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Conceptual Framework for Large-Scale Complex Engineering-Design & Delivery Processes

A Case of Enterprise SCM Network Activities and Analysis

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Julkaisun nimike

Käsitteellinen viitekehys laajojen ja monimutkaisten toimitusketjujen suunnitteluun ja toimitusprosesseihin: Tapaustutkimus ja analyysi yrityksen toimitusketjun verkoston toiminnoista

Tiivistelmä

Laajojen ja monimutkaisten suunnittelua sisältävien toimitusketjujen hallinta on kohdannut haasteita pyrkimyksissään osoittaa olennaisia ongelmakohtia toiminnoistaan. Näitä ovat mm. tiimien tehokas yhteistyö toimitusketjun suunnittelussa ja toimitusketjun hallinnan verkoston tiedonkulku.

Tiedonkulku ja -välitys ovat erittäin tärkeitä toimitusketjunhallinnan verkostossa. Empiirinen tieto kerättiin teollisuuden yritysten toimitusketjun pilotticase-tutkimuksista ja analysoitiin käyttäen Design Structure Matrixia (DSM) määriteltäessä todennäköistä meta-tietokantaa. Tietoa kerättiin myös, kun muodostettiin monista osaamisalueiden taustoista muodostuvia tiimien klustereita verkostoon. Analyysiä tukemaan käytettiin lisäksi kyselylomakkeita, joilla kerättiin tietoa kommunikaation tasosta verkostossa. Otanta tehtiin kahdeksan systeemisuunnittelutiimin toimitusketjun verkostossa. Korrelaatioanalyysiä ja sosiaalista verkostoteoriaa simulaatiotyökalua (UCINet 6) käytettiin menetelmän kolmiomittauksessa analysoitaessa kyselylomakkeiden tietoja. Kirjallisuuskatsaus ja arkistoluettelot ohjautuivat kolmen organisaatioteorian olettamuksen (toiminta, informaatiotekniikka ja viestintä) perusteella, näitä tarkasteltiin ja hyödynnettiin tässä tutkielmassa.

Tulokset osoittavat, että yrityksen toimitusketjunhallinnan toiminnot tavoittelevat saadakseen näkyvyyttä, suorituskykyä ja tehokkuutta toimintoihinsa globaalisti. Ei ole kovinkaan aktiivisesti yritetty löytää ratkaisua olennaisiin toimitusketjunhallinnan haasteisiin koko verkoston tiedonkulussa. Tämä osoittaa tarpeen tunnistaa hyvin menestyvien verkostoiden toimitusketjunhallinnan viitekehys, joka vahvistaa tiedonvaihtoa ja viestintää verkostossa tehokkaasti. Tämä tutkielma ehdottaa käsitteellisen viitekehyksen, jossa osoitetaan olennaiset toimitusketjunhallinnan haasteet.

Joitakin tutkimuksia ja julkaisuja toimitusketjunhallinnan verkoston näkyvyydestä on tehty, ne ovat pääasiassa ketjun yläpään (toimittaja) näkökulmasta tai keskivaiheen (tuotanto) näkökulmasta. Hyvin harva tutkimus on yrittänyt yhdistää koko toimitusketjun verkoston toimintoja arvoketjuhallinnan näkökulmasta. Tästä syystä tämä tutkimus pyrkii ehdottamaan todennäköisen käsitteellisen viitekehyksen mahdollisena ja perusteltuna vaihtoehtona.

Asiasanat Rinnakkaishanke, ERP, rinnakkaissuunnittelu, arvoketjun hallinta, toimitusketjun hallinta, organisaatioteoria

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Abstract
Large-scale complex engineering SCM networks for some time now, have encountered several challenges in the effort to address and streamline key pertinent issues in their activities, such as effective and efficient co-ordination of their SC system-design multidisciplinary teams; information exchange and technical communication on their enterprise SCM network.

For effective analysis of large-scale complex engineering-design and delivery processes, information flow and exchange are very essential on the SCM network. Empirical data were collected from industrial enterprise SCM network pilot case studies and analysed by a design structure matrix (DSM) simulation tool to configure feasible meta-databases constituted within a master database-management system and also to structure productive multi-disciplinary teams/partners' clusters on the SC network. Furthermore, questionnaires were used to collect data on the scale or level of communication network from a sample size of eight Ship Power SC network complex engineering-design and delivery systems-design teams, to enhance a robust SCM network analysis. The systems-design teams/partners consist of at least five members on each team. Statistical correlation analysis and a social network theory (SNT) simulation tool (UCINet 6) were employed in a methodology triangulation approach to analyse these questionnaire data. Literature review and archival record findings guided by the three adopted organization theory assumptions *(Operation, Information Technology and Communication)* were explored and utilized in this research.

Enterprise SCM network activities on large-scale complex engineering-design and delivery processes are seeking to have more visibility, efficiency and effectiveness in their activities in this global era. Not many attempts have been made by MIS vendors and industrial R&D or academia's R&D to find solutions to the pertinent enterprise SCM network challenges for the total network information flow / exchange in real-time and visibility of all the SC activities in real-time. This indicates the need to identify a well-enhanced enterprise SCM network framework, which is well structured in a suitable concurrent multidisciplinary manner that enhances information exchange and communication network more effectively and efficiently. Therefore, this research attempts to propose a feasible conceptual concurrent enterprise framework to address these pertinent enterprise SCM network challenges.

Although there have been some enterprise SCM network visibility aspects researched and published, they are mainly on either just the upstream (supplier) aspect or the intermediate-stream aspect (manufacturing). Very few have attempted to link the entire SC network activities in a complete value-chain management network approach. Therefore, this research seeks to propose a feasible conceptual framework as a viable and validated option.

Keywords: Concurrent enterprise, enterprise resource planning (ERP), concurrent engineering, value chain-management, supply chain-management, organization theory

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KIITOS PALJON!!!

Richard Addo-Tenkorang
Vaasa, May 2014

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Abbreviations

3PLC - Third Party Logistics Company
AI - Artificial Intelligence
AIS - Automatic Identification System
CAD - Computer Aided Design
CAE - Computer Aided Engineering
CAiD - Computer Aided-industrial Design
CAM - Computer Aided Manufacturing
CCE - Collaborative Concurrent Enterprise
CE - Concurrent Engineering
CE+ - Concurrent Enterprise
CPD - Complex Product Development
CRM - Customer Relations Management
CSF - Critical Success Factor
CSV - Comma-Separated Values
DEA - Data Envelopment Analysis
DMM - Domain Mapping Matrix
DMM - Domain Mapping Matrix
DMS -Data Management System
DMU - Digital Mark-up
DSM - Design Structure Matrix
EAI - Enterprise Application Integration
EDI - Electronic Data Interchange
E-DMS - Enterprise Data Management System
ERP II - Enterprise Resource Planning Extension (2)
ERP - Enterprise Resource Planning
ESA - Enterprise System Architecture
E-SCM - Enterprise Supply Chain Management
FTP - File Transfer Protocol
HU - Handling Unit
IaaS - Infrastructure-as-a-Service
ICT - Information and Communication Technologies

ICT	- Information Communication Technology
IDM	- Internet Download Manager
IMDS	- Integrated Master-Data Systems
IMO	- International Maritime Organization
IPD	- Integrated Product Development
IS	- Information Systems
IT	- Information Technology
KML	- Keyhole Make-up Language
KMZ	- Keyhole Make-up Language file
L&SCM	- Logistics and Supply Chain Management
LSPs	- Logistics Service Providers
MDM	- Multi Domain Mapping
MDM	- Multi Domain Matrix
MIS	- Management Information System
N/CPD	- New / Complex Product Development
PaaS	- Platform-as-a-Service
PLC	- Product Life-Cycle
PLM	- Product Life-cycle Management
R & D	- Research and Development
RFQ	- Request for Quotation
ROI	- Return on Investment
SaaS	- Software as a Service
SAP	- System Application Process
SC	- Supply Chain
SCL	- System Life-Cycle
SCM	- Supply Chain Management
SNT	- Social Network Theory
SOA	- Service Oriented Architecture
SOAP	- Simple Object Access Protocol
SQL	- Structured Query Language
XML	- eXtensible Mark-up Language

"Managing the supply chain cannot be left to chance"

Douglas M. Lambert, &
Martha C. Cooper

"No great discovery was ever made without a bold guess."

Isaac Newton

1 INTRODUCTION

Sustaining competitive advantage and operational survival have compelled industries to implement new strategies, based on collaboration with their SC partners and an advanced utilization of enterprise information technologies (IT) and Internet-based services (Geunes et al. 2002). According to Musa, et al. (2013) end-to-end supply-chain product visibility (i.e., product tracking and tracing) has been exploited as a means of product support security, process control and optimization in many industrial sectors. Including huge complex products such as jet engines - aviation, ship power engines - marine, automobiles, etc., (Maier, et al., 2008; Hsu & Wallace, 2007; Addo-Tenkorang and Eyob, 2012). Chandra and Grabis (2007) identified some key triggers for designing and implementing SC with regard to effectiveness, efficiency, flexibility and responsiveness. These key triggers include; introduction of new/complex product(s), upgrades for existing product(s); introduction of new or improvement in an existing product development support process (es). In addition are, allocation of new or re-allocation of existing resource(s); selection of new supplier(s), de-selection of existing ones; changes in demand patterns for complex product(s) manufactured; changes in lead-times for product and/or product support process life cycle; and changes in commitments among the SC network partners, etc.

This research project attempts to propose a conceptual framework for SCM network concurrent enterprise – complex large-scale engineering design and delivery processes. This proposed conceptual framework is intended to make enterprise engineering design and delivery SCM network more efficient in information exchange and flow, effective and visible in operation activities as well as communication network. Thus, this research takes its theoretical underpinning from organization theory's "operation", "information technology" and "communication" processes. Both qualitative and quantitative data were collected via real-life industrial pilot case studies and a questionnaire approach as the primary empirical data for this research thesis. The results in this research have been feasibly validated by scientifically employing design structure matrix (DSM), social network theory (SNT) analysis simulations, and also some statistical correlation analysis testing in a methodology triangulation approach. Furthermore, the results have been industrially evaluated for their adaptation feasibility. The industrial case example was a ship-power (SP) manufacturing SCM network.

The rest of this introduction chapter is divided into five main sections: Section 1.1 elaborates on the research background and Section 1.2 details the objectives of the research as well as the research questions and the ultimate presumptions of this research. Section 1.3 defines the adopted research approach employed for this research's data analysis and Section 1.4 attempts to justify the significance and validity of this research. Finally, Section 1.5 presents an outline of the structure of this report.

1.1 Research Background

The challenges confronted by industrial SCM networks are stern, and most of them find themselves struggling merely to survive. Industrial manufacturing enterprise SCM networks in complex engineering-design and delivery product developments such as marine – ship power engines, aviation – jet engines, automobile manufacturing, etc., are being compelled to improve their SCM network activities. Some of the real-life pressures include evolving customer demands, stiff global competition, and the need to improve time-to-market (Murman et al., 2000; Molina et al., 2005; De Brentani, 2010). All these challenges can be effectively dealt with, if the multi-disciplinary teams / partners on a SC work together effectively and the information flow and exchange as well as communication network among them is effective and efficient. According to Murman et al. (2000), after the cold war, engineering companies were forced to shift their industrial manufacturing standards from just doing anything to enhance their engineering capability to a "best practice" approach of a better, faster and cheaper standard.

Therefore, for decades, industrial manufacturers' SCM activities have seen various product improvements approaches as well as product development support processes such as shorter product development lead-times and higher return on investments (ROIs). However, with all the industrial manufacturing SCM network improvements, in terms of complex engineering design and delivery, there is still a lot more variance to be addressed on the 'better, faster and cheaper' paradigm. Furthermore, attention is needed on multi-disciplinary teamwork collaboration, efficient information exchange systems as well as effective operational communication on SCM networks for industrial manufacturing competitive advantage (Puvanasvaran, et al., 2009).

Marine, aviation and automobile manufacturing industrial SCM networks are some of the most competitive businesses globally. Again, narrowing down further and taking just two examples out of the three mentioned complex engineering design products above; Aviation - jet engines and Marine - Ship Power engines and some systems-operation *(please see Figures 3 – 8 below)* will be focused on. Moreover, the delivery of these products are significantly increasing year-on-year, which directly reflect on their return-on-investments (ROI), *(please see Figures 1 & 2 and Tables 1 & 2 below)*. As this research progresses, it will narrow down further to base its main relevance and build the main industrial case study justification analysis on empirical data collected from the SCM network for a Ship Power engine's complex engineering design and delivery industrial case.

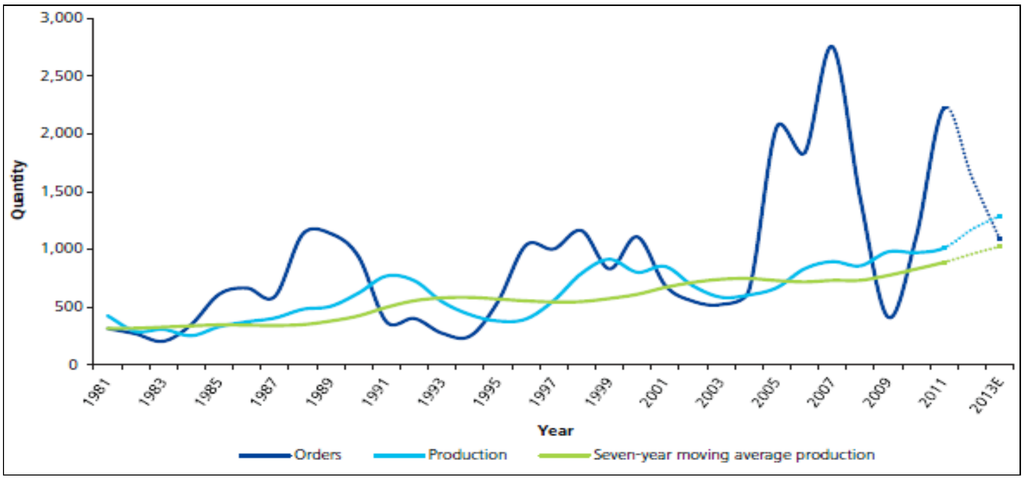


Figure 1. History and Forecast for Large Commercial Aircrafts - Order and Production (1981 - 2013E)

Source: The Boeing Company, News release (2012).

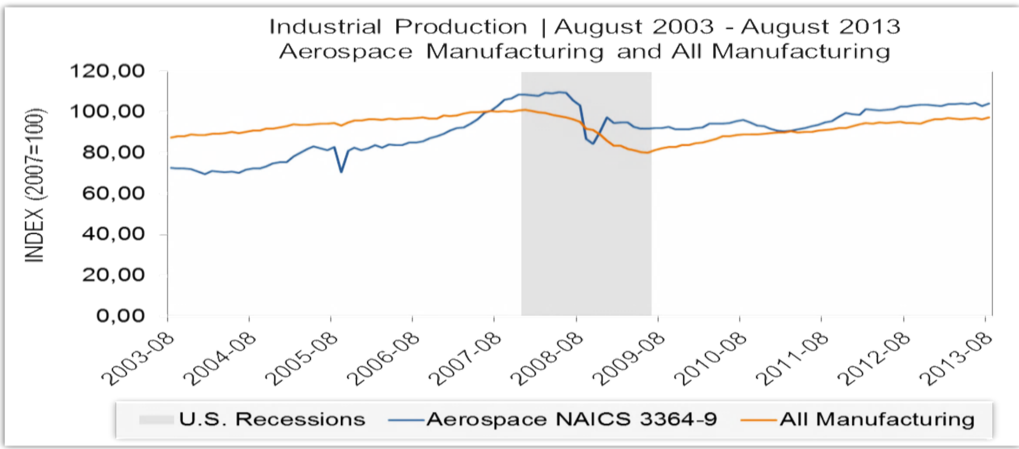


Figure 2. Industrial Production of Aerospace Manufacturing

Source: http://www.bga-aeroweb.com/database/Manufacturing-Sales-MRO.html (Accessed on 22.10.2013)

Table 1. First nine months of 2012 shipments of business and general aviation aircraft manufactured worldwide (US$ billions)

	2012	2011	Change
Pistons	$597	$577	+3.5%
Turboprops	$368	$333	+10.5%
Business jets	$428	$427	+0.2%
Total shipments	1,393	1,337	+4.2%
Total billings (US$ billions)	$12.3	$12.1	+1.4%

Source: General Aviation Manufacturers Association (GAMA - 2012),

Figure 3. Commercial Aircrafts and Military Jet Fighters (Accessed on 26.05.2014). Photographers/Authors-*Registration* (Wo st 01-*G-EUOI*; Adrian Pingstone-*OH-LZB*; TSGT Michael Ammons, USAF; Service Depicted: Air Force Staff Sgt. Simons-*DFST9110835*).

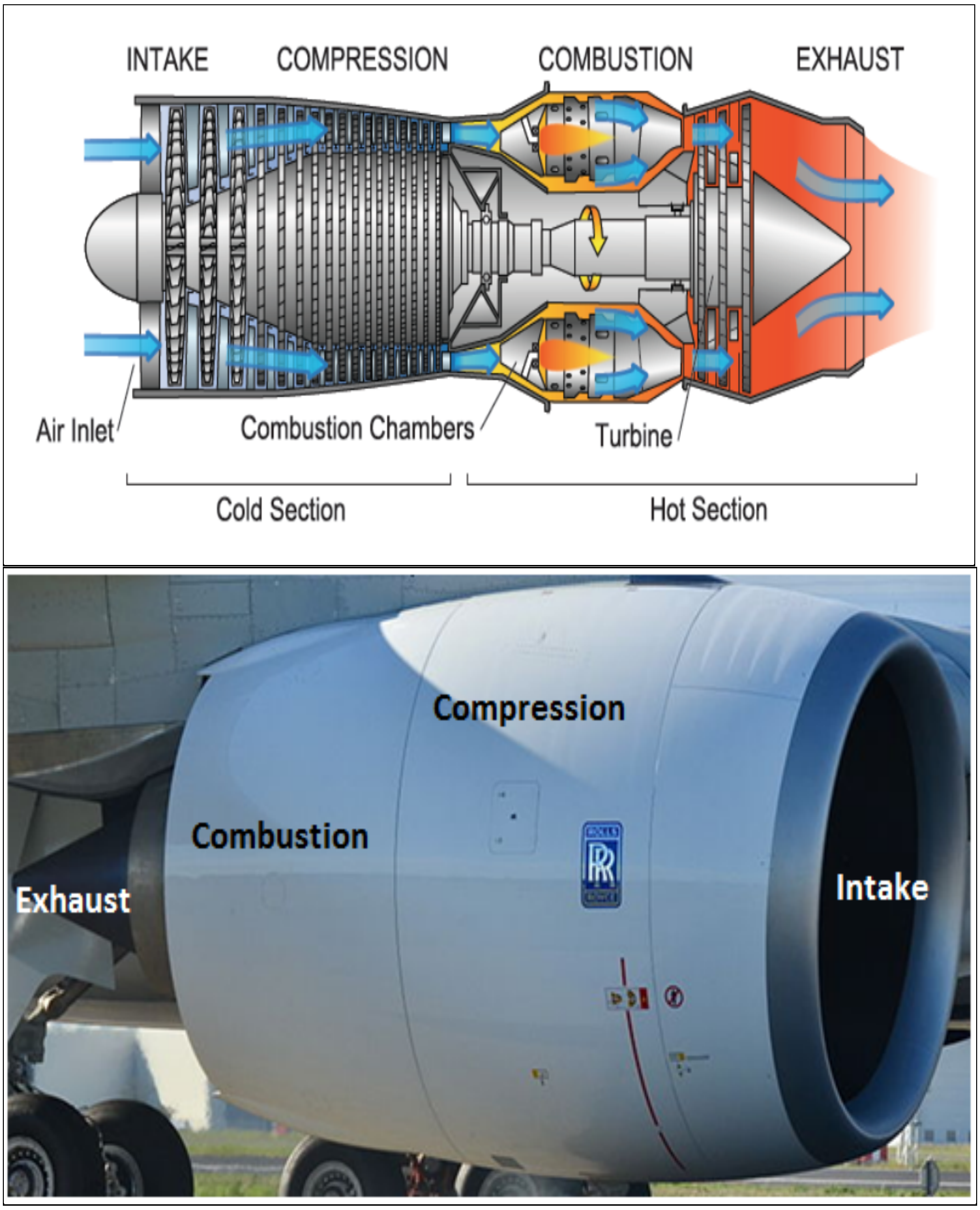


Figure 4. Rolls-Royce Trent XWB - The world's most efficient aero engine, (2014, May 23). Photographer/Author-*Registration* and *Source* (Jeff Dahl-*FAA-8083-3A Fig 14-1.PNG*; Laurent Errera- *F-WZGG* and *DSC_8009-F-WZGG - MSN 003*). (Accessed on 26.05.2014)

Table 2. World Order book at Year-End / World New Orders / World Completions.

Year / Country	2005			2006			2007			2008			2009			2010			2011 1st Half		
	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)
Japan	469	16,434	35.0	534	18,176	34.9	543	17,525	30.6	562	18,656	27.6	576	18,972	24.6	580	20,218	21.0	309	10,678	19.9
S. Korea	326	17,689	37.7	377	18,717	35.9	430	20,593	35.9	520	26,379	39.0	524	28,849	37.4	526	31,698	32.9	305	20,113	37.5
China	420	6,466	13.8	493	7,665	14.7	661	10,553	18.4	861	13,956	20.6	1086	21,969	28.5	1413	36,437	37.8	648	19,274	35.9
Belgium	0	0	0.0	0	0	0.0	1	3	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
Denmark	7	493	1.0	5	538	1.0	6	855	1.5	7	566	0.8	8	449	0.6	8	432	0.4	2	59	0.1
France	8	42	0.1	6	241	0.5	8	191	0.3	4	232	0.3	8	146	0.2	8	258	0.3	0	0	0.0
Germany	67	1,236	2.6	59	1,257	2.4	70	1,362	2.4	70	1,350	2.0	50	781	1.0	36	932	1.0	9	211	0.4
Greece	1	8	0.0	1	2	0.0	1	16	0.0	3	2	0.0	8	11	0.0	7	4	0.0	4	4	0.0
Italy	18	356	0.8	22	519	1.0	26	716	1.2	24	700	1.0	22	554	0.7	34	634	0.7	9	260	0.5
Netherlands	72	170	0.4	91	187	0.4	56	194	0.3	43	140	0.2	33	138	0.2	29	138	0.1	14	120	0.2
U.K.	8	3	0.0	4	3	0.0	3	1	0.0	6	2	0.0	6	1	0.0	8	1	0.0	0	0	0.0
Finland	1	7	0.0	4	227	0.4	4	288	0.5	5	308	0.5	3	304	0.4	2	225	0.2	1	48	0.1
Norway	10	10	0.0	16	24	0.0	17	60	0.1	18	71	0.1	15	44	0.1	12	21	0.0	5	6	0.0
Sweden	0	0	0.0	0	0	0.0	2	8	0.0	2	19	0.0	1	9	0.0	1	13	0.0	0	0	0.0
Spain	77	94	0.2	43	99	0.2	70	233	0.4	64	210	0.3	52	217	0.3	56	288	0.3	23	156	0.3
Portugal	4	22	0.0	5	15	0.0	5	28	0.0	2	16	0.0	6	26	0.0	1	9	0.0	0	0	0.0
Europe total	273	2,440	5.2	256	3,112	6.0	269	3,956	6.9	248	3,616	5.3	212	2,680	3.5	202	2,955	3.1	67	863	1.6
Brazil	12	25	0.1	11	30	0.1	16	31	0.1	24	48	0.1	25	77	0.1	21	47	0.0	10	53	0.1
Poland	55	787	1.7	57	838	1.6	60	587	1.0	63	672	1.0	60	360	0.5	52	167	0.2	14	62	0.1
Singapore	45	68	0.1	47	156	0.3	43	88	0.2	59	157	0.2	34	47	0.1	41	119	0.1	18	19	0.0
Taiwan	19	629	1.3	21	672	1.3	16	671	1.2	18	622	0.9	18	476	0.6	21	580	0.6	8	333	0.6
U.S.A.	46	431	0.9	58	283	0.5	66	162	0.3	109	165	0.2	99	292	0.4	76	238	0.2	25	56	0.1
Croatia	24	546	1.2	25	569	1.1	25	709	1.2	27	617	0.9	16	412	0.5	16	387	0.4	8	218	0.4
Others	440	1,454	3.1	568	1,900	3.6	653	2,444	4.3	751	2,801	4.1	904	2,938	3.8	800	3,587	3.7	294	1,969	3.7
Sub total	641	3,940	8.4	787	4,448	8.5	879	4,693	8.2	1,051	5,083	7.5	1,156	4,602	6.0	1,027	5,125	5.3	377	2,710	5.1
World Total	2,129	46,970	100.0	2,447	52,118	100.0	2,782	57,320	100.0	3,242	67,690	100.0	3,554	77,073	100.0	3,748	96,433	100.0	1,706	53,639	100.0

(Note) 1. Data Source : IHS (Former Lloyd's Register) "World Fleet Statistics". 2011 "World Shipbuilding Statistics".
2. Ship Size Coverage : 100 Gross Tonnage and over.
3. Europe total = Former AWES (present CESA) countries. Excludes Poland (member from '95) , Rumania ('00), Croatia ('02), Lithuania & Bulgaria ('09) for comparisons with former periods.

World New Orders (Shipbuilding)

Year / Country	2005			2006			2007			2008			2009			2010			2011 1st Half		
	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)
Japan	536	16,502	27.5	653	22,557	22.6	616	20,413	12.0	531	14,733	16.7	300	8,509	25.3	427	11,921	14.5	125	3,856	12.1
S. Korea	450	21,609	36.0	699	38,109	38.3	1,201	67,893	40.0	555	34,643	39.4	150	8,522	25.4	473	27,912	33.9	231	18,052	56.4
China	517	10,621	17.7	1,106	27,352	27.5	1,970	61,342	36.2	1,067	29,112	33.1	487	14,947	44.5	1,043	36,118	43.8	253	7,145	22.3
Belgium	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
Denmark	6	594	1.0	1	0	0.0	17	720	0.4	4	238	0.3	1	0	0.0	1	0	0.0	0	0	0.0
France	5	262	0.4	12	395	0.4	9	104	0.1	4	189	0.2	5	5	0.0	8	282	0.3	2	35	0.1
Germany	144	2,669	4.4	74	1,432	1.4	72	1,271	0.7	33	542	0.6	9	8	0.0	22	547	0.7	9	231	0.7
Greece	0	0	0.0	0	0	0.0	0	0	0.0	1	8	0.0	4	3	0.0	0	0	0.0	3	3	0.0
Italy	39	1,058	1.8	31	354	0.4	43	997	0.6	9	539	0.6	5	359	1.1	9	566	0.7	2	8	0.0
Netherlands	126	305	0.5	126	344	0.3	35	165	0.1	35	167	0.2	10	57	0.2	9	22	0.0	13	24	0.1
U.K.	4	1	0.0	2	1	0.0	0	0	0.0	1	0	0.0	2	0	0.0	1	0	0.0	1	0	0.0
Finland	9	465	0.8	4	495	0.5	2	46	0.0	4	98	0.1	1	12	0.0	3	71	0.1	3	6	0.0
Norway	28	118	0.2	80	283	0.3	48	266	0.2	13	45	0.1	14	30	0.1	13	62	0.1	11	51	0.2
Sweden	0	0	0.0	1	10	0.0	0	0	0.0	2	24	0.0	0	0	0.0	0	0	0.0	0	0	0.0
Spain	66	367	0.6	86	412	0.4	70	294	0.2	45	199	0.2	14	45	0.1	24	34	0.0	4	44	0.1
Portugal	4	29	0.0	4	32	0.0	2	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
Europe total	431	5,868	9.8	421	3,757	3.8	298	3,863	2.3	151	2,050	2.3	65	521	1.6	90	1,584	1.9	48	403	1.3
Brazil	8	24	0.0	8	100	0.1	17	504	0.3	50	577	0.7	24	42	0.1	22	92	0.1	5	17	0.1
Poland	59	615	1.0	49	631	0.6	64	202	0.1	36	36	0.0	13	6	0.0	13	83	0.1	8	26	0.1
Singapore	64	120	0.2	46	90	0.1	31	88	0.1	21	121	0.1	12	15	0.0	3	40	0.0	8	49	0.2
Taiwan	18	453	0.8	20	832	0.8	31	1,226	0.7	6	239	0.3	12	264	0.8	8	246	0.3	10	1,027	3.2
U.S.A.	48	346	0.6	94	384	0.4	46	97	0.1	28	24	0.0	23	27	0.1	45	70	0.1	11	58	0.2
Croatia	9	361	0.6	14	275	0.3	27	580	0.3	8	172	0.2	1	24	0.1	6	141	0.2	6	83	0.3
Others	556	3,481	5.8	718	5,513	5.5	1,103	13,392	7.9	807	6,293	7.2	321	723	2.2	650	4,193	5.1	198	1,276	4.0
Sub total	762	5,400	9.0	949	7,825	7.9	1,319	16,089	9.5	956	7,462	8.5	406	1,101	3.3	747	4,865	5.9	246	2,537	7.9
World Total	2,696	60,000	100.0	3,828	99,600	100.0	5,404	169,600	100.0	3,260	88,000	100.0	1,408	33,600	100.0	2,780	82,400	100.0	903	31,992	100.0

(Note) 1. Data Source : IHS (Former Lloyd's Register) "World Shipbuilding Statistics".
2. Ship Size Coverage : 100 Gross Tonnage and over.
3. Europe total = Former AWES (present CESA) countries. Excludes Poland (member from '95) , Rumania ('00), Croatia ('02), Lithuania & Bulgaria ('09) for comparisons with former periods.

World Completions (Shipbuilding)

Year / Country	2005			2006			2007			2008			2009			2010			2011 1st Half		
	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)	No.	'000GT	share(%)
Japan	469	16,434	35.0	534	18,176	34.9	543	17,525	30.6	562	18,656	27.6	576	18,972	24.6	580	20,218	21.0	309	10,678	19.9
S. Korea	326	17,689	37.7	377	18,717	35.9	430	20,593	35.9	520	26,379	39.0	524	28,849	37.4	526	31,698	32.9	305	20,113	37.5
China	420	6,466	13.8	493	7,665	14.7	661	10,553	18.4	861	13,956	20.6	1086	21,969	28.5	1413	36,437	37.8	648	19,274	35.9
Belgium	0	0	0.0	0	0	0.0	1	3	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
Denmark	7	493	1.0	5	538	1.0	6	855	1.5	7	566	0.8	8	449	0.6	8	432	0.4	2	59	0.1
France	8	42	0.1	6	241	0.5	8	191	0.3	4	232	0.3	8	146	0.2	8	258	0.3	0	0	0.0
Germany	67	1,236	2.6	59	1,257	2.4	70	1,362	2.4	70	1,350	2.0	50	781	1.0	36	932	1.0	9	211	0.4
Greece	1	8	0.0	1	2	0.0	1	16	0.0	3	2	0.0	8	11	0.0	7	4	0.0	4	4	0.0
Italy	18	356	0.8	22	519	1.0	26	716	1.2	24	700	1.0	22	554	0.7	34	634	0.7	9	260	0.5
Netherlands	72	170	0.4	91	187	0.4	56	194	0.3	43	140	0.2	33	138	0.2	29	138	0.1	14	120	0.2
U.K.	8	3	0.0	4	3	0.0	3	1	0.0	6	2	0.0	6	1	0.0	8	1	0.0	0	0	0.0
Finland	1	7	0.0	4	227	0.4	4	288	0.5	5	308	0.5	3	304	0.4	2	225	0.2	1	48	0.1
Norway	10	10	0.0	16	24	0.0	17	60	0.1	18	71	0.1	15	44	0.1	12	21	0.0	5	6	0.0
Sweden	0	0	0.0	0	0	0.0	2	8	0.0	2	19	0.0	1	9	0.0	1	13	0.0	0	0	0.0
Spain	77	94	0.2	43	99	0.2	70	233	0.4	64	210	0.3	52	217	0.3	56	288	0.3	23	156	0.3
Portugal	4	22	0.0	5	15	0.0	5	28	0.0	2	16	0.0	6	26	0.0	1	9	0.0	0	0	0.0
Europe total	273	2,440	5.2	256	3,112	6.0	269	3,956	6.9	248	3,616	5.3	212	2,680	3.5	202	2,955	3.1	67	863	1.6
Brazil	12	25	0.1	11	30	0.1	16	31	0.1	24	48	0.1	25	77	0.1	21	47	0.0	10	53	0.1
Poland	55	787	1.7	57	838	1.6	60	587	1.0	63	672	1.0	60	360	0.5	52	167	0.2	14	62	0.1
Singapore	45	68	0.1	47	156	0.3	43	88	0.2	59	157	0.2	34	47	0.1	41	119	0.1	18	19	0.0
Taiwan	19	629	1.3	21	672	1.3	16	671	1.2	18	622	0.9	18	476	0.6	21	580	0.6	8	333	0.6
U.S.A.	46	431	0.9	58	283	0.5	66	162	0.3	109	165	0.2	99	292	0.4	76	238	0.2	25	56	0.1
Croatia	24	546	1.2	25	569	1.1	25	709	1.2	27	617	0.9	16	412	0.5	16	387	0.4	8	218	0.4
Others	440	1,454	3.1	568	1,900	3.6	653	2,444	4.3	751	2,801	4.1	904	2,938	3.8	800	3,587	3.7	294	1,969	3.7
Sub total	641	3,940	8.4	787	4,448	8.5	879	4,693	8.2	1,051	5,083	7.5	1,156	4,602	6.0	1,027	5,125	5.3	377	2,710	5.1
World Total	2,129	46,970	100.0	2,447	52,118	100.0	2,782	57,320	100.0	3,242	67,690	100.0	3,554	77,073	100.0	3,748	96,433	100.0	1,706	53,639	100.0

(Note) 1. Data Source : IHS (Former Lloyd's Register) "World Fleet Statistics". 2011 "World Shipbuilding Statistics".
2. Ship Size Coverage : 100 Gross Tonnage and over.
3. Europe total = Former AWES (present CESA) countries. Excludes Poland (member from '95) , Rumania ('00), Croatia ('02), Lithuania & Bulgaria ('09) for comparisons with former periods.

Source: The Shipbuilders Association of Japan (2011)

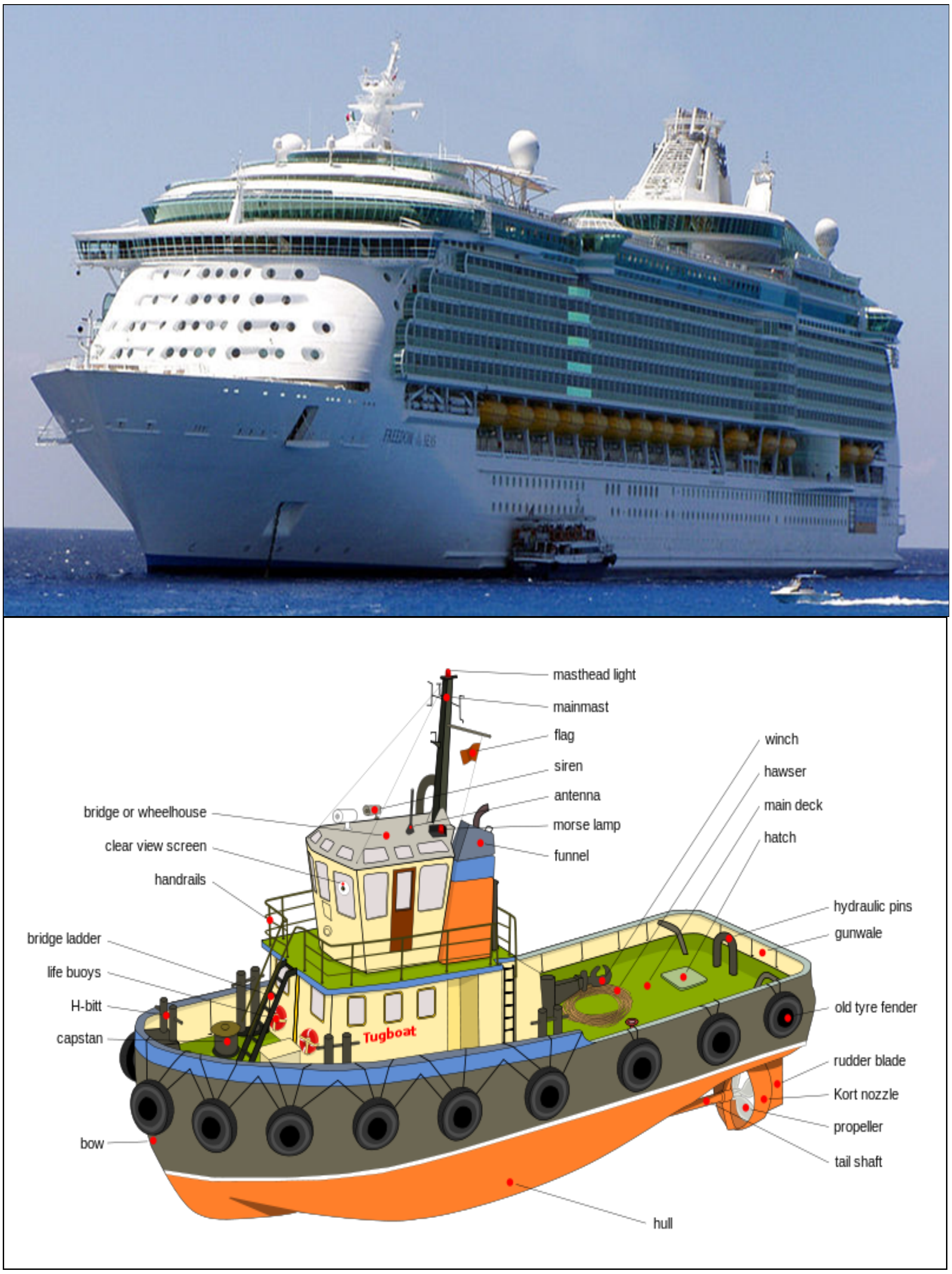


Figure 5. Commercial Cruise Ship and High Power Hybrid Tug Boat. (Accessed on 26.5.2014). Photographers/Authors-*Registration* (Andres Manuel Rodriguez; Al2, captions by Lycaon, font and pointer line fixes by Jeff Dahl)

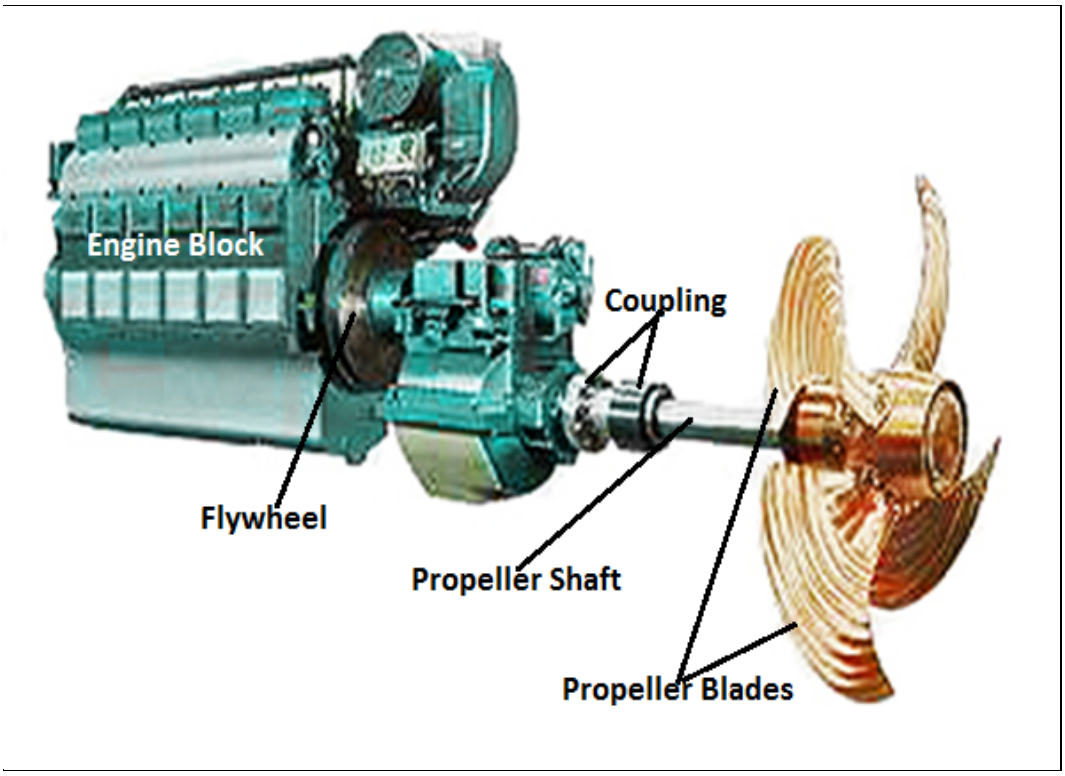


Figure 6. Marine Propulsion System. Photographer/Author-*Registration* (Blair Snow). (Accessed on 26.5.2014)

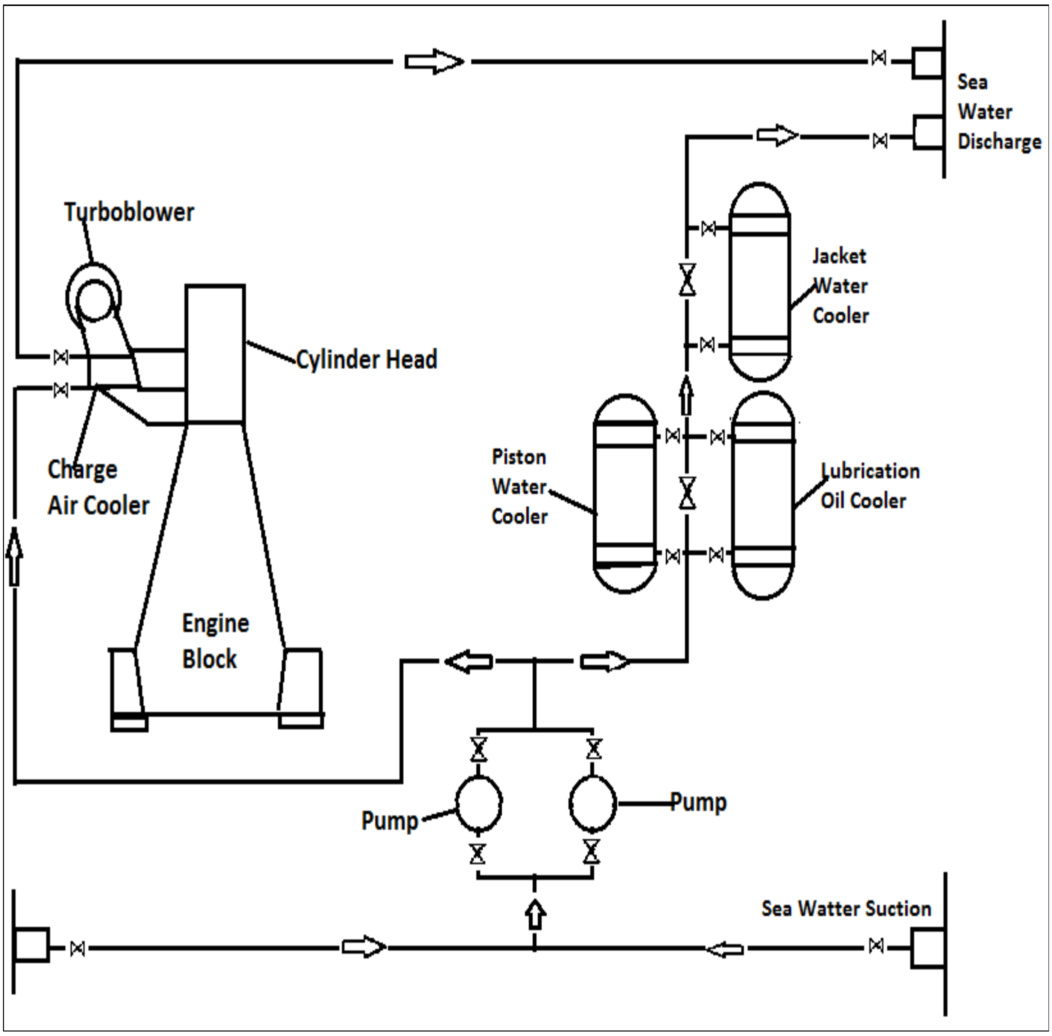


Figure 7. Ship Engine Sea Water Cooling System.

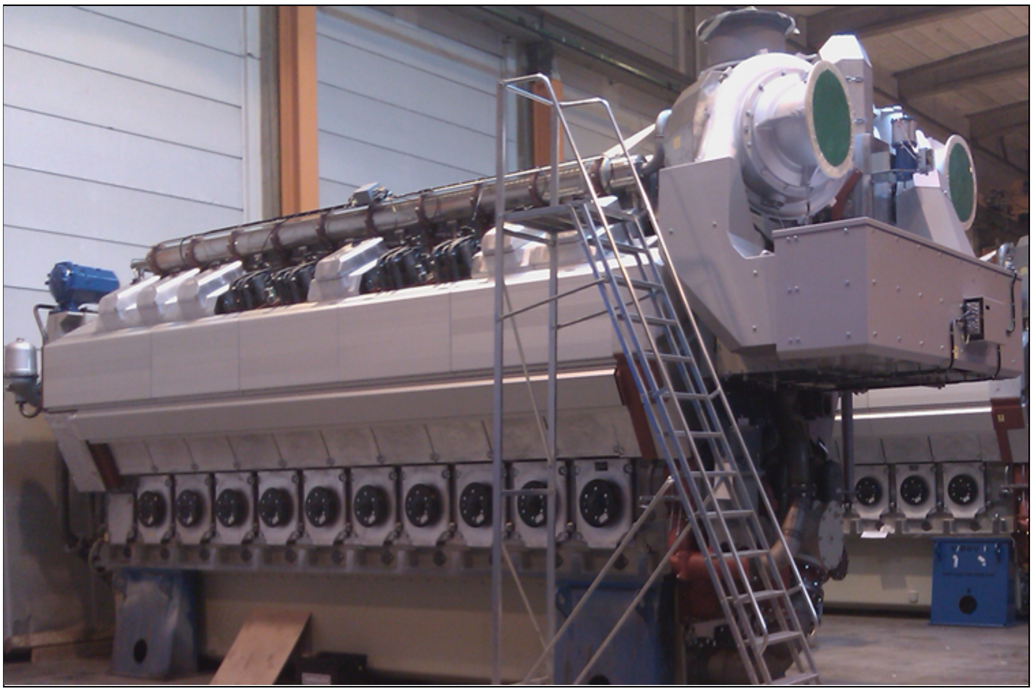


Figure 8. Ship Power Category 32 V – Engine Block.

1.1.1 Research Setting

In order to adopt the appropriate research methodology and also assume the right theoretical underpinning, it is imperative to clarify the context of this applied research. This research focuses on proposing a conceptual framework for the SCM network of complex engineering design and delivery for complex product development *(e.g., Ship Power engines, Aircraft Jet engines, Automobiles, etc.);* in an enterprise manufacturing SCM network activities in a concurrent enterprise approach. This conceptual framework is assumed by enhancing the complex engineering design and delivery integrated product-development process by employing a concurrent engineering process with enterprise resource planning SCM information technology (IT) enablers. The basic principle for concurrent engineering (i.e., the practice of concurrently developing products and their manufacturing support processes in multifunctional teams with all expertise working together from the very onset stages) revolves around two concepts (Anderson, 2008; 2010). Firstly, all elements of a product's life-cycle, from functionality, produceability, assembly, testability, maintenance issues, environmental impact, and finally disposal and recycling, should be taken into careful consideration in the early design phases. Second and finally, the preceding design activities should all be occurring at the same time, or concurrently. While enterprise resource planning (ERP) systems have emerged as a result of developments in organizational resource planning, its collaborative systems application and enabling abilities are focused on addressing the implementation of automated business process management (Sharif, et al., 2005). Thus, ERP SCM – IT systems enablers provide the enabling environment for organizations to manage their core business process data and information across the enterprise SC network *(Please see Figure 9 below).*

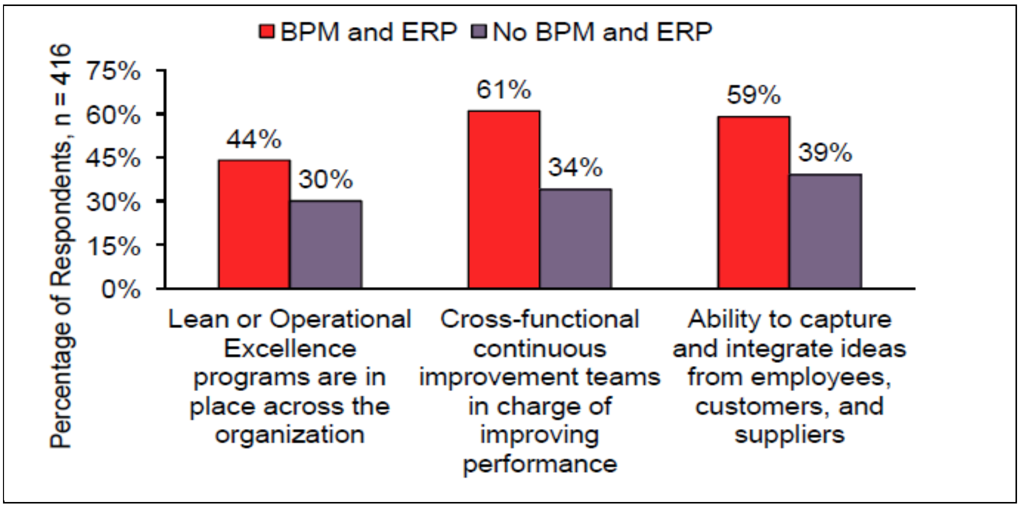


Figure 9. ERP / Business Processes Management – Concurrent Approach Survey

Source: Castellina, N., Aberdeen Group, (2013)

This research's ultimate motive is to significantly contribute to the body of knowledge because this research involves the study of people in social settings. It is therefore, under the overarching of social science research. The term "applied research" has been used from the beginning of this report because this research involves the proposal of a conceptual framework for a real-life industrial setting; therefore, it would be considered to be an applied research in contrast to pure empirical research. According to Kumar (2010), this research can be concluded to have exploratory, explanatory, descriptive and correlation dimensions as per this research's objectives.

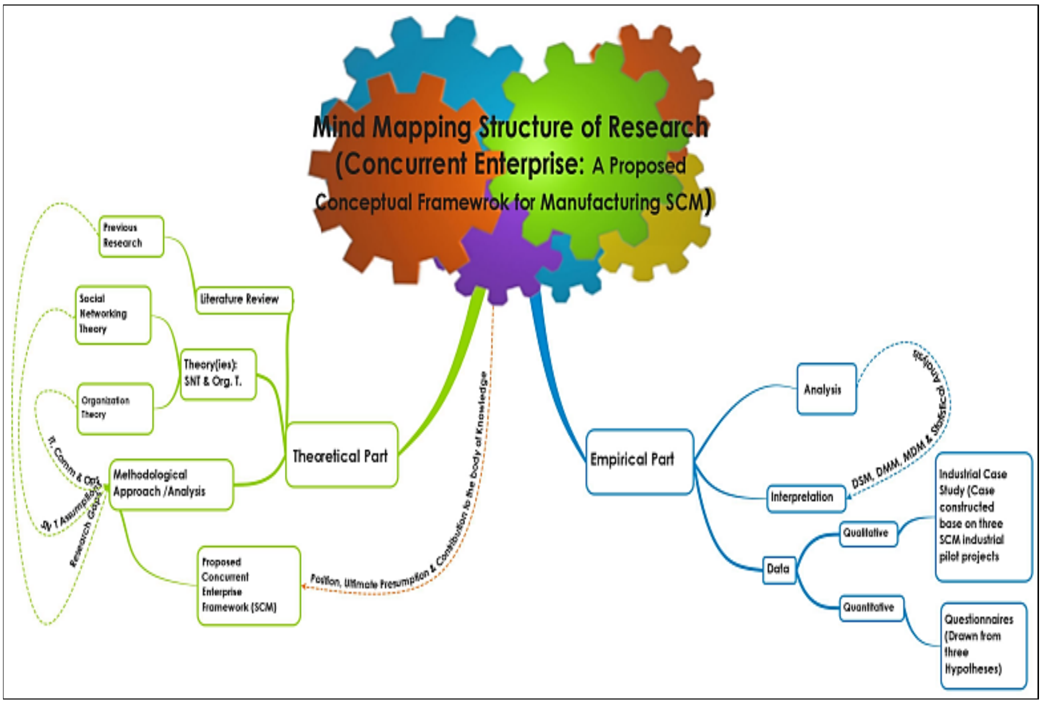


Figure 10. Mind Mapping (Proposed Conceptual Framework for Industrial Manufacturing SCM) Concurrent Enterprise Research.

According to Robson (2011), pragmatism provides a highly compatible theoretical underpinning for mixing two types of method in the same project. Therefore, although some social constructivists suggest knowledge is created because of social interactions, some pragmatists also thinks knowledge is created because of practical deeds. Hence, in order for this research to fit in well with both worlds, Figure 10 above illustrates, that this research is divided into two streams: the theoretical stream and the empirical stream which attempts to validate this research by triangulation of both the social constructivist view and, mainly, the pragmatist view. Robson (2011) describes mixed methods research as a new research paradigm where pragmatism is the social underpinning for the research. Therefore, this research assumed some applications of organization theory as its underpinning theory employed as a guide in conducting the industrial pilot case study for verifying the motives of the research. Some likely benefits of multi-strategy designs have been described by Robson (2011) and Bryman (2006), and include:

- Triangulation due to different data types and methods
- Completeness and comprehensiveness of the research setting
- Ability to answer different research questions

- Ability to deal with complex phenomena and situations
- Explaining findings based on further investigation
- Refining research questions based on qualitative data
- Instrument / Software / Platform / Framework development and testing

1.1.2 Scope of Research Contribution

This research is partly a component of a real-life large-scale engineering-design and delivery of complex product development project *(Logistics Tracking Network [LogTrack] and Future Models for Digital and Global Enterprises [FUDGE])* and the support processes involved. Hence, the scope of this research is to propose a conceptual framework for CE+ SCM network activities (Esposito and Evangelista, 2014; Bottani, 2010). Therefore, the researcher designed and managed the empirical data collection approach and solely conducted the research analysis for the proposed conceptual framework CE+ SCM networks activities' systems-architecture, evaluation and validation methods. On the other hand, the technical prototyping, *(e.g., back-end hard-core programming.)* and eventual industrial-based implementation was conducted separately as another exclusive project, which the researcher was not directly involved in.

1.2 Research Objectives

The purpose of this research is to propose optimal operations for complex engineering design and delivery processes on enterprise SCM networks, by employing strategic enterprise information technologies and effectively analysed communication strategies to enhance an industrial competitive advantage.

This research, first, attempts to identify and systematically propose a solution to the industrial SCM network activities by proposing a suitable structured coordination for the various multidisciplinary systems-design teams / partners / departments, etc., in an enterprise SCM network approach (Klein, et al., 2003b).

Secondly, this research attempts to propose a structured master data-management (MDM) system for SCM network complex engineering design and delivery processes of complex product development. This, attempting to bring all the various enterprise SCM network systems-design teams together concurrently; on a single common information exchange platform. This in turn will enable effective and efficient enterprise SCM network value-adding benefits for industrials seeking to enhance their industrial enterprise SCM (e-SCM) network activities, which is simple and easily laid-out for concurrent enterprise SCM network collaborative competitive advantage (Musa, et al., 2013).

The third objective of this research is to create a collaborative complex engineering design and delivery complex product-development process approach. This will effectively and efficiently enables industries requiring a complex mix of planning, evaluation and decision-making to communicate effectively and strategically to enhance their SCM network industrial competitive advantage. An effective and efficient communication network is thus, seen as the vehicle by which this coordination could be achieved. Moreover, communication itself is influenced by many different factors that are connected (Maier, et al., 2008).

Finally, attaining and sustaining a collaborative concurrent enterprise approach and mentality for an industrial enterprise SCM network is seen as a competitive advantage. This is because this is challenging to most SCM networks. However, the key challenge to the concurrent engineering principle is the effective application of enterprise systems enablers to reduce the excessive lead-time in complex engineering design and delivery for complex product development. Enterprise resource planning SCM information technology (IT) enablers in this wider context and the complexity of its implementation; uses; trends and perspective as well as trainings are significantly lacking as enablers for the complex engineering integrated product development "best practice" process (i.e. Concurrent Engineering). Thus, the ability of an industrial organization to implement these enterprise systems to enhance their complex engineering design and delivery processes faces all sorts of challenges, including system interface as well as change management problems with employees' (multi-disciplinary teams') collaboration issues, information flow and exchange as well as communication network issues, etc. The multiple facets that have to be managed in a large-scale industrial SCM complex engineering design and delivery makes the effective use of enterprise management information systems (MIS) very necessary as enhancing enablers.

The research questions generated from real-life industrial enterprise SCM network issues and also endorsed by the literature-review research gaps identified in this research include:

1.2.1 Research Questions

This research aims to achieve the following milestones – (i.e. find answers or propose feasible solutions to the following Research Questions – RQ):

RQ.1) How can multi-discipline teams, made up from different divisions of a manufacturing enterprise SCM network work, together effectively?

RQ.2) How can information exchange on an SCM network be structured efficiently and effectively to strategically improve N/CPD engineering design and delivery processes?

RQ.3) How can SCM networks achieve strategic and effective communication network on changing parameters of N/CPD engineering design and delivery processes?

RQ.4) How can enterprise SCM networks create a concurrent collaborative enterprise mentality and approach? *(Fighting the not-invented-here syndrome).*

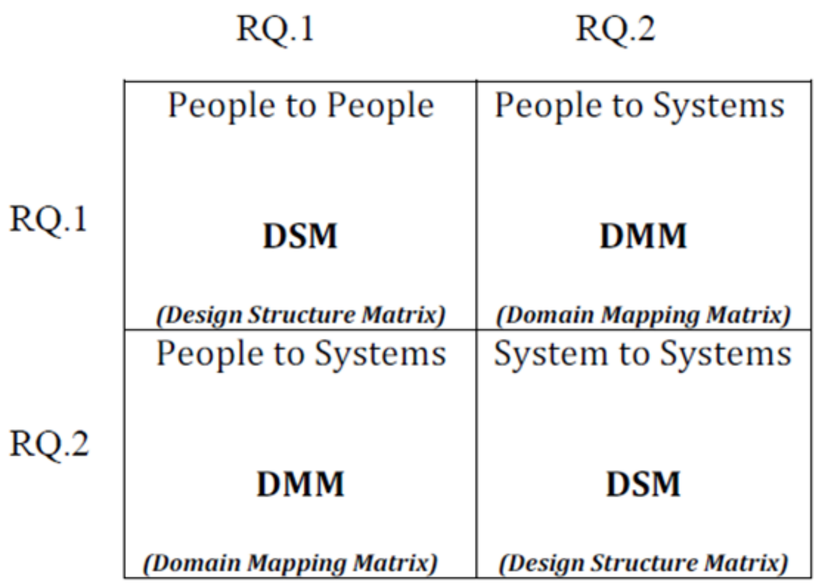


Figure 11. DSM, DMM Data Analysis

	People	Systems
People	***RQ.1***	***RQ.3***
System	***RQ.3***	***RQ.2***

Figure 12. People, Systems Data Interpretation

Analysis: Design Structure Matrix (DSM) + Domain Mapping Matrix (DMM) = [(Multi Domain Mapping (MDM))]. Therefore; RQ.1 + RQ.2 + RQ.3 = RQ.4

Therefore, by using multi-domain mapping (MDM) to analyse the interrelations between the people and systems and vice-versa, *(please see Figures 11 & 12 above)*, manufacturers could create a collaborative concurrent enterprise environment in their industries and also get rid of the "not-achievable" mentality in industries, which is currently costing them a lot in sustaining their competitive edge – (RQ.4). Hence, this would feasibly illustrate and also elaborate how a multi-discipline team made up of an enterprise SCM network could effectively and efficiently work together by using design structure matrix (DSM) to analyse the industrial organization's management information exchange and operations.

Furthermore, the same DSM approach can be used to analyse how MIS could effectively be utilized efficiently in the industrial manufacturing sector to improve their enterprise supply-chain management (SCM) for large-scale engineering design and delivery of new/complex product development and support processes. However, in order to empirically interpret the design structure matrix (DSM) analysis adopted in this research report, Domain Mapping Matrix (DMM) will be used to analyse the people-to-people and the system-to-system structures which were studied and analysed in the light of research question three (RQ.3). Hence, the benefits of the DSM analysis in research questions one (RQ.1) and two (RQ.2) will be utilized to enhance and also manage the large volumes of industrial SCM network activities and data generated from different enterprise-system sources by different system-design team members at different times, whenever needed at real-time

Table 3. Research Questions Aligned with the Research Objectives

(RQ.)	Research Objective	Research Approach
RQ.1) How can multi-discipline teams, made up from different divisions of a manufacturing enterprise SCM network work together effectively?	To scientifically and empirically investigate the correlation advantages and delimitations of multi-discipline teams / partners / stakeholders of a complex product development SCM network: related to Concurrent Engineering “best practice” principles; and how they could positively impart the SC network for a sustainable industrial competitive advantage.	Statistical Correlation analysis to, hypothetically test correlation significance level as outlined in the research objectives. And design structure (DSM) matrix of teams/ partners optimal grouping.
RQ.2) How can information exchange on an SCM network be structured efficiently and effectively to strategically improve N/CPD engineering design and delivery processes?	To propose an optimum configuration of SCM network meta-database management systems constituted within an SCM network Master Database-Management system: related to Enterprise Resource Planning SCM IT enables to, effectively enhance the above “best practice” SC product development initiative for an efficient, authentic and secured information exchange within the SCM network for a sustainable competitive advantage. ***(An improved manufacturing Integrated Product Development paradigm)***	Design Structure Matrix (DSM) analysis tools to; simulate an optimum configuration Master Database-Management system.
RQ.3) How can SCM networks achieve strategic and effective communication network on changing parameters of N/CPD engineering design and delivery processes?	To be able to propose this improved SCM network manufacturing integrated product development paradigm; Efficient, effective and authentic communication over the SC network or among the teams / partners / stakeholders on the SCM network needs to be robust and cannot be left to chances; therefore, if organizations really want to achieve an industrial sustainable competitive advantage in their SC network activities.	UCINet 6 social network theory (SNT) analysis tool to simulate for teams / partners / stakeholders' communication and collaboration frequency and importance, as well as their level of mutual trust and roles and responsibilities on the SC network. As well as employing Statistical Correlation in a Triangulation, approach.
RQ.4) How can enterprise SCM network create a concurrent collaborative enterprise mentality and approach? *(Fighting the not-invented-here syndrome).*	To propose a concurrent enterprise Conceptual Framework for complex product development SCM network activities. It is assumed that this applied research solution will be feasibly replicable in other complex product development, although the case study example was analysed based on data from the Ship Power manufacturing SCM. Furthermore, apart from employing various scientific approaches to feasibly validate this conceptual framework, it has also been industrially evaluated by the industrial partner in this research’s case study example.	Findings and Results from RQs. 1, 2 & 3 will form the solution for this research’s proposed SCM network framework.

1.2.2 Ultimate Presumptions:

Table 4 below seeks to synthesis the ultimate presumptions utilized in this research approach:

Table 4. Research Ultimate Presumptions

Research Presumptions	Focus Area	Reference(s)	Remarks
Organization Theory (Information Technology, Communication & Operations)	Theoretical platform (Literature Review, etc.)	Hatch and Cunliffe (2006)	Research literature review, etc.
Cross-Organizational, Early Complex Product Development Support Processes In SCM Network Integration & Enterprise Information Technology (IT)	Research positioning	Klaus (2009)	Research stream evolution and focus
Theory Testing against Research Questions (RQs) and some hypotheses testing. And, using Social Network Theory (SNT); Design Structure Matrix (DSM); Domain Mapping Matrix (DMM) to analyse empirical "Case Study" data.	Research objectives (RQs). – Efficiently and effectively answer / test research questions to support the research's proposed "Concurrent Enterprise" framework for enterprise SCM network.	Hatch and Cunliffe (2009); Klaus (2009); Sosa et al., (2002); Galaskiewicz, (2011); Yin (2009; 2012); Yassine and Braha, (2003);	Research proposed "new conceptual framework".

As the research progressed, more relevant presumptions were unveiled and considered in the research. For example, further in this research report, key communication factors and/or correlation analysis have been investigated and analysed. The investigation and analysis were conducted between an industrial enterprise systems-design teams such as frequency in communication, concurrent technical/design communication and effective and efficient multidisciplinary design team communication network could be better supported, analysed and validated within the assumptions of the "Social Network Theory" (SNT) analysis (Sosa et al., 2002; Galaskiewicz, 2011). Therefore, to realize added-value and real sustainable competitive advantage within an industrial enterprise SCM network, complex product development (CPD) with complex engineering design and delivery systems-design teams must be able to communicate efficiently and effectively (Puvanasvaran, et al., 2009; Morelli, et al., 1995; Allen, 2000; Eckert, and Stacey, 2001; Loch, and Terwiesch, 1998). However, most of the argument in this research will be towards building or proposing a "best practice" industrial management concurrent enterprise framework for an SCM network competitive advantage.

Therefore, this research positions itself by combining the benefits of two flow streams: cross-organizational (global), complex product development engineering design and delivery in SCM network integration and enterprise information technology (IT) (Klaus, 2009). Hence, this research report attempts to utilize the assumptions of organization theory focusing on the aspects of "operations," "information technology" and "communications" in industrial manufacturing SCM network as its theoretical platform. However, organization theory also considers other applications, as indicated in Table 5 below.

Table 5. Some Applications of Organization Theory

Types of Theory Applications	**Implication of Theory Application**
Strategy/Finance	Business executives who want to improve value-adding of a company need to know how to organize to achieve organizational goals; those who want to monitor and control performance will need to understand how to achieve results by structuring activities and designing organizational processes.
Marketing	Marketers know that to create a successful corporate brand they need to get the organization behind the delivery of its promise; a thorough understanding of what an organization is and how it operates will make their endeavours to align the organization and its brand strategy more feasible and productive.
Information technology	The way information flows through the organization affects work processes and outcomes, so knowing organization theory can help IT specialists identify, understand and serve the organization's informational needs as they design and promote the use of their information systems.
Operations	Value chain management has created a need for operations managers to interconnect their organizing processes with those of suppliers, distributors and customers; organization theory not only supports the technical aspects of operations and systems integration, but explains their socio-cultural aspects as well.
Human resources	Nearly everything HR specialists do from recruiting to compensation has organizational ramifications and hence benefits from knowledge provided by organization theory; organizational development and change are particularly important elements of HR that demand deep knowledge of organizations and organizing, and organization theory can provide content for executive training programs.
Communication	Corporate communication specialists must understand the interpretive processes of organizational stakeholders and need to address the many ways in which different parts of the organization interact with each other and the environment, in order to design communication systems that are effective or to diagnose ways existing systems are misaligned with the organization's needs.

Source: (Hatch and Cunliffe, 2006 Chap-1 pp. 4)

1.3 Research Approach

This subsection presents background information on this research approach as well as the adopted research methods. The focus of this research is on an industrial-based case in its own right considered within the research setting. According to Yin (2012), the in-depth focus on the case(s) in a case study research approach, as well as the desire to cover a broader range of the research's context and other complex settings; leads an extra range of topics to be considered. Therefore, by any given specific case study; making a case study research extend beyond the case of isolated variables, to cover also the other essential aspects is within the merits of a case study research. Therefore, this research employs multiple data collection methods *(Industrial-based pilot case study as the main research data collection approach, Closed-end questionnaires & Extensive Literature Review / Archival Records were also used to collect extra data, which could not be fully collected during the industrial pilot case study)* in a cross-sectional time horizon approach. Moreover, the archival records and aligned literature review employed to streamline the data collection and analysis of this research were guided by some assumptions of Organization Theory (Operations, Information Technology and Communications). Thus, the approach employed by this research was a triangulation approach.

Therefore, the research methods employed for this research are mixed-method / multi-method *(methodology triangulation approach)* for analysing the research questions set above at sub-section *1.2.1*. Mixed-method study involves the collection / analysis of both qualitative and/or quantitative data in a single research in which data are collected concurrently and also involve integration of the data at one or more phases during the process of the research (Creswell, et al., 2003:212). The approach to this research draws on a number of research methods, which are detailed further in this research, *(please see Figure 10 at page 12 above and Figure 13 at page 21 below).* Therefore, this research could be said to employ both qualitative and quantitative approaches. Corbetta (2003) demonstrated that qualitative research is open and interactive and observation precedes theory, whereas quantitative research is structured, and theory precedes observation.

