# Predicting, Prioritizing & Planning Enterprise System's CSFs for Smart Factory: A Balanced Scorecard FPG-Data-Mining Scenario Approach.

Asif Rashid
Dept of Engineering Management National University of Sciences & Technology (NUST) Pakistan

Zainab Riaz
NBS, (NUST) Pakistan

Muiz-ud-Din Shami,
PAC Pakistan

Nawar Khan
NUST EM&E, DEM, (NUST) Pakistan

## ABSTRACT
The research proposes a planning scenario of critical success factors (CSFs) "conceptual-framework" for enterprise systems (ES) of Smart aircraft factory. Application of knowledge discovery and classification algorithms is applied to draw probabilistic inferences based on FP-Growth-algorithm blended with a novel approach based on "balanced scorecard (BSC) architecture".

## General Terms

**ERP**= Enterprise resource planning; An enterprise system for information and resource management so as to optimize sustainable operations based on smart factory scenario planning[1], [2].
**BSC** = Balanced Scorecard.
**CIM & PLM** = Computer integrated manufacturing & Product life cycle management.
**BoB**= Best of Breed.
**B2B, B2C, B2E & EAI=** Stands for business to business, business to costumer, business to employee & enterprise application integration, respectively.
**Smart Aircraft Factory** = A reconfigurable factory designed through Scenario-Planning [1], [2]as per European union vision [3] to cater for any predictable & plausible set of uncertainties. The **business logic of manufacturing-excellence** and its objectives are derived through CIM-philosophy by integration of concepts like; Lean six sigma, Flexible Automation, smart ICT, Nanotechnologies, Cloud computing, SAS and Green technologies for Sustainable-growth. The operations at smart factory are based on integrated information with Intelligent & Networked Machines (synergizing miniaturized design & low-energy consumption) for B2B-B2C-B2E through BoB-EAI of smart sensors and smart devices for optimum "human computer interaction" and knowledge diffusion (K-commerce & diffusion of innovation).

## Keywords
Enterprise systems, ES /ERP, Critical success factors, Smart Aircraft Factory, FPG (conditional probability), BSC, DOI.

## 1. INTRODUCTION & PROBLEM STATEMENT

Global-economy is confronted with distressing escalation, hence, entailing resource-conservation and resources optimization through total quality management (TQM) based lean six sigma and KIAZEN techniques [4]. Contextual to same, the part of the solution could be gaining competitive advantage for excellence & optimum-production through ICT and enterprise systems. The computer integrated manufacturing (CIM) solution, for instance PLM and enterprise resource planning (ERP) could be ranked as most imperative in this regard. The enterprise resource planning (ERP) is of paramount importance for collateral management of complex operations in aircraft industry. As per European union vision 2020; sustainable growth necessitates manufacturing excellence for factories of future[3]. In a smart aircraft factory hence ERP modules are considered vital for optimum resource management and effective control over the industrial and financial activities through integrated business intelligence ((BI) software. This paper elucidates balanced planning aspects for ERP and prediction of frequent patterns utilizing FPG algorithm for prioritizing & planning ES/ERP's Critical Success Factors (CSFs) for aircraft-industry.

## 2. METHODOLOGY AND DESIGN

The paper proposes a literature based survey for planning a scenario for smart factory of enterprise system's CSFs. The paper then introduces BSC based data mining FPG algorithm to predict prioritize & plan; frequent patterns for enterprise system's Critical Success Factors. The contribution of this research is multifold, as compared to previous research. First, it proposes a planning Scenario based on balanced-scorecard (BSC) approach. Then it proposes a socio-technical solution based on employment of "BSC-frequent pattern mining" FPG algorithm to predict CSFs road-map for quick diffusion of enterprise systems knowledge areas. The prediction and prioritization by FPG algorithm of BSC dimensions are synthesized for planning operations of smart factory based on vision driven CSFs.

