Enterprise systems' life cycle in pursuit of resilient smart factory for emerging aircraft industry: a synthesis of Critical Success Factors'(CSFs), theory, knowledge gaps, and implications

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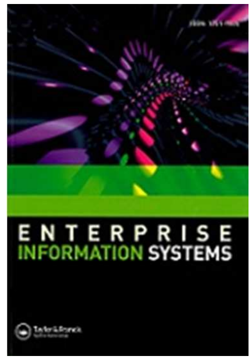

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Enterprise Systems' Lifecycle in Pursuit of Resilient-Smart-Factory for Emerging Aircraft Industry: A Synthesis of Critical Success Factors (CSFs) for Knowledge Gaps and Implications.

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ABSTRACT

Purpose –This research aims to investigate *business value critical success factors* of enterprise systems (ES) through lifecycle in pursuit of resilient smart-factory for emerging aircraft industry.

Design/methodology/approach – An extensive analysis of past twenty two years' literature was carried out. This was based on conscientious criteria of authors: (i) who have published *strategic content* relevant to CSFs, (ii) received more than 300 citations, and (iii) concurrently published two or more papers relevant to ES CSFs. The most cited strategic-CSFs were termed as classical-CSFs. *Process* and *variance* approaches for CSFs were examined. The relevant 22 critical success factors derived from two decades of state-of-the-art review are validated and synthesized, for better understanding of *success* across lifecycle by the aircraft industry experts. This was accomplished in two focus groups sessions, followed by data collection through structured interviews. The empirical verification of classical-CSFs was conducted utilizing **Bayesian method**. The Bayes-Rule is extremely effective for *False-positives* skewed results, and can convert the results from experiment into real probability of an event. Hence, this manifests not only the relative ranking of each CSF but also the relative impact of each CSF through the lifecycle.

Findings –The research has identified 22 CSFs (derived out of 95 most cited CSFs) through exhaustive analysis of literature from past 22 years. The CSFs were selected from 76 journals and 2 doctoral dissertations published between 1994 and 2016. The papers with strategic content and highest citations were selected to cover CSFs throughout the lifecycle. These are termed as classical ones. The top ten empirically verified critical factors have numerous differences with past generic *classical CSFs*, which indicates the unique prominence of the aircraft industry

Research implications – The *process approach* of CSFs is a known neglected area of research. The classical CSFs validated and ranked by industrial experts to identify its vitality with past research and provide a better understanding to conserve resources and intelligent implementation in pursuit of business excellence and resilient smart-factory.

Practical implications – This paper is significant for further developing the emerging aircraft industry e.g. in Asian and eastern European regions. The significant findings for ES-lifecycle can help the practitioners and researchers to make rational decisions throughout the ES lifecycle. The proposed set of 22 CSFs could be of great value to conserve the resources for Asian and Eastern European aircraft industry including SMEs, which are still in an infancy stage to manage ERP-lifecycle by leveraging resource deployment, when it is needed the most.

Originality/Value – This paper canvases real insights of two distinct views: process and variance approaches of the ES-CSFs. The process-approach, which is a neglected research area, facilitates the researchers for identification of ES lifecycle process coupled with a view of resource deployment when it is needed the most. While the variance-approach will facilitate practitioners and researchers in finding out which resource (CSFs) is relatively more important. The findings of this paper have been validated with the aircraft industry experts. The experts found these to be valuable for further advancing the emerging aircraft industry e.g. in Asian and eastern European regions which are presently in the process of either adoption or upgrade of ES. The 22 validated CSFs for the aircraft industry are an addition to the existing state of knowledge.

Key words: Enterprise Systems (ES), Enterprise Resource Planning (ERP), Critical Success Factors (CSFs), ES Lifecycle, Resilience, Smart Factory (Industry 4.0).

1.Introduction and Problem Statement

In past two decades almost every Top-500 fortune company has acquired Enterprise Resource Planning (ERP) / enterprise systems (ES) in pursuit of business-excellence, functional-integration, production-planning, sustainable supply chain and above all hyper-efficient global operations (Umble, Haft et al. 2003; Yusuf, Gunasekaran et al. 2004). The case studies of Rolls-Royce (Yusuf, Gunasekaran et al. 2004), Boeing (Da Xu 2011), USAF (Oxendine, Hoffman et al. 2002), aviation sector (Akkermans and van Helden 2002) and aerospace-sector (Cantamessa, Montagna et al. 2012) have reported enhanced return on investment, reduced inventories, optimized supply chain management as well as time to production. The ES provided by SAP, Siemens (PLM), Oracle, IBM (Asset Management) and INFOR-System (BAAN) are in fact part of the solution to support intelligent cum responsive manufacturing (Masood, Weston et al. 2010; Masood and Weston 2011).

To achieve the vision of responsive cum intelligent manufacturing, Fraunhofer-Institute Germany, has coined the term **Smart Factory** (Industry 4.0), which is a multi-disciplinary endeavor to develop solutions in terms of agile-manufacturing, responsive-manufacturing, cloud-manufacturing, holonic-manufacturing and leveraging Grid or cloud-computing (Zuehlke 2010). Such smart endeavors by Airbus, Boeing and Lockheed Martin information has resulted into cross-integration of smart devices from enterprise level to shop floor level.

However, despite of ES/ERP overwhelming potentials, over 90% ERP projects failed to deliver expected success (Shehab, Sharp et al. 2004) (Momoh, Roy et al. 2010). From the standpoint of aircraft industry, three major worries across the lifecycle are; the Implementation, Manufacturing-Production and Budget (finance as well as time) implications. Evidence supports that such knowledge-gaps, have been rarely discussed in literature from ultimate end users' perspective (Finney and Corbett 2007). A distressing aspect is that, the existing literature on ES-implementation is scattered (Nah and Lau 2001; Nah, Zuckweiler et al. 2003), fragmented (Nah and DELGADO 2006; Ngai, Law et al. 2008) (Kraemmerand 2010), outdated (Ngai, Law et al. 2008) (Shaul and Tauber 2013) (Romero and Vernadat 2016). This necessitates colossal effort by researchers as well as practitioners of aircraft industry to understand the underlying latent risks, determine rational success factors and devise pragmatic strategy for inducting or upgrading ES-packages. During adoption stage of an ES-project, careful selection strategy choices vis-à-vis optimum manufacturing functionality fit (Rashid and Tjahjono 2016), and Middleware technologies or enterprise application integration (EAI) (Yusuf, Gunasekaran et al. 2004) or interoperability (Tchokogue, Bareil et al. 2005) are the next most important considerations for aircraft industry. The adoption stage emphasizes to **pre-plan** and **plan ES-careful-selection-strategy** (Onut and Efendigil 2010) in light of ISO 9126(IEC 25010)(Jung, Kim et al. 2004). This can then render optimum quality of ES-package in terms of; optimum functionality-fit, configuration-fit, reliability, usability, interoperability, portability and maintainability.

From **Implementation-perspective** within-budget implementation (Tchokogue, Bareil et al. 2005), frequent upgrades and maintenance of infrastructure (hardware and software) remain major issues (Yusuf, Gunasekaran et al. 2004; Romero and Vernadat 2016). It is reported that, a UK based firm had to manage 1,315 upgrades in the first nine months of 2001(Oxendine, Hoffman et al. 2002). During implementation process, companies have spent millions of dollars into "one for all-all for one" ES-business applications and have re-engineered their business processes (BPR) around ES core-logic and best of breed industry practices. Retrospectively Air-France (Maldonado Beltrán 2010), Rolls-Royce (Yusuf, Gunasekaran et al. 2004) successfully re-engineered their business processes around core logic of ERP-. However, companies like Lockheed Martin (Rashid, Zainab Riaz et al. 2012) having acquired the ES-projects failed to proceed with further implementation, primarily because business process reengineering (BPR) could have threatened its core business-competitiveness (Davenport 1998).

Reportedly, from **Manufacturing-Production-perspective** ERP has inherent flaw in predicting production lead times thus rendering suboptimal delivery dates (Rashid and Tjahjono 2016), (Moon and Phatak 2005; Ruiz, Giret et al. 2010; Van Nieuwenhuyse, De Boeck et al. 2011). In past Rolls-Royce (Yusuf, Gunasekaran et al. 2004) and aviation maintenance, repair, and overhaul (MRO) organization - (Lee, Ma et al. 2008) have revealed serious integration issues between ES(SAP) and computer aided design (CAD) and product lifecycle management (PLM). At this juncture, it is pertinent to cite that Boeing and Airbus have huge production backlogs necessitating ramp-up. In 2011, Boeing-787 had a backlog of 2000 aircraft (Boeing 2011) and as of 2012 combined backlog of Airbus and Boeing was 9055 (Romero and Vieira 2014) 2015. It is perceived that with existing delivery-rates, the impending backlog will continue for at-least next fifteen to twenty years. Evidence supports (Aboulafia 2001) (Clark 2006) (Dorr 2006) that such operational limitations of ES not only hamper production ramp-ups but also impede productivity and resilience in the face of any disruptions in general (Netland and Aspelund 2013) and for aircraft industry, in particular. The interoperability issues are the major irritants across lifecycle to realize the dream of information integration(Boza, Cuenca et al. 2015). These limitations in turn impede manufacturing excellence and to realize the vision of **smart factory** (Industry 4.0) (Zuehlke 2010; Netland and Aspelund 2013; Chofreh, Goni et al. 2016).

Prominently, from **Budget-perspective** every induction or every single ES deployment is extremely expensive and time consuming. Careful analysis of ES-induction by aircraft industry indicates that price tag ranges approximately 12 Million USD (Yusuf, Gunasekaran et al. 2004) to 30M USD (Conrad and Derek 2001) (Clark 2006) (Rashid, Zainab Riaz et al. 2012) with approximately equivalent amount for acquiring infrastructure (hardware) and additional price tag for maintenance of the infrastructure. The Time-tag for ES-implementation in aircraft industry ranges from three years (Tchokogue, Bareil et al. 2005) to four years (1998-2001) (Yusuf, Gunasekaran et al. 2004) with considerable delay of 30 months (Tchokogue, Bareil et al. 2005) in each implementation or upgrade. The agony remains that even after expending massive finances, time, efforts and resources, a successful outcome (expectation success)(Al-Mashari 2003; Al-Mashari, Ghani et al. 2006) cannot be guaranteed (Tchokogue, Bareil et al. 2005).

Problem Statement: Summarily, fundamental reasons for 90% ERP projects failures have been reported (Shehab, Sharp et al. 2004) (Vilpola 2008; Momoh, Roy et al. 2010; Kataev, Bulysheva et al. 2013; Gajic, Stankovski et al. 2014) but 50% of the reported research (Møller 2005) was for implementation stage alone. In order to address these glaring set of failures, theory of CSF has been employed (Rockart 1978). The classification of past research literature based on CSFs variance and process approaches infers that papers varied from simple to conceptual ones whereby researchers have employed techniques like case study Empirical, leveraging techniques like, Principle Component Analysis (PCA), Regression or Entropy or combination of these techniques with artificial intelligence (AI) to develop expert systems or to rank the CSFs. Rarely was there any research conducted relevant to following issues:

a) What are the teething problems after inducting ES and what technovation issues arise after implementation stage?

b) What are the latent factors of frequent ES-maintenance cum upgrades,

c) What are the ES-adoption stage suboptimal production-planning functionality,

d) What are the critical integration issues between ES and manufacturing execution system (MES), and above all

e) What are the associated factors for entire ES-lifecycle management.

It appears that, past research is fragmented, scattered (Nah and DELGADO 2006; Ngai, Law et al. 2008; Shaul and Tauber 2013), and whatever is available lacked end user perspective for aircraft industry (Finney and Corbett 2007; Romero and Vernadat 2016). The CSFs classification, analysis, and synthesis are seldom conducted, through the unification of *variance and process approaches*, which is a significant pronouncement for future researchers. Pertinently, CSFs voyage across lifecycle is scarce for developing emerging aircraft industry e.g. in Asia and east Europe. Hence, there is a dire need for an in-depth investigation to objectively provide realistic cum coalesced critical success factors based on exhaustive literature analysis. It would be only then appropriate to conduct empirical validation of ES' CSFs through lifecycle from the ultimate end-users perspective. The desired outcome is expected to avert, if not all, at least some of the reported issues related to: implementation, manufacturing/production functionality misfit and budget overruns. Objectively, these knowledge gaps provide reasons to conduct this research.

Aim: Therefore, this research aims to investigate *business value critical success factors* of enterprise systems (ES) through lifecycle in pursuit of resilient smart-factory for emerging aircraft industry.

Objectively, widely cited theoretical-CSFs of past two-decades are empirically validated by experts of Asian-aircraft-industry, specifically indicating the importance of each CSF across the lifecycle. Evidence supports that, those industries which had no strategic plan for ES (SAP) implementation, performed poorly 90% of the time, compared with those, that had a plan (Tchokogue, Bareil et al. 2005; Koch and Mitteregger 2014). The proposed set of factors in this research is expected to facilitate quick implementation, with lesser "financial cum time" tags and with fewer upgrades in pursuit of economics and sustainable-operations. It is hoped that this study will provide fundamental guideline to avoid preplanning, planning and re-planning of all the activities through lifecycle in pursuit of business excellence.

Delimitation – As Markus et al. (Markus, Axline et al. 2000) emphasized, that success of ERP implementation is not restricted to an identifiable single dimension and it informs diverse perspectives. Conversely, success can be perceived differently by several "actors" such as stakeholders, top management, CEOs, managers, end-users, and investors. Retrospectively, it implies that "success" has different meanings once seen from various stakeholders' perspective with each considered as a lens depending upon underlying perspectives. For instance, distinction between two types of success of an "ERP implementation (project success)" and "business value success". Hence, in this study, **ES-Success** will mean the degree of perfection achieved in business (operations, productivity, or manufacturing) and value-creation in aircraft industry by means of the ES implementation across the whole lifecycle.

The rest of the paper is **structured** to provide methodology and exhaustive literature review in section-2. Section-3 contains results. The last portion of secion-3, canvasses the validation of classical-CSFs through structured questionnaire-"classical instrument", the data collected through two Focus-group sessions was empirically verified followed by personal structured interviews for identifying CSFs implications across lifecycle. The Section-4 catalogues discussion (findings, synthesis, Implications and Limitations). Whereas, Section-5, inhibits conclusions and recommendations for emerging aircraft industry coupled with future research directions.

2. Methodology

A comprehensive cum holistic perspective of CSFs was conducted. During the process the CSFs interactions and correlations relative to aircraft smart factory was canvassed based on past 20 years of state-of-the-art (classical literature-review). Open coding (Corbin and Strauss 1990) and content analysis techniques (Silverman 2013) were employed which rendered a total of 76 publications by 22-consulting-authors (Figure-2 and Table-3 to 4). These papers provided foundation for identification of exhaustive list of classical-CSFs, the lifecycle stages and identifying the constructs of "classical instrument"(Annexure-A and Table-3). The research then employed Focus-Group research coupled with structured interviews to collect data. In this research, the process of CSFs, identification, classification, findings, implications, and analysis followed a structured approach; which is depicted in Figure-1:

<Insert Figure-1 here>

2.1 Literature Review Methodology

In **Step-1,** the literature-review search-strategy was formulated and resultants papers were tabulated using MS-Excel and bibliographic software (EndNote).

In **Step-2,** selected papers were filtered based on keywords and analyzed using data-mining (Rapidminer software).

In **Step-3,** the resultant papers were compared with the results of past comprehensive research on literature-review of ES/ERP for instance (Kraemmerand 2010; Leyh 2012; Shaul and Tauber 2013; Romero and Vernadat 2016), (Finney and Corbett 2007) and (Shehab, Sharp et al. 2004).

In **Step-4,** the papers with relevant CSFs material were further analyzed through go-forward and go-backward tools of Thomson-Reuters "web of knowledge" database to identify any left-over classical-authors.

In **Step-5,** a structured content analysis (Silverman 2013) was conducted of resultant papers by reading as well as classifying contents based on Abstract, Method, Findings and Conclusion. During this process, data in spreadsheet was stored and labeled for to be classes of data). Another criteria adopted was screening of literature with highest citation. Highly-cited authors were researched again for additional papers to extract further dimensions and relevant **constructs of CSFs**. The content analysis of literature fetched total of 22 consulting authors with citation above 300+. The content analysis of additional papers by these 22-consulting authors rendered 76 papers with classical contents and constructs of CSFs. Additional papers with lower citation relevant to CSFs Taxonomy, CSFs-Diffusion theory and Dynamic-models were kept aside for the purpose of classification of major streams and constructs of CSFs, this included papers from (Shehab, Sharp et al. 2004), (Dezdar and Sulaiman 2009), (Fichman 1994), (Koch and Mitteregger 2014; Zach, Munkvold et al. 2014; Boza, Cuenca et al. 2015) and (King and Burgess 2006) .