According to Kumar (2010), there are four fundamental purposes and subsequent types of research: explanatory, descriptive, correlational, and exploratory. Therefore, it can be established based on the research objectives that correlational; exploratory, explanatory and descriptive approaches are all suitable in this research case. Research objective one (1) involves explanatory and descriptive research;

and research objective two (2) involves exploratory, explanatory and descriptive research; while research objective three (3) involves correlational and explanatory research; and finally, research objective four (4) requires descriptive and explanatory research *(please see Table 6 below and also Figure 18 further below)*.

Figure 13 below, illustrates the overall research methodology / design approach in the form of an "onion". This embodies the thoughts with regard to the research problem – data collection and analysis in the centre; thus, several layers have to be "peeled away" before coming to the central part of collecting and analysis the required data in order to, feasibly solve the research problem (Saunders et al. 2009). Although diverse categorizations and definitions of these terms exist in different social science research methods, strategies and approaches; the taxonomy put forward by Saunders et al., (2009) is preferred in this research, as it provides an unambiguous overall context for the complete research project.

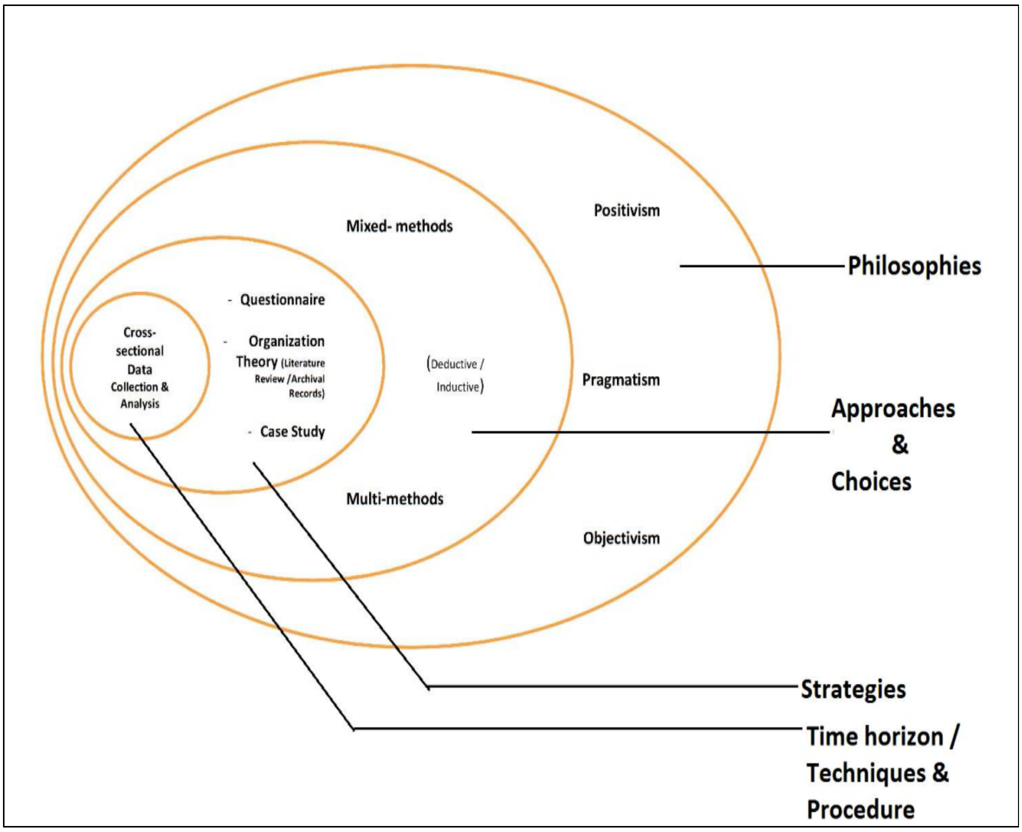


Figure 13. Research Approach Design.

As illustrated in Figure 13 above, this research employs a mixed-methods approach, triangulation, as the most reliable choice for this research. Research has revealed that both qualitative and quantitative approaches have their unique advantages and disadvantages (Hossain, 2012). Denscombe (2007:108), identified three crucial features of mixed-method / multi-method research. Therefore, aligning facts with this research: Firstly, both quantitative and qualitative methods are used in a single industrial-based research project, *(please see Figure 18 at page 84 further below)*. Secondly, with the triangulation approach, it involves viewing something from more than one perspective (Denscombe, 2007). Thirdly, the approach is issue driven; it focuses on different philosophies, (i.e., Positivism, Pragmatism and Objectivism) in order to create a practical value to the research findings (Saunders et al. 2009). Robson (2011) mentioned that, pragmatism provides a highly compatible theoretical underpinning to mixing two types of method in the same project. Researchers employing Objectivist research methods seek to uncover the truth or reality about their research. This means that the researcher needs to be as detached from the research as far as possible, and use methods that maximize objectivity and minimize the involvement of the researcher in the research.

This is best done using methods taken largely from the natural sciences and then transposed to social sciences. Positivism is the most extreme form of this worldview. According to positivism view, the world works according to fixed laws of cause and effect. Therefore, most of researchers employ both quantitative and qualitative methods thus, taking a pragmatist approach to their research, using different methods depending on the research questions they are trying to resolve. Sometimes a mixed method approach combining quantitative and qualitative methods seems the most appropriate in this kind of research direction. The detailed design of this research's approach is simplified and documented in Table 6 below.

Table 6. Research Approach Detail Design

(RQ.)	Type of (RQ.)	Research Aims and Claims	Research Approach	Research Strategies	Research Philosophy
RQ. 1	"How"	Explanatory Descriptive	Mixed-methods (Qualitative & Quantitative)	Case Study, Questionnaire & Archival Record/Literature Review/Underpinning Theory – Organization Theory	Positivism Pragmatism Objectivism
RQ. 2	"How"	Exploratory Explanatory Descriptive	Mixed-methods (Qualitative & Quantitative)	Case Study & Archival Record/Literature Review/Underpinning Theory – Organization Theory	Positivism Pragmatism Objectivism
RQ. 3	"How"	Correlational Explanatory	Mixed-methods (Qualitative & Quantitative)	Questionnaire & Archival Record/Literature Review/Underpinning Theory – Organization Theory	Positivism Pragmatist Objectivism
RQ. 4	"How"	Descriptive Explanatory	Mixed-methods (Qualitative & Quantitative)	Case Study, Questionnaire & Archival Record/Literature Review/Underpinning Theory – Organization Theory	Positivism Pragmatism Objectivism

1.4 Research Justification

Being able to easily access information in real-time on an enterprise SCM network will actually reduce the time and space of decision making and demand changes in complex engineering design and delivery processes as well as complex product development processes (Shamsuzzoha, et al., 2011; Musa, et al., 2013).

Industrial enterprise SCM networks are trying to streamline their operations and also minimize the time to get their products to the customer. These changes along with their support processes constitute new challenges that need to be effectively managed. Some of the primary changes highlighted in previous studies (Tan et al., 1999; Ndubisi et al., 2005; Lummus and Vokurka, 1999) include greater information exchange between industrial manufacturing SC network partners. The need to effectively coordinate early complex engineering design and delivery processes and also complex product development (CPD) processes across the SCM network and the associated competitive pressure to get the product more quickly to the customer and with sequential processes reduced as much as possible; have become a necessary industrial goal. Therefore, to manage these, enterprise industrial MIS; technology integration have become increasingly critical for most manufacturing industries SCM network (Tan et al., 1999; Musa, et al., 2013).

Although some research has been conducted into how to improve SCM network activities. However, little or no work has been done to make it more competitive and sustainable by adopting the "best practice" integrated complex/product process development process (Concurrent Engineering methodology) and employing the right SCM enterprise resource planning (ERP) information technology (IT) enablers. In order to enhance and sustain an industrial competitive advantage *(value-adding)* within enterprise SCM network activities (Lambert, and Cooper, 2000; Ahire and Dreyfus, 2000; Dyer, 2000; Hsu et al., 2006; Petersen et al., 2005; Lummus and Vokurka, 1999; Musa, et al., 2013, Shamsuzzaho, et al., 2011): Thus, what is referred to in this research as "Concurrent Enterprise" for SCM networks. According to Ahir and Dreyfus (2000) teamwork and collaboration are of great significance in SCM complex engineering-design and delivery products such as automobiles, aircraft engines, ship power engines, computer assembly, etc., rather than chemicals or food processing. Therefore, the structure of SCM network processes within the network systems as well as between the partners / teams / stakeholders on the SC is vital for creating superior competitiveness and profitability (Lambert and Cooper, 2000). Musa, et al.'s (2013) recent extensive research on SC product visibility: methods, systems and impacts, covers most aspects of element (3) in the three key interrelated elements of a competitive and sustainable SCM network of Lambert and Cooper's (2000) research. But they appear to have scoped their research to the enterprise resource planning SCM network IT enablers only. Although they also mention the significance of the other two elements. Hence, the three key elements include: 1) SC network structure – teamwork and collaboration of partners on the SC network; 2) SC business processes – "best practice" business approach in terms of operational principles for people/partners and systems on the SC network and 3) SC management components – business information technologies, integration of data-management systems, communication and systems security and authenticity.

As outlined in Table 7 below, the case company employed in this research is a large engineering global enterprise in its own perspective in the list of Original Equipment Manufactures' (OEMs). This case company plays its role fairly and significantly in the global manufacturing sector in its area of operations. Empirical data was collected from the case company in the form of industrial pilot case(s) as well as closed-end questionnaires. The focused research area in this research was their Ship Power manufacturing supply-chain management (SCM) department network activities. The idea was to collect empirical data to analyse, to enable the research to find feasible solution(s) to the real-life industrial enterprise SCM network issues translated into the research questions outlined above in sub-section *1.2.1*. Some of the real-life industrial SCM issues pertinent in most enterprise SCM networks, including this research's industrial partner's SCM network department activities, triggered or motivated the research questions in this research, are included in Table 7 below:

Table 7. Research Triggers or Motivators

#	Research Triggers or Motivators
1	A state-of-the-art e-SCM solution that helps to identify the location of a delivery and shipment of enterprise manufacturers in real-time environment (SC network product and logistics visibility at real-time) . Thus, A good track and trace solution is one that can identify the location of a shipment by answering the questions like; a. What are the current position / locations of the shipment / delivery? (Google Earth – functioned integrated graphical visualization at real-time of products and logistics: - shipments and deliveries). i. What are the conditions inside / outside the delivery shipment (i.e., extras such as temperature, humidity, corrosion / rust level, etc.)?
2	A common team working approach and platform (e-SC network platform).
3	IT (system) enablers to make it competitive & sustainable by proposing feasible e-SCM DMS for the SC network activities.

1.5 Research Report Structure

This research write-up is arranged in the form of a monograph thesis, comprising five chapters that are structured according to the progression of the applied research conducted. An overview of the structural layout of the contents of the chapters is provided in Table 8 below. Some of the chapters start with an introduction intended to help the reader understand the logic behind how the chapter is organised. Summaries are provided at the end of the last two main sub-chapters in chapter 2 *(i.e.,* 2.2 *and* 2.3*)* to help recapitulate contents and sum up significant points.

Table 8. Thesis Structure by Chapters

Chapter	Heading	Sections
Chapter 1	Introduction	▪ Research Background ▪ Research Objectives ▪ Research Approach ▪ Research Justification ▪ Research Report Structure
Chapter 2	Literature Review	▪ Introduction ▪ Concurrent Engineering (CE) ▪ Enterprise Resource Planning (ERP) ▪ Concurrent Enterprise (CE+) - Manufacturing SCM Network Activities
Chapter 3	Research Methodology	▪ Methods Employed for Research Data Collection ▪ Methods Employed for Research Data Analysis
Chapter 4	Research Analysis, Findings and Results	▪ Case Construct and Description (RQ. 1 & RQ. 2) ▪ Case Construct and Description Three (RQ. 3) ▪ Analysing the Case Constructs and Discussions (RQ. 4)
Chapter 5	Conclusion	▪ Discussion of Research Results ▪ Detailed Research Results Discussion ▪ Contribution to the Body of Knowledge ▪ Summary of Research ▪ Limitation of Results ▪ Recommendation for Future Research
Appendixes A - F		▪ Financial Plan and Research Time Line ▪ Sample Research Questionnaire ▪ Questionnaire e-Forms Response Graphics Representations ▪ Ship Power Systems (Wärtsilä 32 Engine Categories) ▪ Correlation Analysis Data: Frequency in Technical Communication, Importance of Technical Communication, Scale/Level of Collaboration in Technical Communication, Scale/Level of Mutual Trust and Scale/Level of Roles & Responsibility. ▪ List of Publications

This research employed a triangulation approach by using more than one data collection method and mode of analysis. However, the research methods were selected based on the information required to achieve the research objectives and also address the finding or gaps identified from the literature review. The following chapter will presents the literature review of the two main industrial organization management streams employed, studied and analysed in this research *(i.e., Concurrent Engineering principle and Enterprise Resource Planning systems solutions in product-development information technology (IT) perspective for SCM network activities).* Therefore, with the collaborative synergy of the two streams mentioned above, the expected output of sustainable industrial competitive advantage harnessed the contribution of this research. Thus, providing the enabling enterprise-systems structures for the researcher to propose and present the conceptual framework for CE+ SCM network activities.

2 LITERATURE REVIEW

2.1 Introduction

According to Robson (2011), literature is what is already known and written down relevant to one's research project. There are many reasons for conducting a literature review. Hence literature review has been recommended beyond the traditional review which includes the systematic search of documents, location, and analysis of these documents containing information related to a research problem or gap. Robson (2011) notes that some other benefits or advantages of a literature review are that it:

- Exposes relevant gaps in literature or knowledge, and identifies main areas of disagreement, discrepancy and uncertainty requiring further study.
- Aids the identification of general patterns to research and research findings by analysing multiple examples of research in the same domain.
- Compares studies with apparently conflicting findings to help explore clarifications for discrepancies.
- Aids researchers to define terminology and identify differences in the definitions used by other researchers or practitioners in the same research domain.
- Aids the identification of appropriate research methodologies and scientific tools for data collection and analysis.
- Develops the researcher's knowledge and understanding of the research topic and domain.
- Assists researchers to prevent duplicating research and avoid consequences and common errors experienced in previous research projects.

Academic literature review(s) may vary depending on its uses or focal drive in research. However, there are also variations in the kind of information that would be considered to be contributions to the body of knowledge. Therefore, original academic research may be published in the form of journal articles, conference papers, books / book-chapters, and academic / industrial research reports. Each of these publications may be subject to peer-review / double-blind-peer-review or any form of academic rigor and scrutiny. This research employed all the forms of academic research literature publications and also used other sources, which are also very insightful and helpful in conducting literature review, such as the Internet and industrial R&D websites; academic databases and portals such as Scopus, Science Direct, IEEE Xplore, Emerald, ProQuest, EBSCO, Springer link, Information Science, etc.; and government and legal publications. Figure 14 below, illustrates a snapshot overview of the literature review in this research project.

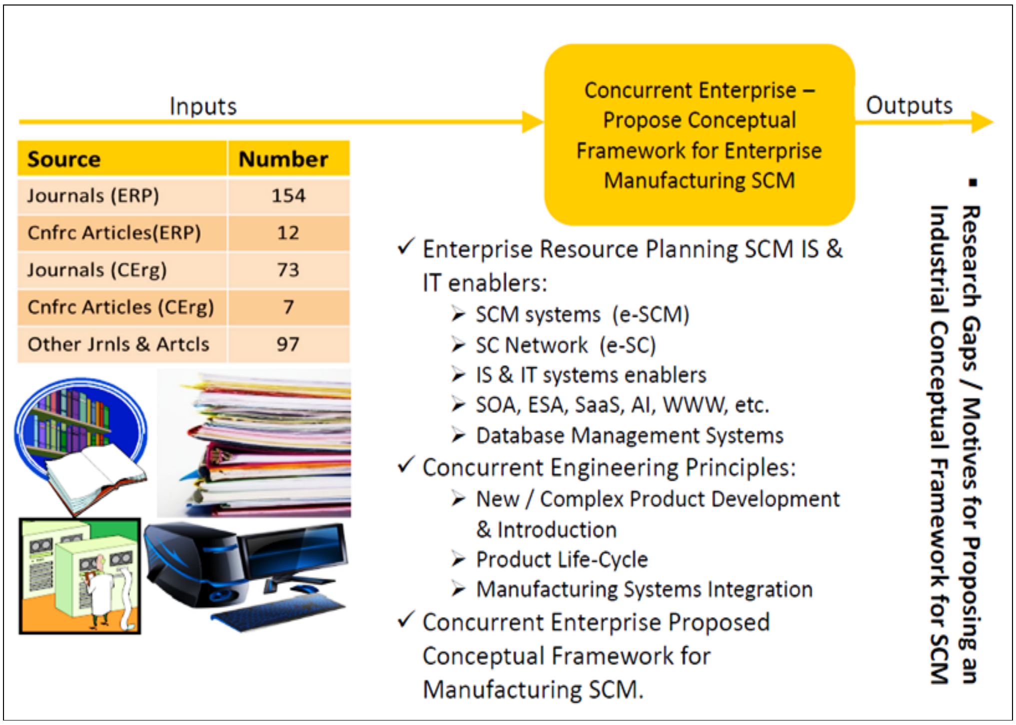


Figure 14. Overview of Research Literature Review

2.2 Concurrent Engineering (CE)

This review section intends to serve three goals. First, it would be useful to researchers who are interested in understanding and following the recent trends within the area of the CE "best practice" approach. Secondly, this review would be useful to businesses or industries that are intending to expand and strategically enhance their operations (SCM network activities); because the observations and findings highlight the unanswered but justified research and development (R&D) pertinent challenges and questions raised in research papers for research and/or developmental needs of industrial organizations. Finally, this review section attempts to identify and summarize key references to aid researchers and industrial R&D departments as well as their entire SCM network activities for new/complex product development teams/partners to find solutions to the research questions in this research report. This section uses key journals and other key forums such as conferences and societies as well as some books on the field of CE, in order to give a wider coverage of identified literature documents to enhance and subsequently support the validation of the findings in this research. This section reports a review of work published in various journals on the topics of Concurrent Engineering (CE) between 2000 and 28th July, 2010 in a deliberate attempt to strategically and purposefully scope this extensive review. A total of 80 articles from 28 journals, eight Conference Proceedings and two books were reviewed. Harzing's Publish or Perish software analytical tool was employed in summarizing this section into table form. This section of the research literature review will also assess the issues and trends, including future perspectives of CE and the CE Product Life Cycle (PLC) issues in product development and support processes.

Over the past decade industries in almost all markets has been facing a rising level of competitiveness. There are many reasons for this, but most of them can be ascribed to some principal trends: shortening product life cycles, globalization of the market, rapid technological changes, environmental issues, and higher complexity of products, customers demanding products with more features, higher quality, lower cost, and demand for more and more customized products. Concurrent Engineering is an integrated product development approach; CE emphasises the response to customer expectations by producing better, cost-effective and much faster products. It also supports multidisciplinary team values for co-operation and trust; thus, it advocates sharing and exchanging required knowledge and information in a manner that will enhance decision-making processes and also places emphasis on simultaneous consideration during the design stage and all the other Product Life Cycle (PLC) aspects of the product development. One of the most salient means to reduce development time is through the use of "concurrent engineering." Concurrent engineering is defined by the Institute for Defence Analysis (IDA) as: "the systematic approach to the integrated concurrent design of products and related processes, including manufacture and support."

Thus, PLC management confronts the need to balance fast response to changing consumer demands with competitive pressure to seek cost reductions in sourcing, manufacturing and distribution. It needs to be based on a close alignment between customer-facing functions (e.g. marketing, sales, customer service) and supply functions (e.g. purchasing, manufacturing, logistics) (Combs, 2004; Conner, 2004; O'Marah, 2003). Hence, Product life cycle (PLC) management as an integrated, information-driven approach in all aspects of a product's life, from concept to design, manufacturing, maintenance and removal from the market, has become a strategic priority in many companies boardrooms (Teresko, 2004).

According to Yassine and Braha (2003) CE is an engineering management philosophy and a set of operating principles that guide a product-development process through to an accelerated successful completion. In general, CE values rely on a single, but powerful, principle that encourages the incorporation of the later stages of production concerns into the upstream phases of a development process. This would lead to shorter development times, improved product quality, and lower development–production costs. Concurrent engineering is hereby aimed at the timely availability of critical design information to all development participants. For most intricate engineering tasks, all significant information required by a specific development team cannot be completely available from the start of that task.

Therefore, CE requires the availability of most of such information and the ability to share and communicate useful information on a timely basis with the right experts. The concept of CE has been known for quite a while now, and it has been widely recognized as a major enabler of fast and efficient product development. This chapter examines the extent to which CE “best practices”, as identified from a broad literature review, are being used effectively in companies. Finally, the positive impact of formal CE programs is confirmed by some of the analysis in this research (Portioli-Staudacher, et al., 2003). Some of the most cited Concurrent Engineering (CE) research authors were identified; for their work and their contributions by using a sample statistical report from Harzing’s Publish or Perish software. Therefore, this section is divided into the following main sections: an introduction to the types of CE multidisciplinary teams; methodology of review analysis; CE product life cycle (PLC); CE trend and perspectives; detailed review of journal articles; and finally analysis and summary of this section of the literature review.

2.2.1 Types of CE Multidisciplinary Teams

CE applications depend on having a very well defined multidisciplinary team that is directed by the project leader or CE team leader. The vital CE team members consist of various departments, such as marketing, product engineering, manufacturing engineering, production engineering, finance, quality, logistic control, systems engineering, services and external consultancy or support teams as well as the customers and brokers (Combs, 2004; Conner, 2004; O'Marah, 2003; Yassine and Braha, 2003; Gunasekaran, 1998). Al-Ashaab and Molina, (2000) some of the CE multidisciplinary team structures include:

- *Functional Team:* This type of multidisciplinary team very much relates to the orthodox over the wall way of communication where each engineer works in his/her own functional department. This team type should be avoided.

- *Lightweight Team:* This type of multidisciplinary CE team is mainly formed with members from the same department. This CE team type is related to part of the complete PLC.

- *Heavyweight Team:* This type of multidisciplinary CE team is a classical cross-functional CE team. With this type of CE team, members work part-time alongside their original departmental duties.

- *Autonomy Team:* This type of multidisciplinary CE team is also a classical cross-functional team where members work full-time from their own offices and also use the departmental resources. With this type of CE team, regular meetings take place among the CE team members.

- *Collocated Autonomy Team:* This type of multidisciplinary CE is much like the autonomy team type of CE, except that, to enhance total dedication to the project as well as the integration of the team, members are brought together in the same working environment with the requisite resources to carry out their activities.

- *The Virtual Team:* This type of multidisciplinary CE team is geographically distributed, thus, employing information technologies (i.e. internet/intranet, as well as telephone conferences and videoconferences) for communication among members.

2.2.2 Technique Utilized – CE Journals Review

It is rather hard to confine a report on Concurrent Engineering (CE) to specific orders; the relevant material is spread out across various journals. The criteria for choosing journal articles for the review were as follows. First of all, the article must have been published in a peer-reviewed and/or archival journal. Secondly, to avoid never-ending revision of the report, 28th July, 2010 was selected as the cut-off date. Finally, only articles with 'Concurrent Engineering' as a part of their title contents were selected. The exceptions are those articles that are explicitly dealing with 'Concurrent Engineering' but for some reasons, the authors decided not to use 'Concurrent Engineering' in the title. The inclusion of such articles was inevitably unplanned.

Consequently, it is possible that there exist more such articles, which are not surveyed for this report. No restrictions were imposed on the field of the surveyed journals. This should allow a comprehensive set of perspectives on Concurrent Engineering by different fields. According to these criteria, a vigorous attempt has been made to collate all the available journal articles. The compilation effort was carried out through exhaustive computer search, database search, Internet search, reference checking, most cited authors using Harzing's Publish or Perish software, *etc.* However, it is always possible that some articles are missing from this list. Harzing's Publish or Perish software statistical results for the most frequently cited authors in the field of Concurrent Engineering between 2005 and 2010 is found in Table 9 below in descending order:

Table 9. Harzing's Publish or Perish Most Cited Concurrent Engineering Journal Articles and Authors*.

Harzing's Publish or Perish - General Citation Search for "Concurrent Engineering (All Time Classics) Title words only.				
Cites	**Authors**	**Title**	**Year**	**Source**
66	A Yassine, D Braha	Four complex problems in concurrent engineering and the design structure matrix method	2003	Concurrent Engineering
65	KJ Cleetus	Definition of concurrent engineering	1992	Morgantown, WV: Concurrent Engineering Research …
64	M Lawson, HM Karandikar	A survey of concurrent engineering	1994	Concurrent Engineering
54	F Mistree, WF Smith, BA Bras	A decision-based approach to concurrent engineering	1993	Handbook of Concurrent Engineering
50	B Prasad, RS Morenc, RM Rangan	Information management for concurrent engineering: research issues	1993	Concurrent Engineering
43	HH Jo, HR Parsaei, WG Sullivan	Principles of concurrent engineering	1993	Concurrent Engineering: …
39	J D'Ambrosio, T Darr, W Birmingham	Hierarchical concurrent engineering in a multi-agent framework	1996	Concurrent Engineering

36	CY Kim, N Kim, Y Kim, SH Kang, P O' …	Distributed concurrent engineering: Internet-based interactive 3-D dynamic browsing and mark-up of STEP data	1998	… Engineering
35	MR Danesh, Y Jin	An agent-based decision network for concurrent engineering design	2001	Concurrent Engineering Research
34	M Klein	iDCSS: Integrating workflow, conflict and rationale-based concurrent engineering coordination technologies	1995	Concurrent Engineering
34	B Prasad…	Towards a computer-supported cooperative environment for concurrent engineering	1997	Concurrent Engineering
34	RP Smith, SD Eppinger	Deciding between sequential and concurrent tasks in engineering design	1998	Concurrent Engineering
32	K Ishii	Modelling of concurrent engineering design	1993	Concurrent Engineering: Automation, Tools and …
32	T Khedro, MR Genesereth	The federation architecture for interoperable agent-based concurrent engineering systems	1994	Concurrent Engineering
32	C Rush, R Roy	Analysis of cost estimating processes used within a concurrent engineering environment throughout a product life cycle	2000	Advances in Concurrent Engineering: Ce2000
31	MJ Hague, A Taleb-Bendiab	Tool for the management of concurrent conceptual engineering design	1997	… in Concurrent Engineering: CE97
29	A Molina…	Modelling manufacturing capability to support concurrent engineering	1995	Concurrent Engineering
26	PED Love, A Gunasekaran	Concurrent engineering in the construction industry	1997	Concurrent Engineering
25	CS Syan	Introduction to concurrent engineering	1994	Concurrent Engineering: Concepts, Implementation
25	HC Zhang…	Concurrent engineering: an overview from manufacturing engineering perspectives	1995	Concurrent Engineering
25	SM Kannapan, KM Marshek	An approach to parametric machine design and negotiation in concurrent engineering	1993	Concurrent Engineering: Automation, Tools, and …
22	B Ramesh, K Sengupta	Managing cognitive and mixed-motive conflicts in concurrent engineering	1994	Concurrent Engineering
20	D Brissaud, O Garro	An approach to concurrent engineering using distributed design methodology	1996	Concurrent Engineering
20	T Wu, P O'Grady	A concurrent engineering approach to design for assembly	1999	Concurrent Engineering
20	SJ Chen, L Lin	A project task coordination model for team organization in concurrent engineering	2002	Concurrent Engineering
19	J Dong	Organization structures, concurrent engineering, and computerized enterprise integration	1995	Concurrent Engineering
19	F Maturana, S Balasubramanian, DH …	A multi-agent approach to integrated planning and scheduling for concurrent engineering	1996	… Concurrent Engineering …
17	M Sobolewski	Multi-agent knowledge-based environment for concurrent engineering applications	1996	Concurrent Engineering
17	C McGreavy, XZ Wang, ML Lu, Y Naka	A concurrent engineering environment for chemical manufacturing	1995	Concurrent Engineering

**Harzing's Publish or Perish Most Cited Authors (Accessed on 28/07/2010). *The Harzing's Publish or Perish software used for general citation search for "Concurrent Engineering" in All of the words field, "Concurrent Engineering" in Any of the words field, "Concurrent Engineering" in The Phrase field and then Title words only box ticked setting the dates for All time Classics till 2010.*

Source: Addo-Tenkorang (2011).

2.2.3 CE Product Life-Cycle (PLC)

Every product or service has a certain life cycle. Product life-cycle (PLC) is an integrated, information-driven approach to all aspects of a product's life, from concept to design, manufacturing, maintenance and removal from the market, which has become a strategic priority in many company's boardrooms (Teresko, 2004). The life cycle refers to the time from the product's first launch into the market until its final withdrawal, and it is divided into phases. During this time, significant changes occur in the way that the product behaves in the market, i.e. its reflection in respect of sales to the company that introduced it into the market. Since an increase in profits is the major goal of companies that introduces a product into a market, the product's life cycle management is very important. Certain companies use strategic planning and others follow the basic rules of the different life cycle phases. Understanding of the product's life cycle can help an industry to understand and realize when it is the time to market or withdraw a product from a market, its position in the market compared to the competitors, and the product's success or failure feasibility. For a company to fully understand the above and successfully manage a product's life cycle, the organization needs to develop strategies and methodologies (Komninos, I. 2002).

Organizational industries should manage their products carefully over time to ensure that they deliver products that continue to meet customer needs. In this way, industrial organizations maintain a cash flow that covers the company's costs and delivers a profit (Sapuan and Mansor, 2014). Without this profit, very few industries can survive in the longer term. The process of managing groups of brands and product lines is called group planning. The life of a product is the period over which it appeals to customers. The sales performance of any product rises from nothing when the product is introduced into the market, reaches a peak and then declines to nothing again (Rush and Roy, 2000).

The classic product life cycle has five stages (Moon, 2005):

- Development
- Growth
- Maturity
- Decline, and
- Withdrawal

The Product Life Cycle of some products may last for hundreds of years, while for others; it may be a few months. If a firm wants to prolong the life cycle of its own distinct product, it is essential to invest well in the development of the product development engineering-design and delivery as well as it's promotion (Rush and Roy, 2000; Sapuan and Mansor, 2014). This may mean that a lot of work is put into the product before the product is launched. Once the product is on the market it may be necessary to periodically inject new life into it. This can be done in several ways, including:

- Product improvement
- Extending the product range
- Improved promotion

The Product Life Cycle process is the mechanism through which products are managed from inception to retirement. The Product Life Cycle does not have to end. It can easily be prolonged by a range of marketing and production innovations (Rush and Roy, 2000; Moon, 2005).

2.2.4 Development Stage

At the development stage, market size and growth is slim. It is possible that substantial research and development costs have been incurred in getting the product to this stage. In addition, marketing costs may be high in order to test the market: It undergoes commencement promotion and set up distribution outlets. It is highly unlikely that industries will make profits on products at the development Stage. Products at this stage have to be carefully monitored to ensure that they start to grow and ramp-up in the market. Otherwise, the best option may be to withdraw or end the product. The need for immediate profit is not a pressure as the lack of it is expected at this time. The product is promoted to create awareness of the market. If the product has no or few competitors, a skimming price strategy is employed to maximize profits. Limited numbers of product will be available in few outlets of distribution. The development stage encompasses a number of activities that will include (Moon, 2000; Rush and Roy, 2000; Sapuan and Mansor, 2014):

- *Concept:* Overview of the customer requirement that an opportunity seeks to address, supported by evidence of market need.

- *Definition:* High-level definition of customer requirements and analysis of a business opportunity.
- *Design:* Analysis of customer requirements creating project plan and detailed product specification.
- *Development:* Data and software (CAD/CAM) development.
- *Development Testing:* Testing of the product against pre-defined test schedules to ensure satisfactory performance against customer requirements.
- *Development of pricing.*
- *Development of user guide*,
- *Introduction of the product* to the market (Time to Market). etc.

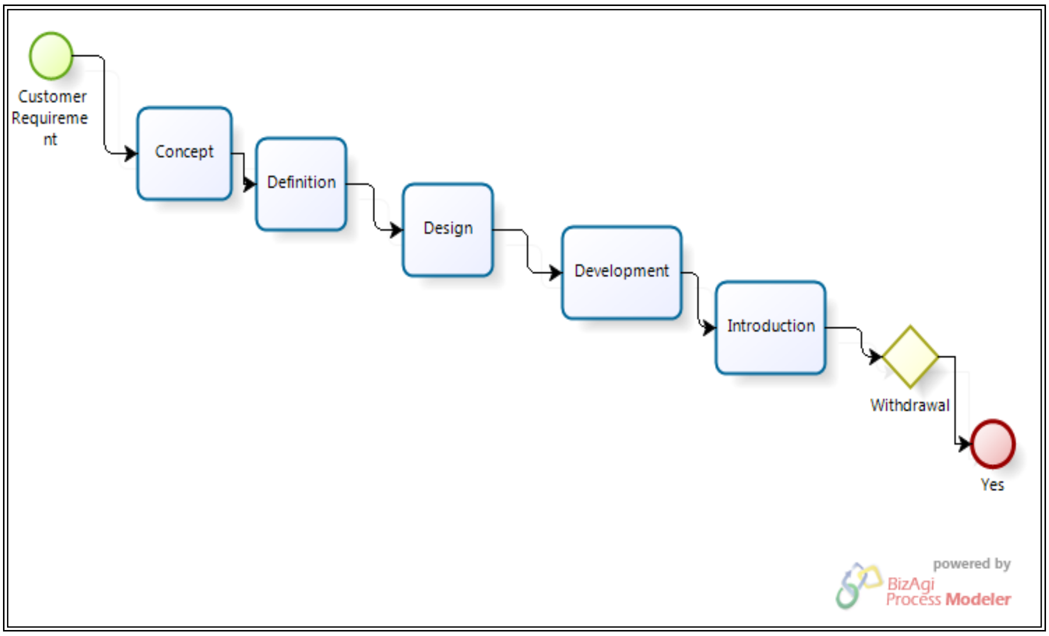


Figure 15. Introduction Stage (Input and Deliverables) *Product Life Cycle (PLC)* - Input and Deliverables.

Sources: Addo-Tenkorang (2011).

It is at this stage that Engineering Design team comes to the fore and have their major contribution. The intention is to ensure that the new product:

- Meets all the customer requirements
- The design time is very much reduced as the process progresses
- Shorter time to market for products
- Shorter time to profitability for new/complex products
- Increase Return On Investment (ROI)
- Earlier payback of investment costs

2.2.5 Concurrent engineering workflow

Concurrent engineering (CE) is a workflow that, instead of working chronologically through stages, carries out a number of tasks in parallel, for example: starting tool design before the detailed designs of the product are finished, or starting on detail design solid models before the concept design surface models are complete. Although this does not necessarily reduce the amount of manpower required for a project, it does drastically reduce lead times and thus time to market. Feature-based Computer-Aided Design (CAD) systems have for many years allowed the simultaneous work on 3D solid model and the 2D drawing by means of two separate files, with the drawing looking at the data in the model; when the model changes the drawing will accordingly be updated. Some CAD packages also allow associative copying of geometry between files. This allows, for example, the copying of some part of a design into the files used by the tooling designer. The manufacturing engineer can then start work on tools before the final design freeze; when a design changes size or shapes the tool geometry will then be updated. Concurrent engineering also has the added benefit of providing better and immediate communication between departments, reducing the chance of costly, late design changes. It adopts a problem prevention method as compared to the problem-solving and re-designing method of traditional sequential engineering.

2.2.6 Design in context

Individual components cannot be constructed in isolation. Computer-Aided Design (CAD), and Computer-Aided industrial Design (CAiD) models of components are designed within the context of part or the entire product being developed. This is achieved using assembly-modelling techniques. Other components' geometry can be seen and referenced within the CAD tool being used. The other components within the sub-assembly may or may not have been constructed in the same system, their geometry being translated from other collaborative product developments - CPD or computer-aided manufacture CAM formats. Some assembly checking such as digital mock-up - DMU is also carried out using product visualization software.

2.2.7 Growth Stage

The Growth Stage consists of rapid growth in sales and profits as the product or service is becoming established. Profits arise due to an increase in output (economies of scale) and possibly better prices for raw materials and manufactured components. There may be fewer competitors, sales are growing and profit margins are good. Now is the time to work out how to reduce the costs of delivering the new product. At this stage, it is cheaper for organizational industries to invest in increasing their business market share as well as enjoying the overall growth of the market. Accordingly, significant promotional resources are usually invested in products that are firmly in the Growth Stage. Competitors are attracted to the market with very similar offerings. Products become more profitable and companies form alliances, joint ventures and take each other over. Advertising cost is high and focuses on building a brand. Market share tends to stabilize in this respect.

2.2.8 Maturity Stage

The Maturity Stage is, perhaps, the most common stage for all markets. It is at this stage that competition is most intense as companies fight to maintain their market share. Here, both marketing and finance become key activities. Marketing cost has to be monitored carefully, since any significant moves are likely to be copied by competitors. The Maturity Stage is the time when most profit is earned by the market as a whole. Any expenditure on research and development is likely to be restricted to product modification and improvement and perhaps to improve production efficiency and quality. Sales growth will slow or even stop at this stage. Production and marketing costs may have been reduced, but increased competition would drive down prices. Hence, this moment is probably the best time to invest in a new/complex product development processes. Those products that survive the earlier stages tend to spend longest in this phase. Sales grow at a decreasing rate and then stabilize. Producers attempt to differentiate products and brands, which is essential. Price wars and intense competition occur. At this point, the market reaches saturation. Producers begin to leave the market due to poor margins.

2.2.9 Decline Stage

The decline stage denotes that the market is shrinking, reducing the overall amount of profit that can be shared among the remaining competitors. At this stage, great care has to be taken to manage the product carefully. It may be possible to take out some production cost, to transfer production to a cheaper facility, sell the product into other, cheaper markets, etc. Care should also be taken to control the amount of stocks of the product. Ultimately, depending on whether the product remains profitable, a company may decide to end the product. From this point forward, there is a downturn in the market. For example, more innovative products are introduced or consumer tastes have changed. There is intense price-cutting, and many more products are withdrawn from the market. Profits can be improved by reducing the marketing cost.

2.2.10 Withdrawal stage

At this stage, product retirement takes place and a migration plan for the company's products and markets will be established to support customers and partners. It is within this stage of the product life cycle that the recycling and final disposals of constituent components have to be addressed. It is of prime importance that this stage of the Product Life Cycle is fully considered during the product development stage. The Figure 15 at *page 37* above, illustrates the process involved in the Product Life Cycle.

2.2.11 Issues with Product Life Cycle (PLC)

In reality, very few products follow such a prescriptive cycle. The length of each stage varies enormously. The decisions of marketers can change the stage, for example, from maturity to decline by price-cutting. Not all products go through each stage. Some go from the introduction to decline. It is not easy to tell which stage the product is at. The Product life Cycle is like all other tools. It is used to inform one's intuition. Industries will often try to use extension strategies to try to delay the decline stage of the product life cycle. However, the maturity stage is a good stage for the company in terms of generating profits. Therefore, the longer a company can extend this stage the better it will be for them.

New/complex products and support processes are the lifeblood of all industrial and organizational businesses. Investing in their development is not an optional extra - it is crucial to business growth and profitability. However, embarking on the development process is risky. It needs considerable planning and organization. Identifying where products or services are in their - life cycle is central to business profitability. Effective research into industrial markets and competitors will help to do this. Industries can extend the life-cycle of a product or service by investing in an "extension strategy" by:

- Increases to promotional spend.
- Introduce minor innovations - perhaps by adding extra features or updating the design
- Seek new markets

Even so, ultimately this only delays a product or service's decline. Ideally, industries should always have new products or services to introduce as others decline so that at least one part of the range is showing a sales peak.

2.2.12 CE Trends and Perspectives

According to Tennant and Roberts (2000), an effective New/Complex Product Development and support processes (N/CPD) which is concurrent, can enhance an organization's competitiveness by compressing product development lead-times, and enabling upstream and downstream processes to be considered when taking decisions at the product concept phase. The application of Concurrent Engineering (CE) (or Integrated Product Development [IPD]) is gradually becoming the norm for developing and introducing new products to the market place (Ainscough and Yazdani, 2000).

However, the degree to which companies have implemented it and the amount of success varies (Ainscough and Yazdani, 2000; Balbontin *et al.*, 2000). Many of the companies competing today in international markets consider new/complex product development as an important factor for achieving sustainable competitive advantages. Both researchers and managers are constantly searching for methods and practices that will allow them to improve the organization and management of their N/CPD, support processes, and boost their effectiveness or success. The average success rate of complex PD projects today is approximately 60% (Cooper and Edgett, 2003). The process is to achieve distinction in three specific objectives: (1) shorter new-product development times, (2) more efficient developments, and (3) superior products.

On the above note, manufacturing companies have re-systematized their N/CPD and support processes and have moved from a sequential path, in which there is a negligible interaction between the departments involved and the activities required. Hence, this approach enhance the ability to develop a product, which is developed out sequentially, towards an integrated path, known as concurrent engineering (CE), in which the activities overlap and all the departments collaborate from the beginning. This new organizational design has helped companies improve their performance by leading to lower costs, higher quality, major knowledge creation and shorter product development lead-times (Barba, 2001; Umemoto et al., 2004), all of which, in turn, has raised their competitive capabilities. Hence, the aim is to avoid continuous setbacks and the other problems that arise with the traditional approach, improving PD performance.

This CE approach, tries to speed up the process, increasing flexibility, adopting a strategic perspective with more sensitivity to change in the environment, solving problems through teamwork, developing diverse capabilities, and improving internal communication (Barba, 2001). To achieve the above-mentioned objectives, CE is based on three basic elements (Koufteros et al., 2001):

1) Concurrent work-flow,

2) Early involvement of all participants and groups contributing to product development, and

3) Team-work. In other words, CE is the early involvement of a cross-functional team to simultaneously plan product, process and manufacturing activities as mentioned earlier in the previous paragraphs.

Many studies demonstrate that CE can successfully solve the typical problems of traditional PD, leading to clear improvements in quality and marked reductions in development lead-time and costs (Calantone and Di Benedetto, 2000; Herder and Weijnen, 2000; Barba, 2001; Koufteros et al. 2001). On the other hand, further recent research also have revealed that the use of CE on its own does not always lead to positive results and that success in improving innovation capabilities depends on the context in which CE is applied; that is, on the prevailing competitive and technological circumstances (Valle and Va´zquez-Bustelo, 2009). Therefore, a conclusion is reached that the scale of vagueness and intricacy present during the process of innovation may moderate the effect of concurrent PD characteristics on performance.

Therefore, the matter to be considered is not whether CE is a mechanism for improving performance through the introduction of new products but, rather under what circumstances such an improvement can accomplished? It seems, however that in spite of many research efforts, in studying this aspect, a consensus is yet to be reached and that there are many empirical disagreements. This lack of agreement is the reason for this part of the review study on the trends and perspective of CE, the main aim of which is to help determine the trends and prospective circumstances under which the application of CE is successful, effective and more efficient.

According to Campbell and Mohun (2007), industrial manufacturing companies endeavour to create an advanced core system analytical solution integration process across their industrial manufacturing processes. Thus, this will enhance the efforts by industrial processes by reducing lead-time variability and minimizing the transition times to achieve performance consistency. This kind of system requires integrated product design and manufacturing collaboration; service-oriented architecture (SOA) turns out to be the preferred systems' application platform suitable for the recommended Enterprise Service Architecture for this integration process. Further to this analytical advantage of CE system applications and processes, this collaboration has also been accordingly confirmed in Valle and Va´zquez-Bustelo's (2009) research on 'Concurrent engineering performance: Incremental versus radical innovation.' According to Gao, et al. (2000), the extensive application of computer-aided engineering (CAE) technologies is necessary so that the maximum design efficiency and effectiveness can be accomplished prior to initial sample production. The main characteristic of such an approach depends largely on the system integration in accordance with the design process.

2.2.13 Review of the Journal Articles

In this sub-section, a brief aggregate summary of the journal articles used in this review report as provided in the following Tables 10 - 12 below. It is not intended to provide a detailed description to each article and references of major topics and sub topics used in this review report. Hence, an attempt to draw a collective summary report is made in this section.

Table 10. Number of articles in each journal (all in alphabetical order)

Journals	**Number of CE Journal Articles**
Academic Press ---	6
Annals of the CIRP--	1
Citeseer---	2
Computers in Industry--	3
CRC---	6
IEEE Transactions on Engineering Management---------------------------------------	1
Industrial Management--	1
Industry Week---	1
Integrated Manufacturing Systems--	1
International Journal of Concurrent Engineering---------------------------------------	2
International Journal of Manufacturing Technology and Mgmt.----------------------	1
International Journal of Production Economics---	4
International Journal of Production Research--	3
International Journal of Project Management--	3
International Journal of Technology Management-------------------------------------	1
Journal of Engineering Manufacture---	1
Journal of Engineering Technology Management--------------------------------------	1
Journal of Knowledge Management--	1
Journal of Management Development---	1
Journal of Materials Processing Technology--	1
Journal of Operations Management---	3
Journal of Product Innovation Management--	2
Management Science---	1
R&D Management--	1
Robotics and Computer Integrated Manufacturing------------------------------------	2
Sage Journal Publications---	25
Springer Publications--	4
Supply Chain Management Review---	2
Total	**80**

Analysis of Journal articles used in this review report.

Source: Addo-Tenkorang (2011).

Table 11. Conference and Society Proceeding Articles

Conferences and Society's Proceeding Articles			
Main Event	**Topic**	**Coordinators**	**Year**
Concurrent Engineering Research Group. International Conference of Concurrent Engineering (CE 99), Bath-England.	Concurrent Engineering Framework: A Mexican Perspective	Al-Ashaab, A., and Molina, A.,	2000
Product Development Institute Inc. Ancaster, Ontario, Canada.	Best Practices in Product Innovation: What Distinguishes Top Performers	Cooper, R.G., Edgett, S.J.,	2003
Urban & Regional Innovation Research Unit, Faculty of Engineer. Aristotle University of Thessaloniki.	Product Life Cycle Management	Komninos, I.	2002
International Conference on Concurrent Engineering	Study on process reengineering and integrated enabling tools of concurrent engineering.	H Zhang, G Xiong, B Li	2002
International conference on concurrent engineering.	Taxonomy of information and capitalisation in a Concurrent Engineering context	M Gardoni, E Blanco	2000
Concurrent Engineering Conference.(forthcoming …	Federated P2P Services in Concurrent Engineering Environments	M Sobolewski	2002
European symposium on concurrent engineering …	Sahraoui 'customising systems engineering concepts: case study on concurrent engineering Context'. ESEC	MHJ AEK	2005
Proceedings of the 9th	Establishment of a	W.D. Li, S.K. Ong, A.Y.C. Nee,	2002
ISPE International Conference on Concurrent Engineering: Research and Applications, UK, pp. 605–612.	distributed design environment		
Book(s) Used			
Publisher	**Topic**	**Author**	**Year**
Wiley Publishing, Inc. 10475 Cross point Boulevard, Indianapolis, IN 46256.	Mastering Enterprise SOA with SAP Net weaver and my SAP ERP	Campbell, S., and Mohun, V.,	2007
CIM Press, P. O. Box 100, Cambria, California 93428-0100.	Design For Manufacture and Concurrent Engineering	Dr. David M. Aderson	2008

Conferences and Society's Proceeding Articles Used in this Review Report & Book(s).

Source: Addo-Tenkorang (2011).

Table 12 below shows the main topics and major research areas used in the journal article included in this literature review. There is no particular sequence among the references listed in the table. It is unavoidable to have an article that is relevant to more than one topic. For example, an article may address implementation issues but provide general information or extension/trends and perspective on CE. In such a case, topics that are more important are chosen to classify the article according to the researcher's judgement. Listing an article under more than one topic was hereby allowed.

Table 12. Topics and references

Topic	References
Implementation	Yassine, A., and Braha, D., 2003; Chen, S., J., and Lin. L., 2002; Aniscough, M., and Yazdani, B., 2000; Kara, S., et al., 2001; Frenandez, M., G., et al., 2005; Yan, H., S., et al., 2002; Anumba, C., J., et al., 2000; Nahm, Y., E., and Ishikawa, H., 2005; Sohnius, R., et al, 2006; Wu, T., et al., 2001; AEK MHJ, 2005; Huang, E., Chen, S., J., G., 2006; Ostrosi, E., et al., 2003a; Zhang, H., et al., 2002; Stokic, D., 2006; Chen, Y., J., et al., 2007; Jardim-Goncalves, R., and Steiger-Garcao, A., 2001; Liang W., Y., and O'Grady, P., 2002; Ostrosi, E., et al., 2003b; Klein, M., et al., 2003; Balakrishnan, A., and Thomson, V., 2000; Gardoni, M., 2005; Kara, S., and Kayis, B., 2005; Ouardani, A., et al., 2004; Antegnard, L., et al., 2006;Yu, B.,T.,W., et al., 2006; Parsaei, H.,R., 2006; Stanescu, A., et al., 2007; Aswad, A.,A., 2006; Fan, I.S., and Filos, E., 2001b; Sackett, P.,J., 2006; Airbus A.,M.,2000; Garro, P.O., et al., 2000; Al Said, 2006; Portioli-Staudacher, et al., 2003; Ainscough, et al., 2003; Coman, 2000; Corti, and Portioli-Staudacher, 2004; Dorf, 2000; Haberle, et al., 2000; Kamara, et al., 2001; Kayis, et al., 2007; Koufteros, et al., 2002; McDermott, et al., 2002; Mileham, et al., 2004; Synodinos, 2003; Wheelwright, and Clark, 2000; Yan, and Wu, 2001;
CE Uses / Value	Rush, C., and Roy, R., 2000; Chen, S., J., G., 2005; Gardoni, M., and Blanco, E., 2000; Anumba, C., J., et al., 2000; Hartkopf, V., et al., 2000; Riedel, J., et al., 2001a; Riedel, J., et al., 2001b; Forsberg, S., et al., 2000; Yarushkina, N., 2002; Roy, R.., and Steigler-Garco, A., 2002; Rush, C., and Roy, R., 2001; Sackett, P., J., 2006; Renaud, J., et al., 2001; Roy, R., 2000b; Van Landeghem, R., 2000; Gardoni, M., and Blanco, E., 2000; Riedelt, J., et al., 2001; Gardoni, M., 2005; Pawar, K., et al., 2002; Bhuiyan, et al., 2004; Hannegham, et al., 2000; Haque, and Pawar, 2001; Thomke, and Fujimoto, 2000; Yarushkina, 2002;
Extension /Trends and Perspectives	Danesh, M., R., and Jin, Y., 2001; Yassine, A., and Braha, D., 2003b; Loch, C., et al., 2003; Tay, F., E., H., 2001; Sobolewski, M., 2002; Jiang, T., and Nevill, G., E., 2002; Monticolo, D., et al., 2006; Pawar, K., et al., 2000; Ishikawa, H., et al., 2000; Stephen, C., Y., 2004; Young, R., I., M., et al., 2001; Ali, Y., D., 2003; Cleetus, J., 2001; Lonchamp, J., 2000; Carduff, T., W., et al., 2000; Fan, I.S., and Filos, E., 2001a; Sobolewski, M., and Ghodous, P., 2005; Semenov, V., 2007; FEH, T., and Ming, C., 2001; Fukuda, S., 2007; Loureiro, G., and Curran, R., 2007; Andrade, L., and Forcellini, F., 2007; Hartescu, F., 2006; Baker, T., 2005; Bouikni, et al., 2008; Cantamessa, and Villa, 2000; Haque, et al., 2000; Hong, and Schniederjans, 2000; Kayis, et al., 2007; Li, et al., 2004; Ruffles, 2000; Thomke, and Fujimoto, 2000; Tucker, and Hackney, 2000;

Analysis of references: major topics used in this review report.
Source: Addo-Tenkorang (2011).

2.2.14 CE Implementation

Effective new/complex product development (PD) and support processes, which are concurrent, can enhance an organization's competitiveness by compressing product development lead-times, and enabling upstream and downstream processes to be considered when taking decisions at the product concept phase (Tennant and Roberts 2000). This approach is typically described as Concurrent Engineering (CE). Hence, CE in an organization signifies the ability of the organization to embrace product development as a series of overlapping stages, which provides customer satisfaction and also the right price by delivering products on time. This is effectively accomplished by employing numerous engineering tools and system techniques during the project management of design product development.

2.2.15 CE Uses / Values

Some of the most notable values and uses of concurrent engineering in recent times are to achieve excellence among other organizational objectives, including shorter new-product development times, more efficiency in development activities or system techniques and superior products with the estimated design period. On this note, industries have reorganized their new/complex product development (N/CPD) and support processes. They have moved subsequently from a sequential path, which means minimal communication among the concurrent teams / departments involved, and the subsequent activities required in developing a new product to one in which the product development teams / departments all collaborate from the beginning an integrated path known as concurrent engineering (CE). With this approach, the activities overlap and hence; all the departments involved collaborate from the beginning. This new organizational design approach has helped industries to improve their performance by leading to lower cost, higher quality, major knowledge creation and shorter product development times (Barba, 2001; Umemoto et al., 2004) all of which increases the organizational competitive abilities.

2.2.16 CE Extension/Trends and Perspective

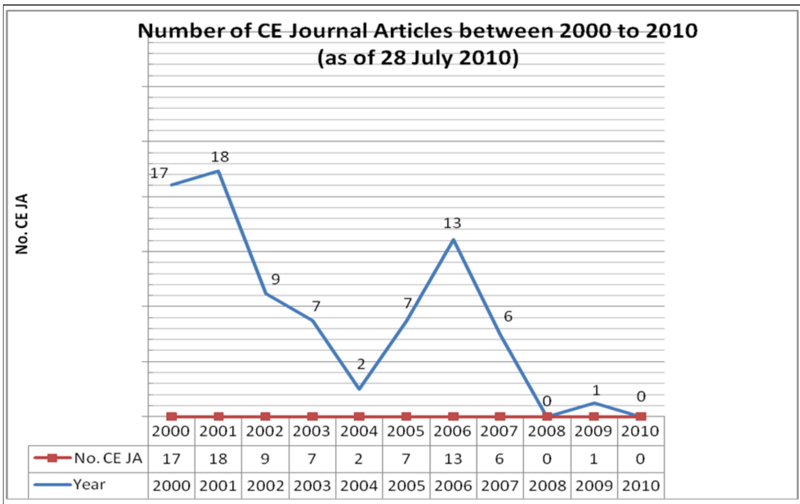
According to Rouibah and Caskey (2003), Information and communication technologies (ICT) have altered the balance of cost between activities within a firm and activities between firms. Easier co-operation allows companies to focus on their core strengths, while forming relations with other firms to supply the other needed skills to bring a product to market. Design, in one firm or in a consortium, is iterative and requires change. The ability of companies to better manage engineering changes during complex product development can decrease cost, shorten development time, and produce higher-quality products. Although organizational aspects of change management have received much attention, relatively little research has addressed engineering change support processes in manufacturing companies related to product development (Huang, et al. 2001).

Industrial manufacturing companies endeavour to create an advanced core system analytical solution integration process across their industrial manufacturing processes (Campbell and Mohun, 2007). This will therefore, enhance industrial efforts and processes by reducing lead-time variability and also reduce the transition times to achieve performance consistency. Stokic (2006) proposed a new information technology platform based on software collaborative services supporting different CE processes, which would be among the first of its kind to attempt to apply collaborative reference architecture to support CE in manufacturing industries. According to Valle and Va´zquez-Bustelo (2009), service-oriented architecture (SOA) seems to be a most suitable system application platform for the integration and collaboration of engineering product design and development. Thus, the extensive application of computer aided engineering (CAE) technologies is essential to enhancing the maximum engineering design efficiency and effectiveness (Gao, et al. 2000).

2.2.17 Analysis and Summary (CE)

The literature review findings indicate that concurrent engineering (CE) has seen a relatively drastic decline over a decade. Figure 16 below and the data table beside it, show the number of journal articles published from 2000, which has somehow seen some drastic fluctuation over time. The significant declines over these recent years are clearly plotted in Figure 16. Earlier journal articles in the field of CE started appearing in the late 1980s and early 1990s through to the

2000s and seemed to have attracted significant research interest from many industrial organizations as well as researchers in a short period of time between the 1990s and early 2000s. From Table 12 above and Table 13 below, CE implementation accounted for about 47.5% of the surveyed articles; articles on CE uses and/or values (i.e., the benefits) formed about 21.3% and finally CE extension/trends and perspectives formed 31.3% of the journal articles surveyed.



Year	# CE JA
2000	17
2001	18
2002	9
2003	7
2004	2
2005	7
2006	13
2007	6
2008	0
2009	1
2010	0
Total JA	**80**

Figure 16. Number of journal articles on CE between: 2000–2010 (as of 28 July 2010) - *(Harzing's Publish or Perish software search results [run on 28/07/2010] statistical chart & table.*

Source: Addo-Tenkorang (2011).

Table 13. Number of published articles for each topic

Topics	Number of Articles	% of No. Of JA Surveyed
Implementation	38	47.5%
CE Uses / Values	17	21.3%
Extension / Trends and perspectives	25	31.3%

A table of Number of Published Articles for each of the CE major topic areas
Source: Addo-Tenkorang (2011).

Also, from the data in Table 12 above, from which the statistical data analysis in Table 13 as deduced; a conclusion could be drawn from the number of journal articles published that topics such as CE Uses and/or Values (i.e. the sustainable benefits of CE) and CE Extension / Trends and Perspective areas. The analysis on these areas actually demonstrates lacking in CE implementation or application in industries as well as research and development. Therefore, as identified in the layout in Tables 12 and 13 above. Hence, the percentage analysis on CE Uses/Values (i.e., benefits) constitutes 21.3% while CE Extension/Trends and Perspective, constitutes 31.3%.

Therefore, from the above statistical analysis aspects there are two findings from the literature review of concurrent engineering (CE) "best practice" approach that are averagely under researched and developed. These areas according to the results are in the areas of CE Uses/Values – that is, the best way to get the most benefits and value from the CE "best practice" approach and also related to the former is CE Extension/Trends and Perspectives, which also reflect the same perspectives as the CE Uses/Values. Thus, equipping the CE "best practice" approach with the right and requisite enterprise resource planning information technologies (IT). To enhance the enterprise SCM enablers necessary to realize the "best practice" uses / values of CE and also to enhance the extension in the trends and perspective of CE "best practice;" as well as industrial activities for their competitive advantage.

The following section elaborates in detail on harnessing these requisite enterprise resource planning (IT) enablers, which could provide the necessary enabling environment for the proposed concurrent enterprise (CE+) approach to realize the industrial competitive advantage needed to enhance enterprise SCM network activities.

2.3 Enterprise Resource Planning (ERP)

This section of the review is also intended to serve three goals. First, it would be useful for researchers who are interested in understanding and following the recent trends within the area of ERP systems. Secondly, it would benefit both researchers and businesses or industries that seek to expand their scope of research and also the industrial R&D. And also benefit SCM network departments. The literature review under this section highlights the current unanswered but justified research and development (R&D) questions raised in research papers for research and/or development needs or persisting issues in SCM network systems efficiency. Finally, it discusses how to harness the requisite enterprise resource planning

IT enablers to enhance integrated complex product development – (concurrent engineering – CE) "best practice" approach. By promoting the requisite environment for a concurrent enterprise in order to effectively and efficiently, enhance enterprise SCM network activities for industrial competitive advantage. This review section attempts to summarize and identify key references to aid researchers and industrial R&D departments as well as their entire SCM network activities for new/complex product development teams/partners to find solutions for the research questions in this research thesis. This section relies on key journals and other key forums such as conferences and societies as well as some books in the field of ERP, in order to give a wider coverage of identified literature documents to enhance and subsequently support the validation of the findings in this research. Harzing's Publish or Perish software analytical tool was employed in summarizing this section into table forms. This section of the research literature review also seeks to assess the issues and trends, including future trends and perspectives of ERP Systems Life Cycle (SLC) approaches into six major topics and sub-topics of the systems interfacing / integration processes.

An ERP system enables an organization to integrate all the primary business processes in order to enhance efficiency and maintain a competitive position. However, without successful implementation of the system, the projected benefits of improved productivity and competitive advantage would not be forthcoming. In its basic definition, ERP is an enterprise-wide information system that integrates and controls all the business processes in the entire organization. The Enterprise Resource Planning (ERP) system is an enterprise information system designed to integrate and optimize the business processes and transactions in a corporation.

The ERP is an industry-driven concept and system, and is universally accepted by businesses and organizational industries as a practical solution to achieve integrated enterprise information systems solution. ERP systems have become vital strategic tools in today's competitive business environment. The ERP system facilitates the smooth flow of common functional information and practices across the entire organization. In addition, it improves the performance of the supply chain and reduces the cycle times. However, without top management support, having appropriate business plan and vision, business process re-engineering, effective project management, user involvement and education and/or training, organizations cannot embrace the full benefits of such complex systems and the risk of failure might be high.

The academic research community has been contributing to the field of ERP in various ways. A typical way of contributing to the field is by publishing archival journal papers for public benefit. The summary will also identify the most cited authors by using a sample statistical report from Harzing's Publish or Perish software. It will serve as a comprehensive bibliography of the articles published during the period stipulated below. The set of papers published in various journals between 2005 and 28th May, 2010, is simply enormous, comprising 210 articles. As a result, it is hard to provide a detailed review of all the articles. Instead, a collective summary for each topic is described, which includes 154 journal articles out of the 210. Direct references are deliberately avoided, but a complete list of references for each topic is provided. The reviewed articles are organized into topics, and some collective properties of the articles are described for each topic and sub-topics where needed.

Esteves and Pastor (2001) provide an annotated bibliography of the main journal and conference articles in Information Systems (IS) during the period 1997–2000. They include a brief summary sentence for each article along with a complete list of references. The total number of articles surveyed is 189. However, the number of journal articles among these is only 21, perhaps reflecting the early years of the field of ERP during that period. Botta-Genoulaz *et al.* (2005b) have also reviewed articles on ERP. They analysed the ERP literature during the period 2003–2004. In parallel to this report, Moon (2007) has also made a review article on ERP; reviewing a total of 313 articles from 79 journals. He also developed six categories and classified the articles under each category. The six categories that he adopted include implementation of ERP, optimization of ERP, management through ERP, the ERP software, ERP for supply-chain management and case studies.

Micchailidou, et al. (2008) has also undertaken a critical review of empirical literature on ERP systems business values, which investigates the impact of ERP systems adoption on various measures of organizational performance. They then critically reviewed in the same journal article the literature concerning the related topic of critical success factors (CSFs) in ERP systems implementation. This aimed at identifying and investigating factors that result in more successful ERP systems implementation, which generated higher levels of value for organizations. Research focuses on the identification and deeper understanding of 'internal' factors (related to the internal functions within the organization), which can increase the business value generated by MIS, such as a business process redesign, new human skills, innovations, 'soft management information systems (MIS) investment', etc. (Arvanitis, 2005; Loukis, et al. (2008). Finally, in the fourth period (from 2005 until today) researchers have started dealing with the effect of ‘external’ factors, which are related to the external environment within the organization, such as generalized competition, strategy, industry concentration, industry dynamism, etc. on MIS business value (Malville, et al. 2007; Loukis, et al. 2008).

A summary is provided as a reference to corresponding articles. One hundred and fifty four (154) articles in total were surveyed. However, more than eight of these are non-journal articles such as conference proceedings and societies publications. In contrast to the previous four review articles, this report surveys only the journal papers and covers half a decade and a more recent period (between 2005 and 28th May, 2010). No restrictions were imposed in the field of the journals, thus representing truly multi-disciplinary views on ERP. Therefore, this section is divided into the following main sub-sections: an introduction to the methodology employed in collecting and analysing the data, ERP trends and perspectives, ERP future trend and perspectives, service-oriented architecture (SOA), Web 2.0 / Software-as-a-service (SaaS), review of journal articles, analysis and summary of this section of the literature review.

2.3.1 Technique Utilized – ERP Journals Review

This section describes the method followed in collating and analysing the articles and journals throughout this report.

It is rather hard to confine the report on ERP into specific orders; the relevant material is spread out across various journals. The criteria for choosing journal articles for the review were as follows. First of all, the article must have been published in a peer-reviewed and/or archival journal. Secondly, to avoid never-ending revision of the report, 28th May, 2010 was selected as the cut-off date. Finally, only articles with ‘ERP’ as a part of their title contents were selected. The exceptions are those articles that are explicitly dealing with ‘ERP’ but for some reason, the researcher(s) decided not to use ‘ERP’ in the title. The inclusion of such articles is inevitably unplanned. Consequently, it is possible that there exist more such articles, which are not surveyed for this thesis review. No restrictions were imposed on the field of the surveyed journal.

This should allow a comprehensive set of perspectives on ERP by different fields. According to these criteria, a vigorous attempt has been made to collate all the available journal articles. The compilation effort was carried out through exhaustive computer search, database search, Internet search, reference checking, most cited authors using Harzing's Publish or Perish software, *etc.* However, it is always possible that some articles are missing from this list. Harzing's Publish or Perish software statistical results for the most cited authors within the field of ERP between 2005 and 2010 is found in Tables 14 - 17 below in descending order:

Table 14. Harzing's Publish or Perish Most Cited ERP Journal Articles and Authors*

Harzing's Publish or Perish - General Citation Search for "Enterprise Resource Planning" -&- "ERP" (2005-2010) Title words only.					
Cites	**Authors**	**Title**	**Year**	**Source**	**Publisher**
62	IC Ehie, M Madsen	Identifying critical issues in enterprise resource planning (ERP) implementation	2005	Computers in Industry	Elsevier
42	YB Moon	Enterprise resource planning (ERP): a review of the literature	2007	International Journal of Management and Enterprise	Inderscience
37	AYT Sun, A Yazdani, JD Overend	Achievement assessment for enterprise resource planning (ERP) system implementations based on critical success factors (CSFs)	2005	International Journal of Production …	Elsevier
25	F Robert Jacobs, FC Ted'Weston…	Enterprise resource planning (ERP)--A brief history	2007	Journal of Operations Management	Elsevier
25	ETK Lim, SL Pan, CW Tan	Managing user acceptance towards enterprise resource planning (ERP) systems-understanding the dissonance between user expectations and managerial policies	2005	European Journal of Information …	ingentaconnect.com
24	M Al-Mashari, M Zairi, K Okazawa	Enterprise resource planning (ERP) implementation: a useful road map	2006a	… of Management and Enterprise …	Inderscience
23	ETG Wang, C Chia-Lin Lin, JJ Jiang, G Klein	Improving enterprise resource planning (ERP) fit to organizational process through knowledge transfer	2007	International Journal of …	Elsevier
18	K Park, A Kusiak	Enterprise resource planning (ERP) operations support system for maintaining process integration	2005	International Journal of Production Research	informaworld.com
18	JH Park, HJ Suh, HD Yang	Perceived absorptive capacity of individual users in performance of enterprise resource planning (ERP) usage: the case for Korean firms	2007	Information & Management	Elsevier
17	C Marnewick, L Labuschagne	A conceptual model for enterprise resource planning (ERP)	2005	Information Management &	emeraldinsight.com
15	WH Tsai, SW Chien, PY Hsu, JD Leu	Identification of critical failure factors in the implementation of enterprise resource planning (ERP) system in Taiwan's industries	2005	… of Management and Enterprise …	Inderscience

13	JR Muscatello, DH Parente	Enterprise Resource Planning(ERP): A Post-implementation Cross-Case Analysis	2006	… Resources Management Journal	infosci-journals.com
12	V Lall, S Teyarachakul	Enterprise resource planning (ERP) system selection: A data envelopment analysis (DEA) approach	2006	Journal of …	ASSOCIATION FOR COMPUTER
12	M Quiescenti, M Bruccoleri, U La …	Business process-oriented design of enterprise resource planning (ERP) systems for small and medium enterprises	2006	International Journal …	informa-world.com
11	MC Kocakulah, JS Embry, M Albin	Enterprise Resource Planning (ERP): managing the paradigm shift for success	2006	International Journal of …	Inderscience
10	JR Muscatello, IJ Chen	Enterprise resource Planning (ERP) Implementations	2008	International Journal of Enterprise …	zonecours.hec.ca
10	M Vlachopoulou, V Manthou	Enterprise Resource Planning (ERP) in a construction company	2006	International Journal of Business …	Inderscience
9	RE McGaughey, A Gunasekaran	Enterprise Resource Planning(ERP): Past, Present and Future	2007	… Journal of Enterprise …	infosci-journals.com
9	P Ifinedo, N Nahar	Do top-and mid-level managers view Enterprise Resource Planning (ERP) systems success measures differently?	2006	Journal of Management and Enterprise	Inderscience
9	C Ozen, N Basoglu	Impact of man-machine interaction factors on enterprise resource planning (ERP) software design	2006	Technology Management for the Global Future, 2006.	