## 3. CONTEXT OF SMART FACTORY SCENARIO IN THIS RESEARCH

As per researcher, [5] "In 1991, Mark Weiser described the vision of a future world under the name of Ubiquitous Computing. Since then, many details of the described vision have become reality". The various institutes at Fraunhofer industrial automation are concurrently involved in a multi disciplinary endeavor to develop solutions for smart factory in terms of Grid-computing [6], for instance; Cloud computing , UML modeling and so on. The partners for smart factory are; SAP, Siemens PLM, DFKI, BASF etc. The enterprise solution by SAP, Siemens PLM and others are merged at research Test bed of SmartFactory$^{KL}$ in pursuit of BoB modular architecture for intelligent manufacturing utilizing ERP, PLM, MES (information integration of Smart devices from enterprise level to shop floor level). Hence it is appropriate to infer as per European vision of 2020 [3] that a smart factory is a reconfigurable factory under demand uncertainty so as to sustain operations. As per this research "smart factory ERP scenario planning" [1], [2] is visualized and seen as a societal system of intelligent & networked machines with smart sensors, miniaturized for low-power consumption thus ensuring go-green and clean operations. Additionally, intelligent machines, smart sensor (programmable logic controllers-PLCs), smart communication devices, production-plans and humans are networked through miniaturized devices or smart hand-held digital devices for optimum operations management. The strategic operations-management philosophy is manifested by CIM-wheel [7] powered by miniaturized computer hardware sensors and software system with E-commerce (B2B,B2C, B2E & EAI) functionality to manage, coordinate, control and e-synchronize the operations, resources, information, as well as per Business-Models[8, 9].

# 4 PLANNING FOR SMART FACTORY'S ERP

The manufacturing operations at aircraft industry are highly perplexed with hundreds of concurrent activities being accumulated in queue to trigger the production cycle. The prevailing automation architecture of today is the spin-off of US Air Force's (USAF) ICAM project(integrated computer aided manufacturing)[10] which dates back to 1960s. Which resulted into inventions of MRP-I/ MRPII and subsequently gave birth to CIM-philosophy which ultimately transpired as two collaborating domains, the ERP and product life cycle management (PLM). While few researchers still considers them having conflicting functional-logics yet positivist researchers have endeavored to merge PLM to ERP for immense collateral competitive advantage. The first CIM–wheel introduced in 1985 by Computer Automated Systems Association (CASA) provided a holistic framework for planning and automation in manufacturing industry[7]. Based on themes radiated by ICAM-project/CASA-wheel the term ERP is used interchangeably for Enterprise systems (ES) and Enterprise resource planning (ERP). Conversely the term CIM is a used as a manufacturing philosophy based on TQM and also as an umbrella to highlight the **business logic of manufacturing-excellence** at an aircraft factory. The CIM-logic is embedded to PLM-suites and ERP-suites e.g. Siemens-SAP collaborative-business-suites provide integration of both concepts through middle-ware technology.

ERP-suite at an Aircraft Smart factory is a corporate wide philosophy for collateral management of operations. ERP-business logic could be embedded to BoB practices utilizing QFD [11]. The design of ERP is unified and presented and seen as visualized and articulated based on ERP-II artifacts as proposed by researcher [12]. The ERP II is an extension of ERP, with four layered artifacts, namely; Foundation, Process, Analytical and portal. The details about artifacts of ERP-II are skipped since covered in depth by [12]. The architecture of the ERP is designed as a single authoritative and unified data-base augmented by data-warehouse functionalities. Most often the ERP software has a service-oriented architecture (SAS) with modular hardware and software "services". The modular design is the backbone of ERP ensuring flexibility for future growth, business add-ons or to reconfigure modules. The dynamic changes in societal-systems asks for reengineering the business-processes which iterates coupling the different vendor's ERP-modules supportability and integration with legacy-applications through middle-ware tools (EAI)[2]. The business intelligence module (BI) synergizes the business through data-mining (DM) frequent patterns [13, 14] and rules-based scenarios[15]. The ERP is the COTS (computer off the shelf software) with best of breed (BoB) business logic embedded into them through experience of last thirty years of implementation across the globe[16, 17]. ERP modules and functional aspects can be customized based on the enterprise own preference of business logic but is not usually recommended by the consultants. Yet almost in every scenario these COTS require little or extensive customization often resulting, into sub-optimized performance. Deriving the performance and resource management requires the trade off and logic of balance between responsiveness, flexibility and standardization. This indeed is planned and embedded as per the firm's business-vision, since ERP is just a facilitator with enormous potential; to serve global society for hyper-efficient resource management, economical-growth, sustainable development and building knowledge based economy. Researcher Majid Almashari [18] remarked that, in short term perspective an organization could, confirm final success of implementation of ERP, but the real business value may not be quickly realized. The realization of a lasting commitment has been rethought by many organizations in light of costly and time-consuming upgrade process to R/3. (SAP) from R/2 system version. These organizations have faced perplexed instances of ERP-suboptimal performance during customization and its associated high costs and implementation problems. Such scenarios are forcing many early adopter organizations to rethink their plans for acquiring and implementing such enterprise systems (ES) to reap long term benefits along the life cycle of organization and enterprise-systems (ERP) itself. To address perplexed life cycle issues this paper proposes a planning scenario as foresighted by researcher[2]for ES in pursuit of competitive advantage for aircraft industry. The ES customization needs complete scrutiny at all functional levels for programming or reprogramming the modules and ERP-business logic. The term "planning" in this research is used to portray planning enterprise resource planning systems during selection, implementation or replacement phase along life cycle which could also be extended and could also mean diffusion of ERP technology to social system. Hence planning during all such conflicting-scenarios [2]requires integrative approach for effectiveness of objectives. The focus of this research would be on Planning ES based on CSFs for smart factory as well as ERP diffusion.