In **Step-6,** 02-doctoral dissertations were consulted which initially rendered 95-CSFs by (Hedman 2003) and various additional constructs of CSFs by (Maldonado Beltrán 2010). The CSFs constructs (dimensions) of step-5 were correlated with list of 95-factors (Hedman 2003). All the constructs of 95-factors were scrutinized for semantics-duplicates. The analytical as well as conceptual correlation and classification of "95-constructs-factors" rendered unique and major streams of classes based on; Citation, Taxonomy (Al-Mashari 2003), Diffusion-CSFs (Fichman 1994) and research-agendas (Al-Mashari 2003). This systematic filtering resulted into 26-classical factors.

In **Step-7**, these 26-CSFs were further analysed for conceptual cum semantics-duplicates. During this process, CSFs such as "Implementation strategy and timeframe" and "Post-implementation evaluation(Performance Measurement)" (Al-Mashari 2003; Finney and Corbett 2007) were merged to "Project management (X16)"; where-as, "Managing cultural change" (Finney and Corbett 2007) were merged to "Organizational Culture & Change Management (X17)". This is because of the fact that Project management PMBOK clearly indicates "Planning-strategy", "Time-frame(Management)" and "Performance-Measurement" as part of PM-fundamental nine-knowledge-areas (Burke 2013). Similarly, "Organizational Culture and Change Management" were merged and certain constructs were added to it such as "Managing Morale" and "CULTURAL CHANGE". Resultantly, 26-CSFs were converged to 22-CSFs.

In **Step-8,** The CSFs were classified into either an Actor (A) / Activity (Ac) as annotated in a separate column at **Table-3,** the description about each factor has already discussed in depth by many past research work such as 45-Constructs by (Nah and DELGADO 2006) and 26-cosntructs by (Finney and Corbett 2007) and 22-cosntructs by (Somers and Nelson 2004), hence, intentionally not discussed in depth at Table-3 or Table-4 . The associated-life-cycle-stages for CSFs were derived, elaborated, and mapped along past-literature based stages (**Table-5**). The contents of Table 3 to 5 were updated after due scrutiny and consultation from Academia of Cranfield University and during Focus group research. In interpretive research the use of theory "more or less is as a 'sensitizing device' to view the world in a certain way"(Klein and Myers 1999). Hence these Tables are then used as sensitizing-devices (Walsham 1993), for CSFs synthesis in Section-4.

In **Step-9,** frequency based weighted theoretical ranking of 22-CSFs was conducted.

The exhaustive 9-step retrospective analysis of past 20-years literature yielded 76-papers by 22-consulting-authors which rendered 22-CSFs across ES lifecycle (extracted, classified and derived from 95-CSFs). The CSFs are presented at Table-3, Table-4, and CSFs lifecycle-stages are canvassed at Table-5.

2.2 Design of Experiment for CSFs-Ranking: Application of "Conditional Probability-Bayes' Theorem"

2.2.1 Focus group settings

A focus group is a form of qualitative research in which groups of people are asked about their perceptions, opinions, beliefs, and attitudes towards a product, service, concept, or idea. The major advantage of focus groups in comparison to participant observation is the opportunity to observe a large amount of interaction on a topic in a limited period of time based on the researcher's ability to assemble and direct the focus group sessions (Morgan 1996). Retrospectively, two Focus groups research was accomplished one at Aerospace-OEM of Lockheed Martin, Turkey and second at Avionics Manufacturing cum MRO in Pakistan. The Turkish MRO had experience of Lockheed Martin Systems, Aermacchi, Agusta Westland, Airbus, Boeing, EADS, CASA, and Eurocopter. Whereas Experts at MRO Pakistan had experience of either, Dassault-aviation, Lockheed Martin Systems, SAAB-aviation, Thales, CATIC and Griffo. Right on the onset experts, who formed a cross-section of "all levels of management" and "contrasted experience of Boeing, SAAB, Lockheed Martin Systems etc.", were briefed about the scope/objectives of Risks relevant to ES through lifecycle. The Focus group experts in an exhaustive brain storming session were solicited to converse, argue, confer, comment, and then devise the validity of failure and success-factors along technovation-lifecycle. The focus group session at Turkey focused on failure-factors, whereas those at MRO-Pakistan focused on success-factors. Each focus group members had experience of two or more ES implementations and had extensive knowledge of CSFs and irritants along ES-technovation lifecycle in aircraft industry. These characteristics suggest that in spite of the relatively small sample size, a diverse group of end-users with deepened experience were interviewed. After the Focus group session exhaustive personal structured interview were conducted with (31) thirty-one senior Industry experts with specialties such as *Aerospace, Avionics and Aeronautical R&D*. Such a cross-section of Industry experts is considered vitally potent source of information for ranking and impact of CSFs along lifecycle. The diversity in the sample is recommended in qualitative studies such as in grounded theory (Strauss and Corbin 1990) and its utilization for ERP acceptance model (Nah, Tan et al. 2005). Whilst the senior aircraft industry experts participated in research but the names of the enterprise and its interviewees are not made available for public dissemination due to confidentiality reason. The data gathered through open ended discussions and interviews was recorded for further analysis. The Table-1 provides the demographic information of aircraft industry interviewees.

<Insert Table-1 here>

Following questions in a structured interview were deliberated to Rank CSFs (at a Likert-scale, 1-5, Low to critical) along six-life-cycle-stages (Annexure A).

> **Question 1**: What was the degree of **importance** of each Factor(X1 to X22) in your **enterprise system implementation project?**
>
> **Question 2:** At which stage (one to six) of ES/ERP-project, was each success factor important (X1 to X22) (consult to Survey instrument, Annexure A)?

The instrument is based on our initial selection of 22 classical factors (derived out of list of 95-CSFof (Hedman 2003)). The instrument was designed based on previous work of (Somers and Nelson 2004), however, the instrument was upgraded and each CSF dimensions were enhanced as well as fortified based on 45-Constructs of (Nah and DELGADO 2006) and 26-cosntructs of (Finney and Corbett 2007) and inputs from academia of Cranfield University and Focus group members (Annexure A and Table 3).

2.2.2 Bayesian Method, Design of Experiment: Assumptions and Variables

In the experiment, Each CSF; player/activity (X1 to X22; independent-variable) is assumed to be independent of each-other and equally important across six lifecycle stages (Dependent-variable). Moreover, the selection of variable is assumed independent of subsequent stages. This means that the success in each lifecycle stage is dependent on accurate and optimal selection of players who will then manage or execute the activities. The details about CSFs and lifecycle stages are mentioned at Table 3 to 5. During the experiment, these 22-variables were graded on a likert-scale (1-5-low to critical). Having given the ranking, the experts were asked to provide their preference for selecting and deputing these players/ activities for subsequent six lifecycle-stages. Hence (independent variables) were given a validity (updated information) by the Aircraft industry experts (whether they would select/require or depute the factors; in terms of either yes=1 or no=0).

2.2.3 Bayesian Method, Theory, Concept and Calculations

The Bayesian method (Bayes' theorem or Bayes Rule) is a natural models for the computational problems of perception. Researcher (MacKay 2003) elaborated that, what we perceive is our "best guess" given both sensory data and prior experience. Bayesian method (MacKay 2003; Kokolakis 2010) (Jiawei and Kamber 2006) depicts, how one can reconstruct this concept in formal mathematical and computational terms. Bayes method is very effective for false positives skewed results. Suppose if one is searching for something really rare (1 in a million). Even with a good statistical test, it's likely that a positive result could turn out to be a *false positive* with a significance levels approx. in the range of 999,999,999. The Bayesian method converts the results of statistically significant test of hypothesis into the real probability of the event (MacKay 2003). Likewise Bayesian Priors, Posteriors, and Estimators can be utilized for CSFs cases (Wackerly, Mendenhall et al. 2007) (Dekhtyar, Goldsmith et al. 2009; Louvieris, Gregoriades et al. 2010). In past, Bayesian method has been employed to assess CSFs for military decision support, (Louvieris, Gregoriades et al. 2010). Based on same theme, this research would focus to calculate the relative importance of ES-CSFs across lifecycle.

Suppose that the sample space can be partitioned into m subpopulations, X_1, X_2, X_3, . . . , X_m, such that, CSFs are **mutually exclusive and exhaustive;** that is, taken together they make up the entire sample space. In a similar way, one can express an event A as;

$$Y= (Y \cap X1)U\ (Y \cap X2)U(Y \cap X3)U \ldots.(Y \cap Xm) \qquad \textit{Equation 1}$$

$$P(A)= P(Y \cap X1)U\ P(Y \cap X2)UP(Y \cap X3)\ \ldots\ldots\ldots\ P\ (Y \cap Xm) \qquad \textit{Equation 2}$$

Let X_1, X_2, . . . , X_n, represent $n(22)$ mutually exclusive and exhaustive subpopulations with prior probabilities $P(X_1)$, $P(X_2)$, ... $P(Xn)$. If an event A occurs, the posterior probability of CSF (X_i) , given Y_j is the conditional probability of lifecycle stages (Y1 to Y6). Contextually, the independent variable probability data distribution and classification, is shown in Table-2, and it has "m" rows and "n" columns.

<Insert Table 2 here>.

The **mn** joint fractional probabilities are calculated as Pij (i = 1; . . . m; j = 1; . . . n), where i to j correspond to players (or activities) and m to n represent implementation stages, respectively.

The fractional probabilities are all nonnegative values and their sum equals to one, same is the case with the m-marginal fractions of the row (pi) and the n marginal fractions of the columns (pj). For instance;

P11= represents the expected importance of "X1-**ES implementation, through clear Business Vision"** in the initiation stage 1)/divided by the (total probabilities of all players/activities for all the stages). Similarly, P1 represents the (total probability of "X1-**ES implementation, through clear Business Vision"** across all stages) divided by the (total of the probabilities of all players/activities).

Whereby the Bays-Theorem is defined as (Wackerly, Mendenhall et al. 2007)Wackerly *et al.* 2007) For i ≠ j; and m≠ n, such that P(Xi)≥ 0;

$$P\ (XIY) = \sum_{im}^{jn} P(x)P(YIX)/P(Y) \qquad \textit{Equation 3}$$

For stage 1 the calculations for ranking of CSFs X2 turns out to be:

$$P\ (X2IY1) = \sum_{im}^{jn} \frac{P(X2)\ \ P(Y1IX2\ )}{P(Y1)} \qquad \textit{Equation 4}$$

Whereby, for Stage one Conditional Probability based on cumulative 22-CSFs-Variables can be calculated through following:

Where $P\ (Y1) = \sum_{im}^{jn} P(Xi)P(YjIXi)$

Or $P\ (Y1) = \sum_{im}^{jn} P(X1)P(Y1IX1) + P(X2)P(Y1IX2) + \cdots\ P(X22)P(Y1IX22)$ *Equation 5*

2.3 CSFs Theoretical background

ES/ ERP is a development from the philosophy of computer integrated manufacturing (CIM) (Gunasekaran, T. Martikirtanen et al. 1994; Gunasekaran and Thevarajah 1997). The emerging automation requirements for 21[st] centenary is a spin-off of US Air Force's (USAF) ICAM project (integrated computer aided manufacturing) (USAF, Command et al. 1981). The CIM is an umbrella term used for automation of; factory, machines, information, method, processes, product-development, and latent functional-domains for optimum human-computer-interaction. The ES-CSFs has two distinct research approach or perspectives, the **Process-(lifecycle)-approach** (Markus, Axline et al. 2000), (Somers and Nelson 2004) and the **Variance-(factor)-approach** (Robey, Ross et al. 2002), which are discussed in subsequent subsection.

2.3.1 Variance-approach

Variance-approach depicts variation in critical factors (outcome-variables) through the association of outcomes with antecedent-conditions and predictor variables. Two particular streams of **Variance-approach** were; a) *ERP's critical success factors,* and b) studies of *ERP's effects*. The ERP's *critical success factors stream* concentrate on the antecedent conditions that predict or explain ERP success, whereas the research stream for *ERP's effects* aim at outcomes of ERP implementation. However, both stream of ***Variance-approach*** provide limited information beyond conventional wisdom to understand ERP implementation across lifecycle (Robey, Ross et al. 2002). While **Variance-approach** hypothesize about the progression of connecting antecedents with outcomes, the **Process-approach** inquiries about, how *technovation-change* transpires, develops, and diminishes across lifecycle thus portraying ES's-Taxonomy. The generic set of ERP-CSFs from Variance perspective for Implementation stage of ES has been discussed by prominent researchers (Al-Mashari 2003), (Akkermans and van Helden 2002), (Davenport 1998),(Finney and Corbett 2007), (Holland and Light 1999), (José-Esteves and Bohorquez 2007), (Nah and DELGADO 2006), (Ngai, Law et al. 2008), (Parr and Shanks 2003), (Somers and Nelson 2004), (Sumner 2006), (Zhang, Lee et al. 2003). Retrospectively, ERPII-CSFs have been proposed by researcher Guaskekaren (Gunasekaran 2001) and (Koh, Gunasekaran et al. 2008) and relevant aspects of supply chain by (Gunasekaran, Lai et al. 2008) (Koh, Saad et al. 2006). Pioneered research for identification of CSFs was conducted by researchers (Nah and DELGADO 2006), (Finney and Corbett 2007), (Ngai, Law et al. 2008). The researcher (Nah and DELGADO 2006) derived 7-CSFs (premeditated from 49 sub-factors) based on 27 literature-articles and applied multiple-case study method based on Process-approach (Markus, Axline et al. 2000). The most comprehensive review of CSFs over a decade was conducted from 2000 to 2010 by (Kraemmerand 2010) based on 885 peer-reviewed journal publications, however, most of the filtration process lacked pragmatic approach to screen the significant papers for CSFs. Conversely the most comprehensive review (1997-2009) of Critical failure Factors (CFFs) by (Shehab, Sharp et al. 2004), that accounted for both the successes and failures of ERP. The Top 10 CSFs by (Maldonado Beltrán 2010) (based on (Markus, Axline et al. 2000; Markus and Tanis 2000) (Loh and Koh. 2004) Variance-approach) are, legendary in a sense that they are concise and relevant to ensure adroit success of ES. Summarily, Past research utilized various models to construct theory and to validate their results. These can be classified as;

I. **Theory building: Conceptual**: (a) Review of ES, Research agendas, Value analysis of ERP systems (b) Implementation associated; strategies, procedures, checklists and success /failure factors (c) Framework/Model building based on integrative Approaches (Literature-review, mapping, data-envelopment etc.)

II. **Theory building: Testing**: (a) Field-studies, (b)questionnaire-surveys or case studies (c) illustrating the extent of ERP implementation and (d) the effects of various factors on ERP-implementation.

2.3.2 Process-approach

Conversely, **Process-approach** explores the **outcomes** by examining sequences of events over time. In past, ES's-Taxonomy, which forms the basis for Process-approach, was initially studied in 1999 (Holland and Light 1999). The study rendered strategic and tactical aspects, however, lacked the interaction of CSFs along taxonomy of lifecycle. Hence, a detailed taxonomy was formulated in 2003 (Al-Mashari 2003). This taxonomy highlighted strong alignment of 12-CSFs (Socio-Technical cum organizational and Project) along the lifecycle coupled with a strong measurement cum reconciliation system to achieve success. The detailed checklist and in-depth analysis of CSFs lifecycle was investigated by Markus and Loh (Markus, Axline et al. 2000; Markus, Petrie et al. 2000; Markus and Tanis 2000; Markus, Tanis et al. 2000; Loh and Koh. 2004; Loh, Koh et al. 2006). An aspect which remained missing was retrospective analysis which requires Herculean-efforts by all vital players to manage the ES-activities. The same was later, deliberated for timely ES/ERP project implementation through an integrative view along lifecycle. Retrospectively, an overarching as well as integrative perspective was formulated in 2004 (Somers and Nelson 2004). For ease of reference termed as technovation for ES, the lifecycle of an ES/ERP could also be defined based on theory of Diffusion of Innovation (DOI). Which could be defined as an S-curve of DOI; enumerating, disruptive technologies triggering innovation and forcing societal-systems to pursue change (Fichman 2004). ES lifecycle has a time-dimension (Rogers and Karyn 2003) which when mapped over Project Management time-dimension can render better comprehension of technovation and change management along a Cartesian-axis. This “hybrid time dimension” for ES-Technovation has various stages discussed in depth by past research work (Rashid, Qureshi et al. 2011). Although, the same are not discussed in depth here, but are considered as the basic stratagem of DOI-processes and are defined in depth at Table-5.

In our research the 6-stage (lifecycle) model by (Rajagopal 2002) and (Somers and Nelson 2004) was considered more accurate and was contemplated for further investigations (**Table-5**) due to its higher level of granularity (Nah and DELGADO 2006). Nevertheless, the four-stage approach is considered equally vital because of its simplicity and conciseness. Summarily, **Process-approach** explores the **outcomes** by examining sequences of events over time. Hence, process based stage theories facilitate stakeholders to anticipate risks, yet rarely, render details of latent-processes. Specifically, Process-approach assumes that organizational changes would rather follow, than precede ES/ERP-implementation, even though either sequence could transpire (Robey, Ross et al. 2002). The Process-stage-models exhibit implied assumptions about the nature of social change emerging through a lifecycle mechanism contained within the entity (for instance aircraft industrial setup) undergoing change. During lifecycle, "the developing entity has within it an underlying form, logic, program, or code that regulates the process of change. This moves the entity from a given point of departure (unfreeze) toward a subsequent end that is prefigured (refreeze) in the present state"(Robey, Ross et al. 2002; Gao, Li et al. 2008).