**Harzing's Publish or Perish Most Cited Authors (Accessed on 28/05/2010, Revised on 07/07/2010).*The Harzing's Publish or Perish software used for general citation search for "Enterprise Resource Planning" in All of the words field and "ERP" in Any of the words field and then Title words only box ticked.*

Source: Addo-Tenkorang and Helo (2011)

Table 15. Harzing's Publish or Perish Most Cited ERP Journal Articles and Authors*

Harzing's Publish or Perish - General Citation Search for "Enterprise Resource Planning" (2005-2010) Title words only.					
Cites	**Authors**	**Title**	**Year**	**Source**	**Publisher**
190	VA Mabert, A Soni, MA Venkata-ramanan	Enterprise resource planning survey of US manufacturing firms	2010	Время	elibrary.ru
90	M Sumner	Enterprise resource planning	2007		books.google.com
69	N Dechow, J Mouritsen	Enterprise resource planning systems, management control and the quest for integration	2005	Accounting, Organizations and Society	Elsevier
62	IC Ehie, M Madsen	Identifying critical issues in enterprise resource planning (ERP) implementation	2005	Computers in Industry	Elsevier
58	FFH Nah, S Delgado	Critical success factors for enterprise resource planning implementation and upgrade	2006	Journal of Computer Information …	areadocenti.eco.unicas.it
44	K Kurbel	Produktionsplanung und-steuerung im Enterprise Resource Planning und Supply Chain Management	2005		books.google.com
42	YB Moon	Enterprise resource planning (ERP): a review of the literature	2007	International Journal of Management and Enterprise	Inderscience
42	R McAdam, A Galloway	Enterprise resource planning and organisational innovation: a management perspective	2005	Industrial Management & Data …	emeral-al-dinsight.com
40	EF Monk, BJ Wagner	Concepts in enterprise resource planning	2008		books.google.com
37	AYT Sun, A Yazdani, JD Overend	Achievement assessment for enterprise resource planning (ERP) system implementations based on critical success factors (CSFs)	2005	International Journal of Production …	Elsevier
36	M Gupta, A Kohli	Enterprise resource planning systems and its implications for operations function	2006	Technovation	Elsevier
30	B Wier, J Hunton, HR HassabElnaby	Enterprise resource planning systems and non-financial performance incentives: The joint impact on corporate performance	2007	International Journal of Accounting …	Elsevier
25	F Robert Jacobs, FC Ted'Weston…	Enterprise resource planning (ERP)--A brief history	2007	Journal of Operations Management	Elsevier
25	Y Yusuf, A Gunasekaran, C Wu	Implementation of enterprise resource planning in China	2006	Technovation	Elsevier
25	ETK Lim, SL Pan, CW Tan	Managing user acceptance towards enterprise resource planning (ERP) systems-understanding the dissonance between user expectations and managerial policies	2005	European Journal of Information …	ingentaconnect.com
24	N Basoglu, T Daim, O Kerimoglu	Organizational adoption of enterprise resource planning systems: A conceptual framework	2007	The Journal of High Technology …	Elsevier

24	M Al-Mashari, M Zairi, K Okazawa	Enterprise resource planning (ERP) implementation: a useful road map	2006a	… of Management and Enterprise …	Inderscience
23	ETG Wang, C Chia-Lin Lin, JJ Jiang, G Klein	Improving enterprise resource planning (ERP) fit to organizational process through knowledge transfer	2007	International Journal of …	Elsevier
22	CS Chapman	Not because they are new: Developing the contribution of enterprise resource planning systems to management control research	2005	Accounting, Organizations and Society	Elsevier
21	S Dowlatshahi	Strategic success factors in enterprise resource-planning design and implementation: a case-study approach	2005	International Journal of Production Research	informaworld.com
21	A Rom, C Rohde	Enterprise resource planning systems, strategic enterprise management systems and management accounting	2006	Management	emeraldinsight.com

**Harzing's Publish or Perish Most Cited Authors (Accessed on 28/05/2010, Revised on 07/07/2010).*The Harzing's Publish or Perish software used for general citation search for "Enterprise Resource Planning" in All of the words field and then Title words only box ticked.*

Source: Addo-Tenkorang and Helo (2011)

Table 16. Harzing's Publish or Perish Most Cited ERP Journal Articles and Authors*

Harzing's Publish or Perish - General Citation Search for "ERP" (2005-2010) Title words only.					
Cites	**Authors**	**Title**	**Year**	**Source**	**Publisher**
127	CC Wei, CF Chien, MJJ Wang	An AHP-based approach to ERP system selection	2005	International Journal of Production …	Elsevier
120	TF Gattiker	What Happens After ERP Implementation: Understanding The Impact Of Inter	2005	MIS Quarterly	csz.csu.edu.tw
97	KB Hendricks, VR Singhal, JK Stratman	The impact of enterprise systems on corporate performance: A study of ERP, SCM, and CRM system implementations	2007	Journal of Operations …	Elsevier
96	V Botta-Genoulaz, PA Millet, B Grabot	A survey on the recent research literature on ERP systems	2005b	Computers in Industry	Elsevier
95	O Hauk, MH Davis, M Ford, F Pulvermüller, WD …	The time course of visual word recognition as revealed by linear regression analysis of ERP data	2006	Neuroimage	Elsevier
94	C Brown…	Managing the next wave of enterprise systems: leveraging lessons from ERP	2010	MIS Quarterly Executive	espace.library.uq.edu.au
91	Z Zhang, MKO Lee, P Huang, L Zhang, X …	A framework of ERP systems implementation success in China: An empirical study	2005	International Journal of …	Elsevier
73	G Buonanno, P Faverio, F Pigni, A Ravarini, D	Factors affecting ERP system adoption	2005	…	emeraldinsight.com
67	CW Holsapple, MP Sena	ERP plans and decision-support benefits	2005	Decision Support Systems	Elsevier
62	IC Ehie, M Madsen	Identifying critical issues in enterprise resource planning (ERP) implementation	2005	Computers in Industry	Elsevier
62	P Kelle, A Akbulut	The role of ERP tools in supply chain information sharing, cooperation, and cost optimization	2005	International Journal of Production Economics	Elsevier
62	MC Jones, M Cline, S Ryan	Exploring knowledge sharing in ERP implementation: an organizational culture framework	2006	Decision Support Systems	Elsevier
61	Y Kim, Z Lee, S Gosain	Impediments to successful ERP implementation process	2005	Business Process Management …	emeraldinsight.com
61	Y Xue, H Liang, WR Boulton, CA Snyder	ERP implementation failures in China: case studies with implications for ERP vendors	2005a	International Journal of …	Elsevier
57	VB Gargeya, C Brady	Success and failure factors of adopting SAP in ERP system implementation	2005	Business Process Management …	emeraldinsight.com
56	C Møller	ERP II: a conceptual framework for next-generation enterprise systems?	2005	Management	emeraldinsight.com
55	D Chand, G Hachey, J Hunton, V Owhoso, S …	A balanced scorecard based framework for assessing the strategic impacts of ERP systems	2005	Computers in …	Elsevier
53	J Benders, R Batenburg, H van der Blonk	Sticking to standards; technical and other isomorphic pressures in deploying ERP-systems	2006	Information & Management	Elsevier
49	HM Beheshti	What managers should know about ERP/ERP II	2006	Management Research News	emeraldinsight.com
47	M Zviran, N Pliskin, R Levin	Measuring user satisfaction and perceived usefulness in the ERP context	2005	Journal of Computer Information …	万方数据资源系统

**Harzing's Publish or Perish Most Cited Authors (Accessed on 28/05/2010, Revised on 07/07/2010).*The Harzing's Publish or Perish software used for general citation search for "E R P" in All of the words field and then Title words only box ticked.*

Source: Addo-Tenkorang and Helo (2011)

Table 17. Harzing's Publish or Perish Most Cited ERP Journal Articles and Authors*

Harzing's Publish or Perish - General Citation Search for "ERP" (All Time Classics) Title words only.					
Cites	**Authors**	**Title**	**Year**	**Source**	**Publisher**
701	P Bingi, MK Sharma, JK Godla	Critical issues affecting an ERP implementation	1999	Information systems …	informa-world.com
603	HV Sem-litsch, P Anderer, P Schuster, O …	A solution for reliable and valid reduction of ocular artifacts, applied to the P300 ERP	1986	…	intersci-sci-ence.wiley.com
511	C Soh, SS Kien, J Tay-Yap	Enterprise resource planning: cultural fits and misfits: is ERP a universal solution?	2000	Communications of the ACM	portal.acm.org
509	CR Holland, B Light	A critical success factors model for ERP implementation	1999	IEEE software	
438	KK Hong, YG Kim	The critical success factors for ERP implementation: an organi-zational fit perspective	2002	Information & Manage-ment	Elsevier
382	K Kumar, J Van Hille-gersberg	ERP experiences and evolution	2000	Communications of the …	en.scientificcommons.org
277	JW Ross, MR Vitale	The ERP revolution: surviving vs. thriving	2000	Information Systems Frontiers	Springer
263	H Ak-kermans, K van Helden	Vicious and virtuous cycles in ERP implementation: a case study of interrelations between critical success factors	2002	European Journal of Information …	ingentacon-nect.com
254	H Klaus, M Rosemann, GG Gable	What is ERP?	2000	Information Systems Frontiers	Springer
248	AW Scheer, F Habermann	Enterprise resource planning: making ERP a success	2000	Communications of the ACM	portal.acm.org
248	ML Markus, C Tanis, PC Van Fenema	Enterprise resource planning: multisite ERP implementations	2000	Communications of the ACM	portal.acm.org
244	Y Van Everdingen, J Van Hille-gersberg, E …	Enterprise resource planning: ERP adoption by European midsize companies	2000	Communications of the …	portal.acm.org
241	M Sumner	Risk factors in enterprise-wide/ERP projects	2000	Journal of Information Technology	informa-world.com
225	A Parr, G Shanks	A model of ERP project imple-mentation	2000	Journal of Information Technology	informa-world.com
211	LP Willcocks, R Sykes	Enterprise resource planning: the role of the CIO and it function in ERP	2000	Communications of the ACM	portal.acm.org
209	K Amoako-Gyampah, AF Salam	An extension of the technology acceptance model in an ERP implementation environment	2004	Information & Manage-ment	Elsevier
191	AM Alad-wani	Change management strategies for successful ERP implementa-tion	2001	Journal, Vol	emer-aldinsight.com
187	J Lee, K Siau, S Hong	Enterprise Integration with ERP and EAI	2003	Communications of the ACM	portal.acm.org

185	HA Akkermans, P Bogerd, E Yücesan, LN Van …	The impact of ERP on supply chain management: Exploratory findings from a European Delphi study	2003	European Journal of …	Elsevier
180	IJ Chen	Planning for ERP systems: analysis and future trend	2001	Journal, Vol	emeraldinsight.com
180	TM Somers, KG Nelson	A taxonomy of players and activities across the ERP project life cycle	2004	Information & Management	Elsevier
178	S Sarker, AS Lee	Using a case study to test the role of three key social enablers in ERP implementation	2003	Information & Management	Elsevier
160	Z Lee, J Lee	An ERP implementation case study from a knowledge transfer perspective	2000	Journal of Information Technology	informaworld.com
160	CA Ptak, E Schragenheim	ERP: tools, techniques, and applications for integrating the supply chain	2004		books.google.com
158	MG Woldorff	Distortion of ERP averages due to overlap from temporally adjacent ERPs: Analysis and correction	1993	Psychophysiology	woldorfflab.ccn.duke.edu
151	S Shang, PB Seddon	A comprehensive framework for classifying the benefits of ERP systems	2000	Americas Conference on Information …	aisel.aisnet.org
145	G Norris, JD Balls, KM Hartley	E-business and ERP: Transforming the Enterprise	2000		portal.acm.org
143	SP Laughlin	An ERP game plan	1999	Journal of Business Strategy	csa.com
143	P Rajagopal	An innovation--diffusion view of implementation of enterprise resource planning (ERP) systems and development of a research model* 1	2002	Information & Management	Elsevier
142	V Kumar, B Maheshwari, U Kumar	An investigation of critical management issues in ERP implementation: emperical evidence from Canadian organizations	2003	Technovation	zwep.net
140	J Motwani, D Mirchandani, M Madan, A …	Successful implementation of ERP projects: evidence from two case studies	2002	International Journal of …	Elsevier
131	N Welti	Successful SAP R/3 implementation: Practical management of ERP projects	1999		portal.acm.org
127	L Brehm, A Heinzl, ML Markus	Tailoring ERP systems: a spectrum of choices and their implications	2001	PROCEEDINGS OF THE ANNUAL …	Citeseer
127	CC Wei, CF Chien, MJJ Wang	An AHP-based approach to ERP system selection	2005	International Journal of Production …	Elsevier
124	W Skok, M Legge	Evaluating enterprise resource planning (ERP) systems using an interpretive approach	2001	Proceedings of the 2001 ACM SIGCPR …	portal.acm.org
124	AN Parr, G Shanks	A taxonomy of ERP implementation approaches	2000	Proceedings of the 33rd Annual Hawaii International …	
122	C Koch, D Slater, E Baatz	The ABCs of ERP	1999	CIO magazine	teaching.fec.anu.edu.au
120	TF Gattiker	What Happens After Erp Implementation: Understanding The Impact Of Inter	2005	MIS Quarterly	csz.csu.edu.tw

120	C Brown, I Vessey	ERP implementation approaches: toward a contingency framework	1999	… of the 20th international conference on …	portal.acm.org
119	A Teltumbde	A framework for evaluating ERP projects	2000	International Journal of Production Research	informaworld.com
118	J Esteves, J Pastor	Towards the unification of critical success factors for ERP implementations	2000	10th Annual BIT conference	
117	M Al-Mashari	Enterprise resource planning (ERP) systems: a research agenda	2003	Industrial Management and Data Systems	emeraldinsight.com
116	C Rolland, N Prakash	Bridging the gap between organisational needs and ERP functionality	2000	Requirements Engineering	Springer
111	M Kremers, H Van Dissel	Enterprise resource planning: ERP system migrations	2000	Communications of the ACM	portal.acm.org
108	DC Hayes, JE Hunton, JL Reck	Market reaction to ERP implementation announcements	2001	Journal of Information Systems	link.aip.org
107	Z Huang, P Palvia	ERP implementation issues in advanced and developing countries	2001	Journal, Vol	emeraldinsight.com
107	O Hanseth, CU Ciborra, K Braa	The control devolution: ERP and the side effects of globalization	2001	ACM SIGMIS Database	portal.acm.org
103	E Bernroider, S Koch	ERP selection process in midsize and large organizations	2001	Journal, Vol	emeraldinsight.com
100	KE Murphy, SJ Simon	Intangible benefits valuation in ERP projects	2002	Information Systems Journal	interscience.wiley.com
100	S Buckhout, E Frey, J Nemec	Making ERP succeed: turning fear into promise	1999	IEEE Engineering Managemant …	万方数据资源系统

**Harzing's Publish or Perish Most Cited Authors (Accessed on 28/05/2010, Revised on 07/07/2010).*The Harzing's Publish or Perish software used for general citation search for "E R P" in All of the words field and then Title words only box ticked. The Table 1d is an "All Time Classics" table, thus, it falls out of the criteria period (2005-2010) for this review report. The reporter intentionally included this citation table 1d, to show that some other Journal Articles are heavily cited which not fall with the scope of this review report.*

Source: Addo-Tenkorang and Helo (2011)

2.3.2 ERP Trends and Perspectives

Journal articles, which belong to this subject mostly, provide introductions to ERP definitions and issues of ERP, common ERP misinformation on business and industrial organizational issues, different perspectives of ERP, survey studies on industry experiences, recent trends in ERP and surveys of the ERP literature. The introductory articles provide enlightening guidelines for managers and beginning researchers in the field of ERPs. The emphasis seems to be on the close relation with Business Process Reengineering (BPR) and a wide range of organizational change issues accompanying ERP implementation. Some articles attempt to clarify the basic meanings surrounding ERP to provide reflections on many years of practices.

A number of survey studies are reported from the findings of current industry's experience with ERP. These survey studies can complement the general introductory journal articles supported by actual data. A number of articles also provide different perspectives on ERP, for example, perspectives from managers, users and/or vendors. Several articles present various types of models for ERP. They range from a conceptual model that explains the ERP system, to taxonomy of success factors of ERP implementation, to a model of ERP governance, and to a user acceptance model. Others try to challenge commonly held views or misconceptions on ERP by asking questions such as 'What are the significant values of an ERP system?' 'What is good about ERP best business practices?' etc.

A common observation on the future trends in ERP is its further expansion in scope. New integration technology such as software modularization, Enterprise Application Integration (EAI), Service-Oriented Architecture (SOA) systems applications, (Web 2.0) web service is introduced and their implications discussed. A couple of articles attempt to provide a sense of direction in the ERP research community by analysing the ERP literature. They identify the gaps between the industry and academia and also within academic research, thus pointing out potential future trends in terms of further expansion (i.e. ERP II). A few articles provide similar information, but on a specific segment. Examples of these segments include public organizations, educational organizations, healthcare organizations, the fashion industry, the manufacturing industry and the service industry. These articles are interesting since they have some common attributes across different segments as well as some unique features of a particular organizational segment analysed.

2.3.3 Future Trends and Perspectives

Organizations are under constant pressure from customers, shareholders, and suppliers to continuously improve and make better products quickly and efficiently. Competing in a dynamic environment and meeting global challenges requires agility. Successful companies must be able to respond quickly and cost-effectively to change. The change could be of any type; shift in customer demands and supply-chain partners, modifications to a business model or business process, business expansion and the need for new initiatives like outsourcing, and regulatory pressures imposed by financial markets, industrial groups, and government bodies. Organizations need to convert their industries into responsive, demand-driven, profit-making enterprises by optimizing their operations. Their competitive advantage and ultimate survival depend on the use of extended information systems applications and/or technology (e.g. ERP II, SOA, WEB 2.0 or Software-as-a-Service – SaaS, etc.). According to Johansson (2009), this has led to an increasing interest among vendors in improving future ERP-systems to support the end-customer organization even better. Below is a brief introduction of each of the above listed extended information systems applications and/or technology.

2.3.4 ERP II

ERP II systems are not just the backbone of the enterprise. They are also the information link for an enterprise in the supply chain. This is because the business of tomorrow is going to play multiple roles in multiple supply chains, from traditional sources to electronic marketplaces. The challenge for ERP II is two-fold. First, it is to aggregate and manage the data surrounding all the transactions of an enterprise as accurately as possible in real-time. Then, it is also to open up the system to make that information available to trading partners in the supply-chain. Zrimsek (2003) identified six key differences between ERP and ERP II systems (*please Table 18 below*), but he did not expect to see a fully realized ERP II system deployed before 2005.

Table 18. Six key differences between ERP and ERP II systems

Role	Traditional ERP was concerned with optimizing an enterprise. Internal optimization, however, it will only take you so far. ERP II systems are about optimizing the supply chain through collaboration with trading partners.
Domain	ERP systems focused on manufacturing and distribution. ERP II systems will cross all sectors and segments of business, including service industries, government, and asset-based industries like mining.
Function	As ERP systems cross sectors and segments, they will no longer be able to present all things to all people. Zrimsek expects ERP II vendors to pick the industries in which they are going to play, and focus on providing deep functionality for those users.
Process	In ERP systems, the processes were focused on the four walls of the enterprise. ERP II systems will connect with trading partners, wherever they might be, to take those processes beyond the boundaries of the enterprise.
Architecture	Old ERP systems were monolithic and closed. ERP II systems will be Web-based, open to integrate and inter-operate with other systems, and built around modules or components that allow users to choose just the functionality they need.
Data	Information in ERP systems is generated and consumed within the enterprise. In ERP II systems, that same information will be available across the supply chain to authorized participants.

Six key differences between ERP and ERP II systems (Zrimsek, 2003)

2.3.5 Service Oriented Architecture (SOA)

One of the main market trends is the technology transformation is Service Oriented Architecture (SOA), which will have the largest effect on redefining the ERP market. As indicated by analysts, SOA will transform software from an inhibitor to an enabler of business change by 2015 (Zrimsek, 2003). SOA will shift revenue from packaged software to subscription services and from monolithic suites to composite applications.

SOA is an approach to designing, implementing, and deploying information systems such that the system is created from components implementing discrete business functions. These components, called 'services', can be distributed across geography, and can be reconfigured into new business processes as needed. The services are 'loosely coupled' allowing for more flexibility than older technologies with respect to re-using and re-combining them to create new business functions both within and across an organization.

The business component architecture forms the foundation of its specialized versions: service-oriented and event-driven architectures. SOA reduces complexity, eliminates in point-to-point integrations and introduces flexibility through process-driven applications. This provides agility to meet the ever-changing needs of the plant, business unit enterprises, and the supply-chain. It provides a controlled and secure environment to meet the requirements of regulatory issues. Most vendors today are in the process of transforming their technology architecture into SOA.

2.3.6 Web 2.0 / Software as a Service (SaaS)

Software-as-a-service (SaaS), in short, is software delivered as a hosted application from a vendor or distributor whom the end-customer can access via a browser. The SaaS-model enables the end-customer organization to decrease the cost of implementation, maintenance and the overall administration of the application. Furthermore, it is independent of existing IT-infrastructure, scalable and flexible (Guptil & McNee, 2008). In that sense, the end-customer organization can focus on its core business without worrying about technicalities that will be handled by the distributor / vendors. There are examples of successful SaaS-vendors (e.g. Salesforce.com), but when it comes to ERP-systems delivered as Software-as-a-Service, there is not yet a solution that has had a commercial breakthrough. However, as already stated the SaaS-model is a key strategic area for SAP AG and most likely also for other ERP-system vendors.

The SaaS-model is, therefore, of much interest when researching in the future of ERP systems; however, there seems to have been little academic research published within this area yet. When looking at the SaaS-model it seems to challenge the distributor's business in the ERP-system value-chain, since the vendor can deliver solutions directly to the end-customer and thereby bypass the distributor. Therefore, this future delivery model might change the current ERP-systems value-chain. This might not completely undermine the business for distributors, as the future ERP-system value-chain could very well include hybrid SaaS-solutions, where the distributors offer customized SaaS-solutions to the end customer. However, if the SaaS-model becomes successful, it could very well threaten the distributor's position. It could be seen as a further enhancement of the 'best practice' approach that undermines the competitive advantage of the distributors. In that sense, the SaaS-model can be seen as a solution that favours the 'best practice' approach.

Furthermore, it is still being argued, if the SaaS-model can have influence on an ERP-system, whether it is perceived as a competitive advance or not within the end-customer organizations, since the IT delivered can hardly be called a scarce resource. Thus, this has only been a short introduction to ERP-systems delivered as SaaS. Hence, it clearly presented as an area that could be interesting for further research (Ellis - IDC Manufacturing Insights, 2010; Epicor White Paper 2011Addo-Tenkorang, et al., 2012). It could be interesting to examine how ERP-systems delivering SaaS meet the Business IT needs of organizations, including the small and mid-sized; and what the implications are for the ERP system value-chain if the paradigm shifts from perpetual licences to SaaS offerings. Both the resource-based perspective as well as the perspective of core competencies could offer interesting approaches when looking at the future of ERP-systems and the value-chain.

2.3.7 Review of the Journal Articles

This section outlines a brief aggregate summary of the journal articles used throughout this review section is provided in the Tables 19 - 21 below. It is not intended to provide a detailed description of each article and references to major topics and sub topics used throughout this review section. But, an attempt to draw a collective summary is documented in this section.

Table 19. Number of articles in each journal (all in alphabetical order)

Journals	Number of ERP Journal Articles
Accounting, Organization and Society --	1
AMR Research Inc.--	1
Business Process Management Journal--	10
Computers in Human Behaviour ---	2
Computers in Industry --	14
Decision Support Systems --	5
Electronic Markets---	1
Electronic Government, an International Journal ---	1
Enterprise Information Management--	1
Enterprise Information Systems ---	1
European Journal of Information Systems--	7
Financial Executive ---	1
Gartner Research --	1
IEEE Computer Society --	3
IEEE Transactions of Engineering Management --	1

IEEE Xplore --	6
IFIP AICT---	1
Industrial Management & Data Systems --	10
Information Technology and People--	1
Information and Management---	3
Information Management & Computer Security ---	5
Information Systems Management---	2
International Journal of Enterprise Information Systems--	2
International Journal of Information Management --	1
International Journal of Management and Enterprise Development ---------------------------	11
International Journal of Operations and Production Management -----------------------------	2
International Journal of Production Economics --	14
International Journal of Production Research --	2
International Journal of Quality and Reliability Management ----------------------------------	1
International Journal of Services and Standards ---	2
Internet and Enterprise Management---	1
Journal of Computer Information Systems ---	2
Journal of Enterprise Information---	1
Journal of Enterprise Information Management ---	14
Journal of High Technology Management Research---	2
Journal of Information Systems ---	1
Journal of Management and Enterprise Development ---	1
Journal of Management Information Systems ---	1
Journal of Manufacturing Technology Management --	2
Journal of Operations and Management --	1
Journal of Strategic Information Systems --	4
Journal of Theoretical and Applied Information Technology ----------------------------------	1
Managerial Auditing Journal---	1
Management Research News --	2
Management Science --	1
MIS Quarterly --	1
MIT Sloan Management Review --	1
PICMET Proceedings ---	1
Technovation --	3
Total	**154**

Analysis of Journal articles used in this review report.

Source: Addo-Tenkorang and Helo (2011).

Table 20. Conference and Society Proceeding Articles

Conferences and Society's Proceeding Articles			
Main Event	**Topic**	**Coordinators**	**Year**
European and Mediterranean Conference on Information Systems	Critical Success Factors in ERP Implementation: A Review	Al-Fawaz, K., et., al.,	2008
IEEE Computer Society, Panhellenic Conference on Informatics	ERP System Business Value: A Critical Review of Empirical Literature	Fontini, M., et. at.	2008
AMR Research Inc.	The ERP Market Size Report 2006-2011	Jacobson, S., et., al.,	2007
Financial Executives	SaaS sets the stage for Clouding Computing	Guptil, B., and McNee, W.S	2008
PICMET Proceedings	Key factors Driving the Success of Technology Adaptation: Case Example of ERP Adaptation	Suebsin, C., and Gerdsri. N.	2009
IEEE Computer Society. The International Conference on Risk Management & Engineering Management	Application of Fuzzy Comprehensive Evaluation Model Based on Variable Fuzzy Set Method in Construction Enterprises'' ERP Project Risk Evaluation	Yunna, W., and Zhijun H.,	2008
US Symposium/Itxpo, 23-27, Gartner Research (25C, SPG5) San Diago	ERP II Vision	Zrimsek, B.	2003/5
ASBBS Annual Conference Proceedings, Las Vegas. Vol 17, No.1	ERP and Success Factors	Snyder, R., and Hamdan, B.,	2010

Conferences and Society's Proceeding Articles Used in this Review Report.
Source: Addo-Tenkorang and Helo (2011)

The six major topics and sub-topics within the domain of ERP in this report are

1) Implementation
   - case study,
   - critical success factors,
   - change management,
   - focused stage,
   - cultural issues.
2) ERP Exploration,
   - change management,
   - decision support,
   - focused function,
   - maintenance.

3) Extension,
4) Value,
5) Trends,
6) Education

Table 21 below is a comprehensive table containing the topics, and their various contextual references under each topic listed above. There is no particular sequence among the references listed in the table. It is unavoidable to have an article that is relevant to more than one topic. For example, an article may address implementation issues but provide general information or trends in ERP. In such a case, the more significant topic is chosen to classify the article according to the researcher's judgement. Listing an article under more than one sub-topic was hereby allowed.

Table 21. Topics and references

Topic	References
Implementation	
General	Soffer et al., 2005; Trimi et al., 2005; Zafiropoulos et al., 2005; Buonanno et al., 2005; Metaxiotis et al., 2005; Light, 2005; Kim et al., 2005; Worley et al., 2005; Gosain et al., 2005; Wei et al., 2005b; Nandhakumar et al., 2005; Ward et al., 2005; Cadili and Whitley, 2005; Al-Mashari et al., 2006a; Bubak et al., 2006; Amoako-Gyampah, K., 2007; Basoglu, N., et., al., 2007; Beheshti, H.M., 2006; Bender, J., et., al., 2006; Bendoly and Schoenherr, 2005;Bendoly, E., et. al., 2006; Biehl and Stehn, 2005; Botta-Genoulaz and Millet, 2005b; Burn and Ash, 2005; Chakraborty and Sharma, 2007; Chand, D., et., al., 2005; Chou, D.C., et., al., 2005; Dechow and Mouritsen, 2005; Elbertsen and Van Reekum, 2008; Fontini, M., et. al., 2008; Gattiker and Goodhue, 2005; Gulledge, T.R., 2006; Helo, P., 2008; Jacobson, S., et. al., 2007; Jocobson, and Sudzina, 2008b; Johansson, B., 2007; Loarne, S.L., 2005; Moon, Y.B., 2007; Newman, and Westrup, 2005; Pairat, and Jungthirapanich, 2005; Rettig, C., 2007; Robert Jacobs, and Ted Weston, 2007; Se' verine, L.L., 2005; Suebsin and Gerdsri, 2009; Vathanophas, V., 2007; Wei, H-L., et. al., 2005a; Yu, C-S., 2005; Zhang, Z., et. al., 2005; Riehle, (2007);
Case study	Gulledge and Simon, 2005; Baki, B., et. al. 2005; Brown and He, 2007; Berchet and Habchi, 2005; Tchokogue et al., 2005; Haigang, and Wanling, 2008; Huang, S-M, et. al., 2008; Jaiswal, and Kaushik, 2005; Lee, and Moon, 2006; Lui, and Chan, 2008; Stefanou, and Revanoglou, 2006; Weider, B., et. al., 2006; Xue, Y., 2005a; Yang, C-C., et. al., 2006; Yusuf, Y., et. al., 2006; Zhang, Z., Lee, M.K.O., et. al., 2005; Yeh et al., 2010;
Critical success factors	Sun et al., 2005; Motwani et al., 2005; Ehie and Madsen, 2005; Dowlatshahi, 2005; Gargeya and Brady, 2005; Al-Fawaz, K., et al. 2008; Al-Mashari et al., 2006b; Law and Ngaia, 2007; Dawson and Owens, 2008; Dezdar and Sulaiman, 2009; Finney, and Corbett, 2007; Ifinedo and Nahar, 2006; Motwani, J., et. al., 2005; Kamal, M.M., 2006; Kamhawi, E.M., 2007; Ngai, E.W.T., 2008; Soja, P., 2006; Plant, and Willcocks, 2007; King, and Burgess, 2006; Verville, J., et. at., 2005; Snyder, R., and Hamdan, B., 2010; Tsai, W-H., et al., 2005a;
Change management	McAdam and Galloway, 2005; Ettlie et al., 2005; Loarne, 2005; Boersma and Kingma, 2005b; Benders et al., 2006; Jacobson, and Newman, 2009; Kelle, and Akbulut, 2005; Kerimoglu, O.,et. al., 2008; Lim, E.T.K., et. al., 2005; Tsia, Chien, Fan, and Cheng, 2005b; Xue, Y., et al., 2005b;
Focused stage	Wei et al., 2005a; Baki and Cakar, 2005; Verville et al., 2005; Huang S.Y., et. al., 2009; Hwang, Y., 2005; Ehie, and Madsen, 2005; Kakouris, and Polchronopoulos, 2005; Karimi, J., et. al., 2007; Wei, C-C., et. al., 2005a;
Cultural issues	Boersma and Kingma,2005a; Xue et al., 2005a; Wang et al., 2005; Zhang et al., 2005; Tsai et al., 2005; Baki and Cakar, 2005; Bendoly et al., 2006; Joneset al., 2006; Yusuf et al., 2006; Jones, M.C., et. al., 2006; Kayas, O.G., et. al., 2008; Ke, W., and Wei, K.K., 2008;
ERP Exploration / Uses	
General	Botta-Genoulaz and Millet, 2005a; Park and Kusiak, 2005; Martin and Cheung, 2005; Yu, 2005; Koh and Simpson, 2005; Voordijk et al., 2005; Brown and Nasuti, 2005; Brazel, 2005; El Sayed, 2006; Koh and Saad, 2006; Botta-Genoulaz and Millet, 2006; Chang, M.K., et. al., 2008; Elbertsen, L., et. al., 2006; Gefen, and Ragosky, 2005; Johansson, and Sudzina, 2009a; Koh, and Simpson, 2005; Law, and Ngai, 2007; Light, B., 2005; Moon, and Phatak, 2005; Shi, and Lu, 2009; Singla, A.R., 2008; Worley, J.H., et. al., 2005; Johansson, and Sudzina, 2009b;
Decision support systems	Holsapple and Sena, 2005; Guptil and McNee, 2008; Lea, B-R., et. al., 2005; Sabherwal, R., et. al., 2006; Wu, and Wang, 2006; Yunna, and Zhijun., 2008;
Focused function	Gupta and Kohli, 2006; Rom and Rohde, 2006; Raymond, L., et. al., 2006; Spath-is, C., 2006; Spathis, and Ananias, 2005; Wang, and Chen, 2006; Wang, and Chen, 2005; Ward, and Hemingway, 2005; Yeh, C-T., et. al., 2006; Zafiropoulos, I., et. al., 2005;
Maintenance	Ekstedt, M., et. al., 2009; Haigang, and Wanling, 2008; Imtihan, R. M., et. al., 2008; Park, and Kusiak, 2005;
Extension	Chou et al., 2005; Burn and Ash, 2005; Moon and Phatak, 2005; Moller, 2005; Bendoly and Schoenherr, 2005; Lea et al., 2005; Jaiswal and Kaushik, 2005; Kelle and Akbulut, 2005; Biehl, 2005; Burca et al., 2005; Sammon and Adam, 2005;

	Sharma et al., 2006; Koh, S.C.L., et. al., 2008; Sherif, and Irani, 2005; Sonnichsen, K., and Gotze, J., 2009;
Value	Zrimsek, B., 2003/5; Spathis and Ananiadis, 2005; Chand et al., 2005; Tsai et al., 2006; Wieder et al., 2006; Wu and Wang, 2006; Spathis, 2006; Allen, J.P., 2005; Zviran, M., et. al., 2005;
Trends and Perspectives	
General	Marnewick and Labuschagne, 2005; Gulledge et al., 2005; Botta-Genoulaz et al., 2005; Newman and Westrup, 2005; Sharif et al., 2005; Hwang, 2005; Lim et al., 2005; Allen, 2005; Volkoff et al., 2005; Lee et. al., 2006; Yeh et al., 2006; Gulledge, T.R., 2006; Wang and Chen, 2006; Beheshti, H.M., 2006; Bjorn-Aderson, 2009; Burca, and Fynes, 2005; Voordijk, H., et. al., 2005;
In a particular sector	Bergstrom and Stehn, 2005; Stefanou and Revanoglou, 2006; Botta-Genoulaz and Millet, 2006; Yang et al., 2006; El Sayed, H., 2006; Peslak, 2005;
Education	Beheshti, 2006; Woo, 2007; Al-Fawaz et al., 2008; Dumbrava, S., 2006;

Analysis of references: major and sub-topics used in this review report.
Source: Addo-Tenkorang and Helo (2011).

2.3.8 Implementation

Implementing ERP systems can potentially allow a company to manage its business best with potential benefits of improved process flow, best data analysis, higher-quality data for decision making, reduced inventories, improved coordination throughout the supply-chain, and better customer service (Gattiker and Goodhue, 2005; Yeh, et al., 2010). An ERP system is a major project requiring a significant level of resources, commitment and changes throughout the organization. Often the ERP implementation project is the single biggest project that an organization has ever launched. As a result, the issues surrounding the implementation process have been one of the major concerns in industry. The concern worsens because of numerous failed cases, including a few fatal disasters, which led to the demise of some companies. Reflecting such a level of importance, the largest number of articles belongs to this topic. It comprises more than 54% of all the reviewed articles.

Many of these articles share implementation experiences from various companies. Some articles attempt to explain why the ERP implementation is difficult and what needs to be done to achieve desirable results. Furthermore, various models of implementation stages and different implementation methodologies are documented. Other topics handled under this subject include comparison between a single system approach and a best of breed system approach, comparison of implementation practices between developing countries and developed countries, issues of hosted ERP systems, data quality issues, and project management issues not forgetting evaluation and validation issues among others. A group of articles are classified under a sub-topic of 'Case Study'**;** these articles typically investigate the ERP implementation experiences at one or several companies and provide real data and observations.

Unlike other articles which also use case studies, here extraction of general knowledge is more emphasized. Furthermore, the articles belonging to this sub-topic tend to focus on individual cases. Some generalizations are occasionally provided in these articles. One of the popular topics in the ERP implementation is to identify or develop 'Critical Success Factors – (CSF)'. According to Amoako-Gyampah (2007), the product life cycle has become very short and technology is changing more rapidly; hence, new success factors may be arising. Likewise, while the CSF for implementation of ERP systems has been discussed and analysed, there have been many inconsistent and inconclusive findings on this topic (Law and Ngai, 2007).

Dawson and Owens (2008) argue that there are many differences in the CSFs researchers have defined. The idea is that some important factors determining the success or failure of an ERP implementation and could be learnt from prior implementation experiences. Some articles focus on generating a list of the critical success factors, and others conduct data analysis regarding those factors. Implementing an ERP system inevitably involves a large portion of the organization and it is often is accompanied by major business process reengineering efforts. Therefore, change management becomes a critical topic in ERP implementation. Some articles address change management by explaining why it is important in the ERP implementation, how to do it effectively, the lessons discovered, and the change management strategies.

ERP implementation has a life cycle beginning with a company's decision adopt it to the final live stage and then subsequently selecting an ERP package. The articles belonging to a sub-topic of 'Focused Stage' each address a particular stage of the ERP implementation life cycle. This stages, covered the ERP system selection process, the customization of the ERP system, the configuration within the ERP system, the determination of a hosting service, *etc.* Finally; a group of articles are also interested in any differences between cultural and/or national views in implementing ERP systems. Comparative studies are conducted, and analyses are provided in terms of differences and similarities. Explanations for such findings have also been attempted.

2.3.9 ERP Exploration/Uses

Upon an organization's successful implementation of the ERP system, the attention moves forward to the most efficient use of the system. Especially since considerable resources have been invested in the ERP implementation, the best possible utilization of the system is anticipated. Indeed, the value of an ERP system is derived from its effective and efficient usage more than from the system itself as the process of moving from functional applications to an ERP system is difficult as well as challenging (Kroenke, 2008). Moreover, the decision to use an ERP system is expensive, and it requires development of new procedures, actions, training and education in conveying or converting data (Zhang, *et al.*, 2005).

Thus, this greatly depends on greater cooperation with senior-level management, a clearer and more defined business plan and/or vision, effective project management priorities, teamwork, appropriate ERP software system selection, user involvement and efficient education/training. The articles under this topic tackle various aspects of using the ERP system during the post-implementation era, ranging from end user acceptance, to end user satisfaction, from business process reengineering after ERP implementation to uncertainty management and to particular functions such as designing return material process and handling Sarbanes-Oxley requirements in finance and accounting.

Additional issues addressed by the articles include version upgrade/migration, managing dirty data, ERP usage by consulting firms, and the political role of ERP systems. These form about 20.5% of the total number of journal articles reviewed in this section of the thesis. Most organizations focus on the operational capability of the ERP system. Some other articles particularly address the decision support functions within the ERP system (i.e. employing intelligent agents), and these are classified under a sub-topic – 'Decision Support Systems' mainly instrumental for forecasting and planning of organizational and industrial operations. The articles accentuating the efficient exploration of ERP systems in a particular function are grouped under a sub-topic – 'Specific Function'. Examples of these specific functions are manufacturing, marketing, accounting, production, strategic/project management, operations, and data archiving.

2.3.10 Extension

The companies, that implemented ERP systems and are relatively satisfied with their operations, are now considering the extension of the functionalities provided by the original ERP systems (i.e. ERP II). Articles on this topic form about 18% of the total number of journal articles surveyed. This shows that businesses and organizations have now started to look for something beyond what ERP can offer. Some companies implement ERP systems even though their ultimate objectives lie in further extended systems. Others implement ERP systems with some plans to extend later.

The articles belonging to this topic deal with the issues of extending ERP systems (ERP II) toward e-business, supply-chain management (SCM), customer relationship management, supplier relationship management, business intelligence, manufacturing execution systems, *etc.,* with some sort of extended software systems such as ERP II mentioned above, Service-oriented architecture (SOA), Software as a Service (SaaS) or Web 2.0 system application. Some articles attempt to understand the direction of the industries regarding these ERP extensions. A few explain enabling technologies of further ERP extensions and integrations; these technologies are as close to virtual enterprise as businesses and industries today have ever seen (e.g., enterprise supply-chain management [e-SCM]). Some simply reports research how to expand the existing functionalities of the ERP system. As most ERP vendors have now developed a broader definition of Enterprise Integration, these articles may well provide a good picture of the trends.

2.3.11 Value

There is no doubt about how valuable information systems implementation and operation are to both the private and public businesses and industries. In this age of globalization, the more sophisticated the supply-chain management system, the higher the need for system tools for businesses and industries to efficiently and effectively manage their activities and to enable them to strategies their operations to survive in today's global village. According to Helo (2008), an information system is considered a fundamental tool for a competitive organization and/or industry.

One of the sought after and/or mentioned information systems in research, businesses and in industries is the Enterprise Resource Planning (ERP) system. It is estimated that in the past decade about $500 billion was invested in the ERP systems worldwide (Gefen and Ragowsky, 2005). In view of the investment and collective efforts required to implement and run ERP systems, which are very significant to any organization, the fundamental question about the ERP system's value has been a key issue. Because of the high investment that is required, the decision to purchase and implement an ERP system is one of the most important decisions business and industrial leaders have to make (Behesti, 2006).

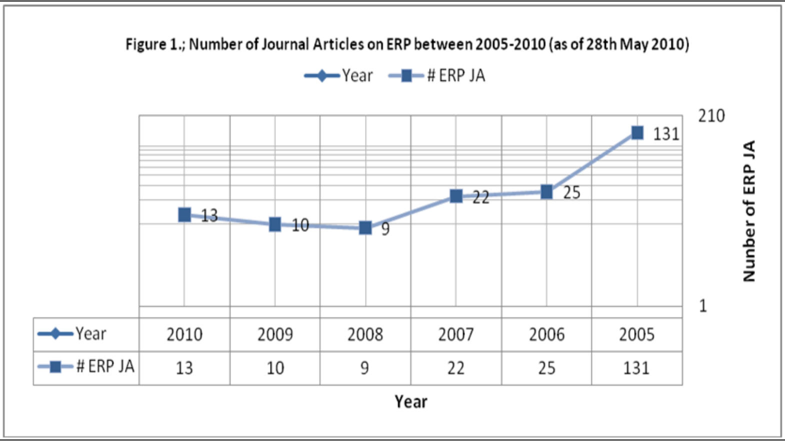
The articles on this topic mainly address these fundamental questions: Is an ERP system of any value in an organization? What are the values an ERP system will bring to in an organization? How do we assess the value of an ERP system? These articles tend to investigate these issues in a more systematic and rigorous fashion backed with some statistical evidence, beyond simply detailing the commonly believed benefits. The values that ERP systems may create are enormous and versatile: operational benefits, financial benefits, benefits for investors, user satisfaction, *etc.* Sometimes, the value may be evaluated by observing market reactions to the mere pronouncement of the ERP project. The value assessment methods can be numerous and sophisticated. For example, the benefits may be evaluated by cost savings, return on investment, asset turnover, return on assets, perceptions by the market forecasts or trends, *etc.* Some articles address relationships between different dimensions while others focus on longitudinal study of the ERP system's impact on company performance. As more companies have implemented ERP systems and more is known about the implementation processes, the questions on the value of ERP systems seem to be investigated more often and rigorously. This is an indication that the practices and understanding of the field have matured enough to warrant some serious reflections on its essential issues. Accounting for about 3.33% of the total number of journal articles surveyed, this made it seem to be an area with potential for more future research.

2.3.12 Education/Training

Educating and training users to use ERP is important because ERP is not easy to use, even with good IT skills (Woo 2007). Beheshti (2006) cited lack of availability of adequate skills as one reason for failure. According to Al-Fawaz et al. (2008) user involvement in terms of education and training is one of the most cited critical success factors in ERP implementation projects. It is quite obvious from above that training and educating users of the ERP system is essential because it improves perceived control through participating in the entire project plan. Due to the importance of user involvement in the initial stages of ERP systems definition in the implementation stages of ERP systems, training and education of the system users cannot be over-emphasized at any stage. However, surprisingly, this topic forms only about 2.4% of the total number of journal articles surveyed, thus making this topic another key potential area for future research.

2.3.13 *Analysis and Summary (ERP)*

The field of ERP according to the literature review in this research report; has matured in a relatively short period. Figure 17 and the side data table below show that the number of journal articles published from 2005 has steadily increased. However, there is a sign of stabilizing and significant declining over recent years as again clearly shown in Figure 17 below. Therefore, considering the fact that most of the earlier journal articles on the topic area started appearing in the late 1990s, this field certainly has gained significant research interests from many researchers as well as the industries in a short period. Confirming the analysis above on the various topics, of the articles surveyed, ERP Implementation formed more than 54%. Journal articles surveyed on ERP Exploration/Uses (i.e., sustainable ERP benefits to enterprise industries) formed 20.5%. ERP Extension and Future Trends formed more than 18%. ERP Values formed about 3.33% *(again this has to do with sustainable ERP benefits to enterprise industries)* and finally, Education/ Training on ERP formed about 2.4% *(please see Table 22 below)*.



Year	# ERP JA
2005	131
2006	25
2007	22
2008	9
2009	10
2010	13
Total JA	210

Figure 17. Number of journal articles on ERP between: 2005–2010 (as of 28 May 2010) - *(Harzing's Publish or Perish software search results [run on 28/0502010] statistical chart & table.*

Source: Addo-Tenkorang and Helo (2011).

Table 22. Number of published articles for each topic

Topics	Number of Articles	Percentage Analysis
Implementation	**115**	**54.76%**
General	46	21.90%
Case study	16	7.61%
Critical success factors	21	10%
Change management	11	5.24
Focused stage in the implementation process	9	4.29%
Cultural (national) issues	12	5.71%
ERP Exploration/Uses	**43**	**20.48%**
General	22	10.48%
Decision support	7	3.33%
Specific function in ERP	10	4.76%
Maintenance	4	1.90%
Extension	**16**	**7.61%**
Value	**7**	**3.33%**
Trends and perspectives	**22**	**10.48%**
General	17	8.10%
In a particular sector	5	2.38%
Education/Training	**5**	**2.38%**

A table of Number of Published Articles for each of the Six ERP major topic and sub-topics.
Source: Addo-Tenkorang and Helo (2011)

Therefore, from the data in Table 21 above, from which the statistical data analysis in Table 22 is deduced, a conclusive analysis could be drawn that ERP Trends and perspectives – (in some specific industrial sectors). These includes ERP in SMEs and ERP in developing countries. There, as per the analysis in this extensive literature review, the areas lacking as gaps for further research are on ERP value or benefits, which includes enterprise SCM networked value systems. Therefore, value-chain for enterprise SC network activities for a sustainable competitive edge for enterprise manufacturing SCM industries is the focus of this research to expand on. Furthermore, ERP Education and Training is another area lacking research and industrial focus *(please see Table 22 above)*. Research on ERP Values and Uses *(i.e., sustainable ERP benefits to enterprise industries)* also comes up as another ERP area lacking adequate research and development *(please see Tables 21 and 22 above)*.

From the data analysis and findings as outlined in Tables 21 and 22 above, percentage analysis shows that ERP Trends and perspectives – in a particular sector constitutes 2.3%, as does ERP Education and Training, while ERP Values and/or Uses constitutes about 3.33%. These are the three least researched and underdeveloped areas according to the findings in this review section. Therefore, they require further research and development. Hence, this could awaken the industrial interest in these areas in order to benefit fully from the collaborative advantage of concurrent engineering principles and enterprise resource planning systems as enablers for a value-adding Concurrent Enterprise approach in order to benefit from a collaborative sustainable competitive advantage.

2.4 Concurrent Enterprise (CE+) – Manufacturing SCM Network Activities

The concurrency in enterprise manufacturing supply-chain management (SCM) network activity for competitiveness is a specific point of view for organizational performance, where competitiveness means to be more efficient and effective in organizational multidisciplinary teams' operational strategies, information technology enablers and communication network than competitors (Pallot and Sandoval, 1998). Concurrency, in this sense also implies a tactical approach to being more creative and innovative *(making the best and most effective use of information technology – IT enablers)* in a faster and cheaper way. The term Concurrent Enterprise is a combination bringing the concepts of Concurrent Engineering to the Extended Enterprise *(with enterprise resource planning systems – IT enablers)* (Thoben and Weber, 1997; Sorli, et al. 2006). Therefore, Concurrent Enterprise in this research's perspective is a distributed, "best practice" alliance of multidisciplinary SCM network teams. Hence, co-operating original equipment manufacturer(s) (OEM), customers and suppliers employ systematic enterprise-systems approaches, methods and advanced information technologies in order to increase efficiency in their complex engineering-design and delivery manufacturing processes for new/complex product-development. By means of a concurrent approach for integrating team work, etc. In order to achieve a strategic sustainable competitive advantage for their enterprise SCM network operations on the global markets.

2.4.1 *Summary of Literature Review Findings and the Concurrent Enterprise Approach Link*

Table 13 *at page 50 above* and Table 22 *at page 78 above*, illustrates the findings and research gaps identified from the broad literature review. These findings from the literature review on Concurrent Engineering and Enterprise Resource Planning journals and articles from the year 2000 – 2010, turns to informing the need for industrial manufacturing CE+ SCM network concept. Therefore, in order for industrial SC to enhance their operational activities strategically towards a CE+ approach, the gaps identified in the literature review and the need for extensions requires consideration. Hence, it will be prudent for the OEMs to address the shortcomings, which would hinder them from achieving their expected sustainable competitive advantage. The core literature review findings above in Tables 13 *at page 50*, shows inadequate CE uses / values forming 21.3% of the surveyed journals and articles. However, there seem to be an interest in CE extension / trends and perspective thus, forming about 31.3%. This then indicates that, the classical CE principles are not attractive to industries anymore, but instead they rather would prefer implementing an extended CE principle enhanced with the right enterprise systems IT enablers (Kayis, et al., 2007; Maier, et al., 2008; Martin and Cheung, 2005).

Similar to the CE literature review, the exploration / uses of ERP systems, although were quite impressive per the findings in the literature review, its comprehension by the individuals or teams who use those systems turns not to be as impressive. Thus, their understanding and/or use of the ERP systems or the best possible way for them to maximize its exploration seems to be lacking (Maier, et. al., 2008; Sosa, et al., 2002; Stokic, 2006; Moller, 2005). Hence, resulting in the very low percentage of ERP systems education / training forming 2.38%. This implies that, to employ a team approach “best practice” principle like CE, it will be prudent that, the right enterprise IT enablers are also employed in collaboration to complement its’ need. Therefore, harnessing the collaborative competitive advantage of CE for complex / new product-development and the essential ERP systems IT enablers enhances the Concurrent Enterprise synergy needed. Hence, allowing industrial manufacturers to achieve an effective and efficient sustainable competitive advantage in their enterprise SCM network activities (Murman and Walton, 2000; Musa, et al., 2013; Ketchen Jr, et al., 2007a; 2007b; Plex White Paper, 2013; Punik and Cruz-Cunha, 2013).

According to Pallot and Sandoval (1998) Concurrent Enterprise refers to an organization SCM network. Thus, building up different enterprise business models, which are accessible through a network so that they integrate, and interface to register for business collaboration in specific stakeholder domains *(Upstream – Suppliers; intermediate – stream – Manufacture(s); Downstream – Customer / Third Party Logistics Company – 3PLC)*. Therefore, Concurrent Enterprise is not only another Internet solution issue but also a business issue in linking enterprise experts and capacities to provide new business opportunities. Hence, relating that to the business integrator strategy for industrial organizations, and real-time access to the global market. Thus, it is a way of linking enterprise SCM network stakeholders' expertise to strategically operate concurrently in order to better serve their customer demands. Therefore, it intends to systematically, establish networked value-systems' dynamic interactions for improving global efficiency during all complex engineering-design and delivery project phases *(e.g., bid preparation, marketing, design, manufacturing, assembly, test, support, service.)* (Pallot and Sandoval, 1998).

Although some enterprises' SCM network concurrency and visibility aspects have been researched and published (Musa, et al. 2013; Bechini et al. 2005; 2008), they are mainly on either just the upstream (supplier) aspect or the intermediate-stream aspect (manufacturing). Very few have attempted to link the entire SC network activities in a complete value-chain and network management approach. Therefore, this research report seeks to propose a feasible conceptual framework for a Concurrent Enterprise SCM networked value-system as a viable and validated option for the still pertinent and persisting enterprise SCM network challenges *(please see Figures 21, 25, 49, 50, 55, 56, and 58 at pages 101, 106, 142, 149, 153, 155, and 166 respectively below)*.

Some of the existing enterprise manufacturing systems in use in industrial organizations as hinted include: Agile manufacturing systems that have to do with enhancing the intermediate-stream – manufacturer aspects. Furthermore, manufacturing Production Control systems, which have different entity aspects for either the upstream – supplier aspect or the intermediate – manufacture aspect and/or lastly, downstream – customer aspects (Gunasekaran, 1998; Vollmann, et al. 2005: pp. 97-104; Plex Systems, 2013a; 2012). Therefore, implementing the Concurrent Enterprise tactical framework approach implies supporting enterprise SCM network stakeholders' interactions by defining and using a common infrastructure platform/portal. This further gives a strong reality to virtual enterprise that does not physically exist and/or is unusual (*e.g.,* back-end programming codes) (Musa, et al., 2013; Plex Systems, 2013a; 2012; Martinez, et al., 2001; Esposito, and Evanglista, 2014; Putnik, and Cruz-Cunha, 2013).

Putnik and Cruz-Cunba (2013) argue further that, virtual enterprise taxonomy or in the case of this research, Concurrent Enterprise currently does not exist, and this lack is reflected in the ambiguous way that some concepts are addressed, leading to a fragment understanding that hinders the development of the science of enterprise systems' effective and efficient integration and management. Hence, it is clear that such concurrent enterprise systems are imminent and needed both in present and future enterprise manufacturing supply-chain management networks to adequately enhance their competitive advantage. Furthermore, this lack of strategic concurrent enterprise systems approaches for complex / new-product development, there have been a rise in their interest for both academic and industrial research and development departments (Esposito and Evangelista, 2014). Hence, they further state that, there are still two main gaps, which needs to be address: that is, conceptualisation of concurrent enterprise models and real industrial cases empirical research investigations in this area (Esposito and Evangelista, 2014; Bottani, 2010). Therefore, it has become strategically necessary that industrial enterprise SCM networks intensively adapt the strategic use of enterprise IT enablers. This is to enable them to canvass for the right, adequate and real-time information in order to exploit innovation and collaborative relationship between their enterprise SCM network partners in a more efficient and effective approach (Iandoli et al. 2012).

2.4.2 Concurrent Enterprise Conceptualisation and Empirical Research(s) Initiated – Aerospace SCM Sector

It is of no coincidence that current research and development in the aerospace sector has just started looking to empirically research further into this concurrent enterprise systems approach. They intend to develop a conceptual framework in this approach by employing product-family design and manufacturing enterprise SCM network approach. Their approach is by employing Set-Based Design and Set-Based Concurrent Engineering (SBCE). Set-Based Concurrent Engineering (SBCE) process is a strategic and convergent complex product-development process guided by consistent technical leadership throughout (Al-Ashaab, et al. 2013). Therefore, SBCE enables the focus on the value-chain within the industrial design requirement and manufacturing outfit.

However, the mode of the SBCE research design is slightly different from the approach adopted in this research report. They adopted a Set-Based Concurrent

Engineering (SBCE) Enterprise Framework approach, because, aircraft complex product development either employs pre-define product sets or a set of complex product designs for their early complex product development and support processes on their enterprise manufacturing SCM networks (Al-Ashaab, et al. 2013). In order to successfully address the current enterprise manufacturing SCM network challenges facing the Aerospace industry, a need to develop a true multi-disciplinary Set-Based Design (SBD) capability that could deploy new technologies on novel configurations more quickly and with greater confidence was acknowledged (Al-Ashaab, et al. 2013).

According to A-Ashaab, et al. (2013), their research is about presenting the initial step towards the development of the set-based design (SBD) / SBCE capabilities by first eliciting the industrial requirements of the SBD / SBCE processes for the aerospace industry. Their approach thus, falls in line with the assumptions and initial conclusions made in this research report and confirmed by the work of Esposito and Evangelista (2014). They stated that, there are two approaches to address the research and development interest in concurrent enterprise systems. These are, by conceptualising and then empirically investigating the with real-life industrial cases (Esposito and Evangelista, 2014).

The following chapter, sections and sub-sections present the various methods employed and triangulated for the data collection and data analysis in this research in order to find feasible solutions to the research questions outlined in section 1.2, sub-section *1.2.1 at page 15 above*. The next chapter also attempts to throw more light on aligning the research cases with detailed research case constructs and modes of data analysis, pragmatically and objectively.

3 RESEARCH METHODOLOGY

3.1 Methods Employed for Research Data Collection

Three different methods were used for the purpose of data collection in this research. However, the main method employed was industrial pilot case studies: Closed-end questionnaires and literature review / archival records were also employed to collect the extra data required for this research. Because some of the required empirical data could not be fully collected during the industrial pilot case studies. The research methods were selected based on the information required to achieve the research objectives. The various methods employed for the data collection in this research are elaborated further in this section. Meanwhile, this section provides an overview of the methods employed. Figure 18 below illustrates the data collection modes linked with the research objectives.

Figure 18. Adopted Data Collection Modes Linked with Research Objectives

The research carried out as part of this study may be divided into two main phases with other attributes to these phases *(see the research mind map - Figure 10 at page 12 above)*. The first phase was an exploratory, explanatory, descriptive and correlational phase (Theoretical Part) where the initial three objectives were addressed and validated by scientific simulations and hypothesis testing. This was followed by the development – also descriptive and explanatory phase (Empirical Part) in which the industrial pilot case studies were conducted as well as the quest to capture relevant data that the case studies could not capture: As a result, a model and systems enterprise platform / portal was developed thus addressing the final research objective. Preliminary analysis was conducted while applying each of the data collection methods and researcher comments were also captured and blended into this research report. The main qualitative attribute of the empirical part of analysis is the series of industrial case studies conducted for data collection. Quantitative analysis was also conducted using data extracted from the literature review and closed-end questionnaires disseminated by the e-forms method. This quantitative data was collated for the Ship Power design engineering-systems' teams considered on this research's case company enterprise SCM network division.

3.1.1 Industrial Pilot Case Study Data Collection Method

The main method of data collection in this research report was industrial-based pilot case studies conducted in series with a Ship Power engine OEM's enterprise SCM network division for large-scale engineering-design and delivery. Case study is an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident (Yin, 2009). According to Yin (2009) it is preferable to employ case studies when "how" and/or "why" research questions are posed and when the focus is on a contemporary phenomenon within a real-life context (Yin, 2012). Employing a case study as a means of conducting applied research may be considered among the most challenging social science research endeavours because of the need to combine and balance between research development – in phases, participation, influence, description and evaluation. Early theoretical positioning / grounding or development depending on the research approach is essential in case study research, whether the purpose of the case study is to be grounded / position the research in a grounded theory or develop / test a theory. According to Yin, (2009) positioning / grounding one's research in a theory also provides a sufficient blueprint for the research study, which requires theoretical assumptions that assist in guiding case study data collection.

Therefore, the case study cases in this research perspective were not intended to be sampling units as assumed with some statistical generalization, but should be considered to be a series of experiment(s) / practical industrial-based pilot projects within and across the large-scale complex engineering design and delivery processes of a complex product manufacturing SCM network. The additional or support research methods that were employed for data collection and validating this research include extensive literature review by: document analysis and reviewing academic journals, databases as well as archive records *(please see Figure 18 at page 84 above)*.

3.1.2 Closed-end Questionnaire Data Collection Method

Research questionnaires are said to be of two types: open-ended (i.e., “open questions” – where the researcher does not provide the respondent with a set of answers from which to choose) and closed-ended (i.e., “closed questions” – where the researcher provides a suitable list of responses (e.g., Yes, No, or Maybe) (Robson, 2011; Mellenbergh, and Adèr, 2008). Questionnaires are the most commonly used tool in survey research. However, the findings and results of a particular survey are worthless if the questionnaire is written inadequately without taking the respondents into consideration. Questionnaires should produce valid and reliable demographic variable measures and should produce valid and reliable individual differences that self-report scales generate (Shaughnessy, et al., 2011; Robson, 2011). Questionnaires have advantages over some other types of surveys in that they are cheap, do not require such a strenuous effort as verbal or telephone surveys, and often have standardized answers that make it simple to compile data. However, questionnaires are also somewhat limited, in some sense, by the fact that respondents must be able to read the questions and respond to them effectively. The questionnaire used in this research was designed and structured into five parts: Part 1: Company’s Design Team Rep. Background Information; Part 2: Frequent Concurrent Design Teams’ Communication Interface. Part 3: Importance of Concurrent Communication within Enterprise Industrial Manufacturers’ Design Teams’; Part 4: Effective and Efficient Design Teams Relational Concurrent Communication; and finally, Part 5: Teams’ Concurrent Communication Interfaces Review & Redesign, *(please see Appendix B at page 219 for a sample of the research questionnaire)*. These methods will be reflected in further detail throughout the subsequent chapters.

3.2 Methods Employed for Research Data Analysis

This section presents detailed information on the type of research scientific and/or simulation tools employed for data analysis in this research. The following paragraphs elaborate more on these research scientific and/or simulation tools in detail.

Spreadsheets and IBM SPSS 20.0 as well as UCINET 6 and DSM were used to support data analysis where possible, primarily to visualize data in the form of tables, graphs / graphics, matrices and charts. Reports were produced throughout the research pilot case study project phases, providing analysis of data at the end of each research phase. The three components of data analysis according to Miles and Huberman's research include data reduction, data display, and conclusion drawing and verification (Miles and Huberman, 1994). Furthermore, Williman (2005) suggests that, the suitable methods to display data are in the form of (matrices, graphs, charts and networks); these enhance reduction in data and its analysis. Data and findings collected were analysed by synthesizing.

This synthesis took place by using a statistical approach, design structural matrix – DSM and domain mapping matrix DMM to analyse and interpret the findings from the empirical pilot case study data. Furthermore, social network theory (SNT) analysis software (UCINET 6) and statistical analysis using Pearson's correlation [r] were employed to analyses collected questionnaire data, which could not be captured during the industrial pilot case study. This provided the grounds for assessing how the implementation of collaborative concurrent enterprise could be measured using industrial pilot project case studies and other methods mentioned above in a triangulation approach for more viable and feasible findings and results. The tools mentioned tools above (DSM, DMM, and SNT and well as Pearson's statistical correlation [r] and hypothesis testing) are elaborated furtheron in this research report.

This section is divided into three sub-sections elaborating on the three main methods adopted in this research. Sub-section *3.2.1* elaborates on the design structure matrix (DSM) approach; Sub-section *3.2.2* elaborates on the UCINet 6 social network theory (SNT) analysis approach and finally, Sub-section *3.2.3* elaborates on the statistical correlation analysis and hypothesis testing.

3.2.1 Design Structure Matrix (DSM)

The design structure matrix (DSM) method is an information-exchange simulation tool that allows the representation of complex tasks / teams / relationships in order to determine a sensible sequence / grouping for the tasks / teams being modelled (Yassine, 2004; Browning, 2001). DSM is one of the research approaches adopted in this research to enable the researcher to analyse the complexity and efficient flow of voluminous data / information within the SC network. Thus, the findings and results from the DSM simulation analysis enabled and also guided the researcher to propose an optimum configuration and feasible master database-management systems' structure comprising well configured, sequenced, banded and optimally partitioned meta database-management systems. These proposed structures are assumed to be secure, because they will be configured and programmed in such a way that the various partners / teams on the SC network have their own unique username and password. In order to access the system to enable the signed-in partner to receive, retrieve and also exchange real-time SC network information / data which are specifically needed for their activities only, on the enterprise SCM network.

Figure 19, below, illustrates the three basic types of relationship between product - system elements (A) and (B); the first type is a "parallel" relationship, where elements do not depend on each other, thus, they may be processed separately. The second type is "sequential" where element (B) is dependent on the input fed from element (A). The last relationship type known as "coupled," refers to a set where elements depend on each other. A change in system element (B) would have an effect back on (A). Thus, this cyclic dependency could also be referred to as "circuits."

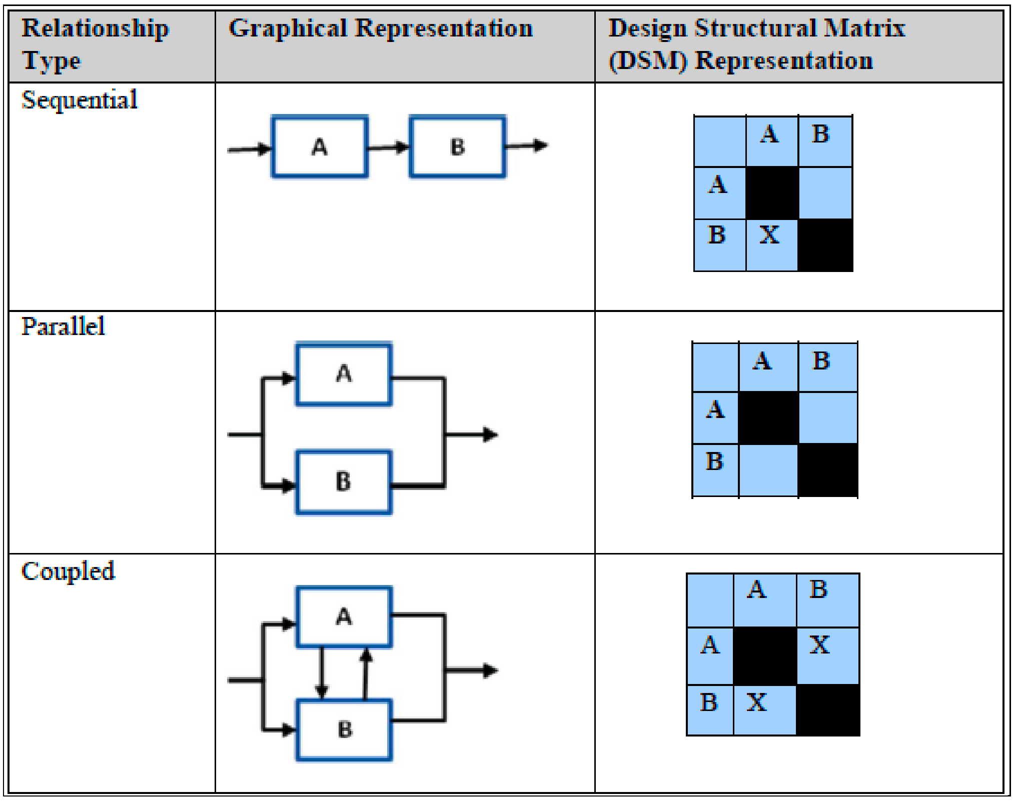


Figure 19. Representations of the three DSM System Configuration Characteristic.

Further to the DSM, approach elaborated above and the detailed explanation of the three DSM system configurations illustrated in Figure 19: Figure 20 below, based on Browning (2001) elaborates further, that DSM elements are represented by the shaded side along the diagonal. Thus, an off-diagonal mark signifies a dependency of one element on another. Therefore, reading across a row reveals what other elements, an element in that row provides to: Furthermore, looking down a column reveals what other elements an element in that column depends on. Thus, reading down a column reveals input sources, while reading across a row indicates output drops. Therefore, in Figure 20 below, element, *(B)* provides something to elements, *(A)*, *(C)*, *(D)*, *(F)*, *(H)*, and *(I)*, and it depends on something from elements *(C)*, *(D)*, *(F)*, and *(H)*, *(as presented by this research in Figure 25 at page 106 below)*.