# 5 CIM & E-COMMERCE FOR AIRCRAFT INDUSTRY CLUSTER

The business models [8, 9] deliberate upon E-commerce value proposition and optimum revenue generation for any business and aircraft manufacturing industry is no exception. The new era of web-ERP has enhanced the working efficiency as well as effectiveness of Aircraft manufacturing industry. The supply chain management (SCM) is considered a vital critical success factor [19] for Canadian aviation cluster [20] thus ensuring optimum supply of bills of materials during MRP production run [21]. These SCM activities for business to business (B2B) and B2C are managed through various modules of ERP system for instance APO (advanced planning optimization) and Production planning [22]. In aircraft industry complexity of shop floor is due to ten of hundreds of activities which run in parallel for collateral management of operations[23, 24] and stringent quality-standards reiterate the need of computer integrated manufacturing (CIM) philosophy and JIT philosophy.

# 6 COMPUTER INTEGRATED MANUFACTURING (CIM)

Disruptive technologies have reshaped the business of global village [25] .The dynamics of societal system has revolutionized stone–age to industrial-age and then its transformation to service sector has brought mutation and the way the business were run in 1900, 1960 and today [26]. As per researcher[27], Computer integrated manufacturing has received growing acceptance from both industries and academia alike". Researcher stressed that there are still wide-spread concerns about the true impacts on the actual performance of the companies implementing CIM. Especially the overall coherence of the entire system has been considered as a key issue articulating the integration of technology, people and business from the viewpoint of a global system. Researcher [28] has argued that, "Though the application of enterprise resource planning (ERP) systems has become widespread, many organizational experiences have shown that resulting outcomes fall short of expectations. Best-practice experiences, however, have proven that effective application is centered on an integrative approach that seeks to achieve a balance between certain key organizational elements". Researcher [27, 29, 30] has argued and conducted case studies to provide a solution to existing enormous ERP alignment-challenges. This research would make an effort for ES alignment and planning issues based on balanced scorecard (BSC)-stratagem.

**Table 1: ES-framework based on CIM-implementation**

| | | |
|---|---|---|
| Strategic level aspects | Original | Alignment between business and manufacturing strategies |
| | Proposed Additives | Balanced Scorecard aspects, Financial aspect via gain sharing, Vision-mission and planning, alignment via TQM-philosophy. A reconfigurable factory under demand uncertainty. |
| Organizational | Original | Structure, Communication |
| | Proposed Additives | Learning Organization & knowledge management along BSC dimension for sustainable growth. |
| Behavioral | Original | Leadership, Teamwork, Incentives, Motivation, Empowerment, Concurrency, Collaboration, Agility, flexibility |
| | Proposed Additives | Collaborative leadership, human centric approach for smart factory. |
| Technological | Original | Knowledge bases, Groupware Networking, Communication Systems, and Databases. |
| | Proposed Additives | Aircraft cluster & social system for CIM & E-commerce |
| Operational | Original | Design, Engineering, Production planning and control system, Accounting |
| | Proposed Additives | Balanced approach based on CSFs along BSC dimensions. |

# 7 SMART FACTORY & BALANCED SCORE CARD (BSC)

The researcher [29] proposed a comprehensive framework elucidating importance of strategic objectives and integrating various elements for ES implementation in a CIM perspective. The domain of framework spanned over strategic, Organizational, Behavioral, Technological and Operational perspectives. Each domain and its enhanced smart factory perspective are elaborated in **Table 1.** This research would utilize Balanced Scorecard as a strategic control tool to translate business-vision into four balanced areas for measuring performance of the defined goals and targets. As per [31] Balanced Scorecard is a concept that translates business-vision to formulate a balanced strategy and set of performance measures.

