An Investigation into the Partitioning Of Major Defence Systems to Help Ensure System Integration Uses the Least Man-Hours

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1. ABSTRACT

This study tried, and failed, to produce a mapping between the two defence equipment development phases of system (functional) partitioning and system integration.

This study defined a defence development contract as a financial instrument called a ‘future’. It then compared defence equipment development to the ‘derivative’ financial instrument and introduced the ‘derivatives issue’. Just as two Nobel Prize winners spectacularly failed to predict the derivatives market, this study failed to produce a mapping between system partitioning and system integration. Research found that defence equipment system integration is far too complex and multidimensional.

This study presents the results from the biggest, as far as the author is aware, defence development public domain data set.

In total their were:

- 38 interviewees.
- 178 survey responses.

The 2 main surveys of this study had 158 respondents.

Given the mapping was not possible this study went on to research defence equipment development as a complex adaptive system and to define a set of leading Indicators to point to the success of system integration.

Research found strong evidence that defence system integration is a complex adaptive system. This study also identified 14 classes of leading indicators and 71 subclasses.

2. REASONS FOR THE RESEARCH

Developing major defence equipment is expensive, even a slight decrease in development costs would represent large savings.

Figure 1, below, shows the development costs[1] of five major defence systems (National Audit Office, 2000 and United States Government Accountability Office, 2006).

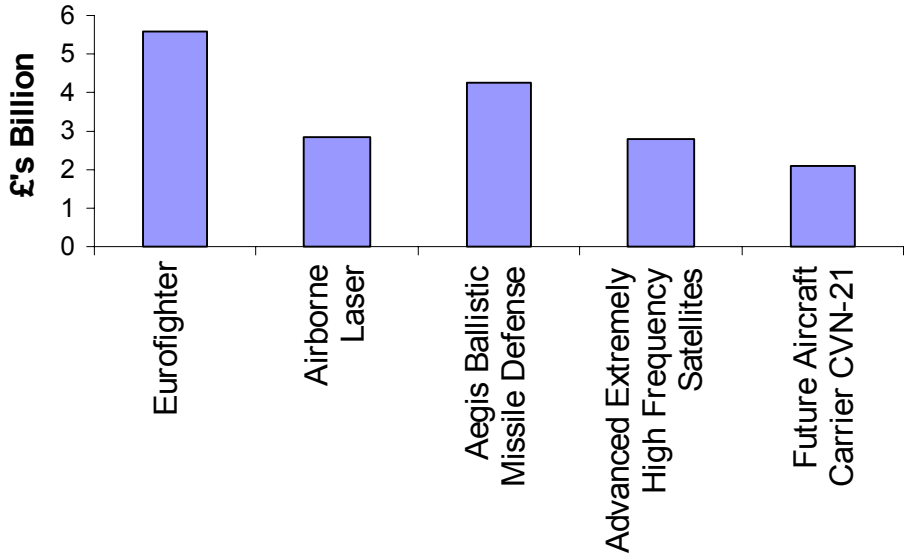

Figure 1 – Defence System Development Costs

Estimates of the percentage of development costs that SI (System Integration) comprises range from 10 to 50%[2]. Even a slight decrease in SI effort will produce large cost savings.

[1] All costs, except Eurofighter, obtained from 'United States Government Accountability Office' (2006). Costs calculated at $2 = £1.

[2] No figures available for percentage of development effort that system integration comprises. The figures are the estimates by 6 Subject Matter Experts.

3. AIM OF THE STUDY

Figure 2, below, shows the aim of this study.