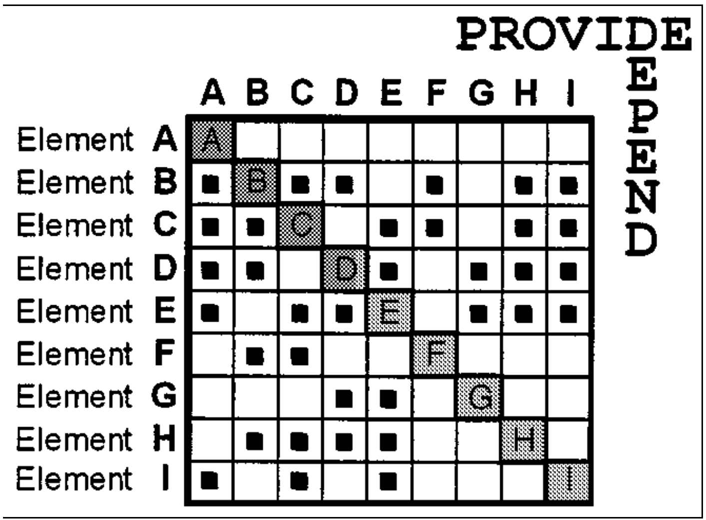


Figure 20. Example of DSM

Source: Browning, (2001)

According to Browning (2001), there are two main types of DSMs: static and time-based. Browning, also stated that with the static DSMs, system elements exist concurrently; such as components of product architecture or groups in an SC network. Static DSMs are usually effectively analysed with grouping or clustering algorithms or models. In time-based DSMs, the ordering of the rows and columns indicates a flow through time: upstream activities within a process precede downstream activities, and terms like "feed forward" and "feedback" become meaningful when referring to interfaces *(please see this research's results in Figure 23 at page 104: Banded DSM Information / data relationship representation)*. Time-based DSMs are typically analysed using sequencing algorithms or model, *(please see this research's results in – Table 24 at page 105 below, Information Single Run Data & Analysis and Figure 24 at page 105 below, – DSM Information / data Sequence and Levels representation details)*.

Therefore, employing the DSM approach in both the two main types explained by Browning is very essential and instrumental in this research's findings and results: Finally, the Partitioned DSM Information Sequence and Levels Relationship meta-data structures illustrated in Figure 25 *at page 106 below*, presents a proposed optimized meta-database management-system. The structure contained in the main proposed enterprise Master Data-Management System of the various partners on the enterprise SC network. Thus, this system represents the core of the proposed Concurrent Enterprise conceptual framework presented in this dissertation. These results, effectively, constitute a feasible solution, for research questions 1, 2 and 3 in this research.

3.2.2 UCINet 6 – Social Network Theory (SNT) Analysis

UCINET 6 for Windows is a software package for the analysis of social network data. It was developed by Steve Borgatti, Lin Freeman, and Martin Everett (2002) and has evolved over time, in terms of upgrades and revised versions. It comes with the NetDraw network visualization tool. A social network could be defined as a set of people, groups or teams of people with some form of relationship or interactions between them (Scott, 2000). Although only 18% of managers believe that effective social network is important to their businesses today, more than 63% assert that, Social Networks will be important for businesses within the next three years (Kiron et al. 2012).

According to Chui et al. (2012) there have been estimates that the economic impact of social network on business could exceed $1 trillion, most of which is gained from more efficient communication and collaboration within and across organizations' SCM network activities. Thus, an effective and efficient SC communication network is very important and seems inseparable from a robust business environment (Puvanasvaran, et al., 2009) and enterprise SCM organization operations' research and development (R&D) activities. Therefore, this research adopted the social network theory (SNT) analysis approach to analyse and propose an effective strategic communication network flow within and across an enterprise SCM network, in terms of frequency, importance and level of collaboration among the SC network systems-design teams as well as the scale / level of mutual trust, and of their roles and responsibilities.

3.2.3 Statistical Correlation Analysis & Hypothesis Testing

Correlation is a term that refers to the strength of the relationship between two or more variables *(in this research; variables refer to the SCM network teams / partners / stakeholders)*. A strong, or high, correlation means that two or more variables have a strong relationship with each other while a weak, or low, correlation means that the variables are hardly related (StatSoft, 2011). Three hypotheses were drawn by this research to test the correlation significance level of SC network systems-design teams / partners within and across the enterprise SCM network. Thus, to assess, analyse, and propose a feasible strategic technical communication network analysis, and also how effectively these systems-design teams /

SC network partners could work together in an enhanced concurrent manner to achieve a sustainable and competitive SCM network (Maier, et al., 2008).

Hence, statistical correlation analysis and hypothesis testing was also adopted by this research in a triangulation approach to analyse the frequency, importance and level of collaboration among the SC network systems design teams as well as the scale / level of mutual trust, and of their roles and responsibilities.

4 RESEARCH ANALYSIS, FINDINGS AND RESULTS

4.1 Case Construct and Description (RQ.1 & RQ.2)

RQ.1) How can multi-discipline teams, made up from different divisions of a manufacturing enterprise SCM network work together effectively?

RQ.2) How can information exchange on an SCM network be structured efficiently and effectively to strategically improve N/CPD engineering design and delivery processes?

Industrial organizations are trying to discover strategies to achieve enterprise competitiveness to improve their flexibility and responsiveness by changing or finding efficient and effective methods, technologies and/or operational strategies that involve the implementation of supply-chain management (SCM) strategy (ies) and information technology (IT). However, thorough and sufficient practical research is yet to be conducted within the area of implementation of SCM and IT for effective and efficient data management and systems integration. Much as it is still pertinent, doing business over the Internet is affordable and very convenient. This enables industrial enterprises to enlarge their view and also grants them an opportunity to easily select and network with their supply chain (SC) partners, thus enhancing the core SCM values of business-to-business operations with information systems (IS) enables data-management workflow systems.

The integral specifics of such data-management information systems make it suitable to be implemented within the industrial enterprise management system. Thus, the main part of this is the information-supported data-management system's inner SC and integrated interfaces. The independent inner systems are linked by the integrated interfaces into an enterprise SCM to manage the logistics tracking network business processes among the independent partners on the SC enterprise system. This dissertation presents a proposed Master Data-Management (MDM) system of a large ship building manufacturing company for their Logistic and SCM product tracking network by using a design structure matrix (DSM) approach. It will also analysed the industrial based case study by addressing or discussing some of the system interfacing issues learned from the industrial based case study DSM approach experience.

Industrial manufacturers are constantly faced with a complex and competitive environment in which to strive for organizational operations management sustainability. Therefore, e-commerce is becoming a preferred tool for today's organizational and industrial operations management to enhance their industrial competitive advantage (Van der Aalst, 2000). Nowadays, the various partners in an industrial supply chain (SC) network their services and resources together as if they were a traditional organizational enterprise. Therefore, integrating or interfacing enterprise organizational engineering systems for effective and efficient data flow within their inter-organizational data-management systems enhances industrial competitive advantage (Dimitrios, et al., 1999).

However, industrial organizations' agility and response to customer demand are significantly critical to their success to, realizing their industrial competitive advantage. Therefore, an integrated enterprise information system (IS) is essential to enhance the promotion of interoperability among the partners within an enterprise supply-chain network. This approach will significantly improve the information flow between them, and also aid the deployment of business activity processes among the various partners / teams within the enterprise SC network to enhance effectiveness and efficiency information flow and data management.

Bowersox and Calantone (1995) mentioned that supply-chain management (SCM) system's integration with information technology (IT) systems and innovations has been recognized and focused on by industries recently, as an essential industrial organization business application tool to strengthen their ability and capability to compete and also sustain their competitive achievements. Information-flow is the automation of data-management system processes. This approach is, thus, adopted as a way of instituting effective and efficient industrial organizational management needed to deploy the integration into the enterprise SC data management process among partners within an SC (Bowersox, et al., 2000). The world-wide-web (www), or Internet-based business applications have, thus, become the primary platform of modern-day electronic commerce (e-commerce) (Liu, et al., 2005). It has therefore been proposed that the most effective and efficient new industrial organization business frameworks are undoubtedly the ones that turn to integrate information technology (IT) to all its business activities within their enterprise SC's value chain (Phan, 2003).

The following sections of this research include a review of the research background, and of data-management systems as well as enterprise supply-chain management of industrial manufacturing organizations. These are followed by the industrial case study and case construct, research findings and also some possible solution models.

4.1.1 Background Review - Case Constructs One & Two

The logistics tracking for supply-chain networks is an important industrial management issue for providing effective and efficient customer satisfaction among industrial manufacturers as well as among their logistics and transportation partners on the SC. A demand in the industrial manufacturing organizations for monitoring their supply chain from the upstream through the intermediate stream to the downstream is significantly on the increase now. Today's enterprise SC approach environment in industrial manufacturing organizations are looking for the appropriate data integration systems to track real-time, data/information from their various partners within their the SC for effective and efficient SC data-management among the partners within the network.

Therefore, it has become imperative for industrial organizations to develop an authentic enterprise SC data-management-system, which will integrate all the partners onto one single and effective logistics network system. This will enable them to operate efficiently with real-time tracking of data within the SC network. This is therefore essential in that, industrial manufacturers rely heavily on quality real-time information within their supply-chain management (SCM) processes to improve their production and products to enhance customer satisfaction; it is therefore valuable for their systems' data and information to be very reliable and authentic.

A data-management system (DMS) is a strategic and efficient management of data with business systems-application management tools for managing data and/or information within an enterprise SC network. The business systems-application tools and some of the programming languages employed within the architecture of the business operation's platform include an SQL Server, WWW Server, Internet browser, using the extensible mark-up language (XML), etc. Thus, a good tracking solution is one that can identify the location of a shipment by answering the questions like; where is the current position of the shipment and transport? What are the conditions inside or outside the products, being shipped (e.g. temperature, humidity, corrosion level, shock, acceleration or accidental drop of product, etc.)? Logistic partners are involved (e.g. courier, freight forwarders, transporters, etc.) These pertinent Logistics and SCM queries could be answered suitably through properly employed enterprise SCM data management systems (Jansen, 1998; Töyrylä, 1999). However, it has been quite a challenging issue for industrial manufacturers to provide a reliable, efficient and effective enterprise data management systems' design structure to deal with these issues.

Design Structure Matrix (DSM), Domain Mapping Matrix (DMM) and Multiple Domain Matrix (MDM) methodologies offer a wide range of options for modelling and analysing complex systems (Lindemann, et al., 2009). However, this dissertation employs a design structure matrix (DSM) methodology to streamline a proposed data-management system to improve the information transfer and exchange between the industrial partners on an enterprise SC network. The DSM approach is a data exchange model that allows the representation of complex relationships among activities in order to determine a sensible structure or simulation for the activities being modelled (Yassine, 2004). Thus, this approach will propose a combination of technologies and system applications, which will provide a suitable structure to enable all partners on an enterprise SC network to access, transfer and exchange the data they require at real-time to improve and enhance industrial product development for customer satisfaction.

Therefore, an integrated version of system tools would be able to effectively and efficiently enhance the enterprise SC network environment, where multi information can be tracked from the same integrated enterprise SC data management system. This integrated tool or methodology would contribute to the industrial processes in terms of potential competitive advantage for logistics service providers (LSPs) and major forwarders and hence the SCM network as a whole (Coia, 2001). Thus, this structural integration approach emphasizes the importance of customers being able to locate the position of the products or shipment in-transit; hence it also contributes to the planning, manufacturing and monitoring of the entire enterprise SC operations and management processes (Dierkx, 2000); Lambright, 2002). Proper and real-time tracking of data and information on industrial product development enhances the industrial manufacturers' productivity and information efficiency by reducing the possible delay and complexity of SCM network operations (Shamsuzzoha, et al. 2011).

4.1.2 Data Management Systems Integration

The increase of the Internet as a communication platform (and its application systems and software) has significantly changed the benefits of information, giving rise to a more enterprise approach such as new opportunities, new industrial partners joining the chain, as well as new relationships between industrial organizations, giving way to new networks of industrial organization transactions (Evans, et al. 2000).

In other words, e-business has a very significant impact on mode of analysis issues in logistics and supply-chains management research, specifically broadening the horizon for the analysis of supply-chain systems and networks. While previous studies into this mode of analysis indicate a broad, holistic perspective to supply chains and networks, however, significant practical research is relatively lacking (Croom, 2000). Research has also shown that fewer studies have been carried out into enterprise supply-chain data management systems (Van Hoek, 2001).

Therefore, as detailed by previous studies, discussion on the implication and impact of enterprise supply-chain processes leading to greater integration and collaboration of the data-management system across the various partners within a supply-chain network (Marchewka, et al. 2000; Johnson, et al. 2002; Lancioni, et al. 2003; Cagliano, et al. 2003; McIvor and Humphry, 2004). Frohlich and Westbrook (2001), in particular, claims that as supply-chain integration increases as a result of e-business, stronger relational ties develop between the partners within the supply-chains. Focusing specifically on the implication of enterprise supply-chain management, Tan (2001) identifies potential for improvements arising from adoption of properly integrated data-management systems among the supply-chain partners in the following areas:

- Cost performance (from improved productivity both product wise and services wise as well as lower input prices);
- Customer service (service quality as well as integrity in the logistics services);
- Process capability (quality consistency on the production floor ensuring that quality is not compromised); and
- Productivity and dependability (from increased control of material flows along the supply-chain in an industrial manufacturing organization).

Especially, where a supply chain handles high volume and low volume products' information and data, there is often either a high inventory or management cost for low volume products' information and data, or conversely, a low customer service performance for high-volume information and/or items. For industrial manufacturing procurement, e-business offers purchase process efficiency gains and effective price reductions (Croom, 2000; DeBoer, et al., 2002). This approach enhances collaborative and integrative relationships within a supply-chain network (Dyer, 2000; Tang, et al., 2001) and provides significant opportunities for improving internal service on the supply-chain partners' level (Stanley and Wisner, 2002). E-business can thus be seen to impact on supply-chain network structures; supply-chain coordination and supply-chain data management systems integrations (Giannakis and Croom, 2004).

In most large-scale industrial manufacturing organizations' data-management systems for their supply chain (SC) network and shipment of complex engineering products within the SC is designed for a single SCM network operation instead of an enterprise one. Therefore, there is the lack of effective and efficient tracking and tracing of data and information in real-time for as required in an enterprise organizational environment (Kärkkäinen, et al. 2004).

4.1.3 Supply chain management

Supply-chain management (SCM) can be regarded as a business process to construct enterprise-wide methods. SCM is, however, defined in many ways. The International Centre for Competitive Excellence defined SCM as ''the integration of key business processes from an end user through original suppliers who provides products, services and information that add value for customers and other stakeholders'' (Changchien, and Shen, 2002). With the implementation of an integrated data-management system in industrial supply-chain management, strategic alliances and long-term cooperative data-management system networks, replace the narrow focus of managers and the adversarial data and information networks between logistics providers, suppliers, and customers.

Industrial suppliers and customers are viewed as partners within an enterprise SCM network instead of adversaries with the objective of ''maximizing competitiveness and profitability to the manufacturing industry as well as for the enterprise data-management system of supply-chain network, including the end-customer'' (Patterson, et al., 2003). According to Levary (2000), the benefits of a supply-chain include:

- Reducing the bullwhip effect,
- Exploiting the efficiency of the activities,
- Decreasing inventory,
- Lessening cycle times,
- Accomplishing an acceptable level of quality.

The major success factors for an efficient and effective data-management system in an enterprise supply-chain are effective management of strategic alliances among the SC network partners, extensive and efficient data-management capabilities, and an advanced inter-organizational information system (IS) to enable better data and information exchange. This promotes authentic and more up-to-date data and also enhances a more accurate inventory response to changes in demand and appropriate inventory levels in real-time (Whipple and Frankel, 2000). However, the participating enterprises usually are independent and dispersed at different locations either nationwide or globally. The affiliation between them has the following characteristics (Heiko and Keith, 1999):

Goal-orientation: Let us say, an industrial enterprise [Y] (manufacturer) needs enterprise [Z] to execute a task (take an order to supply materials); an industry [Y] will set up an agreement between them to carry out the agreed task. After that, industry [Y] will not interfere with industry [Z]'s activities. This means that the SC network activities between enterprises are more dynamic and changing.

Privacy: An industrial organization that operates independently would not want to disclose details of its process models. Therefore, an industrial manufacturer usually does not grant access to all internal information about the ongoing process in order to sustain its competitive edge. Equally, a supplier or a logistics service provider would not want to disclose its process models or organization database to its business partners.

Flexibility: An industrial manufacturer seeks to change its internal procedures without asking permission of or informing its SC partners, unless the change affects the commitment or network partners like the suppliers and logistics service providers. The same is true for the SC partners as well.

Independence: All parties in a SC network want to stay independent of changes in each other's camp, as long as the outcome is not affecting anyone on the SC. Thus an open, standard and adaptable data management system within an enterprise SCM system is needed to carry out business processes across the enterprise chain as well as information-flow. Therefore, Internet technology is the obvious choice for this e-business application approach.

4.1.4 Research Case Study Example

The example of a ship building manufacturing industrial company's logistics and supply-chain management was utilized in this research's case analyses. The company has over 280 major suppliers worldwide. The company aims at improving business process efficiency by integrating its industrial operational process with that of its suppliers and customers as well as sharing and exchanging information smoothly and quickly within its SC network. In order to carry out the enterprise SC processes over the Internet, every independent enterprise need to have an internal information system (IS). However, it was shown through the requirement analysis that there was an efficiently integrated supply-chain management system neither within such an industrial global organization nor among most of its suppliers (863/CIMS, 2000). Therefore, this research seeks to propose an efficient and effective structured master data-management system model, which will serve as a common integrated data-management system (DMS) platform or a DMS e-SCM so that the industrial organization and its suppliers as well as customers could manage their SC data-management processes in a common enterprise environment *(portal)*.

The communication platform is built on web resource applications and some programming languages and international maritime organizations (IMO) services, etc. An independent integrated domain mapping of the DMS interface would be developed in further research, as well as mapping-up multiple domains in future to enhance flexibility and extendibility for more suppliers or customers. This integration will seamlessly provide effective and efficient information exchange within the system of the industrial manufacturer and those of its suppliers and customers on the enterprise SC. Figure 21 below illustrates the architecture of the entire e-SCM system for effectively tracking data in real time and efficiently communicating them authentically among the partners on the enterprise SC.

The industrial manufacturer's data-management system (DMS) is thus, integrated with its customers and suppliers, through the Internet. Therefore, for the customers and/or suppliers who do not have interfacing information systems (IS) capability, the DMS e-SCM platform and the integrated interface would provide access to a portal on the www or the Internet to allow smooth and seamless communication within the integrated interface.

4.1.5 Case Constructs One & Two

- How can management information systems (MIS) among multi-discipline teams/partners on an enterprise manufacturing SCM network? Be efficiently and effectively structured and used to strategically, to improve their SC network activities for efficient information exchange in new/complex product introduction and development?

Figure 21 below illustrates this research's optimized-configuration architecture for an enterprise SCM network systems integration and interfaces.

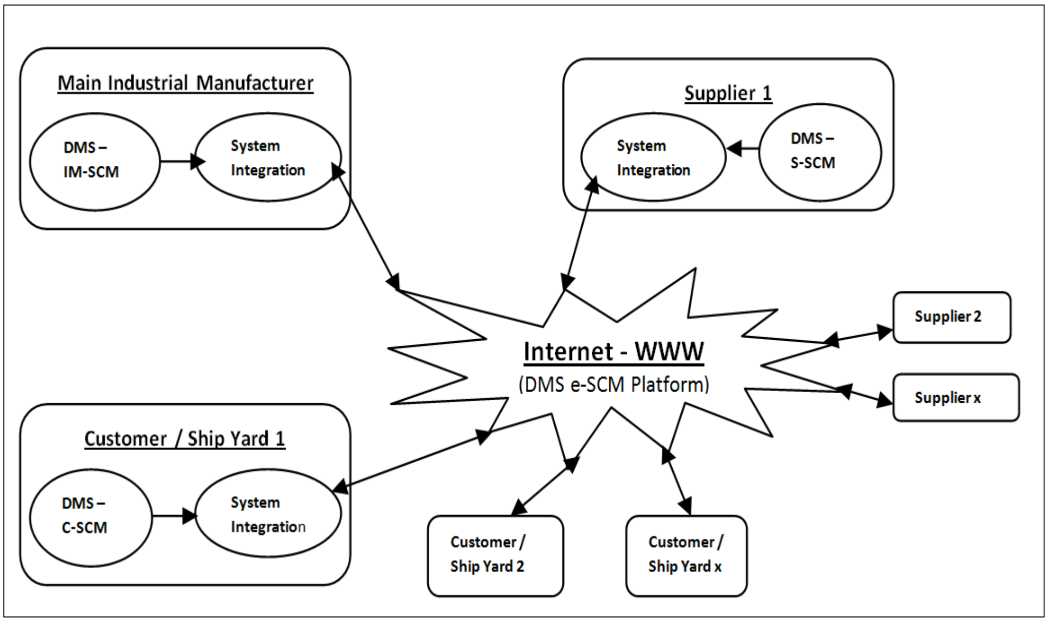


Figure 21. The architecture of industrial manufacturer DSM e-SCM integration or interfaces.

Source: Addo-Tenkorang, et al. (2012).

Table 23 below lists the types of data generated and communicated among the case industrial manufacturer and its partners within the SC network to track data within their e-SCM for efficient data in a new/complex product development and support processes. In order to get an efficient and effective data-management system within an enterprise SC, the DMS should be properly structured to enhance access to tracking and communicating real-time data with an e-SCM network. Helo and Szekely (2005) state that there is a significant link regarding the practicalities of software applications as their trend of integration is intensifying. Moreover, the need for real-time data will become fundamental, putting emphasis on flexible IT-systems such as a very good data-management systems' structure for an e-SCM that can deal with large amounts of data and is also easy to interconnect on a very common and accessible enterprise platform such as the www.

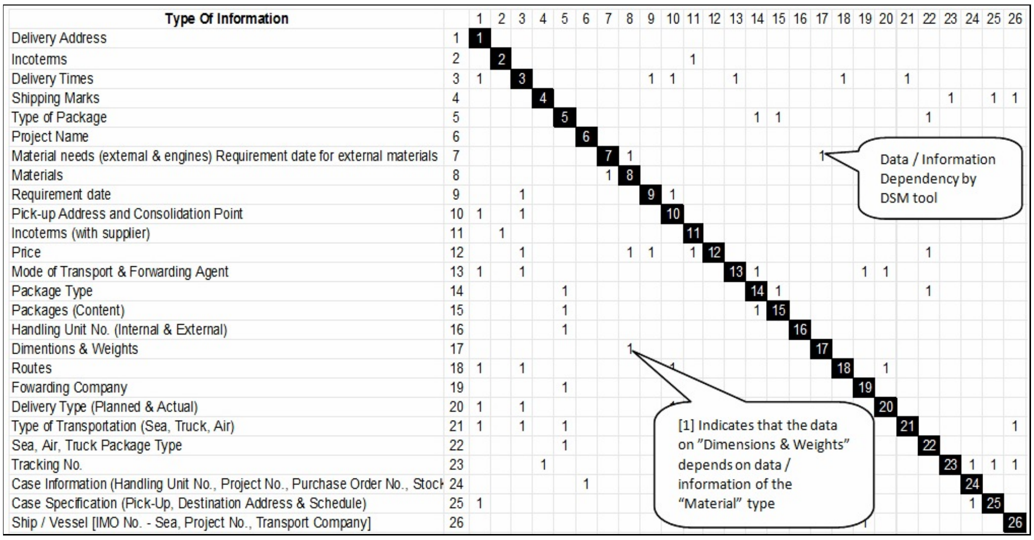
This growing need has led to this dissertation's approach of a proposed master data-management structure for an e-SCM data-management systems design for effective, efficient and real time tracking of data within an industrial SC network.

Table 23. Information / Data Types and Layout

Name of Document	System	Type of Information	Creator	User
Sale Order	SAP	▪ Delivery address ▪ Incoterms ▪ Delivery times ▪ Shipping Marks ▪ Type of Package	Business Control	▪ Business Control ▪ Logistics
Project Builder	SAP	▪ Project Name ▪ Material needs (external & engines) • Requirement date for materials (external materials)	Project Team	▪ Purchasing ▪ Logistics
Purchase Order	SAP	▪ Materials ▪ Requirement date ▪ Pick-up Address and Consolidation point ▪ Incoterms (with supplier) ▪ Price ▪ Mode of Transportation & forwarding Agent ▪ Type of Package	Purchaser	▪ Purchasing ▪ Supplier
Outbound Delivery	SAP	▪ Packages (content) ▪ Handling Unit No. (Internal & external) ▪ Dimensions & Weights	Purchaser	▪ Logistics ▪ Supplier
Shipment	SAP	▪ Route ▪ Forwarding Company ▪ Delivery Type (planned & actual) ▪ Type of Transportation (Sea, Truck, Air) ▪ Type of Package ▪ Tracking No.	Delivery Manager	▪ Delivery Manager ▪ Transport Manager ▪ Business Control
Warehouse List	CRM	▪ Case Information (Handling Unit No., Project No., Purchase Order No., Stock-in Date, Stock-out Date, Storage Location)		
Transport Request Form and Quotation booking (RFQ)	SAP (Email)	▪ Case specification (Pick-up & destination address (es)) Schedule (sent by e-mail)	Transport manager	▪ TSP
Booking Confirmation	E-mail	▪ Exact route & Schedule	TSP	▪ Transport Manager
Way Bill	E-mail IDM	▪ Ship - [IMO number (Sea), Project No., Transport company]	TSP	▪ Transport Manager ▪ Business Control

Source: Addo-Tenkorang, et al. (2012)

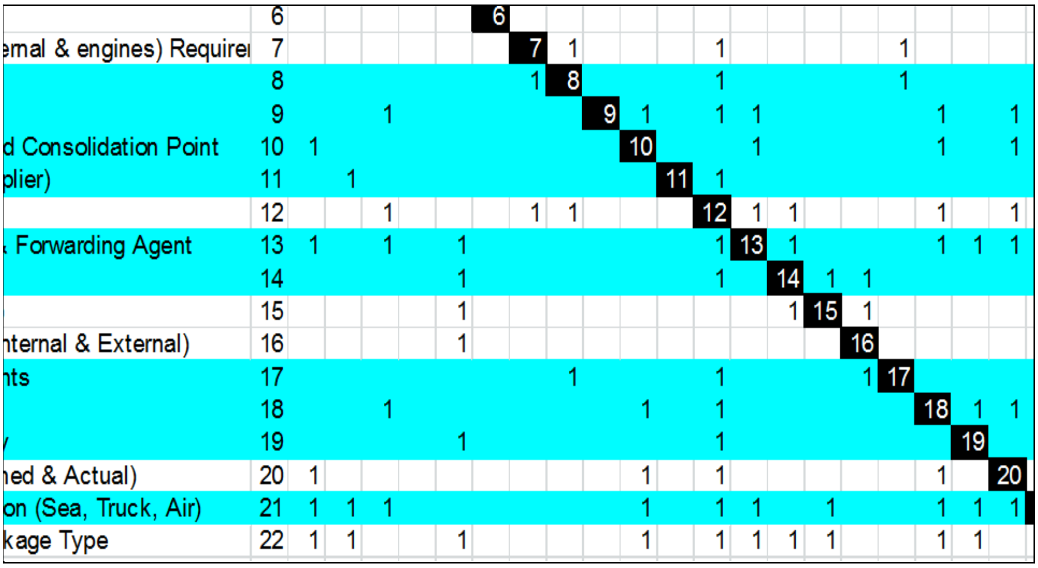
This research uses the DSM approach to analyse Table 23 above. Entries and their relationships are categorically analysed in the various DSM models below *(please see Figures 22 - 25 and Table 24 below)*. The DSM approach is a data exchange model that allows the representation of complex activity relationships in order to determine a practical sequence simulation of the activities being modelled (Yassine, 2004).



Type Of Information		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Delivery Address	1	1																									
Incoterms	2		2									1															
Delivery Times	3	1		3						1	1			1					1			1					
Shipping Marks	4				4																			1		1	1
Type of Package	5					5									1	1							1				
Project Name	6						6																				
Material needs (extemal & engines) Requirement date for external materials	7							7	1									1									
Materials	8							1	8																		
Requirement date	9			1						9	1																
Pick-up Address and Consolidation Point	10	1		1							10																
Incoterms (with supplier)	11		1									11															
Price	12			1					1	1		1	12										1				
Mode of Transport & Forwarding Agent	13	1		1										13	1					1	1						
Package Type	14					1									14	1							1				
Packages (Content)	15					1									1	15											
Handling Unit No. (Internal & External)	16					1											16										
Dimentions & Weights	17								1									17									
Routes	18	1		1															18		1						
Fowarding Company	19					1														19							
Delivery Type (Planned & Actual)	20	1		1																	20						
Type of Transpotation (Sea, Truck, Air)	21	1		1		1																21					1
Sea, Air, Truck Package Type	22					1																	22				
Tracking No.	23				1																			23	1	1	1
Case Information (Handling Unit No., Project No., Purchase Order No., Stock	24						1																		24		
Case Specification (Pick-Up, Destination Address & Schedule)	25	1																							1	25	
Ship / Vessel [IMO No. - Sea, Project No., Transport Company]	26																										26

Figure 22. Design Structure Matrix (DSM) Information Types Relationship Entries.

Source: Addo-Tenkorang, et al. (2012).



	6						6														
ernal & engines) Requirer	7							7	1				1					1			
	8							1	8				1					1			
	9			1						9	1		1	1					1		1
d Consolidation Point	10	1									10			1					1		1
plier)	11		1									11	1								
	12			1				1	1				12	1	1				1		1
Forwarding Agent	13	1		1		1							1	13	1				1	1	1
	14					1							1		14	1	1				
	15					1									1	15	1				
nternal & External)	16					1											16				
nts	17								1				1				1	17			
	18			1							1		1						18	1	1
/	19					1							1							19	
ned & Actual)	20	1									1		1						1		20
on (Sea, Truck, Air)	21	1	1	1							1		1	1		1			1	1	1
kage Type	22	1	1			1					1		1	1	1	1			1	1	

Figure 23. Banded Design Structure Matrix (DSM) Information Types Relationship Entries).

Source: Addo-Tenkorang, et al. (2012)

Banding is the addition of alternating light and dark bands to a DSM to show independent (i.e. concurrent) data and activities (Grose, 1994). The collection of bands or levels within a DSM constitute the critical path (i.e. bottleneck activities) of the system.

Table 24. DSM Information Single Run Data Types Activity Record

Data From a Single Run (r = 1)				
To collect, this option must be turned on on the 'Data & Analysis" worksheet				
				t:
Activity #		Activity Durations	Duration in time steps	**Cumulative S:**
1		18.27	18	1
2		3.65	4	2
3		7.66	8	3
4		2.49	2	4
5		26.19	26	5
6		1.00	1	6
7		9.42	9	7
8		24.50	24	8
9		2.01	2	9
10		1.00	1	10
11		8.58	9	11
12		2.08	2	12
13		0.00	1	13
14		0.00	1	14
15		0.00	1	15
16		0.00	1	16
17		0.00	1	17
18		0.00	1	18
19		0.00	1	19
20		0.00	1	20
21		0.00	1	21
22		0.00	1	22
23		0.00	1	23
24		0.00	1	24
25		0.00	1	25
26		0.00	1	26

Source: Addo-Tenkorang, et al. (2012).

Sequence	1	2	11	5	14	15	22	6	7	8	17
levels											
1	1	2	11	5	14	15	22	6	7	8	17
2	16	19	24								
3	25	26									
4	3	9	10	13	18	20	21	4	23		
5	12										

DSM Sequence/Levels model relationship details (DMS e-SCM)

Figure 24. DSM Information Sequence and Level Types Layout

Source: Addo-Tenkorang, et al. (2012)

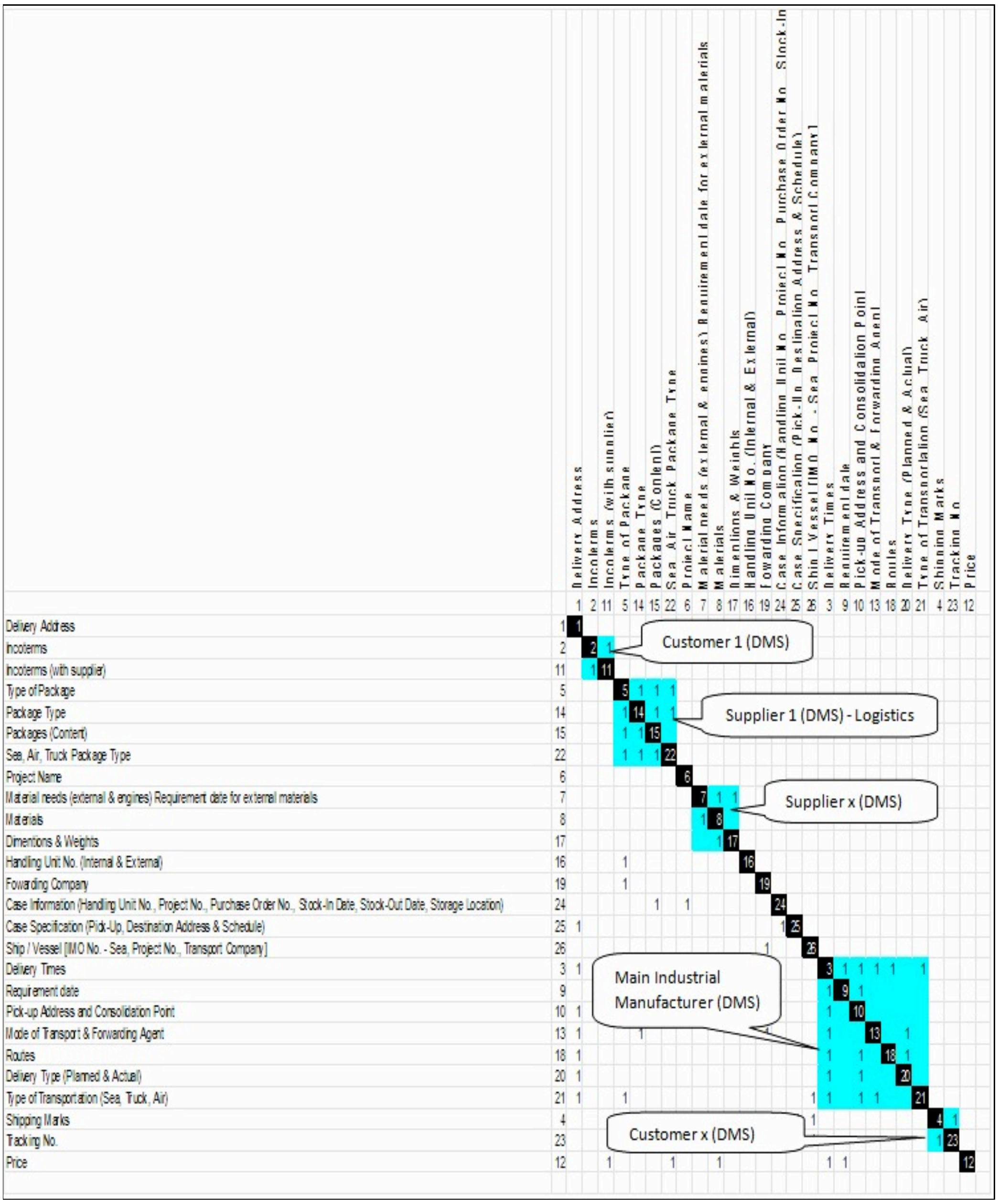


Figure 25. Partitioned DSM Information Sequence and Level Types Relationship Layout.

Source: Addo-Tenkorang, et al. (2012).

Partitioning is the process of manipulating the DSM rows and columns such that the new DSM arrangement does not contain any feedback marks, thus, transforming the DSM into a lower triangular form (Yassine, 2004).

4.2 Case Construct and Description Three (RQ. 3)

RQ.3) How can SCM networks achieve strategic and effective communication network on changing parameters of N/CPD engineering design and delivery processes?

According to Puvanasvaran, et al. (2009) Communication is very important and is inseparable from the business environment as well as enterprise organization management. Hence, designing and delivering complex engineering products, such as ship power engines, power generation plants, jet engines, cars or certain types of application software, requires the harmonization of activities of many participants during the design and delivery processes. Therefore, in generic terms, effective and efficient communication network could explicitly be stated to be certainly an added asset for the business sector to function in a competitive economic network (Le Vassan, 1994; Warten, 1985; Worley, and Doolen, 2006). Furthermore, communication is seen as the vehicle by which this harmonization could be achieved. However, communication itself is influenced by many different factors that are linked. This part of the research case constructs presents an explanation of the correlation analysis between some systems-design teams' communication factors, which will be laid out in the following or sections, based on statistical analyses of empirical data. The research uses data collected via a closed-end questionnaire aimed at collecting some vital technical communication network data among complex products' engineering design and delivery system-design teams.

Thus, the aim is to envisage the "best practice" approach for technical communication network among these systems-design teams and also how the bottle-necks existing could also be effectively and efficiently addressed to enhance a collaborative concurrent enterprise (CE+) industrial competitive advantage in enterprise manufacturing supply-chain management (SCM). In order to arrive at more feasibly scientific research findings and also realistic real-life practical industrial conclusions, this research employed a triangulation methodology approach in analysis in this section of the research report. Thus, a social network theory (SNT) analysis software tool (UCINET 6) was employed to analyse the frequency, importance and also collaboration among product systems-design teams. Three hypotheses were drawn to ascertain whether or not the results will retain the null hypotheses or reject them and address them as bottle-necks while duly capturing them in the research analysis report.

The results offer insights for researching and managing communication networks across inter-departmental or systems-design teams interfaces. It has also made significantly clear, in particular, how directly and/or indirectly linked factors influencing technical communication network among systems-design teams in complex engineering design and delivery as well as product development form a network of correlations. The factors, which this research identifies, seek to directly or indirectly influence technical communication among complex engineering products' systems-design teams includes:

- Frequency in communication (technical) among various design teams.
- Importance of design teams' technical communication for (N/CPD)
- Level of Collaboration among various design teams.
- The Roles and Responsibilities of design teams in relation to other design teams (members).
- The scale / level of Mutual Trust among various design teams.

Importance in technical communication, frequency in technical communication, level of collaboration, roles and responsibilities and the level or scale of mutual trust exhibit thematic significance in correlation. Supply chain (SC) network activities for complex engineering-design and delivery product development and processes result from effective and efficient interactions and communication networks among the supply-chain network partners who work across functional organizational departments and geographical boundaries (Friedman, 2005). In concurrent engineering, roles and responsibilities as well as activities are distributed among SC network teams or individuals and whenever possible executed in parallel, increasing the need for effective and efficient communication networks.

Concurrent collaborative complex engineering design and delivery processes and activities such as effective technical communications networks, etc., are challenging due to strong interdependencies between design decisions. This makes it difficult to converge or customized on changing parameters of a new/complex product systems-design solution that satisfies these technical communication network dependencies, which are acceptable to all partners (Klein, et al. 2003). Classically, the different partners on SC network complex engineering systems-design processes possess different competences, roles and responsibilities, skills and interests, and inhabit network operations differently. Every team or individual on an SC network has a different perspective (De´tienne and Lavigne, (2005)) which can lead to conflicts in technical communications that need to be identified and resolved through negotiations.

A better understanding of each other's intentions, different forms of representation, and information needs could improve the SCM network process. Communication networks are often perceived directly as a problem but the precise problem can be difficult to recognize because of interactions with other factors, such as planning or products, systems or people complexity (Maier, et al. 2008). In practice, it is often possible to analyse specific situations. However, little theoretical understanding of the correlation factors that influences communication in complex product development has been published. This research presents a network of some factors, which influences SCM technical communication networks.

The remaining sections of this chapter are as follows: The background review of the research case construct three; and the methods employed in the data analysis. The adopted theory assumptions (Organization theory – Information Technology, Communications and Operation's perspective). Social Network Theory – its implications and application as a technical communication-monitoring tool among SC products' systems-design teams and the research hypotheses – hypothesis testing, findings analysis and interpretations.

4.2.1 Background Review – Case Construct Three

Researchers, industrial R&D departments and industrial practitioners [Hales, (2000); Sosa and Rowles, (2004); Sosa, et al. (2002)] identify communication as one of the critical success factors of collaborative engineering design and delivery, and efficient industrial activities. Thus, an effective and efficient communication network is especially relevant in complex engineering design and delivery of complex product development due to the large amount of data / information of both complex product components and systems-design teams involved in the industrial manufacturing SCM network processes. According to Allen (2000), based his pioneering work on the role of effective communication in product development processes since the early 1970s, the degree of interdependence between design engineers' work is directly related to the probability that they engage in frequent technical communication. Therefore, Smith and Eppinger (1997) and Sosa et al. (2002) use task interdependency to identify the activities that require higher effort to coordinate in their work.

Loch and Terwiesch (1998) also present an analytical model to study the coupling of uncertainty, dependence, and communication in their work. They suggested that average technical communication frequency increases the level of uncertainty and dependence. In this research, communication is mostly defined as technical or design information transmission among systems and product design teams / partners on an industrial enterprise manufacturing SCM network. Eckert and Stacey (2001), concluded in their research that there are several interaction scenarios. These include, 'handover' or 'joint-designing' where communication discrepancies tend to occur due to the lack of an overview on the structure of activities by the individual systems-design engineers. Hence, the lack of engineering design and delivery technical communication flow, or misinterpretation of technical communication network (Eckert, et al. 2001).

Therefore, the importance of technical communication in collaborative complex engineering design and delivery processes are indisputable. This raises questions of how to effectively research technical communication network collaborative complex engineering design and delivery process among industrial systems-design teams for an enterprise manufacturing SCM in order to improve the design and delivery process, due to high product customization and frequent change in parameters to satisfy customers' requirements.

While the importance of technical communication is generally acknowledged in various industrial manufacturing systems-design activities, there is however, no good or well-defined consensus on how to co-ordinate or, at best, streamline their organizational "best practice" operations to improve and enhance an industrial competitive advantage. For this research, a communication network is defined as the cognitive and social network process by which technical information or data are transmitted and exchanged effectively and efficiently among complex engineering systems-design teams on an industrial enterprise manufacturing SCM.

4.2.2 Organization Theory – Case(s) Contexts

According to Hatch and Cunliffe (2006) the specific focus of a theory is called its phenomenon of interest. Therefore, in organization theory, the primary phenomenon of interest is the organization and the organization's "best practice" philosophies. Thus, a theory consists of a set of concepts and the relationships that tie them together into an explanation (or an understanding, critique or creation) of the phenomenon of interest (Hatch and Cunliffe, 2006).

Daft and Armstrong (2007) described organizations as goal-directed social entities, which were designed as deliberately structured and coordinated dynamic systems that connect and network effectively with the external environment. Tompkins (2005) held the view that organization theory was the study of how and why complicated organizations behave in the way they do. Hence, Organization theory is neither a single piece of theory nor an integrated body of information but a field of studies, which cover various scientific disciplines and subjects (Yue, and WenJun, 2013). Hence, as stated already in the introduction section, this research attempts to utilize some main assumptions of organization theory with a specific focus on the aspects of "information technology" and "communications" in industrial manufacturing "operations" as its theoretical underpinning. Organization theory considers series of applications; however, the relevant application considered for this research includes the highlighted outlines in Table 25 below:

Table 25. Organization Theory Applications Adopted for this Research.

Types of Theory Applications	**Implication of Theory Application**
Information technology	The way information flows through the organization affects work processes and outcomes, so knowing organization theory can help IT specialists identify, understand and serve the organization's informational needs as they design and promote the use of their information systems.
Operations	Value chain management has created a need for operations managers to interconnect their organizing processes with those of suppliers, distributors and customers; organization theory not only supports the technical aspects of operations and systems integration, but explains their socio-cultural aspects as well.
Communication	Corporate communication specialists must understand the interpretive processes of organizational stakeholders and need to address the many ways in which different parts of the organization interact with each other and the environment, in order to design communication systems that are effective or to diagnose ways existing systems are misaligned with the organization's needs.

Source: Hatch and Cunliffe (2006 Chap-1 pp. 4)

Industrial enterprise manufacturing organizations often find great difficulty in quickly making out the required information for various purposes because of the voluminous data, improper segregation, departmental arrangements and unprecedented delays. Industries are therefore, constantly searching for some means or organizational collaborative concepts or frameworks to overcome these disasters, as, the inconvenience will not only be a loss of monetary profits but also antagonism of customers who are made to wait for a long time for a small piece of data about their product(s).

This research attempts to resolve these pertinent issues by employing a Concurrent Enterprise (CE+) framework approach: SCM information technology (IT) enablers of ERP; an integrated computer-based system used to manage internal and external resources, including tangible assets, financial resources, materials, and multidisciplinary teams, and the "best-practice" principles of CE for new/complex product development engineering design and delivery processes. All the stakeholders will be brought to work together on a common / single platform concurrently, as proposed by this research's framework.

4.2.3 Social Network Theory (SNT) Analysis

According to Borgatti and Halgin (2011), Social Network Theory (SNT) refers to the mechanisms and processes that interact with network structures to yield certain outcomes for individuals and groups. Furthermore, according to Brass (2002), social network theory is about the consequences of network variables, such as having many ties or being centrally located. In contrast, theory of networks refers to the processes that determine why networks have the structures they do and the antecedents of their structural properties. Kadushin (2004) stated that social network theory (SNT) analysis was one of the few, perhaps the only theory in social science that is not reductionist. The theory applies to a variety of stages of analysis from individuals or small groups to entire global systems. To be sure, there are emergent properties at different system levels, but these are extensions of what can be done at a lower level and not entirely different forms of organization (Kadushin, 2004). According to Otte and Roussaeu (2002), Social network analysis (SNA) is not a formal theory in sociology but rather a strategy for investigating social structures such as in industrial organizations, etc., as it is an idea that can be applied in many fields. Social network theory and social network analysis are used interchangeably in this research report. It may also be referred in other parts of this write-up as social network theory analysis, which also means the same as the former.

Therefore, comprehending the communication network processes in complex engineering design and delivery and new/complex product development, industrial organizations have been recognized as a key element to improve the new/complex product development engineering design and delivery process performance. It has become imperative to study information exchanges and communication networks among geographically distributed new/complex product development systems-design teams because of the complex nature of industrial engineering-design and delivery SCM network in organizations. Furthermore, employing electronically-based communication information systems technologies has changed how new/complex product development and introduction design teams communicate on an SC network.

Research has been conducted into the way complex engineering design and delivery as well as new/complex product development systems-design teams use various communication network and information exchange technology-systems, etc. Such as e-forms, structured query language (SQL), service-oriented architecture (SOA)' simple object access protocol (SOAP) envelops, electronic data interchange (EDI), e-SCM platforms – customized software-as-a-service (SaaS) e.g., salesforce, integrated master-data systems (IMDS) or data-management systems (DMS), world wide web (WWW), and extensible mark-up language (XML), etc. It has thereby been discovered that a number of factors influences these system-processes of exchanging and communicating technical information. These include geographic dispersion, industrial organizational information communication systems and ties or links such as frequency in technical communications, importance of technical communication, frequency / level of collaboration, mutual trust and degree of team interdependence as well as roles and responsibility of design teams.

Therefore, this research formulates three hypotheses about how these factors influence technical communication network frequency, importance, collaboration, mutual trust and roles & responsibilities in the following subsection of this section. We use empirical evidence from closed-end questionnaires tailored for industrial product-development systems-design teams to test this research's hypotheses, employing UCINET 6 analysis software to effect and evaluate some communication social network-theory simulation analysis. According to Kane et al. (2013~), despite the popular adoption of social media, their application for organizational purposes, including marketing, knowledge management, product development and supply-chains network communication activities has only just begun: Therefore, the impact of social media on organizations represents an important area for information systems research.

To narrow the set of possible theoretical implications, we focus specifically on the implications of these features for one paradigm of organizational research: social network theory analysis (SNT) (Borgatti and Foster 2003; Contractor et al. 2006; Kilduff et al. 2006). SNT analysis has enjoyed increasing popularity in organizational research during recent years, and its focus on human social interactions makes it well suited to support investigations of social media technologies (Ransbotham et al. 2012; Wattal et al. 2010). Based on the above facts and research stream in social network theory analysis, among the product system-design teams within industrial manufacturing organization, this research also seeks to monitor and analyse the technical communications among the system-design teams, to enhance effectiveness and efficiency in achieving a sustainable industrial competitive advantage for enterprise manufacturing SCM. Closed-ended questionnaires were used to capture data for this analysis, because, all the data required could not exclusively be captured during the industrial pilot case study. Therefore, the questionnaires were structured to capture the following required technical communication data from the various product system-design teams. 1) Frequency in communication (technical) among various design teams; Importance of design teams' technical communication for (N/CPD); 2) Level of Collaboration among various design teams; 3) The roles and responsibilities of design teams in relation to other design teams (members); 4) The scale / level of mutual trust among various design teams.

Table 26 below outlines the various Ship Power (SP) product system-design teams employed in this research's social network theory analysis in support of the research's main pilot industrial case study approach.

Table 26. System Types / Teams and Product Components of the Studied Ship Power Engine

Ship Power (SP) Product Design Systems – Types / Teams	# Product System Components
Power Transmission Systems	20
Combustion Systems - Internal / Air	13
Mechanical Systems – Coupling & Mounting	23
Mechatronics Systems	10
Electrical and Instrument Systems	9
Noise and Vibration Systems	5
Automation System - PLC	18
Auxiliary Systems	7

(please see Appendix D for more details)

In using the social network theory (SNT) analysis for simulation; a social network refers to a set of actors, in this case, SC partners / teams; connected by a set of ties. The SC partners, represented in the SNT simulator as "nodes," could be used to represent people, groups, teams, or organizations, and the ties (arrows) are social relationships such as collaboration, importance in communication, or communication frequency, etc. Social network theory analysis studies the social relations between the set of SC partners / actors. SNT argues that the way an individual SC partner, teams, groups or actors behave depends largely on how they tie into that large web of social connections in different perspectives such as in this research, importance in technical communication, technical communication frequency, frequency in technical collaboration, etc., (Freeman, 2004; Wasserman and Faust, 1994).

Therefore, this research also hypothesis that the success or failure of societies, industries or organizations depend on the interactions and ties of their internal entities (Burt, 1992). During the 1940s, Bavelas (1948) mentioned that the arrangement of ties linking team members may have consequences for their productivity, roles and responsibilities. The proposed that the relevant structural feature to study was network significance, which this section of the research attempts to study in the technical communication network aspect of systems-design teams. Hence, social network analysis has extended into many different areas of organizational research (Borgatti and Foster, 2003).

Simulation algorithms are employed to compute and analyse most of these networked structural analysis and properties available and have been implemented in network computer programs such as UCINet 6, which have been employed in this research (Borgatti, et al., 2002).

The following figures below (Figures 26 - 45) illustrate a simulation analysis from (UCINet 6) analytical software tool. This tool is employed to monitor and analyse the frequency, importance and collaborative technical communication activities among the systems design teams, in this research's case, the company's SCM network with its enterprise SC network partners: Details of the questionnaire responses to these factors will be further highlighted in the following sections.

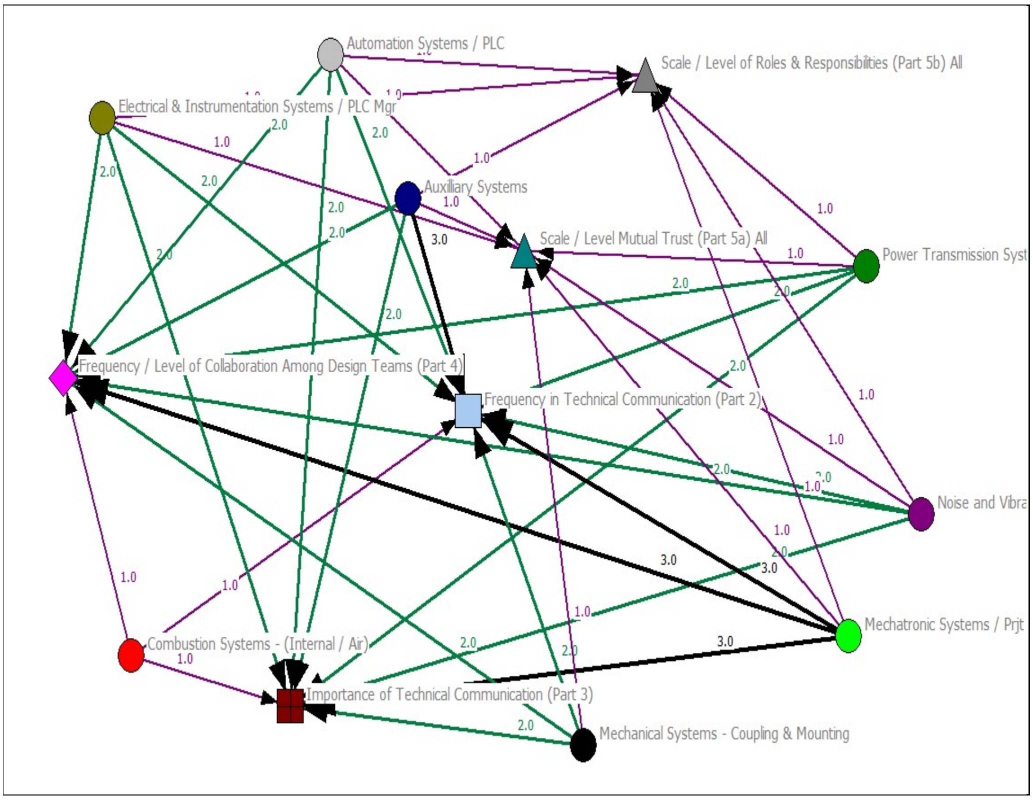


Figure 26. UCINet 6 Simulator – Hybrid Category 32 SP Engine **-** System Design Teams Technical Communication Network Simulation (Frequency, Importance, Level of Collaboration, Mutual Trust, Roles and Responsibilities).

Figure 26 above illustrates the scale or level of technical communication network among the research case's system design teams. The SNT graphical illustration above attempts to simulate in a real-life environment the concurrent enterprise technical communication in terms of the frequency, importance, the level of collaboration, mutual trust, roles and responsibility among the research case's system-design teams on an enterprise manufacturing supply-chain. The scale of variance employed in the UCINet 6 simulators for this analysis are a scale of 1 to 3 (1 = Low, 2 = Average and 3 = High). A critical observation from Figure 26 above, is that the simulator link / tie 1 between nodes is colour coded purple and has a thin link / tie. While the simulator link / tie 2 between nodes is colour coded green and has average thickness, while finally, the simulator link / tie 3 between nodes is colour coded black and is the thickest link / tie. Thus, the scale or level of thickness is directly proportional to the scale or level or frequency, importance, collaboration, mutual trust, roles and responsibility illustrated in the graphic representation of the UCINet 6, simulators. This interpretation is applicable in all the subsequent UCINet 6 simulator figures illustrated below (*Figures 27 – 45 below*).

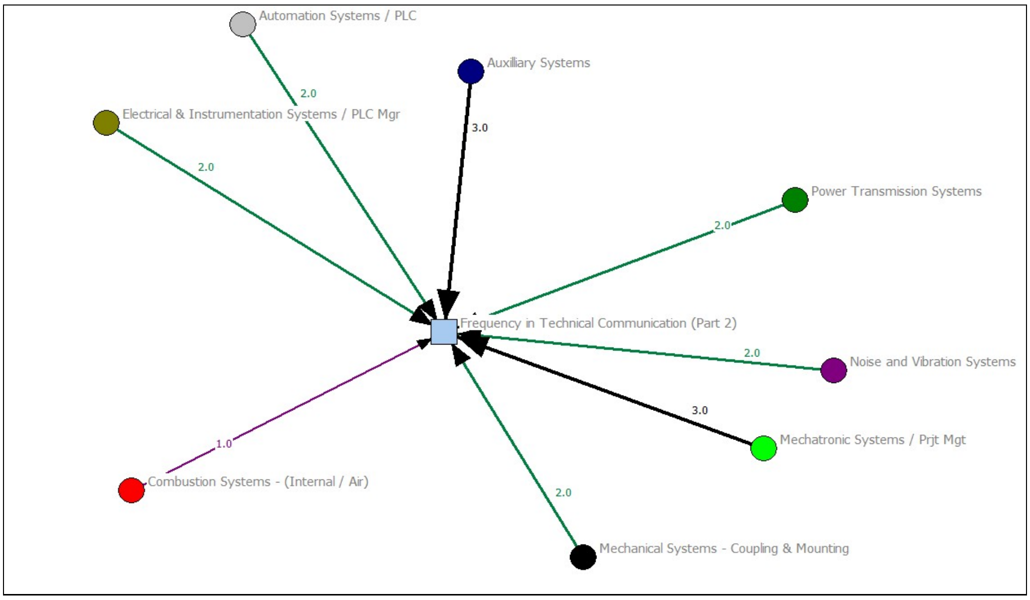


Figure 27. UCINet 6 Simulator – Hybrid Category 32 SP Engine **-** System Design Teams Technical Communication Simulation (Frequency in Technical Communication)**.**

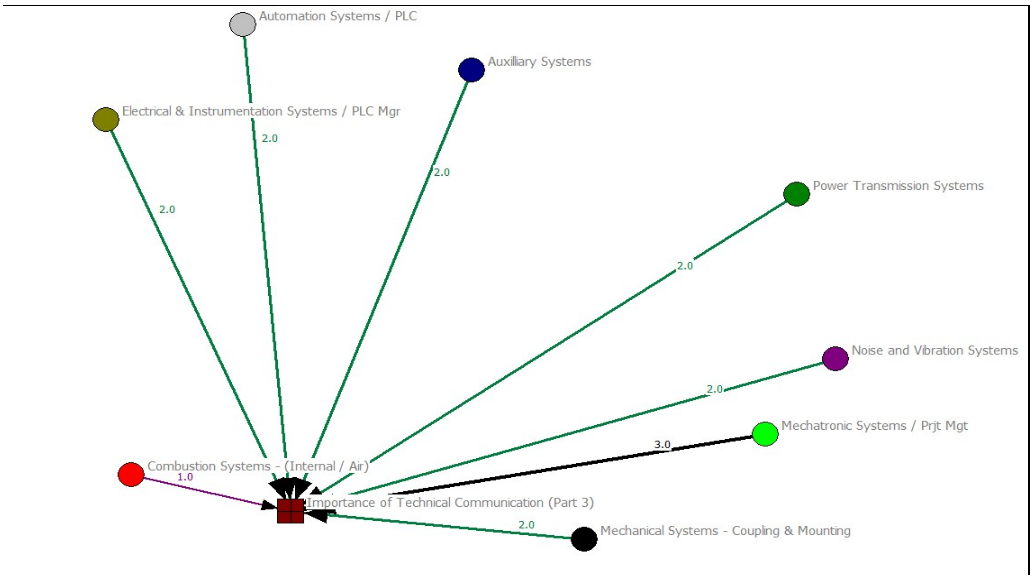


Figure 28. UCINet 6 Simulator – Hybrid Category 32 SP Engine **-** System Design Teams Technical Communication Simulation (Importance of Technical Communication).

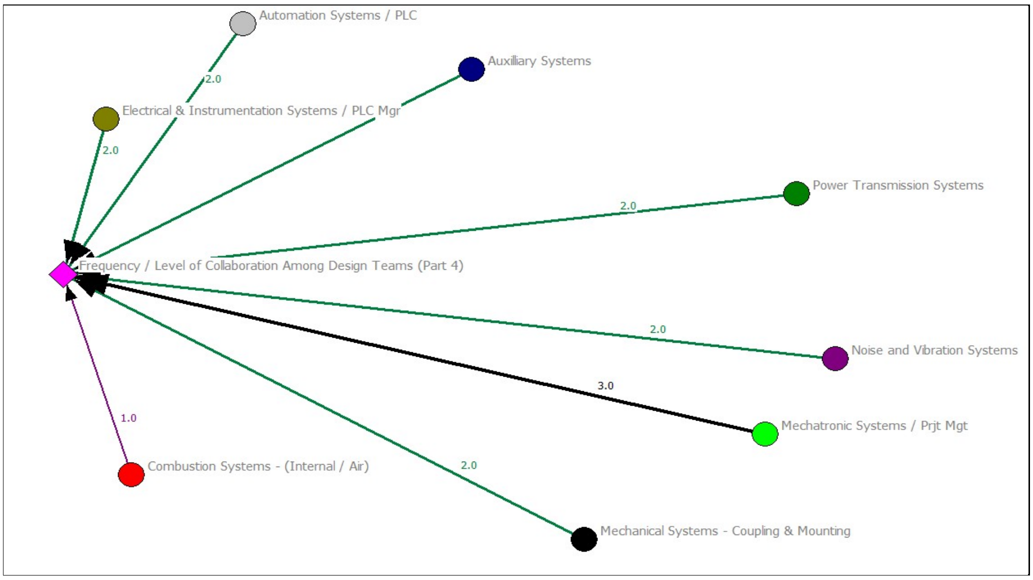


Figure 29. UCINet 6 Simulator – Hybrid Category 32 SP Engine **-** System Design Teams Technical Communication Simulation (Frequency / Level of Collaboration among Design Teams).

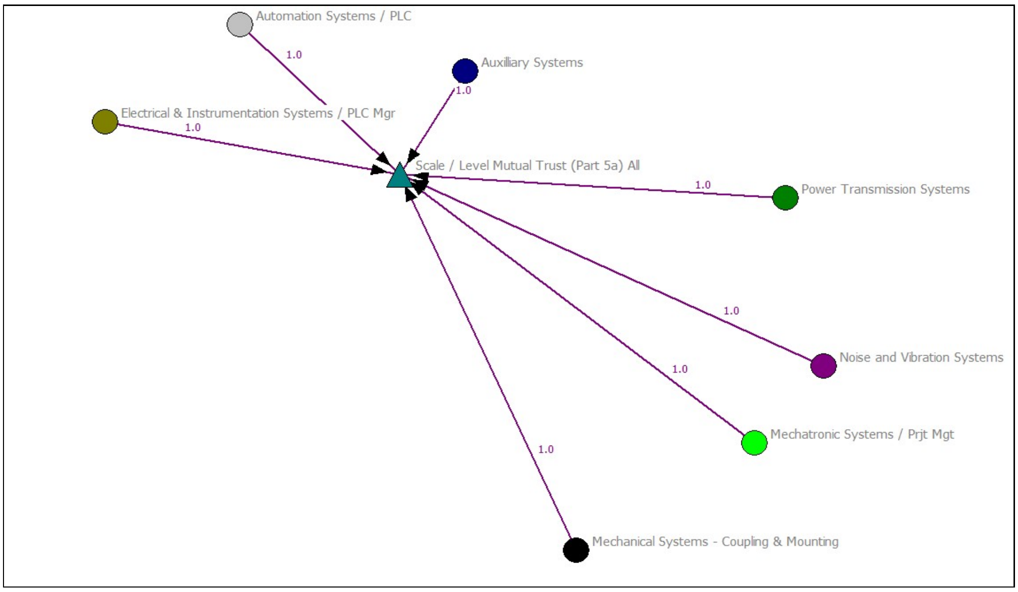


Figure 30. UCINet 6 Simulator – Hybrid Category 32 SP Engine **-** System Design Teams Technical Communication Simulation (Scale / Level of Mutual Trust).

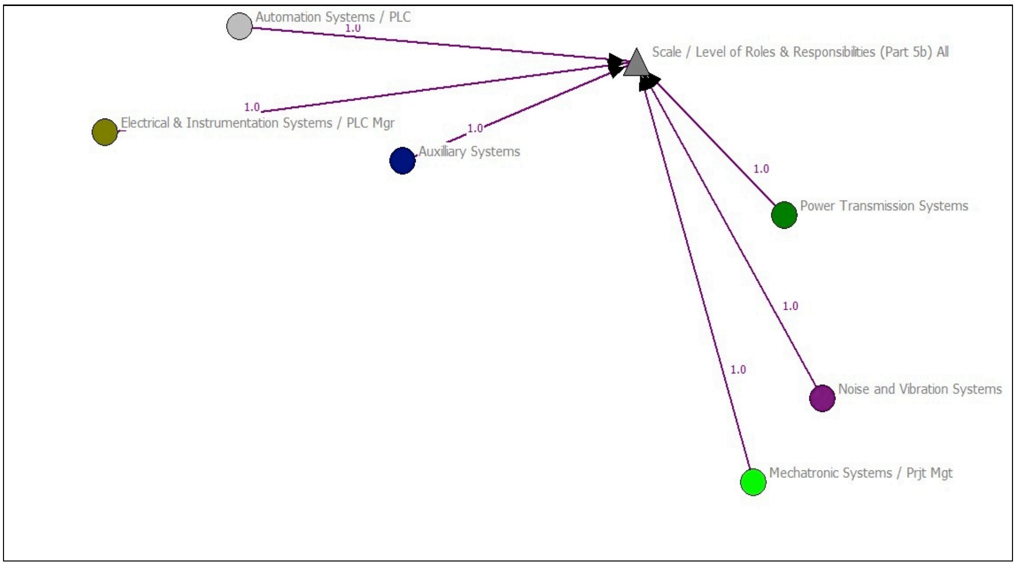


Figure 31. UCINet 6 Simulator – Hybrid Category 32 SP Engine **-** System Design Teams Technical Communication Simulation (Scale / Level of Roles and Responsibilities).

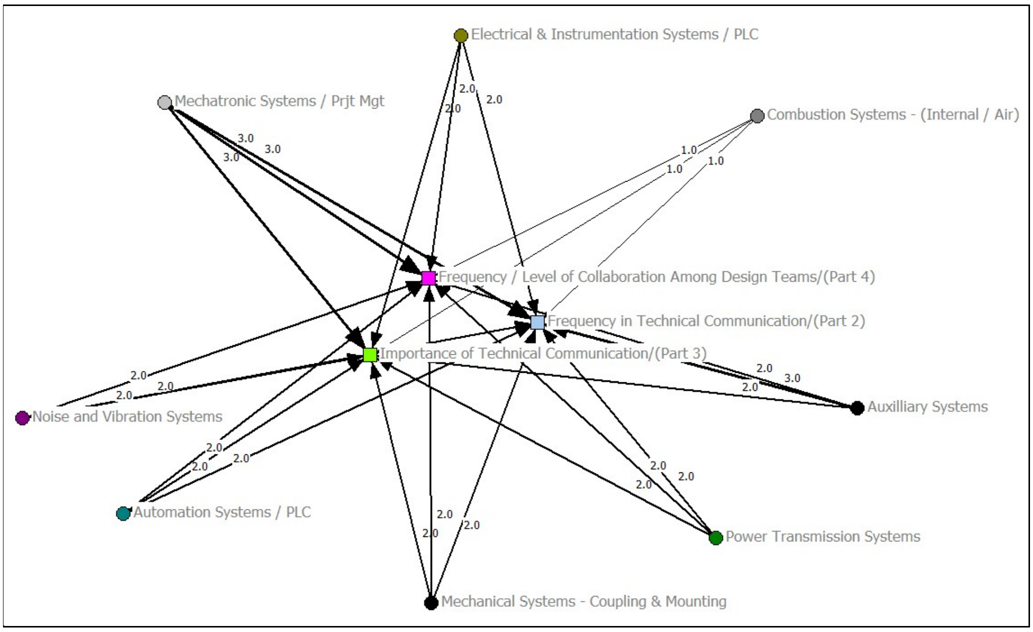


Figure 32. UCINet 6 Simulator – Star Shaped – Hybrid Category 32 SP Engine System Design Teams Technical Communication Simulation (Frequency, Importance, Level of Collaboration, Mutal Trust, Roles and Responsibilities).

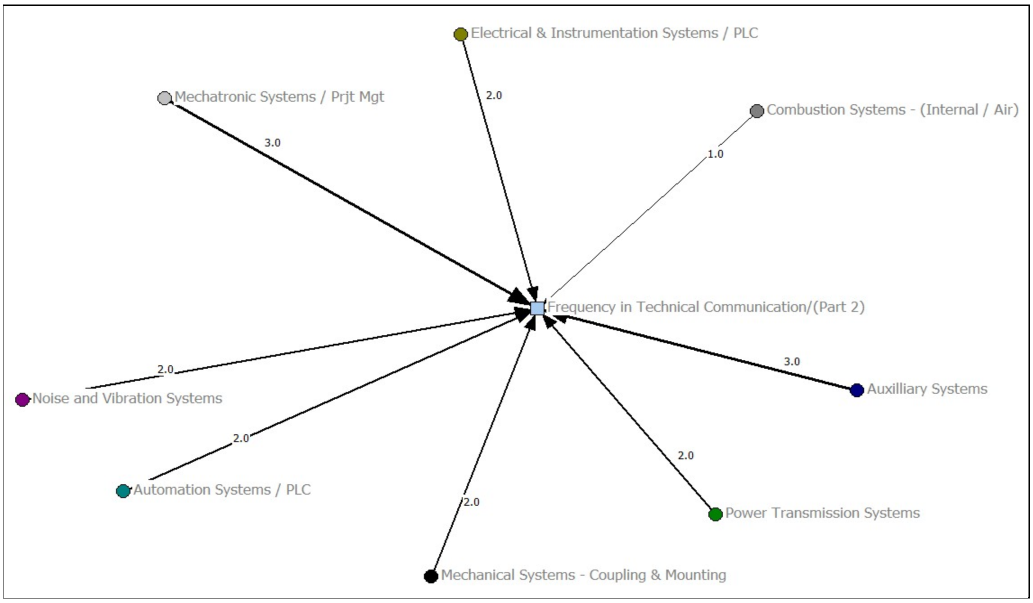


Figure 33. UCINet 6 Simulator – Hybrid Category 32 SP Engine - System Design Teams Technical Communication Simulation (Frequency in Technical Communication).