In a way both approaches, impart knowledge about the critical factors, their very phenomenon, their trend, their importance, and insight into organizational-changes (Robey, Ross et al. 2002). Summarily in past, both variance and process research on ERP have been mostly descriptive and rarely, focused to develop knowledge-gaps, implications and recommendations from the ultimate end-user perspective of aircraft industry(Gao, Li et al. 2008).

2.4 Synthesis of Knowledge-gaps

Whilst most of the studies today only talk about CSFs, they miss out the **Process-approach** of the ERP, which seems to be a neglected research area. Moreover, past research is scattered, fragmented and is more often focused on limited or specific domain of lifecycle. This stress has either been on implementation or upgrade, stage with no emphasis, on issues before or after implementation stage. Pertinently, most of the CSFs Variance-research rendered restricted view of constructs of CSFs. Contextually, Process-research related context and contents were seldom researched (Somers and Nelson 2004). Even those studies that focused on Process-approach, rarely conducted whole lifecycle assessment for a specific industry (Gajic, Stankovski et al. 2014). Conversely, researchers have rarely conducted integrative analysis of exhaustive set of CSFs. Rather a resolute was made based on a specific phase of either the implementation process or subset of CSFs were identified and were validated (limited data-set of CSFs).

Most notably past literature contains fragmented research of CSFs complete lifecycle; whatever is available is inconsistent (Dezdar and Sulaiman 2009) with inconclusive findings (Ngai and Law 2007). Limited research exist capturing importance of CSFs across full ES lifecycle (Somers and Nelson 2004; Møller 2005), but whatever exists, rarely contemplates for both the successes and failures factors (critical-risks) (Shehab, Sharp et al. 2004). Moreover, Semantics issues remained a major debate (Finney and Corbett 2007; Finney 2011). Pertinently, available research on ES- CSFs are fragmented (Nah and DELGADO 2006; Ngai, Law et al. 2008), scattered (Nah and Lau 2001; Nah, Zuckweiler et al. 2003) outdated (Ngai, Law et al. 2008) and lack end user perspective (Finney and Corbett 2007; Olson and Zhao 2007; Finney 2011; Gajic, Stankovski et al. 2014; Boza, Cuenca et al. 2015). The 50% or more of ES-academic research in past have adopted **Variance-approach** for ES-implementation-stage alone (Møller 2005) with insignificant attention on CSFs-taxonomy across lifecycle (**Process-approach**) (Somers and Nelson 2004). Curiously, past research rarely discussed, what happens at start stage (Nah and DELGADO 2006) or what are latent factors, without revealing relative importance of CSFs at up-gradation stage.

Hence, supplementary research and insights are needed. It has been identified that ES Process-approach based studies investigate the context as well as the CSFs interaction along the lifecycle. This is vitally paramount for industry CEOs (Somers and Nelson 2004) and views implementation as a sequence of stages (typically three to six) that seeks to explain how outcomes develop over time. The ERP project (Process-approach) domain is to select, acquire, and deploy resources for its success. Despite their focus on processes that explain ES outcomes, stage models offer more description than explanation (Robey, Ross et al. 2002). One of the classical work for ES lifecycle-management has been conducted in past by Somers et al (Somers and Nelson 2004) which holistically portrays taxonomy of CSFs across lifecycle. The study employed case-study technique based on mail-survey of 144-organizations addressed to all tiers of management. The research had major limitations; firstly, the identification of the CSFs did not adopt structured process of exhaustive literature review. Secondly, CSFs with insubstantial constructs were validated in 144-organizations. Lastly, the process of validation employed Information System-Entropy based function which decreed insubstantial and undesired results. The Information-science-entropy function provides the information-content to classify an attribute (Jiawei and Kamber 2006). In a way, **Shannon's-entropy** is a measurement of heterogeneity or diversity in the opinion of experts and as such, the Entropy-function rendered considerably unexpected results when compared with experts-hypothesized values of CSFs (section-5, page-269) (Somers and Nelson 2004). Hence, the identification of CSFs by (Somers and Nelson 2004) has limited substantiation that too not specific to aircraft industry. For better understanding of aircraft industry ES-CSFs past research was conducted in 2002 (Akkermans and van Helden 2002; Akkermans, Bogerd et al. 2003), but not across full lifecycle. Summarily, little attention has been paid to a unified approach augmented by compelling and validated taxonomy of ES CSFs lifecycle. The same is, however, needed to appreciate the relative impact of CSFs across lifecycle for better deployment of resources when they are needed the most. It seems appropriate to investigate ES lifecycle utilizing **Process theory** perspective. This will provide (a) better understanding of the CSF-trend based on a taxonomy, (b) solutions for future challenges and (c) To-Be functionalities of ES from end user perspective. The ES success can be achieved effectively if careful planning is based on critical success factors (Process-approach). The research reported in this paper adopts a process theory perspective to canvass lifecycle stages. In addition, research exploits Bayesian method to validate CSFs, how they transpire, develop, and diminishes over lifecycle taxonomy through the lens of **Process-approach**.

This research would thus bridge the knowledge-gap that exists in literature by first identifying cohesive and coalesced classical CSFs and then its validation through complete lifecycle for Niche Aircraft industry utilizing Bayes Rule. The CSFs identification by first identifying the authenticity of sources and catering for validity of author's citation could be appropriate technique to validate Classical-CSFs, through lifecycle from end-user perspective. Retrospectively, the empirical verification of classical-CSFs would utilize **Bayesian method** which is a nobler and preferred approach than Shannon's-entropy. **Bayesian method** is enormously effective for ***False-positives*** skewed results, hence, can investigate incredibly rare-cases (1 in a million) and can convert the results from experiment into the real probability of the event. Hence, can cater for limitations of Shannon's-entropy measurement of diversity and would manifest the relative ranking of each CSF coupled with the relative impact of each CSF across lifecycle. In this research, 22 CSFs (out of 95) are identified from exhaustive literature review of past 20-years. These 22 CSFs are analyzed along lifecycle; in terms of Activities and Actors (**Table-3**). Past literature has classified, these CSFs into, **7-Actors and 15-Activities.** The details about CSFs and its artifacts in terms of actor and activity have already been thoroughly contemplated in past literature (Nah and Lau 2001; Loh and Koh. 2004; Somers and Nelson 2004) (Ngai and Law 2007; Ngai, Law et al. 2008), hence, not discussed here. However, this very classification was corroborated during focus group sessions and with Academia of Cranfield University to render specific amendments. A bird's eye view of vital CSFs in terms of actors and activities is enumerated for a better understanding in Table-3, whereby, column 3 classifies the CSFs as an actor and activity. It is presumed that, Actors are the critical people to manage and harness these activities. These Actors presume the Role of ambassador, negotiator, and articulators depending upon nature and prevailing circumstances. The lifecycle stages are defined at Table-5 adopted from model of (Rajagopal 2002) and (Somers and Nelson 2004) based on past literature of 20 years.

3. Results

3.1 Bibliography Statistics: Comprehensive Catalog of Classical CSFs

The generic set of CSFs from Factor/Variance perspective for implementation stage of ES has been discussed by numerous authors. The Strategic nature of contributions was from those authors that remained associated with the Enterprise Systems-research from 1994 to 2016. The relevant results for CSFs are catalogued at Table-3 to 4 and CSFs-lifecycle-stages at Table-5 where as the 22-consulting author year-wise publication data is depicted in Figure-2.

<Insert Figure-2 here>.

The most contributions are from authors a) Al Mashari , 05 strategic journal papers with cumulative citations 1474, b) Gunasekaran et al, with 05 strategic journal papers with cumulative citations 985, c) Lenny Koh in collaboration with Loh, with 05 strategic journal papers with cumulative citations 609, d) Markus with five strategic publications cumulative citations 3193, e) Mooler & Kraemmerand, with five strategic publications cumulative citations 364, f) Parr and Shanks, with 05 strategic journal papers with cumulative citations 505. Whereas 04 publications each are contributed by, Botta-Genoulaz et al, Dasvenport, Loh & Koh , Sumner et al, Somers et al and Yusuf et al. The overall top ranking goes to Loh and Koh who contributed (coauthored jointly) 09 classical Publications. The overall most strategic and far sighted papers are contributed by Markus these papers contemplated Scenarios, future trends, and had technology roadmaps for vendors, practitioners, and academia. The overall most cited author for classical-CSFs was Davenport with 13453+ citations. The second and third most cited authors are Markus with 3193 Citations and Umble with 1754 citations respectively.

The major Journals that published classical-CSFs included, International Journal of Production Economics (08 papers), European Journal of Operational Research (04 papers), and three paper each by Harvard Business Review, Information Systems Management, Information & Management, Computers in Industry, Journal of Information Technology, and Business Process Management Journal.

3.2 The classical-CSFs' Constructs

The Table-3 to Table-5 inhibit exhaustive information regarding the classical CSFs constructs. Moreover, these tables hosts CSFs significant information for the benefit of future researchers and are legendary-guides based on two decades of literature review. In interpretive research the use of theory "more or less is as a 'sensitizing device' to view the world in a certain way"(Klein and Myers 1999). In this very sense, this research mainly draws interrelationship through two theoretical concepts: (1) Inferences about relative importance of CSFs using Variance and Process approaches (Robey, Ross et al. 2002). Hence, Tables-3 to 5 are used as sensitizing devices for synthesis of results from Focus group and structured interviews. The Table 3 and 4 ornate following aspects;

a) *The **CSFs code and short description**, is enumerated at column 1 to 2 (Table-3).

b) The Table-3, column 3 classifies, **CSFs into Actor (A) / Activity (Ac)**, the Factor into either an Actor (A)/ Activity (Ac) which has been deliberated in depth with Focus group, Academia of Cranfield University in light with past research work (Somers and Nelson 2004) to reach to a consensus.

c) The Table-4, exhibits, **Author Citation-index**, indexed on top header row, for 76 classical papers of consulting authors. *The research Citations-index at Table-4 and 5 is synchronized and contains updated information as of May 2016.*

d) The Table-4, **Consulting-Authors cross-reference,** is presented at second header row (column2 and onward), depicting, information of **76-classical papers**. The data of second row is sorted alphabetically for ease of cross-reference.

e) The **CSFs-frequency** based ranking is exhibited correspondingly against each CSF. The weighted cum frequency Ranking is exhibited at Table 4 (refer to last column).

f) **The comprehensive review of the literature categorizes the CSFs into main categories namely, Critical (X), Sub-factor for success(S), Latent success factor (I) and Strategic cum most-Critical (D). The description of each category and its associated degree of importance is given a weight. The CSF-ranking is calculated by multiplying its frequency with corresponding weights of the category as shown below.

Cat	*Weight*	*Description*
X:	**0.9**	Considered as Critical Success Factor/ Critical Failure Factor by the consulting-author of referred past research work.
S :	**0.7**	Considered as a sub-factor of a critical success factor by the past research work**.**
I :	**0.6**	Not Considered critical but **indirectly** discussed as latent cum important ingredients **for success of ES/ERP.**
D:	**1**	Considered strategic as well as critical and discussed in-depth as a vitally important ingredient for success of ES/ERP by the past research work.
$X_{m/sc/I}$ **$I_{m/SC}$**	**0.9** **0.6**	The Subscript-Suffix 'm' or 'sc' ; along 'X' or 'I'; designate either the Manufacturing industry or supply chain Context relevant to CSFs, as deliberated in past research work

g) The importance of each category of CSFs was assigned weights during exhaustive brain storming sessions by focus group members which was subsequently discussed with ES-Consultants and academia of Cranfield University, UK to reach to a consensus.

<Insert Table-3 here>.

Note:

*** Whereby Actor is donated by (A) and Activity by (AC).**

***** For (X2)*** ISO 9126(IEC 25010) *:* This international standard defines a quality model which acts as a framework for the evaluation of attributes that contribute to the **software quality** (Jung, Kim et al. 2004). The initiation stage to adoption stages iterates **ES-careful-selection-strategy** (X2) in light of ISO-9126(IEC 25010). This can then render optimum quality of ES in terms of; **functionality-fit, configuration-fit, reliability, usability, portability, and maintainability.** This would then ultimately ensure appropriate **information integration** coupled with **BoB-Modules integrations** for production excellence and ES functional fit through lifecycle.

Having deliberated the short description and some of the constructs of classical-CSFs, the Table-4 canvasses significant information of consulting authors' contributions for the benefit of future researchers and practitioners based on two decades of literature review.

<Insert Table-4 here>.

3.3 CSFs Process-approach Results

The ERP Process-approach of CSFs selects, acquires, and deploys resources across **staged model.** Contextually CSFs staged model data is canvassed in Table-5, which represents how the dream of information integration cum automation shatters. Interestingly the mapping of stages over DOI-Phases (sub column 2 of column 1) coupled with project-management implementation-phase (Stage 4) have been depicted by researcher (Rashid, Qureshi et al. 2011), hence intentionally not discussed here. The staged model provides a taxonomy of CSFs across lifecycle which can then bring productivity, price-recovery and performance as contemplated and discussed in detail by **(Tangen 2005). In our research the 6-stage model was considered more accurate because of its higher level of granularity as advocated by (Nah and DELGADO 2006).

<Insert Table-5 here>.

Having discussed the CSFs classification and comparative importance/ranking (Table 3 and 4) along with elaboration of lifecycle stages (Table-5). The focus is now devoted to ES lifecycle and empirical validation.

3.4 Empirical Validation of CSFs

In order to bridge the gap between theory and practice, two focus group sessions were conducted for lifecycle assessment of each CSF. Initially a presentation was made to group of experts in a focus group setting, at Aerospace-OEM of Lockheed Martin, Turkey. The Turkish OEM was involved in manufacturing, maintenance, repair, and overhauling (MRO) of various aircraft including, Lockheed Martin F-16 Systems, based on standards like MIL-PRF-83495, MIL-STD-1808, MIL-STD-38784, ATA100, ATA2200, and ASD S1000D. The OEM-MRO had established a modern aerospace facility and successfully realized the co-production of F-16, CN-235 light transport/maritime patrol/surveillance aircraft, SF-260 trainers and Cougar AS-532 general-purpose helicopters. The experts were briefed about ERP failure issues in aircraft sector, which not only provided stake-holders views in an international setting but also fetched the information to improve the instrument-design and constructs. After 6-months of consultation with academia of NUST, Istanbul Technical University (ITU), Middle East Technical University (METU), and Canfield-University, dimensions of instruments were optimized for second focus group session. The second Focus group was conducted at an Avionics MRO in Pakistan followed by personal structured interview with 31-Aircraft Industry Experts for ranking CSFs across lifecycle.

Relevant data was collected utilizing instrument (Annexure A). CSFs ranking was conducted using Bayesian-Rule, the results are tabulated and presented in Table-6 augmented by **Figure-3** and **Figure-4**. The Table-6 is sorted to exhibit topmost important and relevant Actors (indicted in Blue) and Activities which could be influential for the success of ES-implementation in that specific stage, across the whole lifecycle.

<Insert Table-6 here>.

Legend: Whereby **Actors** across lifecycle stages are highlighted in **Blue**, interestingly, most cited cum common factors across lifecycle turns out to be, X1, X20, X16 and X15.

<Insert Figure-3 here>.

<Insert Figure-4 here>.

Legend: Top portion presents CSFs sorted as per cumulative importance across whole lifecycle, whereas bottom portion canvasses integrated importance of CSFs (sorted alphanumerically depicting stage wise importance across lifecycle)

4. Discussion and Implications

The aircraft industry ES are implemented in pursuit of the vision for excellence in terms of *imperatives* such as: *business (strategic)*, organizational cum behavioral *(tactical, socio-technical), technological* cum *operational* and purely *financial* (Gunasekaran, T. Martikirtanen et al. 1994; Gunasekaran and Thevarajah 1997; Cantamessa, Montagna et al. 2012; Romero and Vieira 2014; Rashid and Tjahjono 2016). A vision of future requires thorough understanding of global and transnational settings for business excellence *(tactical-imperatives)*. The smart factory philosophy in line with Euro-vision for 2030 (European-Union-EFFRA 2013) has further expressed the solidarity to the same concern and brought to reality the very concept of *business (strategic)* and *manufacturing excellence (socio-technical imperatives)* in pursuit of digital factories of future (FoF) and smart factory (Zuehlke 2010). It is contemplated that the technologies that existed for the past one decade are fragile and can be easily disintegrated under dynamically changing market needs and rules (Ray 2002; Bannerman 2008). Retrospectively, such limitations dictated, restraining *Software customization* (X5) and promoting extensive *BPR* (X4), to fit an organization as per logic of ES (embedded interoperability /functional fit-*X2*)(Boza, Cuenca et al. 2015).

