Chapter 10
Conclusions and recommendations

"I am not sure I should have dared to start; but I am sure that I should not have dared to stop."

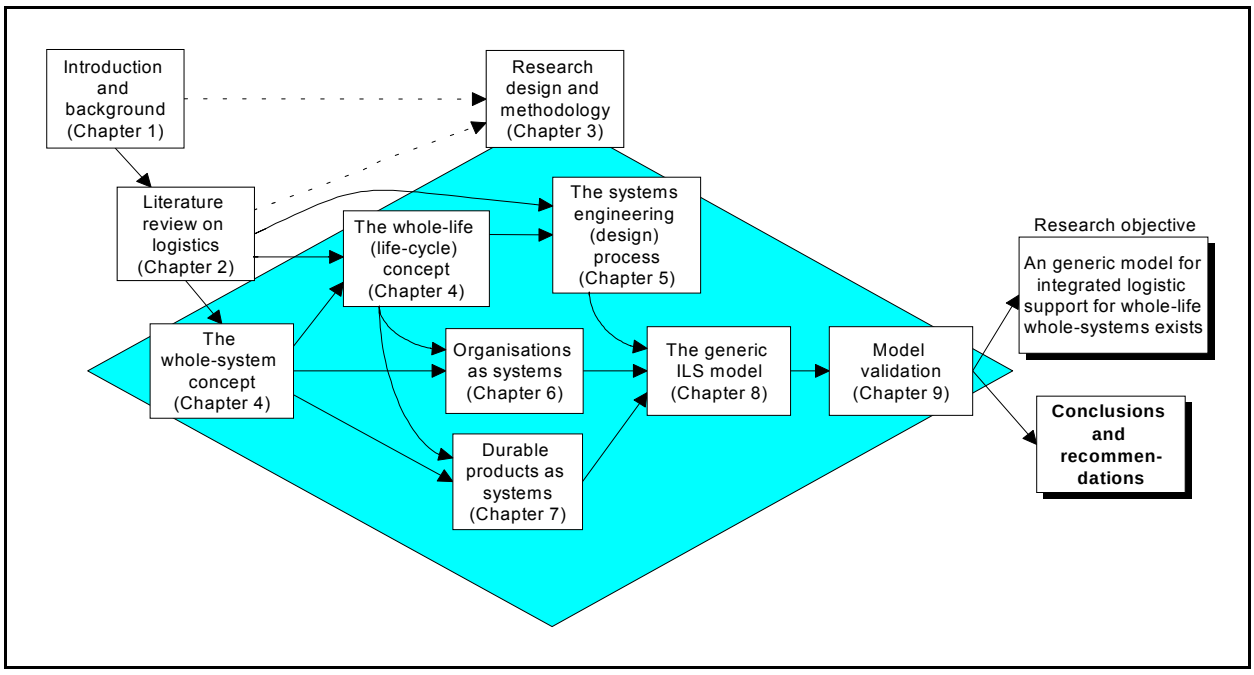
Winston Churchill

"Real knowledge is to know the extent of one's ignorance."

Confucius

"It is better to ask some of the questions than to know all the answers."

James Thurber



10.1 Purpose and outline of the chapter

The purpose of this chapter is to summarise the findings of this research and to draw conclusions. The theoretical contribution and practical application of the research is discussed, and recommendations for further research are made.

10.2 Summary of research results

10.2.1 Dynamic and detail complexity of systems

There is a major difference between the dynamic complexity and detail complexity of systems. Detail complexity is primarily concerned with the workings of the components of systems whereas the dynamic complexity deals with the interactions of system components that causes the emergent properties of systems. Because of the differences that exist between detail and dynamic complexity of systems it is necessary to have a sound understanding of systems in order to recognise and understand these differences. Only then can the system be managed on both the dynamic and detail complexity levels.

10.2.2 Generic sub-systems

It is possible to define sub-systems that are generic for all man-made systems, irrespective of the actual system under investigation. These sub-systems are the operating sub-system, the management sub-system, the support sub-system and the information sub-system. The interactions between these generic sub-systems can be explained using the dynamic complexity of systems. Having defined generic sub-systems for any man made system, it is thus also possible to define a generic approach to each of the generic sub-systems. This research focussed on the generic approach of the support sub-system (or integrated logistic support system), this sub-system being crucial for success of the overall system. If the integrated logistic support sub-system is ignored, the whole-system concept is not valid anymore. In order to be able to present a generic approach to the integrated logistic support system, the approach must be presented on the dynamic complexity level of systems, as the generic character of the approach is embodied in the dynamic complexity of systems. The detail complexity level of systems may require different approaches to integrated logistic support for different man made systems.

10.2.3 The dimensions of the system view

The holistic view of systems allows the understanding of systems existing in a hierarchy, the system having boundaries and interacting with its environment through inputs and outputs, and systems having a life-cycle. Understanding the holistic view of systems allows the importance of the life-cycle to be highlighted and the need for different managerial and technical activities for each sub-system within each phase of the life-cycle.

The synthetic view of systems allows understanding of the system being greater than the sum of its parts because emergent properties exist for the system that do not exist as part of any of the sub-systems, systems are constrained in its output by very few (mostly one) components (making sub-optimisation a very real possibility), and systems are subject to entropy on both the component and interaction levels of the system. Understanding the synthetic view of systems the need for the support sub-system is verified, and also the need to view the dynamic complexity to ensure system optimisation instead of only optimising the support sub-system.

The teleology view of systems allows understanding of the system being goal seeking and that the system exist for a purpose. Being goal seeking, measurements are required to measure the level of achieving the goal. Taking the teleology view and understanding whole-system and whole-life characteristics of systems, generic measurements of system success can be defined, namely ability, availability and affordability. These measurements are applicable to any system irrespective of the type of system or the system hierarchy level on which the system exists and functions.

