Hong Kong Polytechnic University

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Institutionalisation of ERP Extension for Collaborative Engineering and Logistics Services in Aircraft Maintenance Industry

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Certificate of Originality

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_____ (Signed)

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Abstract

The aircraft maintenance and engineering (AME) companies have experienced a major change in the business environment over the last decade owing to increased operational constraints, tighter flight schedules and complex service provision network. The AME's found that an increased aircraft utilisation could affect the airliners' on-time performance (OTP) for revenue flights. In order to enhance competitiveness, AME companies have extended the supply chain boundaries, and employed Enterprise Resource Planning (ERP) systems to improve efficiency. Owing to various constraints, ERP benefits have not been fully employed, leaving a performance gap between the actual and the required level of OTP. This predicament gave rise to a research opportunity for maintenance process improvement.

This industry problem was originated from a "process-system" mismatch within organisations (Gunasekaran, 2003), and it has become more apparent when outsource and in-source activities are entangled with ERP inter-connectivity issues. Bendoly (2003) proposed "ERP Extension" by connecting applicable technologies to match processes and systems in resolving some ERP progression problems as depicted by Gunasekaran (2003), Koh (2006), Markus (1983; 2006), Botta-Genoulaz (2003) and Österle (2001). However, this concept has not been proven in the complex supply chain network (SCN), such as in the AME industry.

In order to improve the effectiveness of the existing independent ERPs in the AMEs, it is proposed that aircraft maintenance data could be made available in certain time-critical

processes by mobile tools on the spot of activities. Hence an industrial-based research was lunched for the benefit of engineering planners, maintenance frontline staff and reliability specialists in using timely information for logistics and process enhancement on unconnected ERPs. This is similar to assisting a group of actors on a stage to perform different roles and characters, but with different versions of scripts. However, this approach has generated many new issues such as players could not be aligned easily, what type of extended ERP applications and how they can be adopted. After a series of case studies and cross-referencing, Chung's Diamond Model (2005) was reinvigorated for theoretical support. Furthermore, the model's player management capacity was expanded to include competitor participation. Finally, the research result was expressed in an innovative task-route matrix supported by a 'Maintenance Theatre' concept created to foster player collaboration.

Through the journey of aligning AME players to extend the ERP applications under a collaborative framework, I discovered a four-stage institutionalisation process to resolve emerging problems. This is by focusing on the following:

a) Visualisation of the opportunity for AME collaboration during ERP extension,
b) Mapping out the feasible paths of extended ERP collaboration; and
c) Alignment of players' interest in SCN that could make or break the relationship.

Having accomplished the above institutionalisation process, this research has closed a knowledge gap in the maintenance service player management arena, under the challenge of extended ERP applications.

Publication Arising from the Thesis

Journal Papers

Leung T.S., Carroll T., Hung M., Tsang A. and Chung W., The Carroll-Hung Method for Component Reliability Mapping in Aircraft Maintenance, Quality and Reliability Engineering International, Vol. 23, page 137-154 (2007)

Leung T.S., Lee K.W. and Chung W.W.C., Systems and Application Development for Portable Maintenance Aid (PMA) - A Performance Perspective, Journal of Manufacturing Technology Management, Vol. 17, No.6, page 786-805 (2006)

Chung W.W.C., Chan M.F.S. and Leung T.S., A Framework of Performance Modelling for Dynamic Strategy, International Journal of Business Performance Management, Inderscience, Vol. 8, No.1, page 62-76 (2006)

Conference Papers

Leung T.S. and Chung W.W.C., Negotiation Support for Contract Engineering and Logistics Service in Airline Operation: A Case Study, Proceedings of Business Excellence I: Performance Measures, Benchmarking and Best Practices in New Economy, eds., Portugal, University of Minho, Braga, Portugal, page 403-409 (2003)

Leung T.S. and Chung W.W.C., Development of Business Process Enhancement Tool (BPET) for Freighter Maintenance, Proceedings of Business Excellence: Proceedings of Supply Chain Management Information Systems 2004 (SCMIS04), Hong Kong Polytechnic University, page 71-79 (2004)

Leung T.S., Lee K.W., Chung W.W.C., System-Application Approach for Portable Maintenance Aid (PMA) in Airline Flight Despatch Operation, Proceedings of Business Excellence and Performance Measures (Track D), Supply Chain Management Information Systems 2005 (SCMIS05), June 6-8, 2005, Thessaloniki, Greece, page 832-843 (2005)

Leung T.S., Carroll T., Hung M., Tsang A., Chung W., The Carroll-Hung Method for Component Reliability Mapping in Aircraft Maintenance, Proceedings of the 4th International Conference on Quality and Reliability 2005 (ICQR05), Beijing, page 713~722 (2005)

Leung T.S., Lee K.W., Chung W.W.C., Literature review: Enterprise Resource Planning Systems Supported Production Network Development, Proceedings of Supply Chain Management Information Systems 2006, Tai Chung, page 570-578 (2006)

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List of Abbreviations and Terminology

Airframer	Terminology for airframe manufacturer, in airline world there are merely Boeing, Airbus, Embrea and Bombardier, the 4 remaining major companies
CELS	Contract engineering and logistics service
AME	Aircraft Maintenance and Engineering is a set of players, which consists of AAME, $CELS_1$, $CELS_2$, … Airframers, ERP solution-providers, etc.
AAME	Airline-AME, i.e. Aircraft Maintenance Engineering function that is retained within the airline (by airline decision), also defined as $CELS_1$
AME player	A representative from the participating company's specific business unit
Coopetition	A terminology combining the features of co-operation and competition
Content Extension	A form of ERP and ERP data source extended to frontline use so that the traditional maintenance nature could be changed
Context Awareness	A process where the context and knowledge of work would be shared by various groups of people in different locations to improve effectiveness
ERP	Enterprise Resource Planning
ERP Extension	A specific set of functionalities from the original ERP to support new business process with special technology toolkits, e.g. mobile configuration
ICTsp	Information communication technology service provisioning unit
IJBPE	International Journal of Business Performance Evaluation
JMTM	Journal of Manufacturing Technology Management
M-theatre	Maintenance Theatre, a definition to be defined for the collaboration frameworks development using a theatre management concept for aircraft maintenance
MISRU	Manufacturing information system research unit
MWM	Mobile workforce management, a group of employees who work under the wireless connection in using the production data to support daily operation
OTP	On-time performance, for aircraft punctual departure for the scheduled flight
PMS	Performance Measurement System for aircraft on-time despatch
QREI	Quality and Reliability Engineering International Journal
SCN	Supply chain network

Chapter 1 Introduction

The global Aircraft Maintenance Engineering (AME) industry has provided a context of study for the phenomenon of institutionalisation of Enterprise Resource Planning (ERP) in a collaborative manner. This research specifically deals with extended ERP applications in a contract maintenance service environment.

There are numerous studies on ERPs, in particular the viable means to realise its effectiveness. Bendoly (2003) advocated the strategic benefits in using "ERP Extension" for system interconnectivity. Consequently, the institutionalisation of information systems (IS) in general, and ERP Extension in particular, has become a new trend of development. ERP Extension is a contemporary phenomenon and has a critical value for research because it has drawn a lot of attentions from the IS solution developers and business users.

The AME companies are chained to provide engineering and logistics services for on-time despatch of airliners. AME logistics operation connects disparate ERPs in various companies, and different players have different objectives. Also, changes in AME have incorporated more parties and generated new problems. Prior research in ERP extension was limited to within a company or confined to a specific business function. No development in this area has yet met with AME companies' common challenges:

a) Asset types complexity, low cost competition, high utilisation, shortened maintenance slot and diminished scheduling buffers in aircraft operation.
b) Incomplete adoption of ERP for business process changes to counteract operational challenges resulted in process mismatch (inherent) and connectivity (external) issues.

Connecting AMEs' ERP are important because that can make or break collaboration as depicted by Markus (1983 and 2006), but many ERPs have not yet delivered their full benefit as per Gunasekaran (2003 and 2005). Business collaborations based on ERPs connections should be motivated as per Hakansson (1993) and Jarillo (1988), even though it is challenging to manage in-source and outsource activities in different directions. Today, the norm for work-sharing between AMEs is still contract-based, thus a term Contract Engineering Logistics Services (CELS) was syndicated. The lack of cohesion in contract relationship is prevalent especially when ERPs connections are required. This background provided a distinctive opportunity for ERP extension research.

1.1 On-time Performance for Maintenance Service Management

On business performance measurement (Kaplan 1996, Seifert 2003), the metric for AMEs is how punctual they can despatch the flights against how frequent the airline can fly their aircraft (Neely, 1997). Holloway (2003) generalised AMEs' management common imperative to increase aircraft utilisation for more revenue, but very often this affects despatch punctuality. Previous researches attempted to improve flight despatch on-time performance (OTP) through planning or quality control with scattered success as depicted by Drury (2000) and Neely (2003). My preliminary study on performance systems and process management found that the theoretical framework for AME work sharing needs strengthening, and how players can extend their ERP support for OTP initiatives lies on the strength of virtual partnership (Chan and Leung, 2005). Hence, this research project was initiated to address the visible OTP issues, and was compelled to resolve ERP interconnectivity behind it, at where the AMEs' common interest stands.

1.1.1 Dilemma: AME OTP performance versus aircraft utilisation

An increase in aircraft utilisation could incur undesirable consequences to maintenance planning, operations and logistics in the supply chain (Holloway, 2003; Neely 2000). The resulting greater variation of maintenance tasks completion time creates problems for AME [ceteris paribus inspection interval, manpower resource and quality control Murbray (1990) and Jardine (1991)]. This dilemma is shown in Figure 1.1.1 that the actual OTP performance departs further from the ideal line as utilisation increases:

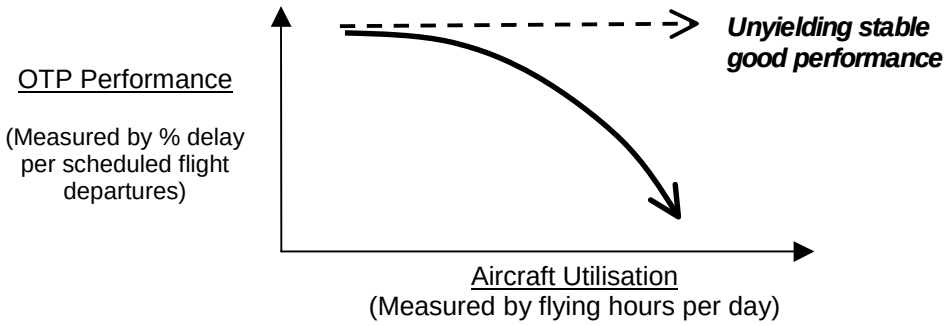


Figure 1.1.1 On-time performance versus assets utilisation

Source: Yakubowsky and Krapp (2003), Boeing and Airbus Joint Reliability Data Collection and Sharing Management Programme - Despatch Reliability Scatter Chart, Copenhagen Conference, Sep 2003.

Figure 1.1.1 depicts an industrial wide phenomenon which has an impact on AME's competitiveness with economical loss. The ownership of problem falls to an airline-AME (AAME) which resides in an airline when co-ordinating maintenance tasks. In order to meet this challenge, AAMEs adopted two basic improvement approaches:

a) Expand the supply chain network (SCN) to increase competitiveness, e.g. outsourcing to capture best core competence around. This incurred new issues with contract agreement.
b) Adopt ERP as a centralised repository for all operational information, but AMEs are rarely contented with the connected ERP effectiveness between players.

1.1.2 Contract maintenance services and ERPs connection issues

Many scholars pointed out that ERP owners lacked momentum to foster players' commitments in contract services (e.g. Browne and Zhang, 1999). Also, outsourcing using dispersed service providers with independent ERP systems could incur data configuration problems. AMEs concerned that the progress in connecting players' ERP by fix-lines to create collaborative synergy will be extremely slow. However, linking the ERPs through mobile toolkits in existence or being incubated by many technology-based researches is piecemeal effort (Nosek, 1996; Drury and Prabhu, 2000; Gilbert and Han, 2004).

1.1.3 Research cases in CELS network

In search of a practical collaborative framework, the author adopted a case studies methodology (Yin, 1994) and case enquiry strategy (Creswell, 2002, p183) in AME companies along with their ERP deployment process. This helps to search for the value creation points, common interests, drivers for success, issues and solutions. Real-life AME incidents have covered a wide range of topics and varied interests, and recorded as cases:

a) Case 1 (QREI journal paper January 2007) - Manage inter-airline development by "Carroll-Hung Method" using pattern recognition to enhance reliability functions for the aircraft component and system failure analysis and remedy.
b) Case 2 (JMTM journal paper August 2006) - Manage the mobile workforce deployment tests using Crystal-1 prototype along with the established ERP data to meet tight aircraft despatch requirements for freighter aircraft fleet.
c) Case 3 (IJBPE journal paper co-author January 2006) - Co-develop a performance measurement framework and a maintenance business process engineering tool to improve critical tasks completion in meeting tighter OTP targets.

d) Case 4 (originated from a Business Excellence Conference 2003 paper) - Established a CELS concept that gave rise to a research opportunity of SCN fundamentals through a theatrical topology. This concept supports institutionalisation theory development.

1.2 Problem Formulation

Initially the AAME management invited the author to address an operational dilemma for high utilisation versus low OTP using operational management (OM) or project management (PM) techniques. After the issues are gradually identified and the research process is unfolded, it is reckoned that only a small portion in the whole "maintenance service performance management" filing cabinet belongs to optimisation or standardisation of ERPs. By sorting these files carefully through literature support, it has led the researcher to a simpler but more prominent research question for institutionalisation of ERP extension.

1.2.1 AME contract service challenge

Extending the ERPs may stimulate collaborative and competitive development of efficient contractual services. A study of the contract service management argued that institutionalising the ERP connection is a prerequisite to expanding the SCN in nowadays business environment (Browne and Zhang 1999; Dyer, 2000; Chan and Chung 2004). Nevertheless, enforcing the ERP extension for contracted service providers is not easy because AMEs lacked experience in connecting the scattered ERPs and sometimes the information communication technology service providers (ICTsp) could not grasp the needs of the industry. As the maintenance tasks are becoming intensified with higher aircraft utilisation, there is no time for scenario study and equipment trial uses.

1.2.2 Issues of ERP extension

On the ERP effectiveness side, AME concerned that if accepting the diminished effectiveness of isolated systems the OTP initiatives will be restricted; but if projecting omni-directional connection with any player's system it will be costly and politically non-viable (Markus 2006). Other scholars have advocated standardisation (Nosek, 1996; Drury and Prabhu, 2000; Gilbert and Han, 2004) but their results are not entirely applicable to the AME industry. How could specifically tailored toolkits to dovetail ERP applications with AME business processes in the high assets utilisation environment (Bendoly, 2005)?

Supply chain effectiveness augmented by ERPs had been researched extensively through various approaches e.g. development strategy (Ash, 2003), application frameworks (Kelle, 2005) and implementation management (Ehie, 2005). However, there is no one-model-fits-all solution for the contract service providers, especially in the AME industry where it demands precise airworthy data such as engineering drawings by the information owners. Mobile ERP extension could be considered as an unsolicited work mode to frontline engineers because people treated wireless tools as 'gadgets' that have not been tested and validated sufficiently to instigate work practice changes (Ehie, 2005). In this complex circumstance how can the researcher strive for ERP effectiveness improvement?

1.3 Research Statement

Within this interdisciplinary research, what type of ERP extension will best support the maintenance planners, service agents, reliability engineers and logistics specialists who need timely information to perform their duties but players use different versions of ERPs? The

term “institutionalisation” is to link various process stations, players and aircraft assets together. With appropriate hardware and software starting from Bapst’s (2000) basic extended mobile ICT concepts, this research explores that for the high utilisation aircraft maintenance.

1.3.1 AME supply chain basic elements

If many ERPs are extended at the same time amongst the SCN it could be chaotic. The players’ reactions may affect the overall results. A smooth deployment in the competitive environment must consider the generic SCN paradigm with inter and intra-organisational factors, hence a basic AME network will be conceptualised as follows:

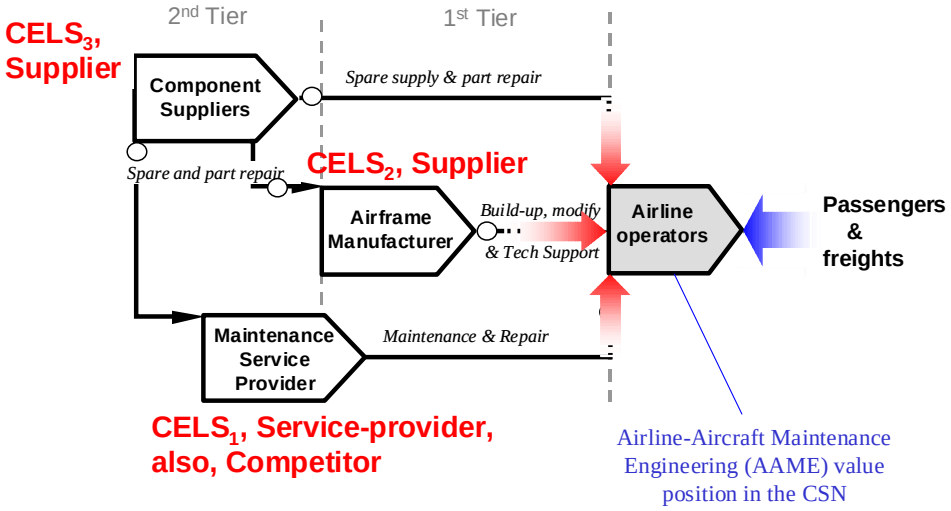


Figure 1.3.1 Topology of AME maintenance service network

Source: Leung and Chung, 2003, Supply chain view from AAME ref. Appendix I for CELS players analysis in AME SCN

The relationships between AAME, CELS companies, potential competitors and collaborators are shown in this simplified SCN, each path of task information sharing will be detailed in Section 3.3. Fung (1998) described that “Squeeze” exists between players, but it also provided an opportunity of brewing the focal points of alignment between them.

1.3.2 Research question

The above concern in ERP extension, conceived as contract services in the maintenance management domain, has been translated into an academic interest. The question is: ***"How can we better understand the process of institutionalisation of Extended ERP application for Logistics Services Partner Collaboration?"***

To address this question, this research has to answer ***"What are the make and break relationship and the transient behaviour of the players engaged, and their respective positions and behaviour."***

The research purpose is to "Advocate a collaborative contract and engineering logistics network to institutionalise ERP applications in aircraft maintenance industry so that any participant is able to gain value through adoption of the model". The challenge is composed of three underlying impediments: firstly, the mismatch between the existing AME's ERP interfaces and the network's increasingly demand on higher OTP support. Secondly, AME's management was not sure about what configurations could be brought from the new entrants and technology providers. Thirdly, frontline maintenance staffs are less-than-interested with the new ERP, let alone mobile application deployment. Fundamentally, people concerned that advanced technology brings automation to reduce manual effort but also causes chaos to their working environment - a general philosophical question that can be traced to Popper (2003).

The existing ERP extension theories cannot resolve the above issues. After a concept distillation process through literature review and situational factor correlation by the case research protocol, the research objectives have been clarified.

1.4 Research Objective

The goal of this research is to alleviate an industrial concern. The service maintenance sector is facing an operational dilemma but it needs a mutually accepted proposal rather than traditional process improvement methods e.g. optimisation or standardisation (Markus, 2006). There is a necessity for alignment between players before the ERP extension is kicked off within the SCN. So, this research has a three-fold objective:

a) Build a model to visualise the opportunity of AME collaboration during ERP extension;
b) Propose alternative roadmap for extended ERP collaboration; and
c) Evaluate the mutual interaction between different players with respect to their focal point of alignment in CELS that lead to the make or break collaboration relationship.

These three objectives are contributing to a better understanding of the key issues for institutionalising ERP collaboration, with a vision to gather knowledge, regurgitated as analysis and then re-distributed through multiple cases of "action learning" (Revans, 1993).

1.5 Thesis Construct

This research combines case analysis approach and process improvement rethink based on case method's objectivity (Yin, 1994) and process improvement controllability (Hussey, 1997). Together with a qualitative analysis to link the case findings, the research logic flow in Figure 1.5 shows the two streams and how they are positioned:

a) Research flow stream follows the standard analysis protocol as basic building blocks.
b) Case studies stream syndicates real-life results from my published papers as empirical data.

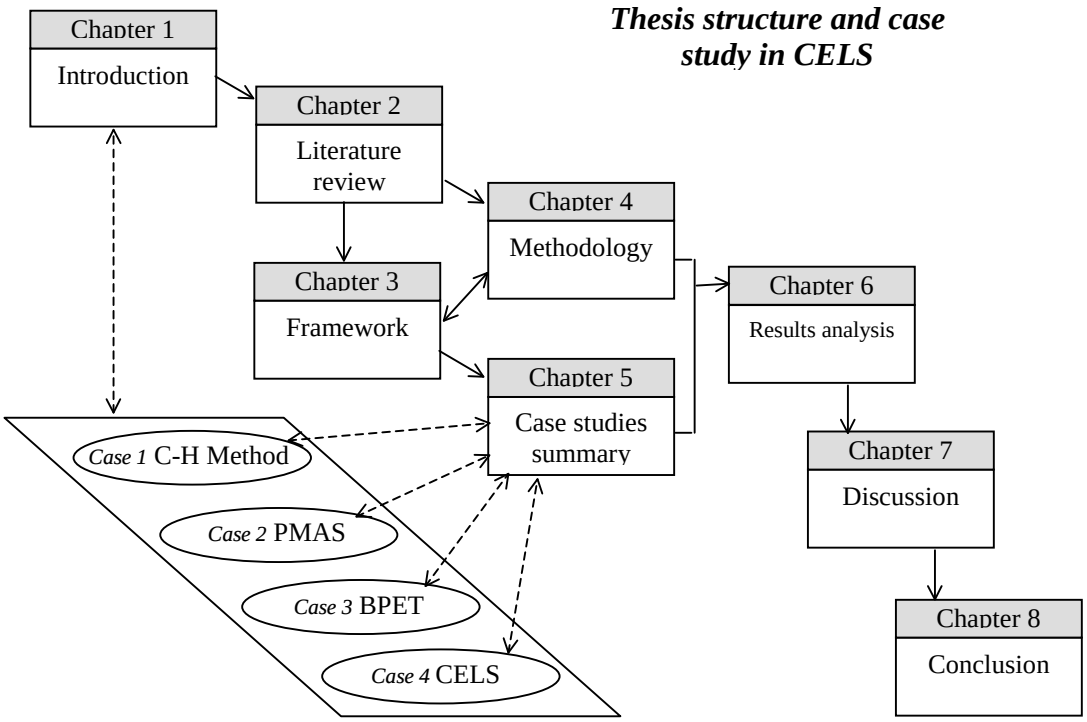


Figure 1.5 Research flow and chapter relationship

The two streams are to be met again in Chapter 6 for case linkage as well as for the subsequent model standardisation for ERP extension.

The Chapter 3 Framework brings in the conceptualisation of the CELS model to the real life cases as documented in journal papers to support Chapter 5 case summaries, rethinks and linkages. Chapter 4 Methodology defines the institutionalisation process and deliverables based on case study designs, field data collection and criteria setting to support result analysis for Chapter 6. The research progress has been extracted from published papers listed in Appendices I to IV including the questions and answers critical to connecting cases. Theory generation support is summarised in Appendices V to VIII using tutorial material for post-graduate classes related to logistics.

Chapter 2 Literature Review

This literature review is supported by four theoretical sources: Competitiveness theories in AME supply chain network (para 2.2); ERP in the last mile process (para 2.3); mobile ERP characteristics (para 2.4) and Chung's Model of collaboration (para 2.5) for players management.

2.1 Why "Process-Focused" AME Cannot Cope with Increased Utilisation

Aircraft maintenance effectiveness has been studied by multiple disciplinary researches, including competitiveness strategy, process reengineering and ERP deployment. These studies arrived at a similar conclusion that individual AME to pursue quality and reliability is not good enough (Holloway, 2003; Chan and Leung 2006; Porter, 1996). Drucker (1997) predicted that a single firm's traditional 'one-stop-shop' process-oriented businesses will become ineffective to cope with increase in assets utilisation, let alone winning the competition in a global scale. AME business by its nature is under a global network hence this is the first set of factors to be considered. Research aiming at solving the AAME's utilisation-OTP dilemma shall reason this "why-not" argument. Literature grouping and relevant industrial experiences referencing provided a four-layer analysis method:

a) Position: Why individual player's core competence cannot fit all positions in SCN?
b) Players: How potential entrants' proposals could tilt the balance formed by old players?
c) Platforms: Where can we find independent ERP's inadequacies and how to remedy issues?
d) Progression: How resource sharing can leverage AAME competitiveness strength? What factors hinder the progression?

2.1.1 What performance gap exists in each value layer?

In these four layers, searching for researchable opportunities could lead to a breakthrough in contract service management. A study of the existing AME process (*programmed*) comparing with the established theories in relevant areas (*questioned*) using Revans' action learning methodology (1983) has shed lights in each layer:

a) Layer 1: What strategic position awareness should player's use to gauge their competence characteristics that leads to better understanding of the SCN evolution?
b) Layer 2: What business potential attracts industrial giants Airbus and Boeing to join the arena to drive changes of the AME environment?
c) Layer 3: What technology platforms may be available somewhere else to differentiate a new mode of operation that did not previously existed?
d) Layer 4: What modes of collaboration may be instigated so the views of vertical or horizontal integration can be illustrated for a possible way forward?

Knowledge gaps in SCN: Wiendahl and Lutz (2002), Zheng and Possel-Dölken (2002) and Ebers (1997) studied process-focused and network-oriented transformation found that "Trust in partner capacity" may help the first consideration amongst the 4-layer analysis. Hence, a shared objective is vital for simultaneous ERP extensions amongst the SCN.

2.2 Global Competitiveness

AME SCN consists of three business groups, a) the maintenance-repair-and-overhaul (MRO) companies, b) AAME organisations, and c) a wide range of companies that have direct contact with the first two groups. Similar to Boutellier's (2000) SCN notion, AME is virtually

supported by many industries (engineering, logistics and communication) to make use of global resources to create opportunities - aircraft transit time and logistics; conjoining the availability of men, equipment and processes (Holloway, 2003).

Trust-based competitiveness modus operandi: Literature sources offered a wide range of disciplines that attest the shaping force for SCN (Porter, 1998; Jurgens et al., 1993 and Nelson, 1998). The necessity for connection, collaboration and competition of AME service provision were originated from Hakansson's (1993) and Jarillo's (1988) production network concept.

2.2.1 "Actors" in SCN development

The SCN evoke images of firms held in a dense web of interactions between firms, generally described as "Activities". Granovetter (1985) depicted that firms can be treated as "Actors" and "linkage for the business" will act as a disciplinary mechanism to distinguish an exchange relationship (e.g. contract). Embedded economic and regulatory factors functioned as disciplinary mechanism to opportunism (Powell, 1990; Chung, 2003). These are "Resources" categorised in the three fundamental groups:

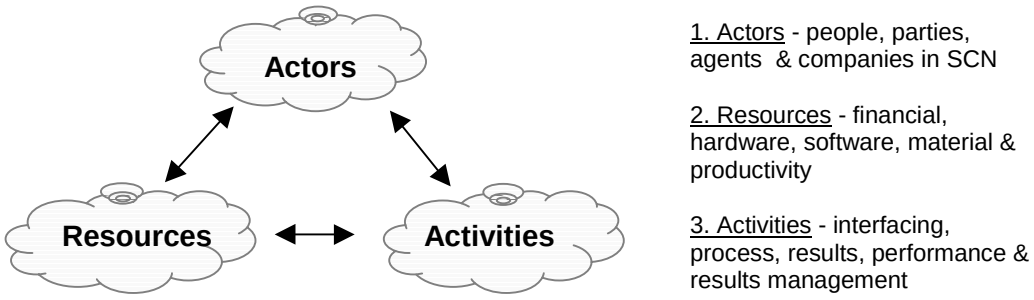


Figure 2.1.1 Industrial and supply chain network basic elements

Source: Hakansson and Johanson (1992), "A Model of Industrial Networks", in Axelsson and Easton. Industrial Networks-A New View of Reality, Rout ledge, 1992

Closing the knowledge gaps in SCN: The resources and actors are matched to meet the heterogeneous customer requirements by value creation (Hakansson, 1992). When applying this analysis, the AME SCN aggregates organisational and exchangeable entities using technological and procedural interfacing for business improvement (Hakansson, 1994). However, Parolini (2000) pointed out that existing knowledge gaps in the 3-factor relationship could not align the value creation characteristics crucial for the SCN. These gaps could be addressed by looking into the competitiveness agreement both within individual firms and external to the network. Managing the players' expectation through an agent is a viable means of collaboration but how to better cultivate the environment is a challenging proposition for ERP deployment.

2.2.2 Competitive advantage in connected maintenance network

The driving force behind resource allocation is competition (Porter, 1998; Marsh, 2006), and inter-firm relationships are built to regulate the allocation and re-location of resources (Boutellier, 2000). In the AME network, real-life experience revealed issues as follows:

a) Interaction: A connected SCN surpasses individual's contribution and overcomes physical constraints (Porter, 1996). New conflicts may arise when interaction in the complicated process related to the final deliverable performance.
b) Restructuring: The benefit of process reforming with new opportunities out-weighs the risk of uncertainty, but role changes are too rapid for players to cope with (Koh, 2004).
c) Sustainability: Balancing the competitive elements by a share of competencies could result in too much mobility (Sawhney, 2001; Sommers, 2003).
d) Incentive: Joining more players can push the improvement initiatives (Ghalayini, 1997) but it might be seen as false signals if there is no mutually agreed goals.

e) Selection: Standardised logistics protocol and best practice management styles can be selected from the pool (Bloomberg, 2002; Zografos et al, 2002); but the problem was unlimited standards will flood the industry.

These views converged the competitiveness theories to "positioning", which is the first conclusion on SCN competitiveness definition in the literature review.

Player roles ceteris paribus: Seifert (2003) stated the basis of collaborative planning forecasting and replenishment (CPFR) between pure competition and coopetition in today complex SCN. Once a company acquired the knowledge for competitiveness management it will still need to instigate collaboration between players because every player in the network should have a fair chance to react. Hakansson (2003), Ebers (1997) and Zheng (2002) similarly suggested that production network development would lead to a contractual bind between one firm and many others in the network. Literature search revealed no theoretical correlation exists to adopt all players' situations in an objective manner.

2.3 Sponsor's Undertaking in ERP's

Having seen no guarantee to gain upper hands in the players' competitiveness race, AME management attempted to extend the ERP applications to support the business process enhancement, as a recognisable means to boost networked productivity and competitiveness as per Österle (2001). One may choose either a 'bottom-up' (i.e. process driven, Gunasekaran 2001) or 'top-down' (strategic requirement, Chakravarthy, 2003) approach. It is useful for both the industry and academia to experience one-stop-shop Corporate Entrepreneur Protocols (CEP) (Zahra, 2006). One may choose mass customisation, flexibility, lean production or

alternative theories to attest conventional approaches of ERP adoption (Leung, 2006c). Normally, using O'Brien's (2003) 3-dimensional IT system formats one can prioritise the development according to positioning, timing or scope. In reality, Airbus (Appendix VI) and Boeing (Appendix VII) adopted different approaches to extend their ERPs for different expectations and performance requirements.

2.3.1 ERP supported SCN process improvement

Depending on the nature of business process (BP), different AME sees the opportunities and challenges in different SCN stages as in Figure 2.3.1. From raw material supplier in BP(a) to ultimate customer service BP(f) the generic supply chain(s) is defined as shown:

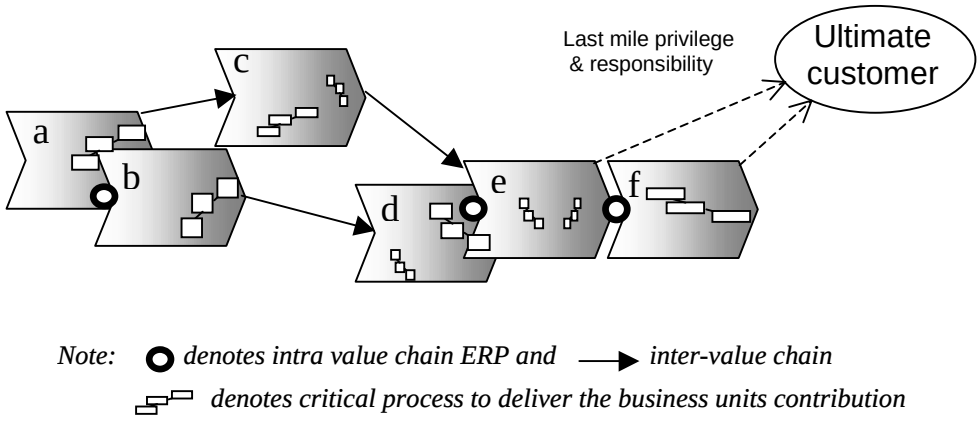


Figure 2.3.1 Generic SCN in clustered production or service network

Source: modified from Wiendahl and Lutz (2002), "Management of variable supply chain networks", in Zhang and Possel-Dölken, Strategic Supply chain network, 2002

The ERP systems enable the businesses to integrate a variety of disparate functions. It is recognised as an effective management tool that has planning and scheduling capability; it also offers better customer service, higher inventory turns, smarter financial analysis and

significant reduction in overall costs. Most AME companies experienced certain extent of ERP benefits as well as difficulties.

2.3.2 "Last-mile" control and ERP deployment

Different levels of players contributed different values in the SCN. So et al (2005) defined the last mile service as the most focused process for the whole value chain success. These are the processes BP(e) or BP(f) in Figure 2.3.1 to deal with the customers directly (e.g. AAME's controller or ramp maintenance engineers). Wiendahl et al (2002) described them as "critical" process owners and those who leverage the last mile benefit also takes up ERP co-ordination responsibility. Depended on the contextual knowledge exists in different SCN, a set of semantic collaborative language would be applicable for the last mile activities (Farhad and Daneshgar, 2005). In reality, contextual and cultural barriers obstructed the horizontal collaboration across the SCN. If there exists ingrained inter-organisation issues between players, the collective decision making in last mile activities is limited, no simple solution for this type of problem as per Hogue (2002).

2.4 Obstacles for Institutionalisation of ERP Extension

The driving force of developing ERPs was business process improvements (Markus, 1983; 2006). During implementation the purpose of ERP may shift from leading a gradual process changes to determining whether tasks are retained or outsourced (Lee, 2000; Hendriks 1999). Two considerations will remain with the final ERP application:

a) Informatics: Lee (2000) proposed a disperse-cohesion tasks effectiveness breakthrough.

b) Knowledge: Hendriks (1999) proposed system-application intelligence sharing.

2.4.1 ERP support for last mile and known issues

Leung and Chung (2006) found that three pillars of ERP development: Systems, Applications and Agility emerges naturally. If these three pillars can anticipate the issues then ERP implementation may be smoother. Hence, a carefully defined collaborative framework could alleviate, if not totally solving the problems associated with ERP, which had been brought up by key scholars in this field:

a) Gunasekaran (2003) concerned that ERP adoption success may not be controllable due to rapid connectivity hence a lower dependence on the adoption protocol.
b) Koh (2006) concerned that uncertainty in ERP deployment affects progress, but real-time extension technology may shorten the duration for data supported decision making.
c) Markus (1983) tackled "Power and Politics" with demonstrated ERP success, could ERP extension bring in early user acceptance thereby gaining the trust for sponsors?
d) Botta-Genoulaz (2003) on ERP collaboration difficulties, blurring of rivals or competitors boundaries, how could a "trust-competitive" form of coopetition be created?
e) Österle (2001) on strategically chaotic implementation especially in big organisations and huge SCN, could extension be used to balance the agility and consolidate applications?