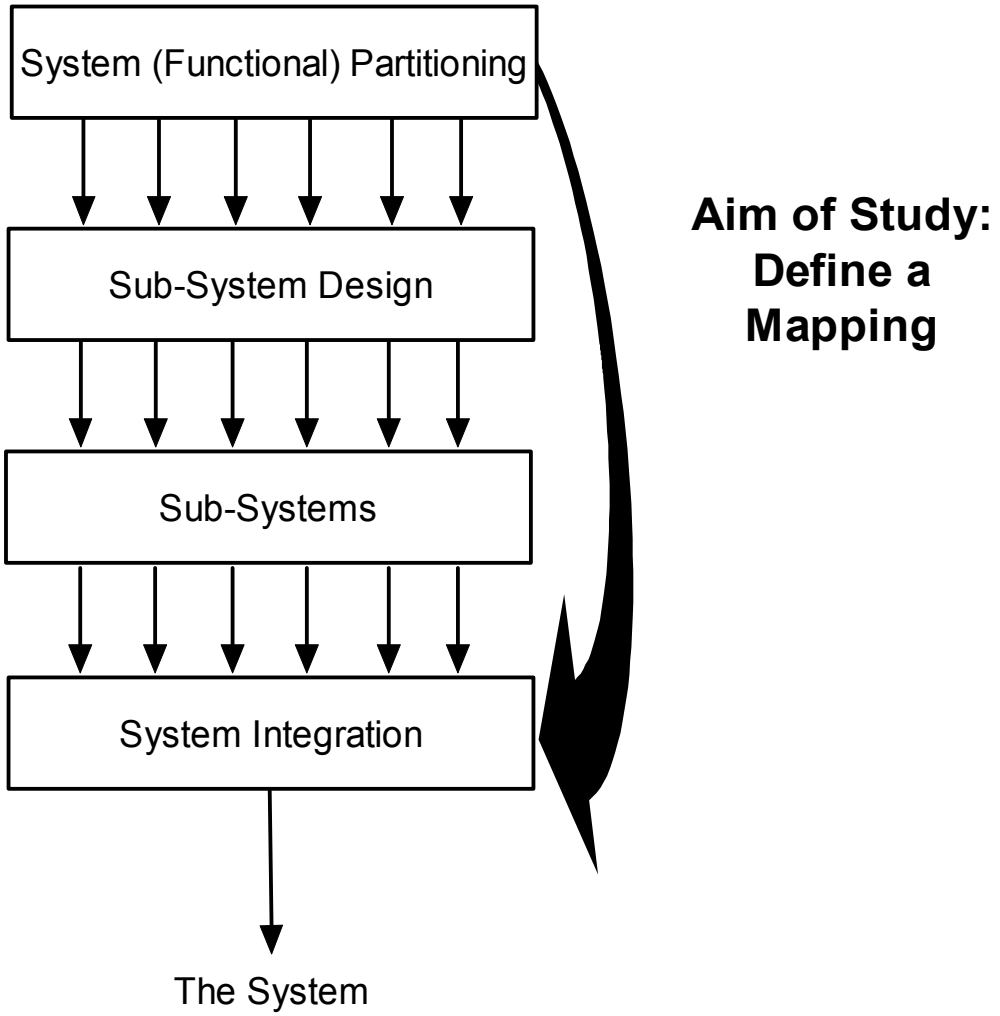

Figure 2 – Aim of the Study

The aim of the study was to define a mapping between the two equipment development phases of system partitioning and SI of the same equipment.

The aim was to produce a mapping that, for instance, system architects could use to aid the functional partitioning of a defence equipment to make SI easier (cheaper).

4. EXPLORATORY SURVEYS AND INTERVIEWS

Exploratory surveys and interviews found many influences, on both system partitioning and the efficiency of SI, were non-technical and subjective.

Their were many different, sometimes conflicting, opinions.

Anderson and Brown (2004) confirm the influence of subjective influences by stating: 'We believe that many of the I&I [Integration and Interoperability] cost drivers are tacit or latent in nature; they are intangible, subjective, and contingent'.

5. MAPPING FEASIBILITY STUDY

A feasibility study into the mapping possible within the timescales of this study showed that only a simple mapping was (maybe) possible.

The feasibility study defined a defence development contract as a 'futures contract' and the value of the contract, to the contractor, as a financial instrument called a 'derivative'.

Robert C. Merton and Myron S. Scholes were jointly awarded the 1997 Nobel Prize for Economic Sciences 'for a new method to determine the value of derivatives' (Nobel Prize, 1997). Merton, Scholes and financial executive John Meriwether founded the company Long Term Capital Management (LTCM).

Between January and September 1998 LTCM lost 'almost 90% of its capital (…) LTCM's trading positions and related positions of other market participants might pose a significant threat to already unsettled global financial markets' (United States General Accounting Office, 1999).

This study took heed of the comments by Sterman (2002) that we should all know the 'limitations of our knowledge'.

