineering emphasizes customization of solution designs to meet service needs, while system engineering accentuates technical performance of the solution. "Service and Support" is a strategic business model. The customer/supplier relationship is different from those of transactional service offerings where interactions are limited mainly to episodic experiences. In this model, the interactions with the customer are enduring, like the systems they support, and a support solution seeks to cement a constructive long term customer relationship. To simplify this process, a generic framework of SSE was drawn by employing a empirical research [21].

SSE framework is consists of 3 elements (People, Process and Product) in an operation environment. Also, it contains three levels structure (Execution, Management and Enterprise). The SSE framework model called 3PE model as shown in figure 4. This model was verified through multiple industrial visits and professionals contribution during data collection process. The SSE framework was able to outline the relation between the elements of system support. However, the details interaction is still yet to be investigated further.

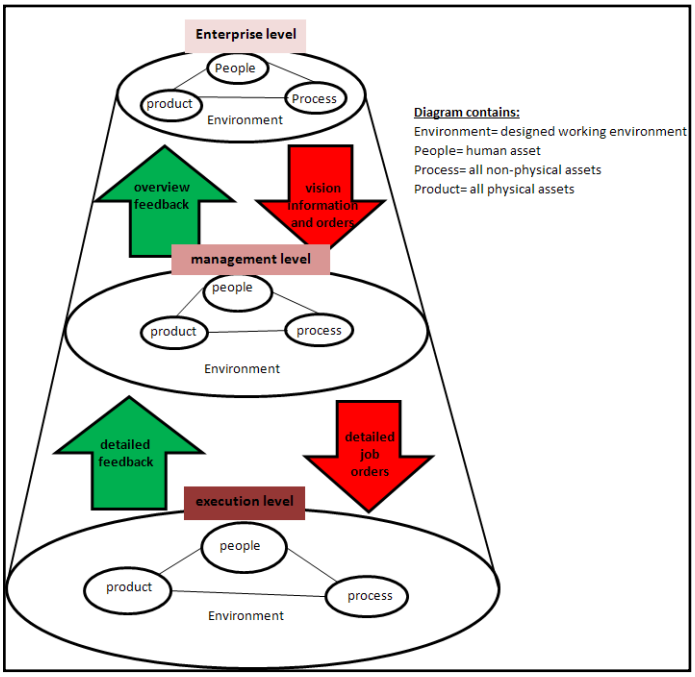

Figure 4: General vision of system support engineering framework (multi-level 3PE).

The system support engineering model could systemically empower the application and implementation of ORPIC practical modern strategies. That though clearly indicates the type, the level of details, interaction elements and the operational environment. As ORPIC is intending to:

1) Higher highly skilled, trained and experienced employees whom have the ability to response to the pressure of change and keep up with dynamicity of the system and in some cases the uncertainty of some point or situates. Basically able to use the available information to deal with what the day could though on them. This require that the employee should clearly understand how the system work, interact and information flow roots and format.
2) Adopt experience and knowledge sharing systems and exercises.
3) Increase the rule of cooperation to the extent of partnership in some cases with its main stakeholder especially licensers and contractors. This basically aims to increase the focus and operation especially of the organization which could positively reflect on the quality of the performance. Moreover, to cut off or minimize cost by introduce saving on some activities. And strategically to get continuance feedback and suggestions form the key stakeholders and keep the gates open for extra business opportunities. This requires a clear understanding of interaction and communication roots, methods and format. Also it requires a clear identification of each party obligations, responsibilities and expectations in case of an extraordinary event.
4) Adopt holistic systemic approach to support high performance and reduce the uncertainties.

The benefits of the system support engineering model in relation to sustain and support operation are:

I. The performance elements in the system are independently measurable.
II. The measures are meaningful to people who use them by capturing a dimension of their performance in a way that they can understand.
III. The measures are continually evaluated in reference to the organization short and long term goals.
IV. The measurement method will depending on the measured element where the most suitable and accurate method will be performed on the element and then later on all the results will be collected together to have overall system performance analysis in order to measure the system overall performance. This process may sound very lengthy but its effective and the process will become faster as the practice continued and the information start to cumulate.

In a case of contracting, the System support framework is used to identify and undertake relationship with each element. Inevitably, the planning process begins by identifying the requirements and the operation environment. Then, by simultaneously considering the requirements changes over time and contribution potential of customers.