Closing the ERP knowledge gap: The above literature analysis offer an opportunity for ERP improvement by defining key attributes in system-process matching. Strategic ERP extension concepts (Bendoly, 2003) help to resolve the above issues, avoiding head-on collision with the users' difficulties.

2.5 Data Configuration for ERP Extension

Many researchers suggested that ICTsp should be involved in the in-service software changes throughout the lifetime of ERP (Allan, 1997; Saynisch and Bürgers, 1997; Voropajev, 1998; Jacobs 2003), so a configurable data source is vital for expansion.

2.5.1 Player expectation and institutionalisation of collaboration

The producers and suppliers in AME industry take a 25~30 years of commitment for the lifetime of an aircraft generation to configure data in the ERP (Holloway, 2003). The ERP expansion needs a protocol control and the network players are expected to participate in the configuration design (Jacob, 2001). However, it is tedious to list the existing AME processes and to match them all with operation data. Allan (1997) proposed that this can be done by re-code the data source for various interface; and Markus (2006) suggested that standardisation between companies. However, both approaches lacked cost-effectiveness justifications. This gave rise to the collaborative opportunity that data configuration that should be focused on critical process applications only.

Closing the gap of ERP extension: The taxonomy development helps the industry to bring ERP extension framework closer to reality. Any attempt of ERP extension, data configuration and functionality enhancement to match the process, must be agreeable with network players and critical process owners. Some sort of algorithms can be tested to meet the last mile success, in order to deliver the early result for a specific function. A skeleton for ERP extension with data configuration for detail design direction should include the key players. To this end, the issue of institutionalisation of player collaboration is becoming a major factor for the success or failure of the ERP extension.

2.6 Diamond Model on SCN Collaboration

A stock-take of the PolyU Manufacturing Information System Research Unit (MISRU) research results was conducted on 39 journal papers and 122 other publications, of which 16 papers are selected for the illustration of Chung's model for SCN player management. Each paper features a unique relevance for player collaboration, especially on multiple users and stakeholders settings. Reference to Calisir's (2004) "reference site focus" method the author created a strategy analysis protocol to find the collaboration paths embedded in each paper, so that a -SUCCESS- relationship (-Sponsor-User-Customer-Competitor-Employee-Supplier-Stakeholder-; see Appendix V) is syndicated for player management. Based on a Diamond Model theorised by Yuen and Chung (2005), the author summarised the literature as follows:

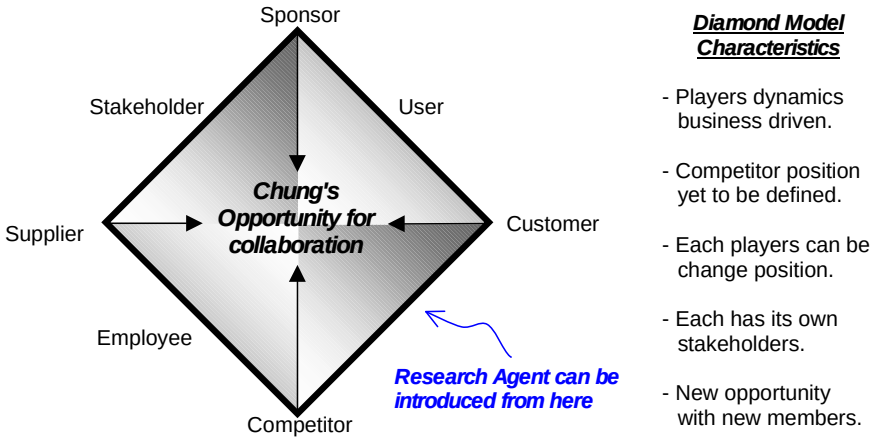


Figure 2.6 Chung's Diamond Model for collaboration opportunity

In the Appendix V it was found that the competitor path has not been prominently reflected in the Diamond Model strategy analysis in all cases, so the author treated it as a missing jigsaw puzzle in the model. Couger (1995; p121) supported the inclusion of "opposing players" for opportunity creation and delineation needed to establish potential collaborators.

2.6.1 Diamond Model transforms competition to co-operation

This theme emerged in the strategy analysis (Chung, 1999, 2000 and 2003) is because a player cannot be treated as a pure competitor or co-operator in today's dynamic SCN environment. Position change in SCN is prevalent but there is no easy way to define the characteristics clearly, a situation similar to the advanced stage of CPFR (Seifert, 2003, p125). If the Diamond Model is refined to connect competitors merely as a form of contextual barrier, then it is possible to allow this research project to find a way to meet the objectives while integrating competitor's actor role in the SCN theatre (Hogue, 2002).

2.6.2 Diamond Model platform

The Diamond Model has also offered an analysis platform for the mobile workforce behaviour associated with specific functions and features in ERP extension (Bendoly, 2005). The player management strategy can be refined with a conceivable process, concept and the brief attributes are shown as follows:

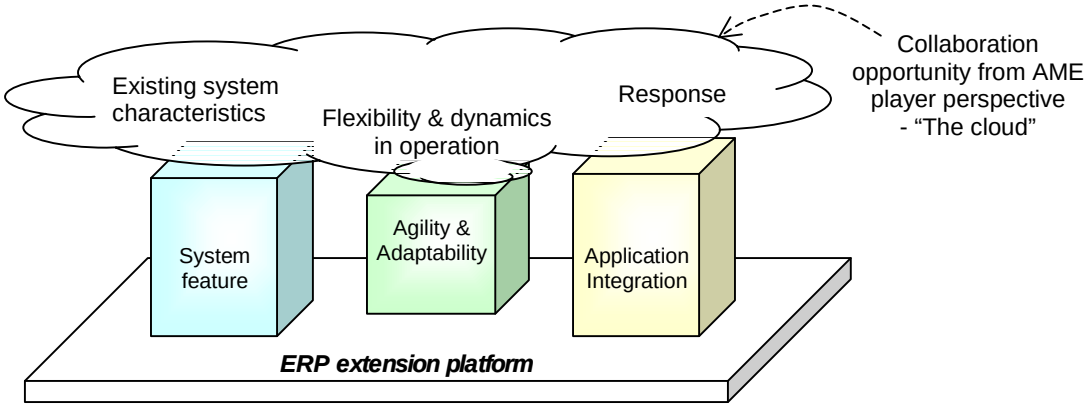


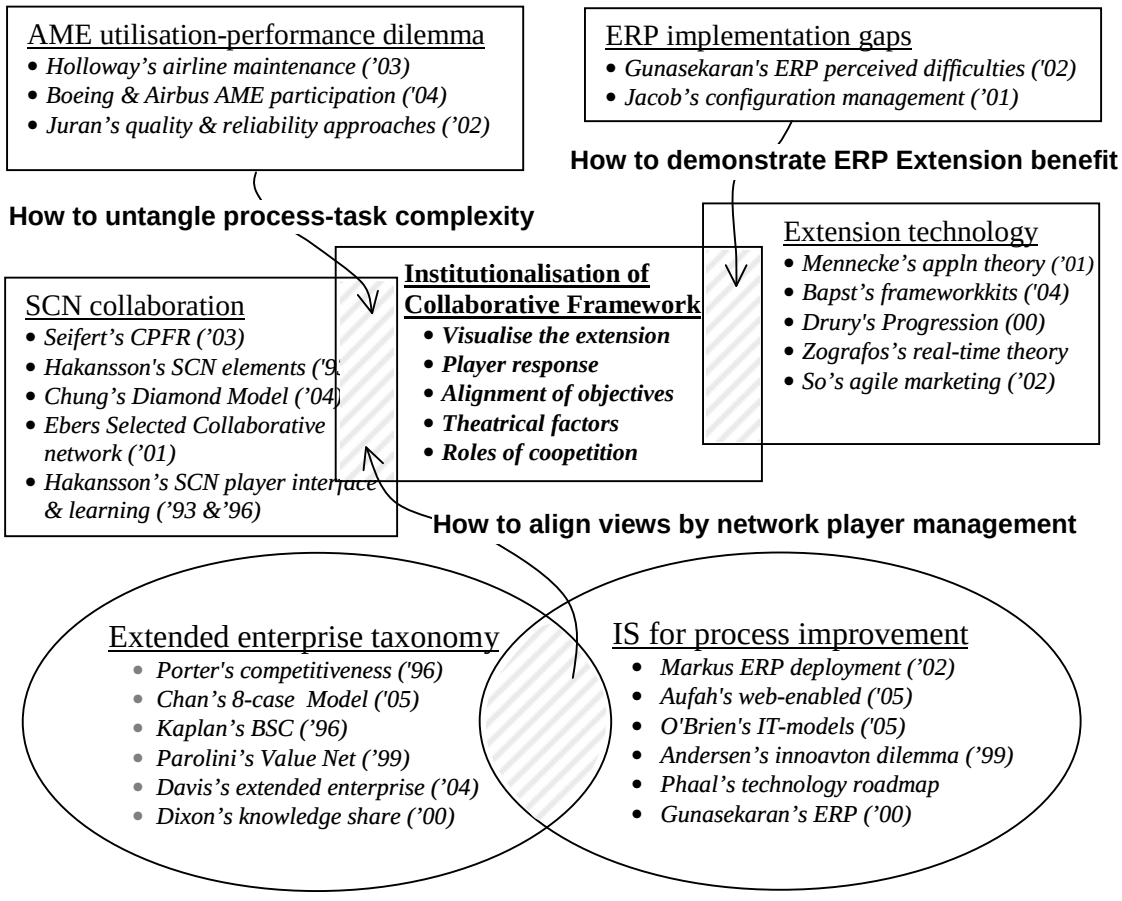
Figure 2.6.2 Three-pillar of ERP extension supports ERP collaboration

This modified platform is constructed on a 3-pillers literature support (*Source: Leung et al 2006 JMTM paper*) for a refined collaborative model to institutionalise player management. As a

whole, building this common platform is to strive for early success, and there is no need to change the original system source codes from various ERPs.

2.7 Literature Summary

After reviewing ERP extension, SCN position and player management in totality, a summary of major scholars view and the knowledge gaps are presented in Figure 2.6. This supported Section 1.4 research objective setting and subsequent research methodology development:



Note: *1. Grey areas between two sets of theories are knowledge gaps*

2. Arrows connect research opportunity with nature of challenge

Figure 2.7 Literature links

Based on the literature links and the knowledge gaps identified, if the collaborative ERP extension framework is to be defined, the following key points must be addressed to drive ERP improvement:

a) The ERP extension success depends on adaptation of the agent (Brehm, 2005) to facilitate implementation process: customisation, extension, and modification (Glass, 2004). In this regard, the institutionalisation steps should be followed to address the 4-level issues identified in para 2.1.1, hence the AMEs can achieve the required OTP imperative:
   - ❖ Level 1 Data: I saw - How can ERP implementation match institutionalisation factors process, skill, tactics and alliance?
   - ❖ Level 2 Circumstantial: I attempted - What new mobile toolkits can support the extension trial with just basic logistics skills instead of advanced skills?
   - ❖ Level 3 Mental: I think - What support the change from pure contractual requirement to collaborative relationship?
   - ❖ Level 4 Satisfaction: I propose - How to demonstration a higher level in SCN using trusted collaboration?

b) In the context of CELS, the emergence of major players from Boeing and Airbus in the AME market could open a new dimension of competition. New benefit for the industry is anticipated hence ERP extension strategy should include them as potential players.

c) ERP "modification" changes source codes whereas "extension" is for process customisation which does not change the basic ERP identity (Bendoly, 2005). Hence future detail design of the extension features should include the system, application and intelligence issues.

Chapter 3 Framework

Based on the data collected in the real life AME operation, a new analysis matrix is defined for the horizontal views (logistics network player topology) and for the longitudinal views (critical process and real-time process management needs).

3.1 The Concept of Maintenance Theatre (M-Theatre)

The AME players cannot solely perform the maintenance tasks alone and they have a range of routes available them. So the framework of research into AME ERP extension should link these routes within the boundaries of task constraints. To start with the modelling, the author uses the generic maintenance service task nature defined by Holloway (2003).

3.1.1 Envision a theatre using collaborative support framework

In addition to delivering the precise information to the right people in the right time (O'Brien, 2003) this framework also envisioned a "right-place" capacity with mobile workforce management (MWM) (Mennecke, 2004). The technical difficulties that Mennecke (2002) and So (2005) have highlighted in the nomadic computing should be considered. The advanced ERP collaborative framework for OTP improvement must include the appropriate locations in the AME business arena.

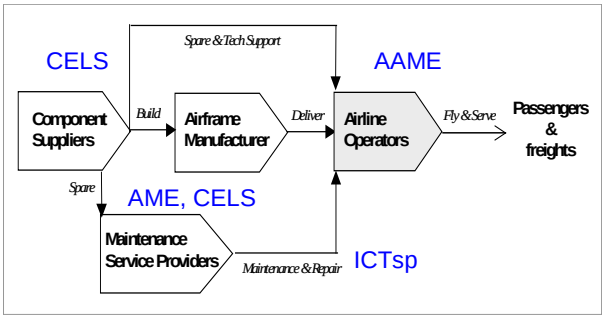
3.1.2 Diamond Model supporting the path finding

The ERP extension model has an opportunity-making focus based on the -SUCCESS- cycle with the help of a research agent. The agent's role is to record a new phenomenology as

empirical data for SCN collaboration. The industry-academic collaboration according to Chung (1995; 1998; 2003; 2005) can cultivate network players to innovate ERP extension. Several preceding Diamond Model researchers (Tam, 1995; Yuen, 2004 and Chan, 2005) offered challenging propositions surrounding the -SUCCESS- cycle. This research framework enforced a stretched agent role to resolve complex operation problems in the OTP improvement process. The agent should also prepare to explore the uncharted areas in collaboration domain under the Diamond Template.

3.2 CELS Relationship and ERP Collaborative Environment

To meet the AME vision, the ERP should be extended to penetrate the AME SCN and attain a good result similar to the hallmark theories such as CPFR (Seifert, 2003). If traditional process can be evolved to new SCN operation, the basic players and AME participants' linkage should be revisited. This new chain will have a potential to surpass traditional AME players positioning (Leung and Chung, 2003). Hence, the contract engineering and logistics service (CELS) layout is designed as follows:



CELS network

AME SCN basic business groups

a) AAME organisations reside in airlines
b) Airframers (Boeing & Airbus)
c) Maintenance-repair-&-overhaul (MRO), maintenance service providers & CELS
d) Companies that have direct technology contact with first three groups, e.g. suppliers, agents and ERP service provider

Figure 3.2 CELS industry segment and players and initial phase

The above CELS layout has been simplified to include a two-tier logistics network that serves the ultimate customers (passengers and freights): on-time and safe flights. The definition of AME industry research element is given as follows:

AME consists of a set of players {AAME, {CELS$_n$}, Airframers, ICTsp…}

Definitions for the AME player group:

a) AME is a supply chain network of aircraft maintenance and engineering firms.

b) AAME is an Airline's AME function of any size.

c) CELS$_n$ is a firm to offer contract engineering and logistics service from AAME.

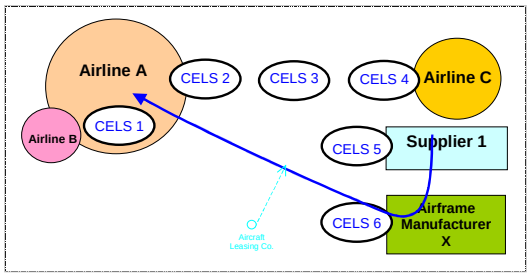
d) ICTsp is a information comunication technology service provisoning unit.

This definition is a generic description for any AME SCN in any airport sites that has a contractual relationship, in a form of logistics topology.

3.2.1 Initial AME working environment

All AME participants will be involved in the formulation of maintenance plans (Holloway, 2003). AME capability and core competence may influence AAME's decision to acquire a new aircraft fleet in the airline and its subsequent maintenance and engineering business plan spanning for a period of 25 to 30 years.

To propose a player relationship topology, in the initial phase for 1~3 years, it is envisioned that CELS network players will manage new aircraft delivery, from the airframer to the airline for entry-into-service operation. Recently, Singaporean Airlines (ready for A380 delivery ref. SCMP, 2006) categorised as Airline A in Figure 3.2.1 representation and Emirates (Airline C) can utilise the CELS$_n$ capability:



Initial phase

AME groups working

a) AAME organisations reside in airlines buys a fleet of A380 from Airbus.
b) Assigning MRO & maintenance service providers CELS$_{n}$ for scheduled & unscheduled tasks.
c) Setting up contracts with suppliers & agents

Figure 3.2.1 CELS industry segment and players and initial phase

3.2.2 Later stages of CELS environment

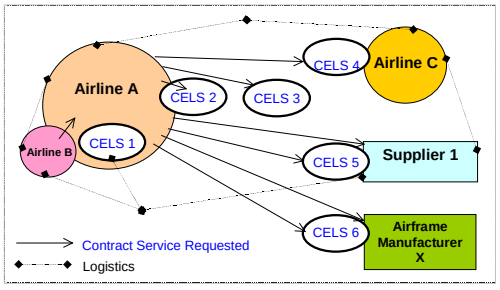
After the aircraft fleet is delivered, the contract services changed and the AME relationship may shift towards more outsourcing. When the fleet is becoming mature until phase-out, the maintenance tasks will need adjustment and suppliers focus change to mid-life improvement. New entrants and players will define the subsequent contractual functions:

a) Roles - Maintenance planning and control, home base and out-port service provision.

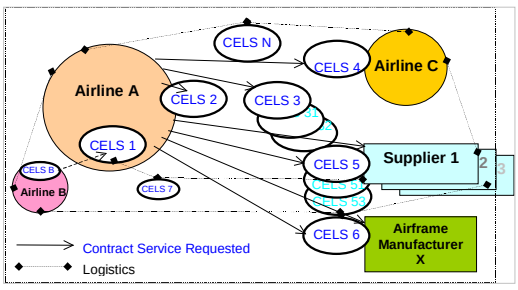
b) Tasks - Tasks are subject to quality assurance and reliability improvement definitions.

c) Relationship - warranty, spare provisioning and development prospects.

In the later stage, new relationships will develop to influence each other. Roles are revised and responsibility may change hands for the selected fleet management periods. The CELS development will incorporate more players in a fully deployed stage:



CELS Development phase



CELS deployed phase

Figure 3.2.2 CELS player roles, functions and areas of concern

Along with the ageing of aircraft, new problems will evolve and the size of CELS network will be expanded in the middle (5~10 years) and the final stage (15~25 years) of operation.

3.2.3 Route specification for AME SCN

The basic task nature of AME is co-ordinated by the airline's operation and applicable to almost any airport. The time and process view for the last mile control is defined by 3 routes:

a) Route-1 - Arrival and departure of the aircraft is regarded as a vertical process to maintain the aircraft in airworthy condition; this is done through a contractor's route.
b) Route-2 - Vertical process between home base and any outstations all around the world. The giant players may engage into the global maintenance network vendor connections (typically Boeing and Airbus); this is done by maker's route.
c) Route-3 - The horizontal paths for all relative smaller suppliers engaged into the daily airport operation. It is envisaged that this route controls the logistics operation between overseas suppliers and control; this is done by the supplier's route.

3.2.4 Task requirements for AME SCN

a) Task A Routine -Weekly or monthly checks; scheduled or preventive maintenance; hangar maintenance; hard-life overhaul programme; major strip inspections. These are important tasks in any stage of the maintenance with new fleets to address the teething problems and to develop new work practices with the new suppliers.
b) Task B Ad-hoc - Troubleshooting, repair or unscheduled maintenance; event investigation; safety remedial actions; emergence spare support. These tasks are difficult in the early stage of the entry-into-service for reliability issues encountered in the infant mortality of the aircraft systems, this type of tasks has a strong OTP implication.

c) Task C Value adding - Product enhancement; cabin interiors renovation; in-flight entertainment etc. These value-adding tasks can revitalise aircraft assets and revamp the out-of-date cabin interior and in-flight entertainment to attract customers.

3.2.5 M-Theatre topology view

If the task and route factors are categorised in two major groups: a) data content management and b) context of use consideration. How to represent the choice from basic elements requires a new approach. A theatrical view assisted in simplifying the existing complex task-route categorisation will meet the first objective of this research. It is possible to group the tasks and routes description in the maintenance theatre proposed for any generic airport operation (Hong Kong's CLK airport is typical), as shown in Figure 3.2.5:

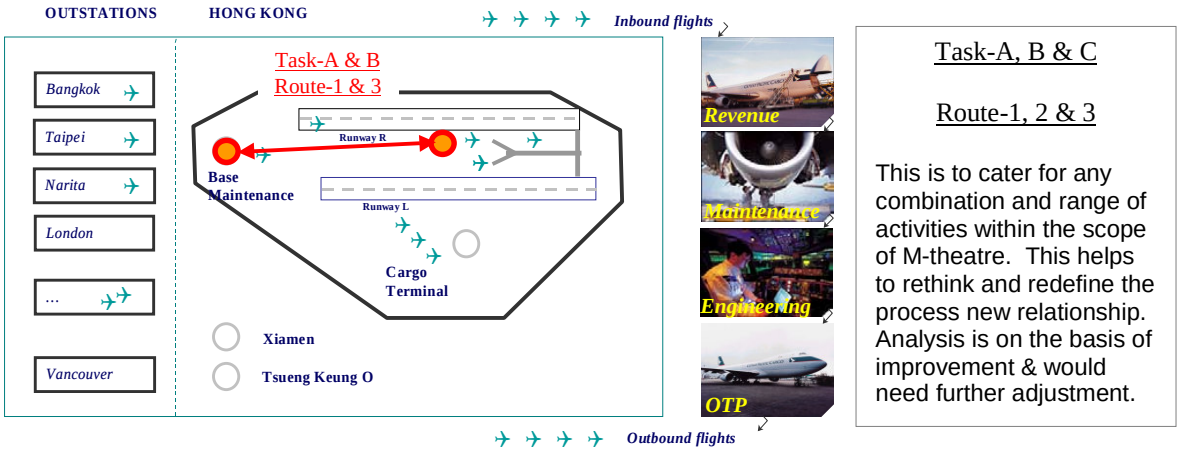


Figure 3.2.5 Maintenance Theatre topology for Route-1 tasks as example

This theatre view covers the daily aircraft transit in a theatre context. Hence, Route-1 operations from Step 1 (arrival of aircraft after a flight), Step 2 (maintenance tasks to rectify the defects), Step 3 (engineering work for value adding tasks) and Step 4 (on-time performance management) dictate overall contribution as in OTP-utilisation initiative.

3.3 Players Collaboration Opportunities

The maintenance tasks under the theatrical view can be captured inside a matrix for the 3 Task and 3 Routes combination. This is to observe the collaboration opportunities between the AAME requirements and that the CELS$_n$ can offer. A set of rules is given as follows:

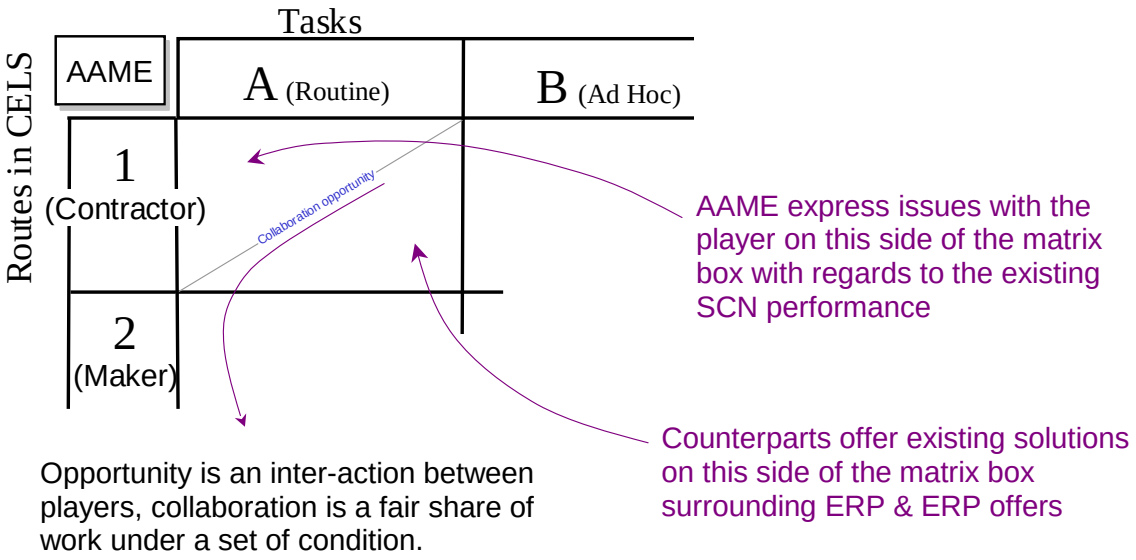


Figure 3.3 Definitions for matrix analysis space in T-R box

For each Task and Route (T-R) pair, the AAME can post the concerns directly related to OTP performance against the offers provided by the AME players. Within the same matrix box, how to establish the opportunity for collaboration is discussed. The cells are not only functioned as analytical and negotiation spaces to explore feasible ERP extensions, but also to provide dialogue between what AAME wants and the potential improvement offered by the CELS$_n$. AAME could alter the service requirement using configuration management. The information obtained from different AME players, maintenance and aircraft operations supports the collaboration. Different formats of suppliers and aircraft manufacturers data based on different ERP's can be linked to the analytical space so that all players can select an

appropriate configuration. A collaboration sign would be installed to denote the highest effectiveness for SCN.

3.3.1 Maintenance Theatre detail route study

The task context belongs to the AAME, in where it can be altered to suit operational needs. The task content, on the other hand, belongs to the frontline business units or the outsource maintenance provider. Hence it should be aware that the last mile control for OTP is not just the AAME but also the $CELS_{2.}$ This leaves a supportive function for the AAME closely tied to the shared ERP usage. Route-2 connection between home-base and the outstations are through web-based ERP frameworks depended on both technology and collaborative traits. Route-2 should be carefully mapped between AAME and overseas players connected to the process. The second-tier AME operation paths are now known as Route-3 and the AAME has a last mile advantage over the suppliers.

The M-theatre tasks and their attributes are described in each route as follows:

a) Route-1 - Mainly to drive OTP to meet daily operation in home base, this process is focused on traditional AME physical maintenance domain by key players. Their respective functions are defined as follows:

- $CELS_2$ - ramp maintenance engineers who have process ownership but not logistics due to lock of SCN process support and spare parts information.
- $CELS_3$ - contracted maintenance parties such as mechanics who do the physical work for general aircraft condition inspection and despatch support.
- $CELS_4$ - dedicated logistics planners, controllers and maintenance liaison to deal with daily issues arising in the scale of economics in operation.

b) Route-2 - Mainly governed by the global operation of the airline nature, AAME will use the man-machine-material-method (4M) combination to optimise overseas maintenance opportunity through global connection (Leung, 2003). The wireless design must emphasis the global reach capability and the major players are defined as follows:

- $CELS_5$ - outstation ramp maintenance engineers have process ownership but also logistics control due to less flight in outstations hence a wider scope of work.
- $CELS_6$ - contracted maintenance and aircraft handling parties such as cargo loaders who perform the physical work for the AAME.
- $CELS_5$ - The engineer who is also the logistics controller and maintenance planner to deal with ad-hoc maintenance needs in outstations.

a) Route-3 - Cross-theatre operations depend on the logistics and operation planning at the home base. The AAME will treat the home base airport as the value adding base, the key players would be defined as follows:

- $CELS_2$ - ramp maintenance engineers may need to expand their roles in ad-hoc defect rectification, logistics support and spare parts information dissimulation.
- $CELS_3$ - contracted mechanics perform the physical work provided arms and legs to assist the engineers, now need to exercise analytical power.
- $CELS_4$ - dedicated logistics planners and maintenance planners who normally deal with routine issues only, now need to extend their knowledge to reliability.

3.3.2 Integrated M-theatre T-R analysis

The complete 3-Tasks x 3-Routes matrix shows the possible combinations using literature survey for AAME, the AMEs and $CELS_n$ players. The matrix illustrates the overall opportunity that exists to allow supportive collaborative framework development with the data

obtained through the existing ERP inter-links. As then, an "agent" (see Section 4.1) will use maintenance policies and SCN theories to help the AAME and AME players to fill up the matrix cells with all T-R combinations:

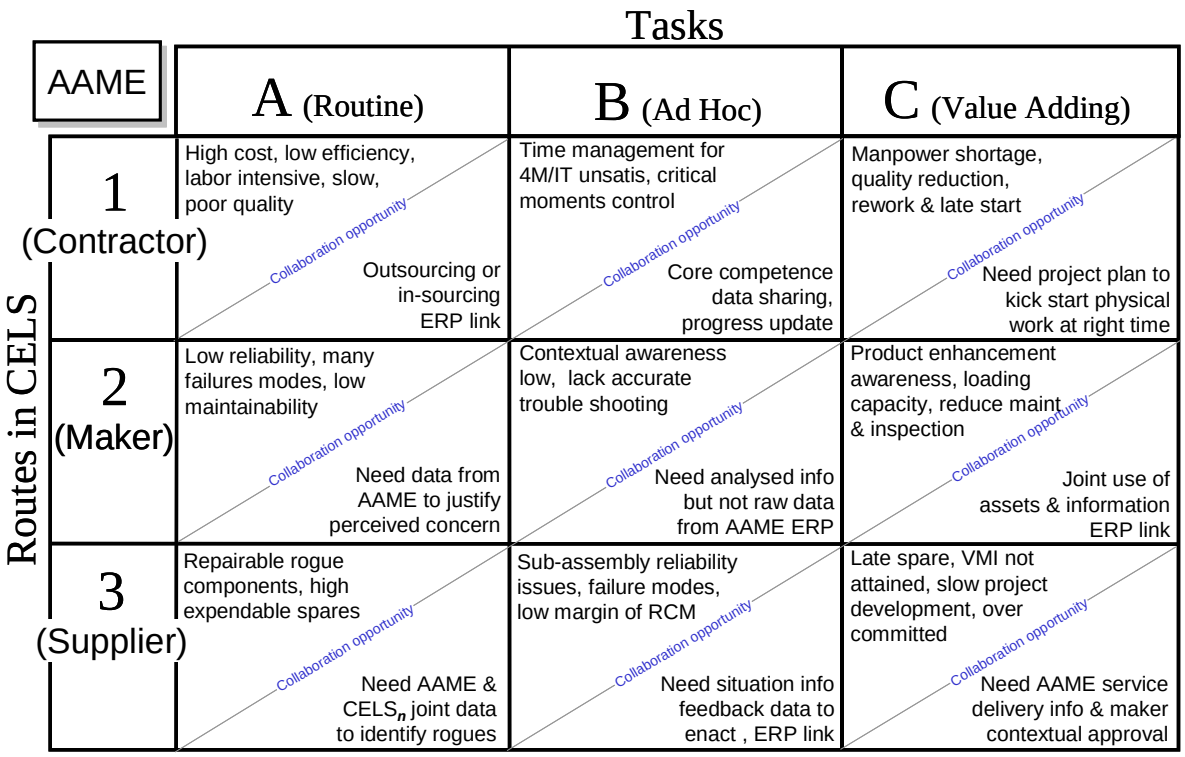


Figure 3.3.2 T-R analysis in M-theatre

The collaboration opportunities are grouped into only a few feasible improvement options because provision for all levels of maintenance services is rather complicated. The AAME may select professionally trained personnel who are stable and capable of working independently to perform certain improvement options as proposed in certain matrix cells. Therefore, this matrix has only provided an analysis model representing the intended levels of the players who need to know AAME's dissatisfaction over the utilisation-led OTP downturn and the options exist for further collaboration.

Finally, the context of competition will emerge while filling the cells. This will drive players to offer better options technologically available for the matrix analysis. To review the completed matrix, a few salient points are listed as follows:

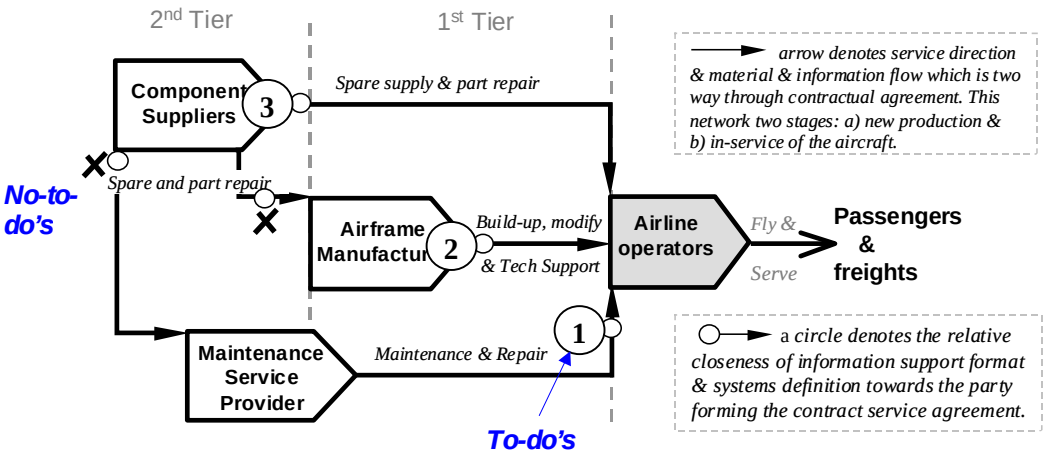
a) Trained engineers work in groups are more efficiently and positively affecting the work organisation unit, based on common analysis of $T_{A,B,C}$-R_1 for context of use.
b) The organisation of a service unit is different from a task force unit, the later is to be disbanded at completion of an ad-hoc job. The program office was arranged in project nature using analysis of $T_{B,C}$-R_2 common concerns.
c) Managing the relationships between engineers belonging to a different organisation could be difficult so the obstacle between them should be addressed adequately. Analysis of $T_{A,B,C}$-$R_{2,3}$ common findings helps to dissect this issue.
d) Real-time data communication through the AAME in the last mile process is beneficial to all the players. The analysis using $T_{A,B}$-$R_{1,2,3}$ supported this view, which is justifiably meeting the sponsor's vision for mobile M-theatre.

All the $T_{A,B,C}$-$R_{1,2,3}$ analysis are open to the AME player participation, that is, given the natures of tasks there could be infinite amount of players to be selected on the basis of economic considerations. However, AME industry is core competence driven hence it is not a completely free market as constrained in the logistics configuration (Figure 1.3.1). In this juncture, a remote access capacity is needed along with the task-route selection.

3.3.3 CELS player remote access and range of options

Given the diverse requirements of AME players and different ERPs and different task nature, the focus of alignment person has to enforce a common goal of OTP for remote ERP access.

Summarising the CELS$_n$ outsource companies choice of routes, process, connection, the following To-do's and Not-to-do's are derived from the Task-Route Matrix:



Where the circle action options are described by the following:

(1) Route-1 - faster to plan scheduled maintenance and operation planning data

(2) Route-2 - sharing of in-service experience and knowledge with airframers

(3) Route-3 - link suppliers for detail component logistics and repair information

✘ Options not taken in this research, assuming that has no major effect on choices

Figure 3.3.3 Range of options opened to players for remote access

The remote access capacity for the above logistics flow, the relative positions of the information "nodes" between any two players represent the closeness of opportunity. The ideal stage of AME SCN competitiveness balance was the common benefit for the network players. On the final result of performance improvement (Kaplan, 1996; Neely, 2003), a chain of validation process should be taken so AAME and suppliers can facilitate a change in work relationship. The focus alignment in all Route-1 to Task-A will help creating the SCN collaboration framework that would excel in the envisioned M-theatre. Hence, the contact and alignment must be tested with each route.

3.3.4 Sponsor airworthiness considerations

Currently, the AME working style is paper-based, task-card control and walkie-talkie based for frontline communications between the dispersed maintenance teams. If drastic measures are employed to test players' process improvement considerable risk could be incurred. AME stakeholders reminded that proposals should not impair air safety in case of failure. In this regard, a "big-bang" approach to re-configure ERP anchored on technology re-design is undesirable. On the other hand, the sponsors are willing to adopt demonstrable ERP frameworks that would initiate subtle changes of mindsets and working modes in adopting the ERP extension. So a 3-pillar support collaboration on systems features, application intelligence (So, 2005) and agility is designed.