6. RESEARCH METHOD

The chosen research method was 'Q-methodology'. Q-methodology is a mixture of the subjective and objective that produces a statistical summary of people's opinions.

British physicist-psychologist William Stephenson developed Q-methodology in the mid 1930's. 'Fundamentally, Q entails a method for the scientific study of human subjectivity' (McKeown and Thomas (1988, p. 12).

Figure 3, below, shows the 4 main Q-methodology steps.

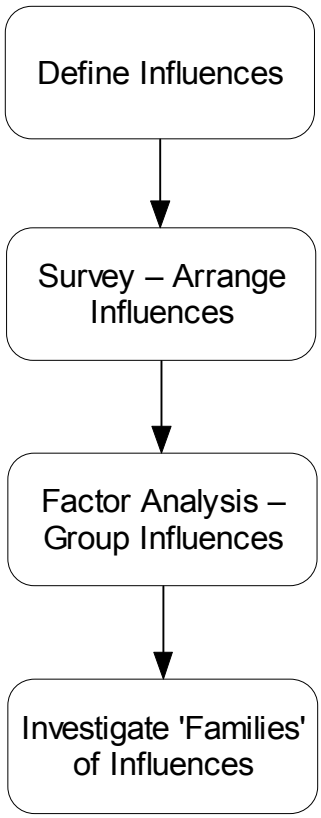

Figure 3 – Q-methodology Process

Q-methodology first discovers the influences (short statements) on the subject area under investigation; influences can come from any source, for instance academic papers or personal interviews.

Survey respondents arrange the influences in a grid depending on how they see the relative importance of each influence. Figure 4, below, shows an example arrangement of influences.

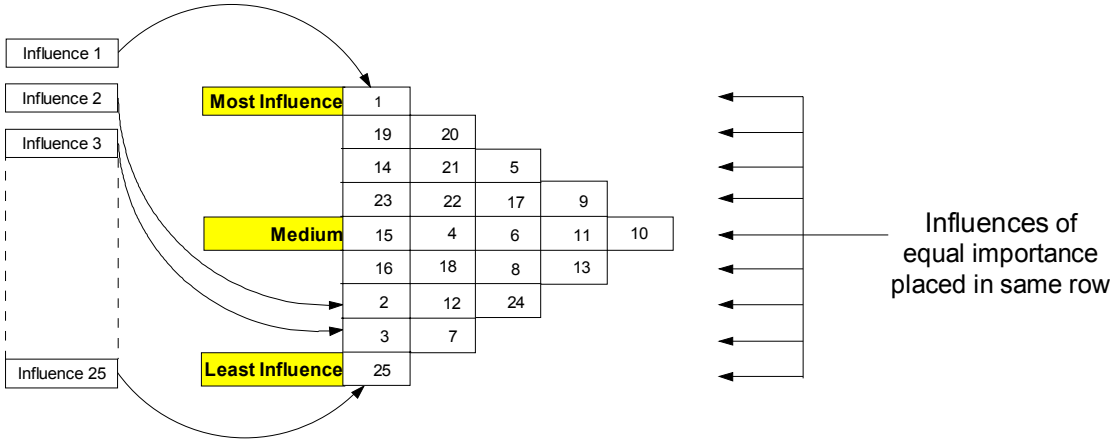

Figure 4 – Q-methodology Influence Grid Arrangement

The survey returns are then subject to factor analysis to group ‘families’ of opinion. Figure 5, below, shows the grouping of opinions.