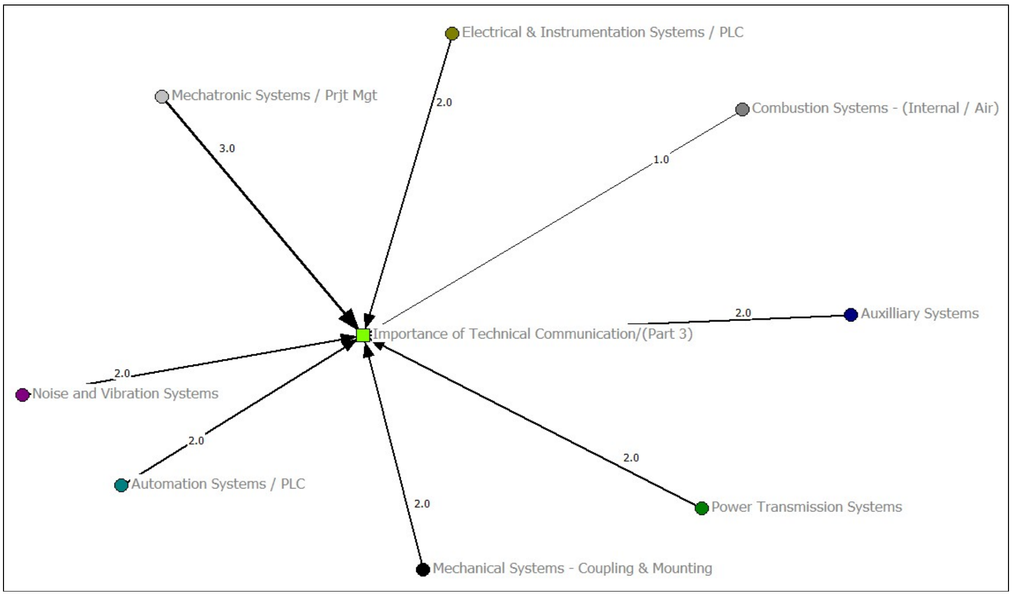


Figure 34. UCINet 6 Simulator – Hybrid Category 32 SP Engine - System Design Teams Technical Communication Simulation (Importance of Technical Communication).

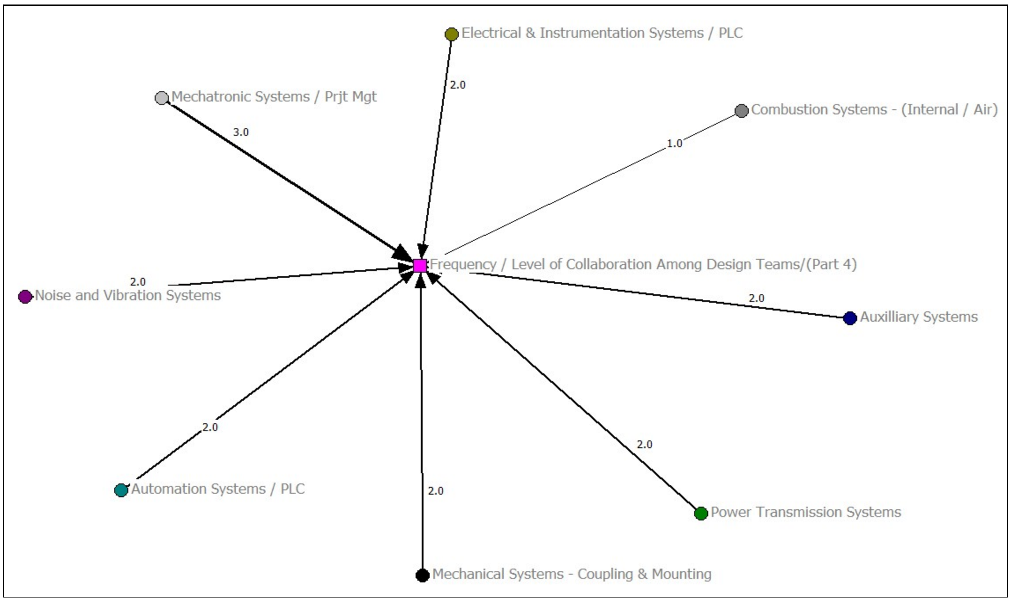


Figure 35. UCINet 6 Simulator – Hybrid Category 32 SP Engine - System Design Teams Technical Communication Simulation (Frequency / Level of Collaboration among Design Teams).

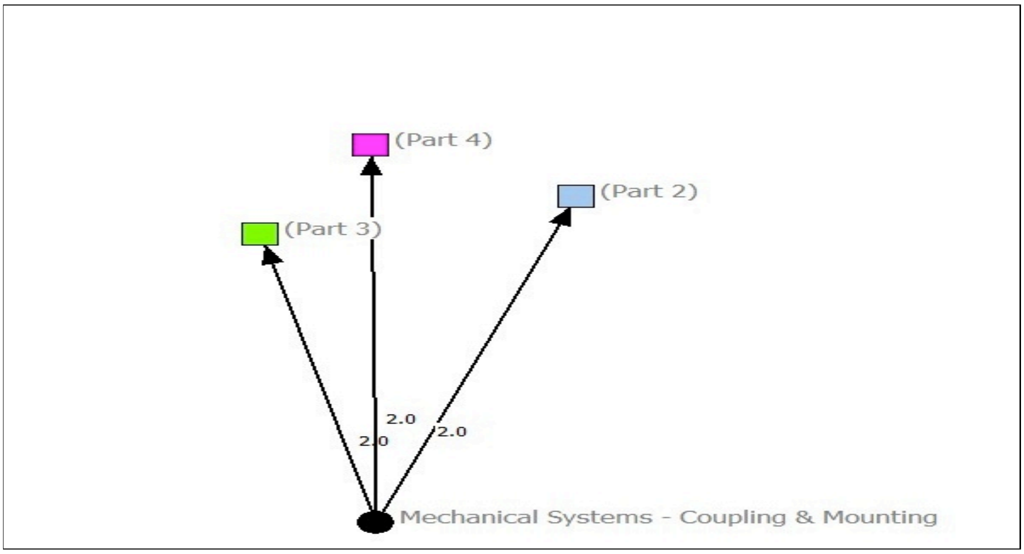


Figure 36. UCINet 6 Simulator – Hybrid Category 32 SP Engine - System Design Teams Technical Communication Simulation (Mechanical Systems - Coupling & Mounting Team).

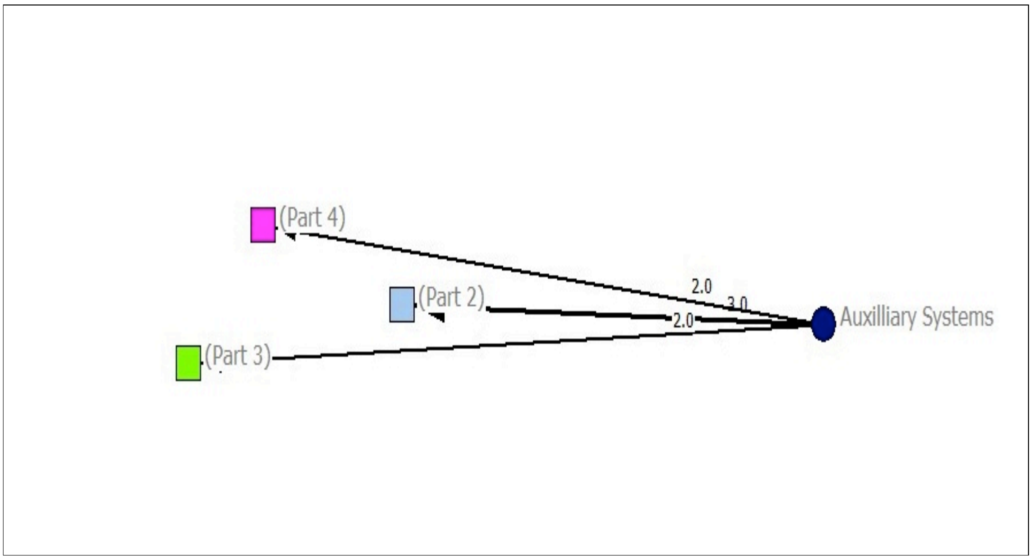


Figure 37. UCINet 6 Simulator – Hybrid Category 32 SP Engine - System Design Teams Technical Communication Simulation (Auxiliary System Team).

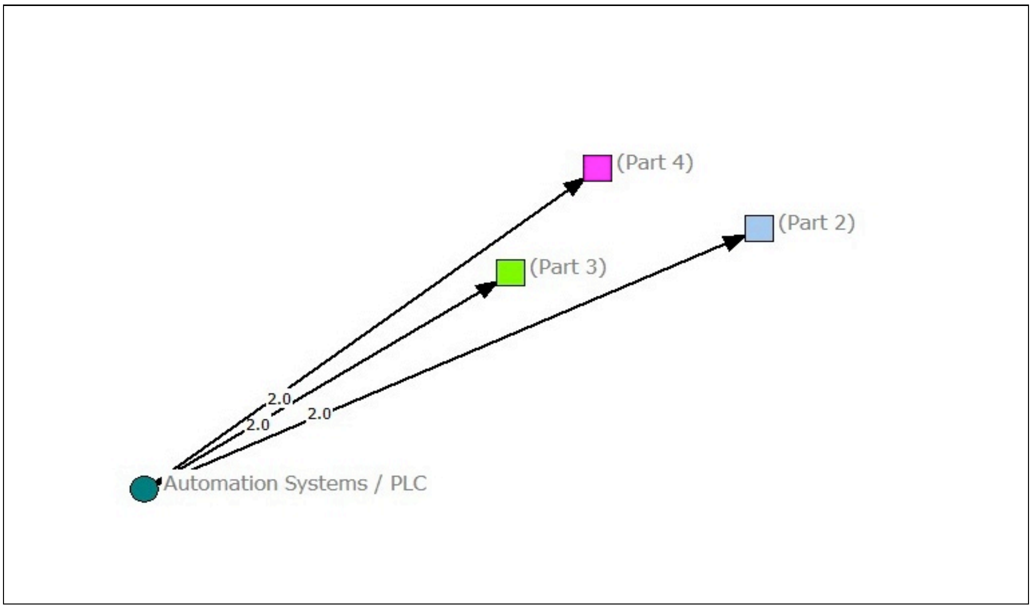


Figure 38. UCINet 6 Simulator – Hybrid Category 32 SP Engine - System Design Teams Technical Communication Simulation (Automation Systems / PLC Team).

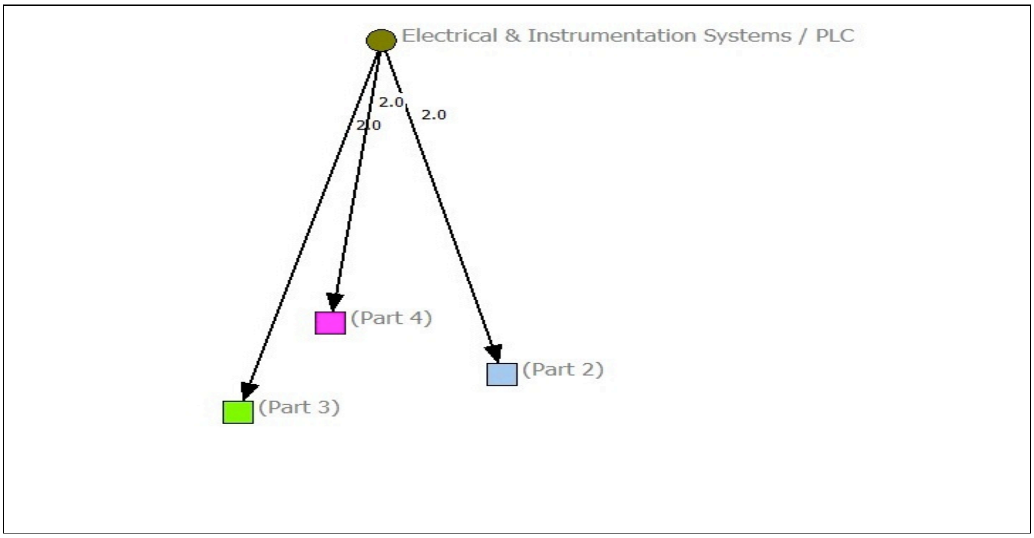


Figure 39. UCINet 6 Simulator – Hybrid Category 32 SP Engine - System Design Teams Technical Communication Simulation (Electrical & Instrumentation Systems / PLC Team).

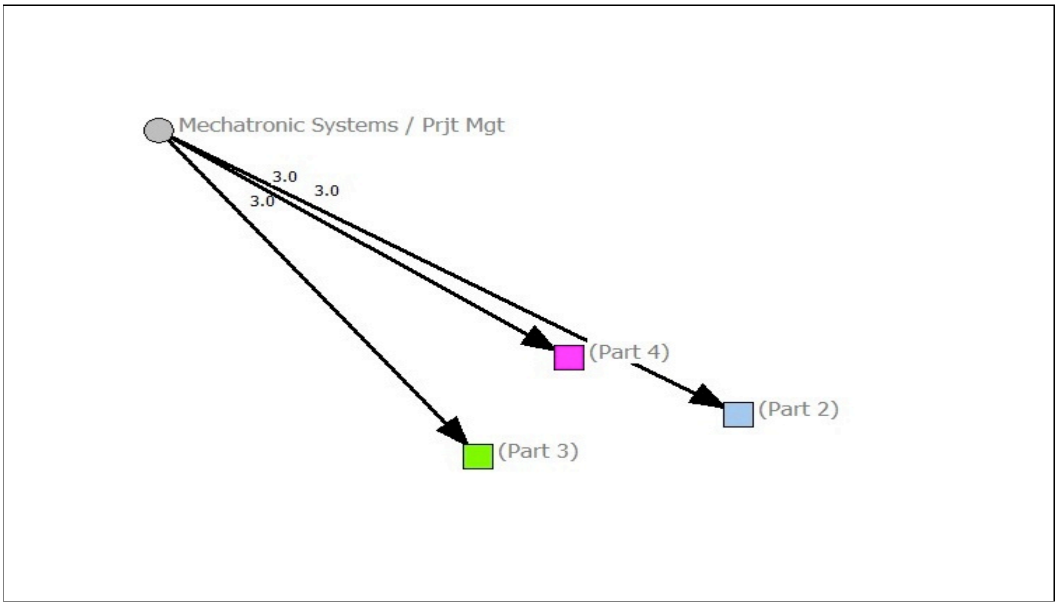


Figure 40. UCINet 6 Simulator – Hybrid Category 32 SP Engine - System Design Teams Technical Communication Simulation (Mechatronics Systems Team).

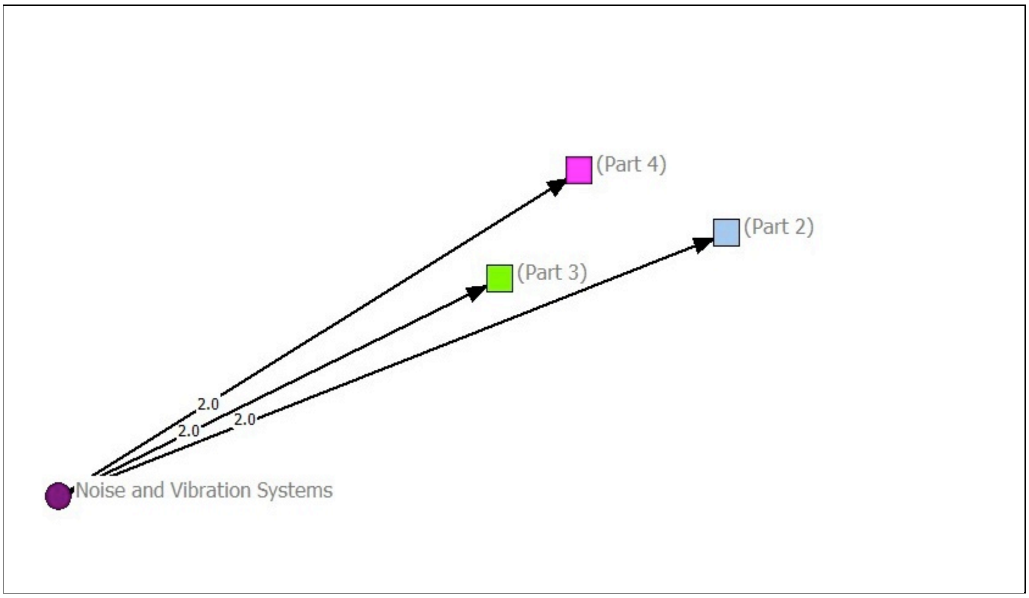


Figure 41. UCINet 6 Simulator – Hybrid Category 32 SP Engine - System Design Teams Technical Communication Simulation (Noise and Vibration Systems Team).

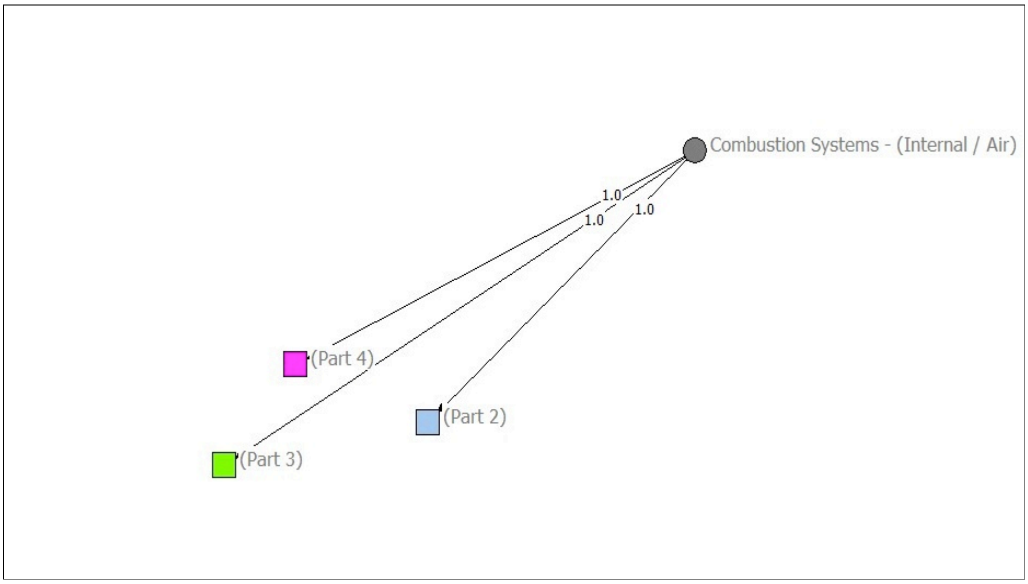


Figure 42. UCINet 6 Simulator – Hybrid Category 32 SP Engine - System Design Teams Technical Communication Simulation (Combustion Systems Team).

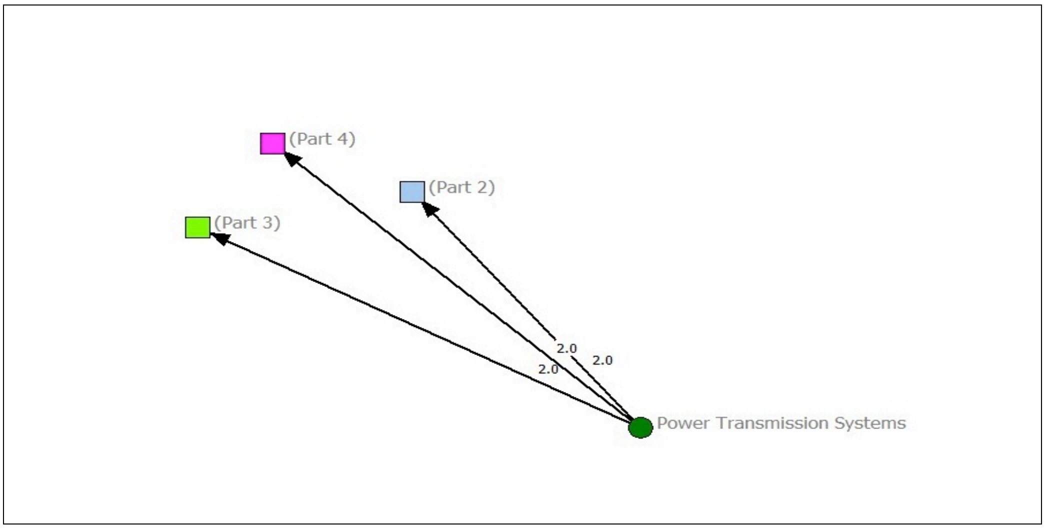


Figure 43. UCINet 6 Simulator – Hybrid Category 32 SP Engine - System Design Teams Technical Communication Simulation (Power Transmission Systems Team).

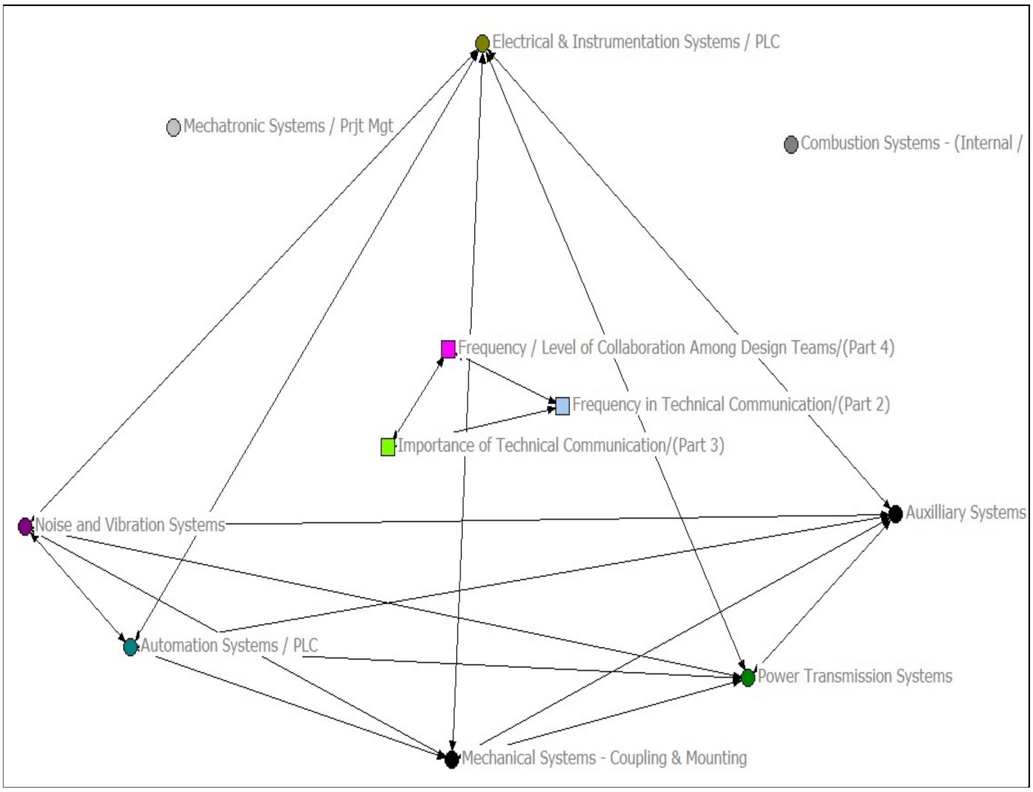


Figure 44. UCINet 6 Simulator – Hybrid Category 32 SP Engine - System Design Teams Technical Communication Simulation (Isolates Analysis).

Figure 44 above, illustrates an UCINet 6 isolates analysis. This isolates analysis shows which of the nodes are isolated from the other nodes and why? Thus, from Figure 44 above, Mechatronic Systems node and Combustion Systems nodes stand out clearly isolated from the other nodes. Therefore, this implies that in a real-life enterprise manufacturing environment, the Mechatronic Systems-design teams and Combustion Systems design teams are most likely or mainly independent in the concurrent or collaborative system design activities in complex engineering-design and delivery product development processes, because their output products interface easily to other systems without any issues or with very trivial issues.

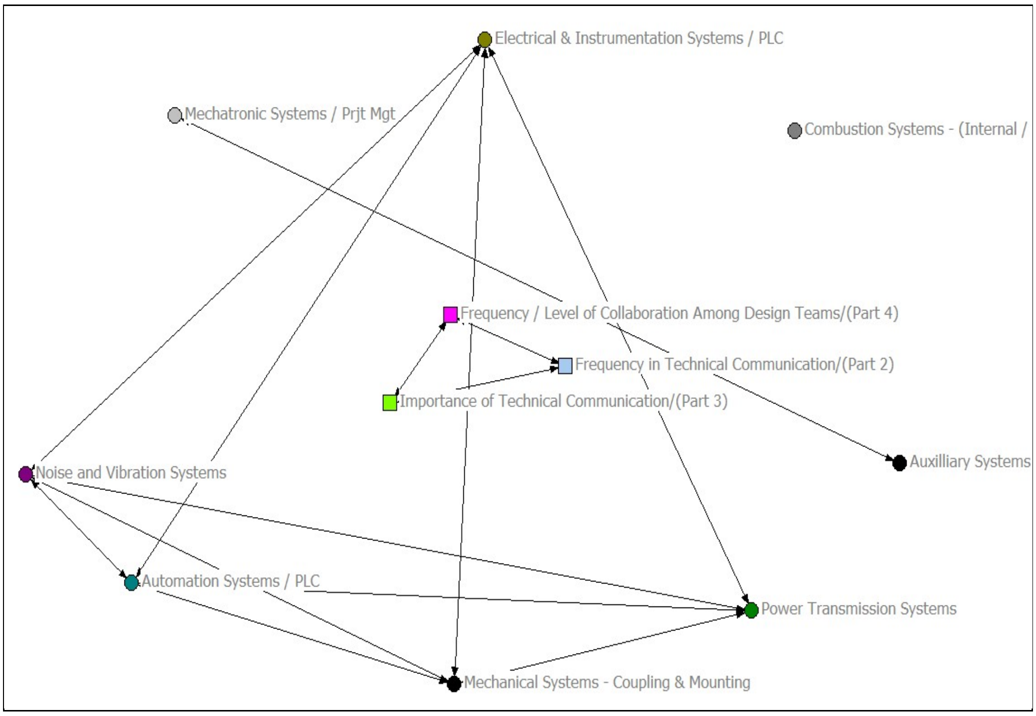


Figure 45. UCINet 6 Simulator – Hybrid Category 32 SP Engine - System Design Teams Technical Communication Simulation (Harmonic Closeness Analysis).

Figure 45 above, illustrates an UCINet 6 harmonic closeness analysis. This harmonic closeness analysis shows which of the nodes are harmonically close to each other beyond all odds, and why they are so. Thus, from Figure 45 above, the Mechatronic Systems node and auxiliary Systems nodes are harmonically closer than the others, while the Noise and Vibration System, Automation Systems, Mechanical Systems – Coupling & Mounting System and Power transmission Systems is another cluster of linked / tied nodes, which is shown to be harmonically close as illustrated in Figure 45 above. This implies in a real-life enterprise-manufacturing environment that system-design teams are most likely or mainly harmonically close in the concurrent or collaborative system design activities in complex engineering-design and delivery PD processes. However, one very significant observation is still the isolative nature of the Combustion Systems node even in the harmonic closeness analysis.

This indicates that the Combustion Systems node is the most independent node among all. This, analysis could be validated in a real-life enterprise manufacturing environment. In a real-life enterprise manufacturing environment, as in the case of this research's case study; a ship power engine could be designed and assembled or manufactured and then have the Combustion System (i.e. the exhaust) chosen and easily interfaced with the main product based on the calculation of the engine capacity. Alternatively, an exhaust could be designed separately for the engine, based on the calculated engine capacity.

4.2.4 Research Hypotheses and Analysis

Inferential statistics are employed to test hypotheses about systems-design teams' technical communication analysis in frequency, importance, collaboration, scale of mutual trust, level of roles and responsibility as well as the generic difference or relationships in populations based on measurements made on samples. Therefore, inferential statistics in this research could enable the research to discover any difference or relationship between system-design teams' technical communication in new/complex product development and support processes in real-time. This understanding could be used to enhance just-in-time (JIT) product development, leaner product development lead-time and also enhance customer satisfaction to make industrial competitive advantage sustainable.

On this note, it is obvious that one of the goals of psychological science research in an industrial organization perspective is to understand human behaviour in terms of relationship or difference in technical communication. However, in order to attain a clearer understanding of the technical communication direction or information, the communication network should be free from ambiguity. In some literature, descriptive statistics is used as one of the bridges between measurement and understanding. With a data set and array of research questions to test three hypotheses, this section of the research turns to both describe and also make inferences about the inferential statistical analysis results. This section of the research also, describes the data, finds reliable differences or relationships, and recommend value adding reliable findings based on the pilot industrial case studies.

In order to attain validated results and also make a substantive contribution to the body of knowledge, ten structured questions tailored into five specific parts were formed into a well-structured closed-end questionnaire to collect the data and information needed from the research's industrial partners *(i.e., their product development systems-design teams in their SCM section). Please see Appendixes B - D from pages 219 – 242 for more details.*

Table 27. Summaries of Hypothesis Testing

#	Hypothesis	Results
H_1	The more frequent the collaboration in design teams' concurrent communication interface, the more efficient the real time quality data/information made available for effective customer satisfaction and industrial engineering management.	Supports the Hypothesis Analysis
H_2	The stronger the 'mutual trust' among the various design team members, the more significant and relevant the various design teams' concurrent communication interface issues are resolved.	Supports the Hypothesis Analysis
H_3	The more effective and efficient design teams' roles and responsibility are identified in concurrently communicating technical data/information the better the enterprise industrial manufacturing systems' integration.	Supports the Hypothesis Analysis

**Correlation is significant at the 0.01 level (1-tailed). $p > 0.01$

*Correlation is significant at the 0.05 level (1-tailed). $p > 0.05$

Employing correlation analysis in this section of the research is essential to derive the scale or level of relativity or correlation between the various variables pertaining to technical communication among the system design teams studied during this research. Although there are certainly many types of statistical correlation analysis, Pearson's (r), as it is often symbolized, can have a value anywhere between -1 and 1 (i.e., -1, 0, 1). The larger (r), irrespective which sign it carries, the stronger the association between the two variables and the more accurately one can predict one variable from knowledge of the other variable. At its extreme, a correlation of 1 or -1 means that the two variables are perfectly correlated, meaning that the values of one variable could be predicted from the values of the other variable with perfect accuracy. At the other extreme, if an (r) is equal to zero, it implies the absence of a correlation. Thus, in that situation, there is no relationship between the two variables.

Table 28. Statistical Correlation Analysis (Pearson [r] Correlation).

Correlations

		Frequency in Technical Communication (Part 2)	Importance of Technical Communication (Part 3)	Frequency / Level of Collaboration Among Design Teams (Part 4)	Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
Frequency in Technical Communication (Part 2)	Pearson Correlation	1	.834**	.834**	-.602	.209	.361	-.602	.162	.552
	Sig. (1-tailed)		.005	.005	.057	.310	.190	.057	.351	.078
	N	8	8	8	8	8	8	8	8	8
Importance of Technical Communication (Part 3)	Pearson Correlation	.834**	1	1.000**	-.577	.500	.000	-.577	.516	.000
	Sig. (1-tailed)	.005		.000	.067	.104	.500	.067	.095	.500
	N	8	8	8	8	8	8	8	8	8
Frequency / Level of Collaboration Among Design Teams (Part 4)	Pearson Correlation	.834**	1.000**	1	-.577	.500	.000	-.577	.516	.000
	Sig. (1-tailed)	.005	.000		.067	.104	.500	.067	.095	.500
	N	8	8	8	8	8	8	8	8	8
Scale / Level of Mutual Trust (Part 5a) Low	Pearson Correlation	-.602	-.577	-.577	1	-.577	-.333	1.000**	-.745*	-.218
	Sig. (1-tailed)	.057	.067	.067		.067	.210	.000	.017	.302
	N	8	8	8	8	8	8	8	8	8
Scale / Level of Mutual Trust (Part 5a) Average	Pearson Correlation	.209	.500	.500	-.577	1	-.577	-.577	.775*	-.378
	Sig. (1-tailed)	.310	.104	.104	.067		.067	.067	.012	.178
	N	8	8	8	8	8	8	8	8	8
Scale / Level Mutual Trust (Part 5a) High	Pearson Correlation	.361	.000	.000	-.333	-.577	1	-.333	-.149	.655*
	Sig. (1-tailed)	.190	.500	.500	.210	.067		.210	.362	.039
	N	8	8	8	8	8	8	8	8	8
Scale / Level of Roles & Responsibility (Part 5b) Low	Pearson Correlation	-.602	-.577	-.577	1.000**	-.577	-.333	1	-.745*	-.218
	Sig. (1-tailed)	.057	.067	.067	.000	.067	.210		.017	.302
	N	8	8	8	8	8	8	8	8	8
Scale / Level of Roles & Responsibilities (Part 5b) Average	Pearson Correlation	.162	.516	.516	-.745*	.775*	-.149	-.745*	1	-.488
	Sig. (1-tailed)	.351	.095	.095	.017	.012	.362	.017		.110
	N	8	8	8	8	8	8	8	8	8
Scale / Level of Roles & Responsibilities (Part 5b) High	Pearson Correlation	.552	.000	.000	-.218	-.378	.655*	-.218	-.488	1
	Sig. (1-tailed)	.078	.500	.500	.302	.178	.039	.302	.110	
	N	8	8	8	8	8	8	8	8	8

**. Correlation is significant at the 0.01 level (1-tailed).
*. Correlation is significant at the 0.05 level (1-tailed).

Correlation is significant at the 0.01 level (1-tailed). ***p* > *0.01*
*Correlation is significant at the 0.05 level (1-tailed). ***p* > *0.05***

Table 29. Measures of Association among Variables.

Measures of Association

	R	R Squared	Eta	Eta Squared
Scale / Level of Mutual Trust (Part 5a) Low * Frequency in Technical Communication (Part 2)	-.602	.362	.683	.467
Scale / Level of Mutual Trust (Part 5a) Average * Frequency in Technical Communication (Part 2)	.209	.043	.387	.150
Scale / Level Mutual Trust (Part 5a) High * Frequency in Technical Communication (Part 2)	.361	.130	.365	.133
Scale / Level of Roles & Responsibility (Part 5b) Low * Frequency in Technical Communication (Part 2)	-.602	.362	.683	.467
Scale / Level of Roles & Responsibilities (Part 5b) Average * Frequency in Technical Communication (Part 2)	.162	.026	.554	.307
Scale / Level of Roles & Responsibilities (Part 5b) High * Frequency in Technical Communication (Part 2)	.552	.304	.655	.429

This implies that the knowledge of one variable gives absolutely no information about what the value of the other variable is likely to be. The sign of the correlation implies the "direction" of the association. A positive correlation means that relatively high scores for one variable are paired with relatively high scores on the other variable, and low scores are paired with relatively low scores. On the other hand, a negative correlation means that relatively high scores for one variable are paired with relatively low scores on the other variable.

H_1 ≈ The more frequent the collaboration in design teams' concurrent communication interface, the more efficient the real time quality data/information made available for effective customer satisfaction and industrial engineering management.

Table 30. Frequency, Collaboration and Importance in Technical Communications among System Design Teams Correlation (Pearson [r]).

		Frequency in Technical Communication (Part 2)	Importance of Technical Communication (Part 3)	Frequency / Level of Collaboration Among Design Teams (Part 4)
Frequency in Technical Communication (Part 2)	Pearson Correlation	1	.834**	.834**
	Sig. (1-tailed)		.005	.005
	N	8	8	8
Importance of Technical Communication (Part 3)	Pearson Correlation	.834**	1	1.000**
	Sig. (1-tailed)	.005		.000
	N	8	8	8
Frequency / Level of Collaboration Among Design Teams (Part 4)	Pearson Correlation	.834**	1.000**	1
	Sig. (1-tailed)	.005	.000	
	N	8	8	8
Scale / Level of Mutual Trust (Part 5a) Low	Pearson Correlation	-.602	-.577	-.577
	Sig. (1-tailed)	.057	.067	.067
	N	8	8	8
Scale / Level of Mutual Trust (Part 5a) Average	Pearson Correlation	.209	.500	.500
	Sig. (1-tailed)	.310	.104	.104
	N	8	8	8
Scale / Level Mutual Trust (Part 5a) High	Pearson Correlation	.361	.000	.000
	Sig. (1-tailed)	.190	.500	.500
	N	8	8	8
Scale / Level of Roles & Responsibility (Part 5b) Low	Pearson Correlation	-.602	-.577	-.577
	Sig. (1-tailed)	.057	.067	.067
	N	8	8	8
Scale / Level of Roles & Responsibilities (Part 5b) Average	Pearson Correlation	.162	.516	.516
	Sig. (1-tailed)	.351	.095	.095
	N	8	8	8
Scale / Level of Roles & Responsibilities (Part 5b) High	Pearson Correlation	.552	.000	.000
	Sig. (1-tailed)	.078	.500	.500
	N	8	8	8

Correlation is significant at the 0.01 level (1-tailed). ***$p > 0.01$*
*Correlation is significant at the 0.05 level (1-tailed). ***$p > 0.05$***

H₂ ≈ The stronger the 'mutual trust' among the various design team members, the more significant and relevant the various design teams' concurrent communication interface issues are resolved.

Table 31. Scale / Level of Mutual Trust among System Design Teams Correlation.

		Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High
Frequency in Technical Communication (Part 2)	Pearson Correlation	-.602	.209	.361
	Sig. (1-tailed)	.057	.310	.190
	N	8	8	8
Importance of Technical Communication (Part 3)	Pearson Correlation	-.577	.500	.000
	Sig. (1-tailed)	.067	.104	.500
	N	8	8	8
Frequency / Level of Collaboration Among Design Teams (Part 4)	Pearson Correlation	-.577	.500	.000
	Sig. (1-tailed)	.067	.104	.500
	N	8	8	8
Scale / Level of Mutual Trust (Part 5a) Low	Pearson Correlation	1	-.577	-.333
	Sig. (1-tailed)		.067	.210
	N	8	8	8
Scale / Level of Mutual Trust (Part 5a) Average	Pearson Correlation	-.577	1	-.577
	Sig. (1-tailed)	.067		.067
	N	8	8	8
Scale / Level Mutual Trust (Part 5a) High	Pearson Correlation	-.333	-.577	1
	Sig. (1-tailed)	.210	.067	
	N	8	8	8
Scale / Level of Roles & Responsibility (Part 5b) Low	Pearson Correlation	1.000**	-.577	-.333
	Sig. (1-tailed)	.000	.067	.210
	N	8	8	8
Scale / Level of Roles & Responsibilities (Part 5b) Average	Pearson Correlation	-.745*	.775*	-.149
	Sig. (1-tailed)	.017	.012	.362
	N	8	8	8
Scale / Level of Roles & Responsibilities (Part 5b) High	Pearson Correlation	-.218	-.378	.655*
	Sig. (1-tailed)	.302	.178	.039
	N	8	8	8

**Correlation is significant at the 0.01 level (1-tailed). $\boldsymbol{p > 0.01}$
*Correlation is significant at the 0.05 level (1-tailed). $\boldsymbol{p > 0.05}$

H3 ≈ The more effective and efficient design teams' roles and responsibility are identified in concurrently communicating technical data/information the better the enterprise industrial manufacturing systems' integration.

Table 32. Scale / Level of Roles and Responsibility among System Design Teams Correlation.

		Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
Frequency in Technical Communication (Part 2)	Pearson Correlation	-.602	.162	.552
	Sig. (1-tailed)	.057	.351	.078
	N	8	8	8
Importance of Technical Communication (Part 3)	Pearson Correlation	-.577	.516	.000
	Sig. (1-tailed)	.067	.095	.500
	N	8	8	8
Frequency / Level of Collaboration Among Design Teams (Part 4)	Pearson Correlation	-.577	.516	.000
	Sig. (1-tailed)	.067	.095	.500
	N	8	8	8
Scale / Level of Mutual Trust (Part 5a) Low	Pearson Correlation	1.000**	-.745*	-.218
	Sig. (1-tailed)	.000	.017	.302
	N	8	8	8
Scale / Level of Mutual Trust (Part 5a) Average	Pearson Correlation	-.577	.775*	-.378
	Sig. (1-tailed)	.067	.012	.178
	N	8	8	8
Scale / Level Mutual Trust (Part 5a) High	Pearson Correlation	-.333	-.149	.655*
	Sig. (1-tailed)	.210	.362	.039
	N	8	8	8
Scale / Level of Roles & Responsibility (Part 5b) Low	Pearson Correlation	1	-.745*	-.218
	Sig. (1-tailed)		.017	.302
	N	8	8	8
Scale / Level of Roles & Responsibilities (Part 5b) Average	Pearson Correlation	-.745*	1	-.488
	Sig. (1-tailed)	.017		.110
	N	8	8	8
Scale / Level of Roles & Responsibilities (Part 5b) High	Pearson Correlation	-.218	-.488	1
	Sig. (1-tailed)	.302	.110	
	N	8	8	8

Correlation is significant at the 0.01 level (1-tailed). ***$p > 0.01$*
*Correlation is significant at the 0.05 level (1-tailed). ***$p > 0.05$***

Table 33. Statistics Report Analysis

Statistics

		Frequency in Technical Communication (Part 2)	Importance of Technical Communication (Part 3)	Frequency / Level of Collaboration Among Design Teams (Part 4)	Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
N	Valid	8	8	8	8	8	8	8	8	8
	Missing	0	0	0	0	0	0	0	0	0
Mean		2.13	2.00	2.00	.25	1.00	.75	.25	1.25	.38
Std. Error of Mean		.227	.189	.189	.164	.378	.491	.164	.366	.375
Median		2.00	2.00	2.00	.00	1.00	.00	.00	2.00	.00
Mode		2	2	2	0	0[a]	0	0	2	0
Std. Deviation		.641	.535	.535	.463	1.069	1.389	.463	1.035	1.061
Skewness		-.068	.000	.000	1.440	.000	1.440	1.440	-.644	2.828
Std. Error of Skewness		.752	.752	.752	.752	.752	.752	.752	.752	.752
Kurtosis		.741	3.500	3.500	.000	-2.800	.000	.000	-2.240	8.000
Std. Error of Kurtosis		1.481	1.481	1.481	1.481	1.481	1.481	1.481	1.481	1.481
Minimum		1	1	1	0	0	0	0	0	0
Maximum		3	3	3	1	2	3	1	2	3
Sum		17	16	16	2	8	6	2	10	3

a. Multiple modes exist. The smallest value is shown

Table 34. Descriptive Statistics Analysis

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	Percentiles 50th (Median)	Percentiles 75th
Frequency in Technical Communication (Part 2)	8	2.13	.641	1	3	2.00	2.00	2.75
Importance of Technical Communication (Part 3)	8	2.00	.535	1	3	2.00	2.00	2.00
Frequency / Level of Collaboration Among Design Teams (Part 4)	8	2.00	.535	1	3	2.00	2.00	2.00
Scale / Level of Mutual Trust (Part 5a) Low	8	.25	.463	0	1	.00	.00	.75
Scale / Level of Mutual Trust (Part 5a) Average	8	1.00	1.069	0	2	.00	1.00	2.00
Scale / Level Mutual Trust (Part 5a) High	8	.75	1.389	0	3	.00	.00	2.25
Scale / Level of Roles & Responsibility (Part 5b) Low	8	.25	.463	0	1	.00	.00	.75
Scale / Level of Roles & Responsibilities (Part 5b) Average	8	1.25	1.035	0	2	.00	2.00	2.00
Scale / Level of Roles & Responsibilities (Part 5b) High	8	.38	1.061	0	3	.00	.00	.00

Descriptive statistics describe patterns in which the general trend in a data set is analysed. In most cases, descriptive statistics are used to examine or explore one variable at a time.

However, the relationship between two variables can also be described, as with correlation and regression**.** In this case, the descriptive statistical analysis in Table 34 above, captures the sample size of the systems-design teams' (N), the mean, standard deviation calculations, the maximum and minimum scale as well the percentiles.

Table 35. Autocorrelations Analysis - Frequency in Technical Communication (Part 2)**.**

Autocorrelations

Series: Frequency in Technical Communication (Part 2)

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic		
			Value	df	Sig.[b]
1	-.002	.296	.000	1	.993
2	-.356	.274	1.690	2	.430
3	.195	.250	2.300	3	.512
4	-.001	.224	2.300	4	.681
5	-.342	.194	5.419	5	.367
6	.006	.158	5.421	6	.491

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic chi-square approximation.

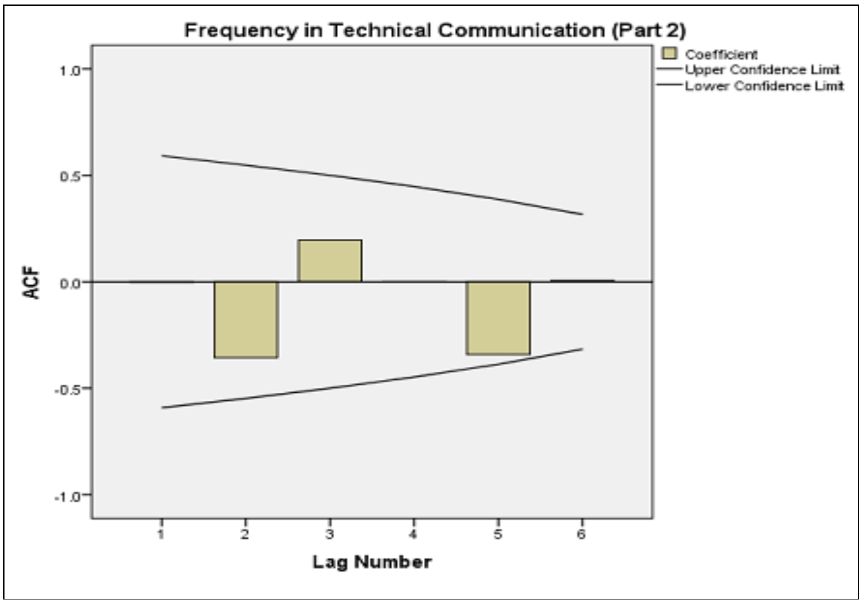


Figure 46. Autocorrelations Analysis Graph - Frequency in Technical Communication (Part 2).

Table 36. Autocorrelations Analysis - Importance of Technical Communication (Part 3).

Autocorrelations

Series: Importance of Technical Communication (Part 3)

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic		
			Value	df	Sig.[b]
1	-.018	.296	.004	1	.951
2	-.424	.274	2.401	2	.301
3	.017	.250	2.406	3	.493
4	-.008	.224	2.407	4	.661
5	-.033	.194	2.436	5	.786
6	-.035	.158	2.486	6	.870

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic chi-square approximation.

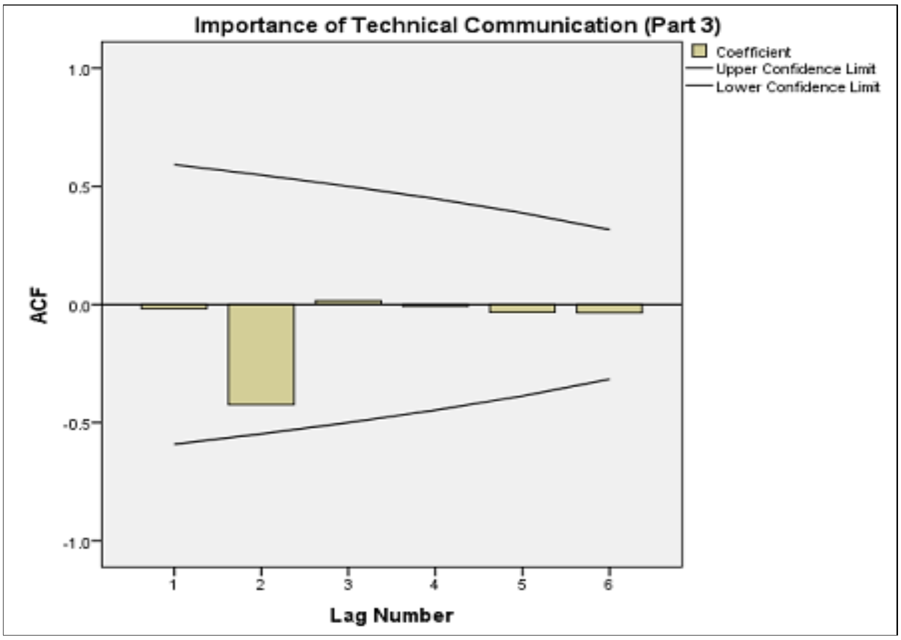


Figure 47. Autocorrelations Analysis Graph - Importance of Technical Communication (Part 3).

Table 37. Autocorrelations Analysis - Frequency / Level of Collaboration among Design Teams (Part 4).

Autocorrelations

Series: Frequency / Level of Collaboration Among Design Teams (Part 4)

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic		
			Value	df	Sig.[b]
1	-.018	.296	.004	1	.951
2	-.424	.274	2.401	2	.301
3	.017	.250	2.406	3	.493
4	-.008	.224	2.407	4	.661
5	-.033	.194	2.436	5	.786
6	-.035	.158	2.486	6	.870

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic chi-square approximation.

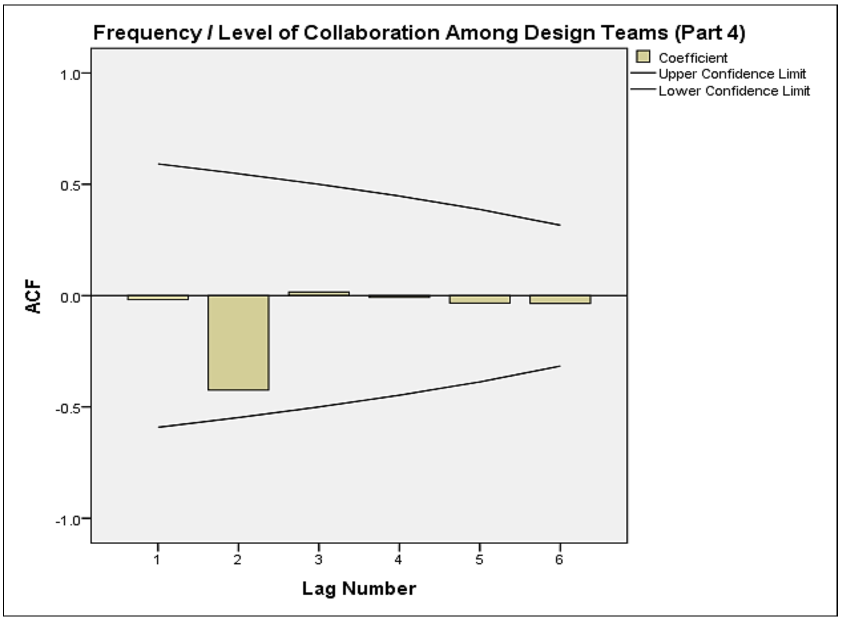


Figure 48. Autocorrelations Analysis Graph - Frequency / Level of Collaboration among Design Teams (Part 4).

Frequency distributions are a way of displaying the chaos of numbers (in the case of this research system design teams' technical communication correlation analysis) in an organised manner so that the technical design communication discrepancies could be addressed easily. A frequency distribution is simply a table that, at a minimum, displays how many times in a data set each response or "score" occurs. A good frequency distribution will display more information than this, although with just this minimum information; many other bits of information can be computed. Frequency distributions usually display information from top to bottom; with the scores in either ascending or descending order as illustrated in Tables 28 to 37 *at pages 130 - 138*; IBM SPSS 20.0, displays the data in ascending order unless it has been programmed otherwise.

The following section provides a further collaborative analysis of the findings and results of the methods elaborated in this chapter. Hence, it details the significance of the findings and results by using the methods elaborated in this chapter to propose feasible solutions to the research questions outlined in section 1.2: sub-section *1.2.1 at page 15 above*. It further proceeds to summarize the essence of this research's case feasibility and validation as per the findings and simulation results presented throughout this chapter. In summary, it provides a detailed research project-plan of how the proposed complex product-development conceptual framework for enterprise manufacturing SCM network output of this applied research is feasibly achievable in a real-life industrial SCM network perspective.

4.3 Proposed Conceptual Framework for Concurrent Enterprise SCM Network Activities

4.3.1 Analysing the Case Construct(s) and Discussions (RQ.4)

RQ.4) How can enterprise SCM networks create a concurrent collaborative enterprise mentality and approach? *(Fighting the not-invented-here syndrome)*

Industrial enterprise organizations are continually undergoing a revolution in terms of improving and efficiently enhancing their operations, strategies as well employing state-of-the-art technologies in response to the challenges and demands of this twenty-first century. Manufacturing enterprises in this twenty-first century have to overcome the challenges of satisfying the demand of customers for products of a high quality but low price, significantly reduced lead-time on their product's time-to-market as well as maximizing their return on investment (ROI).

To achieve this, industrial enterprises need to be responsive to customers' unique and rapidly changing needs while meeting their internal and external challenging needs of the supply-chain management (SCM) network. By making complex engineering-design and delivery of complex product development information or data available and accessible to all the SC partners or stakeholders on the network in real-time. As already extensively elaborated in some of the earlier chapters and sections of this research report, Concurrent Enterprise (CE+) approach is employing the "best practice" methodologies of Concurrent Engineering, in effective collaboration with systems-application process enablers and tools of SCM Enterprise Resource Planning (ERP) systems. To enhance a sustainable industrial competitive advantage of enterprise manufacturing SCM networks. This conceptual approach has been studied (Al-Ashaab, et al., 2013), feasibly evaluated and validated by employing industrial pilot case study approach in this research report.

4.3.2 The Proposed Conceptual Framework for a Concurrent Enterprise SCM Network Actives

Supply-chain management (SCM) has been considered as the most popular operations' strategy for improving industrial organizations and global enterprise competitiveness in this twenty-first century (Gunasekaran, et al. 2007). Also Enterprise resource planning (ERP) systems are highly complex information systems (Umble et al., 2003), which when efficiently employed to provide two major benefits that do not exist in non-integrated departmental systems: (1) a unified enterprise view of the business that encompasses all functions and departments; and (2) an enterprise database where all business transactions are entered, recorded, processed, monitored, and reported as well as made available and assessable to partners *(i.e. supply chain partners or stakeholders)* (Musa, et al., 2013).

Figure 49 below, illustrates in broad terms the big-picture of the proposed conceptual framework CE+ SCM network in this research report. In recent times, it has become essentially necessary for industrial enterprises to increase their unified view on their requirement for interdepartmental cooperation and coordination both within the industrial organization structure and its extended global enterprise SC network (Musa, et al., 2013; Maier, et al., 2008; Plex White Paper 2013; 2012; Puvanasvaran, et al., 2009). Moreover, this also enables industries to achieve their objectives of enhanced communication network (i.e., technical and/or service) and responsiveness to all partners or stakeholders (Maier, et al., 2008; Dillon, 1999; Puvanasvaran, et al., 2009).

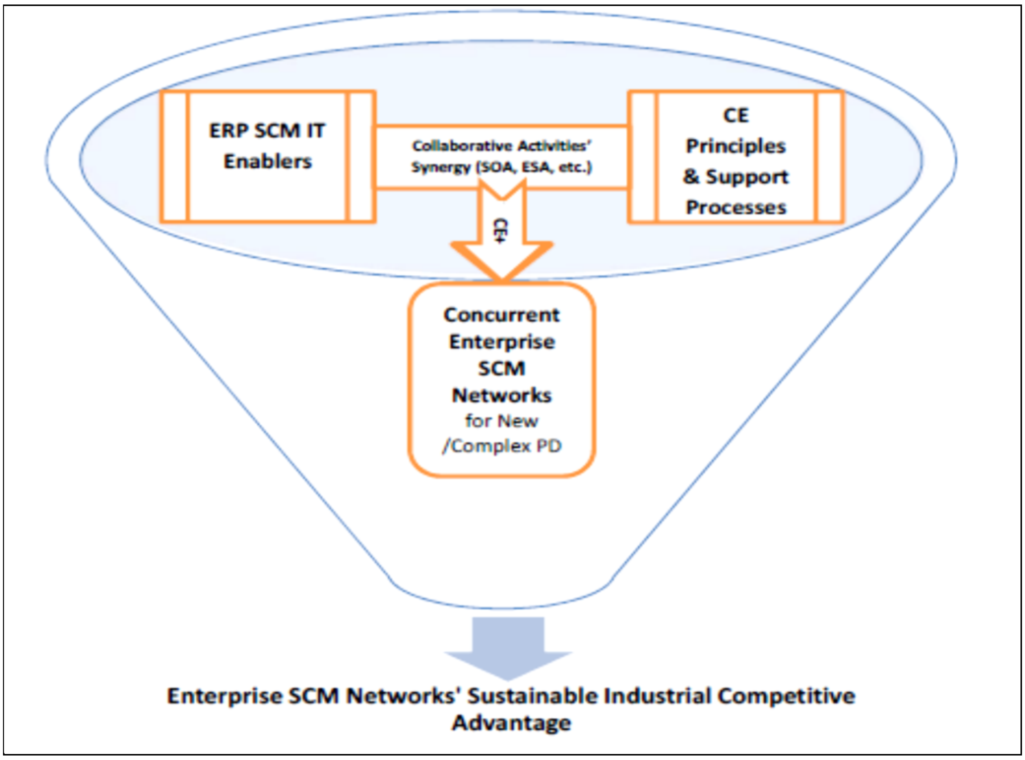


Figure 49. Big Picture Analysis - Proposed Conceptual Framework for a Concurrent Enterprise SCM Network.

Furthermore, Concurrent engineering (CE) in this sense, is an engineering management philosophy. Thus, CE a set of operating principles that guide a product-development process through an accelerated successful completion by bringing all the multidisciplinary teams involved throughout the development of a complex product together on a common or single operating platform (Al-Ashaab and Molina, 2000; Gardoni, 2005; Duffy and Salvendy, 2003; Fernandez, et al., 2005). The overall CE philosophy rests on a single, but powerful, "best practice" principle that promotes the incorporation of the SC downstream concerns into the SC upstream phases of a development process through effective interconnection with the SC intermediate-stream (Cooper and Edgett, 2003). This would lead to shorter development times, improved product quality, and lower development–production costs. Concurrent engineering is concerned with the timely availability of critical design information for all product-development participants. For the most complex engineering-design and delivery tasks, not all relevant information required by a specific product development team can be completely available from the start of that task. Therefore, CE requires the maximization of such information / data and the ability to share and communicate useful information / data on a timely basis (Yassine and Braha, 2003; Maier, et al. 2008; Puvanasvaran, et al., 2009). Therefore, there is an imminent need for SCM enterprise resource planning IT enablers in CE complex product-development processes to enable strategic collaboration between these two streams to achieve the expected output proposed in this research report.

In an attempt to analyse and discuss thoroughly the research question, driving the case, construct at this section of the research: How can enterprise SCM networks create a concurrent collaborative enterprise mentality and approach? *(Fighting the not-invented-here syndrome).* The remainder of the report on this case construct analysis, and discussion is as follows: *4.3.3* - Research significance. Thus, the significance of this research to industry and research academia – contribution to the body of knowledge and *4.3.4* Feasibility, evaluation and validation discussion. Thus its capability to do away with the common enterprise industrial norm of "the not-invented-here syndrome." Moreover, how the proposed solutions to the RQs.1, 2 and 3 have contributed to RQ. 4; realising the proposed conceptual framework for CE+ SCM networks, and how replicable it could be in similar or other industrial enterprise manufacturing SCM settings.

4.3.3 Significance of the Proposed Conceptual Framework for a Concurrent Enterprise SCM Network Activity Analysis

Enterprise industrial manufacturers are seriously exploring a competitive and sustainable potential of enterprise supply-chain management (SCM) to improve their SC network operations and activities. Hence, essential elements of their operational activities such as their design technical communication, real-time availability and accessibility of information as well as an increase in their revenue growth all contributes to the expected competitive advantage. In particular, they are sought to develop a concurrent enterprise supply-chains management for their manufacturing SC network activities. In order to get their product to market faster at a minimum total cost. Therefore, effective CE+ SCM is an essential strategy for success in the global and e-markets. Industrial CE+ SCM incorporates the entire exchange of information / data and movement of goods between suppliers (upstream) and ends customers (downstream), including the industrial enterprise manufacturers (intermediate stream), distributors, retailers, and any other enterprises within the extended SC – *Third-Party Logistics Companies (3PLC)*.

Concurrent engineering (CE) for new/complex product development (N/CPD) (agile manufacturing) gained momentum and received enormous attention from both researchers and practitioners in the early 1990s, and enterprise resource planning (ERP) supply-chain management (SCM) systems began to attract interest in the mid-1990s (Gunasekaran, et al. 2006). Both Concurrent Engineering for new/complex product-development processes and ERP systems - SCM appeared to differ in philosophical emphasis, but each complements the other in objectives for improving industrial organizational manufacturing competitiveness. While CE – product development (PD) - agile manufacturing places more emphasis on strategic SC network partnerships and teamwork (i.e., virtual enterprise environment) to achieve speed and flexibility; the concerns of cost and the integration / interfacing of suppliers and customers have not been given due consideration within the CE – PD agile manufacturing process. However, in contrast, cost gets greater attention in ERP systems - SCM, which focuses on the integration of suppliers, the industrial manufacturers and customers to achieve an integrated value-chain with the help of information technology enablers and system models / framework.

Therefore, with a keen objective of developing a conceptual concurrent enterprise framework for an enterprise industrial manufacturing SC value-adding network, the strategic collaborative approach of industrial enterprise manufacturing significance of both Concurrent Engineering (N/CPD) – (agile manufacturing) and the Enterprise Resource Planning (ERP) systems - SCM for enterprise industrial manufacturers turn to provide the right environment. This approach enables them to improve their performance; competitiveness and sustainability *(please see Figure 49 above at page 142 for details).* In recent times, there has been an upsurge of academic and commercial interest in enterprise manufacturing product-development visibility (Musa, et al. 2013; Plex White Paper, 2013). This interest has translated into numerous architectures, technologies and software for product development visibility, both at the atomic (item) and composite (or aggregate) levels. This keen interest is the basis for this research's applied industrial pilot case study approach, to investigate real-time solutions to some of these key industrial enterprise manufacturing SCM issues in a real-life industrial pilot case (Esposito and Evangelista, 2014).

Furthermore, based on extensive studies on academic journals and articles as well as trade literature, including databases, websites and documents of systems technology vendors and users of the technologies, this research captured, analysed, compared and contrasted enterprise industrial technologies and system model choices, essence, results and the trend of potential future impacts of some of the recent state-of-the-art developments. End-to-end supply-chain product-development visibility *(i.e., product tracking and tracing)* have been explored as a means of product-development visibility security and SC network operational process control. This approach turns to optimise the SCM network activities of many enterprises within the industrial SC sectors. This ranges from manufacturing, transportation, aviation, healthcare down to distribution and retailing of industrial products not forgetting agriculture and food distribution security (Hsu & Wallace, 2007; Hsu et al. 2011; Lee & Özer, 2007; Bottani & Rizzi, 2008; Lee & Lee, 2010 and 2012; MAFF Japan, 2003). The recent ongoing rapid developments in the evolution of communication, information and localisation technologies together with the digitisation of global or public infrastructures in this era has led to the "Internet of things" (IoT). These have also ushered in several methods, systems architectures, various models or frameworks, etc., for achieving visibility of product's development / introduction across enterprise industrial manufacturing supply-chains (Aberdeen Group, 2012; Plex White Paper, 2012; Musa, et al. 2013).

On the above notes, the key significance of this research is to propose a feasible collaborative Concurrent Engineering and Enterprise Resource Planning enterprise (Concurrent Enterprise) manufacturing SCM conceptual framework. This collaborative approach is, in order to enhance a sustainable industrial competitive advantage, which could be, applicable largely in other industrial SCM sectors in this digital globalization era. This Concurrent Enterprise conceptual framework will attempt to resolve real-life enterprise industrial manufacturing SCM network issues' outline as the basis for this research. They are such as the following:

- Multi-discipline teams, made up of different divisions of a manufacturing enterprise SCM, and from different departments work together effectively: This promotes the idea of all stakeholders on a new-product development / introduction SC network coming together to work from a common platform that allows and enhances effective communication and information flow and exchange between stakeholders on the SC network. In turn, this cuts waste in terms of shortening product development lead-time *(which, in other words, makes the SC network activities greener)* as well as maximizing the return on investment (Hsu & Wallace, 2007; Shah, and Shin, 2007).

- Management information systems (MIS) used efficiently and effectively in an enterprise-manufacturing sector in order to, strategically improve their SCM for efficient new-product introduction and development: This makes the SC network much more extendable, integratable and interfacable in real-time. It makes enterprise SC network activities more visible for a sustainable industrial competitive advantage (Hsu & Wallace, 2007; Rai et al. 2006; Lee & Whang, 2000; Li, 2000; Hult et al. 2004; Cai et al. 2006; Shah & Shin, 2007).

- A product's changing parameters and elements in new/complex product-developments systems-design, communicated effectively and efficiently within an enterprise manufacturing supply-chain network: Thus, the first step for approaching any system-level configuration is efficient and effective technical communication among systems-design teams on the SC network, bearing in mind the essential customer requirements. Therefore, it is anticipated that the right information or data communicated at the right time, to the right place will help eliminate "white spots." It has been discovered from previous research that, most of the main product-development issues are at the product engineering-design level which is responsible for a large proportion of the lead-time (Maier, et al., 2008; Addo-Tenkorang, and Eyob, 2012; Sosa, et al., 2002).

Therefore, this research attempts to justify these output significances by seeking to find formidable & viable solutions to the imminent enterprise manufacturing SCM issues posed in the research questions above at *sub-section 1.2.1 - page 15*, which includes:

- To a proposed conceptual framework for CE+ SCM, network activities to enhance a sustainable industrial competitive advantage. Hence, to build on or propose a much viable competitive & sustainable industrial networked value systems-architecture. That thrives on value-adding CE+ SCM network system with a theoretical underpinning in Organization theory.

- To build upon, and put together as many streams of research as possible in both NPD/I in industrial manufacturing SCM to enhance and also enrich the research area using scientific analytical tools such as DSM, SNT, etc., simulation methods as well as testing some three hypotheses with Pearson [r] correlation analysis.

4.3.4 Feasibly Evaluating and Validating the Proposed Conceptual Framework for a SCM Network Activities

In iterating the feasibility and validity of this research's proposed conceptual framework CE+ SCM network, the researcher conducted a real-life industrial pilot case study to ascertain its feasibility and also employed scientific evaluate and validate methods to simulate and analyse the collected empirical data and the findings. Furthermore, the researcher also designed a quantitative close-end questionnaire data-collection method to collect the extra data on systems-design teams' technical communication interactions, which were not expressly available for collection during the industrial pilot case study. Table 38 below outlines details of the case company employed in this research to affirm the subsequent evaluation and validation feasibility analysis.

Table 38. Research Case Example - Feasibility and Validation Details

Case Company	Global Leader in Manufacturing (OEM) & Operation Services
Type of Business	Ship Power, Power Plants, Energy Technologies, etc.
Global Representation	Represented in about / more than 70 countries globally
Market Segment	Have their ship power engine in every third ship globally
Suppliers Information	Over 280 Suppliers globally
Pilot Area of Case Study	Ship Power Engine Manufacturing SCM (Category 32)

The research industrial pilot case study ran in excess of three to four series of pilot cases with each case reflecting some improvements from the preceding case by including more variables to capture the required data / information needed for analysis as a feasible solution to one of the research questions outlined in the previous chapters in this report. Regular, technical and strategic operational meetings with senior industrial department directors, managers, project managers and engineering managers were held during the course of the pilot case study to ensure that the focus of the research remain intact and on track and that, the real industrial issues triggering or motivating the research were being addressed as the case study progressed.