Such aspects are considered as major failure factors, an urgency research memo, yet being neglected for the past one decade (*technological research-collaborations imperatives*). Interestingly, ES in a way dictates its own logic to execute organizational functions in order to reap the dream of information integration, which may conflict with the competitive advantage of that very industry (Davenport 1998). Living with the very logic of ERP comes at a very high cost-price (Davenport 1998), and may not render the desired functionality fit (X2) for real time information integration (Boza, Cuenca et al. 2015) and for real time production (*technological* cum *operational imperatives*) (Rashid and Tjahjono 2016). The operations management and optimisation in midst of the global economic crisis has emphasised the needs for an adaptive and flexible network of intelligent machines, robots and sensors termed as the *society of machines* (*social* cum automation *imperatives*) (Rashid and Tjahjono 2016). Contextually, a smart factory which is a societal system of intelligent and networked machines with smart sensors, reiterates ES-vendors to deliver at least the much needed X7-real-time online planning (OnP) and online control (OnC) as core functionality of advance planning optimization (APO). Despite the fact that ERP system integrates all business processes, existing ES (MRP modules) lacks sophistication for OnP/OnC and acceptable standardisation of data integration (X7), and has limited capability to congregate shop floor dynamics under demand uncertainty (*technological* cum *operational imperatives*). Resultantly, the delivery expectation of ES are far below the standard when viewed specifically from the lens of CSF (X2)-optimum-functional-fit via "APO master-production-plan (MPS)" with integrated simulation to eliminate short-term, horizon delays and inaccuracies (Rashid and Tjahjono 2016) (Moon and Bahl 2005; Moon and Phatak 2005). The idea of run around solutions to integrate and fix the islands of automation distorts the very vision of automation, business-excellence and smart factory (Zuehlke 2010) (*grand-strategic imperative for sustainability*). Limited research exist that is aimed at identifying ES-CSFs corresponding to prevailing operational risks at aircraft shop floor that sophisticated ES still cannot harness optimally. Hence, indications are that the transformation is still in its infancy stage (Nof 2006) (Rashid and Tjahjono 2016) and if not addressed may develop serious *implications* for grand strategic vision of manufacturing excellence for Resilient Smart Factory.

The earlier discussion demonstrates urgency of pursuing the research agenda through *RPM process* (Watkins and Bazerman 2003). The *RPM process* recommends a strategy to avert predictable surprises through three ways: (a) *recognizing* various issues for instance ES functionality / interoperability issues, (b) *prioritizing* them and (c) then *mobilizing* resources for crafting a resilient ES. In the past implementation endeavour of ES (COTS) in the large scale aircraft industry had a price-tag of circa \$12M (Yusuf, Gunasekaran et al. 2004) to \$30M with four to five years of time-tag (Tchokogue, Bareil et al. 2005) with equal amount for ES, maintenance, upgrade and comprehensive customization. Hence, many MNCs resorted to develop in house custom-solutions rather than commercial off the shelf (COTS) software (Madapusi and D'Souza 2005) (*financial imperatives*). ES deployment is not only a cumbersome process but also takes years before it yields and reveals its effectiveness for functional-fit (X2). The ES deployment process includes frequent up-gradations coupled with social, structural, strategic, technical and organizational transformations including reengineering of core business process (Tchokogue, Bareil et al. 2005). Contextually, the agony is that even after spending multi-million dollars it may still amplify massive budget cum time overruns (Yusuf, Gunasekaran et al. 2004) and massive multi-tier transformation of enterprise processes (Tchokogue, Bareil et al. 2005). Resultantly, it has been identified that circa 90 percent of ES implementation projects fail (Shehab, Sharp et al. 2004) to meet desired expectations of aircraft industry (Yusuf, Gunasekaran et al. 2004) (X12-*expectations imperatives*). Additionally, rarely the failure issues are correlated with the critical success factors (CSFs) (Shehab, Sharp et al. 2004; Greve and Seidel 2015).

Summarily, synthesis of CSFs reveals that there is limited research evidence for investigation of such fragmented CSFs across ES lifecycle. Moreover, past research lacked end user perspective of aircraft manufacturing industry. The proposed **22-CSFs** in terms of **7-Actors** and **15-Activities** emerge as the stepping stones to render potential artifacts for success across ES lifecycle. The proposed CSFs are unified and updated while also catering for those missing constructs for functional fit and manufacturing excellence that are rarely researched (Rashid and Tjahjono 2016).

The following subsections present pertinent findings which have significant implications for the emerging aircraft industry and existing ES vendors to institute performance improvement programs (PIP) for success across the ES lifecycle and onward (*lifecycle implications*).

4.1 Qualitative Findings: Focus Group

The multiple *focus group* research not only rendered better understanding of the latent factors but also fetched realistic connotation of the critical factors that might impede successful deployment of ES. The Focus Group at the Turkish OEM-MRO inferred that the MRO had to discard Lockheed Martin supplied industry specific Asset Management system, which was upgraded earlier in 2005. The decision to discard emerged in the midst of seven years of utilization (routinization, stage 4), primarily to enhance functional fit and in pursuit of vision of global operations (X1-X2). The existing ERP suite was replaced with a fully customized (X3 to X6), industry specific, ITIL® based (Pollard and Cater-Steel 2009), home grown ERP solution running on JAVA platform and Oracle Engine. The developed software was fully tailored to provide functional fit (X2, Industry Specific Software) (Netland and Aspelund 2013) and to support manufacturing and MRO operations (X6 and X9). The ERP suite had various modules e.g. production planning and control (PPC), supply chain, PDM and CRM to support manufacturing production line of Lockheed Martin Aircraft systems. However, the *focus group* discussions revealed that both existing and industry specific software (Netland and Aspelund 2013) by Lockheed Martin were devoid of capability to forecast lead time for MPS-short term horizon to avert incorrect ES-APO-logic (X7). Further discussions revealed that the Turkish MRO was utilizing EAI technology to manage integration of legacy system (financial module) with ERP unified database. The *focus group* at MRO in Pakistan indicated that the organisation had experience of more than 25 years with extensive maturity level for ES usage to facilitate operations relevant to aircraft MRO and production. However, the discussions at MRO-Pakistan revealed that strategic visioning(X1) and better functionary fit(X2) pleaded for inducting 3rd ES (third wave to completely replace the existing ES) to realize the smart factory vision in pursuit of manufacturing excellence and *grand strategic imperatives of resilience*.

4.1.1 The impediments across lifecycle and Implications

The *focus group* at MROs revealed that implementation was done in a phased way and was not favored through big bang approach (lifecycle stage 1). The first module implemented in both organizations was MRP, followed by Logistics, PDM, MRO-data analysis, and finally CRM (stages 2-3). The use of middleware technologies, often termed as best of breed (BoB) configurations, were implemented (X3). Extensive training seminars (X22) were conducted to develop critical mass of experts (X17-X18) (stages 3-4). After the hardware and software selection and installation (X2-X3), ERP success was celebrated through explicit set of organizational change activities (X6), through effective inter departmental communication and collaboration among stakeholders (X10-X11). During the process of ES project management (X16) across lifecycle stages 3-4, steering committee (X19), consultants (X21) and project team (X18) were given enough resources (X8) by CEOs (X20) so as to manage activities, resources and infrastructure through strategic alliances with vendors (X13-X15). The vital impediments during implementation (stage 4) were primarily master data management (X7-MDM), software customisation (X5) and business process reengineering (X4-BPR). The MDM was given special attention for accuracy, timeliness, shop floor, planning and scheduling and eradicating lead time inaccuracies, which so far did not concede to expectation success (X12). During stage-5, new innovative cultural-training and change management was managed through organization's socio-economic system, which was intertwined with technology, task, people, structure, and culture (X6 and X1). Additionally, software supportability for future enhancements was exhaustively analyzed during regular software upgrades seminars (X9). During stage-6 (up gradation), work system analysis for high integration of technology, organization, and people (HITOP) were partially conducted by risk management department. Similarly the studies were underway for defining new "standard for the exchange of product model data" (STEP) (Rashid and Uzma 2008). Both industries at Turkey and Pakistan had unpleasant experiences (X12) relevant to inaccurate *careful selection strategy* ES-CSF (X2) for optimum-functional fit and production excellence (Rashid and Tjahjono 2016). (Netland and Aspelund 2013), (Wu, Xu et al. 2009), (Beheshti and Beheshti 2010; Koch and Mitteregger 2014) during *ES adopt stage (stage 1* and *stage 6* of *lifecycle*). As a consequence, both aircraft industries had to first upgrade complete ES suites, and later in third wave they had to resort to mix of BoB from Lockheed Martin supplied ES and indigenously developed ES.

4.1.2 The CSF Implications through the lens of Focus group

The evidence from the *focus group* supports that the OEM-MRO of Lockheed Martin resorted to a similar strategy in quest of better functional-fit (manufacturing operational imperatives) and to economize budget cum maintenance costs (financial imperatives). Retrospectively, the *focus-group* thoroughly deliberated the need of understanding global and transnational settings for business aspects. Hence, *focus-group* recommended better control of the operational processes through better integration between functions (ES-SIM integration for OLP /OLC), which so far has not been offered by Industry-specific ES-vendors (*tactical imperatives*). *Strategic imperatives* in this regard, hence, reiterated vendors (software developers) to embed enhanced functionality into the core of ES to support industry strategy in pursuit of smart factory for responsive, agile, holonic and resilient manufacturing that could harness and manage changes and evolutions as they transpire due to market dynamics (Netland and Aspelund 2013),.

4.2 Quantitative / Empirical Findings: Comparison of Industry Vs Classical-literature

The following observations provide an overview of the empirical findings:

a) A detailed *comparative analysis* is presented in Figure 5, which entails that the top 22 CSFs of the aircraft industry and classical literature based CSFs are in harmony. The comparison reveals that the top 20 industry preferred CSFs are in 90% harmony with classical literature based CSFs. The ranking is based on varying setting and hence is cumulative in a sense, since most of the authors only designed their research for the implementation stage (stage-4: acceptance).

b) However, the comparison of the *top-ten* aircraft industry preferred CSFs with classical literature reveals that the industry preference is 40% different from the literature based. Six specific factors emerged as common amongst two schools of thoughts (which make 60% harmony). These include: X1-clear business vision - objectives/business model, X22-knowledge management and reuse, X15-vendor support and cooperation, X20-CEO/top management support, X16- project management (nine knowledge areas) and X10-communication for ES optimum knowledge diffusion (interdepartmental-external, among stakeholder).

c) The literature based top five most cited CSFs for *implementation stage 4* has 60% harmony with industry specific i.e. three common factor, X1-clear business vision, X22-knowledge management and reuse, and X20-CEO/top management support. The Bayes theorem considers independence of each CSFs, moreover for the purpose of comparative ranking only the *implementation stage 4* is considered.

** The ranking is based on varying setting and hence is cumulative in a sense, since most of the authors only designed their research for the implementation stage (**Stage-4:** Acceptance).*

*** The Bayes-Theorem, considers independence of each CSFs, moreover, the ranking, for the purpose of comparison considers the **implementation stage (4)** only.*

<Insert Figure-5 here>.

4.2.1 Findings specific to the Aircraft Industry Across the lifecycle

Industrial ES lifecycle analysis fetches some interesting findings. The critical resources (actors and activities) for *Stage-4-Acceptance* (implementation stage) require a different interaction composition than infusion up-gradation. For instance, the importance of factors X3, X7, X8 and X9 consistently tumbled across ES lifecycle to a bare minimum at Stage 6 (up-gradation), but are vitally important during the acceptance stage or at the beginning stages. Conversely, the importance of factors *X1, X6, X10, X13, X15,* and *X16* continues to grow throughout the ES lifecycle.

For the aircraft industry, automation through ES is a lifelong commitment. Hence, this requires continual investment for new functionalities and upgrades in order to achieve better fits between business and system, and consequently realize a *strategic* business vision. Accordingly, the most vital *actors* are *X20*-CEO/top management support, *X15*-vendor support, and *X13*-vendor-strategic alliance, their contributions are vital for collateral success, from adoption to upgrade stages. Industry experts ranked these as decisive and deliberated that vendor support (X15) is paramount, throughout the ES lifecycle, for managing any teething problems, emergency repair, maintenance, updates, and data warehouse management. Additionally, personal interviews with industry experts and consultants clearly demanded for strategic alliances with the vendors (X13) to ensure incremental enhancement in the functions (X2) in pursuit of a smart factory to ultimately earn manufacturing excellence and resilience. The importance of X13 and X15 is canvassed at Figure 6.

<Insert Figure-6 here>.

Bayesian analysis infers that commitment from **X19**-Steering Committee and **X21**-Consultants virtues are vital during initial stages of lifecycle. This is particularly because they act as a guiding light and steer the project to destination during difficult and unpredicted scenarios. The personal interviews with industry-experts, clearly reiterated to depute Consultants (**X21**) only once it is extremely necessary. For example, this could be at theadoption stage or during resolution of teething problems or at the upgrade stage to conserve the high cost of inducting full time consultants.

4.3 Synthesis and Implications of Findings (7-Actors and 15-Activities)

The aircraft industry prefers a specific *interaction* of *actors* with each other and with other *activities* for optimum utilization of resource, which may vary along the *lifecycle of ES* (temporal in nature). The optimum interaction of each actor with each activity for conserving resources along the lifecycle is hence, an area of prime interest.

Bayesian analysis of the *top 20 CSFs* infer interaction among *7-actors* and *13-activities* to achieve ultimate organizational goals. The ES deployment necessitates an excellent and unprecedented clear business vision (X1), efficient project management (X16) leveraging nine knowledge areas to carefully select ES (X2) and infrastructure choices (X3). The support and alliance among CEOs/top management (X20), vendor (X15), project team (X18) and project champions (X17) is vital for optimum success across the ES lifecycle. Throughout the lifecycle knowledge management (X22), reuse of knowledge remains an important consideration for onward strategic business excellence and resilience. One of the vital responsibilities of project champions is to arrange, depute, and dedicate resources (X8) as and when required across the ES lifecycle. It is deemed necessary that the industry need to utilize a steering committee (X19), hire competent consultants (X21), deploy project champions (X17) coupled with competent, balanced and cross functional project team (X18). For this purpose, resilient communication plan (X10) guarantees, collaboration and cooperation (X11) may it be interdepartmental or external or among stakeholders to accomplish quick success. A vital prerequisite for this entire endeavor requires respect and trust among the organisation and the vendors (X13). A strategic alliance partnership will flourish streamline business process reengineering (BPR-X4) with necessary software customization (X5) to earn requisite functional-fit (X2) during ES implementation and onward upgrades. Regardless of all interactions, an important aspect remains *real-time information quality* (X7)**,** data accuracy, conversion, timeliness, and robust-analysis through data-mining engines and through education of BPM-business processes. The X7-master data management-MDM, data warehouse management through state of the art mechanism empowers stakeholders for timely decision making through real-time information integration. Throughout ES project, the CEO and project champions need to pay special focus on management of expectations (X12).

The aircraft industry has reiterated the importance of *X22* (the 8th most important CSF) for *lifecycle management (LCM) of knowledge and reuse of knowledge* for concurrent *LCM* of industrial needs. There is a need to mimic how experts make strategic-decisions along the lifecycle of an enterprise, how they program and adapt the ESs (PLM/MRP) for functional-fit in support of organizational experience during ES technology induction, integration, upgrade or during contingency handling across the lifecycle of a project and lifecycle of the enterprise itself. Practically speaking, the aircraft industry, consultants, practitioners, software development community, artificial intelligence experts, data mining community, system engineers, and ergonomics consultants need to collaborate to provide a collateral jump-start in this research domain. An alliance is thus vital to avert follies of the past, because new requirements and growth of complexity are outpacing the business technologies. It will not be practical to convene a team of all relevant players each time a new aircraft is designed or a strategic decision is made for inducting new advanced manufacturing technologies (AMT) or inducting a new ERP system. Hence, the need to endow the concept of *LCM of Knowledge* and *reuse of knowledge for* concurrent *LCM* of an enterprise itself and enterprise software systems is the sound of inevitability (*technological research-collaborations imperatives*).