3.4 Criteria Setting for Collaboration

A modified Criterion Reference Assessment Method (CRAM) originated from Lai (2004) is adopted to assess the research outcome. The academic and industrial measurements for the content and context establishments from the M-theatre basic elements would be used to set the criteria for linkage between cases:

a) Content - The basic elements of tasks, routes, players, mobile support framework formed the scope of extension. The configuration affects the frontline operation will be expanded into areas where existing ERP cannot reach. The need for OTP, as an improvement to the existing ERP connection points (Voropajev, 1998; Jacobs 2003), will be converted to a motivation for extension.

b) Context - The basic elements of network, motive, goal, criteria, opportunity, culture and behaviour are considered as awareness factors. These knowledge based features may

affect the inner core competence of the players, any mismatch between the process and the ERP is made aware to the network players.

3.4.1 Motive for collaboration

The motive of collaboration requires AAME to take initiative in supporting assets utilisation against punctuality, manpower and regulatory constraints. Hence, the CRAM (Lai, 2004) is tailored to reflect the above constrains:

a) Safety and reliability - this give rise to the boundaries of the research.
b) Restriction on daily operations - which limited the boundaries of extension.
c) Utilisation - with worsening aircraft departure delay has a focus on OTP process.
d) Obligation - knock-on effect of delayed departure, which defines the lower bounds of the improvement targets.

3.4.2 Tangible goals to meet sponsors' needs

To address the problem of delayed tracking of reliability performance affecting despatch maintenance decision in frontline, ERP extension is designed to display technical data that are organised in a convenient way for frontline engineers. Analysis of existing practice revealed inefficiency in troubleshooting tasks deferrals for all Route-1 to -3 and Task-A to -B. A 30% improvement (a rather aggressive target) was created for ERP extension.

3.4.3 Activities for value creation

Value creation is the motive of performance activities under the proposed deployment and supportive framework. Activities are tasks initiated by the researcher to capture empirical data are filtered using the criteria proposed. The range of activities is defined as closely related to

the goal of supportive framework deployment to reduce the deviation ***d*** OTP (see Section 4.4.2 for detail calculations). These activities are essential to designing the case study or project deployment for the actual site selection, player connection or process data collection and finally the actual OTP improvement.

3.4.4 Before and after collaboration on ERP extension

Under this cultivated player environment, a new behaviour pattern is targeted between the Routes-1 to 3 players. The supporting AME firms are strive to transform the old relationship for a new level of co-operation, i.e. from the conflicting environment to a collaborative "Win-Win-Win" situation between the players while connecting the ERPs:

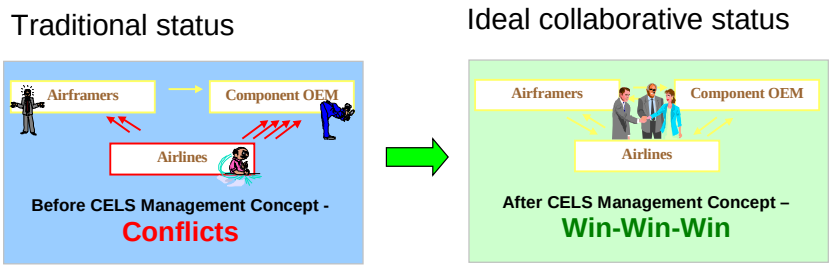


Figure 3.4.4 CPFR transformation AME modus operandi

Conflict is a form of uncertainty as per Koh (2003). To overcome this issue the design of M-theatre must change the existing modus operandi to a “sharing” platform between the players (Leung and Chung, 2003). The benefits may accrue with the different players in the new environment [Tripartite view, ref. Chung, (2003a)] for the new characteristics, features and relationships that will lead to changes of process-ERP matching in the outsource environment. The OTP metric will boost the effectiveness of the whole AME (Kaplan, 1998; Neely, 2000), because fundamentally AME companies and their processes are chained.

3.4.5 Defining collaborative ERP extension framework

This description provided some conceptual insights, based on literature results, survey and analysis for AAME's driving forces. Then, a breakthrough in ERP is envisaged:

a) industry segments and players are encouraged to collaborate, and
b) player roles and functions can be changed, but knowledge sharing and learning is key;
c) value creating activities are taken up by various players in developing infrastructure business, customer relationship and product innovation business, and
d) the researcher will be recognised by the players as an agent of change. Matching the requirement of the processes to fit in M-theatre context on real-time basis, which is vital for ERP extension success.

3.5 Building the M-theatre Performance Criteria

The AME performance metrics using established criteria requires higher incentive. Once players' goals are aligned, successful applications in M-theatres with OTP data definitions will be agreed with each player (Yakubowsky, 2003) in the following 3 steps:

a) "Under control" (minimum achievable for improvement) - This is for maintenance staff to perform the task only, without sharing the awareness of expansion and why ERP has a constrained capacity and connection, for the given OTP targets.
b) "Above average" (slight improvement over the existing situation) - Through the sharing of the knowledge and improved awareness but not due to collaboratively work modes on the same framework. Some alignments will be defined at this stage.

c) “Success” (maximum improvement, so that OTP becomes a straight line whatever utilisation increase is envisaged) - Both the working mode and communication mode are changed to improve the situation.

3.5.1 Grouping of Task-Route for content or context driven extension

The matrix of collaboration opportunity can be used to develop context awareness as a first step to instigate testing projects. Then triangulation methods will be employed to check the route-task combinations. This forms the basis for research result analysis activities in the proposed deployment methods. Since the framework takes care of two fundamentally important roles of the Task-Route matrix, it should be designed to a) identify key issues in AME SCN and b) get players to work along on the feasible path that can lead to alignment of ERP usage in meeting the stakeholder concern.

One approach is through “content extension” Figure 3.4.2a, and the other is through “context awareness” in Figure 3.4.2b with a selected task-route grouping. Empirical data grouping in the case studies supports these two different task groups (Ref. Appendix III.3.3):

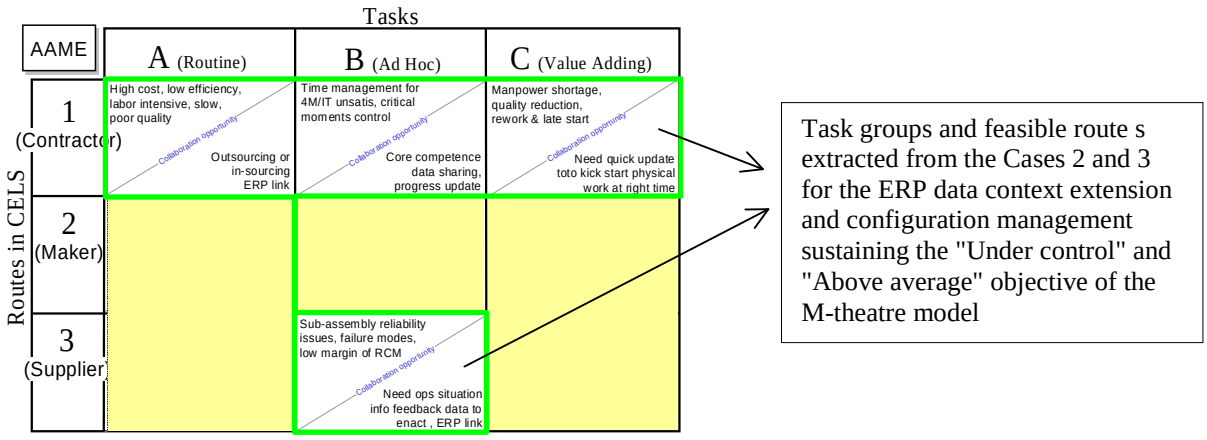


Figure 3.5.1a T-R Matrix to show Content Extension opportunities

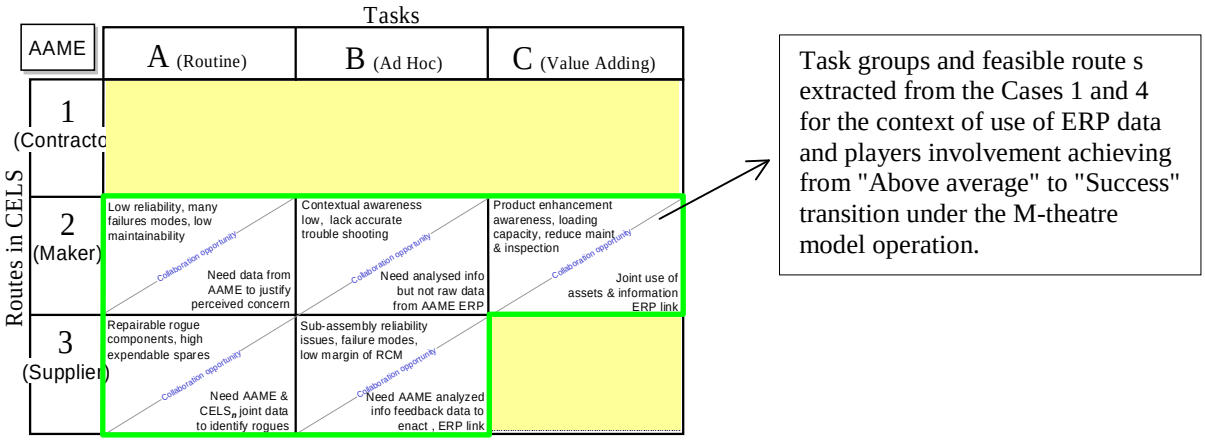


Figure 3.5.1b T-R Matrix to show Context Awareness opportunities

The choice of the groupings is defined for case design and opportunity of change. The OTP improvement by different incidences will be observed in the reference site with the incidences, according to agent's plan the deployment is designed as follows:

a) Context awareness - mainly focus on the process improvement that will shorten the ad-hoc troubleshooting maintenance, to be designated as Case 1, in an environment that would cultivate the back office reliability improvement programme.

b) Content extension on the key process closest to OTP flight despatch - the test of workable mobile framework will allow the maintenance staff to explore the usability of the framework, to be designated as Case 2. Empirical data will be captured for ERP extension toolkit demonstration.

c) Content extension for the capturing of departure data - the capture of real time OTP data will form a continuous stream of "bits and bytes" for ERP extension so that the data is no longer treated through a specialised party, but it will be dissimulated to all usable parties. This is designated as Case 3 for auto data collection on the basis of operational, business and process level KPI calculation.

d) Context of use of frameworks in the theatrical network - the use of theatrical network for designated task-route will be finalised for sponsor's alignment, which give rise to recapitulation of context of use in AMEs collaborative activities. Designated as Case 4, this will be used to finalise the whole maintenance theatre concept.

3.5.2 Diamond Model supported analysis steps

Incidences involve network, people and activities (Hankasson, 2003), the Diamond Model-SUCCESS- has now been refined sufficiently to show the players positions in seeking for ERP extension decision through selected paths by the focal point of alignment. With the task-matrix relationship established, the player management activities can now be defined and gone through the strategic movements to sort out the feasible, shortest and unobstructed path, as shown in Figure 3.5.2a for Case 1:

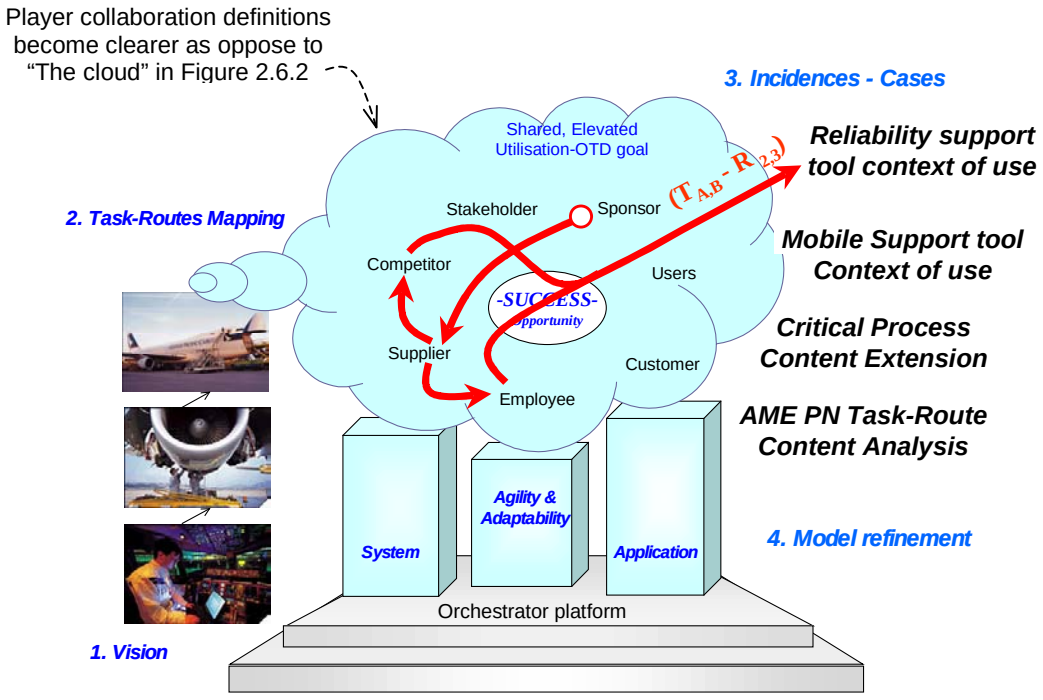
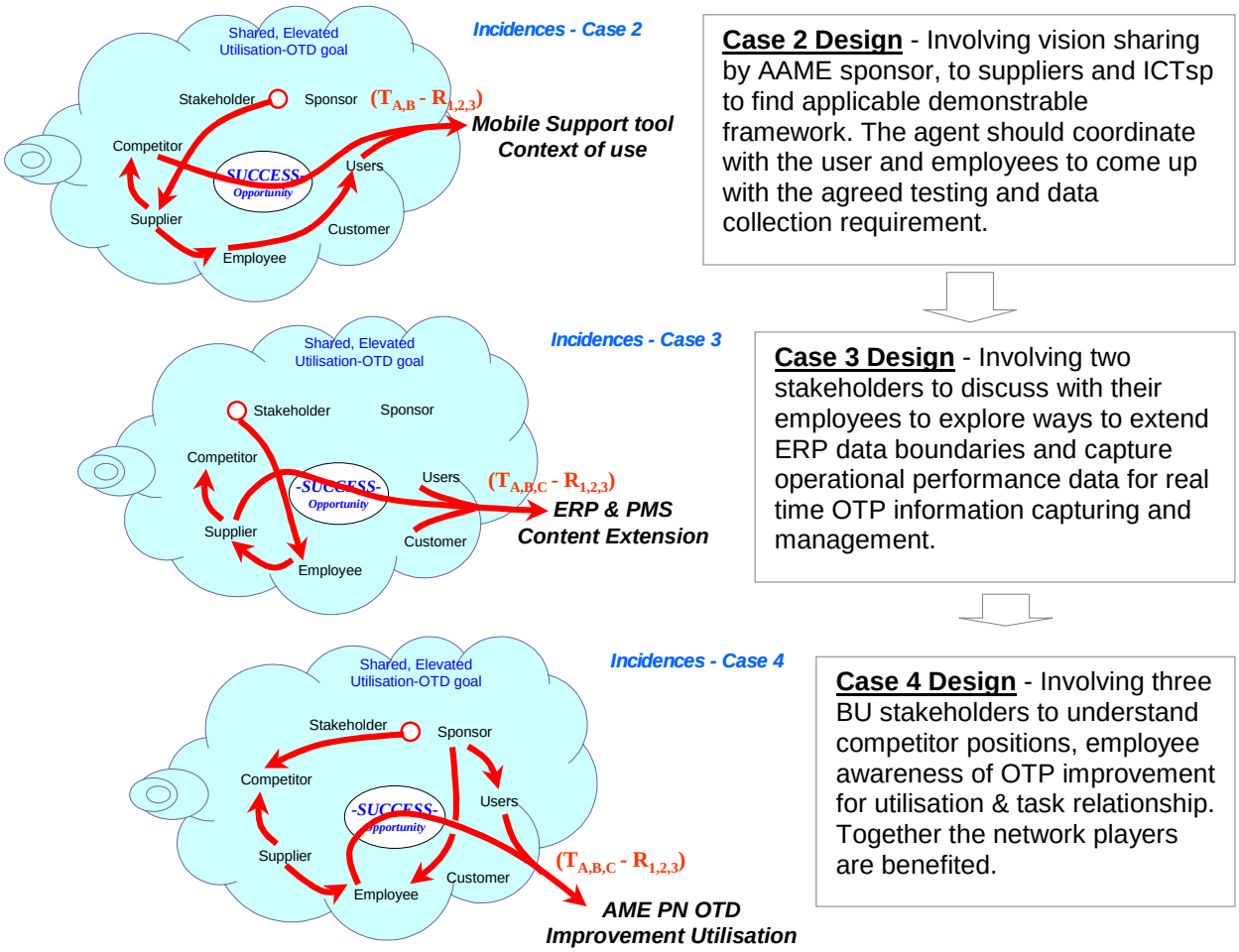


Figure 3.5.2a Diamond Model player analysis routes - Case 1 C-H Method

So the “player management cloud” sits on top of the 3-pillars [system feature (Pak 1999, Yuen, 2005), agility (So, 2005) and application (Chan, 2005)] for ERP extension has become clearer. In each case, the matrix is checked carefully along with the M-theatre task-route paths. The final track as shown in red arrows segments are constructed based on -SUCCESS- player positioning. The following steps illustrate how the path is defined by context awareness, and how players are responded in the alignment roadmap:

a) Step 1 - Engage the sponsor’s vision and check with knowledge gap identified to make sure that the vision can align with the opportunity for growth in that arena.
b) Step 2 - Carry out key process analysis through a task-route matrix analysis for the required level of improvement.
c) Step 3 - Identify collaborative opportunities for the key process and design the case study for each incidence, using the Diamond Model elements to cross check the player dynamics and go through a similar players path analysis through the -SUCCESS- response. Finally, decide on which player needs to be involved with a group consensus.
d) Step 4 - Feedback case major findings to check if theatrical management factors are fitting into the conceptualised path of improvement. If not, reject the case and summarise the points why it was not included. If successful, feed the collaborative elements to the model and register the contribution.

The above process is repeated for the other 3 cases (Case 2 to 4). This will make use of the path illustration within the -SUCCESS- cycle for player management method with a similar arrangement. Hence the second task of this research is to be accomplished through demonstration of the player management cycle as shown in Figure 3.5.2b:



Note: → denotes the player alignment path designated by the -SUCCESS- cycle

Figure 3.5.2b Diamond Model player path analogy for Cases 2 ~ 4 designs

The player contributions and the actual performance improvement in these intricate processes adhered to the natural progress of incidences. There is an important balance between the "case" itself (Yin 1994) and the controllability over the cause of actions (Hussey, 2003) even though some of these industrial incidences are not entirely uncontrollable. The case study design should take care of real life operation constraints where certain testing elements are not entirely designed by the researcher (which is a benefit for the external validity). So the model can sustain with any changes of external factors, as long as the basic assumptions are retained.

3.5.3 Units of analysis

The chemistry inside the "clouds" in Figures 3.5.2 started when the cases that are subject to review and players are connected via a deeper understanding of competitive factors. The units of analysis should be repeatable when the content extension and context awareness are becoming more generic, not for just one individual company. The player collaboration factors should enable the following logic to be measured as repeating units:

a) Check if the players, in the order of path, have shared the same goals of alignment and willingness to improve up to the required performance (validated in Case 3).
b) Check if the players have developed similar ERPs, if not, identify the common points of connection, patterns for interfacing with minimum extra efforts (validated in Case 1 & 2).
c) Check if the players have become aware that the alignment could result in change of landscape in business level (managers, stakeholders) and process level (front line staff) (validated in Case 4).

3.5.4 Critical Success Factors

Successful alignment is based on the feedback of AME players who is willing to test a new collaborative framework. This could result in unsynchronised goal-pursuing if alignment is absence. Hence the M-theatre framework has defined the units of measurement mainly as a) whether AME companies staff are willing to adopt the ERP extension software and toolkits for test or not; and b) the actual quantitative OTP improvement is resulted when the collaborative frameworks are used in combination or standalone. These units of analysis should be tied in with the problem formulation (Section 1.4) and the literature gaps (Section 2.6), which will be illustrated in the Methodology chapter.

Chapter 4 Methodology

This chapter presents the research steps for industrial-academic collaboration, what should be done at different stages and what data needed to conduct cross case analysis. Finally a validation method (para 4.4) is used as per Yin's (1994, p49) multiple cases protocol.

4.1 Research Design for Case Studies Agreeable to AME Management

The first step is to get a certain level of alignment between parties related to content extension and context awareness efforts. These are contributing factors to align M-theatre players and AME managers. Data has been captured in AME maintenance and logistics network to support first syndication and second conceptualisation of ERP extension for CELS through the 4-level concerns defined in literature summary:

- Level 1 Data: ERP implementation must contain the institutionalisation of process, skill, and alliance. Case analysis is needed to confirm the empirical nature of data.
- Level 2 Circumstantial: New technology toolkits must be tested to see how they support and adjust the logistics skills tailored for the new tasks.
- Level 3 Mental: Changes should occur in a natural basis from pure contractual requirement to collaborative support through the use of ERP extension paths.
- Level 4 Satisfaction: Higher level than trusted collaboration is to be gauged to advanced logistics concepts such as CPFR reference points.

These institutionalisation stages are linked to the logistics routes (between companies) and the task process refinement (between actual work done in the aircraft) to instigate collaborative progress. Using the matrix constructed for the CELS concept and M-theatre management in

context of network, individuals who work within established organisations could become socialised into organisational values and norms. This will bring in an alternative method to progress for more structured institutionalised process for ERP extension (Pyka and Küppers, 2002, p171).

This methodology uses the findings from a series of cases to focus an individual's critical judgement and reasoning. However, mental fixation could be resulted in oversight and slow reaction, hindering adaptation to new circumstances. Yin's (1994, p130~140) multiple cases study method suggested that analysing diversified corporate cultures can lead to answers. The circumstantial factors for Task-Route matrix and the -SUCCESS- player management paths will help to answer the following questions:

a) What is the condition for deployment of ERP extension toolkit? (Case 2)
b) What is the environment for populating the software? (Case 1)
c) What is the situation for performance system to excel? (Case 3)

The answers require linkage between cases, through the researcher to feedback the literature relevance, particularly on ERPs across the network. The CELS concept will be validated to see if it was just a good illustrative thought, and ERP extension should only be exist in a vague form. Hence, a more methodological validation is needed.

In order to establish the extended ERP path with academic background, it should be validated from all aspects of project deployment. Using a standard research methodology flow to help the agent to pass the cloud of uncharted player management, this research will meet the required network-wise improvement at the end.

A method developed from Yin's (1994) case study protocol and Creswell's (2003) process improvement is proposed for academic and industrial approval. This is a way forward to validate the concepts and evaluate the level of success as compared to the objectives:

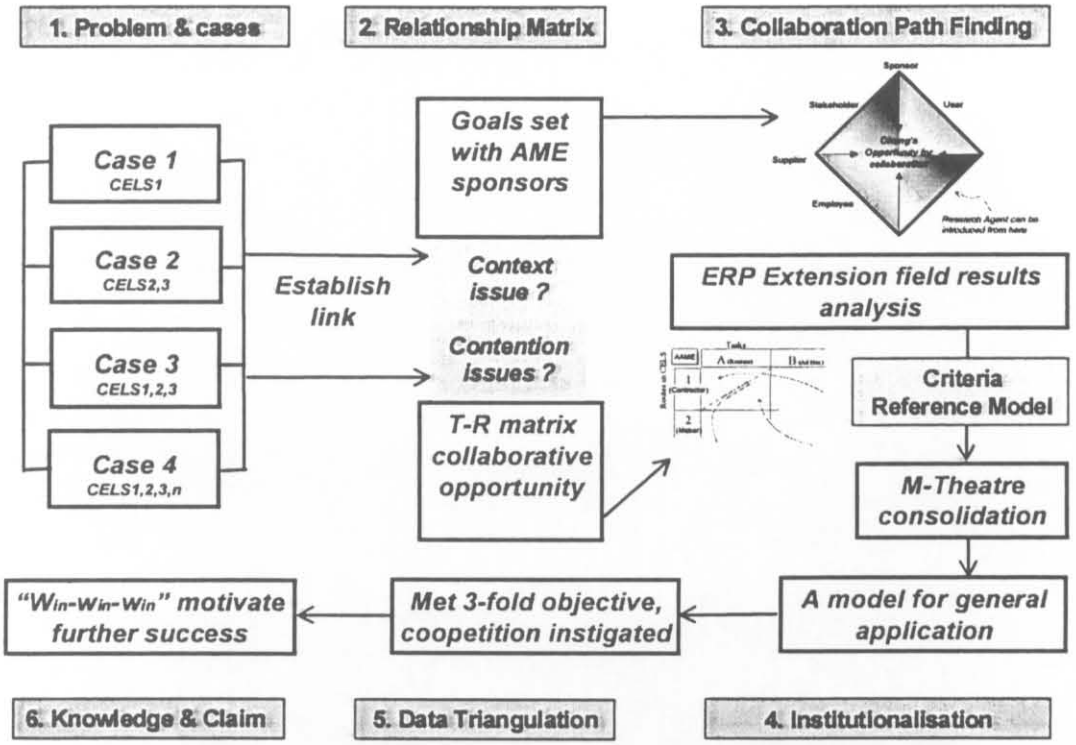


Figure 4.1 Research Method for Collaborative CELS Framework

4.1.1 Rationale of selected research method

The rationale for this method, as opposed to other quantitative methods began from the operational reality in action learning (Revans, 1993). The fleet expansions in the aviation hub in Hong Kong have encountered more aircraft types and quantity (e.g. Cathay Pacific Airways 29%, Dragonair 42%, Air Hong Kong 48% and other smaller operators 66%) in unprecedented scale. Segmented process ownership and de-linkage in critical processes [reference Appendix III, Leung et al, 2004 on business process and performance study] rendered a step-by-step research methodology to be ineffective. This challenge was not

limited to one airline but almost all AME players. The decision on design cases should be linked through agreed focal points. Case 1 originated as a single player initiative to resolve a narrower technical performance to improve OTP hence its deployment was relative close to present date. Case 4 involved 3 layers of supply chain and more, it took almost 4 years to complete:

Case 1 - CELS1 (QREI journal paper Jan 2007)

Case 2 - CELS2, 3 (JMTM journal paper Aug 2006)

Case 3 - CELS1, 2, 3 (IJBPE journal paper co-author Jan 2006)

Case 4 - CELS1, 2, 3,, n (Based on a Business Excellence Conference 2003 paper)

4.1.2 What should be measured at the focal point of linkage?

The researcher and the designated M-theatre players agreed to advance the understanding of the maintenance process paradigm by setting up linkages for each case. By capturing players' focus and their management requirements it would be possible to construct a logical flow path for the M-theatre task-route design and player management (See Appendix III).

Hence the concept of M-theatre player management (Section 3.4) for detail project progress control and analysis would be developed from the CRAM criterion (Lai, 2004):

a) Comparison - Key operational data are taken before and after M-theatre deployment. This would form the basis of OTP improvement and players contributions, as oppose to the increase in utilisation and other assumptions.
b) Integration - Mobile applications discussion took place with designated parties in Airline A for a proposed test to get the benefits of collaborative actions in the logistics and maintenance operation support. Linkage design is important for integration.

4.1.3 Comparing Content Extension

Since the AME industry has no direct process similarity in CPFR methodology (ref. Seifert 2003), this research introduces the necessary portions for comparison, e.g. logistics contribution in the parts arrival counts in each case. The players may not be aware of the benchmarking with newly proposed framework. Task-A, B and C deployment will meet the required Routes-1, 2 or 3 are considered as ERP extension features (Case 2) for such application. So the agent (researcher) developed case linkages method and criteria to record incidences close to CPFR intent, and to support the final argument.

4.1.4 Comparing Context Awareness

The contextual requirement is based on AAME's obligation to keep aircraft in the air as long as possible. The agent should provide the context awareness for players and the service providers to ensure that the following attributes are included in the cases:

a) Safety reliability requirements - take it to Route-2 for the Makers responsibility.

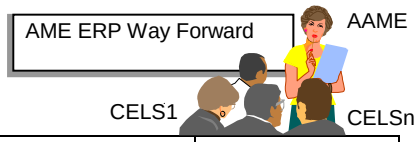
b) Restriction on daily operations - take it to Route-1 and -3 for CPFR targeting.

c) Utilisation with deteriorated departure delay - back to AAME ownership.

d) Despatch reliability falls below world competitors - feed the issue to ICTsp.

4.1.5 Integrating sponsors' need and aligning management views

To recognise the units of analysis, a workgroup meeting was conducted with the AME sponsors CELS1, 2 and 3 for agreed case study data capturing. A "traffic light" (Neely, 1996) analysis method was proposed to engage the AME management and the frontline maintenance staff. This is to set the ERP extension focus and the process technology support for the direction of improvement (also see Appendix III, Case 3 for background details):



M-theatre ERP Extension Alignment	Network Player focus	Process Technology
<u>Collaboration opportunities</u> supported by latest findings in ERP extension strategies way forward:		
1. Grasp ERP deployment critical factors study? *(Gunasekara, 2003)*	*45%*	*34%*
2. Managing of uncertainties in deployment? *(Koh, 2006)*	*78%*	*56%*
3. Inclusion of features to fix "Power & Politics" *(Markus, 1983)*	*59%*	*49%*
4. Address ERP "Win-lose" problem for players? *(Markus, 2006)*	*60%*	*22%*
5. Taking optimisation to the limit? *(Yu, 2005)*	*23%*	*12%*
6. Collaboration difficulty should network help? *(Botta-Genoulaz,2003)*	*50%*	*58%*
7. Strategically chaotic implement for players? *(Österle 2001)*	*60%*	—
8. Players not support *(Somers & Nelson, 2004)*	*43%*	*90%*

M-theatre requirements

N.B. The grey boxes are considered pre-empted areas for ERP extension

The following depicts the traffic light convention for M-theatre successes:

- Very positive feedback for the level of satisfaction achieved

- Positive level of satisfaction in general however critical success yet to achieve

- Delay encountered for not meeting the definite outcome, lack of direction

- Definite dissatisfaction aroused for the proposed criteria

- Some uncertainties exist about the proposed criteria

Table 4.1.5 AME management workgroup summary

Hence, the above Do's and Don'ts would form the specific fleets' OTP requirements for ERP extension, as depicted by Neely's (1997) business performance approaches.

4.2 Reference Site Selection

The agent and work teams designed a “Crystal-1” toolkit to measure the process improvement data against the OTP requirements. This apparatus defines at where the ERP extension support should start and end (detailed in Appendix II). In practice, the agent used Crystal-1 to capture operational data using connection software at initial stage, and then further developed for advanced pattern recognition display as for Case 1 applications.

4.2.1 Practical choices of testing tools for ERP data collection

The proposed studies involved the use of physical tool which enables the existing players’ ERP to be economically connected, and to take up gaps in the new mobile environment as opposed to Bapst’s proposition (2000). A combination of hardware selections was short-listed to carry out MWM test (Case 2):

a) Maintenance dedicated laptop devices (initial mobile application test frameworks) - Tools are already existed but will be used in parallel work with a tailor-made Crystal-1 design.
b) Handheld portable digital aid (PDA) (Crystal-1 design to meet AME player-focus requirement) - Selected by AAME management for test data collection.
c) Tablet PC (general purpose demonstration, proposed Crystal-2 demonstration) - For advanced on-site support and interface which requires further work in the future.
d) Tough Book (military grade portable maintenance system application support) - That could be inline with the future e-flight-bag framework, however cost is an issue.

Finally, the interface design supports ERP extension applications that are closely connected to the real life AME situation. The user interface is articulated by the following approach:

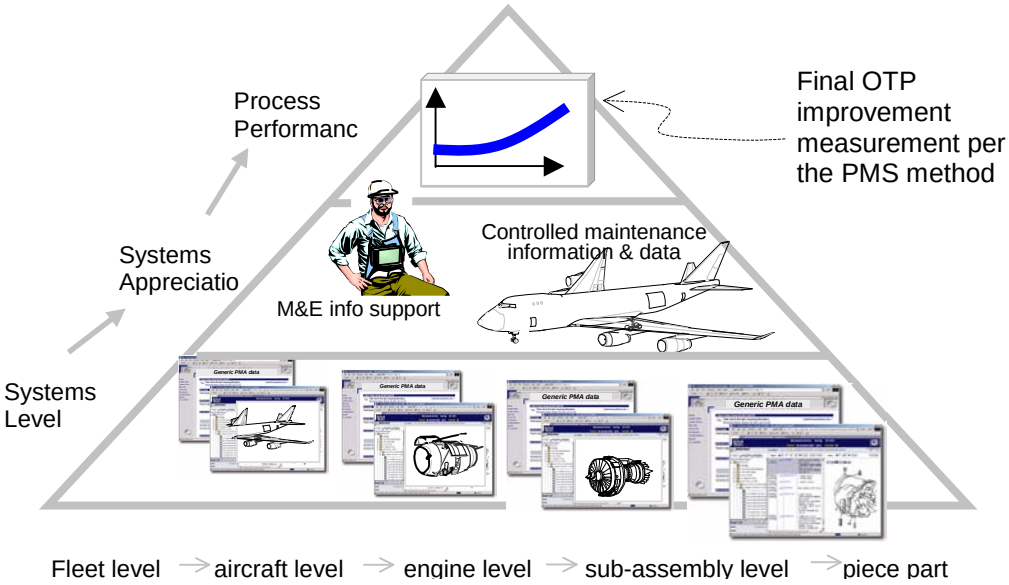


Figure 4.2.1 Range of choice of software and level of tests

Source: Leung and Chung (2005), Systems and application development for portable maintenance aid (PMA) - A performance perspective, JMTM, September 2006

Figure 2.4.1 depicts the approach that the agent would introduce Crystal-1 as a linkage toolkit to test the focal point of alignment between the players (Third objective ref. para 1.4.c). Crystal-1 adoption will commence with frontline staff and maintenance policy makers and planners, and the following were activated for “staging” of each role:

a) Improved overall linkage of content management to core product and service.

b) Streamlined costs associated with content creation, management and delivery.

c) Increased organisational agility and effectiveness by automating delivery.

The Crystal-1 prototype supported the researcher to collect survey data from the users and managers in the meeting or in the flight despatch scenario study (details can be found in Appendix II) for ERP extension in frontline application (Bendoly, 2003 and Bapst, 2000).

4.2.2 Theatre management cases using Crystal-1 as linkage

The theatre approach allowed the researcher to bring out cross-disciplinary information, conflict resolution and logistics update to promote understanding of the "big picture" in the M-theatre to the down stream component suppliers in the CELS network:

a) Initially, Boeing, Airbus and multiple tier suppliers comments are invited on how AME players are using the OEM data. Then, more planning and logistics parameters will be linked by OEMs to help AMEs to meet the overall SCN improvement objectives.
b) Other AME service providers had not been included in the test previously will be invited. This will meet the player development intent, as intermediate linkage.
c) Other airline operators would consider Crystal-1 as an important system technology enabler for their future development will be treated as partners for a final linkage.

4.2.3 Capturing players focus through Crystal-1 prototype

This framework will direct the research projects to seek the necessary proof for the cases although different input formats will be gathered. The Crystal-1 design represented an initial form of alignment amongst the AME industry, maintenance planning and airframers for M-theatre conceptualised ERP extension demonstrator, as shown in Figure 4.2.3:

Crystal-1 Demonstrator

- **Agent purposed features**
- **Pattern recognition display**
- **Support maintenance reliability improvement**
- **On-line access to the ERP information**
- **Frontline engineers usability**

Figure 4.2.3 Crystal-1 prototype for M-theatre testing

4.3 Tangible Measurement and Process Variables

Using the Crystal-1 for Airline A's OTP measurement it was able to directly captured data at the point of departures (in airport ramp). This approach, as shown in methodology step 3 in Figure 4.1 for field data collection is innovative in ERP extension. Not only to demonstrate the use of extension toolkit for the AME players but also to by-stand the actions through decisions aligned in Table 4.5.1 and learning from previous ERP adoption experience. It has initiated a work mode change within participants, in terms of context awareness.

