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Conceptualization of Corporate Setup of an Aviation Engineering Complex through Systems Engineering Process

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Abstract- In this paper, customized Systems Engineering Management Plan (SEMP) is utilized to synthesize a corporate setup for Aviation Engineering Complex (AEC). Systems Engineering (SYSE) tools are used to corroborate the concept of independent mutually supporting business units in an organization. The corporate setup is comprised of Enterprise Resource Planning (ERP), quality, Human Resource (HR), finance & marketing and administration departments to support technical business units. A strong decentralized matrix structure is proposed to support and manage AEC operations. Interface identification and development between system elements is addressed by categorizing interfaces into three types that include within corporate sub-departments, with other systems and external systems outside AEC. The site selection and support plan is done using Quality Function Deployment (QFD), functional analysis using Functional Flow Block Diagram (FFBD) and ERP selection is done using Analytical Hierarchy Process (AHP). These SYSE tools enhance the efficacy and productivity through improved design integrity. The framework proposed in this paper can be adopted in conceptualizing any aviation engineering setup through effective planning and optimal utilization considerations.

Keywords- *Systems Engineering (SYSE), System Engineering Management Plan (SEMP), Quality Function Deployment (QFD), Enterprise Resource Planning (ERP), Analytical Hierarchy Process (AHP)*

I. INTRODUCTION

Aviation sector play an essential role in the national economy in term of providing facilities of good movement across the globe and goods movement throughout the world and contributes a lot towards economic affluence. Overall aviation industry and its numerous related businesses are growing rapidly. Based on economic and demographic growth, International Air Transport Association (IATA) has projected intra Pakistan air traffic to grow at 9.9% and Middle East at 9% over the next 20 years [1]. J M Burger [2] stated that global commercial MRO business is expected to grow by 4.1% per annum from US$ 64.3 billion to US$ 96 billion by 2025. Deloitte [3] in their report highlighted that defence sector revenues are likely to grow by 3.2% in year 2017. Thus, establishment of new engineering setups to cater for this ever growing demands will open doors of new opportunities for business worldwide [4].

Development of any aviation setup entails technical infrastructure, equipment and supporting facilities. Typically, AEC consist of Maintenance Repair & Overhaul (MRO),

Precision Measuring Equipment Lab (PMEL), Small Parts & Harness Manufacturing (SP & HM), Training and Consultancy (T & C), Indenting & Outsourcing (I & O) and Assembly Line (AL) units to provide global services. MRO is main component of aviation engineering hubs.

Kosiakoff et al [5], Blanchard [6], MITRE [7] and Guide to System Engineering Body of Knowledge (SEBOK) [8] emphasized that conceptual planning through SYSE process is vital to warrant success of complex engineering projects. Petrossi [9] highlighted importance of facility planning layout in reducing manufacturing process waste and decreasing lead time. Usage of modeling tools in planning part increases the efficacy of projects. Burge [10]-[14] developed system engineering toolbox for modeling diverse SYSE activities to enhance effectiveness of projects. This tool box was used for SYSE activities to manage development of AEC corporate framework having diversified scope, complexities and domain areas. Apart from this, Enterprise Resource Planning (ERP) success/failure factors from implementation viewpoint, its importance in achieving cost reduction, increase in flexibility and efficiency of MRO activities of firm was also emphasized by Wei et al. [15]; Salimi [16]; Lichtblau [17]; Bari [18].

Project specific SEMPs are being prepared in developed countries for diverse engineering projects and has yielded significant results but no comprehensive study has been conducted utilizing SYSE tools for modeling SYSE activities. Unproductive utilization of SYSE activities and non-preparation of SEMPs for complex engineering project in developing countries are the main reason behind non-accomplishment of project goals within allocated time and resources. This research is meant to fulfill the problems being faced by projects members during execution phases by developing SEMP in conceptual phase and modeling SYSE activities of AEC corporate center via SYSE tools. The Problem statement was aimed at "Development of customized SEMP for corporate framework of aviation engineering complex using SYSE approach"

This research methodology is aimed to highlight the importance of conceptual planning and need of SYSE process for complex aviation engineering projects. Complex projects

involves diverse elements that cannot be engineered independently and require integration to produce a balanced working system. An effective System Engineering team is a must for achieving these integration goals successfully. Apart from this, effective utilization of SYSE process in conjunction with SYSE tools is also ostensible to achieve project objectives. Strong matrix structure provides maximum vertical and horizontal communication during development process which has been proposed in AEC by assigning responsibilities to each functional manager of corporate center. Successful implementation of an industry standard ERP system based on cloud computing for diversified, complex domain areas necessitates thorough understanding of business processes in harmony with evaluation criteria. Thus evaluation criteria have been developed using Analytical Hierarchy Process for A&D sector of developing countries to provide objective and systematic assessment in selecting best suitable system.