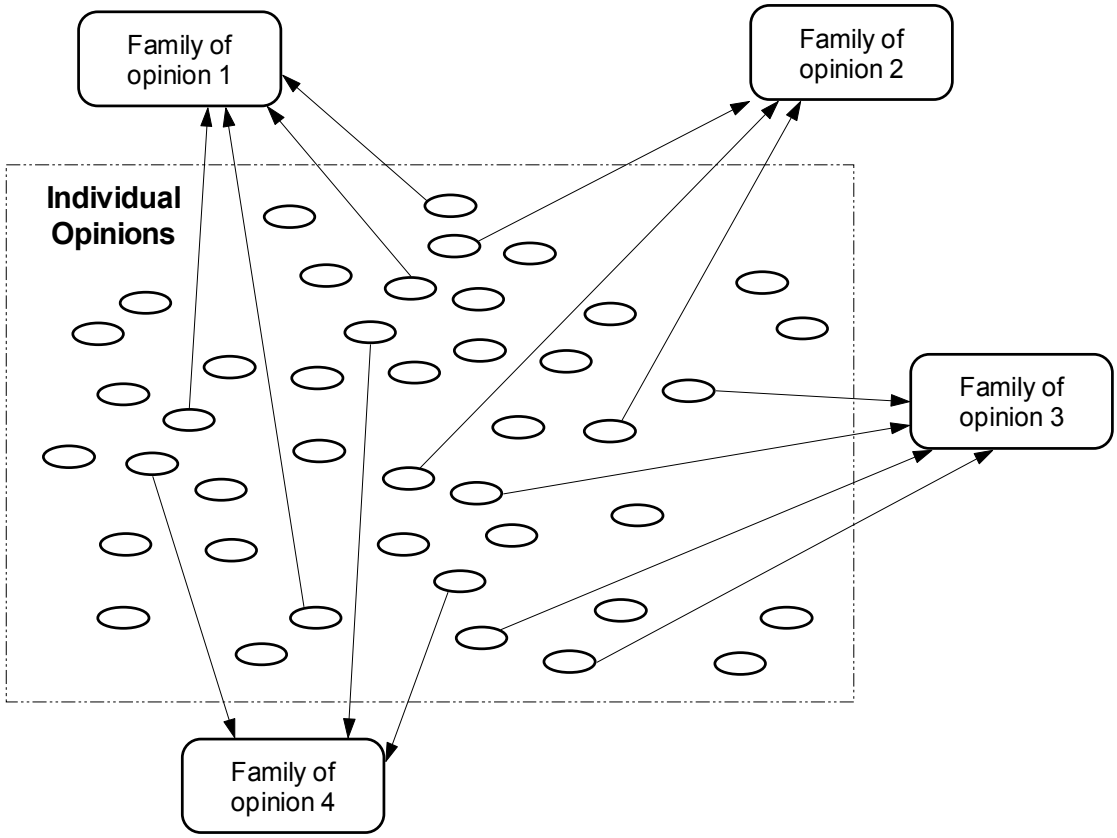

Figure 5 – Q-methodology Grouping of Opinions

The analysis also defines an idealised arrangement of influences for each family. Figure 6, below, shows an example set of idealised arrangements.