During the *adopt stage-2,* the importance of the CSF (*X2*-careful selection strategy) is paramount. Certain MNCs in the past have preferred software development rather than COTS since these COTS tend to enforce their own business logic which may conflict with organizational core business processes. Reportedly, Rolls Royce has preferred a phased implementation methodology (Yusuf, Gunasekaran et al. 2004) rather than big bang. However, depending upon business settings and market dynamics, organizations may choose big bang methodology. The *focus group* has reiterated that it is vital that organisations need to select ES with a vision for functional fit through preferably BoB rather than single vendor exploiting doctrine of ISO-9126(IEC 25010). A cohesive strategy for deployment is the most decisive factor for success of the whole ES lifecycle specifically from the production excellence stand point. The personal interviews with industry experts and consultants at Ankara and IPA Germany strongly reiterated for meticulous efforts to devise *careful selection strategy* during the adoption stage for optimum functionality-fit. This aspect has multi-folded *implications* for developing the emerging aircraft industry e.g. for those emerging aircraft manufacturing companies, in Turkey and China, that might be in the process of ES acquiring or upgrading of PPC module. Hence, the importance of CSF (X2)-*careful selection strategy at ES-adopt stage* with optimum functionality-fit need is exhibited in Figure 6. These aspects are to be taken care off, right at the ES-selection stage so as to avert production delays due to an inaccurate logic of ES-APO-MPS. This misfit in MPS-*short term horizon affects lead-time calculations* and ultimately cause suboptimal production schedules, hence, rendering suboptimal production. The additional drawback is that ES-scheduling and planning core-logic is devoid of sensing dynamic market changes, hence, monolithic to adjust order planning and execution as per the demand of customers. Whatever functionality is being offered by vendors may lack *real time information* of shop-floor to manage customer orders for short-term horizon. Hence, in a way the advance planning optimization (APO) available to achieve (promise) capability is suboptimal to manage online planning (OnP) and online control (OnC). This constitutes a significant finding of this research. A possible solution to avert APO-MPS suboptimal *short term horizon* could be through the integration of ES-APO with simulation Engine as advocated by (Rashid and Tjahjono 2016), (Moon and Phatak 2005; Ruiz, Giret et al. 2010; Van Nieuwenhuyse, De Boeck et al. 2011).

<Insert Figure-7 here>.

4.4 Research Limitations

The present effort is an ongoing research to realize a better understanding of CSFs across the ES lifecycle. In the past five years, an extensive field survey has been conducted with experts in the aircraft industry, administered through academic collaborations with Cranfield University UK, Turkish Universities (METU, ITU and ATILIM) and Universities across Asian countries. However, limitations exist whereby only 31 experts were interviewed /consulted to collect data. Hence, the *focus group* research method coupled with structured interviews was preferred over conventional surveys. This in itself is a much more refined way of conducting an industry specific survey and in a way a better representative of industry specific analysis.

It is expected that after a certain time the efforts would be matured and would be able to conduct a large scale survey for better understanding of CSFs from multiple dimensions for multiple stakeholders. Nevertheless, the existing research is a stepping stone for other researchers to rank, classify, or map these factors over lifecycle through more refined quantification tools and with an enhanced set of statistical population to represent the whole aircraft industry.

5. Conclusion

The European Vision of 2030 for smart factories of future (FoF) iterates concurrently the economical, environmental, as well as societal challenges and has sponsored **€1200 million** to reap the aim of business excellence. Contextual to retrospective analysis of the ERP concept, emerging intelligent e-manufacturing technologies, enabling CIM philosophy and Smart factory automation issues; the paper explored through lifecycle avenues for ERP CSFs. Whilst in the past various research has been carried out, but 50% of these research were for the implementation phase of ES, with no focus of what happens after ES is implemented and what are the associated critical factors that need to be conserved. It was also observed that, CSFs constructs were fragmented, scattered did not cater for end-user perspective. Moreover, in the past identification of the CSFs did not adopt a meticulous process to render tangible, structured, exhaustive and convivial factors based on exploration of decades of literature. The CSFs identification by first identifying the authenticity of sources and catering for validity of author's citation could be an appropriate tactic that could lead to preferred, complete and wide-ranged fusion of CSFs. This study, hence, rendered completely coalesced ES-CSFs through lifecycle from end-user perspective. This research focused on empirical-verification of blended, completely coalesced and most widely cited, critical success factors (CSF), from the past two decades, across the lifecycle of technovation from the end-user perspective. Results, inferred that the Top 20 empirically verified CSFs fairly concede with the literatures based classical CSFs. However, the **Top-Ten** aircraft-industry CSFs are very distinctive. For the aircraft industry, the three major drivers for ES lifecycle management (LCM) are Implementation-perspective, Manufacturing-Operations-perspective, and Budget-perspective. The temptation to acquire and implement ERP without a strategic plan and without considering CSFs voyage along cycle will perpetually result into either complete failure to implement or premature scrapping of ES with frequent upgrades. The **initiation stage to adoption stages, stress** to **pre-plan** and **plan ES-careful-selection-strategy** (X2) in light of ISO 9126(IEC 25010). Resultantly this can then render optimum quality of ES in terms of; functionality-fit, configuration-fit, reliability, usability, portability, and maintainability**.** This would then in turn render appropriate information integration and BoB Modules integrations through ES-lifecycle. The Asian aircraft industry can optimize "financial and time budgets" by deploying CSFs (actors / activities), which are specifically needed the most and when they are required to be employed during the life-cycle. For the aircraft industry the three topmost vital and specific CSFs across whole lifecycle (common amongst stages) are X1 (Clear business Vision: Objectives/Business model), X20 (CEO/Top management Support) and X16 (Project-Management, 9-knowledge-areas). The proposed CSFs provide a basic and high-level understanding to recognize, prioritize, and mobilize the optimum use of actors and activities as well as a methodology to implement business model driven stratagem. The value of this conceptual stratagem is that it simplifies ERP technovation along each stage and reduces ES-implementation to convenient and comprehensible ingredients for each stage of technovation. For practitioners this simplicity will entail focused efforts and attention along six-stages of technovation (lifecycle of ES). It is hoped that future researcher will find this research as a stepping-stone to further harness the in-depth realms of lifecycle of CSFs. It is expected that the study will provide a fundamental guideline to avoid preplanning, planning and re-planning of all the activities along the lifecycle stages in pursuit of business excellence today, tomorrow and future. This in fact is one of the elementary potential urge of developing the Asian aircraft industry (China, Turkey, and Pakistan) presently in the process of either adoption or upgrade of ES-suites.

5.1 Recommendations for Emerging Aircraft Industry

Retrospectively, the Aircraft industry needs to learn from follies of past and adopt **RPM process** (Watkins and Bazerman 2003) to avert predictable surprises through three ways (a) **Recognizing** the various issues with ES-functionality and interoperability (b) **Prioritizing,** preplanning, planning and re-planning of CSF**(X2)-Careful Selection Strategy** (Beheshti and Beheshti 2010; Boza, Cuenca et al. 2015) and (c) then **Mobilizing** resources to opt for Sustainable Enterprise System which could render basic functionality-fit, configuration-fit, reliability, usability, portability, and maintainability. In the past, implementation endeavours of ES (COTS) in the large scale aircraft industry had a Price-tag ranging from USD 12M to 30M (Yusuf, Gunasekaran et al. 2004) with four to five years of Time-tag (Tchokogue, Bareil et al. 2005). Needless to mention that an equal amount is required for ES, maintenance, upgrade and comprehensive customization. Hence, many MNCs, resorted to develop in house custom-solutions rather than COTS. The *Focus group* results support and provide evidence for such in house custom-solutions. Retrospectively, it is noted that at the start stage of the ES lifecycle, vital CSFs challenges are functional fit and BPR, which entails integration among Modules of ES, Machines and Methods. This suboptimal planning and inappropriate functional fit during the start stage has thus caused either abandoning the ES project (Rashid, Zainab Riaz et al. 2012) or frequent upgrades with massive budgetary overruns (British-Airway 1998; Aboulafia 2001; Aboulafia 2003; Alemanni, Alessia et al. 2008; Cantamessa, Montagna et al. 2012). These critical failure issues specific to design insufficiency of ES affect ramping up of aircraft production-operations at the aircraft-shop-floor. As a result, Intelligent Production is hampered due to inappropriate EAI (enterprise application integration) among Modules of Enterprise systems (ES). Examples for this could be inappropriate EAI, amongst MES, Dassault System CATIA, and DMU/ENVIA applications (Rashid, Zainab Riaz et al. 2012). Hence, such critical factors need to be given due respect right at the adopt-stage of ES throughout the lifecycle success and are considered the most decisive CSFs for optimum-functional fit to render manufacturing productivity (Rashid and Tjahjono 2016). The implications of CSFs **X2** (Careful selection to avert inaccurate functional-fit) is decisive at the adopt-stage (stage 2). The evidence from past case study illustrates that Lockheed Martin scrapped the ES-program, because of high cost of implementation, cumbersome customization efforts of IT-package (CSF-X5) to embed desired business processes(X4) in pursuit of optimum-functionality fit (X2) (Rashid, Zainab Riaz et al. 2012), which in itself remains an open ended question. This aspect has multi-faceted implications for evolving the aircraft manufacturing industries in Turkey, Pakistan and China, and those central European countries that are in the process of ES-acquisition or upgrade of APO-production planning, and control (PPC)-module (Rashid and Tjahjono 2016). Hence, the importance of CSF**(**X2)-Careful Selection Strategy at ES-adopt-stage with optimum functionality-fit, configuration-fit, reliability, usability, portability, and maintainability need to be taken care of right at ES-selection stage (adopt-stage of lifecycle) so as to avert scrapping of ES, and avert further production-delays due to inaccurate logic of ES-APO(MPS).

5.2 Future Research

The implications of ES implementation in the aircraft industry, may act as a precursor for future researchers to contemplate interaction as well as impact of individual CSF, through whole lifecycle. As an outcome of the research, the following dimensions emerge as potential areas of future research:

a) Future research may be carried out to capture a more representative of aircraft industry across the globe for further empirical validation using a large-scale survey.

b) Future research may be conducted to explore CSFs-construct using a micro-type of research that could spot internal elements, uncovers CSFs latent working coupled with sophisticated internal relationships, and compute CSFs two-sided effects across the lifecycle staged model.

c) Longitudinal research studies may be carried out for the dependent and independent variables in the aircraft industry by constructing a testable model thereby rendering specific relationships among project success, latent, situational and contextual factors to validate process success in the form of financial, technical, and operational performance excellence.

d) Future studies may be carried out, for mapping the actors and activities that are specifically needed and when they are required to be employed during the lifecycle.

e) The roles of automation and seamless integration of shop floor machines/robots and simulations are increasingly evident in determining an optimum decision making and production planning at a shop floor level. Retrospectively, future research may be conducted not only for optimal integration but also to embed optimal logic for both push and pull production operations, as a core capability of ES-Advanced Planning Optimization (APO) systems (Rashid and Tjahjono 2016).

f) Resilience at smart factory reiterates optimal manufacturing to reap the dream of productivity and manufacturing excellence. Whilst all indications are that ERP system integrates all business processes, yet, existing ES (APO-MPS) lacks sophistication for data integration (X7) vis-à-vis manufacturing functionality(X2) for online planning and Control (OnP/OnC). Hence, there is a need of holistic research in this domain (i) to optimize core capabilities of industry (company) specific production software's (XPS) (Netland and Aspelund 2013) (ii) to embed within APO(master-production-plan-MPS) the capability to congregate shop floor dynamics for optimum-functional-fit through the integration of ES and Simulation (Rashid and Tjahjono 2016).

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Table-1: The Experts demography and Descriptive Analysis

Aspects	MRO Organization	N	Min	Max	Mean
Tenure in the Aviation Industry (Years)	Focus Group Pakistan	5	8	32	13
	Focus Group Turkey	5	3	23	13
	Industry Experts	31	8	55	22.7
Experience of ES Usage, Induction and Implementation (Years)	Focus Group Pakistan	5	8	18	13
	Focus Group Turkey	5	7	15	11
	Industry Experts	31	8	20	14
Number of **ES Project Implemented**	Focus Group Pakistan	5	2	3	2
	Focus Group Turkey	5	1	4	3
	Industry Experts	29	1	3	2
Age (Years)	Pakistan	5	32	42	37
	Turkey	5	27	50	39
	Industry Experts	31	29	58	43
Gender-Female (%)	Pakistan	0		0	
	Turkey	2		40	
	Industry Experts	0		0	
Gender-Male (%)	Pakistan	5		100	
	Turkey	3		60	
	Industry Experts	31		100	

Table 2: Probability Distribution Function for lifecycle stages of CSFs

Probability Data Classification for Players and Activities along ES, lifecycle stages								
	Fractional Probability of Variables							
Independent. Variables	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage mn	Joint Prob. Stage mn
X1	P11	P12	P13	P14	P15	P16	P1n	P1-
X2	P21	P22	P23	P24	P25	P26	P2n	P2-
X3	P31	P32	P33	P34	P35	P36	P3n	P1
:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	:
Xm1	Pm1	Pm2	Pm3	Pm4	Pm5	Pm6	Pmn	P1
Probability of Player (mn)	P-1	P-2	P-3	P-4	P-5	P-6	P-n	1.0

Table 3: Sensitizing-Device 1; State-of-the-art classical-CSFs.

Code	Critical Success Factor	* Classification of CSFs
X1	**ES-implementation, through clear Business-Vision for production-excellence, across the organization, for specific deliverables,** and objectives based on virtues of Business Model: Strategic visioning is the method by which the business model behind the implementation of the project can be clarified (Holland and Light 1999); needless to mention that strategies can be transpired through innovative procedures and actions of the futuristic state of business processes (Davenport 1998b).	**Ac**
X2	**** Careful Selection Strategy Vs Software Development Vs Implementation Methodology**: Selection as per Vision for functional fit and Best of Breed Vs single vendor as per ISO-9126 and Strategy for deployment, Big bang or phased. The use of ISO 9126(IEC 25010)* standard for (ERP) software selection covering both qualitative and quantitative factors using Multiple criteria decision making (MCDM) approach is paramount to analyze these conflicting factors (Onut and Efendigil 2010). The **initiation stage to adoption stages emphasizes to pre-plan** and **plan ES-careful-selection-strategy** (X2) in light of ISO 9126. This can then render optimum quality of ES in terms of; **functionality-fit, configuration-fit, reliability, usability, portability, and maintainability.**	**Ac**
X3	**IT Architectural /Infrastructure Choices**: Centralized Vs decentralized Operations Single site or Multiple Vs Choices of Information Integration Middleware Technologies EAI (SOA; XML). The classical literature stresses on strategic Architectural choices as paramount for ERP success (Al-Mashari 2003b) (Markus and Tanis 2000, Somers and Nelson 2004)	**Ac**
X4	**Level of business process Reengineering (BPR)** Vs Vanilla (minimum is preferred): Initiation project phase is accustomed to have a BPR with minimum customization of software. In manufacturing industry, BPR is often administered as instruments to simplify and improve business processes. Therefore, the 80% of literature prefers vanilla ERP implementation to ensure dissemination of software updates /upgrades and to avoid project delays (Holland and Light 1999) (Al-Mashari 2003b) (Davenport 1998b).	**Ac**
X5	**Software customization**-for quick ES implementation: Literature supports that in order to improve the functionality-fit of the software in accordance with the needs of the organization; an organization should reengineer business processes to fit the software rather than trying to modify the software to fit the organization's current business processes. Reportedly, the cost and the possibility of error would have been more for Rolls-Royce, if software were customized (Yusuf *et al.* 2004). The major changes in logic of software through customization may not guarantee the installation of future updates from the vendor (Ngai *et al.* 2008).	**Ac**
X6	**Organizational Culture & Change Management**: Commitment to change-perseverance and determination: Commitment to change-perseverance and determination, Enterprise wide culture and structure management are paramount for industrial competitiveness and survival. ERP implementation often results in a large-scale organizational change (Davenport 1998b).	**Ac**
X7	**Real Time Information Quality & MDM:** Data Accuracy-timeliness, Analysis, and Conversion; Master Data Management-(MDM): A vital prerequisite for the productivity of any industry is efficiency and effectiveness of master data (Al-Mashari 2003b) and associated timeliness with utmost accuracy (Aboulafia 2003, Yusuf *et al.* 2004, Hirata 2009).	**Ac**
X8	**Dedicating Resources** for ES deployment and for effective software usage: Allocating adequate resources for success of ERP project is of vital importance, (Nah and DELGADO 2006). During the SAP implementation project of Rolls Royce (Yusuf *et al.* 2004) and Pratt & Whitney Canada (Tchokogue *et al.* 2005), the Top management allocated legitimate resources and funding.	**Ac**
X9	**Business processes management & Knowledge Education**: Policy consortia, Modeling and Knowledge Education on new Business processes: The BPM enhances employee and customer value through a process of innovation that aims at flexibility and efficiency. The BPM defines the steps for knowledge management and education of Business Process. The BPM is conducted utilizing the standards such as Service-oriented architecture (SOA), Extensible Markup Language (XML) and Web service (Møller 2005, Møller *et al.* 2008). Evidence supports that BPR education helped the stake holders to fine tune the Rolls Royce processes to align with SAP core logic (Yusuf *et al.* 2004)	**Ac**
X10	**Communication for ES Optimum Knowledge-Diffusion-(Interdepartmental-external; among stakeholder):** Effective inter departmental communication and among stakeholders is absolutely critical to ERP implementation. Among critical aspects that need to be communicated include Vision, Goals, Policies, Expectations, Project-scope and Deliverables, Project progress and Selection-criteria etc (Holland and Light 1999, Nah and Lau 2001).	**Ac**
X11	**Collaboration-Cooperation** and Coordination-Interdepartmental-external, among stakeholders, Involvement , Corporate vide Commitment**:** The ES latent value cannot be guaranteed without strong project oriented coordination of efforts and goals in line with Business model and Vision (Nah and DELGADO 2006). The SAP Pratt & Whitney Canada, implementation project, stressed all collaborating partners for optimum Cooperation, and Coordination across Lifecycle (Tchokogue *et al.* 2005).	**Ac**