Further, on in this research's attempt to validate the research's case and proposed conceptual framework, a real-life enterprise industrial pilot enterprise supply-chain management (e-SCM) network portal was introduced as a progression of the industrial pilot case study. This proposed conceptual framework portal, functions as Software-as-a-Service (SaaS) enterprise-solution approach according to the research gaps identified during the broad literature review and background study in this research. According to the finding in the broad literature review, SaaS is one of the most feasible and the enterprise systems-solution that, this research proposes. Because, it is cost-effective and easy to interface / integrate as an ERP business solution. Thus, it was employed in the conceptual framework systems-architecture in order to enable and enhance feasible enterprise co-ordination on the entire SC network. Therefore, providing a common platform where all the SC partners or stakeholders of a specific project at any particular time could transmit, and access data / information needed to enable and enhance their various activities on the SC network at real-time. These are; the benefits of the networked value-adding system proposed in this research's conceptual framework for CE+ SCM networks. A lot of other technical work such as software engineering work was conducted at the back-end of the e-SCM portal by initially adopting the SaaS function of Salesforce business solution and customizing it to suit the needs of this research approach.

Furthermore, a lot of web-resource application work has been employed to streamline and customize appropriately the front-end of the portal to show or reflect exactly what the proposed conceptual framework aimed to offer in the proposed research CE+ SCM network portal. A lot of ICT hardware and software were strategically matched, cordially integrated, interfaced, and progressively iterated to achieve the proposed CE+ SCM network portal framework, in order to, feasibly make it function as expected. In addition, the industrial partners in this research case scrutinized and evaluated the functional capabilities of this proposed conceptual framework CE+ SCM network portal. It is interestingly fulfilling that, they were satisfied with its solutions and have accordingly decided to prototype the implementation alongside their legacy systems and eventually roll-it-up live as soon as possible. A few of the CE+ SCM network portal screenshots taken during the industrial case study research are illustrated in Figures 50 – 54, below:

Classical Use-Case Scenario - (*Missing Handling Unit –HU)*: With more integrated data communication between SC partners and better tracking and tracing coverage, finding a "lost HU" should become easier. The track and trace system solution integrated in the portal will utilize the transport and third party logistics (3PLCs) companies and consolidation warehousing SC network partner as well as the suppliers' interfacing enterprise data-management systems (e-DMS) as sources of checkpoint data. The main portal is updated whenever an HU is loaded or offloaded and the location of the loading or offloading activity. If an HU is misplaced due to faulty markings, missing case label, transport error, warehouse misplacement or errors, etc., the search field is narrowed down to a specific area in the portal where the SC network activity was last updated. Figure 50 below, illustrates the different functions of the main portal screen in the adopted and customized Salesforce SaaS system to attempt to demonstrate the proposed conceptual framework scenario:

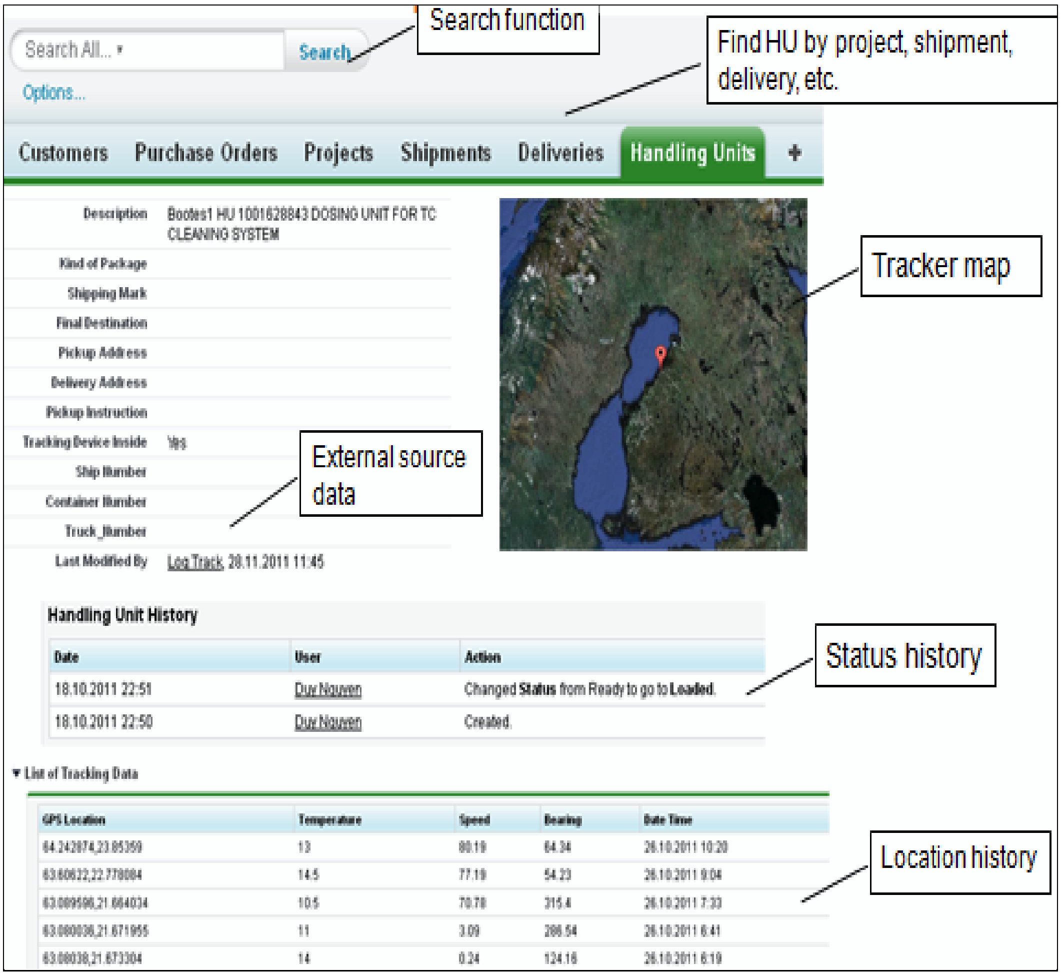


Figure 50. CE+ SCM Networks Activities Tracking - Portal GUI Snapshot.

Source: (*Unpublished LogTrack Final Project Report*)

Therefore, in the scenario where the delivery/project manager knows the HU number, the manager could go directly to the HU tab on the portal screen - either by using the search function or by browsing the HU list for the product as it appears on the screen. Furthermore, the portal could show any tracking data available, from a GPS tracking device data / information input, from the Transport

Company / (3PLC) or from the marine tracking service (IMO, etc.,). Thus, if the “show route” tab is clicked on the portal screen at the bottom part of the HU screen, the last updated location points and coordinates will be plotted on a map, a function of Google Earth with red lines connecting the route links.

Furthermore, if the delivery/project manager does not specifically know the missing HU number, the project/shipment/delivery tabs will allow browsing of all HUs under the shipments / deliveries' section on the portal screen. Thus, the custom ordering options under these tabs allow for a great amount of overview or SC network activity history – where an SC network partner could access as a back-up data / information for current or future product-development projects when needed. This means that the manager can easily pick out the HUs that have not yet been shipped but has actually been raising some project significant alert warnings over time. Proactive overview and product development visibility becomes possible, and the average problem solving time per product-development project is positively impacted.

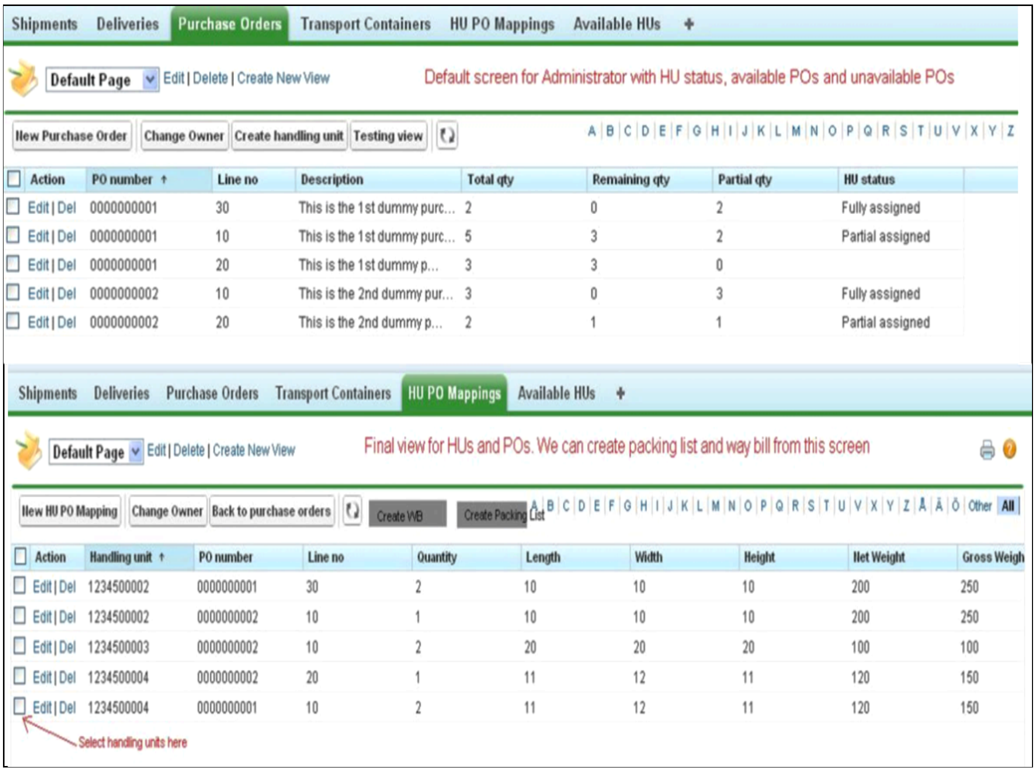


Figure 51. A Customized CE+ SCM Networks Activities GUI of Portal e-SCM DMS systems data / information integration snapshot.

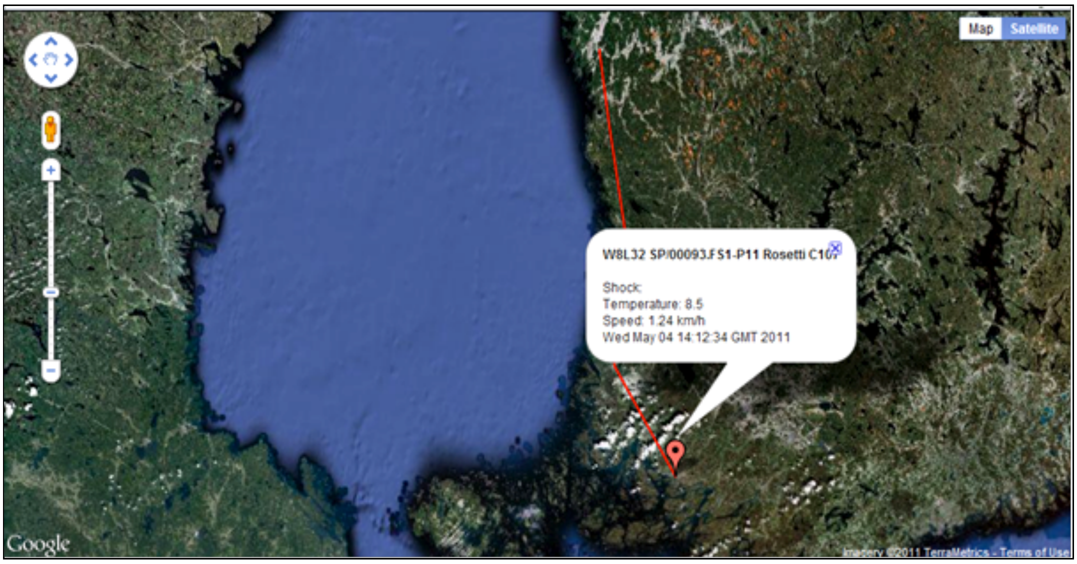


Figure 52. A graphical Google Earth CE+ SCM Networks Activities GUI customized Portal e-SCM DMS systems data integration snapshot – Road transport tracking visibility.

Figure 53. A graphical Google Earth CE+ SCM Networks Activities GUI customized Portal e-SCM DMS systems data integration snapshot – Vessel transport tracking visibility – discrepancies recorded.

Figures 53 above and 54 below, reveals yet another very interesting and significant benefit of this research by way of its unique customized design, functions and structure. The CE+ SCM network portal's benefit as part of the proposed conceptual framework's ability is enabling total visible on the enterprise SC networks in real-time. As illustrated in Figure 53 that, there was a record of shock; which implies that, either the HU has been slammed on the deck of the cargo vessel or has toppled outright on the deck. This slam or fall of the HU if heavy could cause serious damage. Hence, looking at Figure 54, it could be seen that, the HU has been taken off the deck of the vessel again and been sent through the testing Lab at the port to check for any abnormalities, which is the standard procedure or the right thing to do to avoid sending a defective product to the customer (Ship Yard). The benefit of this function is that, it reduces the insurance cost on products in transit, gives the SCM network partners good network activities visibility as well as increases the level of trust in providing quality products and services *(information and communication)* among the SC partners.

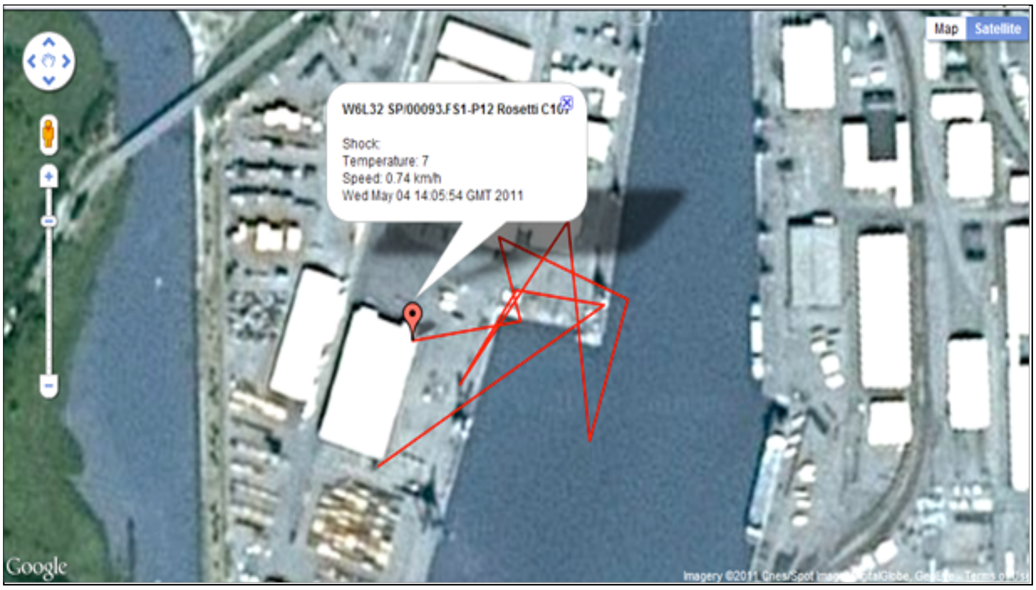


Figure 54. A graphical Google Earth CE+ SCM Networks Activities GUI customized Portal e-SCM DMS systems data integration snapshot – Vessel transport tracking visibility – recorded discrepancies resolved.

4.3.5 Systems-Architecture for the Proposed Concurrent Enterprise Conceptual Framework

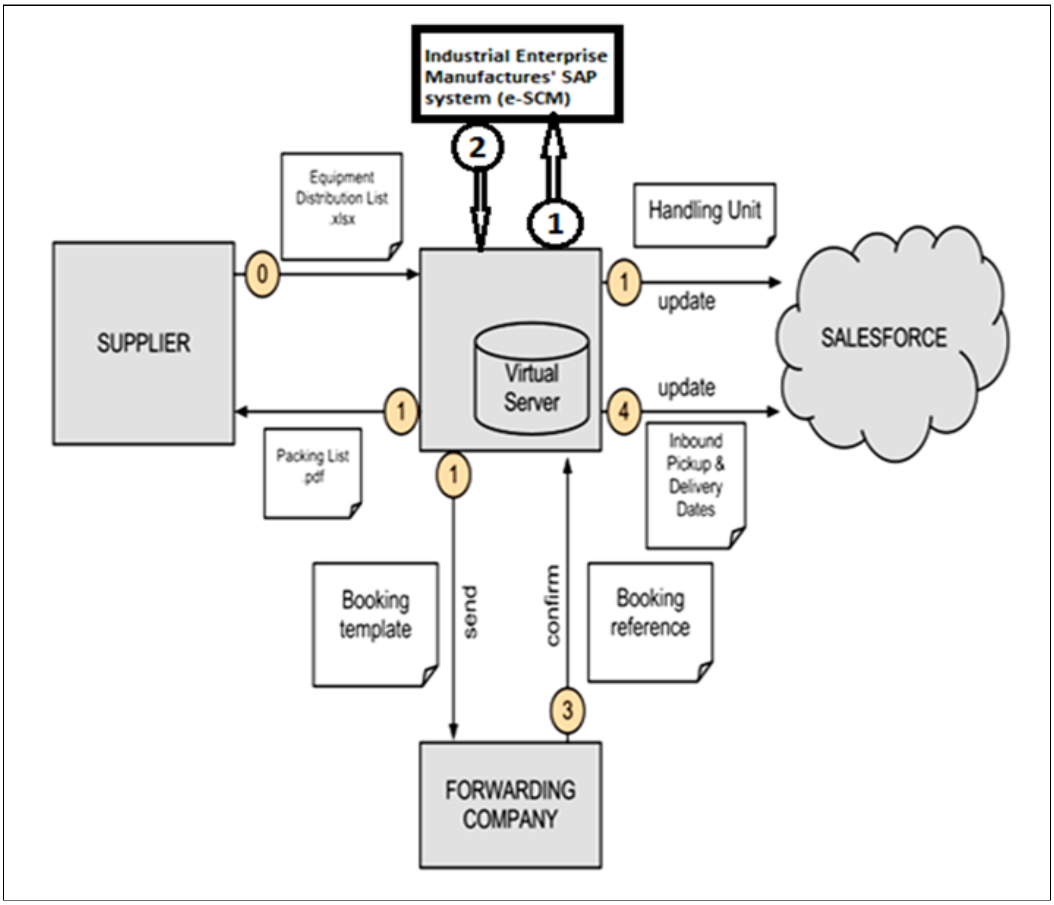


Figure 55. Data / information exchange architecture - proposed conceptual framework for manufacturing CE+ SCM networks activities.

(*Unpublished LogTrack Final Project Report, 2012 - Updated*)

Figure 55 above, illustrates a model of data/information exchange architecture simplifying how data or information flows between the teams or partners on a CE+ SCM network. This proposed model architecture enhance efficient and effect real-time information access on an enterprise SCM large-scale engineering-design and delivery for new/complex product-development network. Furthermore, Figure 56, *at page 155 below* illustrates the main CE+ SCM network's systems-architecture of a total value-chain management. Thus, linking the entire enterprise SCM network from the upstream level *(supplier side)*, through the intermediate stream level *(OEM side)* to the downstream level *(customer/ 3PLCs - distributor/ retailer side(s))*. Therefore, promoting an environment for total enterprise SCM visibility and enhancing a total industrial operations' value-chain management is a necessary industrial enterprise approach, essential for an industrial CE+ SCM network. Hence, the data / information and systems-architectures in Figures 55 above and 56 below demonstrate this feasibility of CE+ SCM network activities.

Table 39. Aligning the Proposed Conceptual Framework for CE+ SCM Network Activities' Architecture with Technology Systems Adopted

#	CE+ SCM Network Architecture Component(s)	CE+ Integrating / Interfacing Technology Systems & Essentials	References / Remarks
1	Industrial Manufacturer – The OEM (OEM factory plants, Consolidation Warehouses, etc.)	- OEM SAP Systems - Consolidating Warehouse Systems - Proposed CF CE+ Portal (SaaS Cloud – Salesforce function) - Proposed CF CE+ Main Server o SOA, FTP, HTTP, HTML, XML, KML, KMZ, Webservices, VFS, CSV-text, EDI, etc.	Musa, et al. 2013; Aberdeen Group, 2012; Plex Systems Inc. 2013; and 2012. * End-to-end supply-chain complex product-development visibility *(i.e., product tracking and tracing)* has been explored as a means of complex product development visibility security and SC network operational process control for a sustainable competitive advantage.
2	Suppliers (Delivery e-forms Confirmations, etc.)	- Supplier(s) API o Webservices, e-forms, etc. - Supplier(s) Netweaver o Netservices, etc.	
3	3PLCs (Transporters & Forwarders, etc.)	- 3PLCs (Transporters & Forwarders) APIs o Webservices, EDIs, etc.	
4	Customer (Ship Yard)	- Customer (s) API o Webservices, EDI, e-mail services, phone services, etc.	
5	Auxiliary Partners / Systems Technology (ies) - (AIS, IMO, GPS, etc.)	- Auxiliary Systems o Webservices, XML, HTTP, KML, KMZ, etc.	

Table 39 above outlines the various technologies, web application systems and processes illustrated in the systems-architecture in Figure 56 below *(i.e., enterprise system application and the different application languages, etc.)* adopted in proposing the conceptual framework structure of the CE+ SCM networks. These web application systems and enterprise systems-application interfaces outlined in Table 39 above, are a function of the CE+ SCM network architecture components listed in same table above *(please see Figures 55 above and 56 below)*.

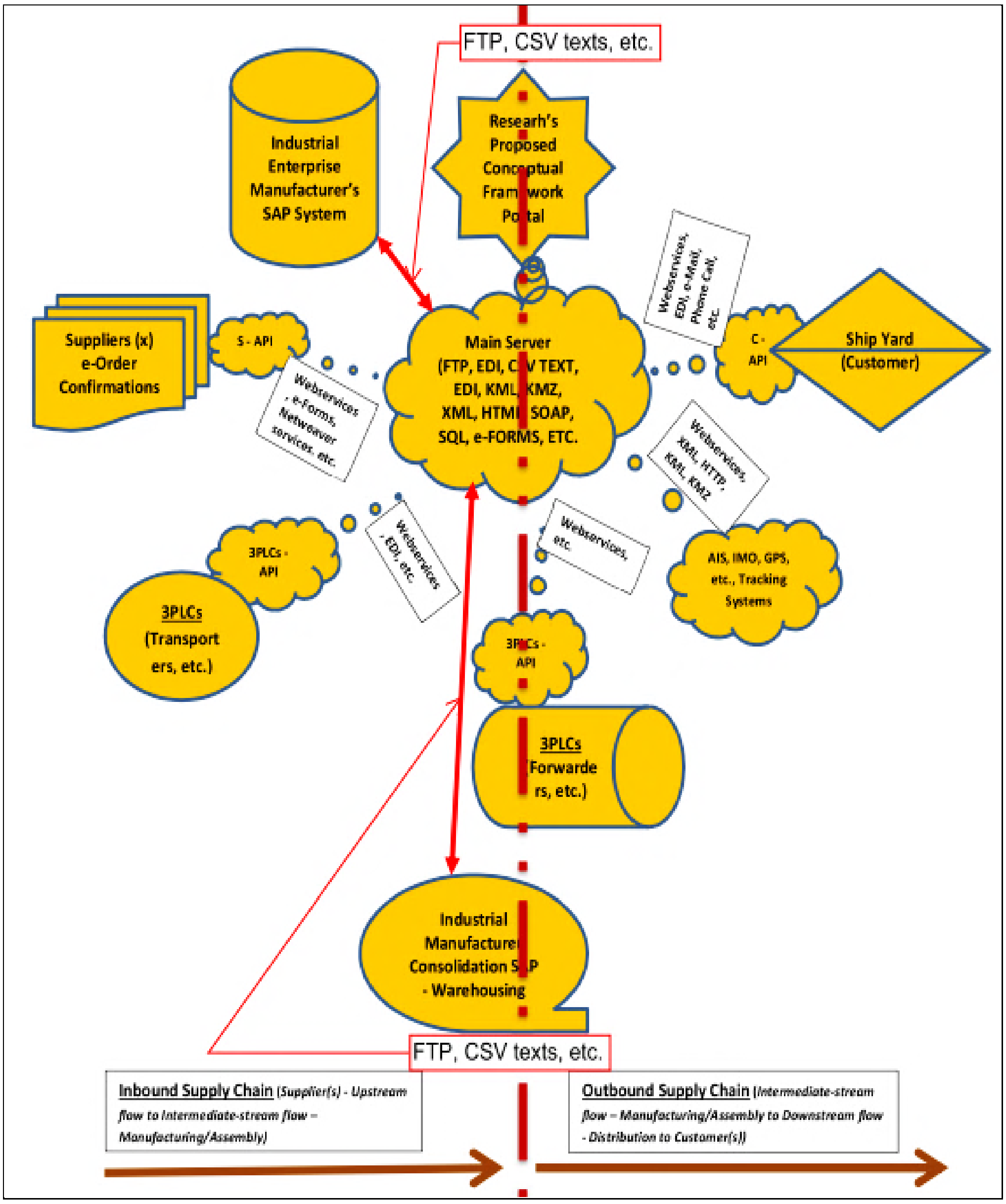


Figure 56. Proposed conceptual framework for manufacturing CE+ SCM networks activities data / information exchange' core integration and interfacing architecture.

(*Unpublished LogTrack Final Project Report, 2012 - Updated*)

5 CONCLUSION

5.1 Discussion of Research Results

The focus of this applied research dissertation is to propose a conceptual framework in a Concurrent Enterprise (CE+) perspective for enterprise manufacturing Supply-Chain Management (SCM) network activities; for a sustainable competitive advantage in product development (PD). It offers a collaborative competitive advantage of employing Enterprise Resource Planning (ERP) system's SCM application solution enablers to improve and enhance the Concurrent Engineering "best practice" methodology for product development (PD) (Addo-Tenkorang and Eyob, 2012). This enhances customer satisfaction both internal and external. In terms of requirements, just-in-time (JIT) delivery of products, reducing the product development lead-time, as well as significantly improving the SC value-chain network activities. By introducing a common platform (portal) to scaling down voluminous data into just relevant value-adding data and making this data secure, authentic and available to partners on the supply-chain in real-time (Addo-Tenkorang, et al. 2012; Musa and Gunasekaran, 2013).

Figure 49 at page 147 above, illustrates some of the derived dimensions within industrial manufacturing – management information systems (MIS); in this case, Concurrent Enterprise (CE+) (Enterprise Resource Planning and Concurrent Engineering) collaborative constructs in terms of the importance of value-chain management and product development (PD).

This chapter discusses the research further, drawing on its findings, contributions and conclusions, on the literature review findings from journals, articles and books in this field as well as current trends in industrial research and development issued and published white papers; etc. Different phases of real-life industrial pilot case studies were conducted in series on the supply-chain management division of a large-scale complex engineering-design and delivery of an original equipment manufacturer (OEM) ship-power (SP) and energy systems company, to collect and collate empirical data for this research. Extra data on the engineering systems-design teams' supply chain (SC) network for complex product-development projects that were not captured during the various phases of the industrial pilot case studies were acquired through closed-end questionnaires, which were administered in the form of e-forms to obtain a higher response rate.

The layout of the remainder of this chapter includes detailed discussion on the research findings and results from the research work and findings on the DSM, SNT and the statistical correlation analysis and hypothesis testing results from the data analysed are reported in Section 5.2. The main contributions of the research to the body of knowledge are summarized and outlined in Section 5.3; while the research summarizes its conclusion's in Section 5.4. Some limitations encountered in the research are also outlined in Section 5.5 and finally, recommendations for future research are made in Section 5.6.

5.2 Detailed Results Discussions

To effectively and efficiently become concurrent an industrial manufacturing enterprise has to develop strategic networked value systems - business frameworks / models that support its supply-chain management (SCM) activities. This strategic approach is characterized by concurrent organization theory applications on their strategic operations, and information technology and communications networked value systems *(please see Table 5 at page 19 above)* that signify a concurrent enterprise for industrial competitive advantage (Hatch and Cunliffe, 2006; Klaus, 2009). These have been the ultimate presumptions or theoretical guide of this research *(Please see Table 7 at page 25 above)*.

Therefore, concurrent enterprise supports industrial enterprise supply-chain (SC) network partners' interactions and systems integration, by defining and recommending a common platform infrastructure. Pallot and Sandoval (1998) noted that proposing a formidable business framework to a virtual enterprise that does not really exist, is a challenge to enterprise manufacturing SCM networks. Discussing this further, a common platform infrastructure based on networked value systems is essential for global SCM network efficiency and effectiveness (Musa et al., 2013). Therefore, this research proposed a conceptual framework that attempts to support the interactions and integration required between industrial SCM network partners and their systems.

Concurrent enterprise is a networked value-system transforming framework approach proposed in this research report as a collaborative enabler for enterprise manufacturing SCM for industrial competitive and sustainable advantage: This provides the enabling and necessary capabilities for classical enterprise SCM networks to operate concurrently in a global environment. Therefore, the findings and results in this research report feasibly attempt to evaluate and validate the motives reflected in the research questions (Hatch and Cunliffe, 2006; Klaus, 2009; Sosa et al. 2002; Galaskiewicz, 2011; Yin, 2009; Yassine and Braha, 2003). These, firmly positions this research report within its ultimate presumptions and are duly analysed and further elaborated in the following paragraphs in this chapter. The findings and results of analysis in this research report have been discussed in details from the literature review findings through to the results analysis. These have been further illustrated in the form of design structural matrix (DSM) - domain-mapping matrix, social network theory (SNT) analysis and some statistical correlation analysis and hypothesis testing of data in the methodology and data analysis chapters respectively.

Earlier on, in the literature review chapter, the main findings that motivated the research questions and triggered this applied research approach include:

- Supply chain network partners, enterprise stakeholders and/or global multi-discipline teams are experiencing great difficulties in agreeing to work together on a common platform in a concurrent manner.

- The full value and uses of ERP systems (SCM) were not being realized and effectively explored.

- Further to the above factors is a common very key essential factor – "Communication" of the right information, to the right place / person at the right time, whithin the SC network is the core of an efficient and effective SCM network.

- Finally, education and training in the collaborative paradigm trends of Concurrent Enterprise are imperative in this era of industrial globalization.

Therefore, based on the above research findings, the research questions were drawn to attempt to find feasibly, evaluated and validated solutions to them as real-life industrial enterprise SCM issues. This was done by means of a real-life industrial case study approach to collect empirical data as well as employing questionnaires to collect extra data that could not be directly or explicitly collected during the various phases of the industrial pilot case study. Below are further discussions on the research results and analysis. Thus, the following subsections include research findings and analysis of design structure matrix (DSM), UCINet 6 social network theory (SNT) and statistical correlation hypothesis testing, findings and analysis, in sub-sections *5.2.1, 5.2.2* and *5.2.3* respectively.

5.2.1 Research Findings and Results (DSM)

The development and design of industrial manufacturing enterprises systems and products require effective concurrent collaborative efforts of their product development SC network partners from diverse backgrounds. This results in complex relationships among both people and systems on their SC network. Table 23 at *page 103* above, outlines empirical information / data communication collected during this research's industrial case study of a real-life inbound Logistics and Supply-Chain Management (L&SCM) network activity. Although there are some classical project management tools, which are quite common in complex product development projects, they fail to address essential issues on interdependency (i.e., product development communication feedback and iteration) within enterprise industrial SC network activities. Therefore, to be able to effectively and efficiently analyse and address these issues, a matrix-based tool known as Design Structure Matrix (DSM) is employed (Yassine, 2004), *(please Figure 11 at page 15 above)*.

Yassine (2004) argues that, this approach differs from the other classical project-management tools, in that it focuses on representing information communication flows rather than work-flows *(please see Table 23 at page 103 above)*. This the DSM approach an information / data communication exchange model that enables the representation of complex product development design teams to relate or correlate in their SC network activities in order to determine a sensible and efficient sequence or clustering in order to effectively enhance the complex product development information / data communication or exchange flows within the enterprise SC network. Figures 22 and 23 at *page 104 above,* illustrate a DSM information types' relation and sequence entries input from Table 23 at *page 103* above. This provides an example of how information / data on "Dimensions and Weights" depend on information / data of the "Material" type. When these input entries are run or simulated in the DSM simulation tool, and the DSM partitioned information sequence and level type relationships results are presented in Figures 24 and 25 at *pages 105 and 106 respectively* above.

5.2.2 Research Findings and Results [UCINet 6 – (SNT)]

A network is a set of items, which we will call vertices or sometimes nodes, with connections between them, called edges (Newman, 2003) *(for an example; please see Figure 26 at page 116 above)*. A social network is a set of people or groups of people with some pattern of contacts or interactions between them (Scott, 2000;

Wasserman, 1994). Validating and entrenching the research findings and results from the DSM analysis on enterprise manufacturing SCM network further, the UCINet analysis result is also considered in a triangulation approach. Hence, the UCINet 6 simulation tool was employed to assess the product-development systems-design teams' frequency of technical communication in the enterprise organization social network analysis, in order to address research question three (3) and proposing a feasible solution based on the research findings and results.

Effective and efficient study of any aspect of organization or enterprise SCM operation could not be robust enough without critically looking into the flow and exchange of data / information (communication) within the enterprise SC network partners / teams in this research. The product-development systems-design teams involved in the case study conducted during this research included eight (8) systems design teams as follows:

1. Automation Systems / PLC
2. Auxiliary Systems
3. Combustion Systems – (Internal / Air)
4. Electrical & Instrumentation Systems / PLC
5. Mechanical Systems – Coupling & Mounting
6. Mechatronic Systems
7. Noise and Vibration Systems
8. Power Transmission Systems

To obtain data from the product development system design teams listed above, a structured questionnaire was employed: please see the graphical illustrations of the results from Figures 26 – 45 from *pages 116 to 127 above*. Figure 26 above, illustrates the findings and results of the entire enterprise SCM network industrial case study conducted for this research. The graphical results illustrated in Figure 26 above, indicate a feasible simulation results of the case company's product-development systems-design teams' technical communication in terms of the Frequency, Importance, Level of Collaboration, Level of Mutual Trust, and the Level of Roles and Responsibility with their Technical Communication within their enterprise SCM network. The various systems design teams have been colour coded and are also represented by different shapes to facilitate identification of the findings and results from the simulation analysis from the UCINet 6 simulation tool. The technical communication Frequency, Importance, Level of Collaboration, Level of Mutual Trust, and the Level of Roles and Responsibility within the enterprise SCM network are represented on a scale between [1] and [3]: with [1] being “Low” and [3] being “High." Figures 26 – 45 above illustrate the simulation results on the individual factors / cases in detail. According to Newton (2003) the study of networks is by no means a complete science yet, and many of the possibilities have yet to be explored in depth. Hence, this research’s attempt within an enterprise SCM network perspective marks an essential genesis of research in this broad and still green area in enterprise SCM research.

The results in the graphical representation in the Figures listed in the paragraphs above indicates the that effective and efficient technical communication as well as data / information flow within an enterprise SCM network are essential in achieving real-time just-in-time (JIT) product development as well as enhanced enterprise SCM visibility (Musa, et al., 2013; Plax White Paper, 2013a). However, the research results from this analysis have also revealed certain weakness within enterprise SCM network that could seriously undermine enterprise SCM network activities for a sustainable competitive advantage in their operation if not checked and addressed accordingly. As mentioned earlier, the social network theory (SNT) analysis conducted in this research offers a validated feasible solution to Research Question three *(RQ. 3) (please see sub-section 1.2.1 and page 15)*.

5.2.3 Research Findings and Results (Statistical Correlation and Hypothesis Testing)

Complex product design and development, such as ship power engines, jet engines, automobiles or certain types of original equipment or software, requires the effective and efficient coordination of the enterprise organizations’ SC network activities of SC network participants during the product development systems design process. Hence, according to Maier, et al. (2008), Communication is seen as the vehicle by which this essential enterprise SCM coordination could be achieved. However, information / data exchange or communication is also influenced by many different factors that are linked directly or indirectly.

Efficient and effective Concurrent Enterprise SCM result from interactions among a multitude of people who work across functional, organizational, cultural, temporal, and geographical boundaries (Klein, et al. 2003b; Friedman, 2005) enhanced with the right IT enablers. Concurrent engineering activities are distributed among individuals and are mostly executed in parallel, thus, increasing the need for effective and efficient communication. The Concurrent Enterprise operational approach is challenging because it requires strong interdependencies between the SC network partners as well as the product development systems-design teams. Hence, it is quite difficult to converge on decisions to satisfy these dependencies in a manner that is acceptable to the SC network partners (Klein, et al. 2003b). This applied research focuses specifically on the enterprise SC network of complex product development and support processes for systems-design teams as mentioned already and outlined above.

Naturally, the different product development SC network systems-design teams in the systems design process possess different capabilities, skills, roles and responsibilities, and interests, and also employ different systems-design tools. Each systems design team has a different perspective and level of understanding (De´tienne, 2005) which could trigger ambiguities that would require resolutions through effective negotiations. These effective negotiations will result in efficient sustainable competitive advantage with the enterprise SCM networked value chain activities. Clark and Fujimoto (1991) relate successful development in the auto industry to effective communication between upstream and downstream activities. Wheelwright and Clark (1992) emphasize the need to improve communication when and where it improves project performance. Ulrich and Eppinger (2000) also emphasize the need to facilitate the exchange of essential data / information communication in order to enhance a just-in-time (JIT) product-development process.

Therefore, analysing the above essential essence of effective and efficient communication within an enterprise SCM network for a sustainable industrial competitive advantage, this applied research attempted to investigate, test, and propose strategic feasible solutions to information / data exchange and communication among the enterprise SC network systems-design teams / partners. Three hypotheses were drawn in this applied research to investigate and test the assumptions in this research in a methodology triangulation approach to address research question three (3) *(please see Table 27 at page 129 above, for the three hypotheses drawn)*. The results from the investigation and hypothesis testing for statistical correlation to analyse their; 1) Frequency in Technical Communication, 2) Importance of Technical Communication, 3) Frequency / Level of Collaboration, Scale / Level of Mutual Trust and 4) Scale / Level of Roles and Responsibilities. These four variables above were analysed among the systems-design teams and all the results turns to support the null hypotheses drawn in the research analysis. *(please see the results' section of Table 27, the Pearson [r] Correlation significance level at 0.01 and 0.05 in Tables 28, 30, 31, and 32 from pages 130 to 134 above).*

However, the hypothesis summary test reveal two rather interesting communication bottle-necks with *correlation significance levels of 0.005* each *(please see Table 5 at page 19 above and 0.44 each in Appendix E page 247 below)*, which falls below the significance level of 0.05 proposed for this type of correlation analysis:

- Aspects of Importance of Technical communication
- Aspects of Frequency / Level of Collaboration among Design Teams

These analyses reject certain aspects of the null hypotheses because there seem to be an equal probability of the level of correlation significance. Thus, these aspects need to be improved to facilitate the required strategic achievement that the proposed conceptual concurrent enterprise framework in this applied research intends to offer. Tables 33 and 34 at *page 135* above, display a detailed statistical report analysis and descriptive statistical analysis respectively.

5.3 Contribution to the Body of Knowledge

5.3.1 Fulfilment of Research Objectives

The main aim of this applied research was to propose an integrated concurrent enterprise conceptual framework which enhances the core value-chain network operations and activities of enterprise manufacturing SCM (Ketchen Jr, et al. 2007b). The proposed framework seeks to effectively co-ordinate and optimize the SC networked value systems actives on an enterprise manufacturing SC from the supplier level on the upstream, through the enterprise manufacturer's level on the intermediate-stream, right down to the logistics / third-party logistics (3PLs) / customer level on the downstream. Thus, the research presents a concurrent enterprise SCM framework for a sustainable industrial competitive advantage illustrated in Figure 49 at *page 147 above.*

Hence, the first objective was to review the working approach of multi-discipline partners / teams on the enterprise SC network and how they could work together effectively (Ketchen Jr, et al. 2007a). Broad reviews were systematically carried out, by initially examining the current trend of research and available literature dating back to slightly over a decade *(please see Table 9 at page 33 and Tables 14 – 17 from pages 55 to 60 above)*. Furthermore, a real-life industrial pilot case study was conducted to collect empirical data from a classical inbound and outbound SCM network for analysis, *(please see Table 23 at page 103 above)*. This approach enabled the researcher to gain deep understanding of the subject and to identify research gaps. The research gaps identified include the need to find or propose an effective method by which multi-discipline partners / teams on an SC network could work together effectively.

The second objective was to propose an industrially validated and feasible enterprise IT systems architecture and enablers to be strategically employed to facilitate effective and efficient enhanced SCM activities for just-in-time product development (Nagurney, 2010). Therefore, the main objective was to propose a well-structured Master Database-Management system, to house a well-orchestrated service-oriented architecture of SC network partners' meta-database systems for easy and secure data / information exchange and flow *(please see Figure 21 at page 101 above)* (Musa, et al. 2013).

The third objective was to ensure the robustness of the organizational operations and the effective performance of the information technology enablers. Therefore, key technical communication flow factors on the SCM network were investigated and tested by social network theory (SNT) analysis and statistical correlation triangulation. The aim of so doing was to propose enhanced "best practice" managerial and practical industrial implication guidance to enhance a sustainable enterprise manufacturing competitive advantage (Maier, et al. 2008).

The fourth and final objective was to evaluate the framework as a rolled-up real-life industrial pilot project. Hence, real-life industrial pilot case studies of an inbound and outbound SCM network for an enterprise Ship Power engine manufacturing case were conducted to test the feasibility of the proposed concurrent enterprise SCM framework *(please see Figure 49 at page 142 above)*. This resulted in some key findings. Thus, the pilot project case yielded positive results, which have motivated the case company to consider adoption and implementation of the proposed conceptual framework. The interesting part of this research is that the framework is assumed replicable in any complex system product development SCM: Thus, this research can conclude based on the broad review of research trend in this subject area that the proposed conceptual framework resolves most of the key challenges encountered by enterprise manufacturing SCM networks. Therefore, this renders this research's proposed enterprise SCM conceptual framework highly significant and relevant within this context. Table 40, and Figures 57 and 58 below graphically illustrate further elaborations in this research's contribution to the body of knowledge:

Table 40. Layout of Research Contribution to the Body of Knowledge

Research Questions (RQ.)	Organization Theory Assumption Link	Research Results and Contribution to the Body of Knowledge
RQ.1) How can multi-discipline teams, made up from different divisions of a manufacturing enterprise SCM network work together effectively?	Operation	Proposed value-chain management for SCM operations managers and partners to enable them to enhance organizational interconnection concurrently both in their SCM network operations and their product-development systems-design integration efficiency.
RQ.2) How can information exchange on an SCM network be efficiently and effectively structured to strategically improve early N/CPD engineering design and delivery processes?	Information Technology	Proposed well-structured conceptual framework for efficient and effective Master Data-Management System for data / information flow within an enterprise SCM network to promote a sustainable competitive advantage within an enterprise manufacturing SCM network.
RQ.3) How can SCM networks achieve strategic and effective communication network on changing parameters of N/CPD engineering design and delivery processes?	Communication	Investigated, tested and simulated an enterprise SCM network data / information-communication network analysis: And proposed some validated feasible optimal, managerial and practical "best practice" communication approach, which is essential for an efficient SCM networked value system activities.
RQ.4) How can enterprise SCM networks create a concurrent collaborative enterprise mentality and approach?	Organizational SCM Concurrent Enterprise	PROPOSED CONCEPTUAL FRAMEWORK FOR ENTERPRISE MANUFACTURING SCM CONCURRENT ENTERPRISE.

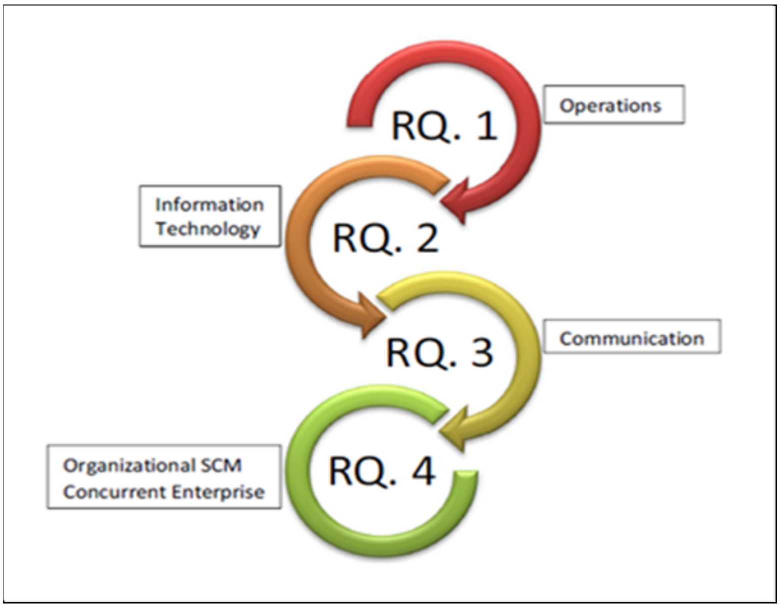


Figure 57. Research Contribution Logic (Research Questions link with Organization Theory Assumptions Adopted for this Applied Research).

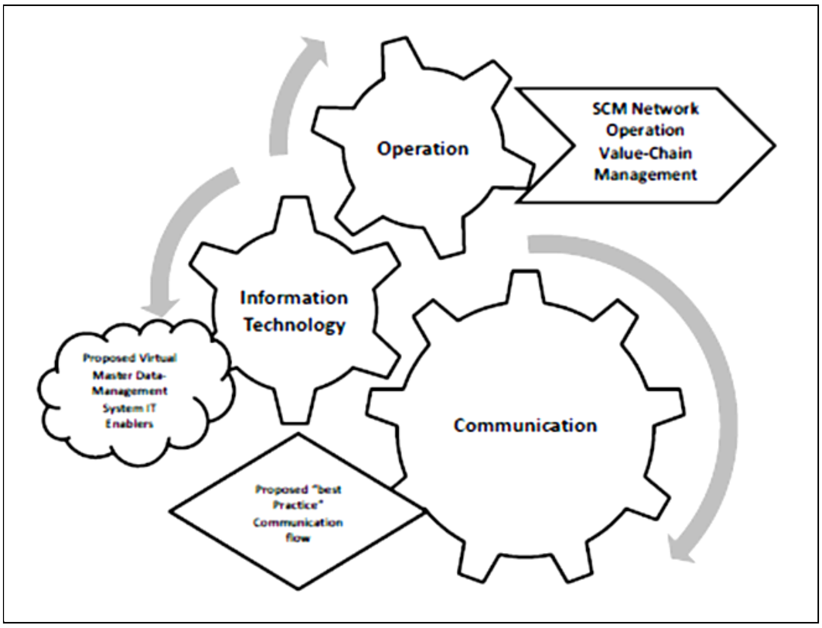


Figure 58. Research Core Theoretical Assumptions (Organization Theory) Adopted.

5.3.2 Industrial Implications (Managerial and Practical)

Researchers and industrial R&D departments have approached enterprise SCM networked systems integration in many different ways. However, the various SC network partners have utilized ERP systems integration delivered as Software-as-a-Service (SaaS) by employing concurrent engineering principles. Although it is not yet a systems integration solution that has had a commercial breakthrough, specifically for supply-chain management (SCM) networks. Therefore, this applied research embarked on a real-life industrial pilot case study with an OEM industrial partner and proposes a conceptual enterprise SCM framework in the form of an ERP-SaaS platform / portal. Thus, this approach attempts to propose an enterprise SCM systems integration solution, which offers value-adding benefits, including low preliminary and anticipated on-going costs, faster implementation and value-adding, affordable ownership cost, greater reliability, improved support, reduced IT complexity, enhanced data / information exchange and communication as well as improved business motivation for a sustainable industrial competitive advantage. Salesforce.com is one example of such successful ERP-SaaS systems solution vendors, which was employed for the validation and evaluation of this research's real-life industrial pilot case study project. Therefore, this research presents very relevant and significant contributions to industries keen on achieving competitive advantage of their SCM network as well as R&D both in the industry and in academia.

However, without top management support, appropriate organizational business plan and vision, business process re-engineering, effective project management, user involvement and education and/or training, organizations cannot embrace the full benefits of such a complex system and the risk of failure might be high level. Hence according to Tewary and Kosalga (2013), the service-oriented architecture (SOA) paradigm introduced some few years ago has already become the driving force behind industrial enterprise systems solutions. They continued to suggest further that it was also a force behind any cutting-edge technology in current times. This research's conceptual framework assumptions on concurrent enterprise SCM network activities are affirmed by Symonds' earlier work. Symonds' (2012) assertion that the use of a cloud-based enterprise SCM network systems integration solution, provided in the form of Software-as-a-Service (SaaS) format, allows users of the service to utilize the latest software and yet avoid the cost and hassle of maintaining the resource. Thus realizing a return on investment in their approach. Symonds (2012) further argues that SaaS is facilitated using multi-tenant architectures, which allow the use of the resource by numerous enterprise industrial organizations, yet allow company-specific attributes to be accommodated, thus, considering the networked value systems' security aspect, which is a key concern to this approach.

Technical communication among design teams / partners on the research case's enterprise SCM network was investigated to assess whether their technical communication frequency, importance, level of collaboration, level of mutual trust, roles and responsibilities of the SC network technological complexity affects the SC network design-teams communication. In this respect, Roberts et al. (2002) come to the conclusion that in moderately complex product development projects, data / information sharing is greater than in highly complex projects, although there is a greater need in the latter for data / information communication and exchange. However, Chiu (2002) also concludes that the type and structure of teams' organization impact the communication network. Tiernan et al. (2002) detected that changes to organizational structure also affect the collaborative design of product development. While the importance of communication is generally acknowledged, there is a little consensus on how it can be directed or, at best, systematically improved.

For industrial enterprise SCM networks to be competitive and sustain competitiveness, key manufacturing industrial SCM network activities (i.e. information exchange, inbound & outbound deliveries, data storing and management, systems integration, effective communication, etc.) are positively associated with industrial competitive advantage within the context of manufacturing industries globally. Thus, the industrial managerial focus of this research would be, to serve as a working R&D and/or conceptual framework approach that could be replicated in different divisions in any enterprise industrial SCM network. Also, this research's investigations revealed some interesting bottle-neck observations, which could practically be managed to enhance the effects competitively *(please see Figures 46, 47, & 48 from page 137 to 139 above; graphical sags of between -3 & -5)*:

- Not all partners collaborate effectively from their end across the SC network, and the observation is quite significant. This observation is identified in the simulation illustration of the "Scale / Level of Mutual Trust"; "Scale / Level of Roles and Responsibilities" *(please see Figures 30 and 31 at page 119 above)*. Therefore, ensuring partners / systems design teams on an enterprise SC network are motivated and encouraged to communicate effectively will greatly enhance the level of collaboration on the enterprise SCM network.

- The research observation also identified that, some of the SC network partners / complex product-development systems-design teams work together more closely *(please see Figure 45 at page 127 above)* while others do not see the need or benefits of belonging to an enterprise SC network. Therefore, they operate in isolation within SC network, which implies that vital technical communication may not be coming from them to the other partners on the SC. Hence, they may also not be attentive to accept any such vital technical communication for the SC systems-design partners *(please see Figure 44 at page 126 above)*. Therefore, this research's proposed framework is very relevant, based on these identified observations, because it attempts to make enterprise SCM network activities more automated and motivating to enhance the enterprise SCM network activities.

5.4 Summary of Research

Recent research on the implementation and benefits of Concurrent Enterprise for complex/ new-product introduction and development seems to lack progressive results due to its very versatile nature. Since Concurrent Enterprise is a collaborative "extension" or evolution of Concurrent Engineering (CE) and Enterprise Resource Planning, it can be expected that many of the benefits attained by Concurrent Engineering methodology and Enterprise Resource Planning system enablers would be achieved within a Concurrent Enterprise collaborative environment. These benefits have been widely documented (Keys, et al. 1991; Hoedemaker, et al. 1999; Duffy and Salvendy, 2000). The research on Concurrent Enterprise has documented benefits as well as some challenges that are similar to those for CE and ERPs (Littler, et al. 1995; Littler, et al. 1998; Bruce, et al. 1995a; Bruce, et al. 1995b; Willaert, et al. 1998; Davenport, et al. 1999; Daniel, et al. 2002). Others have documented the very important role that "suppliers" and SCM network partners play in these collaborative endeavours (Horvath, 2001; Ragatz, et al. 1997; Handfield, et al. 1999; Ragatz, et al. 2002; Ansari, et al, 1999).

There seem to be only a handful of studies about whether or not these potential benefits, barriers, and implementation frameworks / models for Concurrent Enterprise are successfully applicable to or even sustainable in an environment such as an enterprise industrial SCM. Furthermore, the role of industrial research centres as suppliers of technology and expertise presents very useful opportunities to explore this new collaborative paradigm while incorporating aspects of an enterprise resource planning (e.g. supply-chain management – SCM with the enabler aspect's service-oriented architecture (SOA) as a link or communal platform for information and data flow). Thus, the collaborative benefits with the industrial enterprise resource planning system tools with that of concurrent engineering principles' new-product development and introduction will be enhanced in enterprise manufacturing industries' SCM network activities. This validates the interest and focus of this research report, in proposing a Concurrent Enterprise conceptual framework for industrial competitive advantage. An industrial pilot case study was conducted during this research in an applied research approach to this effect.

Further to the above, pertaining to the attributes of Concurrent Enterprise as the focus of this research, the concept of ERP seems to be growing and even expanding. Therefore, it was of interest to investigate how industrial enterprise manufacturers using the ERP system perceive the trends of extension, and how they will cope with the changes and challenges that lie ahead. In order to enhance and sustain the competitive advantage in their manufacturing SC networks. Infrastructures available to them and the kind of skills and expertise required, methodologies required and the kind of models useful in the expansion efforts or approaches, etc., are the essentials needed.

Concurrent Engineering (CE) and Enterprise Recourse Planning (ERP) research area are diverse and very broad. The field is truly multi-disciplinary and interdisciplinary. In a relatively short period of time, the already published literature review chapter in this research report has contributed so much to the field that newer topics are now being covered from diverse points of view and have been cited many times by other researchers in this area (Addo-Tenkorang and Helo, 2011). Elaborating further, supply-chain management (SCM) focuses on implementation of interoperability between independent enterprise systems and deployment of data over multiple enterprise SC networks. In this research report, an SCM system supported by an enterprise SC network value data-management systems' (DMS) model was illustrated and discussed. The architecture of the system model consists of enterprise DMS for supply-chain network activities, and its proposed integrated interfaces *(please see Figure 20 at page 90 and Figures 55 – 56 at page 153 and 155 above respectively and Table 39 at page 154 above)*. The DMS supported enterprise supply-chain management system is proposed to define and control the execution of data flow and systems' communication processes within the enterprise SC network. Through the integrated interfaces, the entire enterprise supply-chain system across the various independent SC network partners' enterprises is proposed to enhance the integration interfaces for effective and efficient data exchange to be fulfilled. However, every system encounters some problems; thus, the proposed framework system in this research report is no exception. Below are some of the systems problems encountered and feasibly resolved during the pilot case study conducted during this research:

1. The interfacing and integration are based on database sharing by encapsulation and encryption; thus, some integrity and safety features are not all well-kept. As a result, the enterprise SC system becomes tightly coupled, which may lead to conflicts between the partner data-base systems. Nevertheless, the idea of enterprise application integration in industrial organizations using the appropriate system design tool(s) such as design structural matrix (DSM) for complex systems may provide a way to solve such problems as per the practical research analysis reported above in the previous paragraphs (Yassine, 2004; King, 1990), *(please see Figures 22 – 25 from page 104 to 106 above)*.

2. Different suppliers have different ontologies, implying that the various suppliers on the industrial SC have their own ontologies, so interlinking them is not easy (Tang, et al. 2001). However, using the appropriate platform with the right digital languages and the international maritime organizations (IMO) services, etc., will enhance the information communication and database management interlinking between the partners on the SC network *(please see Table 39 at page 154 above)*.

Even though the DSM tool is considered to be very dominant and versatile in addressing complex systems or issues, it is also stated that it is not a remedy for all system design related problems or complex issues (Yassine, 2004). The representation control and the decision capacity of DSM are limited in various ways in comparison with other methods, e.g., rule-based, graph-based, etc. but much stronger and more convincing in decision-based or structural-based approaches, which is the theoretical positioning in this research. Secondly, not all information related to a data-management system (DMS) is suitable for DSM representation (Shamsuzzoha, et al., 2011).

The manipulation of a DSM tool such as partitioning and banding can provide some design advantage but is limited to an adequate analytical ability for the decision-making and analysis process (Addo-Tenkorang, et al. 2012). Hence, further research has been conducted into the mapping of database systems with the various data from the various partners on the e-SC network for effective and efficient data-management system and information tracking in an SC network by employing a domain-mapping matrix assumption. Further research will be conducted into the possibility of mapping multi-domain complex systems by employing a multi-domain mapping approach mainly focusing on dynamic knowledge capturing, storing and being made easily accessible to partners on an enterprise industrial SCM network for a sustainable competitive advantage (Addo-Tenkorang, et al. 2012; Musa, et al. 2013).

In conclusion, the DSM simulation analysis illustrates an optimised structure, design and feasible way to cluster partners within a specific product development project's SC network. This will enable the SC network partners and / or teams to work together in collaboration on a common platform, with the right (ERP), IT enablers to competitively and strategically enhance the industrial manufacturing SCM for an effective and efficient new/complex PD - (RQ. 1&2). Also, the significance level of the Statistical Correlation of the Hypothesis testing and SNT simulation analysis, seeks to capture the frequency in collaboration and importance of the technical communication. In addition, roles and responsibilities among system design teams, in terms of the changing parameters and elements in complex PD. To enhance or promote an effective and efficient technical communication 'best practice' approach, within an industrial manufacturing SC network and also recommend the best way forward for the bottle-necks in the communication factors which needs improvements - (RQ. 3). Therefore, successfully and feasibly achieving the above and also the ability to replicate these measures will validate the research's proposed conceptual concurrent enterprise framework, for a competitive and sustainable industrial advantage in enterprise manufacturing SCM - (RQ. 4).

5.5 Limitations of the Research

This section of the write-up outlines the limitations encountered during this research. As is the case of most applied research projects, this research also encountered a few constraints. These are outlined in a way to encompass the entirety of the research project from collation of data – industrial pilot case studies through drafting questionnaire to capturing extra data, which were not easily available during the pilot case study data collection, to the final data analysis and findings.

5.5.1 Outline of Research Constraints:

1. Good access to industrial research case study organizations and professional personnel; has been one of the major constraints in this research, as in similar applied research projects of this kind with industrial manufacturing organizations in Scandinavian. However, as this research project was partly a Department interest, the researcher was able to conduct a series of industrial pilot case studies sufficient to collect, collate data and information to carry out the research analysis.

2. The industrial case studies conducted in this applied research happened to be conducted on a single industry case approach. Hence, the sample size (n=8) of the product-development design-engineering teams seems small. However, this does not weaken the validity of this research's recommendations and findings in any way because the sample company is an enterprise industrial - original equipment manufacturer (OEM) which is fairly placed globally by representation in about 70 countries. It has over 280 suppliers and can confidently claim to have a ship power engine in every third ship, boat, yacht or cargo ship globally. Furthermore, the sample size for respondents, which was eight (8), represents eight different systems-design teams, each composed of a minimum of five (5) design engineering members. This makes an indirect total sample size of 40 responses.

3. Drafting a questionnaire to collect extra data or information needed to make firm strategic and sustainable recommendations was also something of a challenge. In that, the target group, in this case, industrial manufacturing SCM chief executives, directors, project managers and most especially the design-engineering managers and experts, are very busy people who have little time to spare for questionnaires or interviews. Therefore, the questionnaire had to be in a language they could easily understand and very straightforward. Hence, a considerable amount of time and effort was spent to streamline, edited and revise the questions to overcome this constraint. Furthermore, a few questionnaire dissemination techniques were considered and the e-forms format technique of disseminating questionnaire appeared to be the best way forward to send and receive the responses on time as compared to post, fax or e-mailing.

4. Employing DSM are only sequential and parallel tasks and can be ordered by available algorithms. However, the DSM tool is considered to be very dominant and versatile in addressing complex systems or issues. It is not a remedy for all system design related problems or complex issues (Yassine, 2004) such as communicating the right information at the right time to the right destination. Thus, social network theory (SNT) analysis was also employed in this research among SC network complex engineering design and delivery of complex/new product-development systems-design teams in a triangulation approach as a way of concurrently validating the findings and results in this research report. Furthermore, correlation analysis was also employed to test three hypothetical communication network relationships in terms of frequency, importance, collaboration, mutual trust, roles and responsibility among SC network product development systems-design teams in order to increase the validity of the recommendations, findings and results in this research.

5. In industrial-based case study research, there is always a limit to the amount of detail information that the researcher is allowed to discuss in the research report. This somehow limits some of the vital details to be discussed. Making it quite difficult for the researcher to consolidate essential arguments to engage in extensive discussions to make the expected conclusion. Nevertheless, it is always the case that the researcher always communicates the core expected message as effectively as possible to clearly state and discuss the results and findings.

The following section concludes the entire research report and also proposes some recommendations for future research in this trend or a similar vein.

5.6 Recommendation for Future Research

One might expect that the greater the cultural distance between team members and partnerships on an enterprise SC network, the greater the difficulty in exchanging data, information, knowledge, and cooperation. Hence, further research would be useful to investigate how different research areas such as are listed above, as well as the type of manufacturing systems, information, and knowledge are transferred across various industrial enterprise-manufacturing activities.

Furthermore, it is necessary to examine the integrative role of industrial manufacturing. Sustainable knowledge capturing systems / technologies or capabilities such as the use of RFID technologies (Kumar, et al. 2010), could be employed in collaborative enterprise resource planning and concurrent engineering in a Concurrent Enterprise complex engineering design and delivery of SCM network new/complex product-development activities, to facilitate efficiency and effectiveness in their future product development projects.

In the more overt manufacturing activities such as supply-chain management (SCM) and new/complex product introduction development within a manufacturing industry, the interaction between these factors would help to improve manufacturing business performance for industrial competitive advantage by way of adding value to the value network architecture (Al-Ashaab, et al. 2013; Musa, et al. 2013; Maier, et al. 2008).

Therefore, based on the findings of this research, further research in the area of Concurrent Enterprise (CE+) *(i.e. the competitive collaborative benefits of Concurrent Engineering and Enterprise Resource Planning for effective and efficient industrial management)*. This would be in the form of customized SaaS approach, a customized cloud ERP business unit solution or portal such as the conceptual framework approach proposed in this research report. Also incorporating the dynamic knowledge capturing systems perspective seems to be the most sustainable and feasible way to go.

The research literature review chapter above identified the gaps in these very essential areas, which need to be addressed for the common good and for achieving industrial competitiveness, as these areas forms part of the key Concurrent Enterprise maturity drivers in this modern era of concurrent enterprise SCM. Therefore, more work is needed on the collaborative advantage of concurrent engineering with the suitable ERP system application processes in SCM as already identified in this research report. Service-oriented Architecture (SOA) seems to be a most suitable system application platform for the integration and collaboration of engineering product design and development, which needs to be, further researched to prove its suitability in a dynamic knowledge-capturing perspective in value added SC networked activities.

On the above note, businesses and industrial organizations must be very competitive in order to survive. EPR system implementation seems to be a popular method of using technology as a competitive advantage tool by businesses and enterprise industrial organizations. Thus, future research on ERP topics would be very promising particularly the ERP II trends and perspectives (i.e., Software-as-a Service – SaaS / Platform–as-a-Service – PaaS / Infrastructure-as-a-Service - IaaS, Cloud ERP systems or customized portals; *e.g., Salesforce* platform(s), etc.). These are significant research gaps for business and industrial organizations as well as academia (Ellis - IDC Manufacturing Insights, 2010; Epicor White Paper 2011; Addo-Tenkorang, et al. 2012).

The Software-as-a-Service (SaaS), etc., Cloud ERP systems or portals such as customized *Salesforce* platform(s) and other methodologies of ERP systems application administering are more adaptable to be implemented among SC network partners, even in small and medium-scale enterprise organizations, and they are also cost-effective as well. On that note, ERP systems application security comes into the forefront as another area, which is very promising for future progressive research (Addo-Tenkorang and Helo, 2011; Addo-Tenkorang, et al. 2012; Ellis - IDC Manufacturing Insights, 2010; Epicor White Paper 2011).

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APPENDIXES

Appendix A: - Financial Plan and Research Time Line

Financial Plan
Personal funding, also especially soliciting for scholarships. (i.e., University of Vaasa Grants, NISSI Foundation Grants, etc.) [e.g., 25,000€ each academic year].

Research Time Line

ID		Task Name	Duration	Start	Finish
1		**Doctoral Thesis Structure Plan**	**1119 days?**	**Mon 24/05/10**	**Thu 04/09/14**
2		Literature Review	245 days?	Mon 24/05/10	Fri 29/04/11
3		Developing Questionaire and Interview Questions	180 days?	Mon 02/05/11	Fri 06/01/12
4		**Pilot Case Studies**	**90 days?**	**Mon 28/03/11**	**Fri 29/07/11**
5		Case Study 1	90 days?	Mon 28/03/11	Fri 29/07/11
6		Case Study 2	90 days?	Mon 28/03/11	Fri 29/07/11
7		Case Study 3	90 days?	Mon 28/03/11	Fri 29/07/11
8		Case Study 4	90 days?	Mon 28/03/11	Fri 29/07/11
9		**Questionaires and Interviews Administration**	**1 day?**	**Mon 01/08/11**	**Mon 01/08/11**
10		Conferences	1 day?	Mon 01/08/11	Mon 01/08/11
11		Methodology and Data Analysis / Interpretation	152 days?	Wed 02/10/13	Thu 01/05/14
12		**Final Report / Report Submission for Review**	**90 days?**	**Fri 02/05/14**	**Thu 04/09/14**
13		Final Report Further Editing and Defence	90 days?	Fri 02/05/14	Thu 04/09/14

*Conferences could be earlier than planned depending on conference dates/schedules.

Appendix B: - Sample Research Questionnaire.

A COLLABORATIVE INDUSTRIAL COMPETITIVE ADVANTAGE FOR NEW PRODUCT INTRODUCTION/DEVELOPMENT (FINLAND)

PART 1: COMPANY'S DESIGN TEAM REP. BACKGROUND INFORMATION.

1. Name of your company and location of company operations?

____

2. Which of the Wärtsilä categories 32 Ship Power engine system design Team(s) are you a member of?

____

3. Name of the design team's representative / member completing this form and the type of system your team designs?

____

4. Position on company level? ____

5. Position and responsibility in the design team? ______________________________

PART 2: FREQUENT CONCURRENT DESIGN TEAMS' COMMUNICATION INTERFACE.

6. How frequent do members of your design team communicate with the other design teams involved with the entire design of the Wärtsilä Ship Power 32 Engines? ***(Please tick the appropriate box)***

	[Not at all]	***[Somewhat frequent]***	***[Very frequent]***
Fuel oil system team	[ ]	[ ]	[ ]
Lubricating oil system team	[ ]	[ ]	[ ]
Compressed air system team	[ ]	[ ]	[ ]
Cooling water system team	[ ]	[ ]	[ ]
Combustion air system team	[ ]	[ ]	[ ]
Exhaust gas system team	[ ]	[ ]	[ ]
Some other Ship Power functional system team, what / which functional system team?	[ ]	[ ]	[ ]

____

(E.g. Turbocharger cleaning system team, Automation system team, Vibration and noise system team & Power transmission system team).

7. How important is a member of your design team to communicate with the other design teams involved with the entire design of the Wärtislä Ship Power 32 Engines? ***(Please tick the appropriate box)***

	[Not at all]	*[Somewhat frequent]*	*[Very frequent]*
Fuel oil system team	[ ]	[ ]	[ ]
Lubricating oil system team	[ ]	[ ]	[ ]
Compressed air system team	[ ]	[ ]	[ ]
Cooling water system team	[ ]	[ ]	[ ]
Combustion air system team	[ ]	[ ]	[ ]
Exhaust gas system team	[ ]	[ ]	[ ]
Some other Ship Power functional system team, what / which functional system team?	[ ]	[ ]	[ ]

____

(E.g. Turbocharger cleaning system team, Automation system team, Vibration and noise system team & Power transmission system team).

PART 4: EFFECTIVE AND EFFICIENT DESIGN TEAMS RELATIONAL CONCURRENT COMMUNICATION. ~ *(Please tick the appropriate box)* ~

8. How do members of your design team relate to the other design teams involved before and during the design of the entire Wärtsilä Ship Power - 32 Engines in terms of technical and design communications?

	[Not at all]	*[Somewhat frequent]*	*[Very frequent]*
Fuel oil system team	[ ]	[ ]	[ ]
Lubricating oil system team	[ ]	[ ]	[ ]
Compressed air system team	[ ]	[ ]	[ ]
Cooling water system team	[ ]	[ ]	[ ]
Combustion air system team	[ ]	[ ]	[ ]
Exhaust gas system team	[ ]	[ ]	[ ]
Some other Ship Power functional system team, what / which functional system team?	[ ]	[ ]	[ ]

____

(E.g. Turbocharger cleaning system team, Automation system team, Vibration and noise system team & Power transmission system team).