3. Results and Discussion

The framework provided three increasingly detailed views or levels of abstraction from three different perspectives. It allows different people to look at the same system from different perspectives. This creates a holistic view of system support. The framework in this regards helped to:

- Guide to set requirements identification procedure for the development process of an operational support system in the refinery.
- Provide an overview of the behavior vector of support system development process and clearly drawn relations between elements.
- Captures the strategic decisions, inventions and engineering trade-offs.
- Give an appreciation of Technical and commercial issues those are linkable from the maintenance point of view.

Using the philosophies of the SSE a standard development procedure was developed as shown in figure 5.

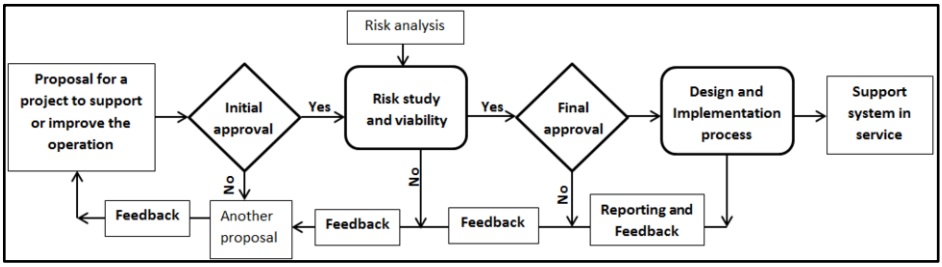

Figure 5: overview of development process of a support system using the SSE concepts.

This procedure was discussed and imputed with the professionals' in the refinery opinion and feedback. Also, it is analyzed through reviewing the literature. This is the startup guideline in applying the SSE concept in the refinery case.

Then, a standard risk analysis process (shown in figure 6) was developed. In support system engineering the risk would be the cost and technical and safety uncertainty effects on the support system outcomes and performance. Risk tolerance will depend on the criticality of the unit or process that the support system is designed for.

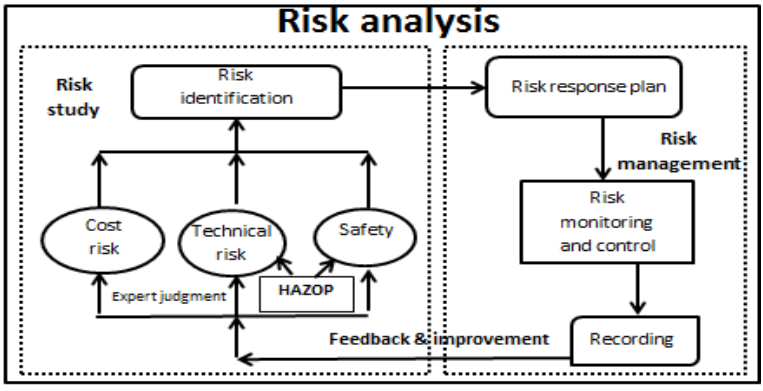

Figure 6: standard risk analysis procedure

The third stage was to develop a standard design and implementation process to fit into the development procedure of a support system, with consulting the refinery professionals. Investigations indicate that the standard design and implementation method should:

- Organizes and covers all the requirements in order to avoid misperception and shortage and minimize reliance on expert judgments.
- Present the nature of the interaction and interface between the elements in the support system where it is clearly identified and gives a clear meaning to all participants.
- Give an allocation for objectives and outcomes which are clearly defined and established. This will be standardly structured to be used for the decision-making process.

Some of the key elements are the order information and feedback information, which are grouped in the same classification in each level (i.e., enterprise, management and process) with different detailed depths. This will provide an easier allocation mechanism for future reference. All the information should be structured in order to provide the basic building unit for the design and implementation method. Figure 7 shows the design and implementation method.