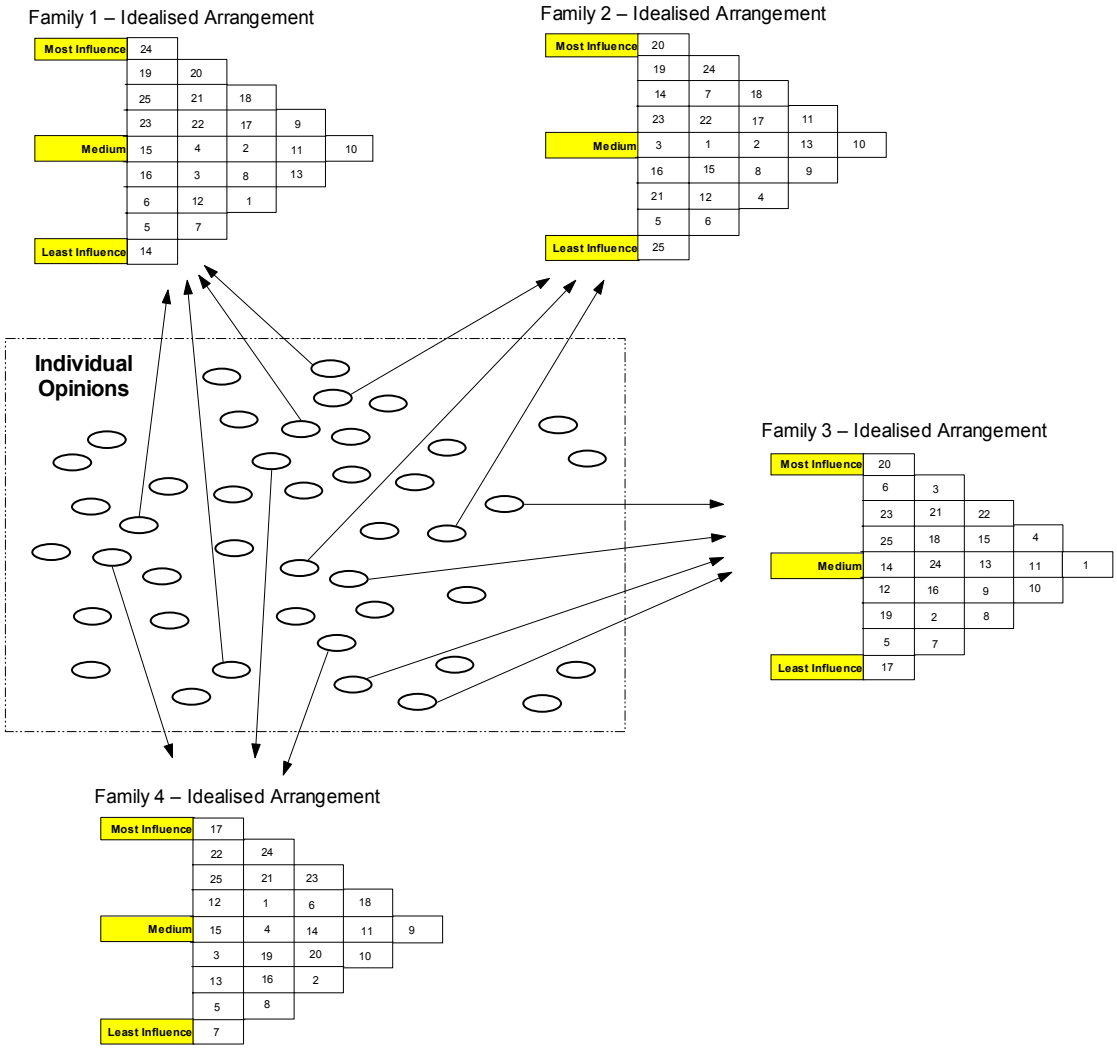

Figure 6 – Q-methodology Idealised Arrangement of Influences

Definition of the mapping, from system partitioning to SI, would be by researching each family of opinion.

7. RESULTS

The SI survey results were subject to detailed analysis to discover if a mapping, onto SI, was practicable – it wasn't.

Figure 7, below, summarises the results of the SI survey analysis.