4.3.1 OTP performance improvement in higher utilisation range

Crystal-1 support a new method to push SCN data to the frontline AME users, this can be compared with the CPFR rated operation in high utilisation fleets (e.g. freighters in Case 2 design). The following activities are measured for improvement (in Case 3 data collection):

a) Tracking maintenance tasks communication has been improved while compiling the "to-do" options to share the information. Instigation of systematic mobile deployment plan, so that back office information can be offered, that was unprecedented in AME operation.
b) The deliver speed of spares to designated location has been increased so that the CPFR concept can be instigated and applied in the task oriented maintenance service industry.
c) This enables up-to-date inventory reports and alleviated the problem for the front line engineers who might not be trained to deal with the spare demand effectively, the time taken to get a spare would be significantly reduced.

Each step taken through Crystal-1 demonstrator was aimed at addressing certain issues identified that have caused flight delays in the previous flight despatch studies.

4.3.2 Delayed performance analysis

Using Crystal-1 supported ERP extension the AAME would be able to achieve improvement based on operational targets: faster routine maintenance, accurate trouble shooting for ad-hoc maintenance, on-time delivery of value adding service as detailed in Task-Route matrix analysis (Ref. Section 3.3). The overall goal is measured by the OTP delta time $\boldsymbol{d}$ by adding the delay time deviation $\boldsymbol{d}$ of the 3 sources where frontline engineers will encounter in each Task-Route deliverable:

$\boldsymbol{d}$ OTP = $\boldsymbol{d}$ (schd maint) + $\boldsymbol{d}$ (ad-hoc maint) + $\boldsymbol{d}$ (renovation process)

These expectations would become the numerical goals, aligning AMEs to overcome difficulties encountered by maintenance staff in the frontline in the high utilisation portion. With this new T-R analysis matrix, the AME workgroup expects to enhance contracted service providers' mutual communication. The work group agreed that Crystal-1 enabled ERP extension should tackle the following inefficiencies in the system:

a) Unable to communicate key maintenance data through walkie-talkies. A survey revealed that this has contributed issues in all Tasks-A to C deferrals for Route-1 by 10% (standard deviation s.d. 2%) [Ref. Case 3 improvement targets Appendix III section III.4.1].
b) Slow to return to the maintenance bay for data analysis to be done in back-office. A survey revealed that this has resulted in issues for Task-B deferrals for Route-1 by 10% (s.d. 2%) [Ref. Case 3 improvement targets Appendix III section III.4.2].
c) Inefficient to handle large amount of data outside the scope of the printed work card. A survey reported this has contributed to issues for Task-C deferrals in all Route-1 to -3 by 10% (s.d. 1%) [Append III section III.4.3].

4.3.3 Data collection design for M-theatre visibility

Through the cases designs, the M-theatre instrumented several qualitative interviews with the frontline engineers, and the feedback are tabulated in Appendix IV.2 and summarised in Section 6.1.2 for results analysis. Four areas are being focused for AME player and it has been decided that some data are to be shared with the competitors:

a) The definition of mobile supported theatre roles related to maintenance applications would be given at the beginning of the questionnaire because the CELS concept is new to them.
b) Each question for M-theatre functionality in the questionnaire was refined with the AME group consensus.
c) The term 'wireless device' in the questions about customer interaction methods used was explained further by giving examples.
d) Each mobile maintenance definition was rated with a five-point scale instead of binary scale for more qualitative message, this also included the competitor's views.

4.3.4 Linking collaboration opportunities as institutionalisation process

Comparing the task-route analysis within the M-theatre concpet, Pyka and Küppers (2002) have provided good institutionalisation checkpoints for the industrial network. The accumulated benefit of ERP extension in the theatre environment captures all the $CELS_2$, $CELS_3$ and $CELS_4$ involvement for real-time information feedback to support task accomplishment:

a) Players will connect flight operation plans to actual maintenance (Case 2 condition).
b) Users will capture specific types of technical data and information (Case 2 condition).
c) Frontline engineers will link problematic areas to effective rectification (Case 1 condition).
d) Measurement indices will cover the Route-1 to 3 features (Case 3 condition).

If a linkage can be built using the institutionalisation process as defined by (Pyka and Küppers, 2002) for each case this will constitute a strong argument for the concept integrity.

4.4 Validation of Research Methodology

This is through continuously writing the case studies (and some are published as journal papers) to check if original concept meets the academic and industrial improvement (Yin, 1994). Hence the methodology will include the technique to check if the results would support the following validation process.

4.4.1 Construct validity

The construction of appropriate operational measures for the M-theatre concept relies on the knowledge gaps identified in the literature reviews. This helps to find out what measurements could be used. The proposition of this research is a collaborative action approach which should be adopted for the benefit of AME companies with cultural awareness and tangible improvement. After meeting with the managers in the AME SCN, it was confident that the M-theatre theory was created from a valid operational OTP shortfall (an apparent problem) to a networking issue (hidden problem) for alignment. This is a logically sound construct and is appropriate for case studies (Yin, 1994).

4.4.2 Internal validity

The internal validity sits within the research project progress. The aim is to acquire certain credibility based on the casual relationship in an explanatory sense. The analytic tactics for each case is to use explanation building and then searching for the causal relationship (Hussey, 1997). Hence the cases are to be analysed at their termination phases and their conclusions

linked to the other cases. As a whole, this progress could be monitored by observations in the extension process hence the results are controlled and are compared with analysis logic:

Results / Controllability	Matching with M-theatre goals	Different from the M-theatre goals
Consistent with the approach or controllable in the case	Relevant for theory building and linkage	Explain, or reject the approach
Deviated form the approach or uncontrollable in the case	Reject	Explain, or reject the approach

Table 4.4.2 Analysis logic for controllability and results

4.4.3 External validity

This portion of the research emphasises on checking the case findings, to validate whether the theory could be generalised under the given assumptions. In this validity check the replication of the new theory should be agreed on another reference site (local and overseas). The approach was synthesised in the form of a maintenance service model so that other industrialists could adopt it. Replication of theory could be tested somewhere else, e.g. by showing that the institutionalisation process be used in another research.

4.4.4 Reliability

This requirement aims at illustrating whether the research could be repeated with the same results, i.e. similar level of success. In this regard the agent (researcher) reported cases to encompass all the details of his intervention and relevant findings. Then a later researcher would be empowered for replication through Case 1 to 4 in operation, on the effect of focal point of alignment.

Chapter 5 Case Studies Summary

The four cases are originated from a local international Airline A and another private Airline B. The linkage of each case to total M-theatre is through Hussey's method (1997, p256). A brief description states the situation followed by result analysis. Finally each case's collaborative characteristic will be depicted a final linkage in Section 5.6.

5.1 Cases Capturing and Criteria for Linkages

Through working together party interaction and the M-theatre collaborative supportive framework, the agent (researcher) has completed four cases. Thus accomplished the required deliverables with measurable of outcomes. The tangible-OTP improvement for the aircraft fleet will be subject to progress analysis; and the situational awareness for the frontline workers and the management are reported so that a new mode of work is evaluated.

5.1.1 Common points on linkages

All cases are subject to a linkage analysis for collaborative framework design (ref. Section 3.4.2) based on theatrical management factors. The propositions are set to use an OTP result back-driven approach, i.e. the first **L1** being a final performance related and the last **L7.** This reflects the case linkage definitions that are defined by Section 4.1.2 CRAM methodology and Section 4.3 tangible measurement against process variables.

5.2 Case 1 - Context Awareness Framework (Controlled)

5.2.1 Carroll-Hung Method reliability improvement

The C-H Method has been established to provide reliability improvement to airline OTP. (Appendix I details the work for Hong Kong and USA based airline) and its potential for global and domestic airlines for such application. The principal activity of the C-H Method is using a new pattern array to speed up reliability decision to support Task B type maintenance.

a) Situation Analysis

With competition coming from other technical management AME service providers in Hong Kong and overseas, higher expectation from airlines demands the reliability tools to be applicable anywhere. AAME wants any CELS partners to align the pattern of reliability picture so that focused effort will be resulted for OTP related maintenance.

b) Initiative Addressing New Algorithm

The partnership arrangement allows greater assets utilisation while ensuring the distribution network is responsive enough for high availability of components. This allows third party players to work with the competitors to access the reliability data and do the analysis by themselves. In this way, greater utilisation of assets will be achieved (Leung et al, 2006).

c) Unit of analysis - User interface of innovative method

The use of the C-H method is a success in both academic and industrial dimensions, also the competitors are willing to change from their critical viewpoints to closer connection and contributed in the knowledge where the new method is developed, tested and finalised.

d) Brief Conclusion

Compared to other reliability tools, the C-H Method eventuate real benefits in AME. Context awareness from Airline A institutionalised a change where SCN can be enhanced through identification of rogue aircraft components. Airline B marketed it as a smart maintenance tool to help Boeing, Airbus and Northrop-Grumman airframers.

5.2.2 Case 1 linkage to M-theatre model

L1: *Software as key reliability tool is crucial with features and knowledge gathering, and training needed for proper mobile integration support.*

The case for the $CELS_{1,2}$ is depended on the mobile display using Crystal-1 deployment in the M-theatre. The nature of the software is to encourage player involved context awareness.

L2: *Task accomplishment through mobile computing is considered as the first priority for the feedback in OTP performance management.*

The benefit is not limited to Route-1 or -3 processes because it has given a long-term effect to all other processes. The AAME A cannot accomplish and advocate all reliability patterns alone, they need to share it with the upstream suppliers.

5.3 Case 2 - Content Extension for ERP (Demonstrative)

5.3.1. Portable maintenance aid system

Airline A has a fleet of 80 aircraft and does not carryout the actual maintenance activity. The overhaul, transit check, component repairs are outsource hence organisational boundary for aircraft OTP management is critical. The delayed departure due to awaiting completion of routine maintenance could be alleviated using mobile ERP extension approach.

a) Situation Analysis

The MWM experience for heavy maintenance on tasks, they are converted into aircraft departure checks. The higher utilisation of the fleet puts pressure on flight dispatch tasks. Hence this prototypic demo is staged in the M-theatre for OTP improvement with Crystal-1 features ERP extension connection and reliability results display purposes.

c) Innovation to Address Emerging Inter-firm M-theatre Issues

The initiative identified by this case is a system-application-intelligence approach in the overall enterprise performance framework to secure the competitive advantage.

d) Unit of analysis - Human and machine adaptability to OTP process

The M-theatre toolkit addressed the OTP issues at the inter-organisational level, through development of new user interface for AME players. Crystal-1 features are refined using Apriori correlation to define the basic building blocks of inter-firm collaboration.

e) Brief Conclusion

This study is important in the vast open area in Chek Lap Kok Airport with complex interactive relationships between CELS. It has forged the effort of connecting loosely linked ERP data (Chan, 2005) for real-time information transmission.

5.3.2. Case 2 linkage to M-theatre Model

L3: *Capturing of trouble shooting data and hardware wireless framework can change people's view about ERP connectivity for the task planning information needed.*

For Task B ad-hoc nature support a large number of data sources will be provided by the increasingly connected airframers (makers) and suppliers information. The suppliers of the specific aircraft type data has different formats which are covered in ERP extension with unchanged ERP codes. The complex technical data should be transmitted to the front line staff as efficient as possible, that will include detail repair instruction steps that can be marginally performed in the M-theatre capacity.

L4: *Frontline staff can link to back-office reliability management perceived benefit using portable maintenance aid support tool as an acceptable means of communication.*

The frontline troubleshooting Task B working party has mutually understood the CELS situation and the sponsor's instruction. The mobile toolkit can make a difference for effective defect fixing, under the perceived and stated conditions. For Task C, the participant who defines the interface would test the systems first due to a wider scope between AAME and the suppliers' Route-3 path (Ref. Appendix II.6.5 for the correlation factors setting). Hence it is theorised that:

Focus of alignment = Process and ERP extension matching in a remote access point

5.4 Case 3 - Measuring Utilisation-OTP Dilemma (Illustrative)

5.4.1 Business process engineering framework for OTP

a) Situation Analysis

AME's OTP improvement incentive has driven the AME players to response more proactively to a jointly developed PMS system. This supports contract maintenance industry with key performance indicator (KPI) for new service requirements. One necessary condition identified for critical process is KPI indexing and reporting.

b) Innovation Initiative Addressing New Inter-firm Arrangement

At the early stage, the actors' relationship linked to various players. The personal connections already created can be spreading with new work process and knowledge sharing routinely between the firms. This allows players to learn more quickly together.

c) Unit of analysis - Process performance measurement alignment

Formulating a strategy to leverage key influences in M-theatre environment can influence other players that are not prepared to share. A newly forged relationship allow AME's and suppliers to secure collaboration at the inter-organisational level.

d) Brief Conclusion

Through an extensive in-depth analysis of OTP KPI's, the agent has led the group to a proliferation of new inter-firm arrangement. In practice, Airline A purchased more safety replenishment stocks and new maintenance arrangement as a result of this study. The OTP improvement enhanced ERP extension success accumulated from previous cases.

5.4.2 Case 3 linkage to M-theatre Model

L5: *Business process in critical OTP steps depends on player awareness of the Last Mile definitions and CELS opportunities to meet the final performance targets.*

Routine Task-A scheduled maintenance last mile management has a player perceived characteristic. Its location and coverage for $CELS_n$ players are important considerations. The OTP steps will be measured by the agent's contribution linking to each player's company in the AME who are interested in M-theatre will have a fair chance to close to a final goal. The nature of last mile is measured by the users, especially $CELS_3$ and $CELS_4$ but not by the customers (Ref. Appendix III.8 for question setting).

L6: *Understanding of critical path management for resolving the constraints depends on player focus on the process smoothness (path management).*

ERP effectiveness shortfall as depicted by Chan et al (2006) could be associated with the increased outsourcing activities with unlinked ERP systems from individual players. The larger scale Task A process constraints must be defined up-front but if uncertainty kicks in, task accomplishment will be depended on Route-1 and -2. Hence, path management is a key factor to critical process success.

5.5 Case 4 - CELS Collaborative Support (Descriptive)

5.5.1 Contract engineering logistics service overview

This project was designed to manage the maintenance service SCN for the understanding of highly specialised core competence driven production domain. The CELS (Leung, 2004) network and industry landscape has many traits in different players. Dixon's (2002) common knowledge for learning pattern and Phaal's (2003) technology roadmap started the CELS strategy analysis and specifications for the expanded ERP applications.

b) Situational problem analysis

The connected AME process offered an important area for contract maintenance service study in customer airlines. The engineering manager identified this area as an important business arena that requires some re-definition. The existing functional silo phenomenon and the disconnected processes require a major overhaul.

c) Innovation initiative new inter-firm arrangement

An initiative is used to redesign and restructure the current practice of AME function in-source or outsource decision. Since the complexity of tasks and inter-connectivity in decision making across the organisational boundary, a combined outcome of ERP system and process knowledge management is proposed. This approach institutionalised an infrastructure for data as well as special knowledge to benefit the enterprise-wide employees.

d) Unit of analysis - players engagement

The dynamic AME market and the new entrants forced existing firms to examine the inter-firm arrangement for competitiveness. This initiative confirmed that inter-organisational agreement will face dilemma in many performance aspects ref. Christensen (2002), but from the AAME perspective it is good to have more choices in the region.

e) Brief conclusion

After the CELS study the AME production network is perceived by many AME managers a connected system. This new configuration has been set in place with the extended enterprise envisaged. The players who are keen to align ERP interests will stand on same ground (more solid as opposed to the "The cloud" in Section 2.6.2).

L7: *A collaborative approach to integrate mobile applications in out-sourced work for the participants to gain value through adoption of the model.*

This gave rise to a coopetitive requirement, making players' will to test the M-theatre toolkits in the high utilisation environment. The knowledge, connection and effectiveness between the frontline staff and the back office transfer are enhanced, so the value of ERP extension is demonstrated (Ref. Appendix IV.1 and 3 for questions setting).

5.6 Final Linkages to M-theatre Case Studies

Finally, the projects deployed in the selected reference sites as in the four cases in Airline A (locally in Hong Kong) and Airline B (in Columbus Ohio, USA) as summarised as follows:

a) Context Awareness - both airlines benefited with the AME-networked processes. Airline A case showed sustainable development linking to their ERPs. Airline B progressed in frontline engineers' use of the framework for **L1**, **L2** to **L3** linkage.
b) Content Extension - the units of analysis in two airlines identified that all possible ways of dealing with the direction of ERP data expansion depended on the nature of the player acceptance and sponsors alignment in the AME, as for **L4**, **L5** to **L6** linkage. Hence the overall theory construct is reflected to the major findings of this research.

In Figure 5.6 the connection of cases and the M-theatre linkages resulted in mindset changes. In that path the institutionalisation effect is taking place so that the cases are linked from the beginning, for a short process on reliability improvement, to the actual ERP extension itself for the content expansion and outsourcing selection. Finally, the connection into a new M-theatre concept paved the way to drive context awareness needed for the OTP improvement. The following path illustrated this relationship from **L1**, **L2** to **L3** linkage and **L5**, **L6** and finally **L7** linkage:

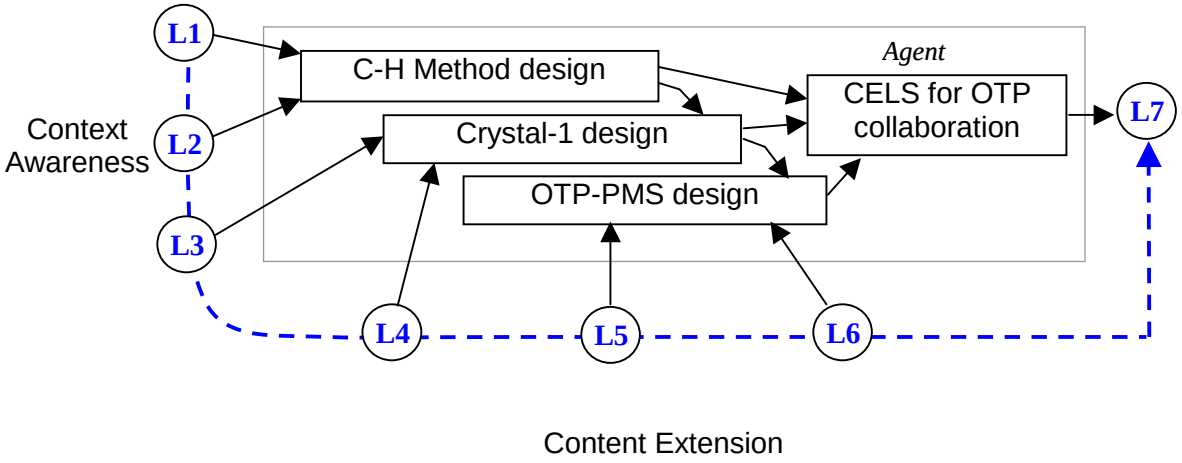


Figure 5.6 Analysis units linkage back to the problem formulation

The connection of cases and M-theatre supported the final argument for the adoption of for **L7**. Thus the whole chain of institutionalisation path is consolidated through the connection of linkage roots from each case. This has fulfilled the analysis required for the empirically captured data in the field, as required by Yin (1994).

This result is important to prove that if there exists a focus of alignment, that can be exist in a form of linkage. It must be useful to adopt the cases (projects) results independently and

match with the basic task-route matrix for the intended research topics. Therefore, the resulting path is characterised for the following features:

a) The toolkit and the agent's involvement in the classic action learning process (Ravens, 1984) which means that the original design of research to make use of ERP extension has demonstrated the required level of understanding between the parties.
b) A critical analytic process deployed at the alignment junction points in SCN so that the progress is no longer depended on the initial ERP capacity but it will be bundled with the growth of knowledge with the progress and perceived importance of the tools (e.g. Crystal-1).
c) This concept is not likely to be limited to AME usage, it could also help the maintenance industries to visualise the collaborative opportunity model to enhance understanding of player collaboration. So that the two routes of institutionalisation process [Figure 1.5 route a) analytical data and route b) case empirical data] can be deployed in parallel to enhance understanding of CELS collaboration.

With the inclusion of competitors (both in AME and ICTsp arenas), the agent took up an arrangement for the subtle role of competitors as a potential collaborator. This suggestion is valuable for future research on the coopetiton analysis of collaboration. Through this approach, the role of focal point of alignment has been demonstrated in a high asset-utilisation and complex logistics scenario entangled by systems and process issues, and finally opportunities are identified for improvement.

Chapter 6 Results Analysis

This chapter captures the overall research results and correlates the observed improvement to the ERP extension model through content extension and context awareness. Also, the progress of institutionalisation supported by case linkage logic flow is syndicated for the task-route model validation.

6.1 AME Network Performance Improvement

The results of content extension through context awareness are analysed by case validation in two airlines (in Hong Kong and Ohio, USA). The framework strengthened AME players' use of ERP for higher performance and to gain greater competitiveness in two categories:

a) Real time support for user applicability may not need to follow the standardised development paths under the multiple players loosely connected ERP situation.
b) Increased awareness and interface can tighten players' cohesion through the -SUCCESS- cycle. Frontline maintenance staff effectiveness can be improved.

6.1.1 Tangible OTP improvement in Airline A

A survey to Airline A for OTP results showed early success of the Crystal-1 application (Case 2) in the frontline environment. This covers the necessary changes for the process depended on real-time data transmission significantly better than the existing tools. The results was impressive on the high utilisation portion for highest 11.5% improvement and not much so in the lower utilisation portion, maximum at 4.3% only. This was due to a logical use of the

maintenance troubleshooting data and arguments to support reasoning incorporated, hence the higher utilisation portion benefited more, as shown in Figure 6.1.1:

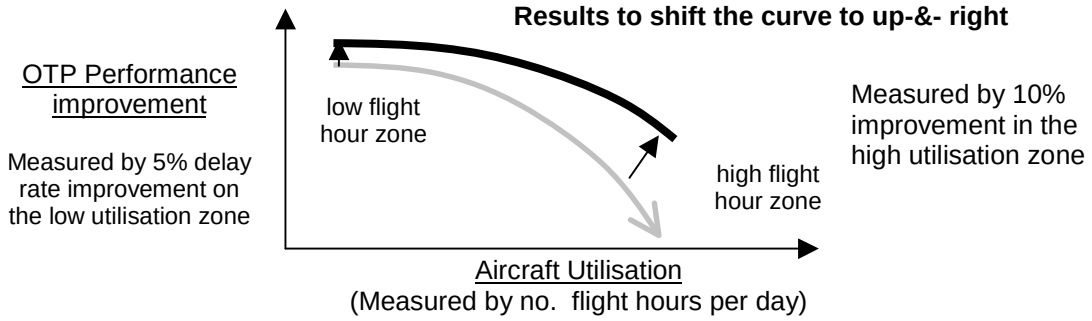


Figure 6.1.1 Performance improved on the high utilisation end

The following table depicts the flight despatch improvement of AAME A throughout the project. Upon completion of M-theatre deployment test for Route-1 Task-A and -B, a set of OTP performance data are collected for evidence are showed as follows:

Airline A freighter OTP	Before M-theatre	After M-theatre in selected process	Projected deployment in all T-R definitions
High utilisation	89.5% (s.d. 3%)	94.3% (s.d. 2%)	96.5% (s.d. 1%)
Mid utilisation	93.3% (s.d. 2.5%)	96.3% (s.d. 1.3%)	97.6% (s.d. 0.7%)
Low utilisation	96.7% (s.d. 2%)	97.4% (s.d. 1%)	98.2% (s.d. 0.3%)

Table 6.1.1 OTP survey results after collaborative framework study

The context awareness for business process study method (Appendix III for details) has resulted in freighter OTP betterment. A significant improvement was evident over the traditional process. The projected PMS framework (Chan and Leung, 2006) is expected to deliver greater performance gain as oppose to the approach proposed by Neely (2003).

6.1.2 Survey to frontline AME engineers collaboration

Upon completion of M-theatre deployment test, a survey was conducted to the AME frontline engineers. The analysis result for the critical process feedback is to see if anything in the ERP extension concept can help the maintenance process for the OTP target, hence their overall effectiveness improvement was measured (derived from Appendix IV.2. baseline questions).

The following table summarises the feedback from 40 frontline staff for the results of all routine, ad-hoc and value adding maintenance processes in Table 6.1.2. The shed areas indicated appropriate case linkages between cases that can be repeated in the survey.

Crystal-1 Real Time Support Improvements		Content	Speed	Flexibility
1.	Business process - what is expected?	*65%*	*61%*	*34%*
2.	Critical OTP steps - what factor is critical?	*55%*	*78%*	*60%*
3.	Critical path management - which part helps?	*58%*	*93%*	*61%*
4.	Resolving constraints - can be optimised?	*59%*	*88%*	*12%*
5.	Maintenance data sources - most important?	—	*97%*	*99%*
6.	Hardware wireless tools - generate changes?	*29%*	*78%*	*34%*
7.	Working parties - linked can be made?	*59%*	*66%*	*88%*
8.	Management expectation - perceived benefit?	*88%*	*92%*	*39%*
9.	Competition hardware - comparison?	*36%*	*31%*	*67%*
10.	Competition user interface - crucial differences?	*61%*	*98%*	*87%*
11.	Task accomplishment - enhancing feedback?	*12%*	*23%*	*89%*
12.	Mobile performance - for extending ERP?	*21%*	*39%*	*72%*
13.	Knowledge gathering - helps trouble shooting?	*77%*	*69%*	*79%*
14.	Training - mobile support technique on?	*43%*	*53%*	*45%*

Conclusion: Much needed Nice to have but not a necessity No need

Table 6.1.2 Real time maintenance support results survey

These results reflected the connection of the survey feedback by the frontline engineers in different stages of the project deployment, as detailed in Appendix IV.4.

6.1.3 Conceptual appreciation of M-theatre in Airline A

The ERP extension concept gave rise to opportunities to maximise ERP capacity and the task-route analysis facilitated overall system changes. Capturing the C-H algorithm which was M-theatre-dependent and then the Cryatl-1 demo which was process-dependent articulated the cycle of ERP extension. This is opposing to the other forms of ERP extension deployment from the existing systems. In Figure 6.1.2 it summarised that C-H Method has instigated the context awareness, followed by the expanded ERP applications into content extension, and then the process is rounded-up through context awareness. Hence the institutionalisation process enriched the M-theatre operands:

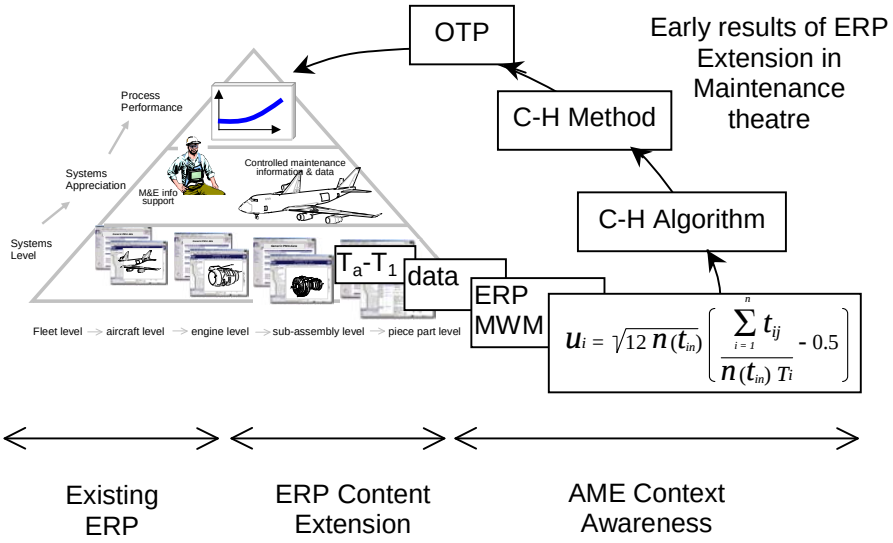


Figure 6.1.3 C-H Method augmented M-theatre support framework

Source: Leung and Chung (2005), Systems and application development for portable maintenance aid (PMA) - A performance perspective, JMTM, September 2006

As a means to push the process improvement to frontline staff, the M-theatre has become a recognised trademark in the collaborative framework. The use of the advanced reliability algorithm for pattern visualisation to "effect" accurate maintenance. As a whole the AME process change was proposed for Route-1 AME workflow for improvement. The AME management bought in the concept of T-R matrix for core competence analysis and ERP deployment to consolidate their positions as new AME SCN networked players, rather than traditional one-stop-shop value process (Paronili, 2000). This institutionalisation process follows the algorithm, method and finally the OTP improvement in real life operation.

6.2 Case Linkage

6.2.1 Sequence of to build the M-theatre theory path

This study uses an array of source-evidence data captured from the four cases. Connecting their contributions in each case (ref. Section 3.4), so that it could be syndicated by the focal point of alignment through the linkages to complete the institutionalisation process. This final linkage will meet the four levels of considerations (Section 2.1) for competitors, deliverables, performance and contribution in the industrial network (Pyka and Küppers, 2002):

a) **L1** to **L2**: The linkages are set to understand the AME landscape evolution over time for the research initiative. This included a significantly improved process from the basic algorithm only understood by the reliability experts (content) previously, making it a frontline usable tool for the maintenance staff knowledge expansion (context) for daily operation. Hence the agent could fill up the institutionalisation table as "Prepare & initialised", "Facilitated" and "Original" and "Basic" as in Table 6.2.1.

b) **L3 to L4**: The linkages developed for critical process allowed the frontline staff to express their needs for potential mobile gear design. The emphasis was shifted to context of use improvement from basic technology. However, it is observed that from linkages 3 to 4 there had been an odd situation that further development of the performance measurement focus was "Rejected" by the competitors due to a lack of definitions in the high utilisation portion of application. Table 6.2.1 is then filled.

c) **L4 to L5**: After deeper understanding of M-theatre towards Task A, B and Routes 2, 3 processes, a better overall OTP improvement is envisaged. This included the initial data acceptance as the institutionalisation concept kick-started the players participation for in-source and outsource decisions. So that in the Table 6.2.1 the main progress was from "Established" to "Coopetition achieved".

d) **L6 to L7**: The argument "articulating the co-operation" is a valid feedback for OTP performance management and practice change through the frontline engineers' cultural change in supporting the mobile-accessible M-theatre concept. Hence the proposition of M-theatre development, improvement tools demo, ERP extension testing and finally result linkage in Table 6.2.1 has been marked as "Institutionalised":

Cases	Competitors	Key deliverables	Performance	Contribution
C-H Method	Prepare initial	Facilitated	Original	Basic
PMAS	Filled	Contented	Satisfactory	Insisted
Performance	*Rejected*	Allowed	Coopetitive	Investment fund
CELS	Developed	Established	Coopetition achieved	Institutionalised

L1 L2 L3 L4 L5 L6 L7

Table 6.2.1 Multiple case linkage from L1 to L7 for institutionalisation

The author experienced a reciprocal effect while applying the T-R analysis in which the player management tactics was refined. Initially, the author was unaware of players' issues in the context. The commencement of T-R analysis has revealed the many facets of the player management cycle, the boundaries of Not-to-do's (ref. Figure 3.3.3) and the lesson learned. This kind of awareness could not be accessible unless it is enacted through action learning as methodised by Revans (1993). It is found that the higher the awareness of player characteristics, the better for an agent to echo in tactics refinement. Such reinforcement of his/her ability to practice T-R analysis will result in a higher confidence in filling Table 6.2.1. This stage is regarded an advanced level of institutionalisation understanding.

6.3 Reinforcing -SUCCESS- Player Management Theories

The enhanced Diamond Model with competitor input as an active partner in the business cluster of SCN affects the M-theatre design. Sometimes opposite comments are introduced but this helps to exploring new methods. The agent has to converge the comments, inputs and the interfaces to adopt the competitors for certain selected paths, this effort is vital for outsourcing policy changes as finalised in Case 4.

6.3.1 Taxonomy for AME players connection

The end result of the case linkages is to follow the project progression in the M-theatre for industrial needs and to create the necessary taxonomy for the academic needs. The industrial result has been demonstrated in the JMTM paper and the C-H Method algorithm (which has won an Engineering Excellence Award for the users in reference site Airline A) signified the achievement through the concept of ERP extension. The taxonomy of institutionalising ERP

extension has therefore been proven in the vigour of the methodology, as a whole, by the three pillars of player involvement on system, application and intelligence.

The rapid development of logistics chain in global operation brings forward a lot of research opportunities for the step-by-step adoption so that M-theatre hardware demo will defines the software (and interface) capacity as follows:

a) Logistics alignment (CELS topology for the contract work requirements) can be applied in the maintenance businesses and any other industry with similar nature.
b) Relevant updating of the maintenance to technical information available from the OEM since the service providers work on mobile support in the critical process of maintenance.
c) Rapid diagnostic of aircraft reliability and maintainability issues as well as to resolve the supplier quality issues using the C-H Method as a guideline.

6.3.2 Leading the transformation from competition to coopetition

Initial findings suggested that competitor should be progressively uninhibited (Dixon, 2000) for sensitive discussion, because this helps future co-operation. The ERP extension is to develop relative positions of competition and collaboration in the AME logistics network. Involvement of competitor in the C-H Method has identified and initialised a resolution for "Win-Win" coopetition.

6.4 Results Validation and Reliability

Reference Section 4.4 the task-route model has been subjected to validity and reliability review. Two approaches are analysed and reported through ERP extension:

a) Validity - the mobile workforce applied in M-theatre has fulfilled the construct validity for the model logic flow as reflected by the cases results linkages. The internal validity has been observed with a positive OTP improvement in relation to the task and route specifications in different maintenance process and engineering logistics arrangements. This follows strictly with the case design criteria in Section 4.4.2 for goal matching. The external validity is based on the improvement recorded in both local and overseas airline companies, each has different inherent culture and operational environment.
b) Reliability - This is reflected in the improvement of OTP in the high utilisation range of operation. This agrees with the different task and route combinations by the research design, as it was focused for this research. Also, the narrow standard deviation measured confirmed the high reliability gained by this research methodology based on ERP extension theme.

Finally, the validity and reliability supported results stated above has confirmed that the AME players collaboration roadmap. It can be viewed as an alternative potential to the standard Porter strategy (1996) and Seifert planning (2003) focuses, in an attempt to maximise the ERP capability in the specific industry.

Chapter 7 Discussion

The M-theatre conceptualisation was set out to address the deeper issue of OTP-utilisation dilemma by shaking up fundamental issue of "***AME companies have different ERP configurations and different ERP yet-to-deliver issues, how can players acknowledge shared benefits in using good ERP data to meet tighter OTP requirement ?"*** in the industry.

This research framework has successfully reduced organisational burden and network stress through a series of cases and projects. To overcome the difficulties experienced in the CELS institutionalisation of ERP extension, a few salient points are captured:

a) Accomplishment of case studies necessitated the definition of ERP extension activities. Demonstrative prototypic toolkits and interfaces in crucial process (not in general process) are important for the researcher to get along with the frontline staff.
b) Conceptualisation of major value adding maintenance processes constructed the theatrical topology. The tasks and routes definitions setting involved in the contract maintenance network were not straightforward.
c) The business process improvement targets with ERP deployment trends, roles of suppliers and competitors (existing and potential) in the SCN must be clearly set.
d) The key findings of each case should be linked to the theatrical management factors. The agent should overcome the take-it-for-granted mentality between the case owners.