While most of the past research used BSC for performance measurement purposes only yet it is innovative enough based to set up its conceptual mapping for planning ERP system. The researcher [18] suggested balanced approach during evolution phase of ERP. Chand [32] suggested its usage for process evolution as per system thinking, the researcher evolved a system of system for balanced scorecard based framework to assess the strategic impacts of ERP systems. Contextually the framework at **table-1** is transformed into balanced set of scorecards, which is a much familiar approach for Business community. This research has proposed certain improvements,

**Table 2: Value chain logic for ERP framework based on BSC. Adopted from [27].**

| ERP-CIM Success factors | BSC Factors for ES CSFs | | | | |
|---|---|---|---|---|---|
| | Strategic Aspect (a) | Financial Aspect (b) | Customer Aspect (c) | Business processes (d) | Learning & Sustainable Growth (e) |
| Strategic | Y | Y | | | |
| Organizational | | | Y | | |
| Behavioral | | | Y | | |
| Technological | | | | Y | |
| Operational | | | | Y | |
| Knowledge management (Learning & sustainable Growth) | | | | | Y |

and then mapped previous framework [29] along BSC dimensions as per stratagem shown in **Table-1& 2**. Contextually, the proposed balanced scorecard (BSC) framework is elucidated in **figure-1**. A conceptual model has been fabricated to map the key issues of planning along ERP BSC dimensions for a smart aircraft factory.