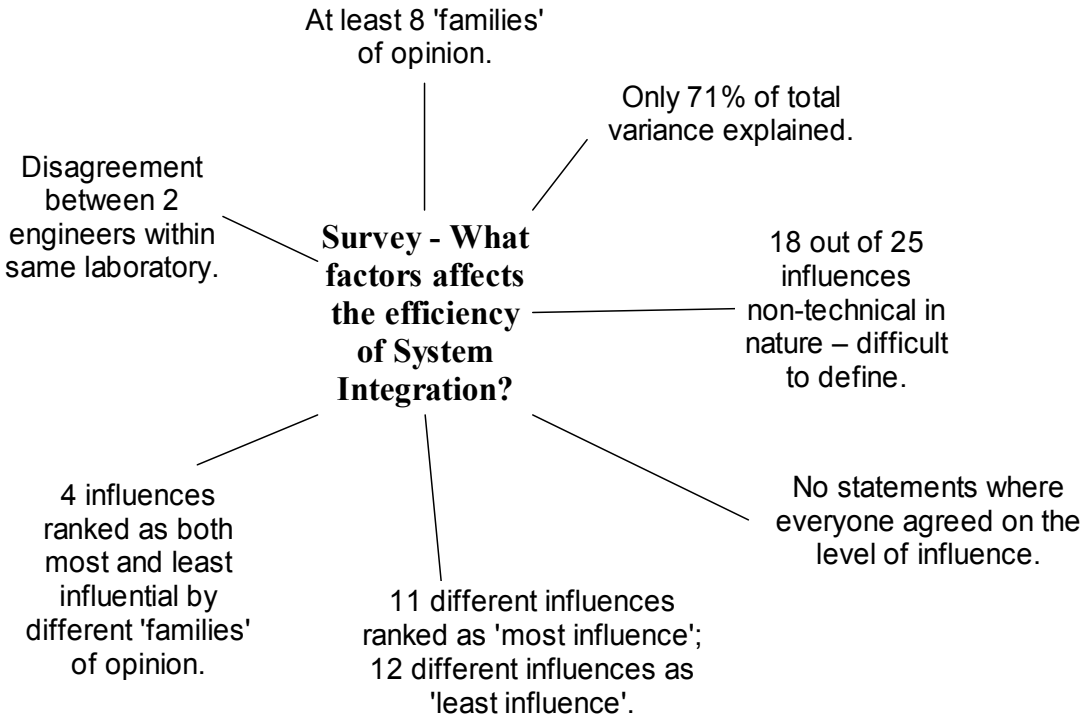

Figure 7 – Q-methodology SI Survey Results

Given the results of the SI survey producing a mapping between system partitioning and SI was not possible within the timescales of this study.

8. Change of Direction

This study used the SI survey results to define a set of 'LIs' (Leading Indicators) to point to the success of SI.

This study used the Q-methodology survey results, interviews, a further survey and a literature review to research defence SI as a CAS (Complex Adaptive System).

9. Leading Indicators

The research defined 14 classes and 71 subclasses of LIs from this study and other research.

Roedler and Rhodes (2007) define an LI as an 'individual measure, or collection of measures, that are predictive of future system performance before the performance is realized'.

This study defined SI as an IS (Information System). Sumner (1995) summarises 12 reasons IS fail. This study used Sumner's (1995) reasons IS fail and 2 more summaries, from this study, as classes of LI.

Figure 8, below, shows the LI classes, source, and number of subclasses in brackets.