7.1 Contract Engineering and Logistics Service Coopetition

The ecosystem of AME originates from the generic contract manufacturing theory (Chan and Chung, 2002), but different types of services demanded suitable competence of service providers (Hagel, 1996). Transformation of the maintenance industry structure has shifted from a "do-it-all-in-house" mentality to "contract-competence" competition (Sturgeon, 1999). In the AME operation, service oriented KPIs are important (Kaplan 1998; Neely 2001) as the AAME has the final responsibility, however, the CELS firms should now be more motivated through the ERP extension framework. The nature of the contract service agreements has many new problems in various stages, so this research tackled issues that are gradually evolved. Finally the following hurdles have been resolved:

a) Role change - positions in SCN and service hierarchy interchanges between the partners and competitors which may upset the balance but with the extension tool, it is more equal.
b) System evolving - system enhancement in functionality and technology to meet nowadays business needs in the fast-changing world is a challenge, aligned decision is the key.
c) Process obsolescence - old processes due to a change of business need and the emergence of new technology could expose inadequate knowledge in elsewhere and diverted the research to low efficiency progress and poor quality of deliverables.
d) Discontinued trust - the worst case scenario is loss of trust in a firm-to-firm level, the researcher should avoid this situation with any player in any reference site.

Experience in AME has revealed that the SCN dependence diminishes as it moved down the chain. In the third or fourth layers of the chain departed from the baseline aircraft asset, the focus may changed and not with the OTP anymore (Leung and Chung, 2003 on CELS characteristics). Hence, this new work concept alleviated the above negative impacts. Also, empirical evidence (Appendix III details) refuted the traditionally “either a collaborator or a

competitor" clear-cut identification (Sturgeon, 2000) towards a mixed relationship. Now it is defined as "coopetitors" that has both traits in the contractually bind SCN. This will be further elaborated in future researches to look into issues such as:

a) AAME's operation planning and real time maintenance info gathering - should it be kept exclusively in-house? What are the relative value adding functions to be explored?
b) Trust in AME partners - should it be built and maintained along with competition, so that deeper nature of coopetition can be revealed?

The M-theatre articulated contract service provision by the characteristics of the ERP rapid connectivity which included the contribution of the competitors, never attempted before in this scale. This fits in the void of a missing piece of jigsaw puzzle in the Diamond template.

7.1.1 Limitations of the existing model

The M-theatre method examined the significant progress of the service SCN using different theatre arrangement techniques and how issues could emerge under the perspective of ERP Extension. This method is vital for empirical data gathering but this approach has a few limitations as listed in the following:

a) Companies that are depended on merger and acquisition are not applicable for the transition from CELS to collaborative logistics process.
b) Companies have not recognised the benefits of collaborative SCN may not be interested in the institutionalisation process (Bose, 2002; Harvard Business-Update, 2000).
c) Companies who are positioned outside the initial players' definitions for the M-theatre test might have been excluded in the collaboration opportunity model (Chung 2003).

d) The AME that have dissimilarity of characteristics in the maintenance rather than generic commercial aviation e.g. private corporate jets (Holloway, 2003; Zikmund, 2003).
e) Players' roles have not been defined with a reasonable timeframes due to situational constraints or not fully analysed, or players don't have business-wise intuitive (i.e. not a pure business environment in semi-open aviation services markets).

7.1.2 Possible M-theatre enhancement by further ERP extension

The shortcomings of the CELS network can be enhanced if different customers are satisfied. Christensen (2002) on "Inventor's Dilemma" emphasised that divergence from conventional ICTsp development approaches may risk failure. So if it could be modified through:

a) Waterfall models - the Routes 1~3 study was a simplified version just to tackle the critical process only but not for the who process, e.g. the Not-to-do's, and
b) Structured implementation methodology - the demonstration Crystal-1 is not comparable to the structural mobile kit evaluation and detail spec establishment.

As then, driving the ERP deeper into AME organisations would result in more functionalities for more potential customers. Extending the footprint beyond the core ERP functionality has to trade-off between "best of breed" features and ease of integration, either way is difficult.

History has told us that ERP has continued to expand, blurring the boundaries of core functionality and process ownership. In fact many added modules and features offered in the original ERP suite have steadily grown over the past decade. For AME users, consolidation within the software industry is having a broader effect than just on ERP itself. This research has a profound effect on the enterprise application and ICTsp landscape. How ERP extension versus "best of breed" decisions are fundamentally made. It is expected that more companies

are exploring the limits of these boundaries and weighing decisions to balance extension efforts and player acceptance against extended features and advanced technology available.

7.2 Critical Success Factor to Institutionalise Network Coopetition

First, get the concept right. The CELS concept initiated a powerful argument for mobile ERP extension in the maintenance network. The constituents in the simplest form of representation should exist provided that the setting of the topology is agreeable with the players. The M-theatre research developed a flow of integrated innovation. To visualise the critical success factors for ERP extension, the system adoption criteria for M-theatre environment has matched the following innovative prototyping method usable for ICTsp:

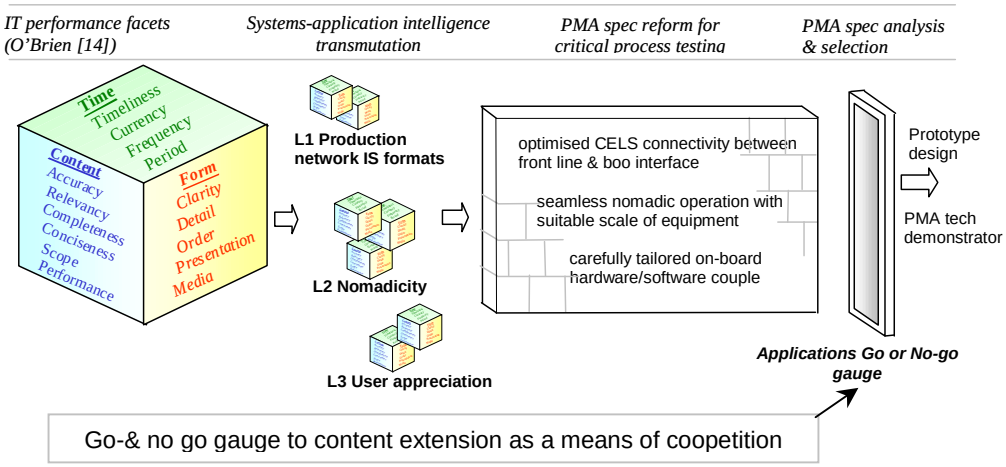


Figure 7.2 Three-Level ERP adoption c.s.f in M-theatre

Source: Leung and Chung (2005), Systems and application development for portable maintenance aid (PMA) - A performance perspective, JMTM, September 2006

Second, follow the error elimination path to support theory development (Popper, 2003). As oppose to conventional O'Brien's Model (2003) for ERP development in networked

companies that has a go-no-go gauge, the coopetitors participation served this purpose. Such adoption appears to be uncommon in service industry (Botta-Genoulaz, 2003), especially on AME businesses which runs on high technical contents of complex applications. This confirming Chung's (2004) collaboration model which relies on "network-process-systems-performance", i.e. another taxonomy to be further investigated.

7.2.1 Salient points in how to repeat the success

This is a group behavioural pattern against limited self-awareness. If there is no leader to navigate the ERP extension project, it will stall due to lack of collaboration. This is like "actors" competing each other for individual performance on a stage without a director. An industrial champion should be nominated to shine at the beginning of each case. Together they should bring other actors to experiment with similar process:

a) Replication of collaborative framework in one company, which all employees will benefit from the extended ERP application.
b) Replication of collaborative -SUCCESS- and the task-route strategic move through the volatile players interchangeable positions to strive for SCN OTP results, at where even prior effort could not deliver (i.e. the high utilisation portion).
c) The external validity of a research design is to concern whether a particular set tools could be generalised in another reference sites beyond the controlled case study.

7.3 M-theatre Theory Validation

According to Juran (1995, p281 to 354), guru of quality and management performance improvement, Sensors and Agents are required to function to detect and connect SCN with the

articulated process management. From the up-stream of supply logistics to down stream of end customer requirement for integration, the agent carries a specific function ERP to support a wide range of collaborative work. This would eventuate the options identified in the T-R matrix improvement initiatives because the analysis work was intrinsic difficult for explanation to the frontline staff at work.

7.3.1 Diamond Model to strengthen the Agent

The agent is designed to fit in to close the gap between the existing player characteristics and its less defensive "role" to the competitors. The purpose of agent configuration softens the complex nature in the AME SCN and sets the independent variables that are fundamentally difficult to be defined with the assumptions and roles.

As depicted by Jürgens (2003), Mennecke (2001) and So (2004) the gap in the existing ERP is dynamic, systematic, theory-linked guidelines for a successful realisation. Could it bridge by an Agent? In the M-theatre the agent directs the configuration design, selection, customisation and implementation plans for features:

a) Systems - to capture ERP concept developments in ERP system development, platform, concepts, process algorithms, software and hardware foreseeable in pursuance of IT supported SCN improvement opportunities.
b) Application - to render ERP applications directives, SCN development and methodologies that can be supported by ICTsp. The process and effectiveness enhancements, global and local network demand and strategic alliance.
c) Agility - to entice users into ERP flexibility, mobility, sustainability, implementation and evaluation for its extension with overall effectiveness. For companies that have committed

to the adoption of certain type of ERP frameworks, agility will reveal the insights that are emerged in other new users' definitions.

Source: Leung T.S., Lee K.W. and Chung W.W.C., Systems and Application Development for Portable Maintenance Aid (PMA), JMTM, September 2006.

This has proven that ERP extension institutionalisation is not just adaptation, codification or optimisation but a series of interactions between the M-theatre players along with deliverables.

7.4 Triangulation of OTP Improvement

The logic of the M-theatre design, based on the traffic light analysis lit the ways for specific requirement as synergy. The agent committed in the grey boxes for M-theatre deliverables. The components of the model's features will bridge the gap of knowledge for mobile workforce behaviour and the associated theory of implementation.

7.4.1 The M-theatre in application context

As depicted by O'Brien (2003) the difficulty is how to make use of the ERP support to build mobile workforce and then to fulfil the sponsor's vision? Similar to ERP, M-theatre poses a small but definitive portion of integration. To this end, the political alignment for either a win or lose couple depends on the speed and flexibility recovered in the extensions:

a) Researcher has a view where LR meets the sponsor action.

b) Survey on users' expectations (need/no need) completed the application expectation.

c) Extraction of certain success factors creates the double loop learning.

d) Coopition can be systematically evolved in the perceived competitive SCN.

7.4.2 Further development M-theatre concept

To attain a significant efficiency improvement, multiple formats linking to supplement the Electronic Flight Bag (EFB) concept in the cockpit is envisaged if could be based on the prototype Crystal-1 design with its form, fit and function:

a) Matching more milestone points to business-system integration and demos in the technology roadmap e.g. bigger screen for advance reliability algorithm.
b) More precise information sensoring, tasks capturing in theatre view to confined details such as RFID/GPS for surgical precision logistics and technical control in all aspects of maintenance work and future linkage to airframers' and airlines' systems.

7.4.3 Future research on Task-Route Matrix as a template

Gates (1999) predicted that ERP deployment and research effort is largely based on the three levels of knowledge worker, business process and e-commerce. The refined model in Figure 6.2.1 successfully captured the 4-case synergies, and advanced the use of Diamond Model to meet Gates' (1999) proposition. In a way, this reflected that research is proven to have internal and external validity.

The M-theatre concept, on its module for management performance development, has been adopted industrial projects in the AME industry. This further supported the effectiveness of the institutionalisation framework, not only used in the AME industry but also on other service industry with similar set of assumptions. The refined model depicted below is the ultimate M-theatre Model based on the data available in this research under the ERP extension argument which constitute elements, but it could be expanded and refined:

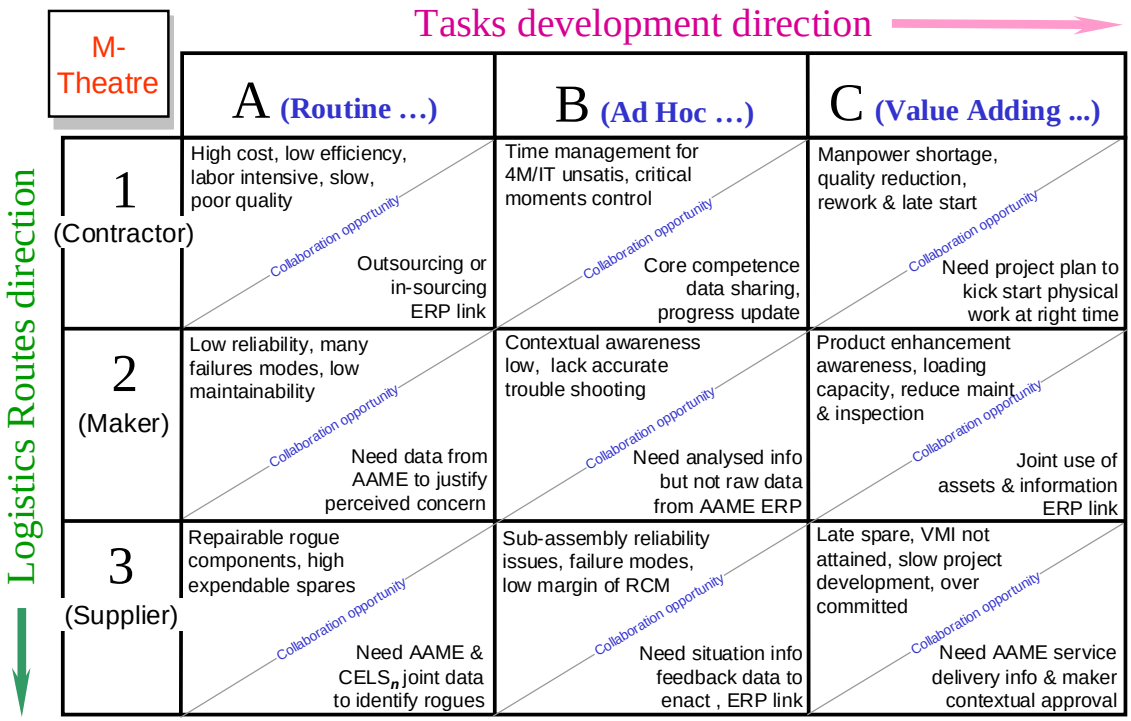


Figure 7.4.3 Proposed M-theatre Generic Template

Of note, another research student under the MISRU scope had adopted the principle findings of the M-theatre's performance definitions to instigate a new MPhil project "Design and development of performance system in a dispersed supply chain network". Also the generic elements of this framework are being summarised as tutorial notes for master degree students for logistics management network in Polytechnic University.

This research result has a profound influence for the organisations and parties who would need to establish a fleet technical management for a start-up airline who has no prior experience in dealing with the technical content and engineering logistics context. Following the above results this will lead them to walk a smoother introductory into service of the aircraft fleet.

7.4.4 Refinement directions

The collaborative matrix offered an attractive research background for deeper analysis of the logistics paths and tasks. Limitation exists in the breath of the matrix coverage, for this template it has only covered 3 logistics routes and 3 major tasks. How can be applied to other service maintenance industries?

The answer lies in the matrix grand list that has been created for this research. In that it gives insight for future research to find the following interesting questions:

a) How far can we achieve next level of collaboration between players?
b) Could it be the tasks categorisation for a further broken down? Or
c) Could the routes be expanded or re-arranged such that generic use of the logistics player sourcing can be started?

With this template, another MPhil study has taken up the matrix to follow the same path for logistics routes performance measurement on the routing analysis. The Task-Route Matrix represent an initial attempt to build the roadmap of institutionalisation of ERP extension, it has not been fully explored as the four case studies just examined two possible means for content extension and context awareness.

7.5 Possible Applications Using the Repeating Units

The model could be used outside the AME discipline because the methodology, the Crystal-1 prototype and the player management paths are independent entities. With the task-route

management and ERP extension techniques it can be defined for possible applications in another industry, the best results are expected with similar actor-theatre settings such as:

c) Healthcare - the mobile workforce concept can be developed for healthcare in remote sites. Not limited to the hospital or centralised medical centres but also supports the graphical illustration and critical process management in a “treatment-anywhere” situation where it is crucial to the live or death. For this way the -SUCCESS- characteristic has to be defined for the higher rating of the customers, i.e. the patients.
d) Other maintenance service industry such as housing, shipping and land transportation systems maintenance could employ the highly robust ERP connection nature of use, rich information presentation in the graphical formats and linkage to the authoritative information source. These features are crucial for the M-theatre concept to be employed and the ICTsp roles can be elaborated owing to the similar nature of industry.

Finally, most of the AME players participated in this research project are aware that players’ collaboration is a must to substantiate competitiveness. This view is alternative to the standard Porter strategy (1996) and Seifert revenue based (2003) approach.

Chapter 8 Conclusion

An innovative collaborative support framework for ERP extension and the institutionalisation of the process was proposed. This research underwent the institutionalisation process which resulted in improvement of maintenance service performance and obtained deliverables with measurable successes. In conclusion, this research has met the three objectives that have been set and achieved the following:

a) Visualised collaborative opportunity model to enhance understanding of player collaboration in the maintenance service domain.

b) Thoroughly investigated two routes of institutionalisation process to enhance understanding of CELS collaboration by content extension and context awareness.

c) Offered an extended model in considering the subtle role of competitor as collaborator is partially validated with suggestions for future research on coopetiton analysis of collaboration.

A number of AME companies' management highly valued the new working mode under the collaborative engineering and logistics service as a higher CELS definition to be better than the traditional view. A change from pure contractual to collaborative relationship is seen. After this research AME management are willing to commit further support and investment into the alignment process, with the help of the focal point of alignment, and this is also evidence by their new strategy of outsourcing. The practical value of this research result in

helping the AME industry to develop a new approach to conduct fleet technical management and outsourcing has been demonstrated.

This institutionalisation model has also provided a portal for future research on coopetiton to achieving a higher level of collaboration. In certain aspects this research validated Diamond Model by context of use of theory, and refined it with the competitor's role enrichment. The initialisation of coopetitor management method has shed light on how and where it could exist to extend knowledge for logistics network. As the theory still has room for further study, it sets the foundation for a higher level research, i.e. a potential topic for PhD study.

This model can be refined and simplified to fit for other service-theatres so that participants can gain value through adoption of the model features. The refined template offered a vision and highlighted the importance of coopetition that helps the industry to understand more the behaviour of players and allow supply chain network players to move ahead in the refined model.

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Appendix 1

Case Study Design on Unscheduled Maintenance Improvement

[QREI Journal paper presented to PolyU MSc. Class; ICQR Conference in Beijing and IMEC Conference in Toronto]

I.1 Advanced Reliability Performance Algorithm

The use of Mean Time Between Unscheduled Removal (MTBUR) measurement is a baseline technique for Condition Monitoring (CM) in aircraft reliability programmes. Many airlines, component suppliers and airframe manufacturers apply MTBUR analysis because of its simplicity and industry-wide acceptance for contractual, performance and technical evaluation purposes. Owing to its aggregated nature, MTBUR alone has little to offer for showing the significant changes within a repairable component population. This case introduces the Carroll Hung Method, an innovative approach for bridging the industrial practice of CM alerts for reliability improvement. Through systematic mapping of modulated time-to-failure patterns onto finger-print charts, trained engineers are able to scrutinise life characteristics and then detect inherent issues by making reference to a C-H pattern guidebook. Applications at two airlines have proved the method to be simple and effective because the C-H algorithm and its unique failure pattern examination technique involve aircraft system knowledge and logistics factors in developing component improvement plans. Possible refinement of the C-H Methodology using non-parametric approach and pattern recognition is scoped for future research.

I.1.1 Problem of Different Failure Codes for Repairable Components

The reliability programmes in most airlines adopt MTBUR calculation as a key performance index for component monitoring. It is the baseline technique for condition-monitoring (CM) as stipulated in many airworthiness legislation documents around the world. It is included in the Maintenance Steering Group (MSG-3) requirements that have been incorporated in modern commercial aircraft design since the Boeing B747. The objective of MTBUR measurement along with 3 sigma (σ) alerts and failure analysis, is to optimise CM application, to drive cost-effective maintenance, and to safeguard airworthiness to the highest possible standard. The first problem concerns logistics management - if deterioration of a repair-replacement programme is undetected, maintenance cost will increase. The second problem is a safety hazard - it may give rise to a dangerous situation when multiple rogue components in close proximity fail in critical systems.

I.1.2 Incomplete Repair Data and Multiple Failure Codes Problem

Owing to high cost of repair, aviation components are expected to bear detailed repair data in their own files. In reality, incomplete or delayed maintenance data is reported 6. Data format and communication issues between asset owners and repairers are not uncommon due to the following reasons:

A) Lack of or missing in-service failure categorisation data, caused by problems of communication breakdown between repairers and airline operators as presented by Yakubowsky and Krapp. Statistical methods e.g. missing data (treated as "additional zero") may be adopted, but partial information renders parametric tests ineffective.
B) A high proportion of up to 75% of the total unscheduled removals (especially with avionics boxes) could be tested with the result of No Fault Found (NFF).

I.1.3 Maintenance Concept and Availability Studies

Limitations exist for in-house comparison alone, and this gives rise to the difficulty of finding sufficient reference to the original design reliability and with sufficient homogeneity, especially for complex repairable aircraft components. Kumar and Crocker used a maintenance free operating period (MFOP) as an alternative to MTBUR and MTBF for aircraft and aero engine parts. This is good for pooled logistics and which are cost conscious, especially small operators. Increased use of pooled repairable components render data collected not applicable for aggregated performance indices. After all, the pressure is on the airline operator who ultimately carries the responsibility of explaining why an unreliable situation occurs for certain systems and how it can be improved, since this requirement is stipulated by the airworthiness rules.

I.2 Statistical Test and Modelling

Two important tests, the Laplace Trend Test (LTT) and the Weibull Test, are considered appropriate for repair-replacement systems analysis. With the problems depicted in the above sections for aircraft component reliability analysis, it is challenging to bring the two tests together and use them effectively.

I.2.1 Laplace Trend Test

For an identical repairable component of the same S/N, given its past repair history and the time to failures tj since new, the LTT can be applied to detect whether a trend exists in the pattern of failure arrivals 11 in a fixed time interval. Of a sample set of data for specific component S/Ni to determine the general trend of performance, and also the randomness of the inter-arrival data pertaining to its repair history.

I.2.2 Weibull Test

If the failure categories are found to be identically and independently distributed (i.i.d.) 11, Weibull analysis can be applied on unscheduled removals (and failures) to characterise the reliability of the items 11. This has been used, especially for aero engines, as a powerful tool to analyse life characteristics of sub-assemblies, and to distinguish specific or random failures in order to optimise maintenance decisions.

I.2.3 Summary of the two important tests

To connect these two tests, engineers appreciate that LTT offers a starting point to clarify the condition of the data. And then by certain means (hopefully it is simple, fast and reproducible), homogenous groups of random data would be grouped and fed into a Weibull analysis to finish the job.

I.3 The Carroll-Hung Model

The bridge between an unconditioned failure data source (Slide 1) and powerful statistical test tools may exist in the domain of non-parametric analysis. So we looked at non-parametric estimation as per Keifer 25 that has the ability to group the "like" data that does not assume a particular distribution of the observed, apparently random variables.

I.3.1 Non-Homogeneous Poisson Process (NHPP) Vs the Carroll-Hung Concept

Since the pooled aircraft component maintenance issue together with multiple failure modes added complexity, Carroll (2003) assimilated key features of NHPP to characterise those for operational significant in the repair-replacement system including inherent-design or operational-logistics factors, and developed the C-H Model. The two models are compared in Slide5.

a) *Formulating the I-R bar patterns*

These codes would be used to define the pattern of the I-R bar towards the R*ij* removal, Appendix I shows the details of C-H failure code definitions and the corresponding bar patterns. These failure codes C*ijq* can be created through a word search routine in the repair data management programmes. The fault confirmation codes *Fijk* can be categorised and stored in the ERP's reliability module.

b) *Ranking factors of S/Ni*

Having completed an individual component's history, the C-H algorithm proceeds to define the likely homogenous status of the removal and failure data referring to the Slide5 flowchart. The ranking of the S/Ni should be re-arranged through calculation of the new *i* th order (*i'*). With a bearing in mind that the objective is to accelerate the pattern recognition process, the algorithm is designed to adhere similar component groups together "concerned samples".

I.4 The C-H Method Application in Two Airlines

The reliability programmes of Cathay Pacific Airways and NetJets Airlines have different focuses owing to operational differences but the core theme of the C-H method has been applied to them both. NetJets initiated the C-H method followed by Cathay. The significance of these studies is to illustrate whether this method makes it possible to advance from MTBUR monitoring to improvement in reliability. They tested various kinds of components to see if this method can provide more indicative direction for reliability and technical action. The result is encouraging in that both airline teams have reported faster than sighting of component issues when compared with traditional analysis methods. A recent sudden surge (highlighted by 3σ alerts) of ATA80 (engine starting) MTBUR showed a deterioration trend from an irregular data batch. After gathering 15 years of removal and repair data, a C-H chart is generated and the result is shown in the C-H Chart in Slide 8. The example of C-H Chart and pattern recognition for reliability analysis where the C-H chart has successfully identified serial number MBxx04 as the first component to deal with, it also highlighted two possible S/N's for the Rogue-Watch programme. ACTION: The repairer was informed and a commercial settlement was called for.

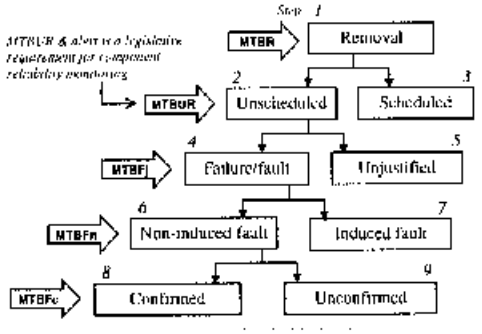
1.4.1 C-H Method to Handle Partially Completed Repair Data

The C-H chart produces a reduced level of doubt for all levels of technical workers and management so they can compare removal patterns with varied data availability since this method is workable for incomplete or partially obscured information. Of note, the C-H logic flow chart is tailored for repairable components in the aircraft maintenance but it could be modified for repairable components with significant pooling arrangements.

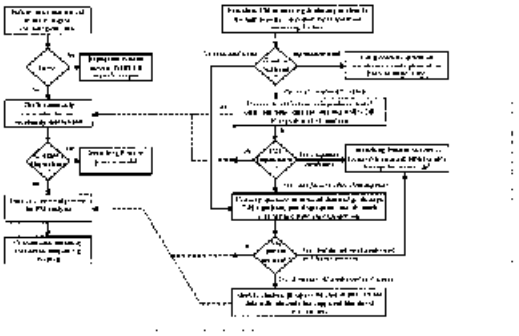
1.5 Conclusion for C-H Method

This paper proposed an innovative reliability analysis tool, which was found to be simple, fast and effective to support technical reliability analysis, especially under the constraint of incomplete data and multiple failure modes. A favourable comparison was made to benchmark traditional methods both on the theoretical basis (existing approaches for aircraft components) and in real life application (cases in two airlines). Implementation wise it is revealed that different operators may have a common or some dissimilar ways of viewing certain priority issues arising from the performance change but this can be built into the same C-H Method of analysis. The C-H Method introduced a data visualisation tool for pattern recognition of failure histories and it drives specific technical or logistical improvement actions to support the "reliability-in-action" mentality. The C-H Method will be measured for its contribution in the ad-hoc maintenance improvement for meeting the on-time departure maintenance challenge.

C-H Method slide 1 - challenge in industry



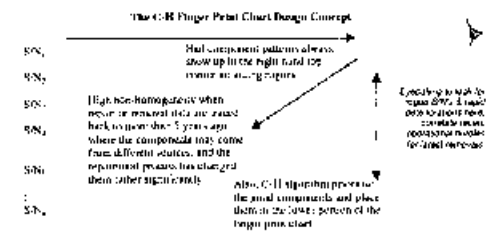
C-H Method slide 2 - new workflow



C-H Method slide 3 - innovative algorithm to support the use reliability centered maintenance concept for critical process

$$I' = \begin{cases} \dfrac{u_i * F_{cc} * V_{ii}}{f_{TTF}} & \text{For } u_i > 0 \quad \text{---------(8)} \\ \dfrac{u_i * f_{TTF}}{F_{cc} * V_{ii}} & \text{For } u_i < 0 \quad \text{---------(9)} \end{cases}$$

C-H Method slide 4 - innovative way of monitoring aircraft component performance



Further Work

The C-H Method deployment in one of the testing company, at Cathay Pacific Airways, was so successful that the management decided that the award of "Engineering Excellence" was given to the inventor Ms May Hung and the Mr. Tom Carroll. The author played an important role to introduce the similarity of thoughts between the two reliability experts, each located in the opposite sides of the globe to each other. This resulted in a complement of each other's best skills (Hung's algorithm to shorten the array sorting time and Carroll's graphical analysis technique) together, to create the C-H Method. Not only that it is being published in QREI, but also being widely applicable to the airline reliability communities.

Questions and Answers with the Students:

- Which party of AMEs can use C-H Method by successful network to facilitate unscheduled / ad-hoc tasks effectiveness improvement? What is the change in the context of use?

Answer: Use of C-H Method under back office environment was proven to be better than trained reliability improvement specialist so that the hidden defects in the aircraft can be rectified faster. Frontline staff will be trained with this tool to improve trouble shooting where in the past that needs lengthen data transfer between back office.

- What significant impact will bring to the front line operational maintenance if the algorithm is integrated with their routine job?

Answer: Frontline staff may use this tool to achieve unprecedented high accuracy in trouble shooting for complex systems, thereby reducing the machine down time. Hence satisfying ad-hoc maintenance task performance.

- What factors needed considered if this tool is to be used both for own AME function and competitors'?

Answer: This algorithm was open for discussion, the competitor (an upstream supplier) may open a concern to the AAME. So the AAME expertise took up the challenge and completed the theoretical analysis and designed agreeable that the competitor may use the C-H method and data.

Appendix II

Case Study Design on Mobile Workforce Management Prototyping

[From a journal paper of JMTM for data discussion in PolyU MSc. class]

II.1 ICT Supported Process Improvement

Information and Communication Technology (ICT) innovations brought significant process improvement in various facets of commercial air transportation so that airlines can optimise effectiveness as depicted by Laudon (2002) and Afuah (2004). This is to achieve a desirable level of business success in the course of maximising assets utilisation whilst leveraging all business, political and economics elements in the dynamic market place. One key success in ICT supported optimisation is the cost-effectiveness, technical and logistics management surrounding the modern jumbo jets. ICT can support the four streams of players in the industry:

a) airframe manufacturers who build the aircraft based on airline market demands,
b) airlines who fly the aircraft based on passenger and freight demands,
c) multiple-tier sub-contractors, suppliers based on first the airframer's specification (supplier furnishing equipment, SFE) and second airline's demand (for buyer furnishing equipment, BFE).
d) and lastly the MRO agents who provide the maintenance and logistics services to the aircraft.

II.2.1 Imperative for Process Improvement

Commercial aviation saw many cases of spinning off cases are abundant, lots of type 4 companies (MRO's) detached from type 2 companies (airlines) e.g. Lufthansa Technik in early 90's. In generic form, 4 types of businesses as shown in engineering and logistics flow in Slide1 Generic Engineering and Logistics Service in Airline Industry. The overall shape is a cluster of specialised organisations, established and marketed by their core technical competencies to serve a definitive scope of customers. Problems arise in airline operation where equipment and system breakdown in extravagant courses thereby resulted in huge maintenance burden for the airline:

a) rapid reliability deterioration of equipment which arouse a series of consequences in operation such as flight delays and cancellations, warranty and remedial actions,
b) long lead time for the suppliers and airframers to develop resolution with the consent on technical and commercial agreements between all parties involved,
c) diversified failure modes and categories.

In many cases, the time taken to resolve these issues is long for airline operators to see a genuine performance improvement. Prolonged unsolved technical issues affect airline's despatch reliability and worst still, on safety aspects interrupting airline operation to an extreme level this is detrimental to airline's competitiveness.

II.2 Portable Maintenance Aid Systems (PMAS)

This paper introduces a systems-application approach for mobile information system (IS) development for commercial aircraft maintenance engineering (AME) business so that economic advantage of portable maintenance aid (PMA) can be eventuated for network players. Since AME industry is characterised by intensive technical information managed tasks in dispersed locations, if PMA is employed intelligently this is anticipated to drive significant effectiveness and efficiency improvement. However, when compared with other industries' mobile successes in new economy applications, e.g. speed post, warehouse, asset, estate and even entertainment management as their crucial business process reference, mobile ICT support for airline AME is still appeared to be rudimentary. There have been attempts to develop PMA for airlines but no general rules to be found.

II.2.1 The Challenge – From Global Operation Management to Precise Control of Nuts and Bolts

As airline operation becomes more dynamic and aircraft asset utilisation escalated, it remains critical for front line maintenance business units to work exactly to the airframer's specifications and to streamline the logistics concerning repair, overhaul and modification to global scale. This challenge, as illustrated by Chan, Leung and Chung (2006) is to handle precise real-time information, attain performance targets and demonstrate unwavering tasks accomplishment standards in dynamic real world scenarios.

II.3 Literature for Mobile Workforce Management

Mennecke (2004) states that development agents should understand the highly specialised core competence driven production domain to better conceptualise contract engineering and logistics services CELS (2005) network and the industry landscape. In reciprocation process (and network) agent (2001) should pay attention to the pattern of technology roadmap (2001) and its effect on systems perspectives. An effective systems-application insight may start form existing issues and establishments to facilitate building of viable, alternative concepts.

II.3.1 AME Contract Entry Requirements for Information and Systems Handling

Information technology in contract manufacturing, service and product development business to create, monitor and measure operational effectiveness. Chan and Leung (1999) describes performance measurement basics that drive real time information. Gunasekaran et al (1993) depicted key issues of ICT supported business process engineering thus lit the way for CELS players access to network essential operation data. Also several studies (1996) pointed out that after the contract, high degree of collaboration exists between contracted parties exists for co-development and co-defining systems for their long time partnerships (10 years). Crucial to AME firms competitiveness as Holloway (1997) depicts, these are core infrastructure considerations for all systems to be developed, including PMA.

II.3.2 Technology Edge in Military - A Different Focus

To conceptualise airline PMA to drive business effectiveness hence a greater value for mission accomplishment, a new breed of airline maintenance expertise to innovate the existing process (mainly paper based) should be conceptualised. A viable means for technology adoption is taking the highly financed research such as in military developments. The highest grade aviation PMA's may exist in some airforce-based applications. Bapst et al (1993)

illustrated a total of 33 cases of high-grade PMA applications, out of these sustaining developments only 2 appeared in commercial airlines. The most reported application so far is the EDNA system for the F-16 aircraft diagnostic, preventive and responsive maintenance support. Bajst's report revealed that the focus on airline application is significantly different to military with the following characteristics for commercial airlines:
a) more dynamic business strategy, less focus on fleet standardisation and relative faster equipment roll over rate;
b) more on collaborative model between CELS players than the governance model in military for system adoption;
c) more on cost-effectiveness, users preference and than the disciplinary and ordinance practices.

II.3.3 The Commercial Airframer's Alternative - Software System Adoption

Airbus AIRMAN is software conceived and developed by Airbus for maintenance support (1995). AIRMAN is web-based that provides three major and unique features to airlines' on-line and night check maintenance. It supports real time receipt and management of messages from aircraft on-board maintenance system through the ACARS/ATSU (Airborne data communication systems) and allows mechanics to prepare a maintenance action list while the aircraft is still in-flight. Boeing PMA is software includes Boeing Allowable Configuration Manager (ACM) and other modules. This mobile gear is designed based on the concept of self-sufficiency to reduce the time and effort needed to research, manage, source, order, and track parts thus shortening process time.

II.3.4 Future Mobile and Nomadic Network – A View from the Technology Roadmap

Having seen existing options is deem necessary to perform a bearing check in the technology roadmap, to see if key issues for nomadic computing development has reached a level of maturity in specific application concepts. From the angle for PMA technology progress, Phaal (2004) suggested that:

a) Research and Development - the existing boo systems and PMA systems can be expanded into the nomadic operation with a few critical technology breakthrough e.g. light-weightness but these are predictive products.
b) Product and Service - A group of forward thinking users and companies to help to build the initial test results and application intelligence, early success is a must.
c) Further Development - Larger scale of development for multiple layer of CELS players is created.
d) Re-invention of Process - Technology application come to its desirable stage.