Code	Critical Success Factor	* Classification of CSFs
X12	**Management of expectations** Vs User Satisfaction: Beyond any mystification ERP, implementation teams and vendors need to pay specific attention to the quality of system to meet users-expectations. The ES success can be classified into a) Correspondence-success, where ES matches the specific planned goals and objectives; b) Process-success, where ES project is completed within scope, time and budge; c) Interaction-success, where users attitudes towards ICT/IT are positive; c) Expectation success, whereby IT-packages match users expectations (Al-Mashari 2003b).	**Ac**
X13	**Vendor Vs organization-Trust, Strategic Alliance**-Partnership-for ES implementation & onward upgrades: The long term and sustained vendor–customer partnerships are vital for successful ERP projects. In view of organization's competitiveness, the relationship between the software buyer and vendor should be strategic in nature, for any industry, irrespective of other considerations throughout the lifecycle and particularly during the stage of transformation from first lifecycle to next wave of upgrade or technovation (Markus and Tanis 2000).	**A**
X14	**Vendor State of art software Tool's & templates** quality Vs utilization**:** The rapid implementation tools include software based business process modeling tools, industry-specific-templates for standard operating procedures, customized hardware for streamlined operations of ERP software and integrated package of software, services, and support. Such tools significantly lower the finances, efforts and time (Holland and Light 1999).	**Ac**
X15	**Vendor-Support & Cooperation-**Organization Involvement and Vendor response time**:** During ES-lifecycle industry, need ultimate vendor support, in the form of stabilizing teething problems for global multi site ES (Madapusi and D'Souza 2005). This include extended technical assistance, emergency maintenance, updates, and special user training, during the post-implementation stages (Markus and Tanis 2000),(Somers and Nelson 2004).	**A**
X16	**Project Management for ES implementation (9-knowedge Areas):** Project management is all about optimistic planning, scheduling, and controlling of project activities to meet project deliverables within time and budget. Effective project management is critical for timely and within budget completion of ES(Nah and DELGADO 2006).	**Ac**
X17	**Project champions /Best (Permanent) People on team:** The project champion is normally a senior executive who facilitate goal setting, effective rollout of ES, legitimizing change, episodically manages resistance and facilitates monitoring and has profound knowledge of the business and ability to acquire resources in the organization (Nah and DELGADO 2006), (Al-Mashari 2003b).	A
X18	Project Team (Competence: Balanced & cross functional team): The SAP Pratt & Whitney Canada, successful go live , across five global sites, is credited entirely to the state of art collaboration of a great Project-team which was Balanced & cross functional (Tchokogue *et al.* 2005).	A
X19	**Steering Committee Virtues:** During the ES-project lifecycle management, Steering committee (a consortium of experienced stakeholders) steers the direction of project to achieve the targets as per the vision of productivity and operations excellence. The vitality and involvement of Steering committee is paramount during initial stages and decreases as project proceeds (Markus and Tanis 2000, José Esteves and Pastor 2001, Al-Mashari 2003a, Loh and Koh. 2004, Somers and Nelson	**A**
X20	**CEO/Top Management Support:** The ERP project is clearly and explicitly designated as top priority by top management. During the SAP implementation project of Rolls Royce (Yusuf *et al.* 2004) and Pratt & Whitney Canada (Tchokogue *et al.* 2005), Top management determination, commitment , approval and support earned successful and timely execution of ES-project.	A
X21	**Consultants Virtues and Optimum Utilization: During Various Stages for Efficiency & Effectiveness:** The SAP Pratt & Whitney Canada (P&WC), hired 45 external consultants for optimum project management within time and budget (Tchokogue *et al.* 2005). These consultants had the comprehensive knowledge of certain modules, and experience of the software applications.	A
X22	**Knowledge Management and reuse: Users training of ES-software & Organizational Learning (HRD / reuse of knowledge for optimum ES-use and effectiveness):** Formal education and training is seen as most vital and self sustaining aspect by manufacturing and aerospace industry (Yusuf *et al.* 2004). Another area of concern is knowledge reuse and knowledge areas diffusion across lifecycle. In this context, Learning Portals/LMS can facilitate in quick knowledge dissipation for digital learning, knowledge-based engineering, deeper diffusion, and analytics. The knowledge based factory services reiterate compliance to Data security; Knowledge generation, Machine Learning, for **Use** and **Reuse** of knowledge through Enabling reference architectures, Grid computing and Cloud computing (Dalkir 2011) .	Ac

Table 4: Sensitizing-Device 2; Classical-CSFs-Unified Perspective and Ranking, based on State-of-the-art

Consulting Authors' Cumulative CITATION-INDEX of 76 Articles	1474	1243	997	680	13453	462	985	1461	604	298	311	3193	364	1627	764	505	613	693	749	1754	512	764		
CSF Code	Consulting-Authors																						Frequency Based Ranking	Weighted Ranking
	1.Al Mashari(Al-Mashari and Zairi 2000, Al-Mashari 2001, Al-Mashari 2003b, Al-Mashari and Al-Mudimigh 2003, Al-Mashari et al. 2006)	2. Akkmerans (Akkermans and van Helden 2002),(Akkermans et al. 2003)	3. Brown (Brown and Magill 1994, Brown and Vessey 1999, Brown and Vessey 2003)	4. Botta-Genoulaz(Botta-Genoulaz and Millet 2005b, Botta-Genoulaz and Millet 2005a, Botta-Genoulaz et al. 2005, Mamoghli et al. 2011)	5. Dasvenport (Davenport 1998a, Davenport 1998b, Davenport 2000, Davenport 2013)	6. Finney (Finney and Corbett 2007, Finney 2011)	7. Gunasekaran et al(Gunasekaran et al. 1994) (Gunasekaran and Thevarajah 1997, Motwani et al. 2002, Gunasekaran and Ngai 2004, Kamhawi and Gunasekaran 2009)	8. Holand(Holland and Light 1999){Holland et al. 1999)	9. José-Esteves(José-Esteves and Pastor 1999, José-Esteves and Pastor 2001, José Esteves and Pastor 2001)	10 Koh (Koh et al. 2002, Koh et al. 2005, Koh et al. 2006b, Koh et al. 2008, Koh et al. 2011)	Loh & Koh (Loh et al. 2003, Loh and Koh. 2004, Loh et al. 2006)	12. Markus (Markus et al. 2000a, Markus et al. 2000b, Markus and Tanis 2000, Markus et al. 2000c)	13. Mooler & Kraemmerand (Møller 2005, Møller et al. 2008), (Kraemmerand et al. 2003) (Møller 2006) (Kraemmerand and	14. Nah (Nah and Lau 2001, Nah and DELGADO 2006)	15.Ngai(Ngai et al. 2004, Ngai and Law 2007, Ngai et al. 2008)	16. Parr and Shanks (Parr et al. 1999, Parr and Shanks 2000) (Parr and Shanks 2003) .(Shanks et al. 2000) (Shanks 2000)	17.Rajagopal(Rajagopal and Frank 2000, Rajagopal 2002, Rajagopal and Frank 2002)	18.Sumner (Sumner 2000, Beard and Sumner 2004, Sumner 2006, Sumner et al. 2006)	19. Somers(Somers et al. 2000, Somers and Nelson 2001, Somers and Nelson 2004) (Karim et al. 2007)	20. Umble Elizabeth(Umble et al. 2001, Umble and Umble 2002, Umble et al. 2003)	21..Yusuf (Yusuf et al. 2002, Yusuf et al. 2004, Yusuf et al. 2006, Gopalakrishnan et al. 2012)	22..Zhang M K O Lee (Zhang et al. 2003, Zhang et al. 2005)		
X1	D		X	X	X	X	Xm	X	X	X	X	X	X	X	D	X	X	X	D	D	Im	X	**5**	**3**
X2	Xm	X	X	X		X	Xm	S	D	Isc	D	X	X	X	X	X	X		D	D		X	**11**	**8**
X3	X	X	X	X	D	X	I	X	X	X	X	X	X	X	X	X	X		D	D		S	**10**	**7**
X4	Xm	X	X	X	X	X	Xm	X	X	Im	X	X	X	X	X	X	X	X	X	S	Xm	X	**4**	**4**
X5	X		X	X	X	X	Xm	S	X	Xs	S	X	X	X	X	S	X	X	X	S	Xm	S	**8**	**12**
X6	X	X	X	X	X	X	Xm	S	X	X	X	X	X	X	X	X	X		X	X	Xm	X	**6**	**6**
X7	I			X	S	X	X	I	X	Xsc	X	X	I	S	X	X	X		X	X	Xm	X	**14**	**16**
X8	X					I	X	I	X	I	X	X	I	S	X	X		S	X	S	Xm	S	**17**	**18**
X9	I					X	Im		I	I	I		X	I	X				X			S	**21**	**21**

Consulting Authors' Cumulative CITATION-INDEX of 76 Articles	1474	1243	997	680	13453	462	985	1461	604	298	311	3193	364	1627	764	505	613	693	749	1754	512	764		
	Consulting-Authors																							
CSF Code	1.Al Mashari(Al-Mashari and Zairi 2000, Al-Mashari 2001, Al-Mashari 2003b, Al-Mashari and Al-Mudimigh 2003, Al-Mashari et al. 2006)	2. Akkmerans (Akkermans and van Helden 2002),(Akkermans et al. 2003)	3. Brown (Brown and Magill 1994, Brown and Vessey 1999, Brown and Vessey 2003)	4. Botta-Genoulaz(Botta-Genoulaz and Millet 2005b, Botta-Genoulaz and Millet 2005a, Botta-Genoulaz et al. 2005, Mamoghli et al. 2011)	5. Dasvenport (Davenport 1998a, Davenport 1998b, Davenport 2000, Davenport 2013)	6. Finney (Finney and Corbett 2007, Finney 2011)	7. Gunasekaran et al(Gunasekaran et al. 1994) (Gunasekaran and Thevarajah 1997, Motwani et al. 2002, Gunasekaran and Ngai 2004, Kamhawi and Gunasekaran 2009)	8. Holand(Holland and Light 1999){(Holland et al. 1999)	9. José-Esteves(José-Esteves and Pastor 1999, José-Esteves and Pastor 2001, José Esteves and Pastor 2001)	10 Koh (Koh et al. 2002, Koh et al. 2005, Koh et al. 2006b, Koh et al. 2008, Koh et al. 2011)	Loh & Koh (Loh et al. 2003, Loh and Koh. 2004, Loh et al. 2006)	12. Markus (Markus et al. 2000a, Markus et al. 2000b, Markus and Tanis 2000, Markus et al. 2000c)	13. Mooler & Kraemmerand (Møller 2005, Møller et al. 2008), (Kraemmerand et al. 2003) (Møller 2006) (Kraemmerand and	14. Nah (Nah and Lau 2001, Nah and DELGADO 2006)	15.Ngai(Ngai et al. 2004, Ngai and Law 2007, Ngai et al. 2008)	16. Parr and Shanks (Parr et al. 1999, Parr and Shanks 2000) (Parr and Shanks 2003) ,(Shanks et al. 2000) (Shanks 2000)	17.Rajagopal(Rajagopal and Frank 2000, Rajagopal 2002, Rajagopal and Frank 2002)	18.Sumner (Sumner 2000, Beard and Sumner 2004, Sumner 2006, Sumner et al. 2006)	19. Somers(Somers et al. 2000, Somers and Nelson 2001, Somers and Nelson 2004) (Karim et al. 2007)	20. Umble Elizabeth(Umble et al. 2001, Umble and Umble 2002, Umble et al. 2003)	21..Yusuf (Yusuf et al. 2002, Yusuf et al. 2004, Yusuf et al. 2006, Gopalakrishnan et al. 2012)	22..Zhang M K O Lee (Zhang et al. 2003, Zhang et al. 2005)	Frequency Based Ranking	Weighted Ranking
X10	X	X	S	X		X	Xm	X	X	X	X	X	X	X	X	X	X	S	X	X	Xm	S	9	9
X11	I		X			X	Xm	I	X	X	X	X	X	S	X	X	X	S	X	S	Xm	X	13	14
X12	D			X	X				I	I	S	X		I	X				X	I			20	20
X13			X			I	Xm	I	X	X	S	X		S	X			X	X	I		X	19	19
X14	I					I		D	S	I	S	I	X	S	X			I	D				22	22
X15	X	X		X			I	I	X	Isc	S	X	I	I	X	X	X	X	X	X	Im	X	12	10
X16	X	X	X	X	X	X	Xm	X	X	Xs	X	X	X	X	X	X	X	D	X	X	Xm	D	2	1
X17	X		X	X		X	Xm	I	D		X	X		X	X	X	X	X	X	S		S	15	13
X18	I	X	X	X	X	X		I	X		X	X		X	X		X	X	X	X		S	16	15
X19	I			X	X	X	Xm			Isc		X		I	X	X	X	X	X	S	Im	S	18	17
X20	X	X	X	X	D	X	Xm	X	X	X	X	X	X	X	D	X	X	X	X	X	Im	X	1	2
X21	I	X	X	I	X	X	Xm	X	D	I	S	X	X	S	X	X	X	X	D	I		S	7	11
X22	X	X	X	X	X	X	Xm	S	D	X	S	X	X	S	X	X	X	X	X	X	Xm	X	3	5

Table-5: Sensitizing-Device 3, ES-Process-approach

Authors Citation Index ⇨		749	391	948	929	311	1627	604
Process Approach -Staged-Model ⇩		Somers (Somers *et al.* 2000, Somers and Nelson 2001, Somers and Nelson 2004)	(Rajagopal 2002)	Al Mashari issues (Al-Mashari 2003b)	Markus (Markus and Tanis 2000)	Loh (Loh and Koh. 2004)	Nah (Nah and Lau 2001, Nah and DELGADO 2006)	Esteves (José-Esteves and Pastor 1999, José-Esteves and Pastor 2001, José Esteves and Pastor 2001)
Stage I	**Pre-adoption-phase,** whereby Problem recognition, exposure is envisioned in pursuit of productivity enhancement through automation. Leadership gets exposure to the idea of technovation. Vision of a smart-factory is realized to espouse automation.	Initiate		Setting up	Chartering			Adoption Decision
Stage II	Willingness and consensus is reached to acquire ES. Hence, Vision communication to stake holders is initiated for funding in pursuit of optimum cum sustainable operations. Elaborated feasibility plans are devised for bench-marking analysis as well as a trade off among various technology alternates for instance Relative Advantage, Compatibility Vs Adaptability, and Complexity Vs Transfusion. A **careful selection strategy** is then formulated for technovation, resource-planning to adopt ES-Package with optimum functionality-fit.	Adopt			Project			Acquisition
Stage III	The ES technovation-development (acquiring) phase considered as **Adaption.** IT-package is installed and becomes available. Change Management strategy executed for streamline organization transformation from unfrozen-state to a new state. Planning execution for ES-Software customization, BPR and MDM to fit organizational needs.	Adapt						Implementation
Stage IV	*The **Technology-diffusion** phase which could be considered as a **mega-project** comprising of "Project-Initiation-stage, Planning-stage, Execution-stage, Controlling-stage, and Close-out-stage". Organizational members employ ES-package in organizational work, deploying sand box based-BPR to eliminate bugs.	Acceptance		Implementation				Use & Maintenance
Stage V	** ERP-technovation for optimum use, to render **triple-P-effect**. IT- package is no longer perceived as innovation, more bugs fixed, realistic planned **vision** is achieved for optimum ES-diffusion, and knowledge re-use. Technological quality would predict information-quality, productivity, and developing of HR-skills.	Routinization			Shakedown			Evolution

Authors Citation Index		749	391	948	929	311	1627	604
Process Approach -Staged-Model		Somers (Somers *et al.* 2000, Somers and Nelson 2001, Somers and Nelson 2004)	(Rajagopal 2002)	Al Mashari issues (Al-Mashari 2003b)	Markus (Markus and Tanis 2000)	Loh (Loh and Koh. 2004)	Nah (Nah and Lau 2001, Nah and DELGADO 2006)	Esteves (José-Esteves and Pastor 1999, José-Esteves and Pastor 2001, José Esteves and Pastor 2001)
Stage VI	IT-package is used optimally for sustainable operations. An upgrade is conceived as a recommended solution for enhanced productivity. Environmental Rivalry, PEST influences for organizational growth as per latest ES-technology Infusion, retirement, or reuse of knowledge for next ERP iterative cycle (KM & reuse).	Infuse and onward		Evaluation	Onward and upward			Retirement

*Table-6: Importance of CSFs **Actors-Activities** across lifecycle of Technovation.*