PART 5: TEAMS' CONCURRENT COMMUNICATION INTERFACES REVIEW & REDESIGN.
~ (Please tick the appropriate space) ~

Exhaust gas system team	__Low	__Average	__High
Some other Ship Power functional system team, what / which functional system team?	__Low	__Average	__High

____

(E.g. Turbocharger cleaning system team, Automation system team, Vibration and noise system team & Power transmission system team).

10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?

Fuel oil system team	__Low	__Average	__High
Lubricating oil system team	__Low	__Average	__High
Compressed air system team	__Low	__Average	__High
Cooling water system team	__Low	__Average	__High
Combustion air system team	__Low	__Average	__High
Exhaust gas system team	__Low	__Average	__High
Some other Ship Power functional system team, what / which functional system team?	__Low	__Average	__High

____

(E.g. Turbocharger cleaning system team, Automation system team, Vibration and noise system team & Power transmission system team).

THANK YOU FOR YOUR COOPERATION.

Please return the questionnaire (***data collection for "Concurrent Enterprise" doctoral thesis***) to:

Professor Petri T. Helo, Head of the Network Value System (NeVS) Research Group,

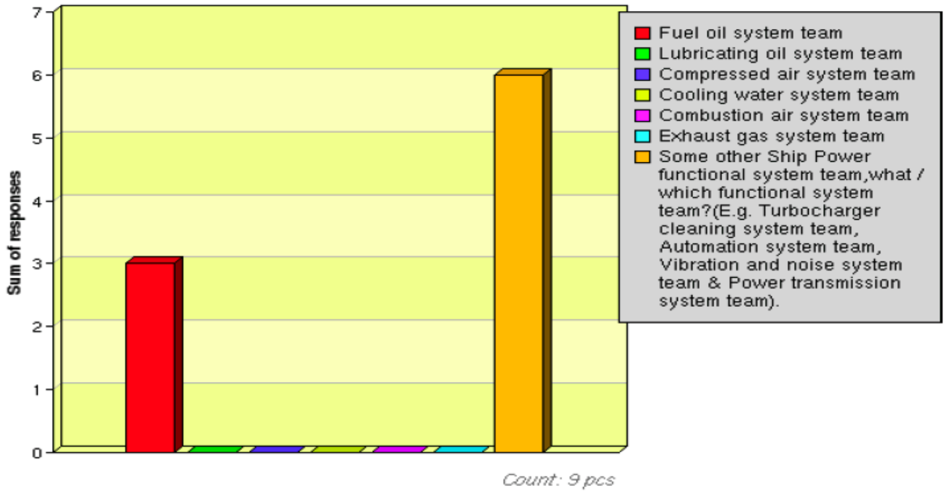
Richard Addo-Tenkorang, *Doctoral Student / Researcher* – Member University of Vaasa NeVS Research Group, Department of Production – Industrial Management Unit, University of Vaasa, P. O. Box 700, FIN-65101 Vaasa, or Fax: + +358-6-324 8467.

(*You could also scan a completed questionnaire and e-mail to: (phelo@uwasa.fi & ratenko@uwas.fi)

Appendix C: - Questionnaire e-Forms Response Graphics Representations

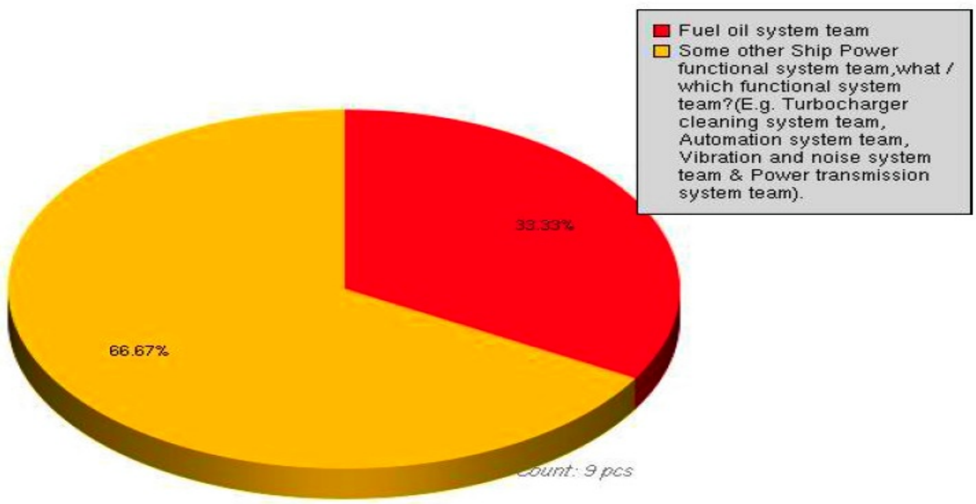
6. How frequent do members of your design team communicate with the other design teams involved with the entire design of the Wärtsilä Ship Power 32 Engines? (Please select your design team from the drop down menu)

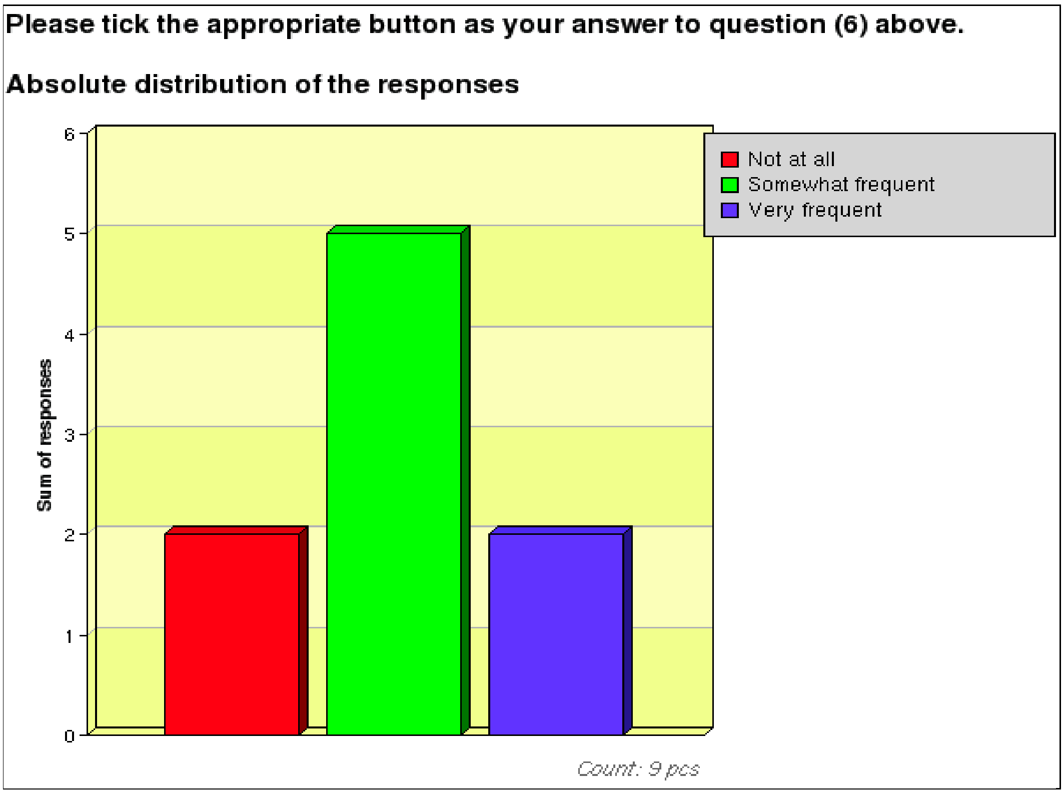
Absolute distribution of the responses

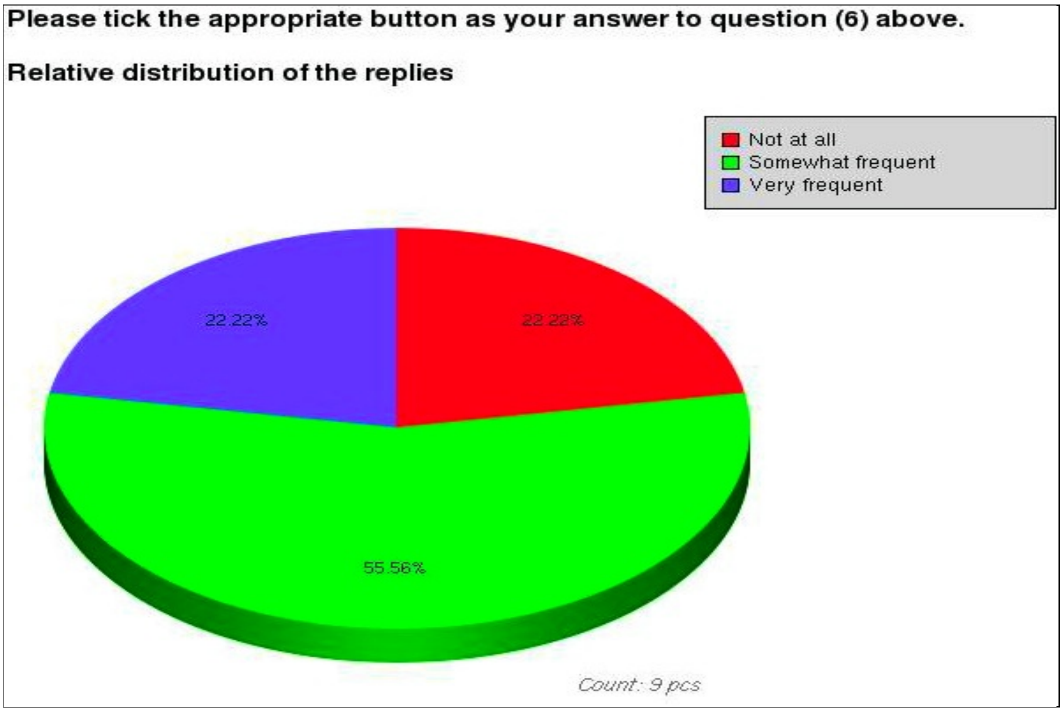


6. How frequent do members of your design team communicate with the other design teams involved with the entire design of the Wärtsilä Ship Power 32 Engines? (Please select your design team from the drop down menu)

Relative distribution of the replies

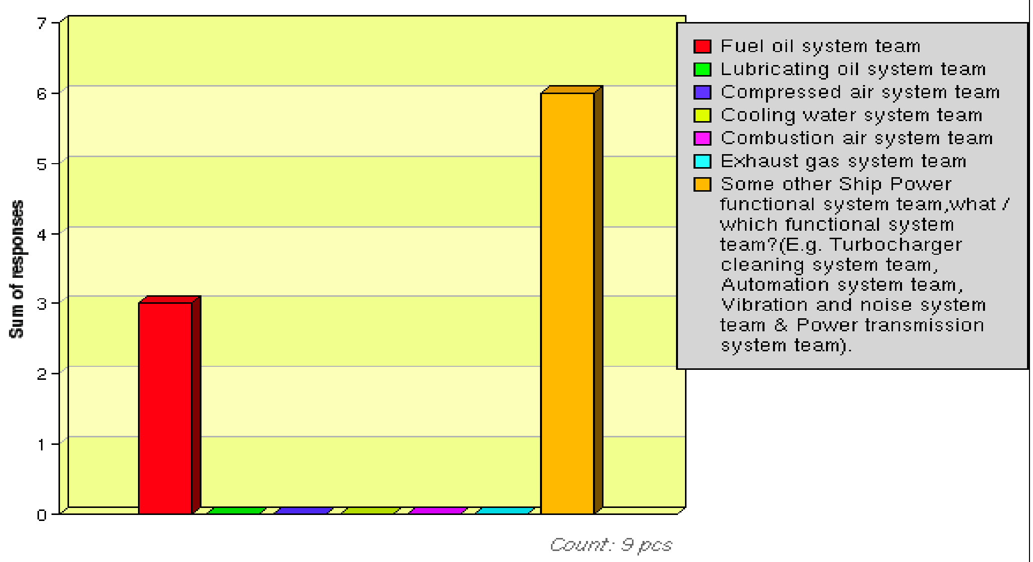



Please tick the appropriate button as your answer to question (6) above.
Absolute distribution of the responses
Sum of responses
6
5
4
3
2
1
0
Not at all
Somewhat frequent
Very frequent
Count: 9 pcs


Please tick the appropriate button as your answer to question (6) above.
Relative distribution of the replies
Not at all
Somewhat frequent
Very frequent
22.22%
22.22%
55.56%
Count: 9 pcs

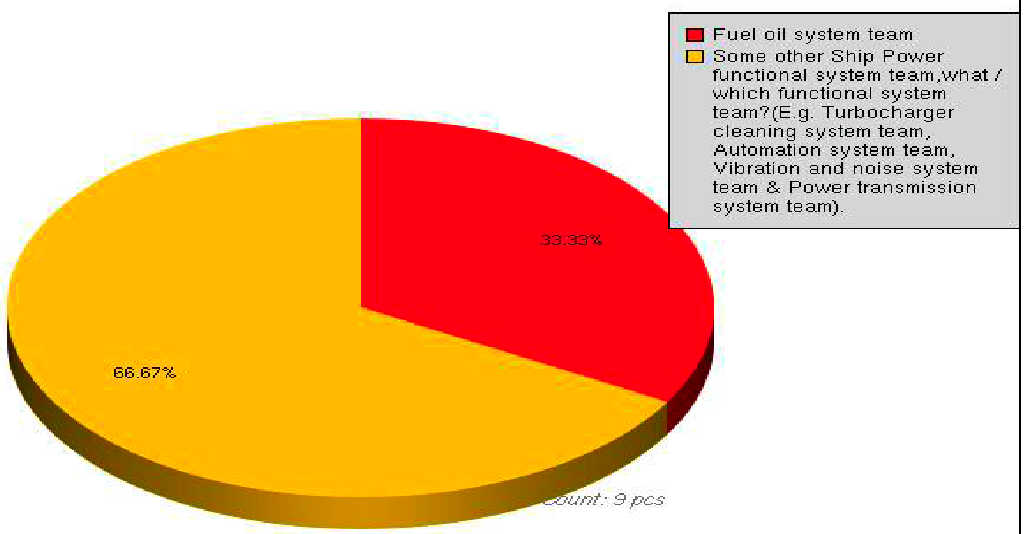
7. How important is a member of your design team to communicate with the other design teams involved with the entire design of the Wärtislä Ship Power 32 Engines? (Please select your design team from the drop down menu)

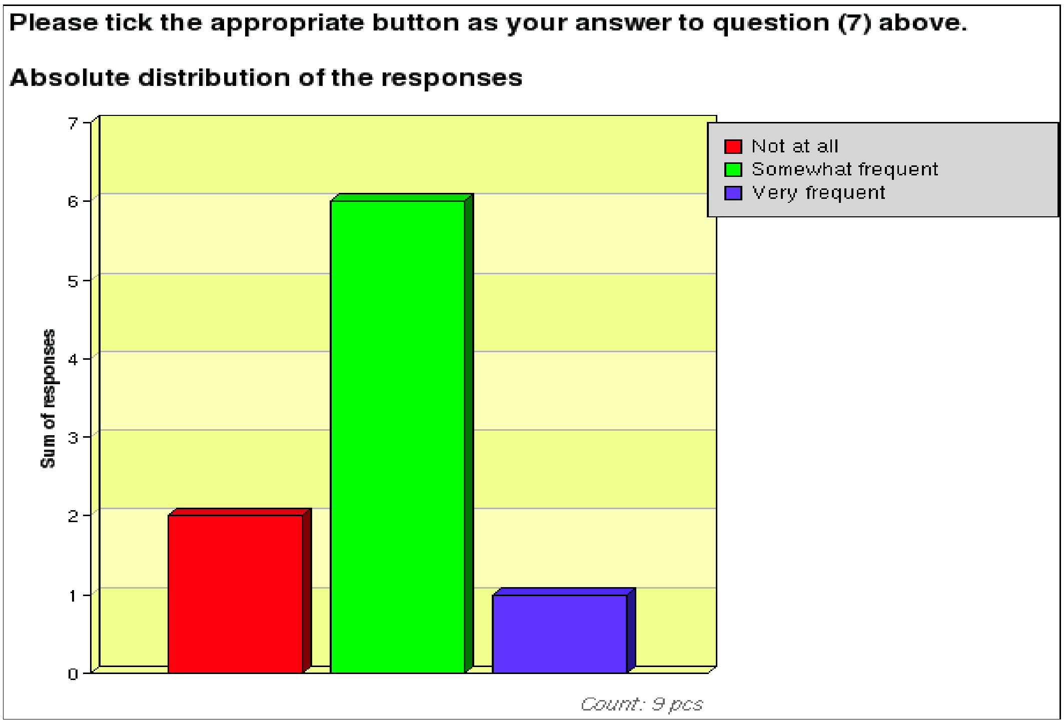
Absolute distribution of the responses

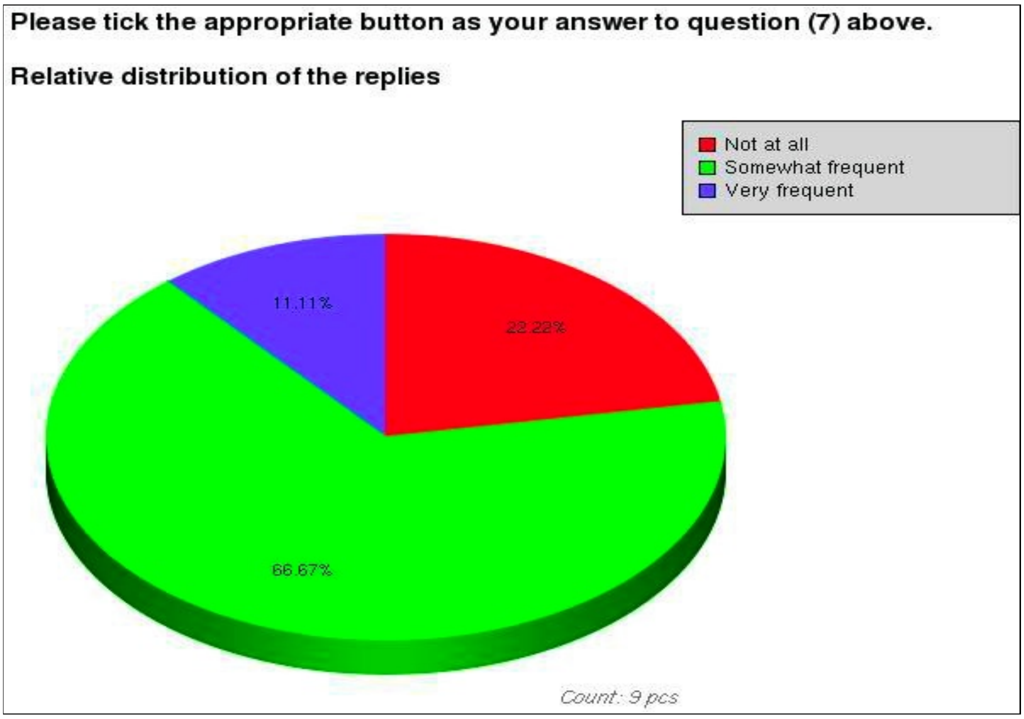


7. How important is a member of your design team to communicate with the other design teams involved with the entire design of the Wärtislä Ship Power 32 Engines? (Please select your design team from the drop down menu)

Relative distribution of the replies

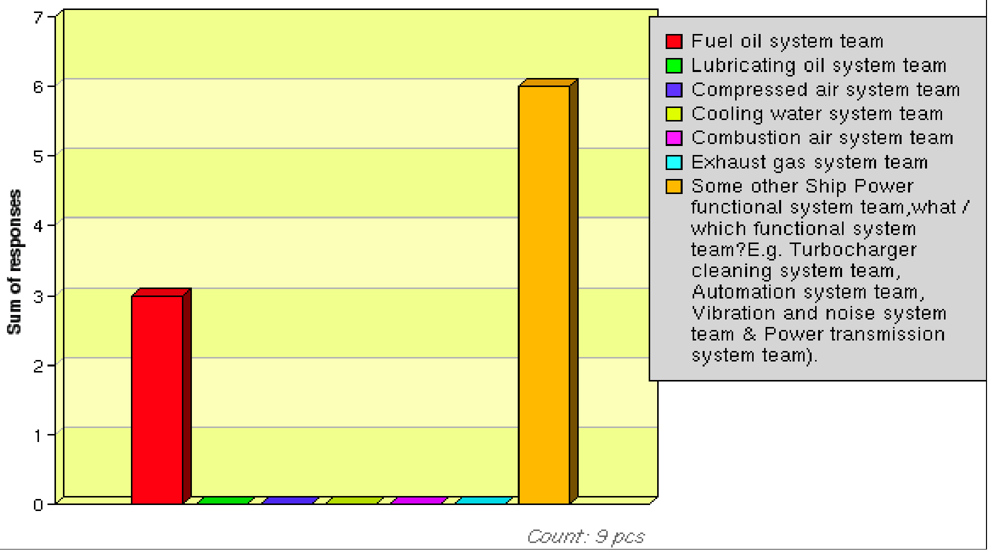



Please tick the appropriate button as your answer to question (7) above.
Absolute distribution of the responses
Sum of responses
0
1
2
3
4
5
6
7
Not at all
Somewhat frequent
Very frequent
Count: 9 pcs


Please tick the appropriate button as your answer to question (7) above.
Relative distribution of the replies
Not at all
Somewhat frequent
Very frequent
11.11%
22.22%
66.67%
Count: 9 pcs

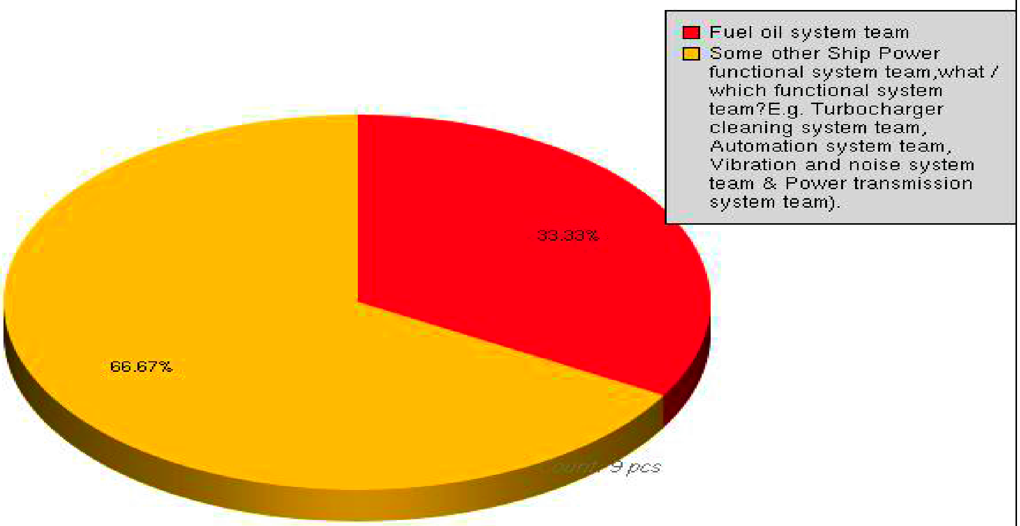
8. How do members of your design team relate to the other design teams involved before and during the design of the entire Wärtsilä Ship Power - 32 Engines in terms of technical and design communications? (Please select your design team from the drop down

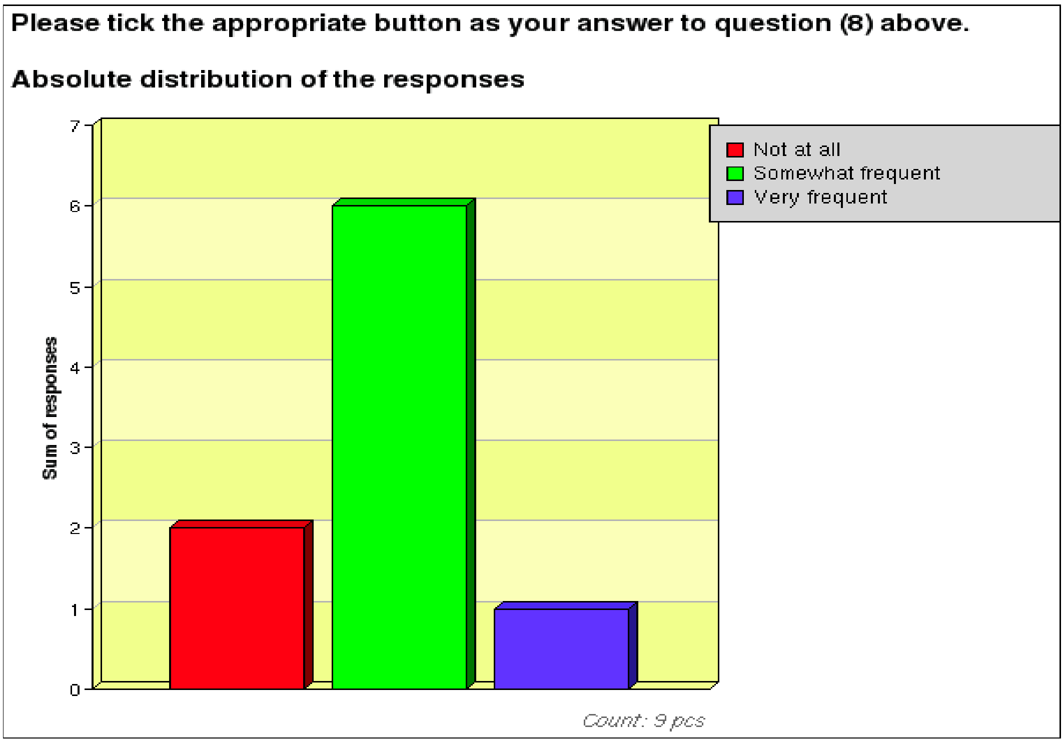
Absolute distribution of the responses

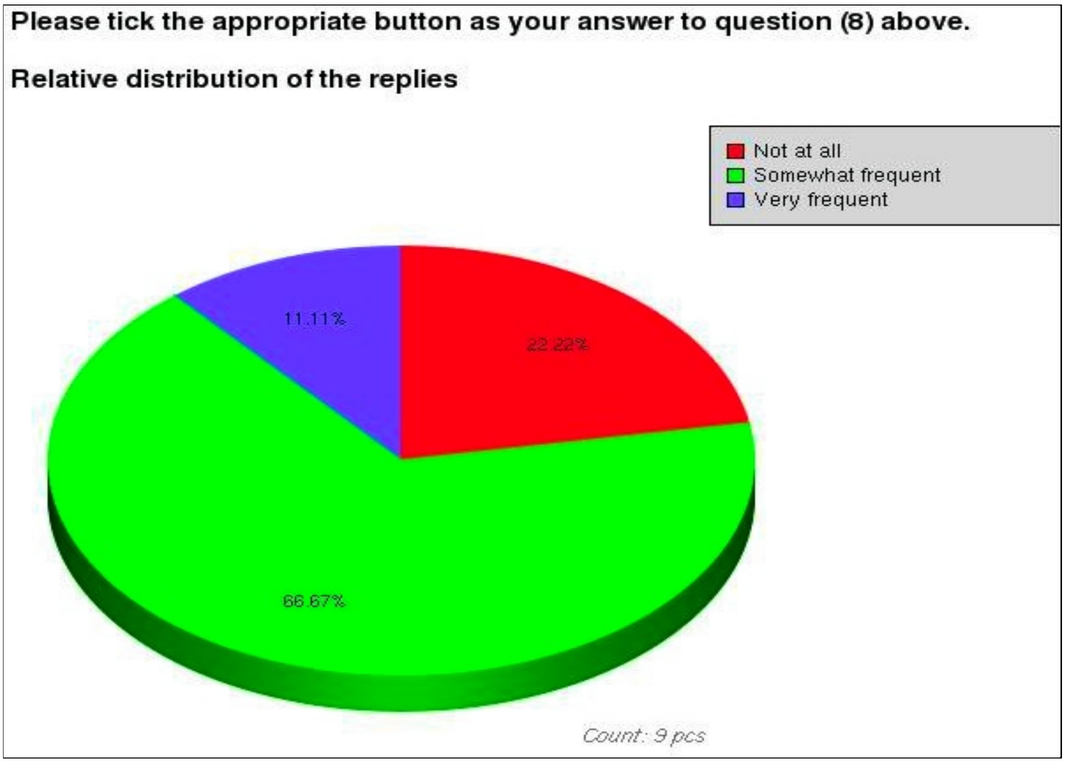


8. How do members of your design team relate to the other design teams involved before and during the design of the entire Wärtsilä Ship Power - 32 Engines in terms of technical and design communications? (Please select your design team from the drop down

Relative distribution of the replies

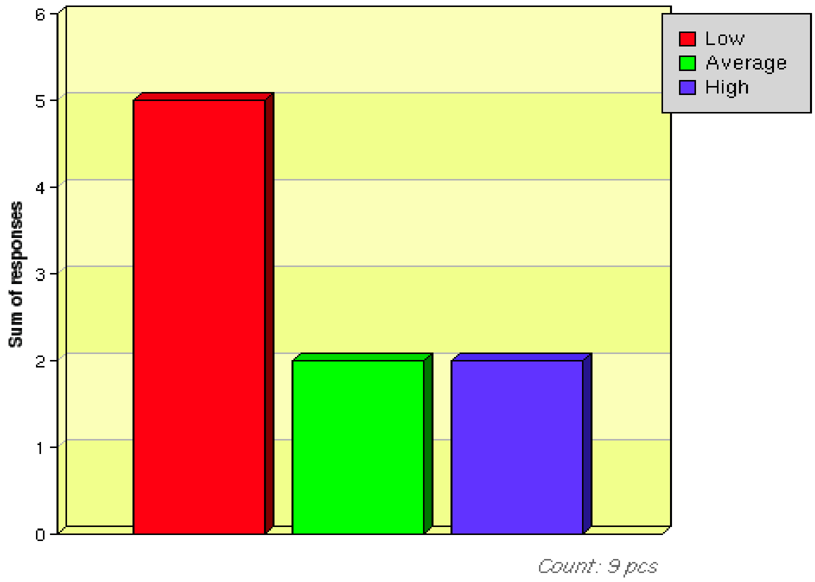



Please tick the appropriate button as your answer to question (8) above.
Absolute distribution of the responses
Sum of responses
0
1
2
3
4
5
6
7
Not at all
Somewhat frequent
Very frequent
Count: 9 pcs


Please tick the appropriate button as your answer to question (8) above.
Relative distribution of the replies
Not at all
Somewhat frequent
Very frequent
11.11%
22.22%
66.67%
Count: 9 pcs

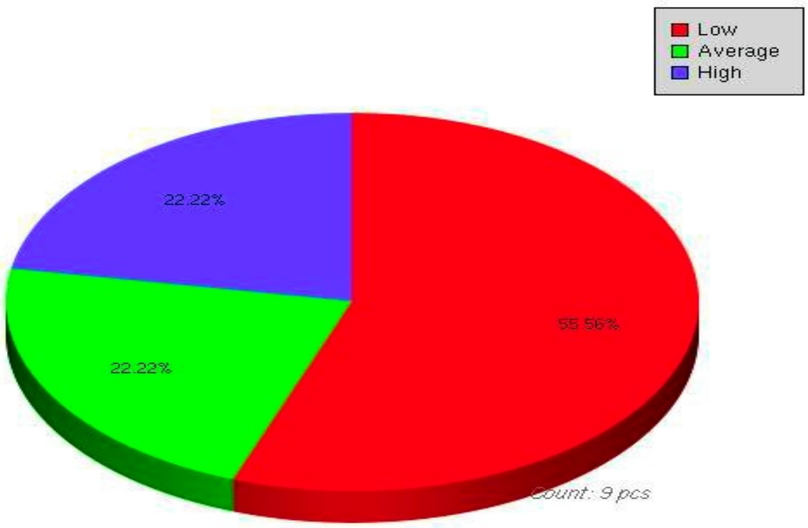
9. How much of the other design teams' systems; interfaces with your design team's systems, that is usually changed by your design team's systems? Fuel oil system team

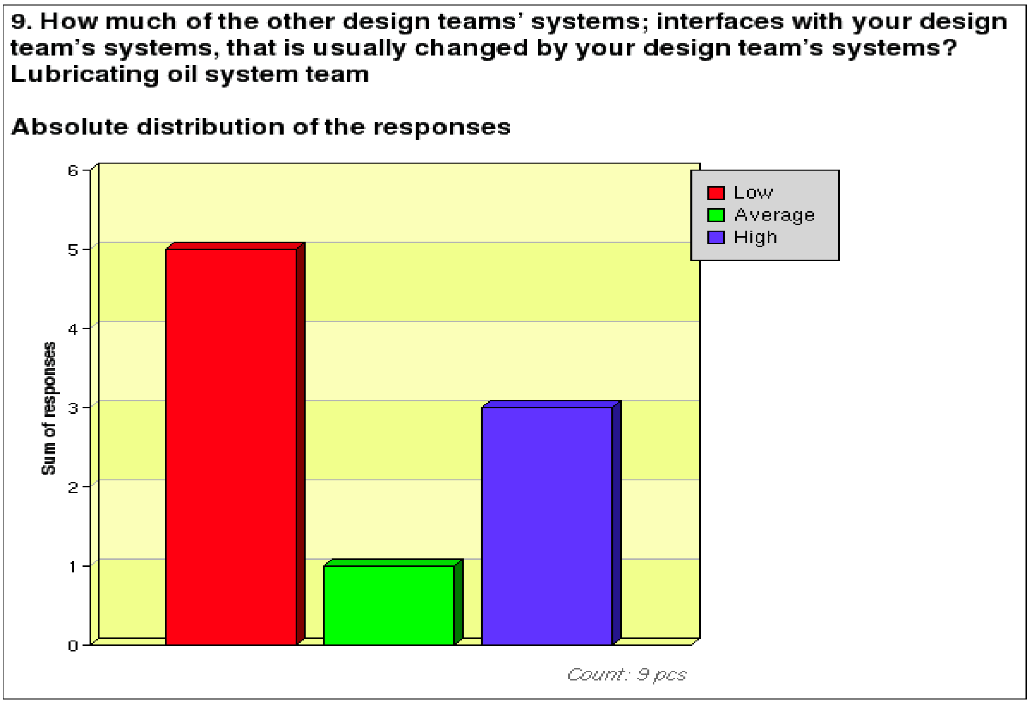
Absolute distribution of the responses

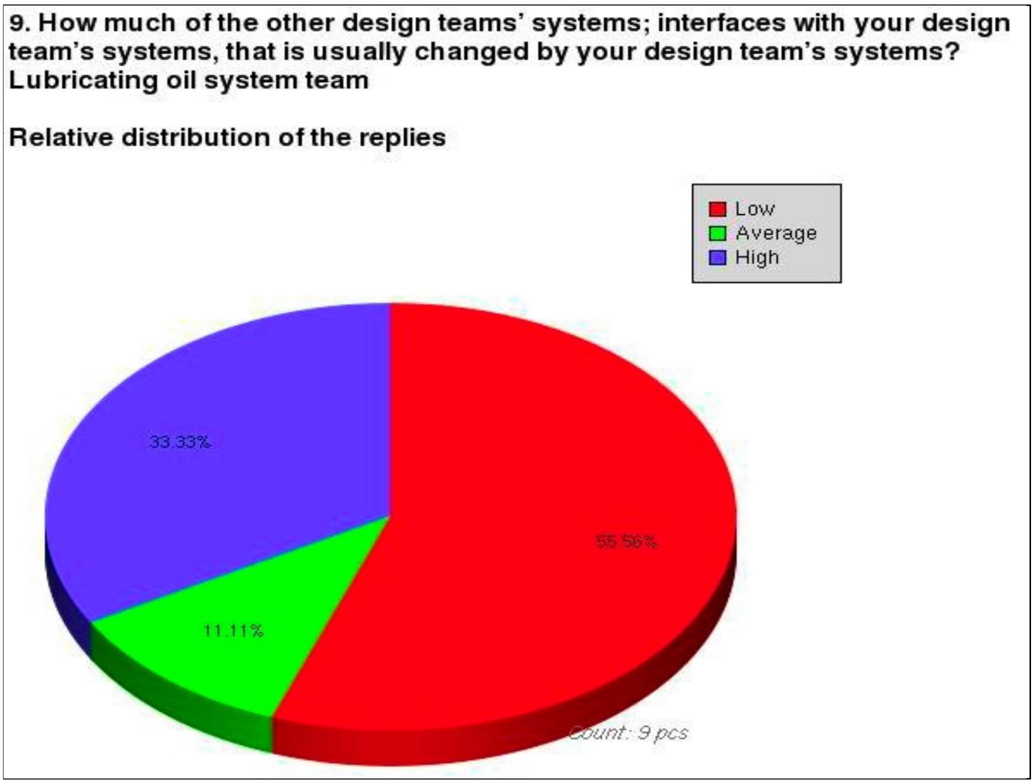


9. How much of the other design teams' systems; interfaces with your design team's systems, that is usually changed by your design team's systems? Fuel oil system team

Relative distribution of the replies

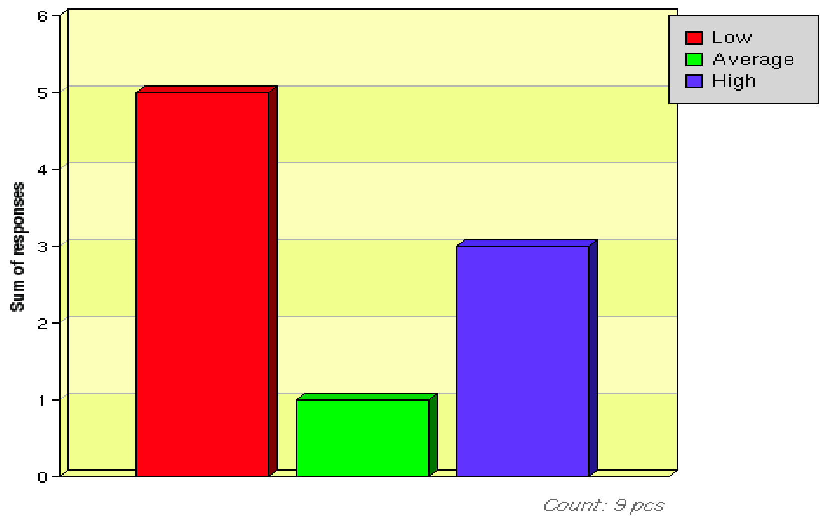



9. How much of the other design teams' systems; interfaces with your design team's systems, that is usually changed by your design team's systems?
Lubricating oil system team
Absolute distribution of the responses
Sum of responses
0
1
2
3
4
5
6
Low
Average
High
Count: 9 pcs


9. How much of the other design teams' systems; interfaces with your design team's systems, that is usually changed by your design team's systems?
Lubricating oil system team
Relative distribution of the replies
Low
Average
High
33.33%
55.56%
11.11%
Count: 9 pcs

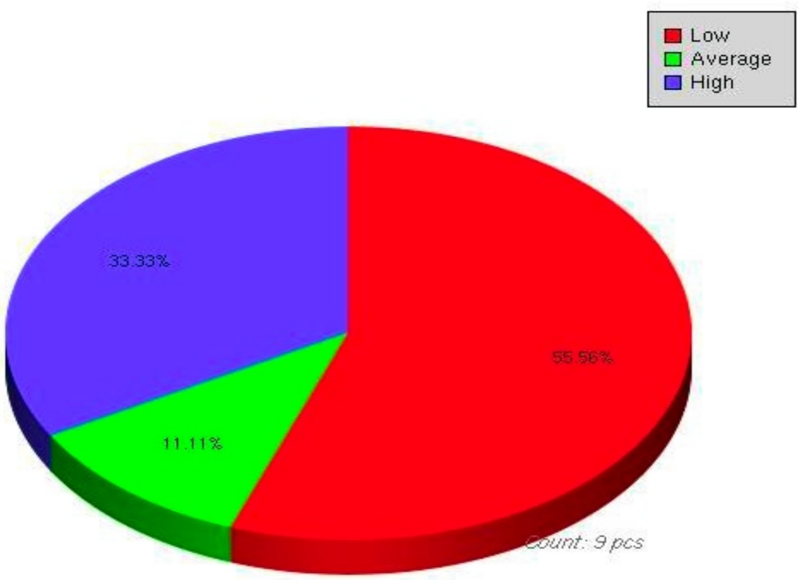
9. How much of the other design teams' systems; interfaces with your design team's systems, that is usually changed by your design team's systems? Compressed air system team

Absolute distribution of the responses



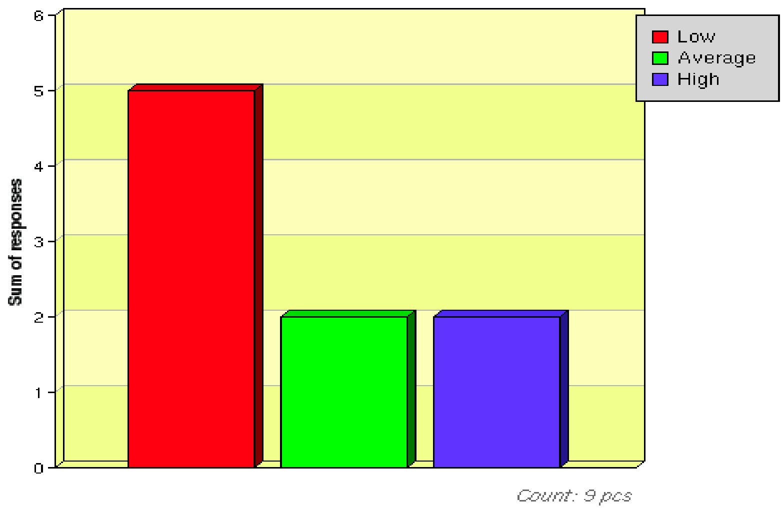
9. How much of the other design teams' systems; interfaces with your design team's systems, that is usually changed by your design team's systems? Compressed air system team

Relative distribution of the replies



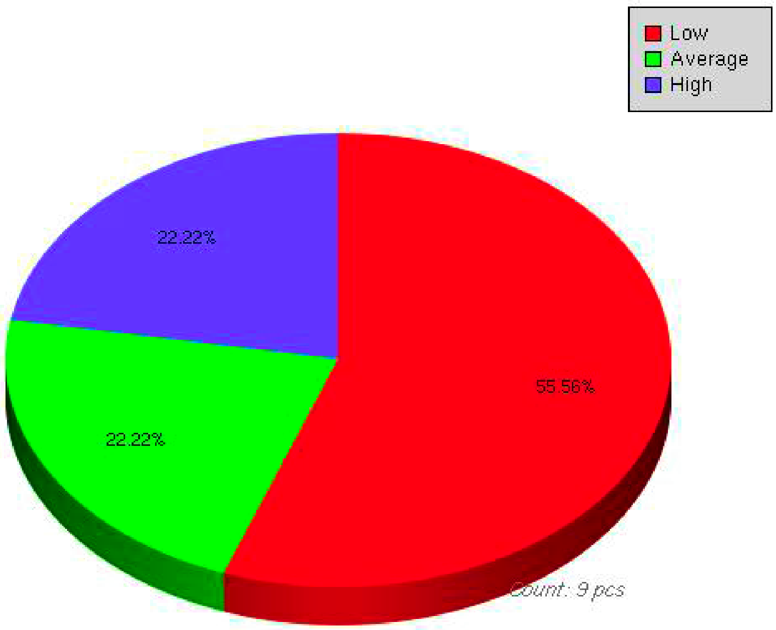
9. How much of the other design teams' systems; interfaces with your design team's systems, that is usually changed by your design team's systems? Cooling water system team

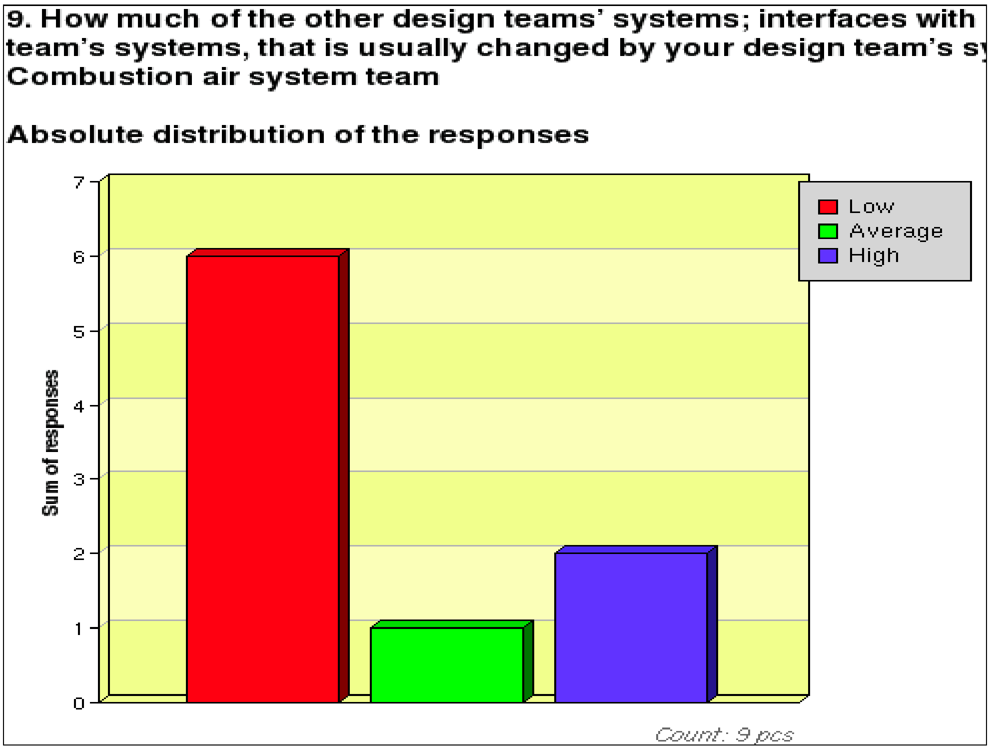
Absolute distribution of the responses

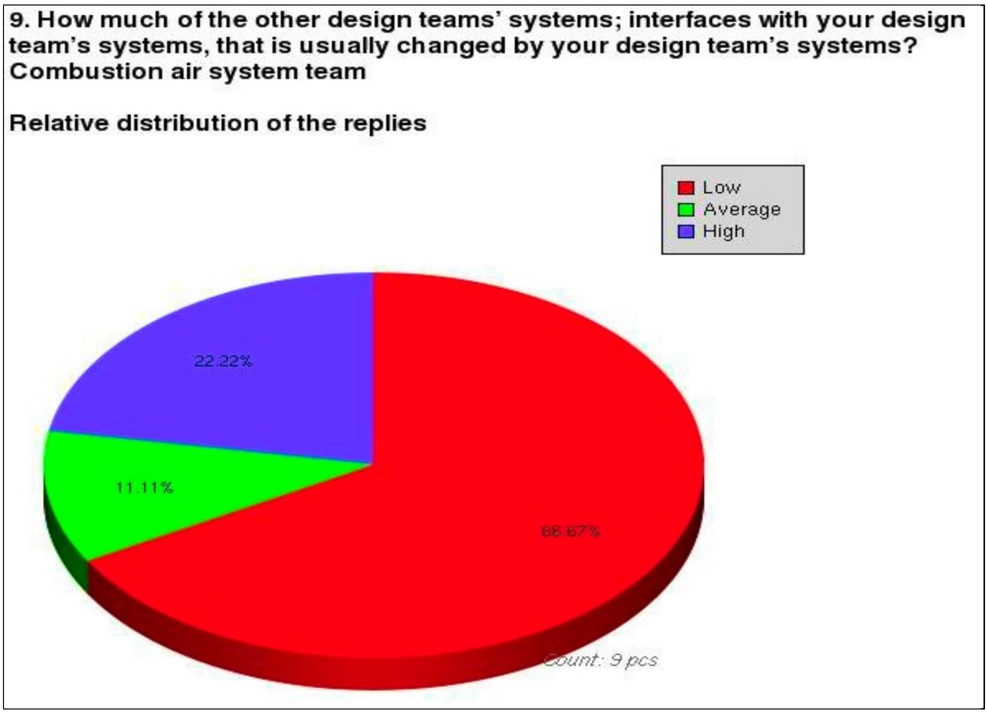


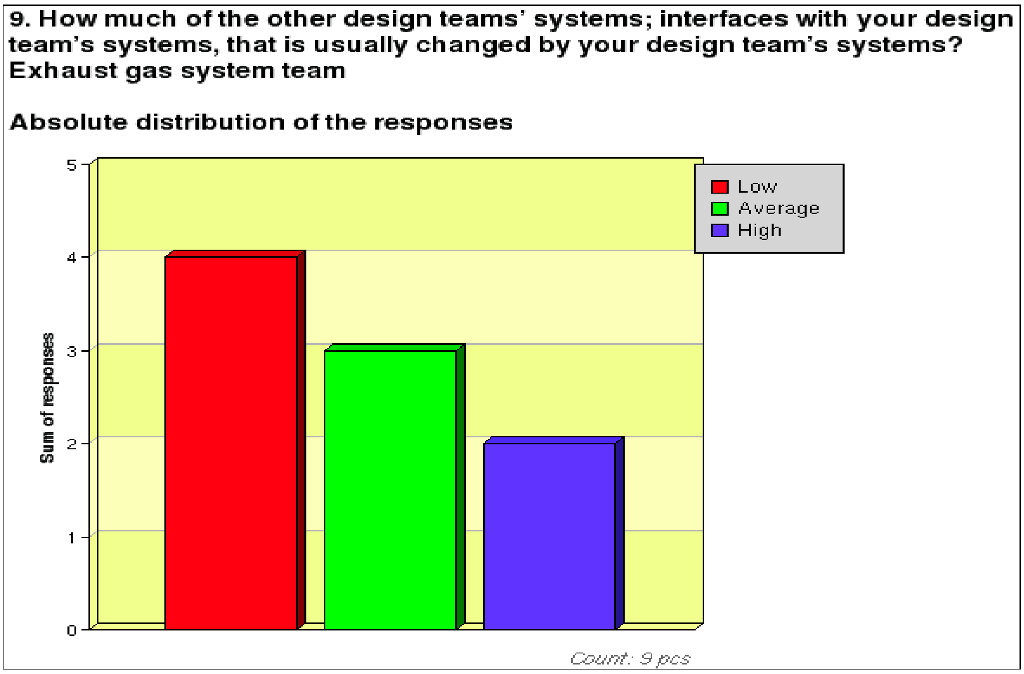
9. How much of the other design teams' systems; interfaces with your design team's systems, that is usually changed by your design team's systems? Cooling water system team

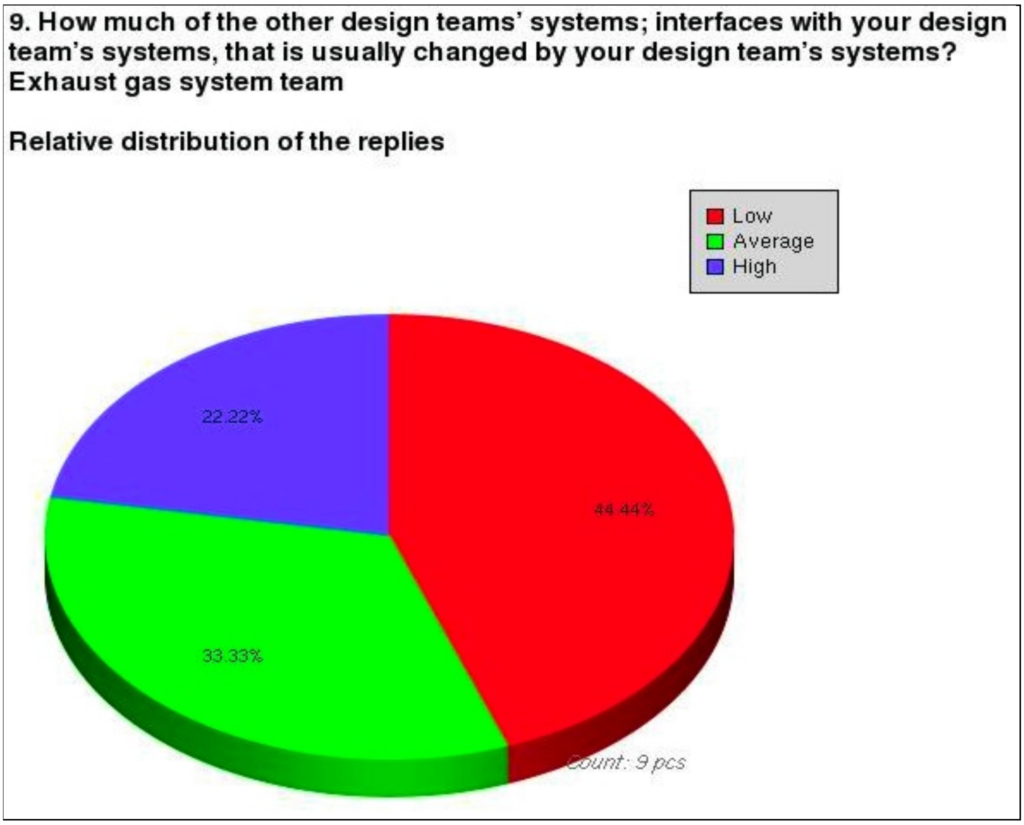
Relative distribution of the replies




9. How much of the other design teams' systems; interfaces with
team's systems, that is usually changed by your design team's sy
Combustion air system team
Absolute distribution of the responses
Sum of responses
0
1
2
3
4
5
6
7
Low
Average
High
Count: 9 pcs

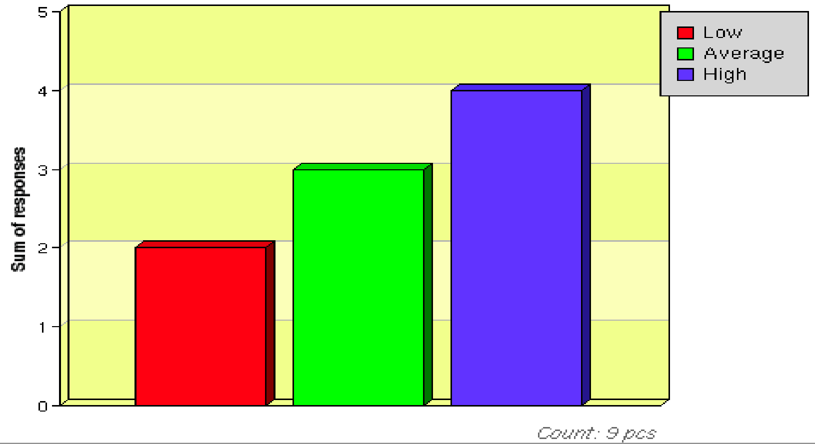

9. How much of the other design teams' systems; interfaces with your design
team's systems, that is usually changed by your design team's systems?
Combustion air system team
Relative distribution of the replies
Low
Average
High
22.22%
11.11%
66.67%
Count: 9 pcs


9. How much of the other design teams' systems; interfaces with your design team's systems, that is usually changed by your design team's systems?
Exhaust gas system team
Absolute distribution of the responses
Sum of responses
0
1
2
3
4
5
Low
Average
High
Count: 9 pcs


9. How much of the other design teams' systems; interfaces with your design team's systems, that is usually changed by your design team's systems?
Exhaust gas system team
Relative distribution of the replies
Low
Average
High
22.22%
44.44%
33.33%
Count: 9 pcs

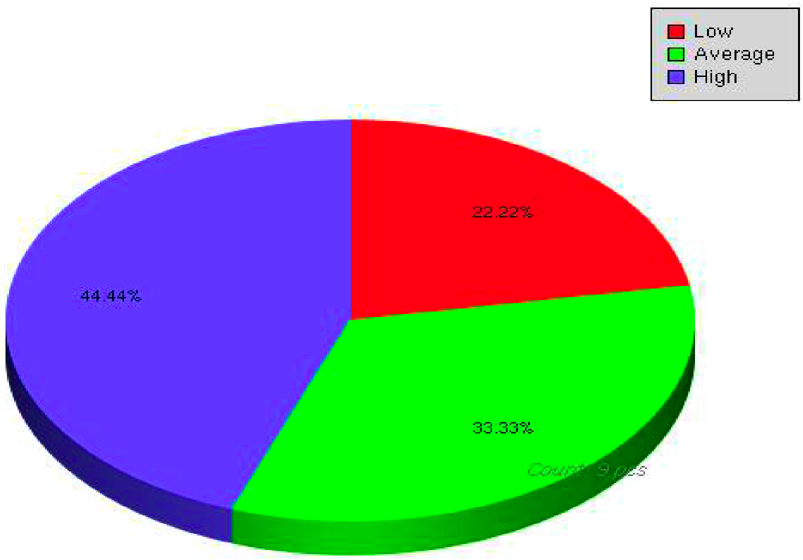
9. How much of the other design teams' systems; interfaces with your design team's systems, that is usually changed by your design team's systems? Some other Ship Power functional system team, what / which functional system team? (E.g. Turbocharger cleaning system team, Automation system team, Vibration and noise system team & Power transmission system team).

Absolute distribution of the responses



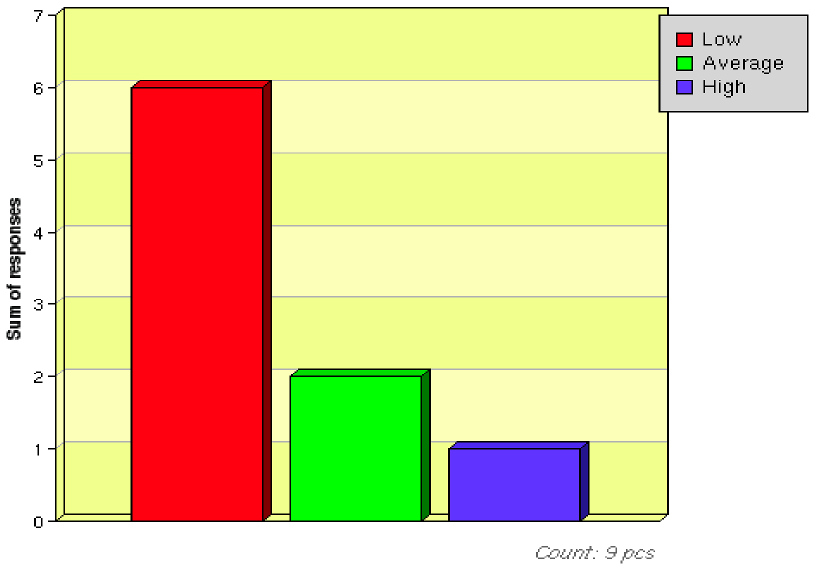
9. How much of the other design teams' systems; interfaces with your design team's systems, that is usually changed by your design team's systems? Some other Ship Power functional system team, what / which functional system team? (E.g. Turbocharger cleaning system team, Automation system team, Vibration and noise system team & Power transmission system team).