II. METHODOLOGY

Methodology used in this paper is to develop AEC using SYSE approach is quite novel. Several SYSE tools have been used to support SYSE process in developing AEC. Feasibility study was performed using logical method of SCOPE analysis that encompasses situational exploration, core competencies, obstacles, prospects and expectation for AEC. Site and Support plan were prepared using QFD. SYSE process was initiated from need analysis by classifying them into mandatory and preferential requirements. These requirements was analyzed using Holistic Requirement Model (HRM), functional analysis using Functional Flow Block Diagram, Interface Management using Block diagrams, System Model using System Modeling Language (SysML), Risk Management Plan using Risk Chart followed by Technical Performance Measures (TPMs), final disposal and engineering specialty integration. ERP Evaluation & Selection using AHP is new concept introduces in A&D sector of Pakistan. The methodology is shown below:

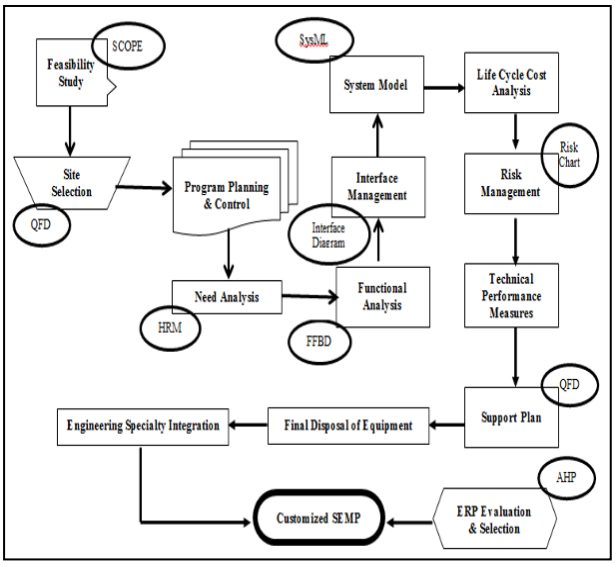

Figure 1. Research Methodology for Building AEC

First step after determining feasibility of project is selection of appropriate site for any project. Choosing site is not a simple task as selected site has to be accessible and more importantly, linked to its customers though modern means of communication. Criteria for site selection by a company varies significantly in terms of their manufacturing strategy, work force organization, management styles, in-house inventory controls and local laws. Thus keeping all these aspects in mind, site selection factors were classically brainstormed. The factors considered during site selection process for AEC are connectivity, economical, safe & secure area, availability of quality manpower, availability of raw material, civic developments, availability of utilities, demographic profile. HOQ was prepared to select the most appropriate site keeping all important factors in mind. It is a planning matrix that relates customer requirements (What the customer wants) to technical requirements (How a firm that produces products is going to meet those wants). The body of matrix is a comparison of Whats vs Hows and roof of matrix is a comparison of "Hows vs. Hows". All the information is documented and analyzed. HOQ for site selection is shown below:

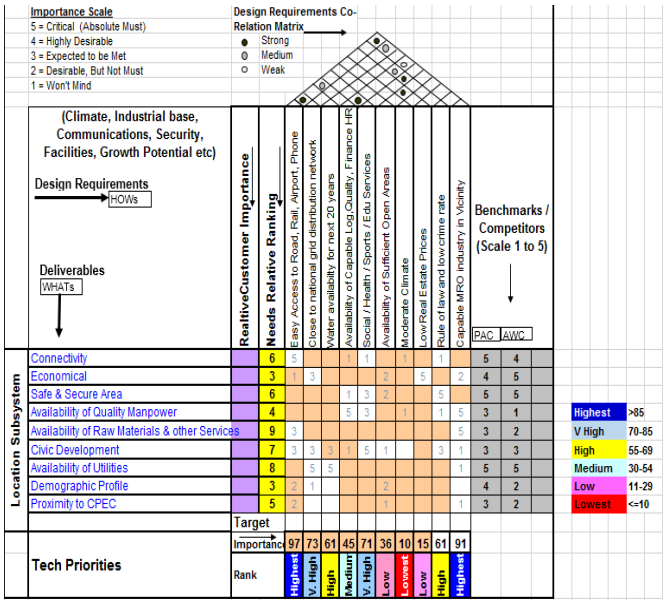

Figure 2. Site Selection HOQ

The illustration 2 shows or indicated that technical descriptors easy access to rail, road network, capable MRO industry in vicinity, close to national grid and social facilities in area seek more weightage in site selection. Thus, Kamra situated near Attock, Pakistan is the most ideal location for AEC because it not only meets technical descriptors but also has basic facilities of life, clean environment, lot of open space all around. It is safe & secure place and has gained high popularity because of huge capabilities in A&D sector.

Organizational chart of the project is unique in which decentralized strong matrix structure is proposed. Chief Executive Officers (CEOs) supported by 5 directors having specialty in their respective areas of concern will form the AEC. Corporate centre will support six independent, mutually supporting business units having their own CEOs. All of these units have complex processes, diversified scope of work, unique specialties, different fields of training, development and business environment, which necessitates involvement of managers in decisions making process on regular basis. Thus, the organogram will be:

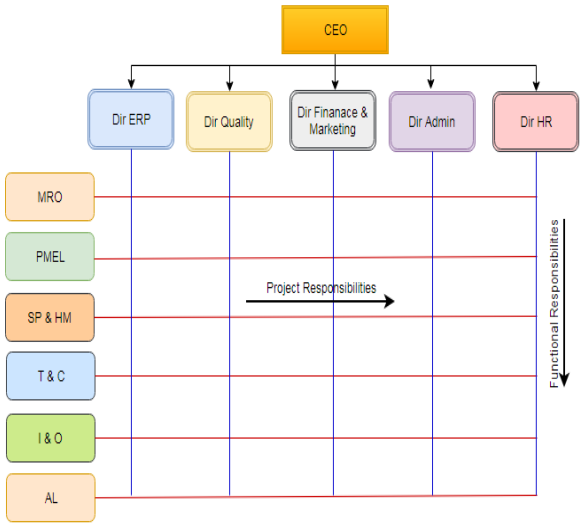

Figure 3. AEC Organization

Assigning responsibilities to every director is effervescent for smooth execution of any setup. These responsibilities were assigned using the use cases diagram. A use case depicts all the possible scenarios that may arise to achieve a particular goal. The responsibilities have been assigned keeping in view the assigned deed and tasks by respective directors. CEO is responsible for management of AEC business on day to day basis, resource planning, interface and risk management, conflict resolution. His other responsibilities include Oversees design, marketing, promotion, delivery and quality of programs, products and services, financial, tax, risk and facilities management, human resource management, community and public relations and fund raising.

Director Administration is responsible for making of architectural design and construction, operation and maintenance of AEC infrastructure, identification of security needs, human resource induction, and liaison with civil agencies. The role of the Finance Director is to manage funds of AEC during development phase, analyze figures of business units and implement recommendations based on these findings, with the most profitable outcomes. He is also responsible for filing of tax returns. Director Quality is responsible for determining, negotiating and agreeing on in-house quality procedures, standards and specifications for obtaining international quality certifications of ISO 9001:2015, AS 9100 Rev D, CAA (Pak). ERP Director is responsible for the creation of an integrated project schedule that encompasses all aspects for the ERP Program and for the actual execution in conformance to plans and the continuing update and adjustment of plans and execution to fit changing circumstances. He will also obtain & evaluate ERP proposals obtained from different firms and select best suitable industry standard ERP system for AEC. Director HR is responsible for determination of corporate sector HR, recruitment and training of HR and develop skill matrix of HR.

Interface identification and development are vital for smooth functioning of any complex engineering project which is also the core responsibility of System Engineers. Interface of corporate framework were categorized into three types: interface within subsystems; interface with other systems and interfaces with external systems. All of these interfaces will contribute towards success of project. Admin department has to arrange transport, security, utilities, Civil Works planning, development, maintenance and central procurement of generic equipment. Quality department has to develop Quality procedures for business units, ERP department has to provide ERP support, Finance section to provide financial assistance, tax return and HR to provide recruitment and training. The overall system model developed is shown below:

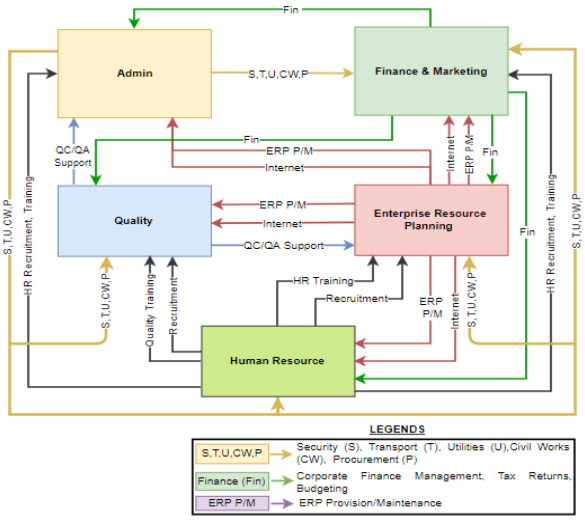

Figure 4. System Model

Development of all these activities is subject to greater risk areas. Effective risk management will help us to achieve objectives within constraints. Risk management will requires risk planning through identification of all possible risk areas, then assessing impacts of these risk areas viz-a-viz probability of occurrence on project. Nine major risk areas were identified that may hamper the efficiency of project. Subsequently, risk chart of risk areas impact and their probability of occurrence were developed. Risk chart depicting all risk areas is appended below:

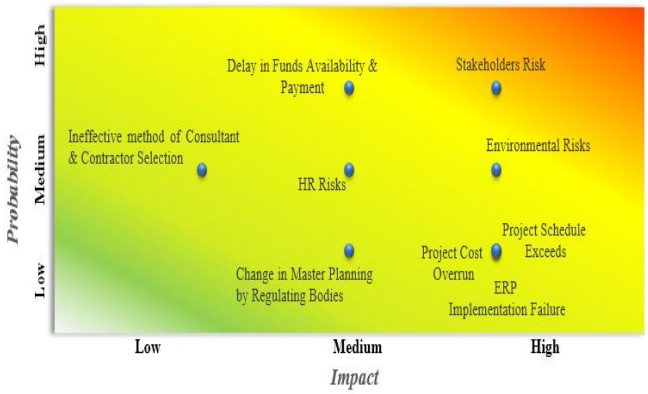

Figure 5. Risk Chart

AEC is planned to be involved in diversified operations like MRO, PMEL, manufacturing, indenting and so on. There is no denying the fact that effective management of such broad areas is not possible without an effective ERP solution. An industry standard ERP system having Accounting & Finance, Human Resource, Administration, Supply Chain Management, MRO, Manufacturing, Quality Management and Production Planning modules with necessary customization will be deployed in AEC. Deployed ERP must be flexible enough to integrate additional modules such as Business Reengineering, Customer Relationship Module in future and shall be helpful in improving visibility through planning and scheduling.

Business process trailed in ERP will be based on the concept of independent, mutually supporting BU in which each CEO will be independent to run their respective BU and services obtained from other units will be charged. Similarly, services provided / hired by the corporate center will also be charged from the respective unit at less rates compared to open market to corroborate the concept of less pricing for products and services being offered by AEC. Each unit may also charge other units for services being offered / hired and all such activities will be managed through Finance module of ERP. Number of ERP solution providers is available. All of these provide customized business processes with requisite modules The selected ERP shall be modular design comprising of many distinct business modules, shall provide seamless data flow among each other, increasing operational transparency, efficiency through standard data interfaces, shall provide traceability of parts, components and task responsibilities with accurate anticipation of functions. The business process for ERP will be as figure 6.

Selection of ERP for any sector necessitates development of assessment criteria to be used in evaluation & selection process. ERP selection for AEC is based on seven factors criteria established using AHP. These factors are cost, implementation time, implementation risk, functionality, lifespan, scalability and cloud adaptation. Priority matrix was using pairwise comparison considering these seven factors. The pairwise comparison uses relative importance scale in response to all other factors. Based on these, priority vector was calculated. Subsequently, Consistency Index (CI) and Consistency Ratio (CR) were determined to validate subjective judgments made in developing priority matrix.