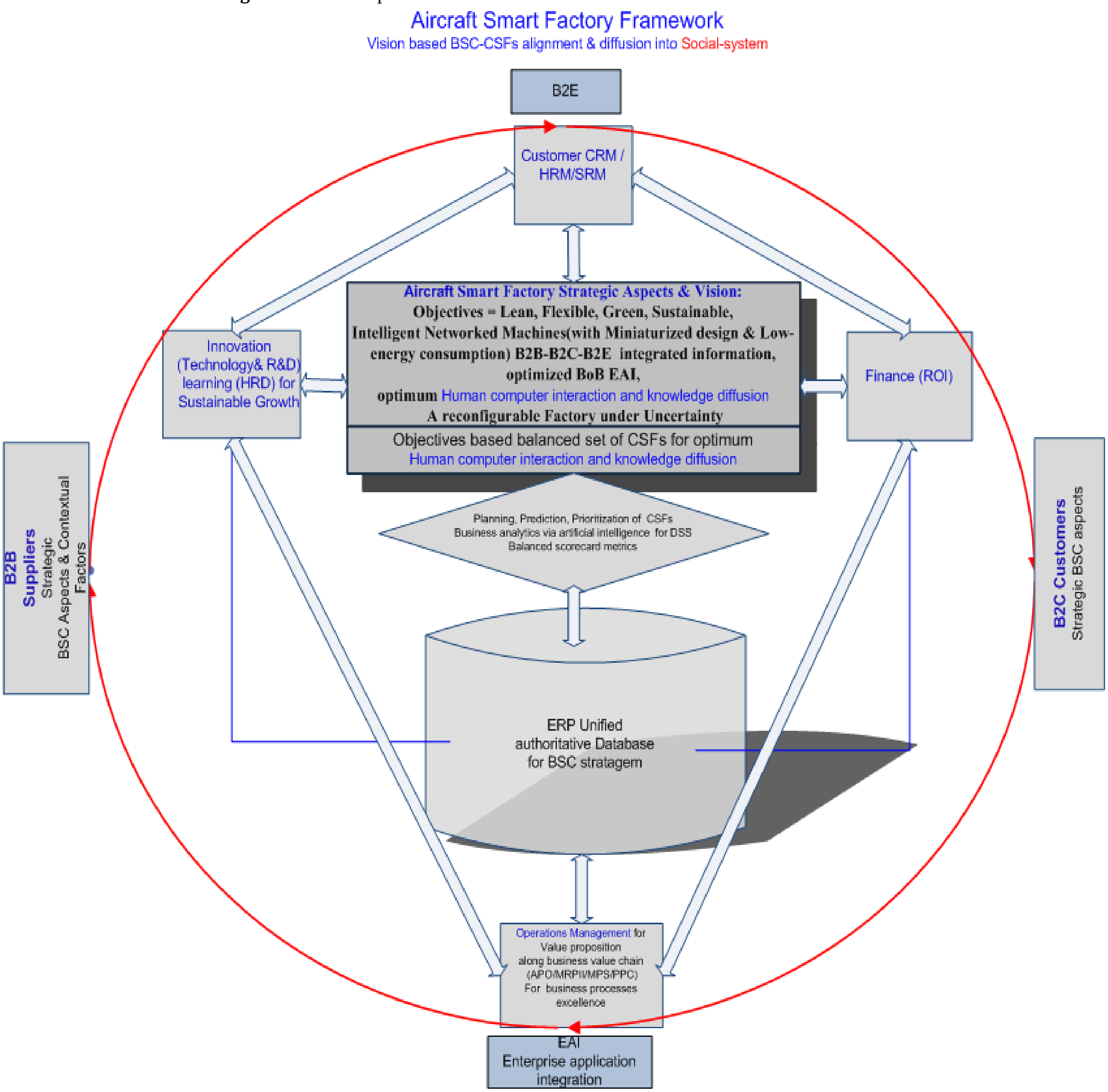


**Figure 1: Aircraft Smart Factory ERP-framework based on Vision driven BSC-CSFs. Alignment & Diffusion**

## 8. CSF DEFINITION & LITERATURE BASED BSC-CSFs & ITS PREDICTION FOR SMART FACTORY.

Researcher [33] defined Critical Success factors as**,** "The limited number of areas whose results, if satisfactory, will ensure successful competitive performance for the organization. They are the few key areas where things must go right for the business to flourish. If results in these areas are not adequate, the organization's efforts for the period will be less than desired." Researcher [33] explained: CSFs as "areas of activity that should receive constant and careful attention from management.". Researcher [34] observed that "Critical Success Factors are the limited number of areas that will ensure successful competitive performance for the organization. Critical success factors are applied within the context of business objectives". As per researcher [35] the ERP implementation concerns all aspects of implementation including developing the initial business case and planning the project, configuring and implanting the packaged software, and subsequent improvement to business processes. Critical success factors have been defined by [35] as "those few critical areas where things must go right for the business to flourish".

Contextually a data set of critical success factors was formulated through classical literature review (most relevant or most cited research papers). These factors were considered as transactions for mapping along BSC dimensions as shown in **Table 3**. Conversely knowledge discovery algorithms were critically analysed and selected to identify and predict frequent patterns as well as synthesis for scenario planning in a smart factory in pursuit of excellence.

## 8.1. Application of FP-Growth for Vital frequent pattern Prediction & Prioritization.

The FP-growth algorithm is one of the fastest means to fetch and mine frequent transactions "item set" [14]. It administers and eradicates "multiple scans of transaction database". It thus divides and conquers general conception of Apriori for the massive candidate's workload and support counting. A case for vital artifacts was explored for Vital-ERP CSFs.

**Table 3: FP growth data sets; frequent datasets for exhaustive ERP-CSFs along five BSC dimensions.**

Legend : Al Mashari [18], Elisabeth [17], Moller [12], Markus [2], Ngai [36] & Somers [37].

| **Classical literature based Researcher's Transactions.** | **Strategic Aspects (a)** | **Financial Aspect (b)** | **Customer Aspect (c)** | **Business processes (d)** | **Learning & Sustainable Growth (e )** |
|---|---|---|---|---|---|
| **T1.** Al Mashari | **Y** | **Y** | **Y** | **Y** | **Y** |
| **T2.** Elisabeth | **Y** | **Y** | **Y** | **Y** | **Y** |
| **T3.** Moller | **Y** | **Y** | **Y** | **Y** | |
| **T4.** Markus | **Y** | **Y** | **Y** | **Y** | |
| **T5.** Ngai | **Y** | **Y** | **Y** | **Y** | **Y** |
| **T6.** Somers | **Y** | | | **Y** | **Y** |

The Data-set was considered that contained a six by five matrix (six researcher's transactions for vital variables and its mapping along balanced scorecard dimensions.) The minimum support considered was 30%. The FP growth algorithm[8] was deployed for mining and to predict / prioritize all possible scenarios (frequent pattern) for vital artifacts of ERP-design considerations.