Relative distribution of the replies



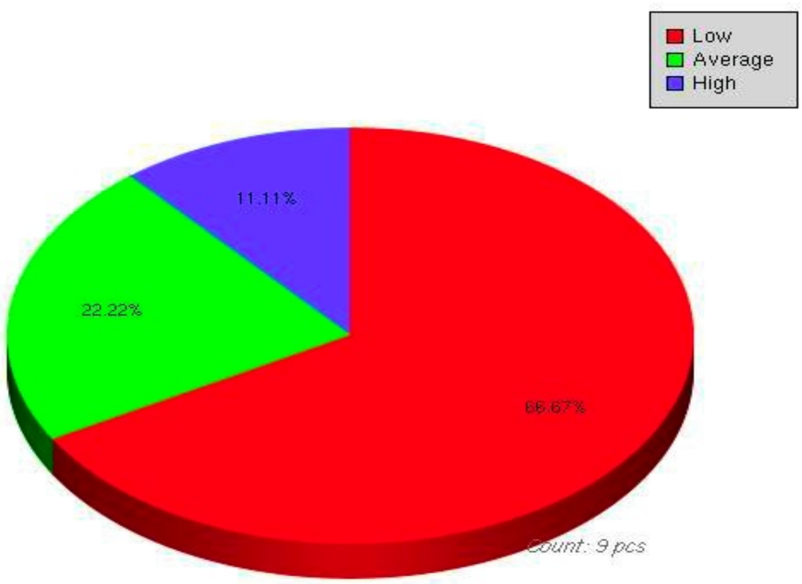
10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?
Fuel oil system team

Absolute distribution of the responses



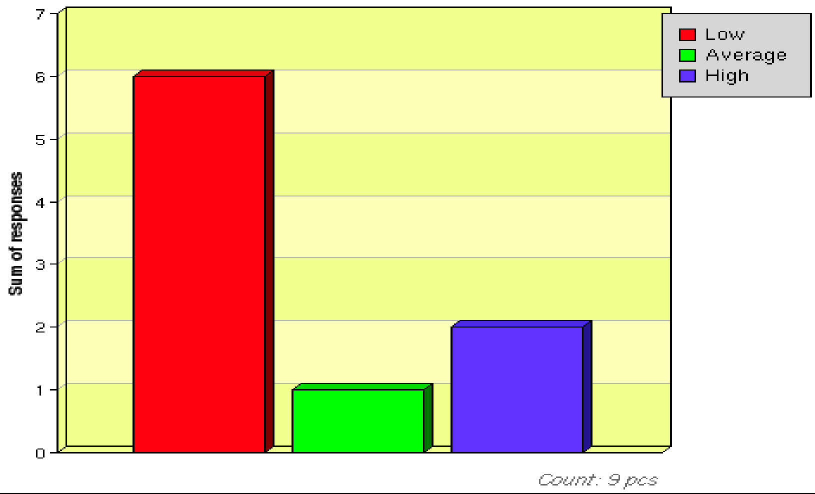
10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?
Fuel oil system team

Relative distribution of the replies



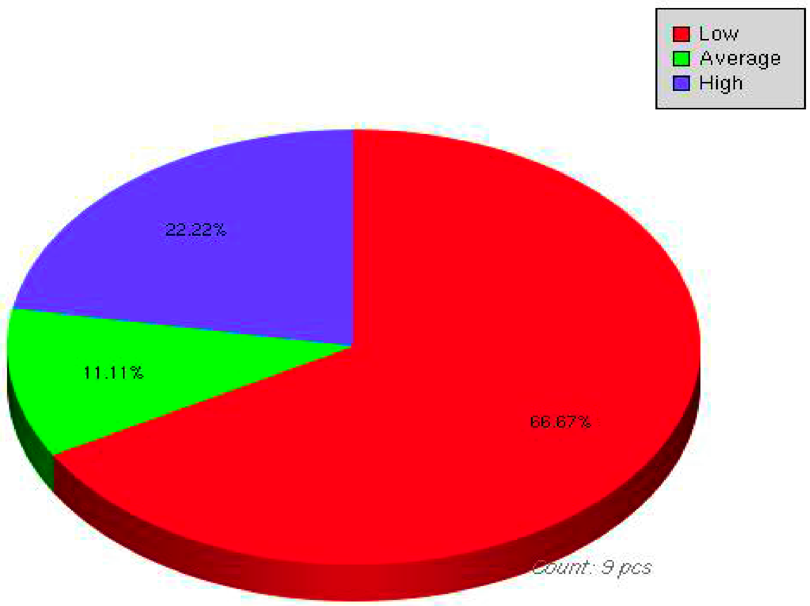
10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?
Lubricating oil system team

Absolute distribution of the responses



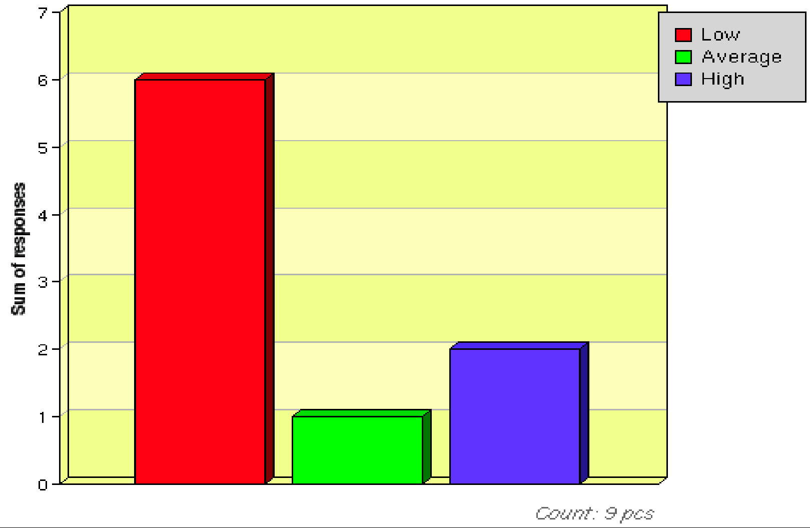
10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?
Lubricating oil system team

Relative distribution of the replies



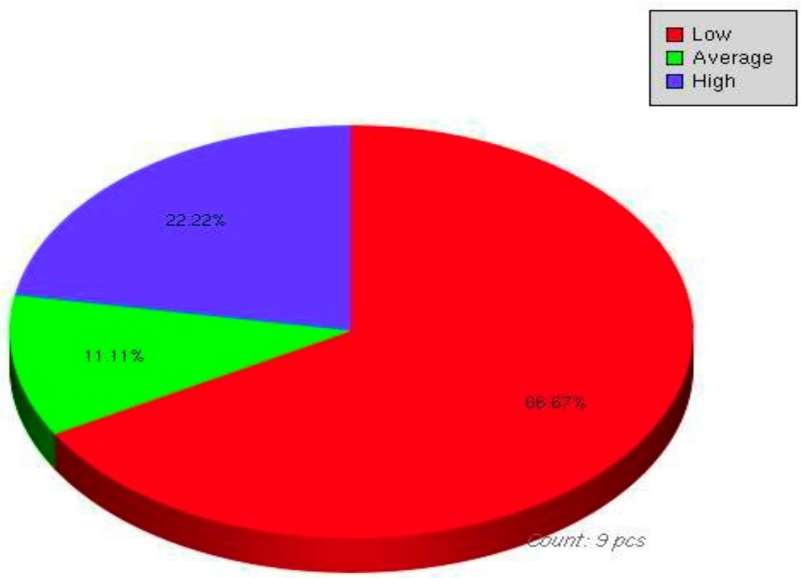
10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?
Compressed air system team

Absolute distribution of the responses



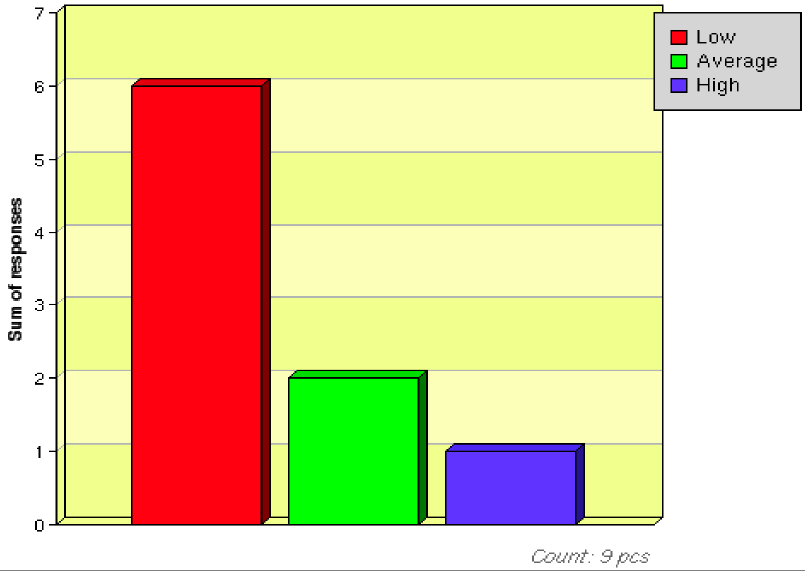
10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?
Compressed air system team

Relative distribution of the replies



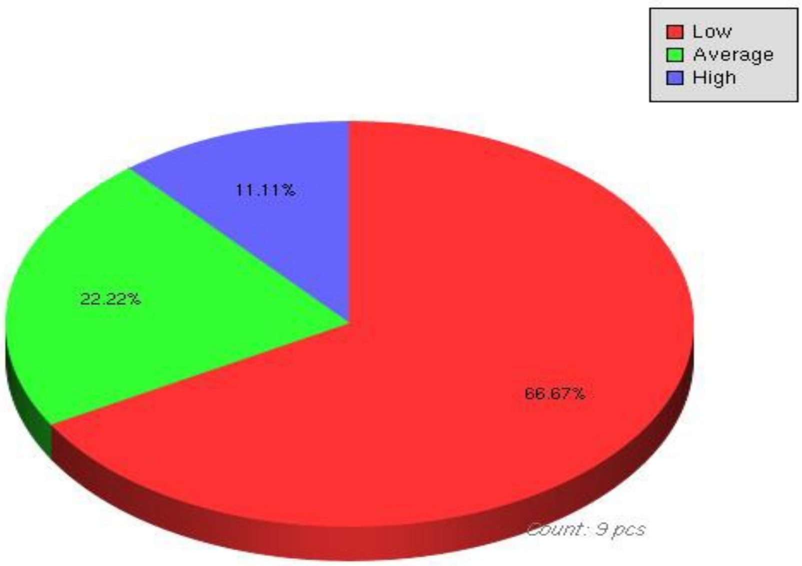
10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?
Cooling water system team

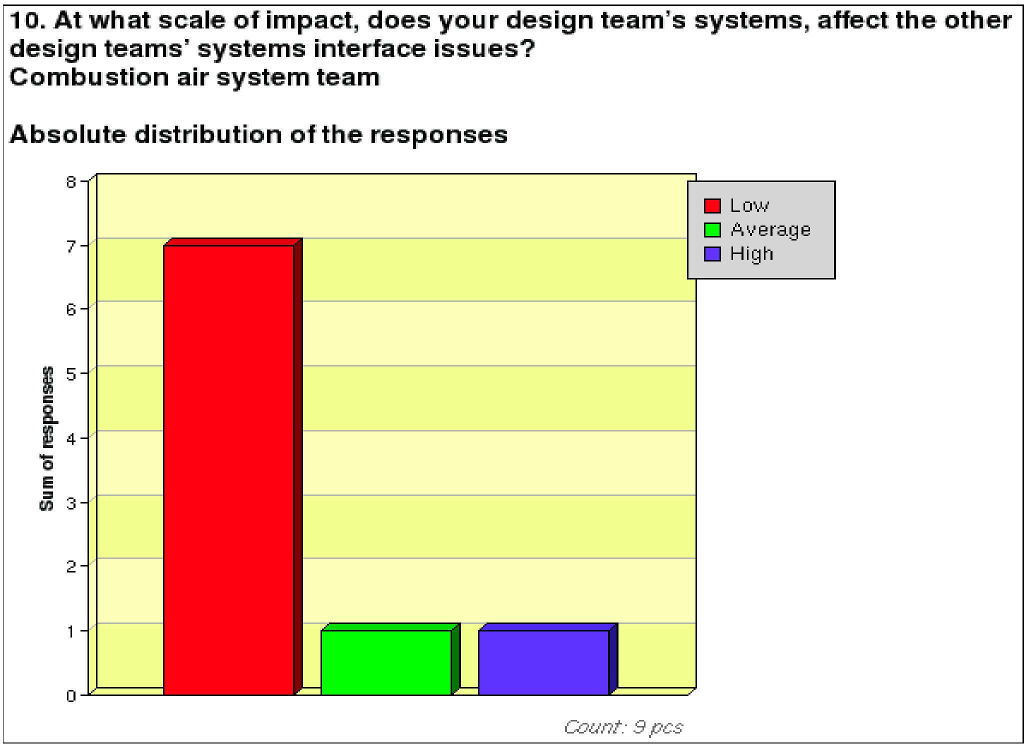
Absolute distribution of the responses

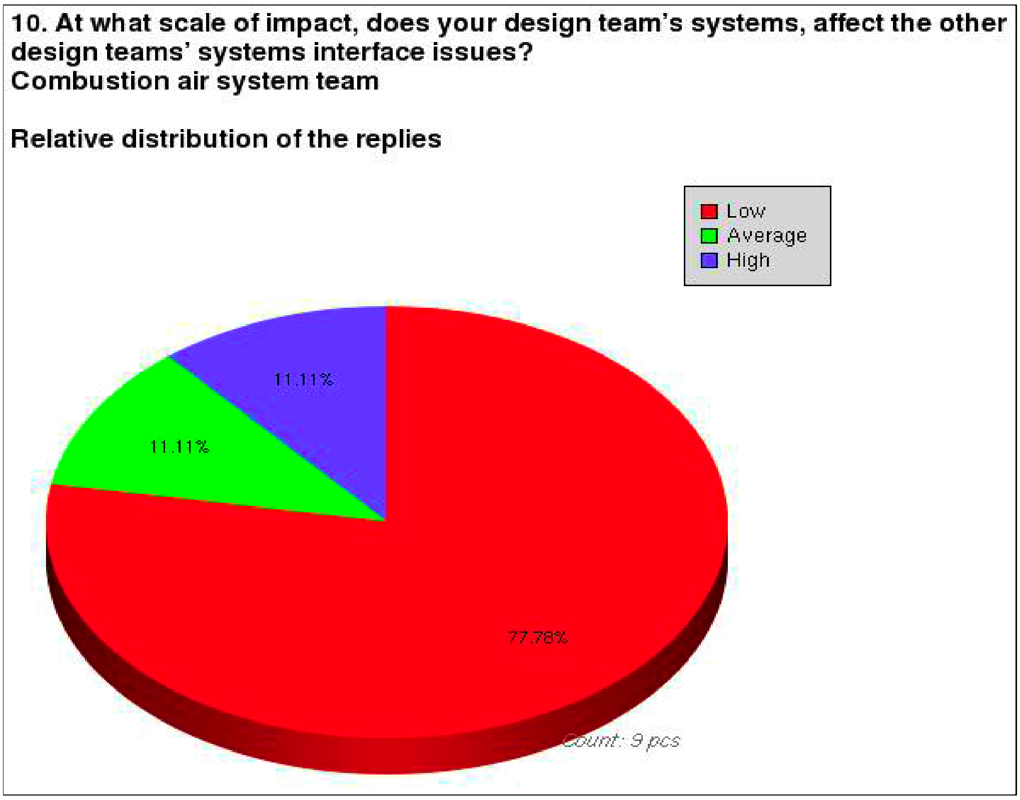


10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?
Cooling water system team

Relative distribution of the replies

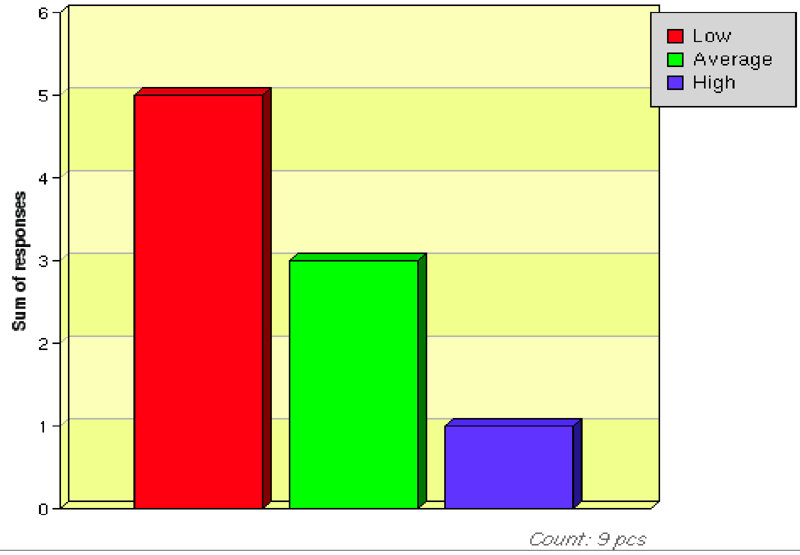



10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?
Combustion air system team
Absolute distribution of the responses
Sum of responses
0
1
2
3
4
5
6
7
8
Low
Average
High
Count: 9 pcs


10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?
Combustion air system team
Relative distribution of the replies
Low
Average
High
11.11%
11.11%
77.78%
Count: 9 pcs

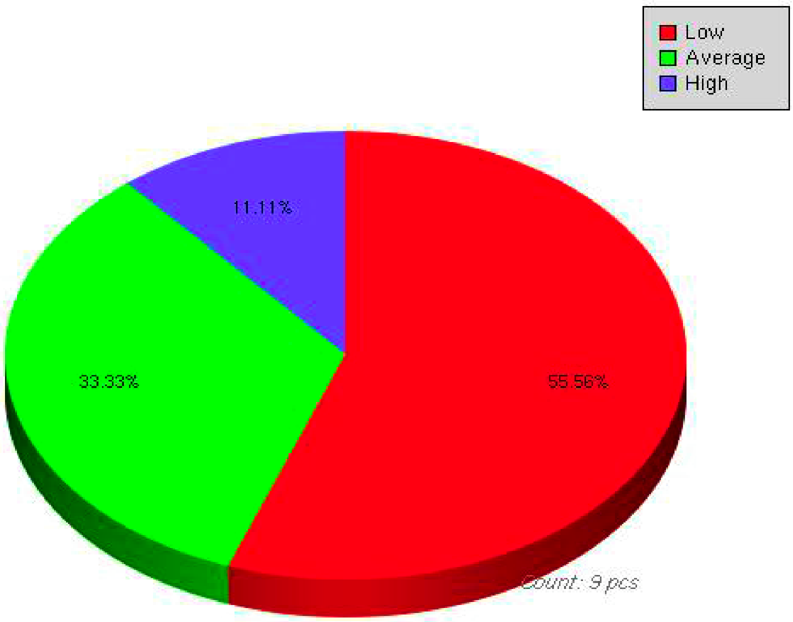
10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?
Exhaust gas system team

Absolute distribution of the responses



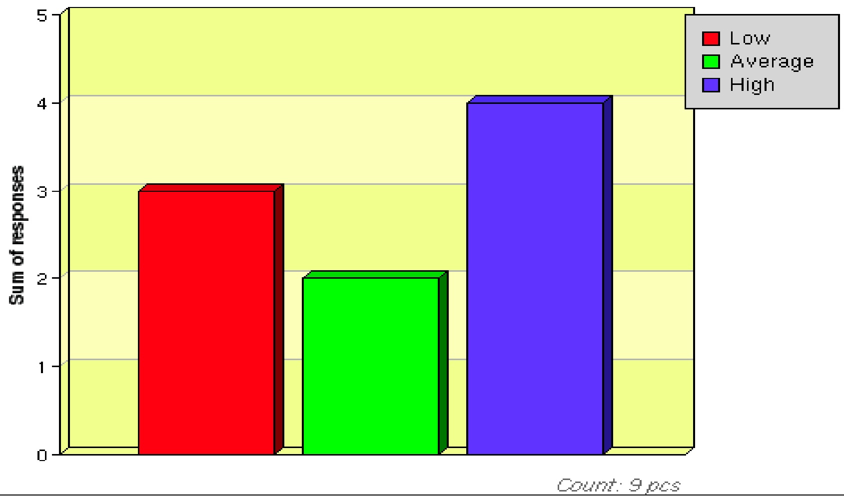
10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?
Exhaust gas system team

Relative distribution of the replies



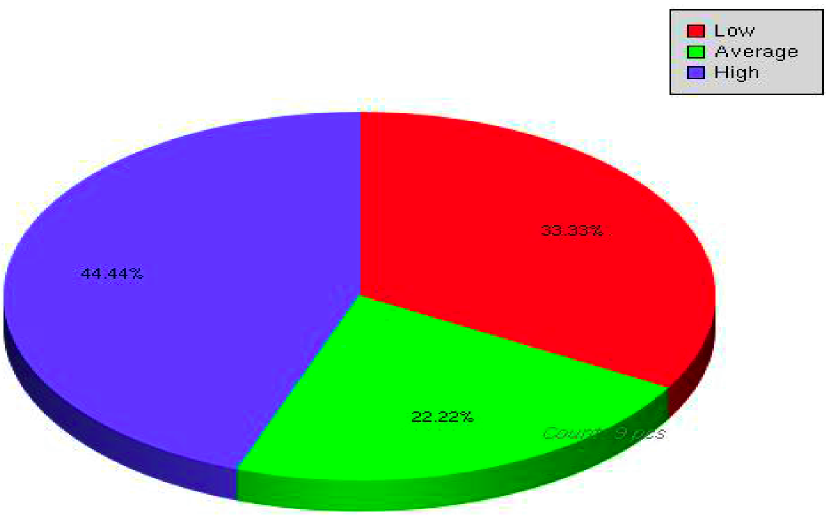
10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?
Some other Ship Power functional system team,what / which functional system team?(E.g. Turbocharger cleaning system team, Automation system team, Vibration and noise system team & Power transmission system team).

Absolute distribution of the responses



10. At what scale of impact, does your design team's systems, affect the other design teams' systems interface issues?
Some other Ship Power functional system team,what / which functional system team?(E.g. Turbocharger cleaning system team, Automation system team, Vibration and noise system team & Power transmission system team).

Relative distribution of the replies



Appendix D: - Ship Power Systems - Wärtsilä 32 Engine Categories.

System Types and Components of the Studied SP Engine(s)

Systems Types	Number of Components
Fuel Oil System (FOS)	20
Lubricating Oil System (LOS)	13
Compressed Air System (CmpAS)	23
Cooling Water System (CWS)	10
Combustion Air System (CmbAS)	9
Exhaust Gas System (EGS)	5
Automation System (AtmS)	18
Power Transmission	7

29/105

Fuel Oil System

1. Acceptable fuel characteristics
2. Internal fuel oil system
3. External fuel oil system

System components:

1. Heater (booster unit)
2. Day tanks (HFO & MDF)
3. Overflow valve (HFO & MDF)
4. Cooler (MDF, booster unit)
5. Flow meter (booster unit)
6. Stand-by pump (MDF)
7. Leak fuel tanks (clean fuel & dirty fuel)
8. Quick closing valve (fuel oil tank)
9. Booster units (heater, cooler, suction filter, automatic filter, flow meter, viscosity meter & fuel feed pump)
10. Safety filter (HFO)
11. Circulation pump (booster unit, HFO / MDF)
12. Pump and filter unit (HFO / MDF)
13. Suction filter (booster unit)
14. Automatic filter (booster unit)
15. Viscosity meter (booster unit)
16. Feeder / booster unit
17. De-aeration tank (booster unit)
18. Charger valve

19. Pressure control valve (MDF, booster unit)
20. Venting valve (booster unit)

Lubricating Oil System

1. Lubricating oil requirements
2. Internal lubricating oil system
3. External lubricating oil system
4. Crankcase ventilation system
5. Flushing instructions

System components:

1. Heater (separator unit)
2. Separator pump (separator unit)
3. Suction strainer (main lubricating oil pump, Prelubricating oil pump & stand-by pump)
4. Stand-by pump
5. Suction filter (separator unit)
6. Separator
7. Condensate trap
8. System oil tank
9. Separator unit
10. Sludge tank
11. Renovated oil tank
12. New oil tank
13. Renovating oil tank

Compressed Air System

1. Instrument air quality
2. Internal compressed air system
3. External compressed air system

System components:

1. Main starting air valve
2. Starting air distributor
3. Starting air valve in cylinder head
4. Blocking valve, when turning gear engaged
5. Air containers
6. Pneumatic stop cylinders at each injection pump
7. Non return valve
8. Starting booster for speed governor
9. Flame arrester
10. Safety valves
11. Drain valve
12. Start solenoid valve CV321

13. Stop solenoid valve CV153-1
14. Stop solenoid valve CV153-2
15. Waste gates
16. Air filter (starting air inlet)
17. Starting air compressor unit
18. Air dryer unit
19. Starting air vessel
20. Compressor (starting air compressor unit)
21. Separator (starting air compressor unit)
22. Starting air inlet
23. Control air waste-gate valve.

Cooling Water System

1. Water quality
2. Internal cooling water system
3. External cooling water system

System components:

1. Heater (preheating unit)
2. Central cooler
3. Transfer pump
4. Circulating pumps
5. Air venting
6. Preheating unit
7. Drain tank
8. Evaporator unit
9. Expansion tanks
10. Temperature control valves (heat recovery)

Combustion Air System

1. Engine room ventilation
2. Combustion air system design

System components:

1. Turbocharger with filter
2. Louver
3. Water trap
4. Combustion air fan
5. Engine room ventilation fan
6. Fire dampers
7. Outlets with direction guide/flaps
8. Combustion air duct connected to turbocharger with a flexible bellow
9. Changeover flap with air filter (outside / inside air) for starting in cold climate

Exhaust Gas System

1. Internal exhaust gas system
2. Exhaust gas outlet
3. External exhaust gas system

<u>System components:</u>

1. Air filter
2. Turbocharger
3. Charge air cooler (1-stage & 2-stage)
4. Exhaust gas waste gate valve
5. Air by-pass valve (main engines only)

Automation System

1. UNIC C2
2. Functions
3. Alarm and monitoring signals
4. Electrical consumers

<u>System components:</u>

1. Unified Controls Codes (UNIC C2)
2. Power Unit
3. Ethernet communication unit
4. Local control panel and local display unit
5. Engine safety system
6. Cabling and system overview
7. Functions (start, start-blockings, stop-&-shutdown, speed control-main engine mechanical propulsion, generating set)
8. Alarm and monitoring signals,
9. Moto starters and operation of electrically driven pumps
10. Engine turning device
11. Pre-lubricating oil pump
12. Stand-by pump, lubricating oil (if installed)
13. Stand-by pump, HT cooling water (if installed)
14. Stand-by pump, LT cooling water (if installed)
15. Circulating pump for preheater
16. Sea water pump
17. Lubricating oil separator
18. Feeder/booster unit

<u>Ship Power Functional Systems</u>

Vibration and Noise

1. External forces and couples
2. Torque variations

3. Mass moments of inertia
4. Air borne noise
5. Exhaust noise

System components:

1. External force and couples
2. Mass moments of inertia
3. Air borne noise
4. Exhaust noise

Power Transmission

1. Flexible coupling
2. Clutch
3. Shaft locking device
4. Power-take-off from the free end
5. Input data for torsional vibration calculations
6. Turning gear

System components:

1. Flexible coupling
2. Connection to generator
3. Clutch
4. Shaft locking device
5. Power-take-off from the free end
6. Input data for torsional vibration calculations (Installation, reduction, propeller-&-shafting, main generator or shaft generator, flexible coupling/clutch, operational data)
7. Turning gear

Appendix E:- Correlation Analysis Data: Frequency In Technical Communication, Importance Of Technical Communication, Scale/Level Of Collaboration In Technical Communication, Scale/Level Of Mutual Trust And Scale/Level Of Roles & Responsibility.

Frequency in Technical Communication (Part 2)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	12.5	12.5	12.5
	2	5	62.5	62.5	75.0
	3	2	25.0	25.0	100.0
	Total	8	100.0	100.0	

Importance of Technical Communication (Part 3)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	12.5	12.5	12.5
	2	6	75.0	75.0	87.5
	3	1	12.5	12.5	100.0
	Total	8	100.0	100.0	

Frequency / Level of Collaboration Among Design Teams (Part 4)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	12.5	12.5	12.5
	2	6	75.0	75.0	87.5
	3	1	12.5	12.5	100.0
	Total	8	100.0	100.0	

Scale / Level of Mutual Trust (Part 5a) Low

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	6	75.0	75.0	75.0
	1	2	25.0	25.0	100.0
	Total	8	100.0	100.0	

Scale / Level of Mutual Trust (Part 5a) Average

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	4	50.0	50.0	50.0
	2	4	50.0	50.0	100.0
	Total	8	100.0	100.0	

Scale / Level Mutual Trust (Part 5a) High

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	6	75.0	75.0	75.0
	3	2	25.0	25.0	100.0
	Total	8	100.0	100.0	

Scale / Level of Roles & Responsibility (Part 5b) Low

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	6	75.0	75.0	75.0
	1	2	25.0	25.0	100.0
	Total	8	100.0	100.0	

Scale / Level of Roles & Responsibilities (Part 5b) Average

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	3	37.5	37.5	37.5
	2	5	62.5	62.5	100.0
	Total	8	100.0	100.0	

Scale / Level of Roles & Responsibilities (Part 5b) High

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	7	87.5	87.5	87.5
	3	1	12.5	12.5	100.0
	Total	8	100.0	100.0	

Descriptive Statistics

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Frequency in Technical Communication (Part 2)	8	1	3	2.13	.227	.641
Importance of Technical Communication (Part 3)	8	1	3	2.00	.189	.535
Frequency / Level of Collaboration Among Design Teams (Part 4)	8	1	3	2.00	.189	.535
Scale / Level of Mutual Trust (Part 5a) Low	8	0	1	.25	.164	.463
Scale / Level of Mutual Trust (Part 5a) Average	8	0	2	1.00	.378	1.069
Scale / Level Mutual Trust (Part 5a) High	8	0	3	.75	.491	1.389
Scale / Level of Roles & Responsibility (Part 5b) Low	8	0	1	.25	.164	.463
Scale / Level of Roles & Responsibilities (Part 5b) Average	8	0	2	1.25	.366	1.035
Scale / Level of Roles & Responsibilities (Part 5b) High	8	0	3	.38	.375	1.061
Valid N (listwise)	8					

Scale / Level of Mutual Trust (Part 5a) Low Scale / Level of Mutual Trust (Part 5a) Average Scale / Level Mutual Trust (Part 5a) High Scale / Level of Roles & Responsibility (Part 5b) Low Scale / Level of Roles & Responsibilities (Part 5b) Average Scale / Level of Roles & Responsibilities (Part 5b) High * Frequency in Technical Communication (Part 2)

Report

Frequency in Technical Communication (Part 2)		Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
1	Mean	1.00	.00	.00	1.00	.00	.00
	N	1	1	1	1	1	1
	Std. Deviation	.	.	.	.	.	.
	Minimum	1	0	0	1	0	0
	Maximum	1	0	0	1	0	0
	Std. Error of Mean	.	.	.	.	.	.
	Kurtosis	.	.	.	.	.	.
	Std. Error of Kurtosis	.	.	.	.	.	.
	Skewness	.	.	.	.	.	.
	Std. Error of Skewness	.	.	.	.	.	.
2	Mean	.20	1.20	.60	.20	1.60	.00
	N	5	5	5	5	5	5
	Std. Deviation	.447	1.095	1.342	.447	.894	.000
	Minimum	0	0	0	0	0	0
	Maximum	1	2	3	1	2	0
	Std. Error of Mean	.200	.490	.600	.200	.400	.000
	Kurtosis	5.000	-3.333	5.000	5.000	5.000	.
	Std. Error of Kurtosis	2.000	2.000	2.000	2.000	2.000	.
	Skewness	2.236	-.609	2.236	2.236	-2.236	.
	Std. Error of Skewness	.913	.913	.913	.913	.913	.
3	Mean	.00	1.00	1.50	.00	1.00	1.50
	N	2	2	2	2	2	2
	Std. Deviation	.000	1.414	2.121	.000	1.414	2.121
	Minimum	0	0	0	0	0	0
	Maximum	0	2	3	0	2	3
	Std. Error of Mean	.000	1.000	1.500	.000	1.000	1.500
	Kurtosis	.	.	.	.	.	.
	Std. Error of Kurtosis	.	.	.	.	.	.
	Skewness	.	.	.	.	.	.
	Std. Error of Skewness	.	.	.	.	.	.
Total	Mean	.25	1.00	.75	.25	1.25	.38
	N	8	8	8	8	8	8
	Std. Deviation	.463	1.069	1.389	.463	1.035	1.061
	Minimum	0	0	0	0	0	0
	Maximum	1	2	3	1	2	3
	Std. Error of Mean	.164	.378	.491	.164	.366	.375
	Kurtosis	.000	-2.800	.000	.000	-2.240	8.000
	Std. Error of Kurtosis	1.481	1.481	1.481	1.481	1.481	1.481
	Skewness	1.440	.000	1.440	1.440	-.644	2.828
	Std. Error of Skewness	.752	.752	.752	.752	.752	.752

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
Scale / Level of Mutual Trust (Part 5a) Low * Frequency in Technical Communication (Part 2)	Between Groups	(Combined)	.700	2	.350	2.188	.208
		Linearity	.543	1	.543	3.397	.125
		Deviation from Linearity	.157	1	.157	.978	.368
	Within Groups		.800	5	.160		
	Total		1.500	7			
Scale / Level of Mutual Trust (Part 5a) Average * Frequency in Technical Communication (Part 2)	Between Groups	(Combined)	1.200	2	.600	.441	.666
		Linearity	.348	1	.348	.256	.635
		Deviation from Linearity	.852	1	.852	.627	.464
	Within Groups		6.800	5	1.360		
	Total		8.000	7			
Scale / Level Mutual Trust (Part 5a) High * Frequency in Technical Communication (Part 2)	Between Groups	(Combined)	1.800	2	.900	.385	.699
		Linearity	1.761	1	1.761	.753	.425
		Deviation from Linearity	.039	1	.039	.017	.902
	Within Groups		11.700	5	2.340		
	Total		13.500	7			
Scale / Level of Roles & Responsibility (Part 5b) Low * Frequency in Technical Communication (Part 2)	Between Groups	(Combined)	.700	2	.350	2.188	.208
		Linearity	.543	1	.543	3.397	.125
		Deviation from Linearity	.157	1	.157	.978	.368
	Within Groups		.800	5	.160		
	Total		1.500	7			
Scale / Level of Roles & Responsibilities (Part 5b) Average * Frequency in Technical Communication (Part 2)	Between Groups	(Combined)	2.300	2	1.150	1.106	.400
		Linearity	.196	1	.196	.188	.683
		Deviation from Linearity	2.104	1	2.104	2.023	.214
	Within Groups		5.200	5	1.040		
	Total		7.500	7			
Scale / Level of Roles & Responsibilities (Part 5b) High * Frequency in Technical Communication (Part 2)	Between Groups	(Combined)	3.375	2	1.688	1.875	.247
		Linearity	2.397	1	2.397	2.663	.164
		Deviation from Linearity	.978	1	.978	1.087	.345
	Within Groups		4.500	5	.900		
	Total		7.875	7			

Scale / Level of Mutual Trust (Part 5a) Low Scale / Level of Mutual Trust (Part 5a) Average Scale / Level Mutual Trust (Part 5a) High Scale / Level of Roles & Responsibility (Part 5b) Low Scale / Level of Roles & Responsibilities (Part 5b) Average Scale / Level of Roles & Responsibilities (Part 5b) High * Importance of Technical Communication (Part 3)

Report

Importance of Technical Communication (Part 3)		Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
1	Mean	1.00	.00	.00	1.00	.00	.00
	N	1	1	1	1	1	1
	Std. Deviation	.	.	.	.	.	.
	Minimum	1	0	0	1	0	0
	Maximum	1	0	0	1	0	0
	Std. Error of Mean	.	.	.	.	.	.
	Kurtosis	.	.	.	.	.	.
	Std. Error of Kurtosis	.	.	.	.	.	.
	Skewness	.	.	.	.	.	.
	Std. Error of Skewness	.	.	.	.	.	.
2	Mean	.17	1.00	1.00	.17	1.33	.50
	N	6	6	6	6	6	6
	Std. Deviation	.408	1.095	1.549	.408	1.033	1.225
	Minimum	0	0	0	0	0	0
	Maximum	1	2	3	1	2	3
	Std. Error of Mean	.167	.447	.632	.167	.422	.500
	Kurtosis	6.000	-3.333	-1.875	6.000	-1.875	6.000
	Std. Error of Kurtosis	1.741	1.741	1.741	1.741	1.741	1.741
	Skewness	2.449	.000	.968	2.449	-.968	2.449
	Std. Error of Skewness	.845	.845	.845	.845	.845	.845
3	Mean	.00	2.00	.00	.00	2.00	.00
	N	1	1	1	1	1	1
	Std. Deviation	.	.	.	.	.	.
	Minimum	0	2	0	0	2	0
	Maximum	0	2	0	0	2	0
	Std. Error of Mean	.	.	.	.	.	.
	Kurtosis	.	.	.	.	.	.
	Std. Error of Kurtosis	.	.	.	.	.	.
	Skewness	.	.	.	.	.	.
	Std. Error of Skewness	.	.	.	.	.	.
Total	Mean	.25	1.00	.75	.25	1.25	.38
	N	8	8	8	8	8	8
	Std. Deviation	.463	1.069	1.389	.463	1.035	1.061
	Minimum	0	0	0	0	0	0
	Maximum	1	2	3	1	2	3
	Std. Error of Mean	.164	.378	.491	.164	.366	.375
	Kurtosis	.000	-2.800	.000	.000	-2.240	8.000
	Std. Error of Kurtosis	1.481	1.481	1.481	1.481	1.481	1.481
	Skewness	1.440	.000	1.440	1.440	-.644	2.828
	Std. Error of Skewness	.752	.752	.752	.752	.752	.752

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
Scale / Level of Mutual Trust (Part 5a) Low * Importance of Technical Communication (Part 3)	Between Groups	(Combined)	.667	2	.333	2.000	.230
		Linearity	.500	1	.500	3.000	.144
		Deviation from Linearity	.167	1	.167	1.000	.363
	Within Groups		.833	5	.167		
	Total		1.500	7			
Scale / Level of Mutual Trust (Part 5a) Average * Importance of Technical Communication (Part 3)	Between Groups	(Combined)	2.000	2	1.000	.833	.487
		Linearity	2.000	1	2.000	1.667	.253
		Deviation from Linearity	.000	1	.000	.000	1.000
	Within Groups		6.000	5	1.200		
	Total		8.000	7			
Scale / Level Mutual Trust (Part 5a) High * Importance of Technical Communication (Part 3)	Between Groups	(Combined)	1.500	2	.750	.313	.745
		Linearity	.000	1	.000	.000	1.000
		Deviation from Linearity	1.500	1	1.500	.625	.465
	Within Groups		12.000	5	2.400		
	Total		13.500	7			
Scale / Level of Roles & Responsibility (Part 5b) Low * Importance of Technical Communication (Part 3)	Between Groups	(Combined)	.667	2	.333	2.000	.230
		Linearity	.500	1	.500	3.000	.144
		Deviation from Linearity	.167	1	.167	1.000	.363
	Within Groups		.833	5	.167		
	Total		1.500	7			
Scale / Level of Roles & Responsibilities (Part 5b) Average * Importance of Technical Communication (Part 3)	Between Groups	(Combined)	2.167	2	1.083	1.016	.426
		Linearity	2.000	1	2.000	1.875	.229
		Deviation from Linearity	.167	1	.167	.156	.709
	Within Groups		5.333	5	1.067		
	Total		7.500	7			
Scale / Level of Roles & Responsibilities (Part 5b) High * Importance of Technical Communication (Part 3)	Between Groups	(Combined)	.375	2	.188	.125	.885
		Linearity	.000	1	.000	.000	1.000
		Deviation from Linearity	.375	1	.375	.250	.638
	Within Groups		7.500	5	1.500		
	Total		7.875	7			

Measures of Association

	R	R Squared	Eta	Eta Squared
Scale / Level of Mutual Trust (Part 5a) Low * Importance of Technical Communication (Part 3)	-.577	.333	.667	.444
Scale / Level of Mutual Trust (Part 5a) Average * Importance of Technical Communication (Part 3)	.500	.250	.500	.250
Scale / Level Mutual Trust (Part 5a) High * Importance of Technical Communication (Part 3)	.000	.000	.333	.111
Scale / Level of Roles & Responsibility (Part 5b) Low * Importance of Technical Communication (Part 3)	-.577	.333	.667	.444
Scale / Level of Roles & Responsibilities (Part 5b) Average * Importance of Technical Communication (Part 3)	.516	.267	.537	.289
Scale / Level of Roles & Responsibilities (Part 5b) High * Importance of Technical Communication (Part 3)	.000	.000	.218	.048

Scale / Level of Mutual Trust (Part 5a) Low Scale / Level of Mutual Trust (Part 5a) Average Scale / Level Mutual Trust (Part 5a) High Scale / Level of Roles & Responsibility (Part 5b) Low Scale / Level of Roles & Responsibilities (Part 5b) Average Scale / Level of Roles & Responsibilities (Part 5b) High * Frequency / Level of Collaboration Among Design Teams (Part 4)

Report

Frequency / Level of Collaboration Among Design Teams (Part 4)		Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
1	Mean	1.00	.00	.00	1.00	.00	.00
	N	1	1	1	1	1	1
	Std. Deviation	.	.	.	.	.	.
	Minimum	1	0	0	1	0	0
	Maximum	1	0	0	1	0	0
	Std. Error of Mean	.	.	.	.	.	.
	Kurtosis	.	.	.	.	.	.
	Std. Error of Kurtosis	.	.	.	.	.	.
	Skewness	.	.	.	.	.	.
	Std. Error of Skewness	.	.	.	.	.	.
2	Mean	.17	1.00	1.00	.17	1.33	.50
	N	6	6	6	6	6	6
	Std. Deviation	.408	1.095	1.549	.408	1.033	1.225
	Minimum	0	0	0	0	0	0
	Maximum	1	2	3	1	2	3
	Std. Error of Mean	.167	.447	.632	.167	.422	.500
	Kurtosis	6.000	-3.333	-1.875	6.000	-1.875	6.000
	Std. Error of Kurtosis	1.741	1.741	1.741	1.741	1.741	1.741
	Skewness	2.449	.000	.968	2.449	-.968	2.449
	Std. Error of Skewness	.845	.845	.845	.845	.845	.845
3	Mean	.00	2.00	.00	.00	2.00	.00
	N	1	1	1	1	1	1
	Std. Deviation	.	.	.	.	.	.
	Minimum	0	2	0	0	2	0
	Maximum	0	2	0	0	2	0
	Std. Error of Mean	.	.	.	.	.	.
	Kurtosis	.	.	.	.	.	.
	Std. Error of Kurtosis	.	.	.	.	.	.
	Skewness	.	.	.	.	.	.
	Std. Error of Skewness	.	.	.	.	.	.
Total	Mean	.25	1.00	.75	.25	1.25	.38
	N	8	8	8	8	8	8
	Std. Deviation	.463	1.069	1.389	.463	1.035	1.061
	Minimum	0	0	0	0	0	0
	Maximum	1	2	3	1	2	3
	Std. Error of Mean	.164	.378	.491	.164	.366	.375
	Kurtosis	.000	-2.800	.000	.000	-2.240	8.000
	Std. Error of Kurtosis	1.481	1.481	1.481	1.481	1.481	1.481
	Skewness	1.440	.000	1.440	1.440	-.644	2.828
	Std. Error of Skewness	.752	.752	.752	.752	.752	.752

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
Scale / Level of Mutual Trust (Part 5a) Low * Frequency / Level of Collaboration Among Design Teams (Part 4)	Between Groups	(Combined)	.667	2	.333	2.000	.230
		Linearity	.500	1	.500	3.000	.144
		Deviation from Linearity	.167	1	.167	1.000	.363
	Within Groups		.833	5	.167		
	Total		1.500	7			
Scale / Level of Mutual Trust (Part 5a) Average * Frequency / Level of Collaboration Among Design Teams (Part 4)	Between Groups	(Combined)	2.000	2	1.000	.833	.487
		Linearity	2.000	1	2.000	1.667	.253
		Deviation from Linearity	.000	1	.000	.000	1.000
	Within Groups		6.000	5	1.200		
	Total		8.000	7			
Scale / Level Mutual Trust (Part 5a) High * Frequency / Level of Collaboration Among Design Teams (Part 4)	Between Groups	(Combined)	1.500	2	.750	.313	.745
		Linearity	.000	1	.000	.000	1.000
		Deviation from Linearity	1.500	1	1.500	.625	.465
	Within Groups		12.000	5	2.400		
	Total		13.500	7			
Scale / Level of Roles & Responsibility (Part 5b) Low * Frequency / Level of Collaboration Among Design Teams (Part 4)	Between Groups	(Combined)	.667	2	.333	2.000	.230
		Linearity	.500	1	.500	3.000	.144
		Deviation from Linearity	.167	1	.167	1.000	.363
	Within Groups		.833	5	.167		
	Total		1.500	7			
Scale / Level of Roles & Responsibilities (Part 5b) Average * Frequency / Level of Collaboration Among Design Teams (Part 4)	Between Groups	(Combined)	2.167	2	1.083	1.016	.426
		Linearity	2.000	1	2.000	1.875	.229
		Deviation from Linearity	.167	1	.167	.156	.709
	Within Groups		5.333	5	1.067		
	Total		7.500	7			
Scale / Level of Roles & Responsibilities (Part 5b) High * Frequency / Level of Collaboration Among Design Teams (Part 4)	Between Groups	(Combined)	.375	2	.188	.125	.885
		Linearity	.000	1	.000	.000	1.000
		Deviation from Linearity	.375	1	.375	.250	.638
	Within Groups		7.500	5	1.500		
	Total		7.875	7			

T-Test

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Frequency in Technical Communication (Part 2)	8	2.13	.641	.227
Importance of Technical Communication (Part 3)	8	2.00	.535	.189
Frequency / Level of Collaboration Among Design Teams (Part 4)	8	2.00	.535	.189
Scale / Level of Mutual Trust (Part 5a) Low	8	.25	.463	.164
Scale / Level of Mutual Trust (Part 5a) Average	8	1.00	1.069	.378
Scale / Level Mutual Trust (Part 5a) High	8	.75	1.389	.491
Scale / Level of Roles & Responsibility (Part 5b) Low	8	.25	.463	.164
Scale / Level of Roles & Responsibilities (Part 5b) Average	8	1.25	1.035	.366
Scale / Level of Roles & Responsibilities (Part 5b) High	8	.38	1.061	.375

One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Frequency in Technical Communication (Part 2)	9.379	7	.000	2.125	1.59	2.66
Importance of Technical Communication (Part 3)	10.583	7	.000	2.000	1.55	2.45
Frequency / Level of Collaboration Among Design Teams (Part 4)	10.583	7	.000	2.000	1.55	2.45
Scale / Level of Mutual Trust (Part 5a) Low	1.528	7	.170	.250	-.14	.64
Scale / Level of Mutual Trust (Part 5a) Average	2.646	7	.033	1.000	.11	1.89
Scale / Level Mutual Trust (Part 5a) High	1.528	7	.170	.750	-.41	1.91
Scale / Level of Roles & Responsibility (Part 5b) Low	1.528	7	.170	.250	-.14	.64
Scale / Level of Roles & Responsibilities (Part 5b) Average	3.416	7	.011	1.250	.38	2.12
Scale / Level of Roles & Responsibilities (Part 5b) High	1.000	7	.351	.375	-.51	1.26

Oneway

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Scale / Level of Mutual Trust (Part 5a) Low	Between Groups	.700	2	.350	2.188	.208
	Within Groups	.800	5	.160		
	Total	1.500	7			
Scale / Level of Mutual Trust (Part 5a) Average	Between Groups	1.200	2	.600	.441	.666
	Within Groups	6.800	5	1.360		
	Total	8.000	7			
Scale / Level Mutual Trust (Part 5a) High	Between Groups	1.800	2	.900	.385	.699
	Within Groups	11.700	5	2.340		
	Total	13.500	7			
Scale / Level of Roles & Responsibility (Part 5b) Low	Between Groups	.700	2	.350	2.188	.208
	Within Groups	.800	5	.160		
	Total	1.500	7			
Scale / Level of Roles & Responsibilities (Part 5b) Average	Between Groups	2.300	2	1.150	1.106	.400
	Within Groups	5.200	5	1.040		
	Total	7.500	7			
Scale / Level of Roles & Responsibilities (Part 5b) High	Between Groups	3.375	2	1.688	1.875	.247
	Within Groups	4.500	5	.900		
	Total	7.875	7			

Correlations

Correlations

Pearson Correlation	1	.834*	.834*	-.602	.209	.361	-.602	.162	.552
Sig. (2-tailed)	8	.010	.010	.114	.620	.379	.114	.702	.156
	8	8	8	8	8	8	8	8	8
Pearson Correlation	.834*	1	1.000**	-.577	.500	.000	-.577	.516	.000
Sig. (2-tailed)	.010	8	.000	.134	.207	1.000	.134	.190	1.000
	8	8	8	8	8	8	8	8	8
Pearson Correlation	.834*	1.000**	1	-.577	.500	.000	-.577	.516	.000
Sig. (2-tailed)	.010	.000	8	.134	.207	1.000	.134	.190	1.000
	8	8	8	8	8	8	8	8	8
Pearson Correlation	-.602	-.577	-.577	1	-.577	-.333	1.000**	-.745*	-.218
Sig. (2-tailed)	.114	.134	.134	8	.134	.420	.000	.034	.604
	8	8	8	8	8	8	8	8	8
Pearson Correlation	.209	.500	.500	-.577	1	-.577	-.577	.775*	-.378
Sig. (2-tailed)	.620	.207	.207	.134	8	.134	.134	.024	.356
	8	8	8	8	8	8	8	8	8
Pearson Correlation	.361	.000	.000	-.333	-.577	1	-.333	-.149	.655
Sig. (2-tailed)	.379	1.000	1.000	.420	.134	8	.420	.725	.078
	8	8	8	8	8	8	8	8	8
Pearson Correlation	-.602	-.577	-.577	1.000**	-.577	-.333	1	-.745*	-.218
Sig. (2-tailed)	.114	.134	.134	.000	.134	.420	8	.034	.604
	8	8	8	8	8	8	8	8	8
Pearson Correlation	.162	.516	.516	-.745*	.775*	-.149	-.745*	1	-.488
Sig. (2-tailed)	.702	.190	.190	.034	.024	.725	.034	8	.220
	8	8	8	8	8	8	8	8	8
Pearson Correlation	.552	.000	.000	-.218	-.378	.655	-.218	-.488	1
Sig. (2-tailed)	.156	1.000	1.000	.604	.356	.078	.604	.220	8

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Hypotheses Test Summar

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The categories of Names of System Design Team Leaders occur with equal probabilities.	One-Sample Chi-Square Test	1.000	Retain the null hypothesis.
2	The categories of Frequency in Technical Communication (Part 2) occur with equal probabilities.	One-Sample Chi-Square Test	.197	Retain the null hypothesis.
3	The categories of Importance of Technical Communication (Part 3) occur with equal probabilities.	One-Sample Chi-Square Test	.044	Reject the null hypothesis.
4	The categories of Frequency / Level of Collaboration Among Design Teams (Part 4) occur with equal probabilities.	One-Sample Chi-Square Test	.044	Reject the null hypothesis.
5	The categories defined by Scale / Level of Mutual Trust (Part 5a) Low = 0.00 and 1.00 occur with probabilities 0.5 and 0.5.	One-Sample Binomial Test	.289[1]	Retain the null hypothesis.
6	The categories defined by Scale / Level of Mutual Trust (Part 5a) Average = 2.00 and 0.00 occur with probabilities 0.5 and 0.5.	One-Sample Binomial Test	1.000[1]	Retain the null hypothesis.
7	The categories defined by Scale / Level Mutual Trust (Part 5a) High = 0.00 and 3.00 occur with probabilities 0.5 and 0.5.	One-Sample Binomial Test	.289[1]	Retain the null hypothesis.
8	The categories defined by Scale / Level of Roles & Responsibilities (Part 5b) Low = 0.00 and 1.00 occur with probabilities 0.5 and 0.5.	One-Sample Binomial Test	.289[1]	Retain the null hypothesis.
9	The categories defined by Scale / Level of Roles & Responsibilities (Part 5b) Average = 2.00 and 0.00 occur with probabilities 0.5 and 0.5.	One-Sample Binomial Test	.727[1]	Retain the null hypothesis.
10	The categories defined by Scale / Level of Roles & Responsibilities (Part 5b) High = 0.00 and 3.00 occur with probabilities 0.5 and 0.5.	One-Sample Binomial Test	.070[1]	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

[1] Exact significance is displayed for this test.

Correlations

		Frequency in Technical Communication (Part 2)	Importance of Technical Communication (Part 3)	Frequency / Level of Collaboration Among Design Teams (Part 4)	Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
Frequency in Technical Communication (Part 2)	Pearson Correlation	1	.834**	.834**	-.602	.209	.361	-.602	.162	.552
	Sig. (1-tailed)		.005	.005	.057	.310	.190	.057	.351	.078
	N	8	8	8	8	8	8	8	8	8
Importance of Technical Communication (Part 3)	Pearson Correlation	.834**	1	1.000**	-.577	.500	.000	-.577	.516	.000
	Sig. (1-tailed)	.005		.000	.067	.104	.500	.067	.095	.500
	N	8	8	8	8	8	8	8	8	8
Frequency / Level of Collaboration Among Design Teams (Part 4)	Pearson Correlation	.834**	1.000**	1	-.577	.500	.000	-.577	.516	.000
	Sig. (1-tailed)	.005	.000		.067	.104	.500	.067	.095	.500
	N	8	8	8	8	8	8	8	8	8
Scale / Level of Mutual Trust (Part 5a) Low	Pearson Correlation	-.602	-.577	-.577	1	-.577	-.333	1.000**	-.745*	-.218
	Sig. (1-tailed)	.057	.067	.067		.067	.210	.000	.017	.302
	N	8	8	8	8	8	8	8	8	8
Scale / Level of Mutual Trust (Part 5a) Average	Pearson Correlation	.209	.500	.500	-.577	1	-.577	-.577	.775*	-.378
	Sig. (1-tailed)	.310	.104	.104	.067		.067	.067	.012	.178
	N	8	8	8	8	8	8	8	8	8
Scale / Level Mutual Trust (Part 5a) High	Pearson Correlation	.361	.000	.000	-.333	-.577	1	-.333	-.149	.655*
	Sig. (1-tailed)	.190	.500	.500	.210	.067		.210	.362	.039
	N	8	8	8	8	8	8	8	8	8
Scale / Level of Roles & Responsibility (Part 5b) Low	Pearson Correlation	-.602	-.577	-.577	1.000**	-.577	-.333	1	-.745*	-.218
	Sig. (1-tailed)	.057	.067	.067	.000	.067	.210		.017	.302
	N	8	8	8	8	8	8	8	8	8
Scale / Level of Roles & Responsibilities (Part 5b) Average	Pearson Correlation	.162	.516	.516	-.745*	.775*	-.149	-.745*	1	-.488
	Sig. (1-tailed)	.351	.095	.095	.017	.012	.362	.017		.110
	N	8	8	8	8	8	8	8	8	8
Scale / Level of Roles & Responsibilities (Part 5b) High	Pearson Correlation	.552	.000	.000	-.218	-.378	.655*	-.218	-.488	1
	Sig. (1-tailed)	.078	.500	.500	.302	.178	.039	.302	.110	
	N	8	8	8	8	8	8	8	8	8

**. Correlation is significant at the 0.01 level (1-tailed).

*. Correlation is significant at the 0.05 level (1-tailed).

Descriptive Statistics

	Mean	Std. Deviation	N
Scale / Level of Mutual Trust (Part 5a) Low	.25	.463	8
Scale / Level of Mutual Trust (Part 5a) Average	1.00	1.069	8
Scale / Level Mutual Trust (Part 5a) High	.75	1.389	8
Scale / Level of Roles & Responsibility (Part 5b) Low	.25	.463	8
Scale / Level of Roles & Responsibilities (Part 5b) Average	1.25	1.035	8
Scale / Level of Roles & Responsibilities (Part 5b) High	.38	1.061	8
Frequency in Technical Communication (Part 2)	2.13	.641	8
Importance of Technical Communication (Part 3)	2.00	.535	8
Frequency / Level of Collaboration Among Design Teams (Part 4)	2.00	.535	8

Correlations

Control Variables			Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
Frequency in Technical Communication (Part 2) & Importance of Technical Communication (Part 3) & Frequency / Level of Collaboration Among Design Teams (Part 4)	Scale / Level of Mutual Trust (Part 5a) Low	Correlation	1.000	.	.	.	.	.
		Significance (1-tailed)	.	.	.	.	.	.
		df	0	3	3	3	3	3
	Scale / Level of Mutual Trust (Part 5a) Average	Correlation	.	1.000	.	.	.	.
		Significance (1-tailed)	.	.	.	.	.	.
		df	3	0	3	3	3	3
	Scale / Level Mutual Trust (Part 5a) High	Correlation	.	.	1.000	.	.	.
		Significance (1-tailed)	.	.	.	.	.	.
		df	3	3	0	3	3	3
	Scale / Level of Roles & Responsibility (Part 5b) Low	Correlation	.	.	.	1.000	.	.
		Significance (1-tailed)	.	.	.	.	.	.
		df	3	3	3	0	3	3
	Scale / Level of Roles & Responsibilities (Part 5b) Average	Correlation	.	.	.	.	1.000	.
		Significance (1-tailed)	.	.	.	.	.	.
		df	3	3	3	3	0	3
	Scale / Level of Roles & Responsibilities (Part 5b) High	Correlation	.	.	.	.	.	1.000
		Significance (1-tailed)	.	.	.	.	.	.
		df	3	3	3	3	3	0

Correlations

Control Variables			Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
Frequency in Technical Communication (Part 2) & Importance of Technical Communication (Part 3) & Frequency / Level of Collaboration Among Design Teams (Part 4)	Scale / Level of Mutual Trust (Part 5a) Low	Correlation	1.000	.	.	.	.	.
		Significance (2-tailed)	.	.	.	.	.	.
		df	0	3	3	3	3	3
	Scale / Level of Mutual Trust (Part 5a) Average	Correlation	.	1.000	.	.	.	.
		Significance (2-tailed)	.	.	.	.	.	.
		df	3	0	3	3	3	3
	Scale / Level Mutual Trust (Part 5a) High	Correlation	.	.	1.000	.	.	.
		Significance (2-tailed)	.	.	.	.	.	.
		df	3	3	0	3	3	3
	Scale / Level of Roles & Responsibility (Part 5b) Low	Correlation	.	.	.	1.000	.	.
		Significance (2-tailed)	.	.	.	.	.	.
		df	3	3	3	0	3	3
	Scale / Level of Roles & Responsibilities (Part 5b) Average	Correlation	.	.	.	.	1.000	.
		Significance (2-tailed)	.	.	.	.	.	.
		df	3	3	3	3	0	3
	Scale / Level of Roles & Responsibilities (Part 5b) High	Correlation	.	.	.	.	.	1.000
		Significance (2-tailed)	.	.	.	.	.	.
		df	3	3	3	3	3	0

Proximities

Case Processing Summary

Cases					
Valid		Missing		Total	
N	Percent	N	Percent	N	Percent
8	100.0%	0	0.0%	8	100.0%

Proximity Matrix

	Euclidean Distance							
	1:Jan Holmberg	2:Tomas Södö	3:Mranal Gupta	4:Tomi Vesterbacka	5:Johnny Remsu	6:Stig Klockars	7:Leif Backlund	8:Giampaolo Fabro
1:Jan Holmberg	.000	3.606	.000	1.732	3.606	.000	5.196	3.162
2:Tomas Södö	3.606	.000	3.606	4.690	4.243	3.606	5.099	1.732
3:Mranal Gupta	.000	3.606	.000	1.732	3.606	.000	5.196	3.162
4:Tomi Vesterbacka	1.732	4.690	1.732	.000	4.000	1.732	5.292	3.606
5:Johnny Remsu	3.606	4.243	3.606	4.000	.000	3.606	3.742	3.873
6:Stig Klockars	.000	3.606	.000	1.732	3.606	.000	5.196	3.162
7:Leif Backlund	5.196	5.099	5.196	5.292	3.742	5.196	.000	4.583
8:Giampaolo Fabro	3.162	1.732	3.162	3.606	3.873	3.162	4.583	.000

This is a dissimilarity matrix

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	8	100.0
	Excluded[a]	0	.0
	Total	8	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items[a]	N of Items
.029	-.122	9

a. The value is negative due to a negative average covariance among items. This violates reliability model assumptions. You may want to check item codings.

Inter-Item Correlation Matrix

	Frequency in Technical Communication (Part 2)	Importance of Technical Communication (Part 3)	Frequency / Level of Collaboration Among Design Teams (Part 4)	Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
Frequency in Technical Communication (Part 2)	1.000	.834	.834	-.602	.209	.361	-.602	.162	.552
Importance of Technical Communication (Part 3)	.834	1.000	1.000	-.577	.500	.000	-.577	.516	.000
Frequency / Level of Collaboration Among Design Teams (Part 4)	.834	1.000	1.000	-.577	.500	.000	-.577	.516	.000
Scale / Level of Mutual Trust (Part 5a) Low	-.602	-.577	-.577	1.000	-.577	-.333	1.000	-.745	-.218
Scale / Level of Mutual Trust (Part 5a) Average	.209	.500	.500	-.577	1.000	-.577	-.577	.775	-.378
Scale / Level Mutual Trust (Part 5a) High	.361	.000	.000	-.333	-.577	1.000	-.333	-.149	.655
Scale / Level of Roles & Responsibility (Part 5b) Low	-.602	-.577	-.577	1.000	-.577	-.333	1.000	-.745	-.218
Scale / Level of Roles & Responsibilities (Part 5b) Average	.162	.516	.516	-.745	.775	-.149	-.745	1.000	-.488
Scale / Level of Roles & Responsibilities (Part 5b) High	.552	.000	.000	-.218	-.378	.655	-.218	-.488	1.000

Inter-Item Covariance Matrix

	Frequency in Technical Communication (Part 2)	Importance of Technical Communication (Part 3)	Frequency / Level of Collaboration Among Design Teams (Part 4)	Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
Frequency in Technical Communication (Part 2)	.411	.286	.286	-.179	.143	.321	-.179	.107	.375
Importance of Technical Communication (Part 3)	.286	.286	.286	-.143	.286	.000	-.143	.286	.000
Frequency / Level of Collaboration Among Design Teams (Part 4)	.286	.286	.286	-.143	.286	.000	-.143	.286	.000
Scale / Level of Mutual Trust (Part 5a) Low	-.179	-.143	-.143	.214	-.286	-.214	.214	-.357	-.107
Scale / Level of Mutual Trust (Part 5a) Average	.143	.286	.286	-.286	1.143	-.857	-.286	.857	-.429
Scale / Level Mutual Trust (Part 5a) High	.321	.000	.000	-.214	-.857	1.929	-.214	-.214	.964
Scale / Level of Roles & Responsibility (Part 5b) Low	-.179	-.143	-.143	.214	-.286	-.214	.214	-.357	-.107
Scale / Level of Roles & Responsibilities (Part 5b) Average	.107	.286	.286	-.357	.857	-.214	-.357	1.071	-.536
Scale / Level of Roles & Responsibilities (Part 5b) High	.375	.000	.000	-.107	-.429	.964	-.107	-.536	1.125

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.111	.250	2.125	1.875	8.500	.599	9
Inter-Item Covariances	.002	-.857	.964	1.821	-1.125	.126	9
Inter-Item Correlations	-.012	-.745	1.000	1.745	-1.342	.305	9

Hotelling's T-Squared Test

Hotelling's T-Squared	F	df1	df2	Sig
.000[a]	.	.	.	.

a. There are not enough cases to compute Hotelling's T-Squared.

Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.003[a]	-.070	.274	1.030	7	56	.421
Average Measures	.029[c]	-1.449	.772	1.030	7	56	.421

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type C intraclass correlation coefficients using a consistency definition-the between-measure variance is excluded from the denominator variance.

c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

Chi-Square Test

Frequencies

Frequency in Technical Communication (Part 2)

	Observed N	Expected N	Residual
1	1	2.7	-1.7
2	5	2.7	2.3
3	2	2.7	-.7
Total	8		

Importance of Technical Communication (Part 3)

	Observed N	Expected N	Residual
1	1	2.7	-1.7
2	6	2.7	3.3
3	1	2.7	-1.7
Total	8		

Frequency / Level of Collaboration Among Design Teams (Part 4)

	Observed N	Expected N	Residual
1	1	2.7	-1.7
2	6	2.7	3.3
3	1	2.7	-1.7
Total	8		

Scale / Level of Mutual Trust (Part 5a) Low

	Observed N	Expected N	Residual
0	6	4.0	2.0
1	2	4.0	-2.0
Total	8		

Scale / Level of Mutual Trust (Part 5a) Average

	Observed N	Expected N	Residual
0	4	4.0	.0
2	4	4.0	.0
Total	8		

Scale / Level Mutual Trust (Part 5a) High

	Observed N	Expected N	Residual
0	6	4.0	2.0
3	2	4.0	-2.0
Total	8		

Scale / Level of Roles & Responsibility (Part 5b) Low

	Observed N	Expected N	Residual
0	6	4.0	2.0
1	2	4.0	-2.0
Total	8		

Scale / Level of Roles & Responsibilities (Part 5b) Average

	Observed N	Expected N	Residual
0	3	4.0	-1.0
2	5	4.0	1.0
Total	8		

Scale / Level of Roles & Responsibilities (Part 5b) High

	Observed N	Expected N	Residual
0	7	4.0	3.0
3	1	4.0	-3.0
Total	8		

Test Statistics

	Frequency in Technical Communication (Part 2)	Importance of Technical Communication (Part 3)	Frequency / Level of Collaboration Among Design Teams (Part 4)	Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
Chi-Square	3.250[a]	6.250[a]	6.250[a]	2.000[b]	.000[b]	2.000[b]	2.000[b]	.500[b]	4.500[b]
df	2	2	2	1	1	1	1	1	1
Asymp. Sig.	.197	.044	.044	.157	1.000	.157	.157	.480	.034

a. 3 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 2.7.

b. 2 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 4.0.

NPar Tests

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
Frequency in Technical Communication (Part 2)	8	2.13	.641	1	3	2.00	2.00	2.75
Importance of Technical Communication (Part 3)	8	2.00	.535	1	3	2.00	2.00	2.00
Frequency / Level of Collaboration Among Design Teams (Part 4)	8	2.00	.535	1	3	2.00	2.00	2.00
Scale / Level of Mutual Trust (Part 5a) Low	8	.25	.463	0	1	.00	.00	.75
Scale / Level of Mutual Trust (Part 5a) Average	8	1.00	1.069	0	2	.00	1.00	2.00
Scale / Level Mutual Trust (Part 5a) High	8	.75	1.389	0	3	.00	.00	2.25
Scale / Level of Roles & Responsibility (Part 5b) Low	8	.25	.463	0	1	.00	.00	.75
Scale / Level of Roles & Responsibilities (Part 5b) Average	8	1.25	1.035	0	2	.00	2.00	2.00
Scale / Level of Roles & Responsibilities (Part 5b) High	8	.38	1.061	0	3	.00	.00	.00

Runs Test

	Frequency in Technical Communication (Part 2)	Importance of Technical Communication (Part 3)	Frequency / Level of Collaboration Among Design Teams (Part 4)	Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
Test Value[a]	2	2	2	0[b]	1	0[b]	0[b]	2	0[b]
Cases < Test Value	1	1	1	0	4	0	0	3	0
Cases >= Test Value	7	7	7	8	4	8	8	5	8
Total Cases	8	8	8	8	8	8	8	8	8
Number of Runs	3	3	3	1[c]	6	1[c]	1[c]	4	1[c]
Z	.000	.000	.000		.382			-.206	
Asymp. Sig. (2-tailed)	1.000	1.000	1.000		.703			.837	

a. Median

b. All values are greater than or less than the cutoff. Runs Test cannot be performed.

c. Only one run occurs. Runs Test cannot be performed.

Runs Test 2

	Frequency in Technical Communication (Part 2)	Importance of Technical Communication (Part 3)	Frequency / Level of Collaboration Among Design Teams (Part 4)	Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
Test Value[a]	2.13	2.00	2.00	.25	1.00	.75	.25	1.25	.38
Cases < Test Value	6	1	1	6	4	6	6	3	7
Cases >= Test Value	2	7	7	2	4	2	2	5	1
Total Cases	8	8	8	8	8	8	8	8	8
Number of Runs	5	3	3	4	6	5	4	4	3
Z	.540	.000	.000	.000	.382	.540	.000	-.206	.000
Asymp. Sig. (2-tailed)	.589	1.000	1.000	1.000	.703	.589	1.000	.837	1.000

a. Mean

Runs Test 3

	Frequency in Technical Communication (Part 2)	Importance of Technical Communication (Part 3)	Frequency / Level of Collaboration Among Design Teams (Part 4)	Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
Test Value[a]	2	2	2	0[b]	2[d]	0[b]	0[b]	2	0[b]
Cases < Test Value	1	1	1	0	4	0	0	3	0
Cases >= Test Value	7	7	7	8	4	8	8	5	8
Total Cases	8	8	8	8	8	8	8	8	8
Number of Runs	3	3	3	1[c]	6	1[c]	1[c]	4	1[c]
Z	.000	.000	.000		.382			-.206	
Asymp. Sig. (2-tailed)	1.000	1.000	1.000		.703			.837	

a. Mode

b. All values are greater than or less than the cutoff. Runs Test cannot be performed.

c. Only one run occurs. Runs Test cannot be performed.

d. There are multiple modes. The mode with the largest data value is used.

Model Description

Model Name		MOD_1
Series Name	1	Frequency in Technical Communication (Part 2)
	2	Importance of Technical Communication (Part 3)
	3	Frequency / Level of Collaboration Among Design Teams (Part 4)
	4	Scale / Level of Mutual Trust (Part 5a) Low
	5	Scale / Level of Mutual Trust (Part 5a) Average
	6	Scale / Level Mutual Trust (Part 5a) High
	7	Scale / Level of Roles & Responsibility (Part 5b) Low
	8	Scale / Level of Roles & Responsibilities (Part 5b) Average
	9	Scale / Level of Roles & Responsibilities (Part 5b) High
Transformation		Natural logarithm
Non-Seasonal Differencing		0
Seasonal Differencing		0
Length of Seasonal Period		No periodicity
Maximum Number of Lags		16
Process Assumed for Calculating the Standard Errors of the Autocorrelations		Independence(white noise)[a]
Display and Plot		All lags

Applying the model specifications from MOD_1

a. Not applicable for calculating the standard errors of the partial autocorrelations.

Case Processing Summary

		Frequency in Technical Communication (Part 2)	Importance of Technical Communication (Part 3)	Frequency / Level of Collaboration Among Design Teams (Part 4)	Scale / Level of Mutual Trust (Part 5a) Low	Scale / Level of Mutual Trust (Part 5a) Average	Scale / Level Mutual Trust (Part 5a) High	Scale / Level of Roles & Responsibility (Part 5b) Low	Scale / Level of Roles & Responsibilities (Part 5b) Average	Scale / Level of Roles & Responsibilities (Part 5b) High
Series Length		8	8	8	8	8	8	8	8	8
Number of Missing Values	Negative or Zero Before Log Transform	0	0	0	6[a]	4[a]	6[a]	6[a]	3[a]	7[a]
	User-Missing	0	0	0	0	0	0	0	0	0
	System-Missing	0	0	0	0	0	0	0	0	0
Number of Valid Values		8	8	8	2	4	2	2	5	1
Number of Computable First Lags		7	7	7	0	0	0	0	0	0

a. The minimum value is .000

Model Description

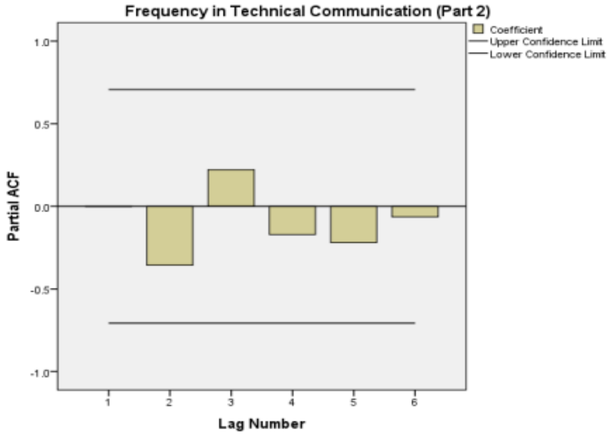
Model Name		MOD_2
Series Name	1	Frequency in Technical Communication (Part 2)
	2	Importance of Technical Communication (Part 3)
	3	Frequency / Level of Collaboration Among Design Teams (Part 4)
	4	Scale / Level of Mutual Trust (Part 5a) Low
	5	Scale / Level of Mutual Trust (Part 5a) Average
	6	Scale / Level Mutual Trust (Part 5a) High
	7	Scale / Level of Roles & Responsibility (Part 5b) Low
	8	Scale / Level of Roles & Responsibilities (Part 5b) Average
	9	Scale / Level of Roles & Responsibilities (Part 5b) High
Transformation		Natural logarithm
Non-Seasonal Differencing		0
Seasonal Differencing		0
Length of Seasonal Period		No periodicity
Range of Lags	From	-7
	To	7
Display and Plot		All lags

Applying the model specifications from MOD_2

Partial Autocorrelations

Series: Frequency in Technical Communication (Part 2)

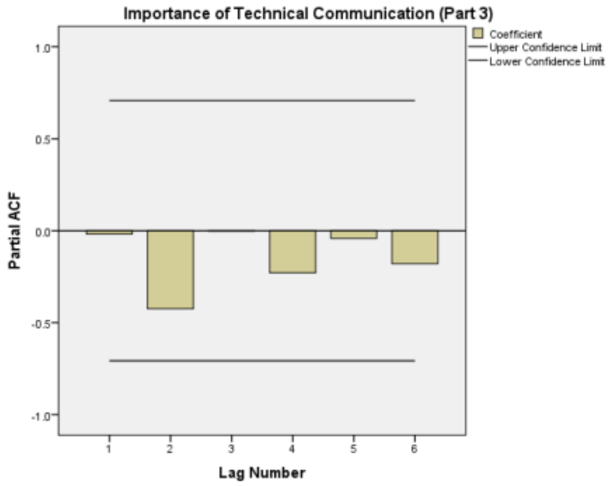
Lag	Partial Autocorrelation	Std. Error
1	-.002	.354
2	-.356	.354
3	.221	.354
4	-.171	.354
5	-.220	.354
6	-.064	.354



Partial Autocorrelations

Series: Importance of Technical Communication (Part 3)

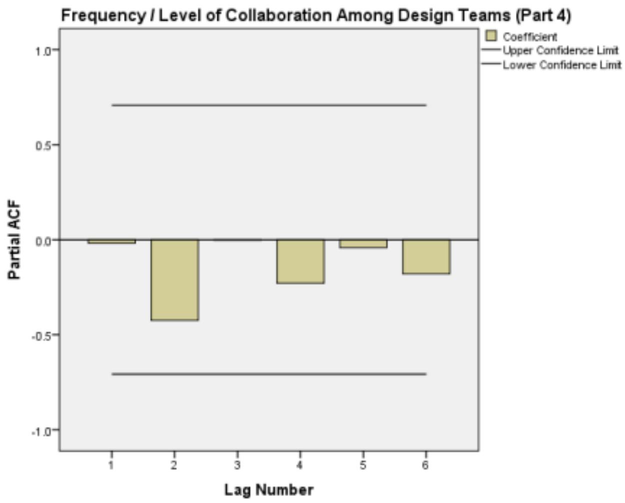
Lag	Partial Autocorrelation	Std. Error
1	-.018	.354
2	-.425	.354
3	-.002	.354
4	-.229	.354
5	-.042	.354
6	-.179	.354



Partial Autocorrelations

Series: Frequency / Level of Collaboration Among Design Teams (Part 4)

Lag	Partial Autocorrelation	Std. Error
1	-.018	.354
2	-.425	.354
3	-.002	.354
4	-.229	.354
5	-.042	.354
6	-.179	.354



Appendix F: - List of Publications

Title / Author	Year
Enterprise Resource Planning (ERP): A Review Literature Report Addo-Tenkorang, R., and Helo, P. Proceedings of the World Congress on Engineering and Computer Science. Vol. 2, pp. 19-21	2011
A study of technology adoption in manufacturing firms Kristianto, Y., Ajmal, M., Addo-Tenkorang, R., and Hussain, M. Journal of Manufacturing Technology Management. Vol. 23, No. 2, pp. 198-211	2012
Logistics tracking: An implementation issue for delivery network Shamsuzzoha, A.H.M., Addo-Tenkorang, R., Phuong, D., and Helo, P. Technology Management in the Energy Smart World (PICMET), 2011 Proceedings ...	2011
Performance evaluation of tracking and tracing for logistics operations Shamsuzzoha, AHM., Ehrs, M., Addo–Tenkorang, R., Nguyen, D., and Helo, P. T. International Journal of Shipping and Transport Logistics. Vol. 5, No. 1, pp. 31-54	2013
Logistics & supply chains management tracking networks: Data-management system integration/interfacing issues Addo-Tenkorang, R., Helo, P. T., Shamsuzzoha, AHM., Ehrs, M., and Phuong, D. Technology Management for Emerging Technologies (PICMET), 2012 Proceedings ...	2012
Engineer-to-Order: A Maturity Concurrent Engineering Best Addo-Tenkorang, R., and Eyob, E. Customer-Oriented Global Supply Chains: Concepts for Effective Management, 112. Information Science Reference	2012
Supply Chain Efficiency Of Environmentally Friendly Microalgae-Based Biodiesel Production. Addo-Tenkorang, R, Zhu, L., Neaga, E. I., and Marasová, D. International Journal of Transport and Logistics. Vol. 12, No. 23, pp. 1-12	2012