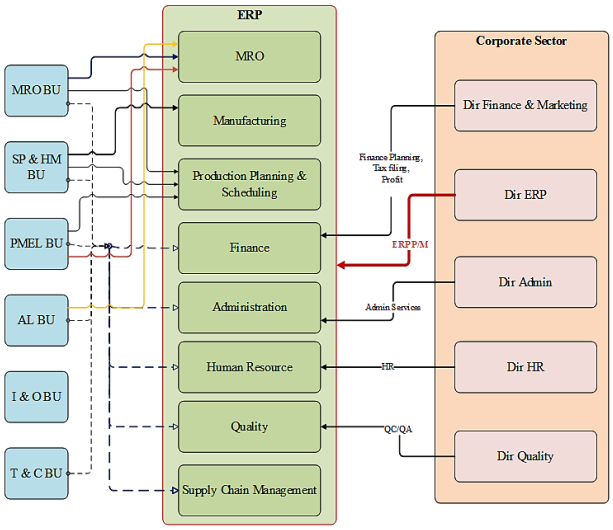

Figure 6. ERP Model for AEC

Results of CI and CR were 0.04 and 0.03 respectively which validates that judgments are trustworthy and reliable. Thus, weightage percentage of criteria factors in evaluating ERP proposal for AEC comes out to be cost 26%, functionality 22%: implementation risk 20%, lifespan 11%, flexibility 11% implementation time 6% cloud adaptation 4%.

AEC will provide MRO services of Aircraft's and Helicopter's accessories, avionics and instruments from OEM certified facilities, Spares And Logistic Support (SLS) for assemblies, sub-assemblies and components, Calibration and repair of Test Measurement and Diagnostic Equipment (TMDE), Precision Measuring Equipment's (PME), instruments and testers through renowned setup and facilities, small parts manufacturing, training in fields related to aviation manufacturing and auxiliary systems and consultancy in ERP and QFD for aviation related setups.

Complex aviation engineering setup development entails immense technical infrastructure, high quality support infrastructure, industry standard ERP and availability of sufficient funds. A support plan using QFD was prepared keeping in view the requirements of timely support to external and internal supplier, quality products with economical cost and timely delivery. This support plan also helps to set the focus areas of project. Thus, we can see that, high quality infrastructure, good interface with production system, high quality HR, implementation of capable ERP system and availability of sufficient funds are indispensable for AEC to successfully accomplish support plan.

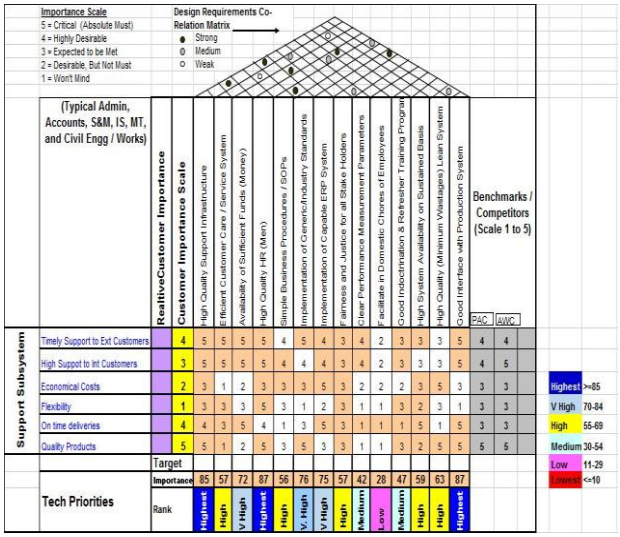

Figure 7. Support Plan HOQ

III. CONCLUSION AND RECOMMENDATIONS

Supporting business unit supported by single corporate center. The research paper has proposed a framework for preparation of explicit SEMP for complex aviation engineering projects, identification of missing requirements / functions and more importantly developing a proactive approach for interface & risk management. ERP proposals evaluation & selection utilizing developed criteria will provide objective and systematic assessment to measure efficacy, suitability, conformance and effectiveness of selected proposal among various alternatives.

It is a pioneering research study based on system engineering approach for development of an Aviation Engineering Complex in developing countries utilizing SYSE tools and techniques. Being novel research that conglomerates SYSE process via SYSE tools to corroborate the concept of independent mutually supporting business unit supported by single corporate center. Author also determined ERP selection criteria using AHP approach based on seven factors for AEC, which has never been accomplished in A&D sector.

Identification of requirements at component level, development of sub criteria's for each ERP selection factor for more irrefutable evaluation of ERP proposals, ERP proposals evaluations & selection from vendors based on criteria developed using AHP from implementation viewpoint can be worked out in future. Planning, developing quality procedures and achieving international certifications can also be accomplished as part of future work. Furthermore, explicit SEMP covering SYSE activities through SYSE tools can be prepared for both public and private sector projects as master planning documents to complete them within allocated time and resources particularly for developing countries.

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