**Algorithm:** FP-growth*: Version 4.18 by researcher* [14] *was utilized for mining frequent patterns*
**Input**: An ERP critical success factors dataset (table-3) developed during literature survey, and a minimum support threshold *ξ (30%)*.
**Output**: The complete set of frequent pattern set (table 4).
**Method**: Call FP-growth *Version 4.18 by researcher* [14]

## 8.2 FP-Growth Results Assumptions & Limitations.

While more refined iterations and selection would have fetched interesting patterns, however, for ease of understanding only six transactions were considered. Since the focus was to indicate the viability and potential of FP-growth algorithm to explore frequent pattern-set for ERP vital artifacts necessary for design consideration and exhaustive CSFs. The resultant conditional probability for frequent item set of Enterprise systems CSFs are shown in **Table 4.**

## 9. CSFs ANALYSIS & FINDINGS

As per researcher, [5] , "A large portion of the problems in smart factory have their origin in the planning methods commonly used today, which are closely associated with hardware factors. As a rule, today's planning procedures normally start with an initial, top-down rough planning in which the structures, components and production methods and parameters of the product are defined. Thereafter, the bottom-up detailed planning begins, in which the required machine parts and components are selected and engineered; wiring schemes planned in detail, and finally, the control hardware and software is developed. Today there are many advanced CAX systems used for this. With CAD, for example, STEP models can import and integrate mechanical data; CAE tools for SCADA development like PCS7/WinCC (Siemens) facilitate the design of control software, and visualization (or simulation) tools allow for the simulation of the entire plant already in early design planning

**Table 4**: **FP growth data sets output; frequent datasets for exhaustive scenario-planning of ERP (Five vital Dimensions); Researcher Transactions selected (T1, T2, T3, T4, T5 & T6)**

| Researcher item-IDs vital variables | BSC Variables set | Support-count |
|---|---|---|
| a | **Strategic Aspects** | 4 |
| e | **Learning & Sustainable Growth** | 4 |
| d | **Business processes** | |
| c | **Customer Aspects** | 4 |
| b | **Financial Aspects** | 1 |

| FPG: Frequent Patterns of BSC based critical success factors |
|---|
| **Conditional-probability- for ERP CSFs With 30% support count**<br>**ade (16.7)**<br>**abcd (33.3)**<br>**abcde (50.0)** |
| (Algorithm Time to predict =0.03 Seconds **)**<br>**Input file : (abcde, abcde, abcd, abcd, abcde, ade)** |

stages. Unfortunately, these systems often lack adequate data integration: Although they are internally model-based, the models are often incompatible with one another. It is precisely this model-based integration that takes on increased significance in the lean planning process of the future. Here, solutions are most urgently needed to create an improved planning situation." The aircraft industry faces intense turbulence during ERP-framework-design for information integration. The factories of future and knowledge factory strive for smart-objectives and hyper efficient operations. The effectiveness of objectives efficiency of operations could render high productivity[25] for smart factory vision [5]. While enterprises like Airbus, Boeing, Lockheed Martin, Dassault aviation (France) utilize state of art ES/ ERP (SAP-mySAP/ IBM-Asset-management systems) for Operations Management. However the delivery expectations from these systems are still far less than expectations. The dream realization for smart factories could be achieved as an output of planning holistic with a systems thinking in mind. Based on same theme it is proposed that a "one for All-All for one" Information-integration and planning for enterprise Systems could emerge as only viable option. In the same perspective CSFs based balanced scorecard (BSC) perspective provides a quick and holistic solution. The CSFs along enterprise BSC artifacts can earn a double sword effect. The information integration and beyond that the-balanced and holistic knowledge management through artificial intelligence reasoning, business intelligence coupled with data-mining capabilities. The ES successful implementation along BSC dimension iterates deployment of FPG so as to predict &prioritize future frequent patterns through CSFs-approach. The FPG algorithm predicted that literature based CSF in the dimension of BSC are about 50% , where as 33.3 % literature predicts CSFs along Strategic Aspect (a) ,Financial Aspect (b),Customer Aspect (c) Business processes (d). The 16.7% literature supports enterprise Systems CSFs in the dimension of Strategic **aspect** (a), Business processes (d) and Learning & sustainable Growth (e)