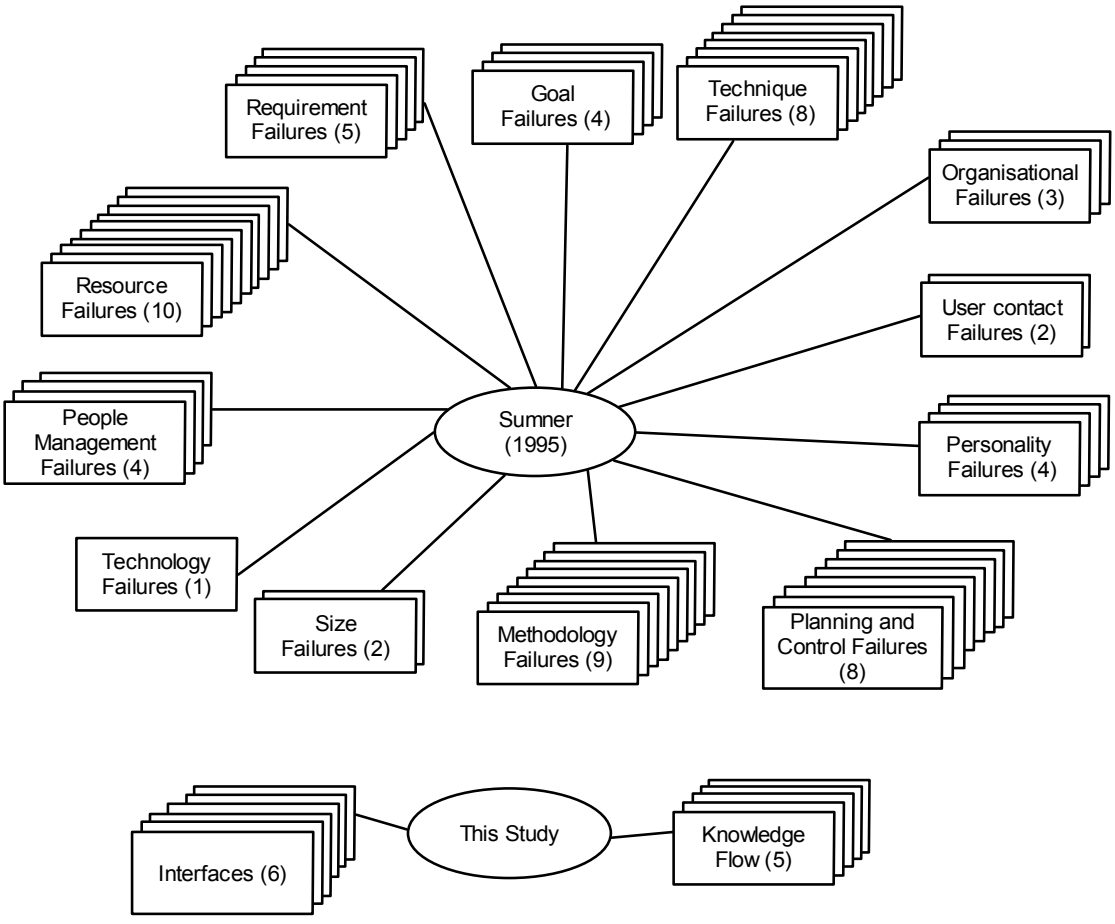

Figure 8 – SI Leading Indicator Classes and Number of Subclasses

This study identified 71 subclasses, 30 from this study and 41 from other studies.

This study assigned each of the 71 subclasses to one of the 14 classes.

10. DEFENCE SI AS A CAS

This study found strong evidence that defence SI is a CAS. O'Neil (2007) summarised the complexity of SI; 'System Integration is 'touchy-feely' – it's a women's thing'.

Tan et al (2005) define a CAS as 'a collection of individual, semiautonomous agents that act in ways that are not always predictable and whose actions seek to maximize some measure of goodness, or fitness, by evolving over time'.

This study conducted a survey, interviews and a literature review to research defence SI as a CAS.

Figure 9, below, summarises the results of the survey and interviews.

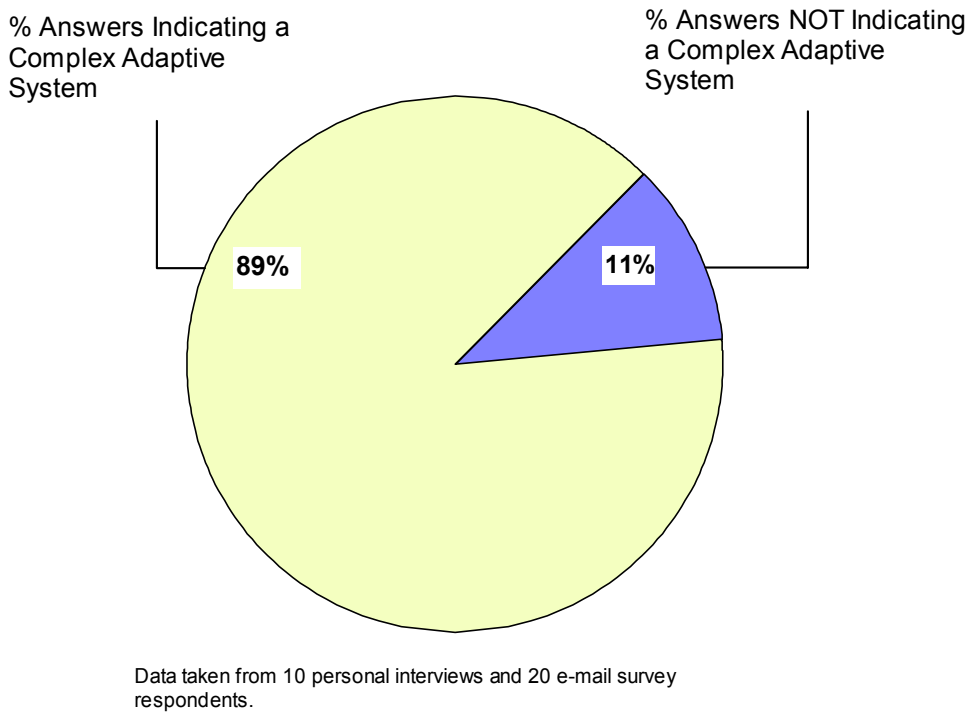

Figure 9 – Defence SI as a CAS Survey Results Summary

A literature review revealed more evidence that defence SI is a CAS, for instance Anderson and Brown (2004) state that integration and interoperability 'programmatic efforts' are 'often termed multi-agent systems, or complex adaptive systems'.

11. CONCLUSIONS

This study concludes:

- **It is not possible to define a mapping between system (functional) partitioning and the system integration of the same system.** Defence system integration is too complex and multidimensional.
- **Defence system integration is a Complex Adaptive System.**

This study also identified 14 classes and 71 subclasses of 'Leading Indicators' that point to the success of defence system integration.

12. REFERENCES

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