II.3.5 Narrowing the Gap between Existing Systems and the Value Network

Parolini's (2003) proposed all economic activities for the creation of a value network can be grouped in three layers: supporting, tools creating and transaction activities. The CELS network is expected to achieve the targeted improvements in terms of the three groups of activities: technology adoption, IT implementation and performance.

II.3.6 Summary of Literature Review to Correlate Process, Nomadic Network back to Industry Needs

Porter (2001) summarised competitive organisations should lead their industry must find opportunities to improve efficiencies, reduce costs and added value. The concept for this paper should demonstrate the process whereby systems-application intelligence to shed sufficient light for effectiveness, in that correlation of the soft-hardware couple to match nomadic network in supporting the production network will be eventuated.

II.4 Methodology

The intelligence gathering through advanced use of the devices and systems lies in matching in process and network. Modelling such action research is challenging in a way to understand the complex CELS management operation first and how fewer obstacles to result in early success. The suitable hardware-software couple would give rise to a demonstrator concept. Since no standard has been set for such nomadic applications (as oppose to a standalone laptop), data collected should be subject to correlation test [Apriori Analysis]. As oppose to IT performance criteria stated by O'Brien (Laudon), a approach to break down the huge block for boo performance and to transmute into the tiny blocks mobile concept, as stated below is effected.

II.4.1 First Layer L1 - CELS for Aircraft Maintenance under the CELS Value Intelligence

Since AME companies are striving to find ways to incorporate existing information basis to enhance core competence, understanding of the CEL relationship resolves system level information format bias. Layer 1 is to getting together with airframe manufacturers and multiple tier suppliers as from the CELS information provision to build Layer 1 bias of formats so shown in slide 2. Latest observation on CELS information flow as per Laudon (2003) is controlled by the 1st and 2nd tier players. The argument is that with knowledge on network functions, one would acknowledge of the information basis, format and key protocols for the existing digitised documents and operational data sources. However, the responsibilities of the CELS players limited the scope.

II.4.2 Second Layer L2 - Nomadic Maintenance Support in Critical Process Intelligence

The network IS formats are then subject to layer 2 design which stress on real-time, compressed, and accurate, communicate information between off-sites so that inter-firm linkages bring together various trades effortlessly. The development agent offers the integration effort to rationalise nomadic specifications gives rise to specific applications, in this case the flight despatch critical software support. This layer is equipment centred to cater for different and complex operational situations so that lap tops, note books and PPC can be used. In contrast to the huge effort needed to customise every piece, each is installed with most compatible software for comparison.

II.4.3 Third Layer L3 - User Appreciation to the Systems-Application Blending Intelligence

The last layer is the capturing of the users feedback for the construction of L1 and L2. Through the study the following setting is designed to define the sub-layers of the test, in which the user experience is rated to feedback to the researchers. In order to narrow the scope and the 3 questions have been set to answer critical evaluations:

a) Is the business that you are working tie into the mobile device that you are using closely?
b) Is management buy-in an important factor for you to use or not to use the PMA in the device?
c) Is training a critical factor for the use of PMA device that you are using?

All data are collected for the 5 types of devices to be tested in comparison using Apriori method. A 3-layer systems-application intelligence capturing so a selected critical AME process is tested with various equipment and software

to support the flight despatch sensitive maintenance task accomplishment. Laptop computer was used as datum, as then a final prototype is produced from the intelligence capturing as re-datumed equipment spec.

11.5 PMA Evaluation in the On-Time Departure Scenario

An international airline which operates a fleet of 50 jumbo jets is involved in the study. It adopted the CELS network approach to manage the outsourcing tasks in different companies with a view to create i) supply chain logistics and ii) technical competence management. The systems-application parameters are taken to understand the business dynamics between the CELS companies and business units for aircraft maintenance, as to match the methodology:
a) to validate applicability of mobile technology in the CELS network with particular reference to specified process of ad-hoc maintenance and situation management for layer 1 (L1) design,
b) to translate the lessons learnt in resolving user interface and design issues into the application intelligence so that the result would allow the designers exploit layer 2 (L2) refinements, and
c) to capture general features of mobile applicability by the users in the simulated and real life situation and subject the data to layer 3 (L3) analysis.

A selected group of in-house and outsource functional users are designed to run the mobile network hardware and software in the selected process from bottom-up. This included lap-top, notebook computers, PDA and pocket-PC and even phoned-PC, etc. Data is collected use a map which to capture the maintenance to see if the application intelligence can be pin-pointed in the Hong Kong's CLK Airport's maintenance activities across the CELS network for flight despatch. The PMA support and their performances in different equipment meets maintenance process, and aiding functions of the PMA to assist info supported maintenance to departure aircraft in a typical scenario.

Step1 Step 2 Step3 Step 4

Figure 11.5 The 4-Step maintenance process illustration for routine tasks

11.5.1 Systems Changes from Trailed Process

The purpose of the experience was to show case that the concept of maintenance theatre activities works and can be visualised. The hardware and software mobile connectivity had been tested for usability in the selected CELS with no difficulties, hence the technology roadmap is trusted at the development stage, thus can be moved to service stage. The user focus group formed to evaluate the functionality and the improvement in operational efficiency for the traditional one and the newly proposed and tested one, PMA systems are compared if improvement envisioned.

With the similar set of software provided, including AIRMAN and Boeing ACM, the equipment are compared with the lap top computer as datum in terms of nomadic application The overall intelligence capturing generate the

required operating benefits with the advance use of hard and software. See Slide4, Hardware and Software Couple Analysis and Performance Scores by Users. The team captured necessary comparative data and re-datum the PMA equipment. Then a prototypic technology demonstrator for the CELS network critical process is created as Crystal1.

II.5.2 Business and Process Analysis

Before this proposed CPFR concept it was proposed as a model, the "upstream" worker does not communicate with "downstream" workers interactively with ICT support. Proposing the "M-Theatre" as the model of an environment that provides the channel for communication, the workers upstream and downstream in AME industry along the critical workflow process.

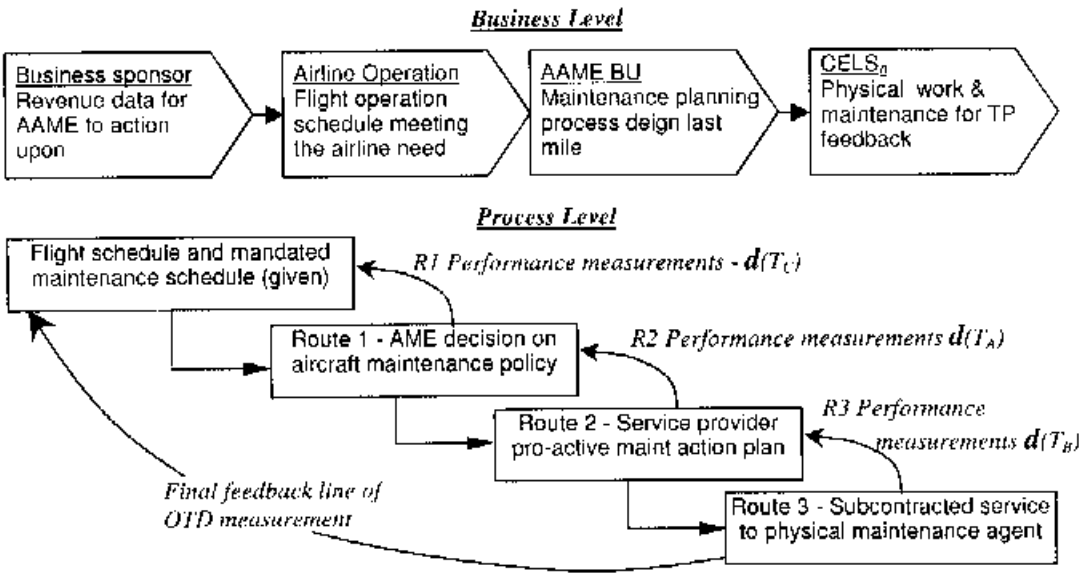


Figure II.5.3 Business and process level analysis for the four step

Having completed the Crystal1 prototype the following observation was generated for detail discussion of the methodology in capturing the systems-application intelligence in this CELS process. Nomadic is the final layer to glue the 1st and 2nd layer process to form. The knowledge creation depended on and workstation constraints that made it difficult to update content between remote site and back office. With a single solution as the re-datum PMA enterprises can automate their content management process, by creating, managing, reviewing and publishing structured mobile XML/SGML methodology would be to measure the following measurements appears reasonable:

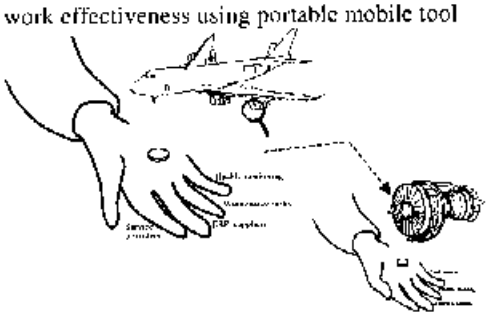
a) Improved overall linkage of content management to core product/service measurement.
b) Streamlined costs associated with content creation, management and delivery measurements.
c) Increased organisational agility and effectiveness by automating delivery measurements.
d) The above setting tested the various PMA/equipment for flight despatch. More data from the overall maintenance effectiveness review needed for not only the despatch phase but all working phases.

II.6 Case Study Design - Application Intelligence Formulation

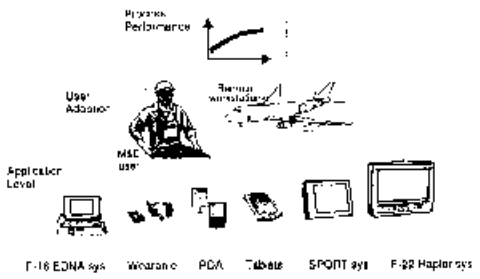
II.6.1 Theatre Management Proposal Using Mobile Workforce Concept

The theatre approach to bring cross-disciplinary issues to one point for conflict resolution promoted understanding of the "big picture" of operation. Through this excise the PMA developed extensive intelligence to join strong business partnerships with complementary CELS organisations who are willing to test the nomadic network as well as to provide constructive feedback. I.2 study allows researcher to study broadband across large network areas made use of secured wireless technologies including wireless LANs. On Layer 3, promoted and effective use of resources and PMA in both the airlines and AME firms because the whole purpose of systems-application for PMA adoption depended on a number of factors interwoven between the sub-layers. Hence that an Apriori analyse is used to find out the correlation between the elements defined in the 3 layers of systems-application intelligence and critical paths identified for early success factors for theatre management.

PMAS slide 1 - Sponsor vision to create new work effectiveness using portable mobile tool

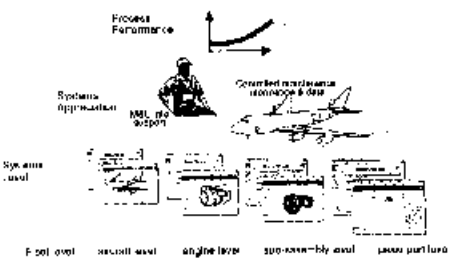


PMAS slide 2 - Hardware competitions

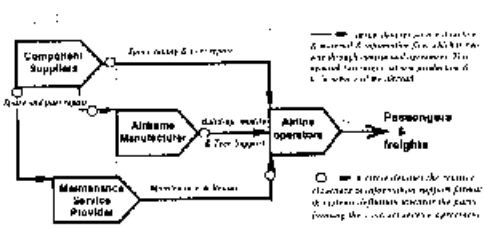


The MWM could start with a sponsor's vision, where electronic technology support may not 100% achieved the level of performance required for the AME requirement today (PMAS Slide 1). However, it is of practical and researchable importance that the existing information setting should match the future deliverables of mobile tool kits. ICTsp offered a list of equipment as shown for AME sponsors to make use of and link their dreams to reality.

PMAS slide 3 - software competitions

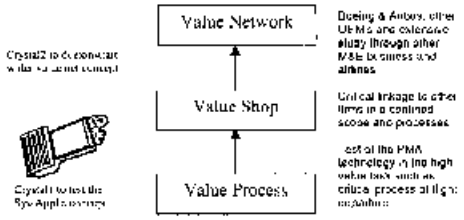


PMAS slide 4 - network player analysis



PMAS slide 5 - PMAS demonstrator to connect the hardware and software interface for the process improvement, leads the way to study competitive interface and its usage.

PMAS slide 6 - the concept of Value Process, Shop and Network to support further development of the networked algorithm.



Having designed the CrystalI and demonstrated the innovative approach to use a physical workable support tool for AME process and front line users it is necessary to link up the network players to join the study for network benefit analysis and implementation. A player management model for AME industry using ICT deployment is needed with the support of ICTsp offers and suggestions.

II.6.2 AME business level and process level in connected service

The study objectives were fulfilled by qualitative and quantitative methods, helps to study fully the behavioural pattern of the concerned unit in minute details. This method served as a check of model validation and important variables omission. Progressively the presentation to the panel experts for way forward.

a) Relate the activities carried out at the business level - The nature of the business level deliverables are depended on the progress of the players expectation. Converting that the users must engage the following key issues:

- Operation planning data that fits the 4-steps revenue cycle
- Statistical improvement for spare support as good as CPFR

b) Issues against that carried out at the process level - The nature of the process driven deliverables are technology driven hence the design features of the mobile kit should cater for the following:

- Usability driven System, Application and Agility couple
- Ergonomic factors pertaining the issues unseen in the back office

Since business level and process level in connected service Identify all the key activities that could be lined up in a spectrum of activities to form a ruler or scale to be measured in later chapters for project deployments. When user participation is compared to technology available, the shape of combination is expected to fall into a certain shape.

II.6.3 CELS, BPET and PMAS formulation

Through a five visits over three months in Airline A, each visit was to collect data and was collected from CELS representatives in AME's and the design features for the M-Theatre testing. So that the 4-step method consist of sufficient layers for detail analysis. Control of heterogeneity in configurations study affect the outcome of the research outcome is through a simple performance measurement tool called the "Traffic Light" method (Neely,

1998). Those measurement factors are to be used to ensure the final result is not much affected by subjectivity of the test. However, the discretion of the signals (red, amber, green or in between) could be called for alternative explanation (Lewis, 2001). A four-stage detail "questioned" method (Revans, 1984 for Action Learning) was developed. The respondents indicated that the research model was a proper representation of the factors affecting the M-Theatre software package. A number of valuable suggestions from the AME users have been obtained.

II.6.4 Data collection design integration M-Theatre visibility

The M-Theatre instrument during the qualitative interviews, five changes were made for the test in the real life airline environment, a lot of which may be shared with the competitor:

a) The definition of M-Theatre-related applications had to be given at the beginning of the questionnaire. At the beginning the definition was not given.

b) Each M-Theatre functionality listed in the questionnaire was given with a definition.

c) The item 'Wireless device' in the question about customer interaction methods used was explained further by giving some examples (i.e. mobile phone or PDA).

d) Each M-Theatre definition was rated with five-point scale instead of binary scale for meaningful data, but not shy away from the competitors.

II.6.5 How to match ICT and critical process?

The appropriate action to ask the people if the completed project progress is to be seen and the researcher's contribution would be measurable? Existing methods suggested that (Zikmund, 2003) a high percentage of response should be existing to show the success. So a three-week follow-up of contacting non-respondents by various methods (phone, e-mail and fax), a total of 40 responses were returned from the frontline users. The data can be feed to the Apriori test for the correlation of the work for the study any ICT tool to maintain the airline.

a) Survey data for mobile function correlation

The following summarises the survey data as required for the

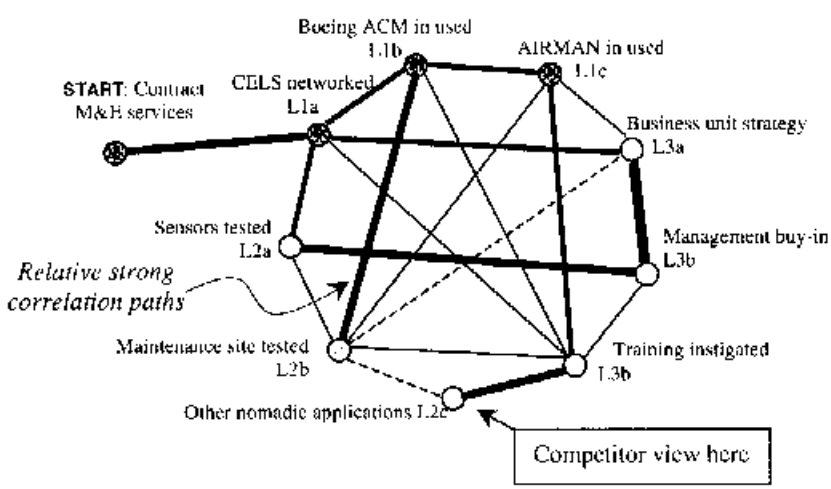
Linkage	Description	Surveyed parties	Correction
L1a	Generic Maintenance Value Network	AAME, CELS1, CELS3	30%
L1b	Boeing ACM in used	AAME, CELS1, CELS2	10%
L1c	Airbus AIRMAN in used	AAME, CELS1, CELS2	20%
L2a	Nomadic Support in Critical Process	AAME, Boeing, Airbus, ICTsp	30%
L2b	Management buy-in	AAME, CELS1, CELS2, CELS3	40%
L2c	Training instigated	AAME, CELS3, Boeing, Airbus	20%
L3a	Appreciation sensor tested	AAME, Airbus, ICTsp	10%
L3b	Maintenance site tested	AAME, CELS1, CELS2, CELS3	10%
L3c	Other mobile application	AAME, CELS1, CELS2, CELS3, Boeing, Airbus	10%

The significant test showed strong association between expected and unexpected association between one and another. The minsup (minimum support expressed as a percentage of the total number of transactions in data) and mincon (minimum confidence also expressed as a percentage of the total number of transactions in data) bot have quite small values because of the size of the databases.

b) Apriori Correlation

Linkage	Correlated	Correlation results	Feedback	Correlation
L1a	-	Nil significant matched	70%	Weak
L1b	L2b	Boeing ACM test more matches maintenance sites as it reflects the existing preference of usage	45%	Strong link
L1c	-	Weak correlation to other 6	33%	Weak
L2a	L3b	Sensor testing matches management buy-in for investment consideration	72%	Strong link
L2b	-	Weak correlation to others 6	23%	Weak
L2c	-	Weak correlation to others 6	12%	Weak
L3a	L3b	Business unit strategy matches management buy-in the correlation was most significant in the survey	89%	Strongest link
L3b	-	Weak correlation to the other 6	34%	Weak
L3c	L2c	Training instigated match other nomadic application so that frontline staff can make better use of all mobile tools	77%	Strong link

The Agent facilitated data collection and help developed competitor's view on the Apriori analysis for the linkage between the CELS players and their critical process needs:



Apriori Linkages

- Systems Link
- Application Link
- Agility Link

Strongest Linkage

The strong link between L1b - L2b, L3a - L3b and L2a - L3b are identified using the Apriori test, but each group makes no linkage to the others.

What to connect these Links

There is no obvious relationship for these factors. Hence PN collaborative too needed to make connection concept fully applicable.

Figure II.6.5 Apriori diagram showing the relative correlation

II.6.6 Direct Benefits to Airline and AME Firms through the PAMS Trial in the Reference Site

In future this rich content PMA can incorporate the configuration control which manage and publish customised data for individual aircraft configuration. Dynamic linkage to multiple formats including web and PDF as well as to directly linking to supplement the Electronic Flight Bag (EFB) concept in the cockpit (for flight crew). Future issues can be analysed on ground of the re-datum prototype:

a) More accurate technology roadmap bearing and location - Matching some milestone points to business-system integration for benefit realisation demonstration.
b) More precise "Theatre Management" - Taking sensoring, network, tasks in theatre view to confined details such as RFID/GPS for surgical precision logistic and technical control.
c) Crystal2 Development - Analysis of conceptual nomadic effectiveness based on newer prototype for more enriched mobile information display to connect with EFB.

II.6.7 Limitations of Systems-Application Intelligence Approach

As a whole, PMA test is effected on airline CELS players in the confined process for flight despatch. This test has not included component suppliers who reside in down stream of the CELS value chain. In future studies more data should be captured in further dispersed e.g. OEM and outstations.

II.7 Conclusion for PMAS-MWM Demonstration in a Local Airline

The objective of this research to bring systems and application together through a modulated approach has resulted in a method capturing the systems-application intelligence for the specific process in CELS network in a critical process. Through correlation analysis some key features of the technology demonstrator has been refined hence the upcoming of Crystal1 prototype. For a satisfactory demonstration, which incorporates elements sufficient for rich content PMA thereby improving overall product/service offering in defined process is conceptualised and presented. Thus generated a set of guided rules for PMA development path especially in the complex network-nomadic-appreciation intelligence gathering. It is also found existing support specialisation, mobile solutions and products available exhibit constraint traits as "islander systems" in connected process linked.

Through a systems-application approach in a defined domain of aircraft maintenance the final design in a core competence dependent process, the soft and hardware blending integrated into Cystal1 prototype is considered as a stage-wise success. This research found that if this methodology is applied under a set of guided rules, its application knowledge can be dissimulated for early success.

Further work

The mobile toolkit and the process correlation matching provided a real life data to support the on-time departure performance of the aircraft maintenance. How to measure its success, especially aligned with the C-H Method case would be an interesting development for the AME players to envision network wise application.

Appendix III

Case Study Design on Extending ERP for AME Performance Management

[From a paper presented to the SCMIS04 Conference for data gathering in PolyU MSc. Class developed to a journal paper presented for IJBPM PolyU MSc. Class and SCMIS05 jointly developed with Chan (2004)]

III.1 Airline Maintenance Engineering Business Process Improvement

Airlines business has two main streams: passenger and freight transportation. Many airlines' air cargo business divisions generate high percentages of profit, however, it appears that freighter operation could not be comparable to the more lustrous business for passenger flights. Not only within the airlines, but also in the operating environment - majority of the world's air cargo terminals are built farther away from the runways as compared with the passenger terminals that makes aircraft movement e.g. taxing and towing time 15~30% longer than passenger planes. Freighter bay remoteness adds difficulties to communication, logistics support, workflow monitoring and management. These are critical to effective maintenance. According to the airframe manufacturers reports, the On-time Departure (OTD) is about 5% worse across the fleet and the average delay duration is 10% higher than in the freighter fleets.

III.1.1 Process re-engineering opportunities

The airlines engineering organisation (AEO) is formed under the airlines responsibility by law. AEO oversees all the engineering and maintenance activities including the delegation of work to the selected maintenance and repair organisation (MRO). Owing to diversification of core competence MRO further outsource some of the work to selected service providers, e.g. aircraft towing. Any changes from the AEO side, in the already tensed flight schedule would result in the following chains of activities and flight delay is experienced.

III.1.2 "ERP Extension" strategy for improvement

ICT supported BPR has many attributes to meet the challenges of outsourcing. This strategy is backed by textbook success formula that a new ICT "power pack" would enable productivity enhancement, process efficiency and product development cycle improvement thereby significantly enhanced the revenue cycle. New ERP also resolves intricate issue in modern SCM. Many studies reported Enterprise Resource Planning (ERP) development challenges:

a) slow and volatile process to source, intake, customise and implement of ERP,
b) unsynchronised peace between developing the vanilla version of ERP to changing business process dynamics,
c) change of specification, change of requirements etc.,

This will result in deferred commencement of operation benefit realisation. Once developed, the concrete and stable web based ERP are extremely powerful tools to drive new business opportunities. Hence, combining deliverables of new ERP and BPR that would become the winning formula in the contracted engineering and logistics services.

III.2 Literature Review for BPR and ERP inefficiencies

There are voluminous studies on BPR since Hammer (2001) defined BP-Reengineering for business strategy management in early '70s. Usually SCM process studies commenced with internal requirements within companies, owing to inherent inter-firm linkages and their evolving roles, BPR linking to networked players in the CELS on corporate and business units levels. Lean manufacturing, quick time to market and strive for early success are the key drivers to restructure the Supply Chain Management (SCM) through business process change.

III.2.1 ERP development obstacles in contract service environment

Companies accomplished the ERP path should eventuate the business benefit however almost all researchers regarded not only the ERP study a difficult subject but also a perceived low success rate. From the AME perspectives, there is no easy way to achieve the required level of business improvement and the following pain are gathered for ERP to be effectively used in the CSN so that the whole network can rejoice new ERP usage:

a) *Complex* - ERPs are regard by Cadili (1999) and most cases from onwards for which to deal with cases which have rigid, and difficult to adapt of-the-shelf ERPs to specific workflow and business process of a wide range of companies. Complexity is cited as one of the main causes of their failure. EAI is aimed to address the complexity.

b) *Inherent design issues* - difficult to use, some systems are either too simple or over-engineered relative to the actual needs of the customer hence it could hinder the process of existing simple, successful and profitable business rather than helping it. The value of greater visibility of work in progress and performance measurement affected.

c) *Weakest Link* - inefficiency in one connection or at one of the partners in the PN may affect other participants with positive anticipation. However, cases supported that only a few exceptionally good ERP can improve PN linkages, most of the weakest link exposed.

d) *Resistance to share* - Many researchers e.g. Hermosillo reported sensitive internal information are locked between departments (obviously worsened between external players in PN players who are segmented process).

e) *Unclear company boundaries* - the differentiation between the views of application and potential users and implementation services has widened. the applicated advocates instigate good prospects of ERP and solving problems of blurring boundary issues.

f) *Switch barrier* - switching cost are high for PN players which significantly reduce flexibility of non-homogenous ERP's in PN. Hence, flexible ERP's was proposed (Cadali, 2003). Homogenous may solution providers lost their own identify. Worst still, same branded ERP's may not be interconnect-able rendering reduced PN competitiveness. *Compatibility issues* - Problems encountered with the various legacy systems of the partners, in terms of definition, usage, process flow and impacts as defined by Bomersa (2003). If this is added to the homogeneity issues in PN and low interconnectivity the business network competitiveness would be suffered in near term (Dixon, 2000).

Recent ERP research suggested that the next level of development, on top of EAI methodology should involve process improvement and widening PN towards a greater chance of success and highest competitiveness, a term later defined as "ERP Extension".

III.3 Performance Management System Theories

An increasing number of studies have demonstrated the importance of performance measurement system (PMS) in production and operation management. Companies generally assumed that PMS is linked to the business strategy by supporting senior management decision making and actions. The study of PMS has been focusing on what to measure (strategic, tactical and operational level) and how to measure (performance indicators), but not why to measure. There is still much debate about the use of PMS information as the key driver for building strategy, increasing performance and enhancing responsiveness in the external dynamic environment. Much of the work has been concentrated on linking PMS with strategy without paying much attention to modelling the actual performance of the complex management operation. The literature discussion on the applying PMS exists in disparate.

III.3.1 Literature Support for PMS

A number of PMS studies that appear in literature of business, industry and strategic management have been specifically writing about "what" and "how" to measure to ensure business process continuity. Examples of these are the different levels of measurement (strategic, tactical and operational measurement) in the field of production, logistics and operation management and the different perspectives of Balanced Scorecard (financial, customer, business process, learning and growth) in the field of strategic management.

III.3.2 PMS development to supplement ERP

Evidently, the intention of using PMS is to support management decision making and take appropriate action. However, there has been much debate over how PMS can support strategy or improve operational performance. This is because of the dependency of PMS on hard and highly formalised information that has been criticised for its limitation. PMS development heavily relies on somebody with expert technical knowledge in on-site operation. It is difficult to define and execute PMS without such knowledge. Hand-on experience in on-site operation in the operation among the favourable criteria to ensure PMS implementation success for high value, highly customised service.

III.4 Current Challenge in PMS for Production and Service Network Management

In the dynamic business environment, linking PMS with business strategy can be a challenging endeavour. PMS can reflect not only the process performance but also the performance resulting from the integration of processes in the delivery of final goods and services to customers. The synergetic effect arising from process integration is important

a) *PMS Data Granularity* – PMS are supposed to be prominent, hard data. Careful decision on the nature of data is as important as the performance management itself. Designer must balance the need between collecting too much and too little data. Well tempered term Key Performance Indicator (KPI) is resulted.
b) *Correct and Accurate Data Capture* – measurement data is an objective measurement of the subjective reality. Hard information is often limited in scope, lacking richness and often failing to encompass non-quantitative factors.
c) *Performance Monitoring* – the need to link measurement data with action, otherwise the measurement is merely a reporting mechanism. The art of linking measurement data with actions requires coordinated organisational effort.
d) *Top Management Support* the need for senior to convey message that the measurement system is to measure for sustaining improvement as opposed to presupposing individual output.
e) *Necessity of High Technical Knowledge* – to ensure measurement is reliable and relevant to operation, it is necessary to have qualified, independent marker who has the common knowledge in that industry as on-site operational expert.

III.4.1 How to expand ERP in supporting connected PN process

Common views on ERPs allow grouping of literatures into 3 major types and how it would be detrimental to grouping factors analyse on key issues of the implementation and development efforts to tackle the right areas (Yin, 1998). These three areas of review, are listed in LR for the perspectives of the following 3-pillars improvement:

A) Systems $\longrightarrow$ B) Applications $\longrightarrow$ C) Agility

In any given industry, that has been subject to lots of research in pursuance of the possible extension. The priority should rest on network development itself rather than operational routine (Markus, 2004). With the considerations for these three groups, it is clear that review of the above issues may fall into extended literatures outside the development-implementation doctrine. ERP implementation to cover the issues drop behind from the systems and the applications initiatives identified many gaps for further progress. The above gaps, also as opportunity, may offer significant improvement for certain key variables to be developed in the face of the ERP integration challenge.

III.5 The Performance Modelling Framework

This section looks at performance modelling under a networked enterprise operation with implications for dynamic strategy. The discussion arising from this section advances the literature on PMS implementation. The rationale for exploring PMS further in this aspect is because of the difficulty in using PMS in a way that economic benefits can eventuate. The proposed performance modelling framework provides the basis for the formulation of a system implementation project that encapsulates PMS as the generic best practice.

III.5.1 Enterprise Model Development

A model is an abstract representation of reality expressed in terms of some formalism. Similarly, Porter defined model as an abstract of complexity to isolate a few key variables whose interactions are examined in depth. The significance of each model depends on the fit between its assumptions and reality. Corporate objectives can define an

enterprise model and the content of an enterprise model is whatever the enterprise considers important for its operation. The generic value chain can also be an enterprise model, since it is used to describe an enterprise. An enterprise model comprises a number of separate models to provide an integrated picture of the enterprise. Because the value chain explicitly describes both the primary and support activities, it is an enterprise model that integrates together various individual models to give a generic picture of an organisation.

III.5.2 Collaborative Planning Forecasting and Replenishment as target

Seifert (2003) theorised CPFR through successful operational experience for Wal-Mart etc. that BPR through collaborative networking with high content of outsource could be an important breakthrough for effective SCM BPR. Not only to articulate productivity of one company but a range of network players as well as multi tier suppliers denotes as (T_1, T_2 ... T_n):

a) low readiness partners with varied level of ICT support,
b) lack of internal collaboration focus due to core competence shift, and
c) segmented links in the value chain with varied degree of participation

III.6 Case Study Design - Airline A On-time Departure Critical Tasks

Many airliners are concerned about their on-time-performance (OTP). A bad performance can destroy customer satisfaction and incur a consequent business loss. On average, most airliners kept their OTP at a level greater 90% of all dispatches. In reality, complex aircraft operations in a busy airport hub can lead to a significant low rate of OTP. One definite contributor is, aircraft maintenance operation has a direct impact on OTP performance. Aircraft fleet maintenance operation can be categorised with scheduled or unscheduled maintenance. Scheduled maintenance represents tasks that can be planned while the unscheduled ones can only be reacted.

III.6.1 The Airliner Operational Challenges

Slide 3 illustrates a competitive analysis between Airline B and a selected competitor who has relatively higher integration, in terms of maintenance operations, the competitor's configuration has a more controllable OTP. In view of the operational requirement Airline B's maintenance division senior management is attempting to develop a performance measurement system (PMS) to control OTP.

III.6.2 Process enhancement and collaborative supportive tool

Hammer (1998) introduced BPR concept and Peters refined it, still, industry is generally lack of toolkits to enable change agents to initiate and sustain BPR, many view it as bulldozing efforts at critical moments of the change.

The BPET model is an abstract representation of operation elements expressed in terms of some formalism in lieu of several key BP features such as airworthiness, safety and business continuity that cannot be overruled in the selected field. BPE3T has a clear time-to-market goal that "quick success" oriented model. The model's fitness between its

assumptions and reality would be tested through hypothesised and actual performance. The simplest form and then capture stake/shareholders and executives/managers in the selected AME firms:

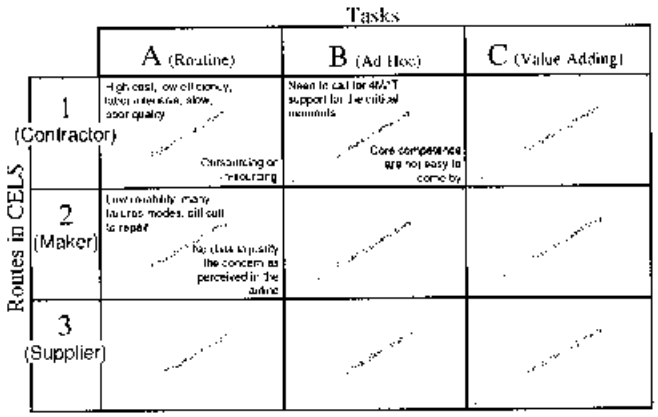
a) customers - target service delivery, products

b) technology providers – total ERP solution or partial solution supplier

c) employees, knowledge workers and staff participate in the collaborated study

III.6.3 Task Rote analysis

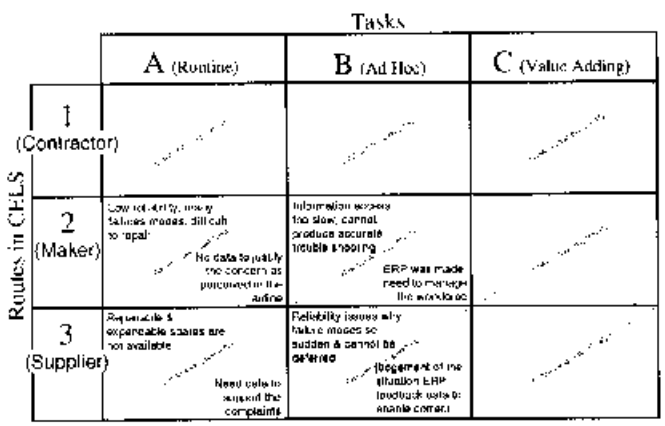
The concept of studying the to dimension of the process has been promulgated by various groups of studies in the face of rapid business developments. The purpose of the variation study enables the players to put all necessary information on the table for evaluation, in that the relative significance can be located for improvement and future ICT deployment. The following analysis attempts to group the collaboration relationship between the task and the routes in several ways. The resulting grouping unable a task-route analysis by various parties in the AME to check if certain combination would yield the required results. Since all tasks are listed on the table hence any combination would be allowed for the players to feedback the preference. An introductory notes and a training is provided as follows:



a) Layer 1 Analysis

For the daily routine work it is necessary to identify the major issues associate with the task s details. The feedback from the frontline staff replied that the traditional working method is limited to job-shop style. In anticipated work profile trained engineers work in groups and more efficiently and more positively affecting the work organisation unit, based on common analysis of TA,B,C-R1.