	Factors	Stage 1	Factors	Stage 2	Factors	Stage 3	Factors	Stage 4	Factors	Stage 5	Factors	Stage 6
1.	X1	0.0644374	X1	0.1127986	X1	0.0595308	X1	0.0622238	X1	0.1389129	X1	0.1410082
2.	X16	0.0616358	X16	0.1078943	X17	0.0576104	X22	0.0622238	X16	0.1376186	X16	0.1398728
3.	X20	0.0596475	X20	0.1009334	X20	0.0569425	X15	0.0622238	X10	0.1121657	X20	0.1198910
4.	X2	0.0542250	X10	0.0854295	X15	0.0556901	X20	0.0615024	X20	0.1091458	X10	0.1089918
5.	X10	0.0542250	X2	0.0696092	X22	0.0556901	X8	0.0615024	X15	0.0893011	X15	0.0887829
6.	X7	0.0536828	X15	0.0618573	X16	0.0551056	X16	0.0595184	X22	0.0644953	X13	0.0667575
7.	X19	0.0536828	X3	0.0571112	X7	0.0551056	X18	0.0595184	X13	0.0588870	X17	0.0417802
8.	X15	0.0519657	X4	0.0420819	X8	0.0551056	X17	0.0580756	X17	0.0446506	X12	0.0408719
9.	X3	0.0515138	X7	0.0417655	X18	0.0551056	X7	0.0555505	X14	0.0427092	X14	0.0286104
10.	X21	0.0497967	X5	0.0379687	X13	0.0526008	X10	0.0541077	X18	0.0379638	X4	0.0258856
11.	X5	0.0488025	X8	0.0348046	X10	0.0517659	X13	0.0530255	X12	0.0301984	X9	0.0258856
12.	X4	0.0463624	X9	0.0330644	X2	0.0500960	X4	0.0496889	X4	0.0245902	X5	0.0227066
13.	X8	0.0457298	X17	0.0327480	X3	0.0491776	X5	0.0468933	X11	0.0172563	X18	0.0199818
14.	X17	0.0457298	X12	0.0316406	X4	0.0491776	X9	0.0462621	X9	0.0163934	X7	0.0199818
15.	X13	0.0455490	X13	0.0299003	X5	0.0484262	X14	0.0454504	X21	0.0163934	X19	0.0199818
16.	X22	0.0436512	X18	0.0243632	X12	0.0467563	X12	0.0450897	X7	0.0142364	X11	0.0181653
17.	X12	0.0397650	X14	0.0227812	X14	0.0450864	X21	0.0445487	X6	0.0142364	X21	0.0172570
18.	X18	0.0397650	X19	0.0174023	X9	0.0444185	X3	0.0257011	X5	0.0129422	X22	0.0156676
19.	X14	0.0390420	X11	0.0158203	X21	0.0317275	X2	0.0198395	X8	0.0047455	X2	0.0136240
20.	X9	0.0377768	X21	0.0150293	X19	0.0091843	X19	0.0099197	X19	0.0047455	X6	0.0099909
21.	X11	0.0090375	X22	0.0145547	X11	0.0083493	X6	0.0099197	X2	0.0043141	X8	0.0099909
22.	X6	0.0039765	X6	0.0104414	X6	0.0073474	X11	0.0072144	X3	0.0040984	X3	0.0043143

Figures

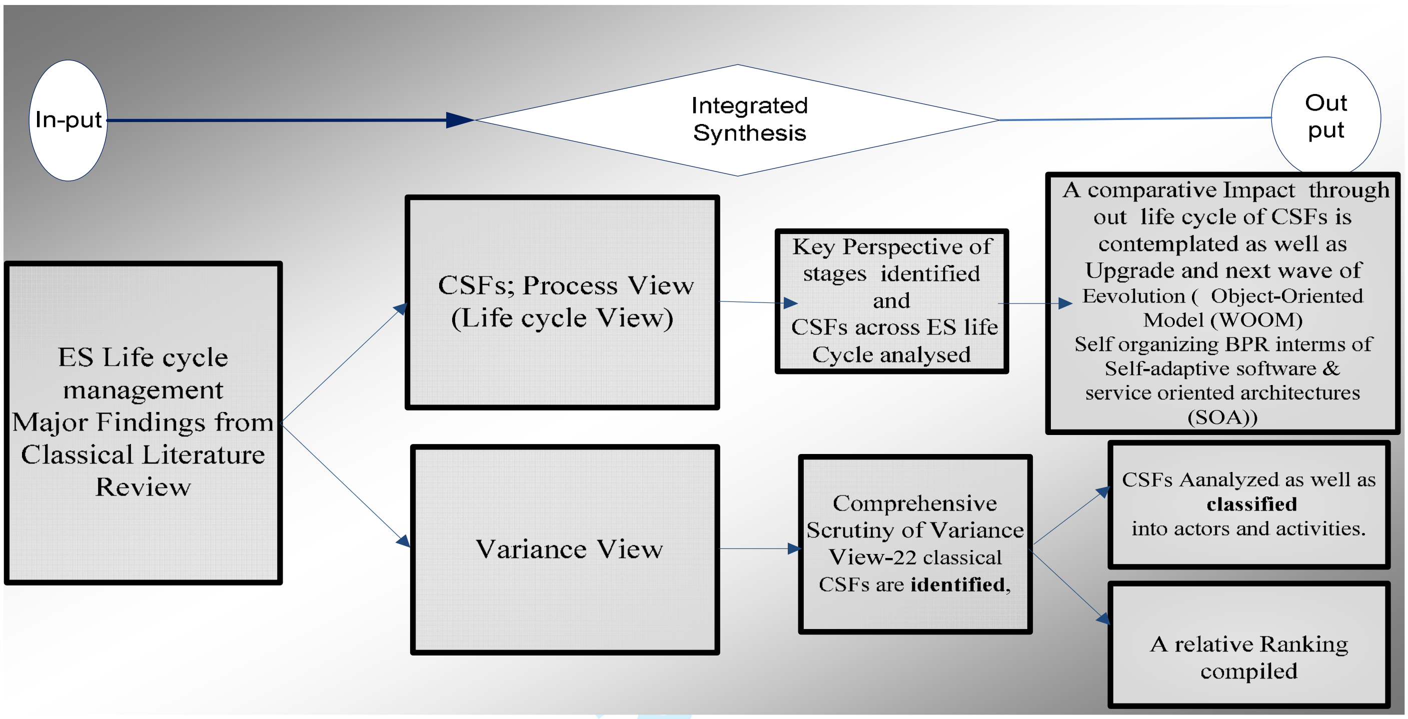


Figure 1: *Structured Framework for ES Lifecycle Integrated Analysis*

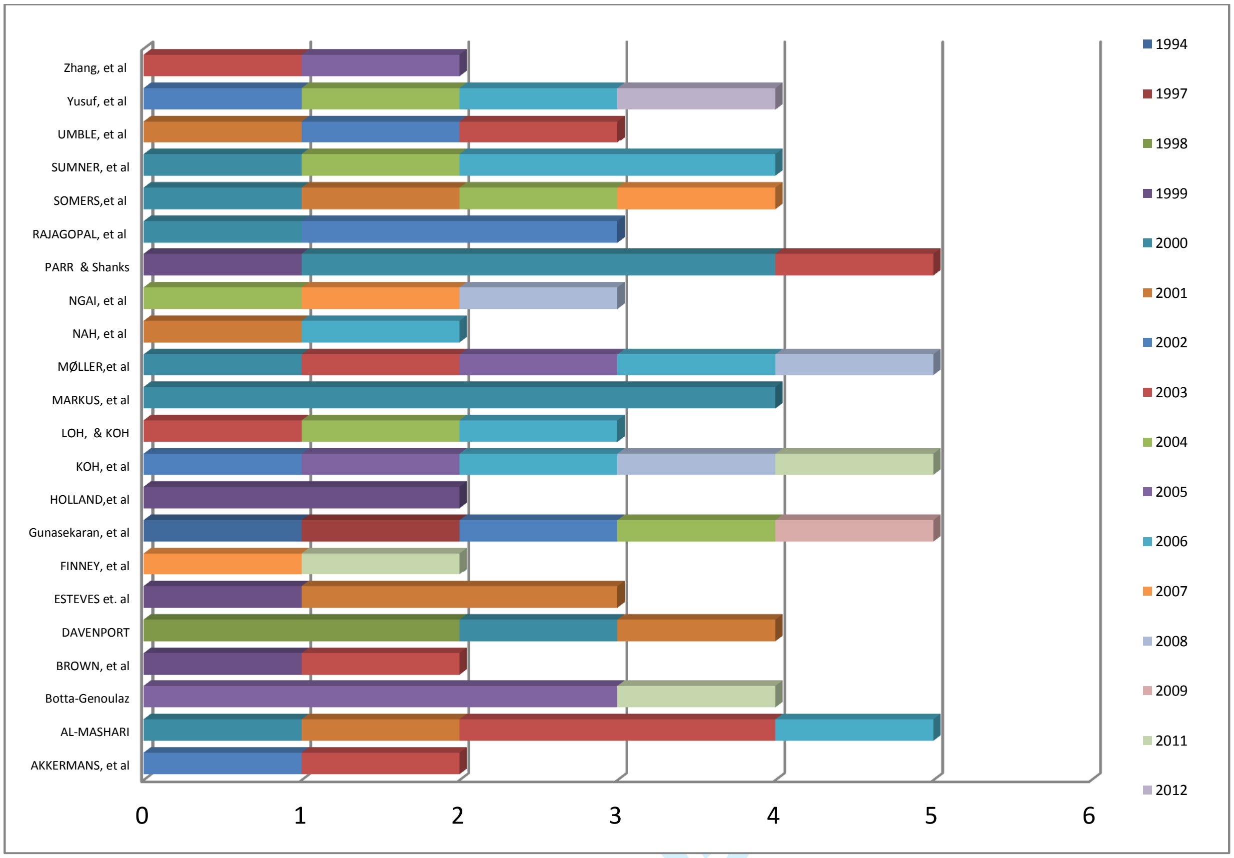
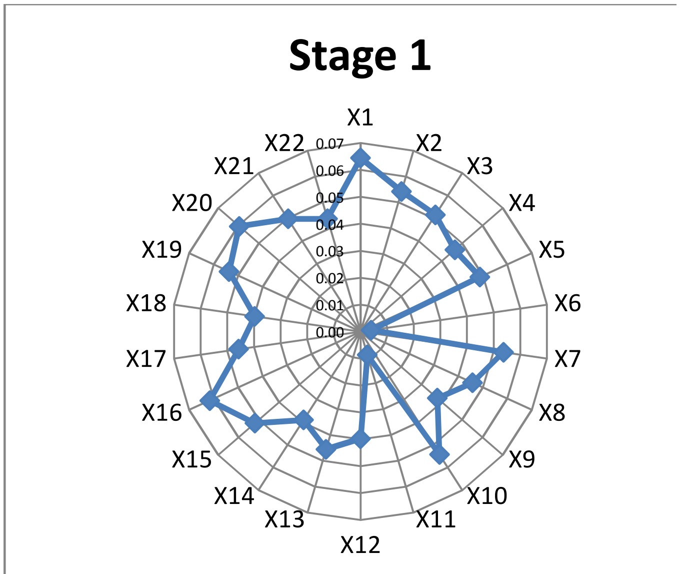
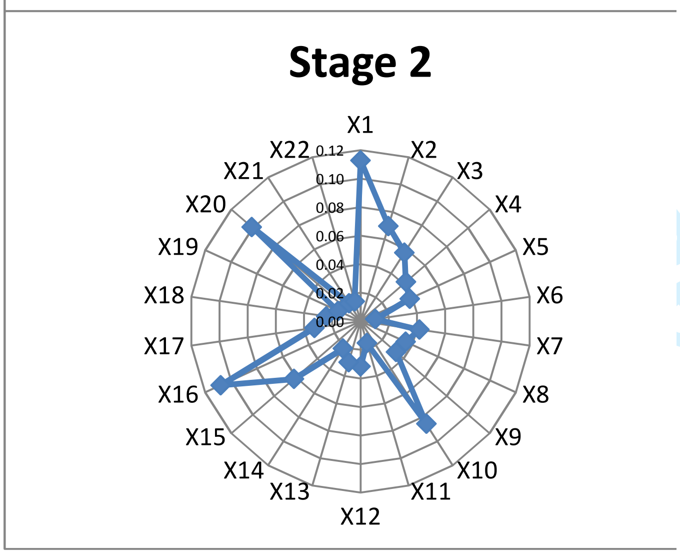
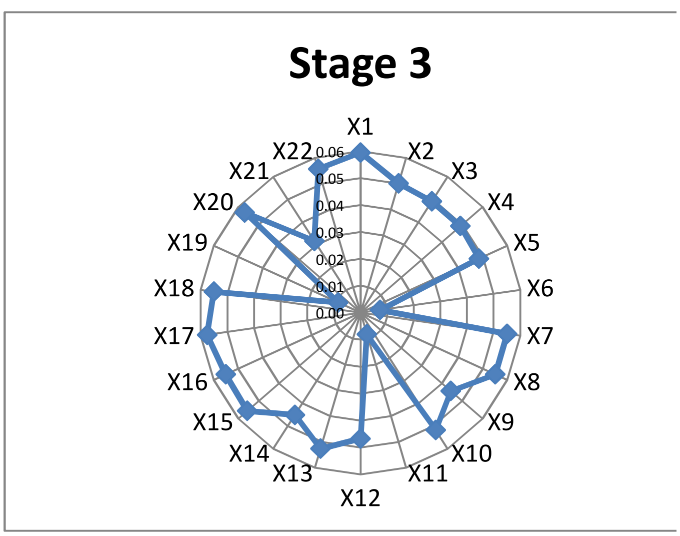
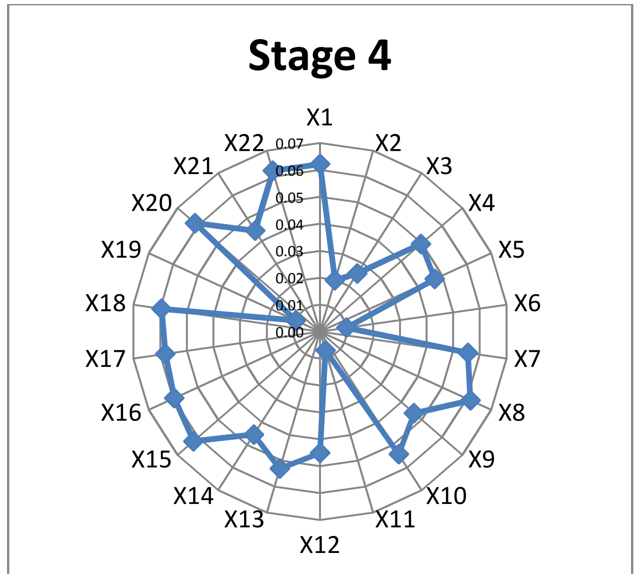


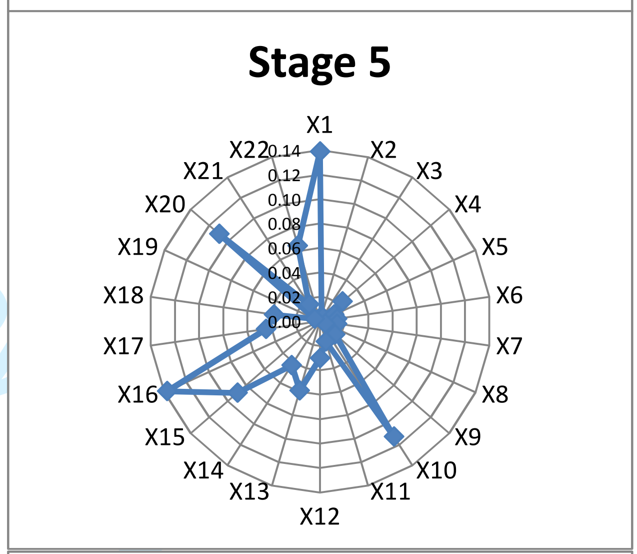
***Figure-2* (Colour):** *Yearly-Contribution to the, State-Of-Knowledge by 22-Consulting Authors*


Stage 1
X1
X2
X3
X4
X5
X6
X7
X8
X9
X10
X11
X12
X13
X14
X15
X16
X17
X18
X19
X20
X21
X22
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00


Stage 2
X1
X2
X3
X4
X5
X6
X7
X8
X9
X10
X11
X12
X13
X14
X15
X16
X17
X18
X19
X20
X21
X22
0.12
0.10
0.08
0.06
0.04
0.02
0.00


Stage 3
X1
X2
X3
X4
X5
X6
X7
X8
X9
X10
X11
X12
X13
X14
X15
X16
X17
X18
X19
X20
X21
X22
0.06
0.05
0.04
0.03
0.02
0.01
0.00


Stage 4
X1
X2
X3
X4
X5
X6
X7
X8
X9
X10
X11
X12
X13
X14
X15
X16
X17
X18
X19
X20
X21
X22
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00