10.2.4 The systems view and its relation to the support sub-system model

The above systems views can be applied to any man-made system. For the purpose of this research, these system views can be applied to all organisations (public and private, for-profit and not-for-profit) organisations as they all exist as systems. The systems view can also be applied to all durable products, as they also exist as systems. Services and

consumable goods are not systems in themselves but exist as part of organisational systems.

Using a systems and life-cycle view, it can be demonstrated that a generic approach to the managerial and technical activities of the support sub-system for all man made systems can be taken. This generic approach to the support sub-system is presented as a graphical model and is called the generic approach to integrated logistic support for whole-life whole-systems. The fundamental system characteristics that were considered for the development of the model are the following:

- Systems go through a birth-life-death cycle (the life-cycle concept). Phases in the life-cycle follow a certain sequence which cannot be changed around.
- Apart from the technical activities that take place within a system, a system also requires managerial activities to plan, organise, direct and control the technical activities, and both the technical and managerial activities differ from life-cycle phase to life-cycle phase.
- A system exists for a particular purpose, which implies the need for measurements to measure goal achievement, requiring the integrated logistic support system to fit in with the system measurements.
- Due to the dynamic nature of systems, integrated logistic support actions taken during a particular phase may be aimed at providing positive system outcomes much later in the system's life-cycle.
- Systems need both operating and maintenance support for continuous goal achievement.

10.2.5 Implications of the model for integrated logistic support

System success can be expressed by the generic system measurements. Using the integrated model for whole-life whole-systems, strong relationships between actions taken during the early phases of the life-cycle and system success (generic system measurements) later in the life-cycle can be defined. The implication of applying the model to the system life-cycle can be demonstrated using the relationships between the actions

and the system success measurements. Having a thorough understanding of these relationships can aid any designer to improve decision making from a system perspective. Implication diagrams provide a mechanism to conduct a thought experiment to allow the comparison of systems who choose to employ a whole-life whole-systems approach to integrated logistic support and those systems who choose not to employ a whole-life whole-systems approach to integrated logistic support.

These thought experiments can be considered a high level system dynamic simulation arguing the logic of the relationships between the actions proposed by the model and system success, rather than assuming the validity of relationships and using real life data to make comparisons. For the researcher interested in the detail complexity of systems, the relationships between the actions proposed by the model and system success measurements presented in this research can be used as the basis for detail complexity simulations and research.

10.2.6 Contributions of the research

The contributions of this research are the following:

- It provides a life-cycle approach to integrated logistic support as opposed to the functional view of logistics.
- It emphasises the dynamic nature of integrated logistic support sub-system within the system context as opposed to the detail complexity of logistics which often leads to sub-optimisation of the system of which the support sub-system is part.
- It shows the relationship between the managerial and technical activities within each major phase of the life-cycle.
- It highlights the importance of the logistic sub-system and the sequence of technical and managerial activities in its contribution towards system success.
- It provides a high level mathematical relationship between the managerial and technical activities associated with integrated logistic support and the generic system measurements of ability, availability and affordability.

10.3 The principal conclusions of the research

In order for any system to be successful, the correct system measurements need to be defined that will fully support the stated goal. All sub-systems that are part of the system should be measured according to their contribution to the overall systems success, and not according to some sub-optimising measurement for the sub-system itself.

Taking a functional view of logistics often leads to sub-optimisation of the overall system, as certain support activities (such as maintenance) are measured separately from the overall system and not according to its overall contribution to system success. Furthermore, much of the bad support system performance during the operational phase of the system life is the result of poor initial system design, i.e. focussing on functional design and ignoring or neglecting the support design.

Integrated logistic support should be based on a life-cycle approach for both the operational and maintenance support, from both a technical and managerial point of view. Failing to do so, will lead to sub-optimised system performance. The major contribution that can be made by the support sub-system, is during the early life-cycle phases. Placing the emphasis on support design during the early life-cycle phase does not mean providing the support can be neglected later on in the life-cycle.

A structured, integrated approach to designing and providing the system support, based on sound system measurement, is needed throughout the life-cycle. Both the sequence of managerial and technical activities are important. The generic integrated logistic support model for whole-life whole-systems provide such an approach.

10.4 Further research

Further research is necessary to investigate the detail complexity of integrated logistic support to ensure that it ties in with the dynamic complexity of integrated logistic support i.e. how counterintuitive actions can be eliminated from the detail complexity of integrated

logistic support to fully support the dynamic complexity of systems expressed as optimum ability, availability and affordability.

As has been stated in § 10.2.5 the relationships between the actions relating to the support sub-system and the system measurements can be used as the foundation for models that describe the detail complexity of integrated logistic support. Further research can use the model and relationships between the support actions and the system measurements to identify areas of system improvement. Typical questions that may be investigated may include the following:

- How large (or small) should lot sizes be?
- What impact will the improvement of reliability and maintainability have on the system measurements?
- Should a design be changed to have less support requirements?
- How many support levels are needed for the system?
- How should the supply chain be designed?
- Will a major redesign during the operational phase provide sufficient benefits?
- How much protective capacity is needed within the maintenance department?

The key to success would be to establish the detail relationships between the operational and maintenance support action, and the ability, availability and affordability of the system.

"It is not the critic who counts, not the man who points out how the strong man stumbled, or where the doer of deeds could have done better. The credit belongs to the man who is actually in the arena, whose face is marred by dust and sweat and blood, who strives valiantly, who errs and comes short again and again, who knows the great enthusiasms, the great devotions, and spends himself in a worthy cause, who at best knows achievement and who at the worst, if he fails, at least fails while daring greatly. His place shall never be with those cold and timid souls who know neither victory nor defeat."

Theodore Roosevelt