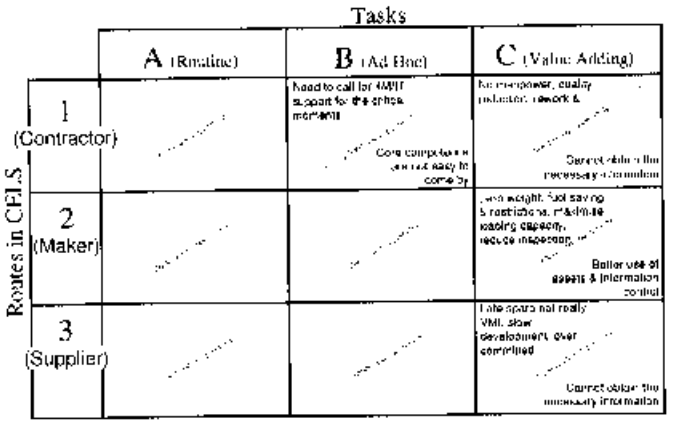
This is called the essential portion of M-Theatre.



b) Layer 2 Analysis

For the tasks that are collated to the industry by nature, that is a global network of AME players outside the home base. The organisation should consider a different for m of work that of a task force unit which is disbanded at completion of an ad hoc task, and the difference for the program office arranged to discharge an initiative, using analysis of TB,C-R2 common concerns.

This is generally called the global network view.



c) Layer 3 Analysis

The high value task, are also shared between the PN network players who are enticed to join the AME PN. Managing the relationships that exist between engineers belonging to the different organisation units could be difficult if the issues affecting their work are not addressed adequately, using analysis of TA,B,C-R2,3 common findings.

This is generally called the value chain enhancement portion.

Figure III.6.3 Figures showing the possible combination of Task-Route analysis groupings

III.7 Case Study for Freighter Maintenance Effectiveness Improvement

III.7.1 Expected performance improvement

New ERP enable EDI for higher effectiveness. The collaborative supportive performance scores embed in RCPS algorithm. This platform articulated principles of CPFR in CPF-Scheduling. The results for alerting D value are highly accurate (average 92%). But as for action, the hypothesis improvement and effectiveness enhancement over the use of the forecasted data for balancing is not so successful (less than 50%). Through discussion and meetings the team appreciated CPFS, its inability to revert the actual to prevent freighter delays, hence not a full CPFR attainment.

III.7.2 Collaborative tool application survey

One of the greatest constraint identified in this program for freighter maintenance is the need for real time updating tool for the situation. In the maintenance bays, where the MRO team has to deal with 3~8 airlines at the same time, the network would need a suit of collaborative support tool to sustain the maintenance operation. Currently the ramp activity data, which is equivalent to the sales data on the counter and the remaining goods in the shelf for supermarket replenishment owing to the problem of not updated fast enough.

The task-routes analysis for this case created an opportunity for the AME players to jointly evaluate the process associated with the collaborative tool and the maintenance process for different layers of work. This will form the basis of performance evaluation and measurement and a feedback path for the task-route analysis. Hence a survey to reveal the maintenance staff's need as follows:

Survey Questions to AME Critical Process Owners (Please Cycle as Appropriate)

BPET Question: OTP Real Time Support Requirements	Content	Speed	Flexibility
1. Business process - what is to be expected form a change?			
2. Critical OTP steps what factor is critical to your work?			
3. Critical path management - which part helps trouble shooting?			
4. Resolving constraints - optimised for the logistics?			
5. Maintenance data sources - most important for linkage?			
6. Hardware wireless tool - generate changes in areas of interest?			
7. Working parties - linked can be made between AME's?			
8. Management expectation - perceived benefit from the systems?			
9. Competition hardware – comparison with other toolkits?			
10. Competition user interface - crucial differences in use?			
11. Task accomplishment - enhancing feedback for work done?			
12. Mobile computing - most helpful for your job?			
13. Knowledge gathering - helps trouble shooting?			
14. Training - mobile support technique on the key functions?			

Note: Feedback to be marked as: Much needed Nice to have but not a necessity No need

III.8 Conclusions for OTD PMS Improvement Direction

This case showed that PMS are interdependent elements for the successful deployment of performance modelling to support strategy. In the discussion of dynamic strategy we have viewed strategy and performance as being affected by the context of production network currently playing an important role in the field of production and operation management. In the context of production network, the enterprise model provides the structure for the integration of performance measurement system in day-to-day operation while the performance measurement system provides the feedback mechanism to support the changes of enterprise model. In the section about the case study, we have described how the two elements work and support each other to handling the interdependency that exists between.

Appendix IV

Case Study Design on AME Meeting the Utilisation-Performance Challenge

[From a paper presented to the SCMIS03 Conference for discussion in PolyU MSc. class]

IV.1 Aircraft Maintenance and Engineering Collaborative Support Tools

Global air transportation has experienced drastic changes from the air travel boom in 90's with drastic changes and more fierce competitions, higher uncertainties, tighter regulations and tougher operating doctrines. Problems aroused using traditional intricate logistics within the value network aggregates complexity. According the Bernstein (2003) AME (e.g. $CELS_2$) has to serve parent airline and the customers to achieve the following:

a) maintain highest safety and security through cost effective maintenance and engineering of the aircraft fleet,
b) protect the best interest of the airline within the contracted production and service agreements, for Buyer Furnishing Equipment (e.g. $CELS_3$) and Seller Furnishing Equipment (e.g. $CELS_4$) systems in the aircraft,
c) optimise aircraft asset utilisation so that their revenue generation capability is guaranteed,
d) ensure continued performance improvement through knowledge and asset development in order that the long term competitive edge of the airline is maintained; new service are created.

The generic issue in applying the relevance ICT in other contracted services:

a) Any contracted activities in the multiple organisations and locations with different business scopes?
b) Any optimisation in the engineering and logistics services for different core competencies?
c) Is matching or resolving diverse objectives of dispersed business units, means to resolve and prevent conflicts?

a) Phase 1 - Production and Entry-Into-Service (EIS)

Aircraft parts are shipped for assembly line in the aircraft manufacturer for final construction of the aircraft. The whole set-up has been defined by the configuration of the aircraft while it was in order, e.g. whether a freighter or passenger plane, ref. Belstein (2000). From airline engineering's perspective, the challenge in this period is on spec definition and delivery project management.

b) Phase 2 - In Service Contracted Engineering and Logistics Services

The airline's Engineering department CELS 1 has a mission to effectively allocate the tasks depended on complexity, skill and equipment level, that would be out-source to CEL 2 or 3. In this stage, the essence of contracted engineering are applied, which was originated from the one-stop shopping concept of contract manufacturing developed over the last decade. First appeared in the pharmaceutical and the electronic industry for contract manufacturing and packing. This concept is now adopted in this industry for innovation market needs.

c) Phase 3 - Development of the CESLS Elements Within the Network, Evolved Stage

CELS development in this stage allows the contracted service providers in network to optimise the business results in blending the logistics elements through evolving cycle to achieve sustainable business growth and competence:

a) Man - technologists, logistics and schedulers, managers, stakeholders, project members,

b) Machine - information systems, ICT, web-enable architecture, data flow optimisation etc.,

c) Material - aircraft, airborne equipment, ground equipment, expendable and consumables,

d) Method - using contract service principles, performance measurement and management, negotiation support.

This is operated on a paradigm of time and information hence a short term for 4M-it.

d) Phase 4 - Competitors - Rise of Fourth Party Logistics and Service Extension

Since mid 80's a new type of company appear in the network, which are in the form of now common known as 4PL business. Some well-known companies in the industry don't own the hardware, but owns the process of ensuring the required maintenance is performed, this type of company has the lowest assets to knowledge weight ratio.

IV.2 Case Study in CELS Delay Prevention by Task Category

After interviewing a group of both frontline operational and back office support staff and managers to explore possibility of collaboration by means of ICT to resolve the technical and commercial issues. A summary is developed to capture the knowledge worker's (engineers, schedulers and logistics managers) expectation for ICT deliverables that can create long term and more sustainable business value and personal value. Modelling the Contract Engineering and Logistics Service (CELS) concept for the three stages of contract services provided for CELS development in the industry starting from the delivery of the aircraft, to midlife maintenance management, and finally retirement of the aircraft as supported by the CELS service agents.

IV.2.1 Survey to Contract Maintenance Service Network Practices

Survey is required to determine the nature of contract service provided to the airlines to generate performance issues in contract execution. Their AME function has an irreplaceable responsibility to ensure the best deals with business partners are negotiated technically and commercially. Survey design is to collect issues around the airline-airframer-service providers, also called the Tripartite relationship:

a) Cost saving practice to achieve year by year productivity and efficiency frontier improvement.

b) Aircraft despatch reliability management so that are they stay at top range of world fleets.

c) Innovation and learning progress for all technical, scheduling and logistics staff.

IV.3 High Utilisation Environments Process Matching

In a case study for an international airline that flies 80 jumbo's, Engineering controls 20% of company expense to maintain the safety and operability of aircraft to the predefined standard. The standards represent the pledge that the airline core competence is delivered to customers. In establishing the scope of CELS operations, Engineering derives policies that represent own airline policy to sustain brand name and business model.

a) macroscopic inbound and outbound logistics are handled with no difficulties,
b) microscopic logistics. In terms of information flow, strategic match of info with the value chain should be strategically matched as depicted by Laudon (2003) and Bloomberg (1994).

The airline core business collaborative value is relatively distant to the micro- and macroscopic value creation in the parent business, hence it is likely that some functions are outsource, ERP is needed to control the maintenance and engineering work progress.

IV.3.1 CELS1 cultural awareness by task type

The management of complex logistics issues through Tripartite relationship to harmonise and accelerate the conflict resolution process. Expansion of the competitiveness required collaboration of the CELS network players:

a) Fundamentals to support businesses re-module needs improvement
b) Long term solution and good relationship to fix aircraft reliability issues

However, Airline A management suggested that CELS network could not increase the AME productivity purely by outsourcing the tasks alone, airline business is after all, not for low-end service benefits. Hence it is required to encapsulate a logical illustration of the existing firms relationships and their supply network relationship.

IV.3.2 Network OTD KPI and task sensitivity

For the airline CELS 1 to maintain a balanced performance from all of its business facets requires a lot of data and judgmental input. The data and info collected have been used in a variety of performance measurement. The NSS system collected data, which are always in the completion format, supplements a lot of raw data collected in the front line operation. The fullness of the tech performance and cost picture provided a stable and level playing field. The survey from several CELS companies summarised that ICT could support real time updating of the KPI data for management. The existing KPI repository was not achieving this design intent, no true representation of the actual operational performance was visible.

IV.3.3 Connected network through ERP extension

Airline and MRO engineers who must share knowledge about issues encountered in operation effectively with airframers and component OEM. In the past sharing of engineering knowledge is rather difficult. In the computerised engineering environment requires that much of the knowledge sharing be on a tool-to-tool, system-to-system basis, rather than human-to-human. If a successful experience is captured, the ERP offers a rapid spreading platform to share, first within the $CELS_1$ and then the $CELS_2$...n organisations, with double loop learning methodology using the ERP data support. However, the result was not very satisfactory due to lose connection between individual ERP's.

IV.3.4 Articulated Expectation for CELS Organisations in AME ERP Usage

ERP systems will be deployed to cannot make appropriate connections between the players, using the results of the NSS process data, the performance KPI is not only to use for reviewing the past with the $CELS_2$ (alliance level). The

depth and agreeable level of data allows prediction of the future to be used, so that both business units can better plan ahead the future activities, cost and profit profile as well as performance profile.

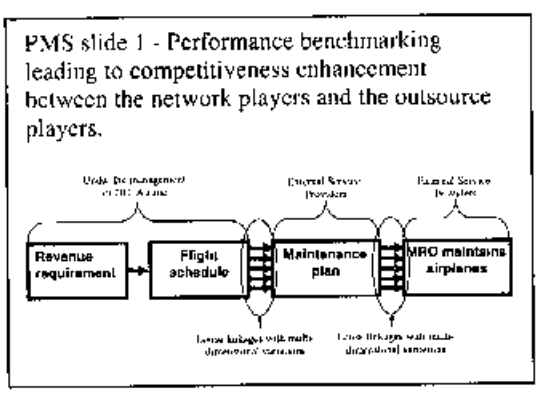
IV.4 Tangible OTD Improvements by Collaborative Support Tool Types

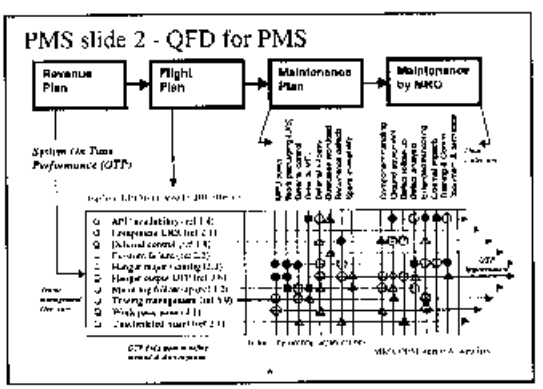
Based on obligation charter AAME has set its goal to achieve faster routine maintenance, accurate trouble shooting for ad-hoc maintenance, on-time delivery of value adding service. The overall goal is measured by on-time departure delta time $\boldsymbol{d}$ by adding the delay time deviations $\boldsymbol{d}$ of the 3 sources where frontline engineers will encounter for the maintenance activities:

$$\boldsymbol{d}\text{OTD} = \boldsymbol{d}\ (\text{schd maint}) + \boldsymbol{d}\ (\text{ad-hoc maint}) + \boldsymbol{d}\ (\text{renovation})$$

To set the numerical goals to overcome the difficulties encountered by the maintenance staff in the frontline would be tied in with the T-R analysis matrix including the following task and collaborative support tool type categories:

a) Schedule Maintenance - Applying the mobile workforce deployment, as it aimed to answer the performance gap identified through the PMS QFD study (slide2) in the 4-step revenue-maintenance cycle has provided communication tools for key maintenance data over the existing walkie-talkies. Survey revealed that this contributed to Tasks-A to C improvement by 12.5% for the process, according to the survey results:





$\boldsymbol{d}$ (schd maint) improvement total = 12.5%, s.d. = 4%	Content	Speed	Flexibility
1. Business process overall	● ◐	● ◐	● ◐
2. Critical OTP steps in last mile	● ◐	● ◐	● ◐
3. Critical path management trouble shooting	● ◐	● ◐	● ◐
4. Resolving constraints for logistics	● ◐	● ◐	● ◐
5. Maintenance data sources linkage	● ◐	● ◐	● ◐
6. Hardware wireless tool improve thought process	● ◐	● ◐	● ◐
7. Working parties linked between AME's	● ◐	● ◐	● ◐
8. Competition user interface crucial for use	● ◐	● ◐	● ◐

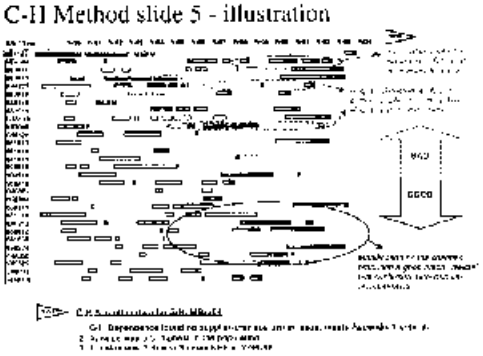
9.	Task accomplishment feedback					
10.	Mobile computing helps sched maint jobs					
11.	Knowledge gathering for new defects					
12.	Training mobile support technique on the key activities					

Note: Feedback to be marked as: 20% or more 10% or less No improvement

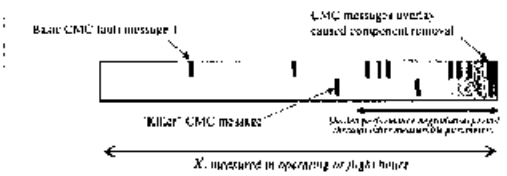
Feedback rate for schedule maintenance survey = 70% for 50 questionnaire sent ref. III.2.8.2.

b) Ad-hoc non-routine and unscheduled maintenance - The problem of slow to return to the maintenance bay due to ad-hoc arising and problematic aircraft systems that cannot be rectified due to lack of support data. The support data analysis should be done in back-office previously. With the use of the C-H Method the survey revealed that this contributed issues in to the Task-B deferrals for Route 1 by 11.5%, according to the frontline staff:

C-H Method slide 5 - illustration



C-H Method slide 6 - shading insights for future aircraft system performance monitoring interface



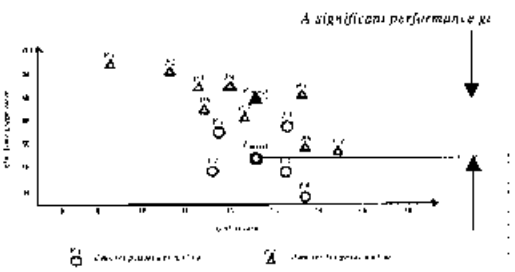
d (schd maint) improvement total to 11.5%, s.d. = 2%		Content	Speed	Flexibility
1.	Business process overall			
2.	Critical OTP steps in last mile			
3.	Critical path management trouble shooting			
4.	Resolving constraints for logistics			
5.	Maintenance data sources linkage			
6.	Hardware wireless tool improve thought process			
7.	Working parties linked between AME's			
8.	Competition user interface crucial for use			
9.	Task accomplishment feedback			
10.	Mobile computing helps ad-hoc jobs before departure			
11.	Knowledge gathering for new defects			
12.	Training mobile support technique on the key activities			

Note: Feedback to be marked as: 20% or more 10% or less No improvement

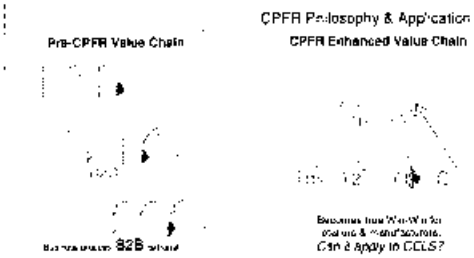
Feedback are collected through Crystal1 demonstration and work along with 10 frontline staff and 4 managers, feedback rate = 100% using action-discussion approach.

c) Value-adding process - The traditional problem of unable to obtain sufficient maintenance data and project data was due to closeness of the projects as these are considered as classified. Inefficient to handle large amount of data outside scope of printed work card. Survey reported this contributed to issues in for Task-C deferrals for all Route-1 to -3 by 16.5%. To be able to aware of the current situation for the renovation project team, and the opportunity to allow partners and competitor to join and work the schedule out the use of the collaborative tool, in the form of mobile support of pattern recognition would enable task accomplishment to meet AAME targets:

BPET slide 1 – Squeeze of performance from the players, highly competitive benchmarking.



BPET slide 2 - Coopetitor work together to create collaboration for new network formation.



d (renovation process) improvement = 9.5%, s.d. = 3%		Content	Speed	Flexibility
1.	Business process overall	● ◐	◉ ◐	● ◐
2.	Critical renovation process in last mile	◉ ◐	● ◐	◉ ◐
3.	Critical path management issues arising in renovation	◉ ◐	◉ ◐	● ◐
4.	Resolving constraints for logistics	◉ ◐	● ◐	◉ ◐
5.	Maintenance data sources linkage	◉ ◐	◉ ◐	◉ ◐
6.	Hardware wireless tool improve thought process	◉ ◐	◉ ◐	● ◐
7.	Working parties linked between AME's	◉ ◐	◉ ◐	◉ ◐
8.	Competition user interface crucial for use	● ◐	◉ ◐	◉ ◐
9.	Task accomplishment feedback	◉ ◐	◉ ◐	◉ ◐
10.	Mobile performance - overall	◉ ◐	◉ ◐	◉ ◐
11.	Knowledge gathering for new defects	◉ ◐	◉ ◐	◉ ◐
12.	Training mobile support technique on the key activities	◉ ◐	◉ ◐	◉ ◐

Note: Feedback to be marked as: ● 20% or more ◐ 10% or less ◐ No improvement

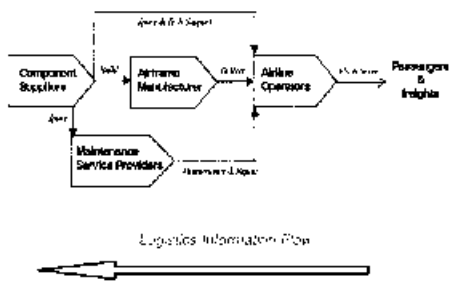
Feedback rate = 40% for renovation maintenance related suppliers and AMEs.

d) The overall improvement is impressive using the d OTD formula, the total improvement is 33.5%. The survey resulted that traditional method was unable to manage complicated tasks through manual script due to lack of flexibility. Survey indicated mobile supported that the use integrated collaborative tools, as supported by the agent will result in significant delay prevention, one-third of OTD is protected despite of utilisation increase.

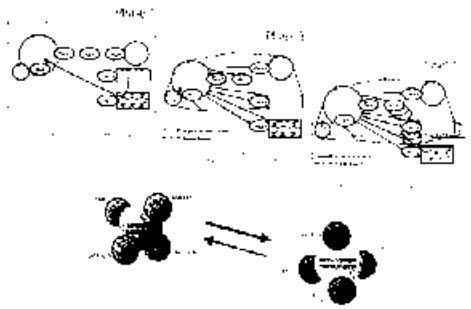
IV.3 Conclusion for the CELS Network Joint Effort to Reduce Delay Times

Reference previous work precautionary steps have been taken to lower engineers resistance to web-based NSS, therefore relative little impact on the process is seen. The political issues in the organisation, e.g. understanding the 'relationship importance' to 'substantive importance' has been taken care of. A suggestion is that it is required to review previous commercial negotiations and put generic strategies into easily referable site for re-apply and enhanced application because commercial negotiation requires a lot of tacit skills and knowledge.

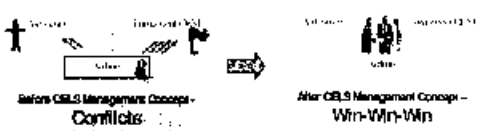
CELS slide 1 – Industry overview



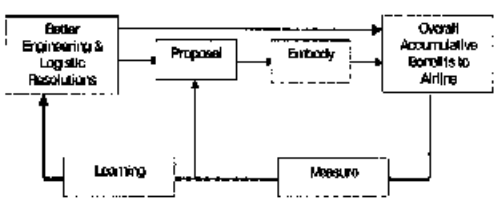
CELS slide 2 – Squeeze for CELS1



CELS slide 3 – Negotiate the core function effectiveness between CELS1 to transform the competitor position to win-win-win cooperator hence the term coopetitor (Seifert 2003) raised.



CELS slide 4 – Transform the squeeze between the CELS players to second order learning as a coopetition network.



Further Work - Major Findings Assisting Concept Development

An innovative approach using the case study linkage and collaboration support tools based on Diamond Model for AME industry ICT deployment, a theatrical view of the production network. This tool would enable theory building for the theatrical management for the designated reference site.

Appendix V

Tutorial Notes on Diamond Model Player Management - A Theory Support for Dynamic AME Environment

[Notes for MSc. ILS Class (2003 and 2004) – On AME industry complexity review]

To handle the multiple users and stakeholder situation with information system deployment one has to consider the applicability of the system to be introduced to the defined reference site and the users and suppliers who need to adopt the instrument (Calisir, 2004). Under the normal electronic device study this needs to be expanded to include network acceptance (Amoako-Gya, 2004) which extended to network players' position, especially the competitors proposals. The MISRU research projects covers the theory and concept building that have resulted in industry improvement over the last 15 years. In the early 1990's, Chung proposed Diamond Model for collaboration, this approach has resulted in a lot of key issues within EAI and other activity based researches. This give rises to opportunity where the existing model can be revised to tackle a enlarged scope of interest using a -SUCCESS- (Ref. 1.6 for the player constituents) relationship revised from Chung's Diamond Model was created and defined:

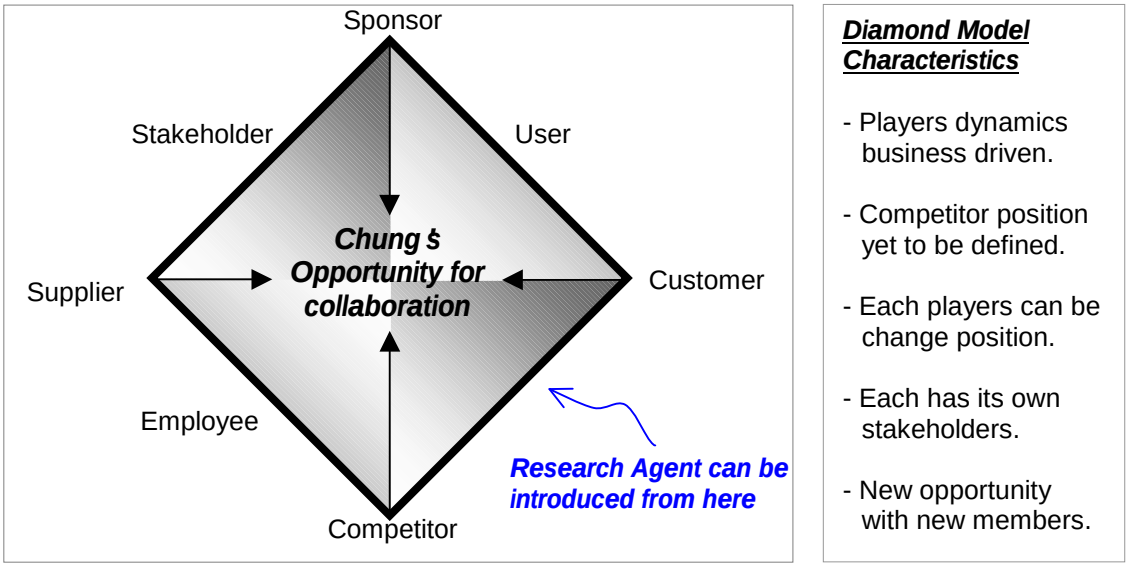


Figure V. Diamond model generic collaboration opportunity

Chung's collaboration model has resulted in numerous cases for opportunity generation and many are later translated to successful applications ref. Chung (2005; 2004). Over the course of the MISRU development there have been

many application with the use of the Chung's Diamond model. Many paths of roadmap had been explored and many cases of successful applications. The -SUCCESS- case can be expanded to show the relative importance of the roles of each character, so that the model of business and process development can be analysed, also improvements:

V.1. Ng (2006) on shipping PN ICT deployment

Ng's study addressed issues of distributed shipping with tactical use of sponsor power to drive the employee to consider customers expectations (Wong, 2003). Through applicated ICT deployment, employees are encouraged to develop new partnering relationships with the existing customers hence "ICT deployment" model is created.

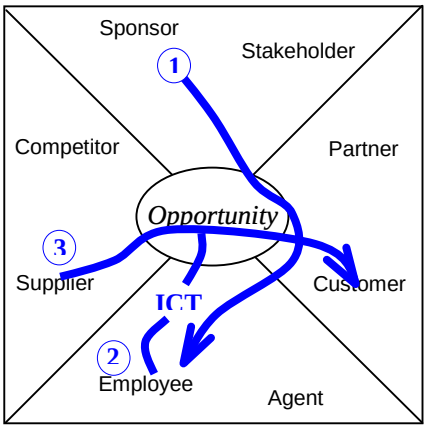


Figure V.1

V.2. Ko (2006) 3PL building business strategy

Yu's 3PL case reported a business strategy change from traditional local demand and work process to use third party logistics. The use of this new approach enables the sponsor to create a PN-wise freedom and enhanced initiative of the suppliers hence that the supply chain is no longer limited to traditional approach but a new level of performance is achieved. Hence the new 3PL.

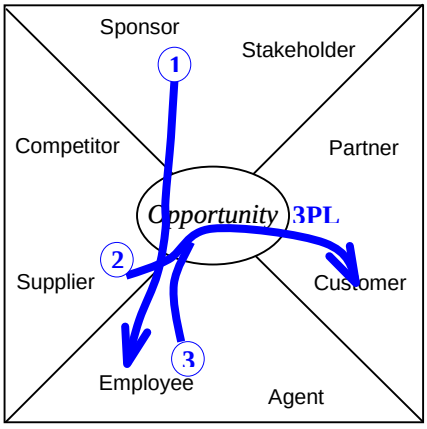


Figure V.2

V.3. Lee (2006) Co-developing new customer service

The enterprise case depicts a collaboration that the business partners approached the sponsor to develop a new service in a selected service site. By resolving a lack of knowledge issue with the sponsor a new formation of alliance with the partners and discuss with the supplier for that installation using a special form of product research and co-development

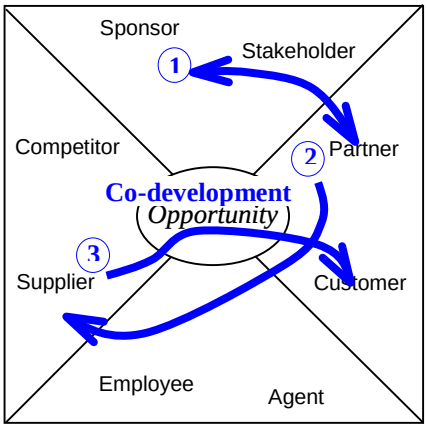


Figure V.3

protocol that has not been used in the selected industry before. Hence the taxonomy of "service oriented co-development" is created for "win-win" situation.

V.4 Yuen (2005): Internal MIS and process control

The use of the ICT deployment has resulted a new way of working out a specific issue in the management succession study. The use of internal process control is similar in nature to that of the ICT development by the shipping cases, hence that the model is repeated in a different operation with different setting of business nature.

V.5. Chan M. (2002): Eight-case model No.1 - Artake business diversification strategy change management

Michael uses a different business process change approach to deal with the issue of the changing business environment so that the partners and the customers are working closer to make use of the existing setting and production network to fulfil new sets of requirement. The nature of the collaboration is different to that of the 3PL collection however the formation of the path is exactly the same so that the use of the 3PL approach is applicated in the ICT supported environment for business success.

V.6. Chan M. (2003): Eight-case model No. 2 - LK co-develop of new products

The LK machinery and Tsing Hua University collaboration to research into a new form of magnesium alloy for new product development is crucial to the future development of the die cast machinery development company. The results are also a way of expressing the co-development protocol especially for the emerging markets.

V.7. Chan M. (2004): Eight-case model No. 3 - Shell production, logistics distribution business process overhaul

The use of the Chung's Diamond Model extended to a new level when the BPO approach is devoted to the complete business not just selected process (marketing and distribution) in the business unit. Hence the label of BPO is also applied for this type of development model. The control of it fell into the sponsor more tightly and the role of the agent, where the researcher was positioned to drive the changes around the BPO process through the network.

V.8. Chan (2006): Eight-case model No.4 - Airline PMS for dynamic operation

Further developed from the internal information and performance control use for the management succession, the concept of the PMS management (Kaplan, 1996) has been introduced to the dynamic airline environment as perceived by the Chung's Diamond Model (2001) while using the ICT for internal process control. However, Chan (2004) in this research case extended the PMS influence (Gott, 1996) to the third party through the use of data committed from the work contract service providers.

V.9. Chan (2004): Eight-case model No.5 - Toy marketing and PN for new products

Chan and Yuen (2005) The Hasbro case provided a reference site using the escalated PN concept for new product development strategy. Hasbro's non-exclusive distribution network to maximise the capacity of the supplier hence a new approach to deal with the sponsor to develop a new "service" form of distribution network. The sponsor plays a new role in the alliance of the toy industry hence that with the partners and discuss with the supplier for that using a special platform for research and development business process. This protocol was a first time in the applicated PN management, which sites before the business process re-engineering is taken place. Hence the term "BPO" created for this type of taxonomy formation.

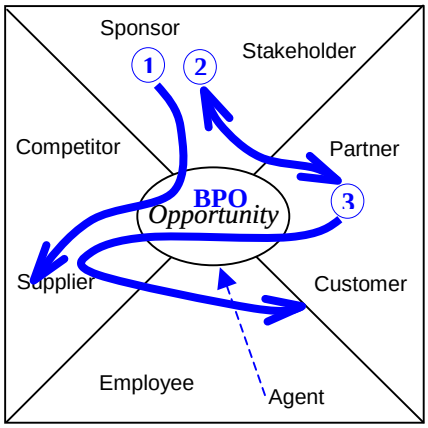


Figure V.9

V.10. Chan (2003): Eight-case model No.6 - Johnson Electric PN and logistics distribution

Chan (2003) illustrated the BPO approach as it was devoted to the complete business but not just selected process (marketing and distribution) in the business unit. Hence the label of BPO is also re-applied for this type of development model. PN control fell into the sponsor where originally tightly controlled process agent dependent. Chan and Leung (2006) applied the player management approach to depict the applicable model to instigate collaborative support tool development. Using the typical case study method it sis possible to link the concurrent progress, as a form of project or cases designed so as to create benefit for all the players involved.

V.11. Pak J. (2001): QFD BPR improvement

The use of the of QFD methodology as reported by Pak (1999) was to develop Rocom as PN adopted new concept for the new service development strategy.

Pak and Chung (1998) created QFD supported network to maximise several types of service sectors enhancement in supporting the sponsor to develop an agent innovated service and product distribution networks. The sponsors and judges as depicted by Pak, (1999) plays a vital role for partners formation in the QFD BPR improvement. This gave rise to the player management research scope for MISRU.

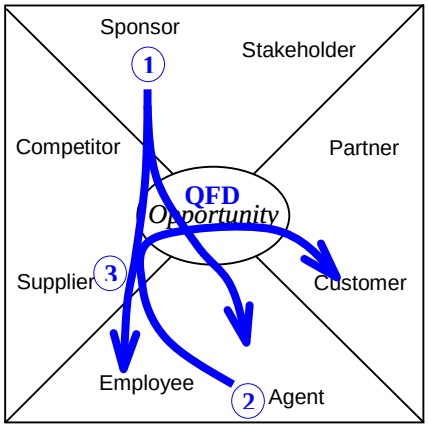


Figure V.11

V.12. Lee (2006): development of BOM for ERP adoption

Lee (1998) reported use of BOM for ERP development has results in a new way of doing BPO for the distributor. The share of it is not limited on the production network and people involvement but also on the share of ERP development technology and ERP usage. BP improvement focused on advanced approach so that the PN finalised.

V.13. Tam (1993): Consultant OEM to develop 4M

The initiation and basic formation of the agent theory combined with the Chung's model to develop the required amount of progress through the use of the consultant service,

as a form of research provided by the new product development process was original by Tam (1996).

In that an alternative form of collaboration is designed for any given network to maximise the capacity of the supplier, so that a new approach is required to tackle 4M to deal with the sponsor to develop a service from a new agent supported network. Hence this is called the consultant network for the many scenario subjected

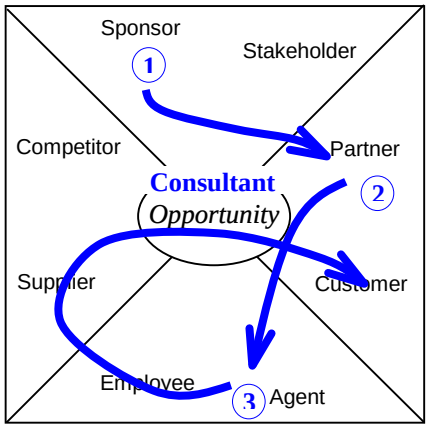


Figure V.13

for study, which forms the foundation of "consultant focused service" in the originally non-connecting networks, also a new definition for service industry.

V.14. Tam (2005): In-source strategy technology transfer

Tam reported an innovative approach to enrich MISRU that in-sourcing business process management for the manufacturing PN. The network has provided a powerful evident (Tam, 2003) to deal with the common issues arising form merger and acquisition where the newly joined business partners non-straightway follower to the existing protocol.

V.15. Competitors - A missing proof for the Diamond Model

The above research was to deal with a lot of different scenarios in the Diamond Model for the Sponsor / employee and customer relationship, then goes to the employee. And the supplier that goes with the competitor and vice versa. In most cases, the issue of the competitor has been brought into the picture. Hence it gives the researcher a good opportunity to measure up the position of the competitor to deal with the situation, and its function in the Diamond Model, where the ICT supplier situation are prevailing in the supplier / competitor position. If the conditions of the above players are appropriate the position of the players are inter swapped of their relative position. So that the competitor can become the suppliers and the employee may turn competitor, etc. So the importance lies in the process why the transformation takes place and also how can this be managed so that Chung's collaboration model can be sustained.

