9 Conclusions and Recommendations for Future Work

This chapter presents the conclusions of the research described in the thesis. The aim and objectives of the research, outlined in chapter 1, are reviewed and their achievement addressed.

Proposals for future work indicated by the research are suggested.

9.1 Conclusions

The aim of the research was:

- To develop and demonstrate a methodology to design for jigless assembly and a process of selecting assembly features to enable jigless assembly

To achieve the research aim, a research methodology was designed, a vital part of which was the setting of objectives that, when completed, would seek to incrementally fill the gaps in the boundary of knowledge and realise the research aim.

The objectives of the research are listed below. All of these objectives were completed as part of the research. Furthermore, the results obtained as a direct consequence of meeting these objectives are stated.
Chapter 9 – Conclusions and Recommendations for Future Work

- **Development of a methodology to design for jigless assembly (section 3.2)**
  - The methodology to design for jigless assembly has provided the means to analyse and compare alternative assembly concepts
  - The assembly concept selection of the alternative assembly concepts was in the first instance based on engineering judgments and practicalities; Error Budgeting was used to select the preferred assembly concept

- **Definition of a selection process of assembly features, in particular for jigless assembly (section 4.3)**
  - The assembly feature selection process to enable jigless assembly worked effectively to aid the designers in selecting appropriate assembly features
  - However, the ‘Re-engineering Ground Rules’ restricted the choice of assembly features that were available for selection and hence, it could be argued, that the selection process was not fully tested
  - The greatest benefit to arise from the application of the assembly feature selection process to enable jigless assembly was its simplicity in use and the way in which it forced the designer to adopt a structured, repeatable and logical approach
  - The selection process of location features is based upon basic kinematic principles and four fundamental areas of selection criteria – design, manufacturing, cost and accuracy
  - Although more work needs to be done on each one of these selection criteria and the inter-relationships they possess
  - The broadening and expansion of the definition of an assembly feature has helped to encompass the whole range of major activities involved in assembly; this has assisted in apportioning the correct area of functionalities, in terms of location, support, clamping and fastening within an assembly
• **Formation of a Feature Library to facilitate jigless assembly (section 4.4 and Appendix B)**
  - The development of a Feature Library to facilitate jigless assembly has given a vehicle by which the assembly feature selection process can be directly applied
  - The Feature Library also includes the much broader and expanded range of assembly features, particularly to facilitate jigless assembly, than conventional forms of Feature Libraries that can be found in typical Feature Based Methods

• **Demonstration of the methodology, selection process and Feature Library in the redesign of a Case Study demonstrator structure for jigless assembly (section 5.4)**
  - The application of the methodology to design for jigless assembly, the assembly feature selection process to enable jigless assembly and the Feature Library for Jigless Assembly, has resulted in a re-engineered design that enables jigless assembly
  - The preferred assembly concept managed to only use one form of tooling, i.e. the Build Tool, which served as the jig for the Spar; no other product-specific tooling was used
  - Evidence was shown that the use of the methodology to design for jigless assembly, the assembly feature selection process to enable jigless assembly and the Feature Library to facilitate jigless assembly could have a large and considerable impact on both the Non-Recurring and Recurring costs associated with the design, manufacture and assembly of aircraft
9.2 Recommendations for Future Work

The weaknesses and limitations of each of the three tools and techniques developed in the research study have indicated the following areas as recommendations for further work.

- **The design for jigless assembly methodology**
  - Development of the manufacturing element of the methodology to incorporate and take into account factors such as Process Capabilities
  - Extend the scope of the methodology by considering requirements for jigless assembly with other possibly conflicting requirements from different sources, such as design or manufacturing

- **The assembly feature selection process to enable jigless assembly**
  - Develop a more rigorous method for the Location Feature Pairs selection process involving the different selection criteria used
  - Develop a method for the selection of the other Assembly Features: Support, Clamping and Fastening features
  - Define the required information and content of databases storing generic information about assembly features, at the early stages of product development, to be able to select the Location Feature Pairs

- **The Feature Library to facilitate jigless assembly**
  - Collect quantitative and qualitative data about each of the feature types in the Feature Library to support the assembly feature selection process
  - Investigate the most effective organisation and specification of the individual features and the taxonomy of features within the Feature Library