## 10. CONCLUSION

ES/ERP Technology has an enormous potential to serve aircraft industry. However, ERP diffusion & implementation failure rate is extremely high. The paper suggested that planning parameters for ERP could be based on balanced set of CSFs. The BSC approach was selected since it is more popular and acceptable to business community. Hence this research provided a holistic and balanced scorecard (BSC) based "ERP planning framework" for aircraft manufacturing industry. This balanced scorecard framework was attenuated with Critical success factors (CSFs) theory for a smart factory. The BSC based employment of CSFs is expected to earn quick fix solution so as to minimize ERP diffusion/deployment-span in terms of time and to inhibit financial overheads. The prediction of balanced CSFs was considered vital for early implementation and quick diffusion of ERP technology. The Paper recommended a data mining FPG algorithm to predict balanced set of ERP CSFs. A short illustration of effectiveness of data mining FPG algorithm was cited by selecting some very vital literature based CSFs. The deployment of data mining FPG algorithm predicted that 83.3% of classical literature, on ERP partially predict and concedes (4-dimensions) and 50% literature fully predict and concedes with the proposed BSC-framework. The CSFs with relevance to **planning, prediction, prioritization** for ERP in the domains of selection, implementation & diffusion can be solicited utilizing FPG-algorithm, based on proposed BSC-framework. The artifacts of "balanced scorecard (BSC) architecture" hence suggest that critical success factors of ERP planning needs to consider five basic dimensions namely Strategic **aspects**, **Customer aspects**. **Business processes and Learning & Sustainable-Growth.**

## 11. REFERENCES

[1] Davis, G., Scenarios as a Tool for the 21st Century, in Probing the Future Conference. 2002: Strathclyde University.

[2] Markus, M.L., D. Petrie, and S. Axline, Bucking the Trends: What the Future May Hold for ERP Packages. Information Systems Frontiers, 2000. **2:2,**: p. 181-193.

[3] European-Union-EFRA, FACTORIES OF THE FUTURE PPP STRATEGIC MULTI-ANNUAL ROADMAP, in 2010: Belgium.

[4] Evans, J.R. and W.M. Lindsay, Management and Control of Quality. Sixth ed. 2005: Thomson.

[5] Zuehlke, D., SmartFactory--Towards a factory-of-things. Annual Reviews in Control, 2010. **34**(1): p. 129-138.

[6] Lucke, D., C. Constantinescu, and E. Westkämper, Smart Factory - A Step towards the Next Generation of Manufacturing, in The 41st CIRP Conference on Manufacturing Systems 2008.

[7] CASA/SME, The New Manufacturing Enterprise Wheel, in BLUE BOOK 1993, CASA SME-Society of Manufacturing Engineers: USA.

[8] Laudon and Traver, E-Commerce: Business, Technology, Society, . Vol. 6/e. 2010: Printice hall.

[9] Straub, D., Business Models, Foundations of Net-Enhanced Organisations. (Weill & Vitale Chapter 8). 2004, USA: NJ: John Wiley and Sons ( Straub, D.).

[10] USAF, A.o.E.C.o.C.-A.M., U.S.A.F.S. Command, and N.R. Council, Technical review of the ICAM Program, June 25-27, 1980: a report to the Air Force Systems Command, U.S. Air Force. 1981: National Academy Press.

[11] Adiano, C. and A.V. Roth, "Beyond the house of quality: dynamic QFD". Benchmarking for Quality, Management & Technology, 1994. **Vol. 1 No. 1**: p. pp. 25-37, 1351-3036.

[12] Møller, C., ERP II: a conceptual framework for next-generation enterprise systems? Journal of Enterprise Information Management, 2005. **Vol. 18 No. 4, 2005**: p. 483-497.

[13] Bashir, S., et al. Improving Frequent Itemset Mining Algorithms Performance Using Efficient Implementation Techniques: A Benchmark Solution. in Emerging Technologies, 2006. ICET '06. International Conference on. 2006.