V.16. From Competition to "Cooperation"

In today's dynamic business environment, it cannot view a pure competitor or pure co-operator in a given business setting Seifert (2003). The reason being, position change in the mutually dependent commercial world there is no easy way to define clearly the characteristics of a party in competition or a party in collaboration. Seifert (2003) defined the concept of "coopetitor" (a combined word for the competitor and co-operator) who accepts that the condition of competitor, as the same time they are potential collaborators. This give rise to new way of dealing with competitors who may be at one time becomes the collaborator or reversibly, the collaborator today may turn to a strong competition in the forthcoming PN development and the narrowing of market perspective.

Research Questions from the Diamond Model:

- What is the MISRU research objective? How to cultivate the features of the network relationship deployed expected response from the players?
  Answers: Group consent is, don't shy away from the competition, take communication opportunities, try to align with the common interest, stay with a competitive mind.

- When the assumptions of the player characteristics changes, it is possible that the role of the players have been changed, what is the best approach to go through the -SUCCESS- consideration?
  Answers: Identify the roles of the players first, revise as time evolves and make necessary correlation between the parties so that the true relationship is established through working together, even with the competitors.

- What has left from the Chung's -SUCCESS- Model through the applicated researches in MISRU and the reference site methodology research protocol?
  Answers: If the information about the competitor is non-existing the problem in how to manage the players contribution, especially the competitor's role, is still exist.

- Can the competitors be managed in the network analysis of collaboration?
  Answers: The student group has no consensus about this is question, they suspect that only the opportunity creation and sharing sessions, workshop, conference or gathering may not achieve anything but deeper conflicts, reduced chance of co-operation. The group suggested that the agent must be re-shaped and re-equipped to take more "productive" role e.g. as a demonstrator to test controller to exercise the Diamond Model so that they can align with the common interests, stay with a competitive mind but exploring more collaboration.

Based on the evidence furnished from an interpretation of the papers, and the answers from the questions and discussions with the students, a projection for the Diamond Model expansion and the role of the agent for competitor management are as follows:

Further Work

a) Take the lead in the ensuing competition for the system integration.
b) Involve the competitor to participate on AME player characteristics change in the system adoption.
c) Instigate coopetition between the players, on selected portions of the system integration.
d) Apply Diamond Model to assist AME PN players task-route selection for collaborative support to design.
e) Simplify the player movement with the Diamond Model.

Appendix VI

Tutorial Notes on AME Future Challenges – A380 Logistics

[Notes for MSc. ILS Class (2003, 2005) - On AME industry Complexity Review]

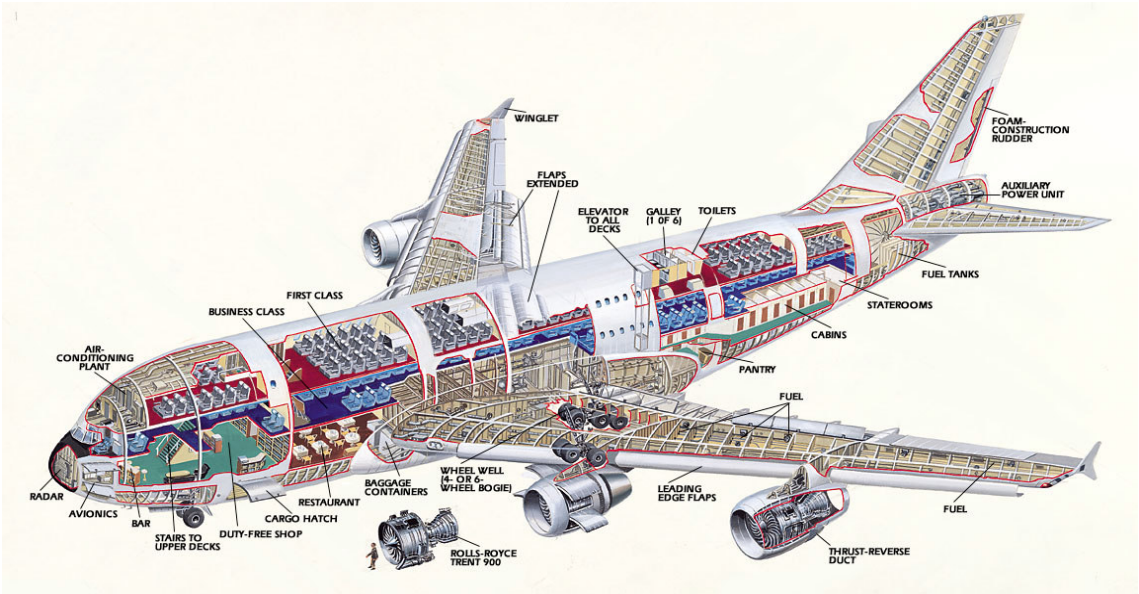
VI.1 Background

This is a presentation of the Airbus latest aircraft type, A380 and the specification of its maintenance data and information. The objective is to show advanced logistics information to be provided for the AME PN as the industry involved in my research. The layout is such that researchers can imagine the process logic and maintenance service, also ref. Taneja (2002, page 109 to 117, A380 Opportunities Driven by Emerging Aircraft Technology):

a) Describe with support of the system diagram where the routine work in repair of the giant aircraft
b) Point out the tools and techniques used to repair and enabled by AME's own ERP
c) Establish the SCM using existing approaches with related technology, what will make a difference?
d) Propose your approach to contribute knowledge in doing the reliability improvement or trouble shooting jobs
e) Current and future research projects that might come along with this new Airbus designs

V1.2 A380 illustrative analysis for the systems maintenance to support OTP improvement

To install a complete and detailed information on the A380 PN information we can visualise the whole and logistics network as a connected activity between the suppliers. First, check out this cutaway diagram and pictures from the assembly of the new Airbus 380 that it could consists 28 levels of systems that could be manageable for the AME PN considerations:



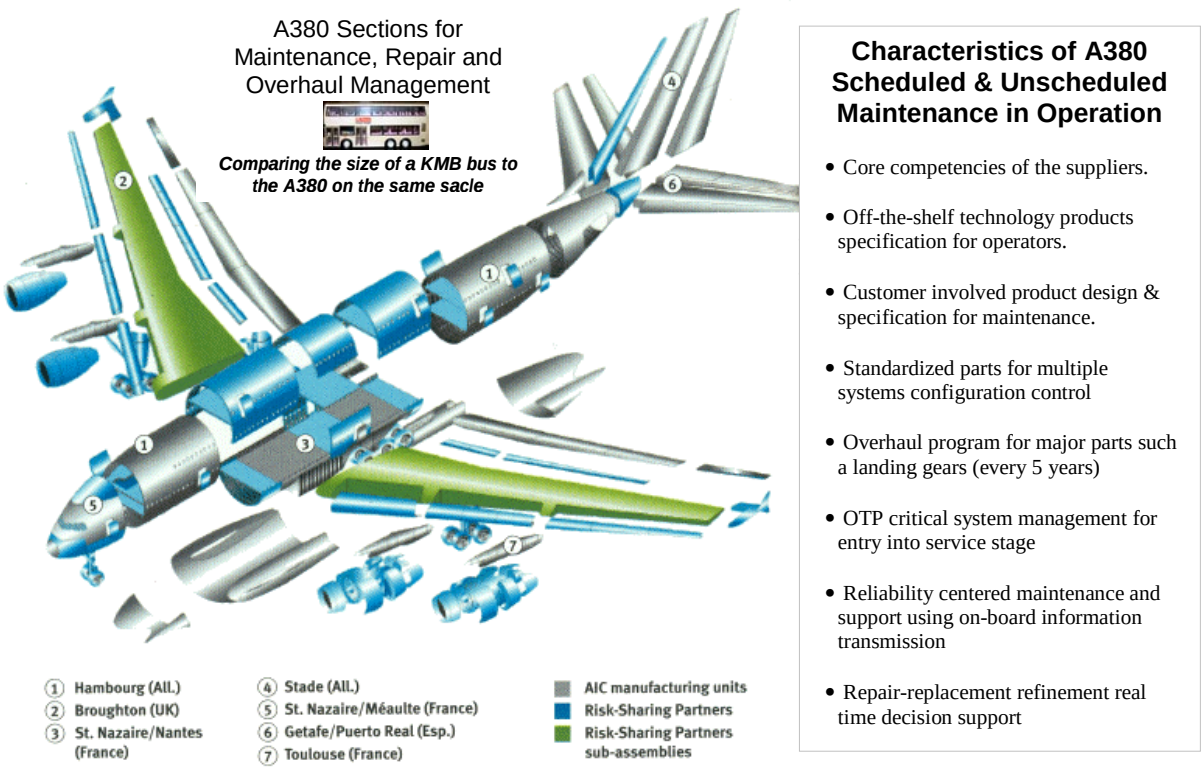
Slide A1.1 Airbus A380-800 Systems Illustration for Maintenance Complexity

Source: Airbus Consortium for the published general layout of the A380 as airliner of the future

Having looked at the integrated view of the aircraft and the systems that contribute to the whole functionality of the airliner. Students should now begin to appreciate the complexity of the aircraft systems and the joint function or the components, in very brief view of how the big airship can carry the passengers around, and more importantly how the systems are behaved on ground and in the air. It is because you may be aware that if anything is not working properly, it is the AME's job to make use of any forms of maintenance data support, information sharing and knowledge gathering to help fixing the defects that might affect the OTP. This forms the basis of the reliability improvement using available information and support. In daily operation, aircraft defect rectification in the critical phase of the ground maintenance is crucial: because only effective unscheduled maintenance, early or prognostic defective component identification, punctual accomplishment of repair can guarantee OTP performance. Hence there is a demand for the effective reliability interface tool for all AME staff to work along with the aircraft, being in the front line physical work or in the back office logistics, a common platform would be on highest priority.

VI.3 Working Dimensions of scheduled maintenance tasks for the future AME organisation

With a wing span of 79.8m (261ft 10in), length 72,75m (238ft 8in). Height 24,08 m (79ft), the A380 is a giant movable workstation for AME to complete the maintenance tasks. In the case of planned maintenance for this integrated, yet each components to be maintained and serviced separately, this exposed view give you an idea of how many major parts that could be subject to in-depth overhaul and repair-replacement programme.



SlideA1.2 Airbus Maintenance Systems for PMAS designs

Source: Airbus Consortium for maintenance characteristics & system analysis

VI.4 Logistics Capacity for Process Management

Even though for such a giant aircraft, the A380 has 49% less components count but 35% more seats (in 555 seat configuration) than the 747-400, allowing room for maintenance data to be handled possibly in the real time basis. The challenge is the real time data transmission through the existing wireless and intercommunication system between the ship and the ground maintenance centre. However, it would be necessary to discuss with all the parties with the operation to know where and how this information can be transmitted to the required party:

a) airport ICT management party
b) airline flight operation & ground operation control
c) AME's service network
d) airframer's information supply

So that all parties are agreed on the changes to enable real time information can be transferred.

VI.5 Issues in Development and Production Network

The A380 maintenance data storage would be a step leap compared with the last generation A330/A340, the reasons being that the new aircraft will hold more onboard information to sustain real-time on-line maintenance and flight data transmission. However, it would be interesting to see how the AME production network could change to meet the revised operational requirements. Hence the hardware and software interface, as well as the mode of operation needed revision from the existing state of the AME maintenance engineer to that of the future knowledge workers.

VI.6 Content supplier for service commitment for the maintenance of large aircraft

Airbus and AME's first began studies on a very large centralised maintenance database. The European manufacturer saw developing a competitor and successor to the Boeing 747 as a strategic play to end Boeing's dominance of the very large airliners AME's. Airbus began the real-time engineering data and transmission for such new aircraft. Using the most advanced technologies for real-time rich information transmission, the A380 central maintenance computer is therefore designed to have 500% more powerful than the previous generation.

VI.7 Conclusion for A380 preparation for real-time aircraft data supported maintenance

The nature of aircraft maintenance information management requires AME to deal with large amount of data in text or graphic forms so that the system designing, developing and integration effort can be nicely tied in with the existing ERP systems within all the players of the industry. The shear size and systems of the aircraft, the complex construction of the aircraft and the immensely variation of relationship between the one component to another, meant that the data and information management is very different to the previous generation. The A380 thus has a great potential for improvement over the existing paper document converted formats that would deliver the so call “business (process) at the speed of thoughts” (Gates, 1999) dream. This is because the existing technical data support is still far away from the perfect scenario of maintenance support.

Questions and Answers from the Students:

- What is the purpose of Airbus' advanced maintenance data support development from production to post-delivery maintenance? What is the key value of muti-million spending on data management in A380?

Answer: It is envisaged that the content of the maintenance and flight information be crucial for the next generation aircraft because the future aircraft are designed to provide rich information content for AME, if AME's don't make use of it, it is a waste. The next level is the speed of using the data, this include the transmission speed and also the speed of clicking the number of times on the display to reach the information required. Applying the rules of thumb for internet application designs, any interface requires more than 3 clicks is a failure.

- Do you envisage a more effective production network if the maintenance data distribution can be shared between the dispersed maintenance stations? Do you envisage more competitive or more co-operative setting for the future AME business under the existing and evolving environment?

Answer: The students responded with univocal view that the future maintenance process, especially in the critical steps should be benefited from the advanced maintenance data support, if the AME operation is aware of the change and make necessary connection. To be able to "plug-in" the socket provided by Airbus to effect a workable hand-shaking is the first consideration. The next is to see how can the future AME PN is arranged such that connected maintenance is a whether a systematic / regulated OR open for dynamic competition.

- Where can we expand of the CELS network to connect such an intricate A380 which encapsulated apparently all the necessary information for maintenance? Which group of external parties can join?

Answer: From the view point of the AME, flexibility and agility is the key to the future success of connection to the A380 applications. It is not yet fully understood the final shape of the future maintenance system from Airbus (and perhaps Boeing) hence that the safe rule of participation is be flexible. Hence i.e. the connection, the linkage and data exchange between the AME ERP's and the Airbus's original design and the data sources are to be tightened through the use of non-rigid designs and interfaces. Hence, opportunity exists for local data management houses.

- If real time data management technology can be tested through AME's connected PN activities around the aircraft maintenance and service work here in Hong Kong, what can a local supplier be participated?

Answer: The use of Portable Digital Aid (PDA) or the Portable Maintenance Aid (PMA) to support the daily task management in the AME operation. This is a main stage in the latest real time data transmission between the ship and the maintenance center's planning and operation, and between the individual ERP of the AME companies. Hence that the interested parties (who would operate the A380 or Boeing equivalent) who be interested to cross check with the research progress.

Appendix VII

Tutorial Notes on Global AME Business – Emergence of the Giants

[Literature review presented and discussed with a group of ISE Engineering Doctor students, 18 Nov 2004]

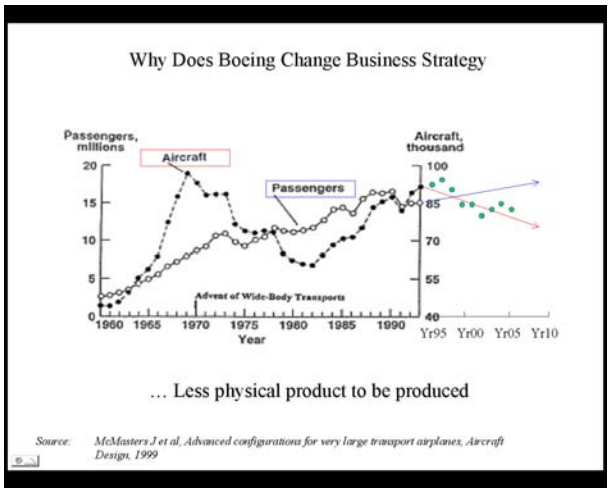
"Welcome everybody, the reason myself and Prof. Chung ask you to attend, as a group very successful EngD students for this class, is to review some of my latest findings in the AME development. Is it really important to enhance the core competence of this industry? Or going back a bit, why is such a mega size company (Boeing) would be interested to take a share of this market? So we are very glad that you may share your experience in establishing the right direction, because you gentlemen's impressive background as senior management in the leading technology companies would face this challenge. How AME industry is a way forward for doing business?"

VII.1 Background

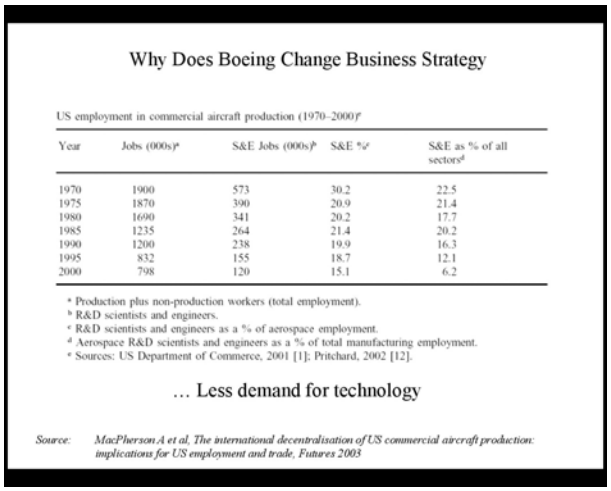
Boeing, a long time aircraft manufacturer, has turned the tide of the AME industry by attempts to market her maintenance-and-engineering (AME) service support in the civil aviation industry (MacPherson & Pritchard, 2003). The following slides showed the reason why Boeing has adopted a new business strategy, and to search for a new core competence development. So that Boeing product and service is no longer one stop shopped airframe manufacturing, but will turn itself to become more after-sales integration and other soft deliverables in logistics.

Let's see the following illustration slides, and we will show Boeing choice of AME development should move:

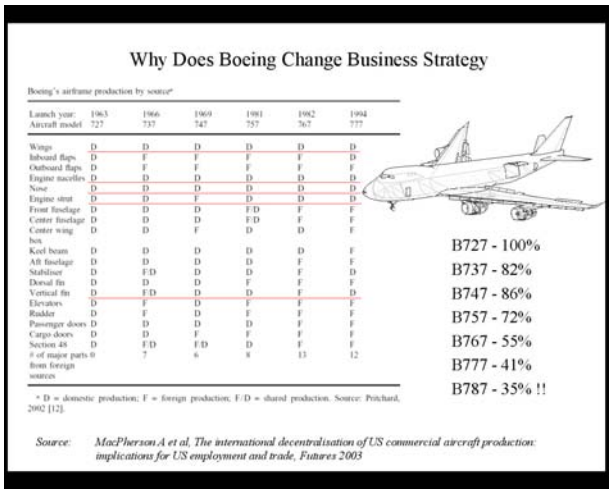
Slide1 The trend of production



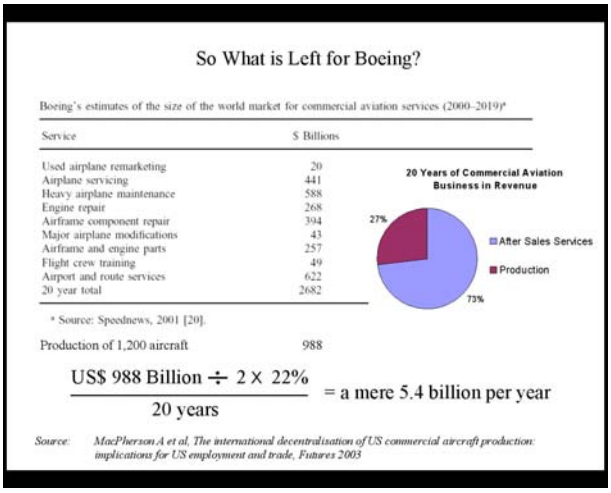
Slide 2 Where should Boeing go?



Slide 3 Diminishing physical production



Slide 4 Lion's share of future AME business



VII.2 Way Forward to Join the AME Business

Having seen Boeing's development history, and the rationale that supports Boeing decision to develop service strategy in the after-manufacturing market, it is important to discuss how this model is developed. What influential factors have caused this industrial giant to change its course? Is that to opt for a clearer visualised future other than aircraft manufacturing that Boeing has sophisticated for years? There is little evidence from the external studies to see how it was merely derived from Boeing's strategy formation conference rooms, OR, it might have captured a significant amount of intelligence in the industry. Let us, from an objective analysis approach, to summarise the key issues that Boeing has encountered, which led her to proposed this solution for future:

a) Boeing has identified clearly what the situational problem is observed around its business development, what is the significance of this observation? How does it relate to the research on local AME competitiveness enhancement?
Answer: The group consensus [a 100% common view] was Boeing has found its situational problem within their traditional manufacturing restrictive. The solution may lie outside the production arena, outside the plants to enlarge the business scope. It is possible that Boeing AME arm will reach the local market and affecting local AME's such as Cathay Pacific Engineering, DragonAir Engineering and HAECo?.

b) Boeing (typically as a firm) wants to achieve a certain target as a new entrant to the AME industry, could it be product domination? Service expansion? Or diversification? Please describe based on the facts provided:
Answer: The group of EngD students offered a lot of suggestions. Boeing might change (improve) the AME industry efficiency, or work standard. Most likely it would bring in greater competition to the existing businesses, along with new collaboration opportunity to share resource and knowledge.

c) What production network problems could exist with the use of current methods, theory and practice in a company with the entry to the AME industry? Why are they not applicable to this Boeing business development case? [The

Boeing case contributes knowledge to the pool of cases in the AME industry, as the Boeing case adds her model which may stimulate new approach development]

Answer: The group of EngD students had divided view about the selection of the existing methods, starting from business strategy building, product range, target customer selection, systems support or deliverables. The common understanding was that Boeing should adopt progressive approaches to gain trust and dependence by the local customers, may be those small operators first and then to develop greater linkage with the local AME players.

A key area in my research is a significant system integration effort to start from a selected small scope problem rather than a full-fledge deployment in the local AME's full functionality because the work scope covers logistics management, operational management, ICT deployment and integration. If a new system is to be developed for the AME's, where would it meet Boeing's new service offers? Boeing is expected to become a new competitor on top of the existing "original maintenance data" provider role.

d) Boeing needs to describe its research design and show its implementation in the company. This demonstrates a case of its market research was based on a reliable process. Doing business research at the company level is more important in the long-term success than obtaining short-term results. Could this be implications for the research in generating a theory of "ERP Extension" for the AME's?

Answer: The Boeing approach will set a comparative path to the mobile workforce research that I will employ for my way forward as breakthrough. The concept, scope and areas of coverage may not be the exactly same, however, the results may be used to compare each others e.g. in the area of applications integration and the competitiveness gain.

e) A firm like Boeing innovated its process to deal with the situational problems to find a solution that can be developed as its own business model. This case is a demonstration of making innovation in application of its own industrial knowledge and wisdom. Observation from what Boeing is doing could lead to re-invention of current methods into new applications. From making of big aircraft in the plant, to maintenance and servicing for those mobile and revenue making flying machine around the world.

f) The Boeing case provides details on how it converted its service provision into a development model. How does this approach affect the design of my MPhil research study?

Answer: the MPhil research project adopted a production network view to create a future organisation. The organization assumed a collaboration network with a mobile workforce, rather than continuing the success of an existing production network with the engagement of new activities.

Slide 5 Boeing Proposal for knowledge work

Slide 6 A Boeing concept of theatre-in-the-air

Source: Boeing Aircraft Health Management Programme for future aircraft [www.Boeing.com]

Being has found methods to measure their success in both the research results and company results. Although the approach would affect many years to come but its importance to show the early success is observable through the implementation.

Analyse the difference of its new business service model with others so as to find Boeing's innovation or contributions in the new market. The evidence exists to collect and to show the possibility of back-to-back comparison for Boeing AME expansion and the mobile workforce demonstration for interpretation. There is a challenge for Boeing to move from huge plants of production for big aircraft, and move some of their skilled or knowledge workers to handle the intricate details of logistics management and after sales service, maintenance reliability improvement and OTP performance enhancement. In our case, we must use practical data support academics query. So the researcher would envisage that Boeing would not follow or repeat exactly what is being done in local AME's. Instead, they will instigate a new practice of work, a new forum for process enhancement in critical phases of the AME business process; and finally a new paradigm for sharing to define the future shape of the AME contribution to the air transportation. Develop associated systems supports to shape the AME way forward.

Discussions with the Engineering Doctor Students:

- Where can Boeing case support the CELS network view for future development of proper competencies for selected industries, e.g. the AME network in Hong Kong? What is the maintenance and logistics landscape for the industry and the peripheral factors (e.g. government's aim for) if either the B777, B787 or even the A380 series of aircraft were adopted?

Answer: My CELS concept (or the logistics view) allows all players to see if the squeeze from the production network players can be balanced, vertically integrated or longitudinally improved for the business efficiency. The CELS

concept could lead to many outcomes for the ensuing engagement with Boeing AME service arms in the local industry. There is one common element that has not been formally addressed: that the critical process for OTP. No matter the type of aircraft: Boeing, Airbus or Embraer (Brazilian aircraft manufacturer, world's 3rd largest, ref. Holloway, 2003) made airliner.

- If the extension of the CELS network supported such view, what data is needed for ICT system adoption or integration? What are the opportunities remaining for local or global mobile information development agents and suppliers to strive for participation, and taking the business opportunities?

Answer: The CELS network may ask for some sort of mobile tool kit to support the integration of the existing maintenance data. The players might opt for a combined solution so that the mobile workforce can use the data that are half contributed by Boeing (or Airbus) and half supplied by a local AME supported mobile agent. A study of the engagement analysis, the production network development trends in the local AME's, a collaboration-competition relationship may be staged for all players to participate, as long as each owns unique core competence and competitive advantage. In turn, this arrangement makes a lot of business sense, and opportunities will emerge.

VII.3 Conclusion

Sharing of the design of my AME development data gathering achieved the intent to compare Boeing, as the potential arch competitor, to my proposed research result (way forward) in domain. My survey from the participant in this work supported my claim that AME industry has a future for Cathay Pacific Engineering, likewise DargonAir and Haeco. If we can work more closely on this subject, making a joint success, not necessary a totally "winner-takes-all" scenario but encouraging formation of work groups that will make collaboration-competition a workable arrangement for those who participate in progress. If this is true, the above qualifications and experiences the EngD students participant offered would be very helpful for me to assimilate the key elements for decision making in compiling a strategy for detail design requirements in the ensuing test.

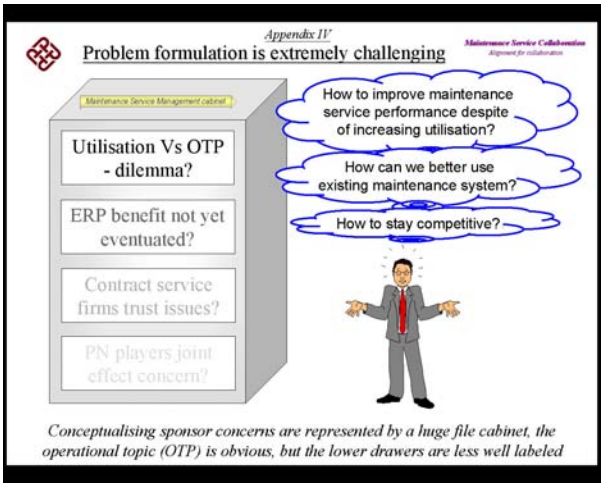
So that the use of sampled data from the future test would mean a lot as to compare the progressive results published by Boeing. And thank you again for accepting my selection as representative of players in the leading technology companies and the interest parties in the AME industry to offer expert opinions for my study. Here we are let me summarise what EngD have given me the "adhesive" so that I can link the following for my research:

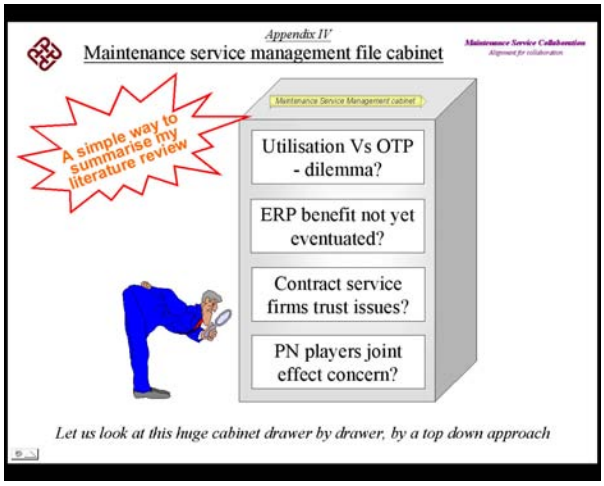
a) There would always by external new entrant (Boeing, as giant competitors) to AME markets, local or overseas.
b) Who will bring new ideas, new tools and new standards to the existing AME forum.
c) A justification to encourage existing local AME players, competitors and scattered systems developers/suppliers to work on a coopetitive approach to integrate mobile workforce integration,
d) Linking the existing scattered individual ERP's as extensions, will be a demonstrable outcome in my research.

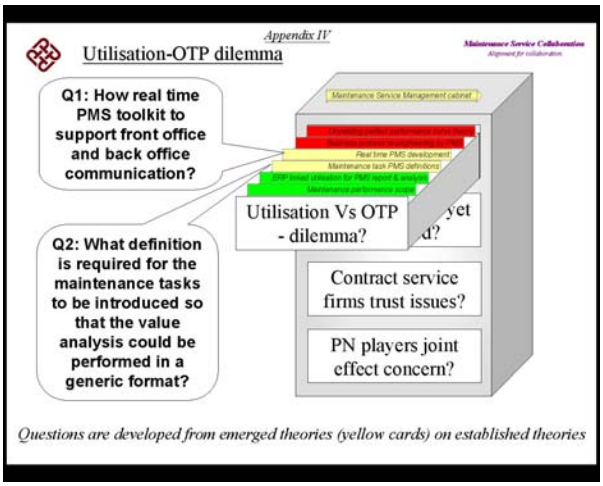
Appendix VIII

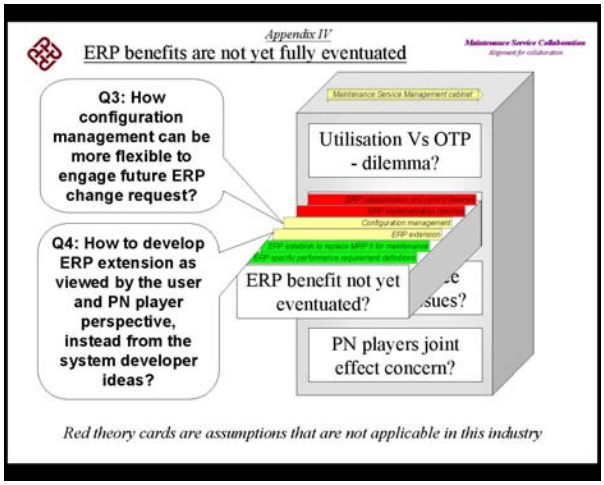
Tutorial Notes on Research Methodology - From Industrial Problem to Research Question Setting

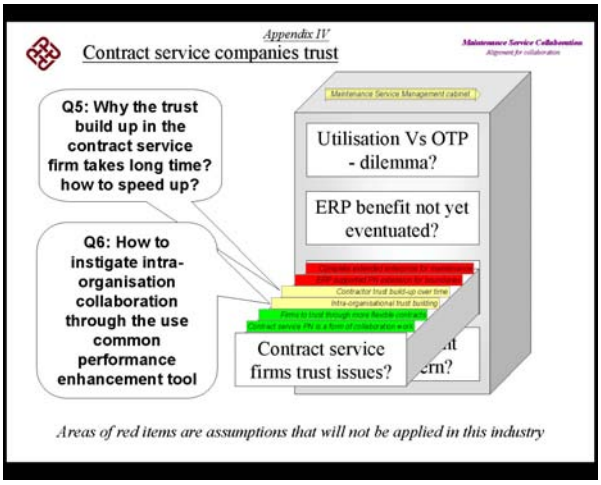
[Literature review methodology presented to ISE ILS class, 18 January 2007]

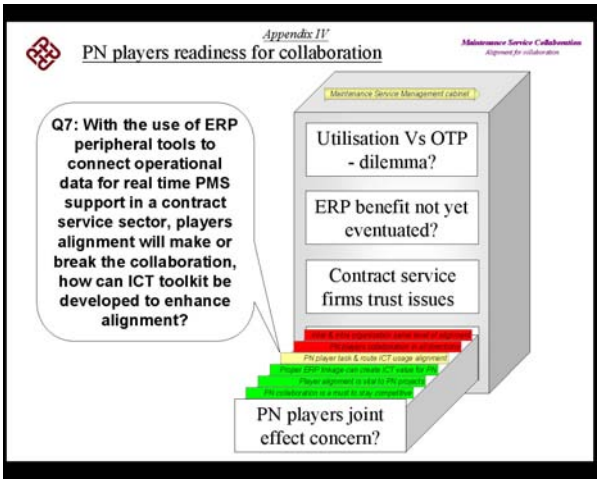


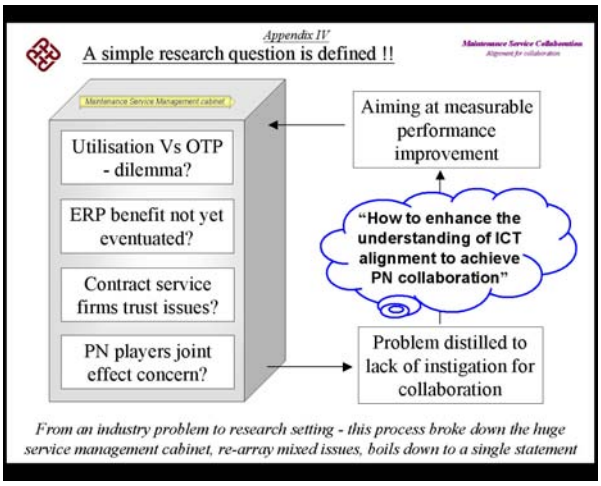


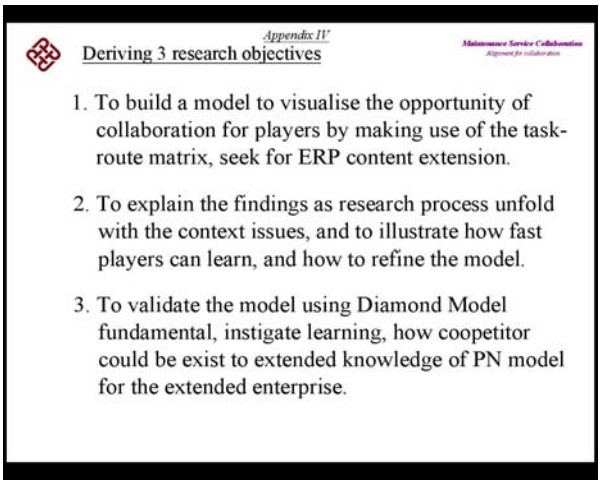









Appendix IV
A simple research question is defined !!
Maintenance Service Collaboration
Alignment for collaboration
Maintenance Service Management cabinet
Utilisation Vs OTP - dilemma?
ERP benefit not yet eventuated?
Contract service firms trust issues?
PN players joint effect concern?
Aiming at measurable performance improvement
"How to enhance the understanding of ICT alignment to achieve PN collaboration"
Problem distilled to lack of instigation for collaboration
From an industry problem to research setting - this process broke down the huge service management cabinet, re-array mixed issues, boils down to a single statement


Appendix IV
Deriving 3 research objectives
Maintenance Service Collaboration
Alignment for collaboration
1. To build a model to visualise the opportunity of collaboration for players by making use of the task-route matrix, seek for ERP content extension.
2. To explain the findings as research process unfold with the context issues, and to illustrate how fast players can learn, and how to refine the model.
3. To validate the model using Diamond Model fundamental, instigate learning, how coopetitor could be exist to extended knowledge of PN model for the extended enterprise.