Stage 5
X1
X2
X3
X4
X5
X6
X7
X8
X9
X10
X11
X12
X13
X14
X15
X16
X17
X18
X19
X20
X21
X22
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00

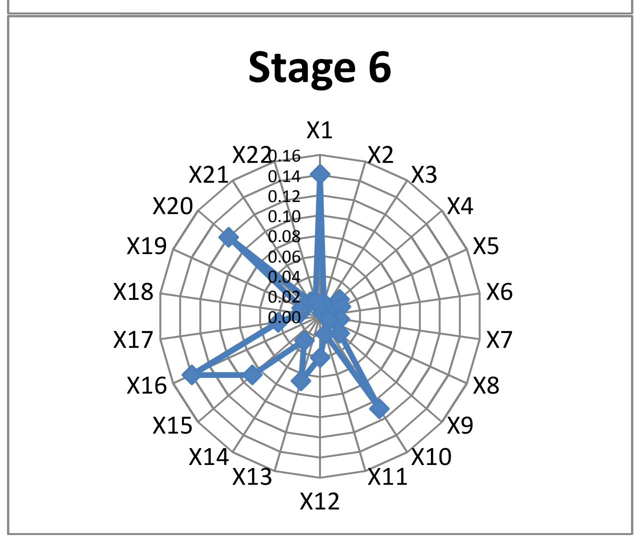
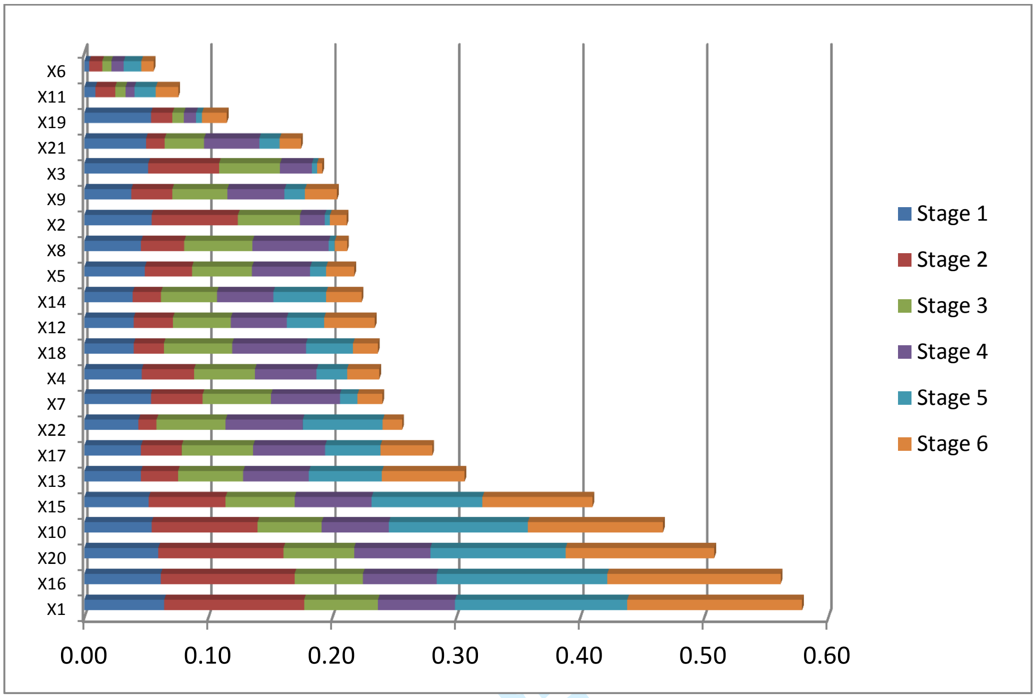

Stage 6
X1
X2
X3
X4
X5
X6
X7
X8
X9
X10
X11
X12
X13
X14
X15
X16
X17
X18
X19
X20
X21
X22
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00

Figure-3: Importance of CSFs ***Actors-Activities*** *Across Lifecycle of Technovation*



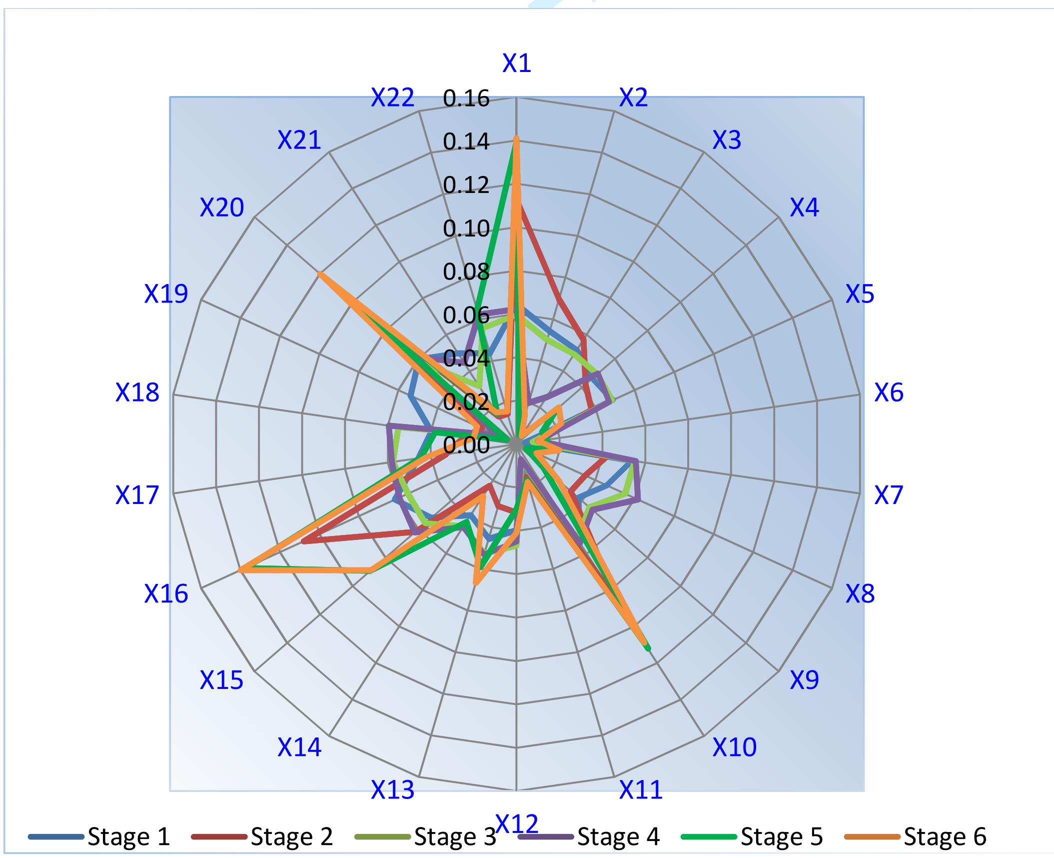


Figure-4: *Importance of CSFs across lifecycle of Technovation (Unified Perspectives)*
Legend: Top portion presents CSFs sorted as per cumulative importance across lifecycle, whereas bottom portion canvasses CSFs (sorted alphanumerically depicting stage-wise importance across full lifecycle)

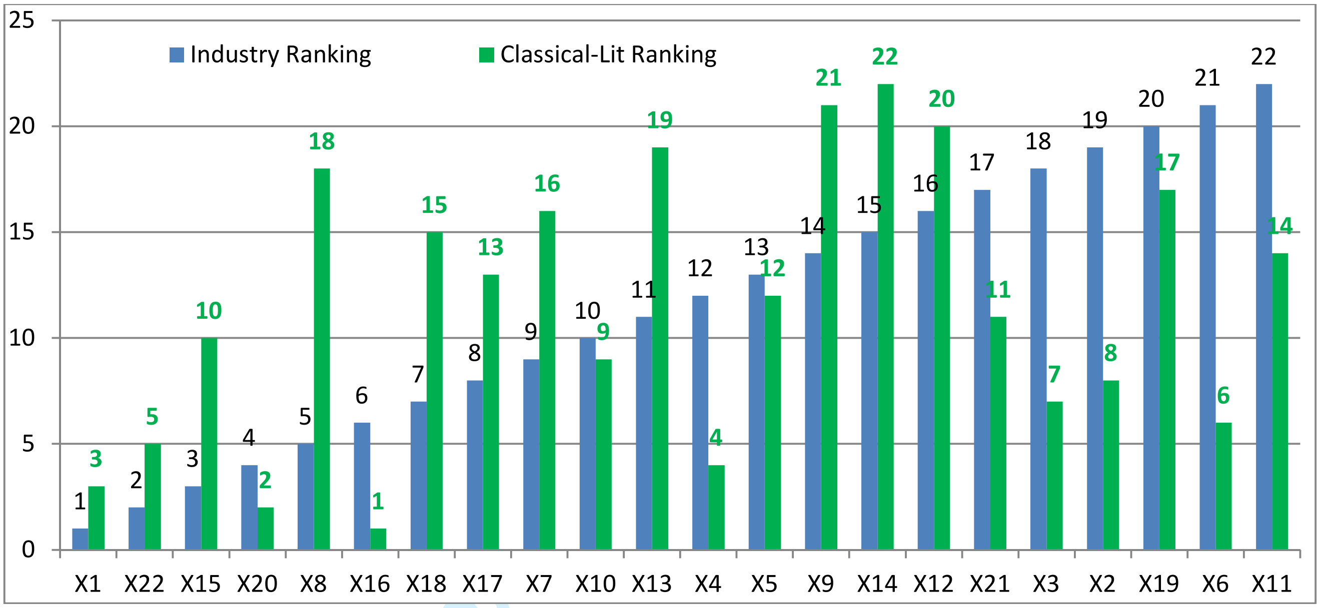


Figure-5(Colour): **Stage 4-Comparative Ranking of Top 15 CSFs Industry VS Classical-CSFs**

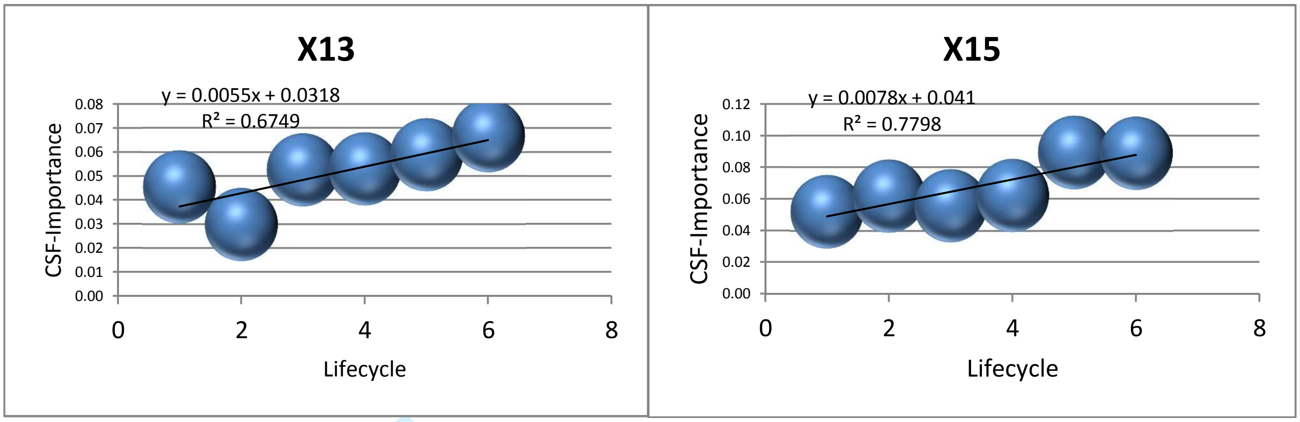


Figure 6: **CSF X15-X13-Vendors Importance and Alliances across Lifecycle**

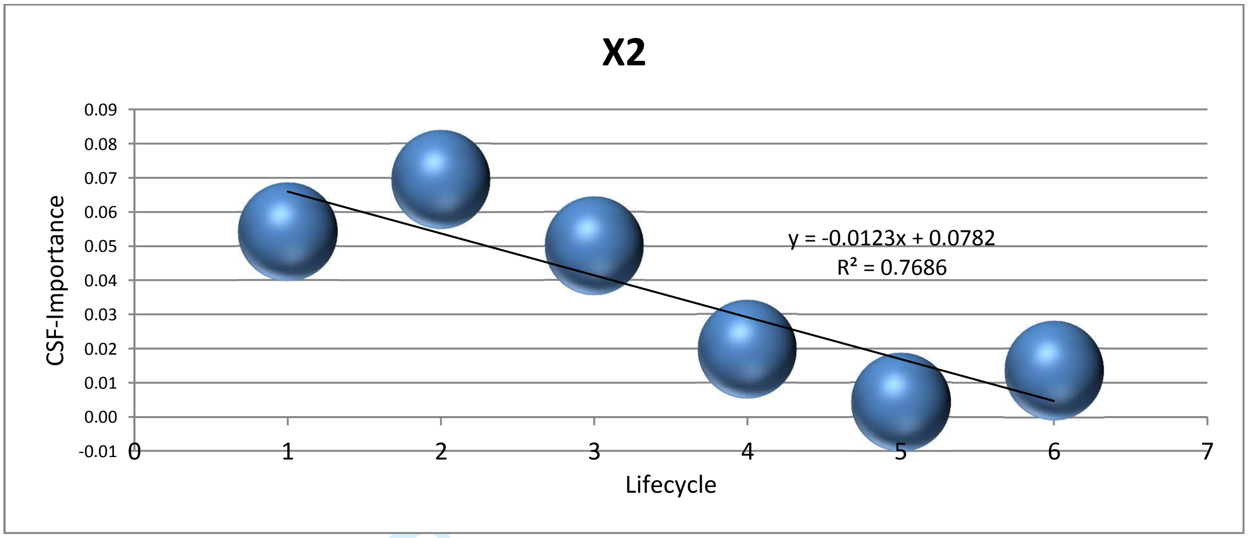


Figure-7: X2-Importnce across Lifecycle (Careful selection for functional fit)

Annexure A

Questionnaire Instrument: Enterprise System (ES) Success

[(ERP)/ MRP / Asset Management Industry Specific (MRO /IT -Package /COTS)]

This research is being conducted by the NUST, College of E&ME in collaboration with Cranfield University, UK, for Aircraft Industry Manufacturing Impediments and knowledge gaps, by synthesizing, Enterprise Systems, information integration, and Success factors across whole lifecycle. The purpose of the survey is to contribute towards a clearer picture of the information modeling and Enterprise systems to ascertain how the critical success factors change over implementation lifecycle of an IT-project (termed as technovation) in pursuit of Excellence (Industry-4.0). It is realized that those working within the industry provide a unique and valuable view of what is actually happening. Because of your association with aircraft industry, your meaningful feedback is solicited for research and analysis.

Name : ________________________ ;Age : _________________________;Industry Experience :_____________

Email:_____________________________

Department / Specialty:	□ Aircraft Group; □ Engine Group; □ Avionics Group; □ Quality; □ Aircraft Logistics ; □ Others / Factory Support Units

There are two questions to be answered (Q1: The degree of importance) and (Q2: Stages of ES Project in which factor was important).

Please read the six descriptions of IT success / implementation phases before answering Q2

1. Initiation	ES Problem realization for growth; search for good match; an ES with attractive functionality-fit found, for organizational sustainable operations
2. Adoption	A decision or consensus is reached to pursue and **Planning** for IT-project: Vision communication for Business Process Reengineering (BPR) then Funding/ getting resources to adopt Package.
3. Adaption	IT-package is installed and becomes available to HR: Transition stage: Planning and customizing for organizational fit and Change Management and Master Data Management(MDM) /new BPR
4. Acceptance	Organizational members employ IT package in organizational work: Change Management: Deploying sand box based -new BPR/eliminating bugs
5. Routinization	IT- package is no longer perceived as something out of ordinary: Bugs fixed actual planned vision achieved for optimum info and productivity-Management of Expectations
6. Infusion/ onward upgrade	IT-package is used optimally for sustainable operations and upgrade is suggested due to environmental PEST influences for organizational growth as per latest ES-technology

Q1: What was the degree of importance of each Factor in your **Enterprise System (ES) implementation project** (please circle the proper response)

Q2: At which Stage(s) of ES/ERP project was each factor important (please check all that apply)

	Q1:							
S. NO	Factor Constructs	**Low**	**Moderate High**	**Very High**		**Critical**	N/A or Don't know(DK)
1	**X1; ES-implementation, through clear Business-Vision for production-excellence, across the organization, for specific deliverables,** and objectives based on virtues of Business Model:	**1**	2	3	**4**	**5**	N/ A
2	**X2 ……..** **……Xn**	**1**	2	3	**4**	**5**	N/ A

Q2:					
Initiation	Adoption	Adaption	Acceptance	Routinization	Infusion/ onward
□	□	□	□	□	□
□	□	□	□	□	□

CSFs Constructs- brief summary was presented to experts as per Table-3, to rank the classical-CSF. (From X1 to X22