[14] Borgelt, C., An Implementation of the FP-growth Algorithm, in OSDM'05, August 21, 2005, Chicago, Illinois, USA, A. 1-59593-210-0/05/08, Editor. 2005.

[15] Gharib, T.F., et al., An efficient algorithm for incremental mining of temporal association rules. Data & Knowledge Engineering, 2010. **69**(8): p. 800-815.

[16] Davenport, T.H., Putting the enterprise into the enterprise system. Harvard Bus. Rev., 1998. **76**(4): p. 121-131.

[17] Elisabeth-J.-Umble, R.R. Haft, and M.M. Umble, Enterprise resource planning: Implementation procedures CSFs. European Journal of Operational Research, 2003.

[18] Al-Mashari, M., Enterprise resource planning (ERP) systems: A taxonomy of critical factors. European Journal of Operational Research 2003. **146 (2003) 352–364**.

[19] Mark, K., T. Ashutosh, and M. Jörn, A review of soft computing applications in supply chain management. Applied Soft Computing, 2010. **10**(3): p. 661-674.

[20] Canadian Public Library, Canadian Aerospace Cluster, DOD, Editor. 2004, Québec, Canadian Public Library. p. 7 -23 & 42.

[21] Nof, S.Y., et al., From plant and logistics control to multi-enterprise collaboration. Annual Reviews in Control, 2006. **30**(1): p. 55-68.

[22] Yusuf, Y., A. Gunasekaran, and M.S. Abthorpe, Enterprise information systems project implementation:: A case study of ERP in Rolls-Royce. International Journal of Production Economics, 2004. **87**(3): p. 251-266.

[23] Heizer, J., Principles of Operations Management. Vol. 4th edition. 2000: Prentice Hall.

[24] Richard B Chase, et al., Operations Management for Competitive advantage (TQM , Six Sigma & MRP calculations ( Page 8-23,339-511 -668-340)). Vol. Eleventh Edition. 2007.

[25] PROPENKO, J. and K. NORTH, Productivity & Quality management. 1996: ILO.

[26] Ainger, A.W.S., A stair-like CIM system architecture. IEEE Transactions on Components, Packaging, and Manufacturing Technology, Part C, , 1997.

[27] Gunasekaran, A. and K. Thevarajah, Implementation of computer- integrated manufacturing: a survey of integration and adaptability issues. International Journal of COMPUTER INTEGRATED MANUFACTURING, 1997. **VOL. 10,** (NO. 1-4, ): p. 266- 280.

[28] Madapusi, A. and D. D'Souza, Aligning ERP systems with international strategies Information systems management 2005.

[29] Gunasekaran, A., et al., Implications of organization and human behaviour on the implementation of CIM in SMEs: An empirical analysis. International Journal of Computer Integrated Manufacturing, 2001. **14**(2): p. 175-185.

[30] Gunasekaran, A. and K. Thevarajah, Implications of Computer-Integrated Manufacturing in Small and Medium Enterprises: An Empirical Investigation. The International Journal of Advanced Manufacturing Technology, 1999. **15**(4): p. 251-260.

[31] Kaplan, R.S. and D.P. Norton, The Balanced Scorecard-Translating Strategy into Action, in Harvard Business School Press Cambridge-MA, H.B.S. Press, Editor. 1996.

[32] Chand, D., et al., A balanced scorecard based framework for assessing the strategic impacts of ERP systems. Computers in Industry, 2005.

[33] Rockart, J.F., Chief executives define their own data needs. HBR, 1979. **57**(2): p. 81-93.

[34] Feindt, S., J. Jeffcoate, and C. Chappell, Identifying Success Factors for Rapid Growth in SME E-commerce. Small Business Economics, 2002. **19**(1): p. 51-62.

[35] G. Shanks*, A.P., B. Hu*, B. Corbitt*, T. Thanasankit* and P.Seddon, Differences in Critical Success Factors in ERP Systems Implementation in Australia and China: A Cultural Analysis. Melbourne, 2007.

[36] Ngai, E.W.T., T.C.E. Cheng, and S.S.M. Ho, Critical success factors of web-based supply-chain management systems: an exploratory study. Production Planning & Control: The Management of Operations, 2004. **15**(6): p. 622 - 630.

[37] Somers, T.M. and K.G. Nelson, A taxonomy of players and activities across the ERP project life cycle. Information & Management, 2004. **41**(3): p. 257-278.