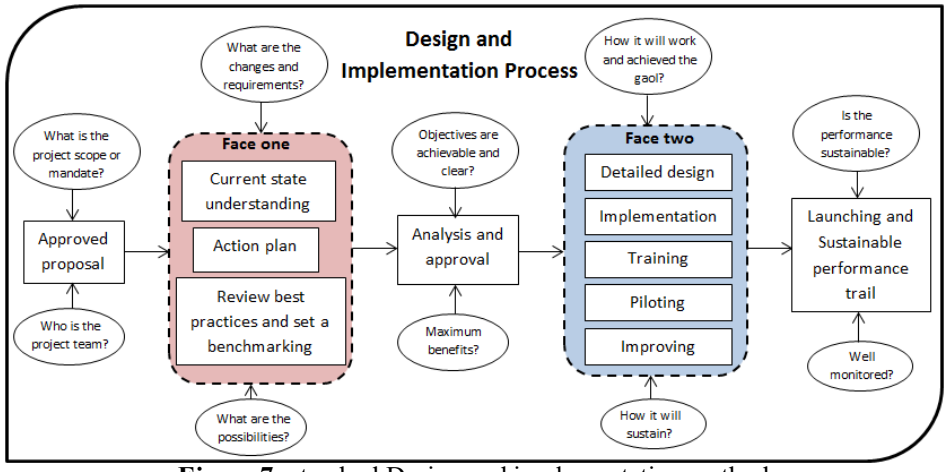

Figure 7: standard Design and implementation method

As now the obligatory procedures and methods are offered for the refinery professionals, the next step is to develop information structure format which will travel and carry information through the development process of a support system. Several versions of information structuring tables were developed and tested against the proposed or planned projects in the refinery. The table in Figure 8 showed the best results so far and was implemented by practitioners in a project. This will give a unified information arrangement construction where the information category is defined to avoid misunderstanding or confusion.

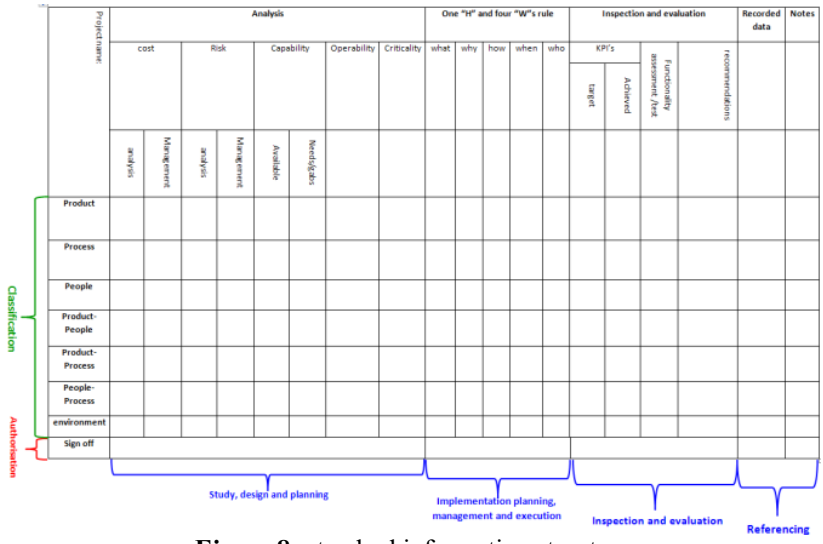

Figure 8: standard information structure

This format can be uploaded and integrated to the Enterprise Resource Planning (ERP) which is SAP in the Sohar refinery case. Where the information could be made available to a variety of users and controlled by classified accesses gates.

4. Conclusion and Future Research

This paper explored the nature of the support system design for a refinery. The research work explored the operation support system from a range of perspectives, interviewing managers from across the refinery organization. The factors contributing to complexity of a support system are described in context is presented. It has been proposed that system support engineering generic framework may be used as a tool for developing, analyzing and managing support system design procedure.

Further investigation is suggested for future research:

- The information exchange system need to be further investigated from the IT point of view. Where the investigation will concentrate on the technical requirements to develop the logic gate and automatic information system software which will control and filter the flow of information.
- The performance indicators (KPI's) need to be further investigated to improve the details and accuracy of measurement of the developed procedures and this KPI's are integrated to the ERP system.

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6. Authors Biography

6.1. First author:

Mohammed S. ALSaidi is practicing Engineer and a PhD candidate in RMIT University under supervision of Prof. John Mo. He got B.E with (Hon) in Manufacturing Engineering and Engineering Management (2009). He holds number of professional memberships. He attended several industrial trainings and successfully achieved industrial projects. His research interests are system engineering, engineering and operation management, and manufacturing system.

6.2. Second author

Prof. John Mo is Discipline Head of Manufacturing and Materials Engineering at RMIT University, Australia. Prior to joining RMIT, he was Senior Principal Research Scientist in CSIRO and led research teams including Manufacturing and Infrastructure Systems. In his 11 years in CSIRO, his team worked on many large scale government and industry sponsored projects including electricity market simulation, infrastructure protection, wireless communication, fault detection and operations scheduling. He was the project leader promoting productivity improvement in furnishing industry and consumer goods supply chain. John has over 200 publications in referred journals, conferences and book chapters, and close to 100 confidential reports.

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