

Chapter 9 Analysis Package

9.1. Introduction

Four FORTRAN programs and a spreadsheet based on the analyses as outlined in previous chapters were developed for eventual incorporation into existing MDO codes. Programs CONFIG, LIMIT, PAVE, and GEARWEI can be used together in an iterative fashion to study the global effects of variations in the landing gear design parameters on configuration, system integration, airfield compatibility, and weight. In addition, the programs can be used individually to analyze a particular aspect of a given concept. In both cases, aircraft configuration characteristics have to be imported either from existing aircraft sizing codes or disciplinary analyses, while landing gear-related parameters must be specified by the user or set up as defaults. Within an optimization framework, these parameters would be treated as design variables whose optimum values would be computed by the optimizer to achieve a desired objective. However, the goal here is to demonstrate the algorithms, which can be used to help automate the landing gear design process.

In addition to the four programs as mentioned above, a simple Microsoft Excel-based spreadsheet was created to establish the maximum permissible *cg* range of a particular aircraft concept. The spreadsheet requires estimated component weights be imported from existing aircraft sizing code, while the corresponding component *cg* ranges can be specified by the user or set up as defaults.

9.2. Description of Programs

A simple spreadsheet software is used to establish the forward and aft limits of the permissible aircraft *cg* range. Given the aircraft configuration characteristics and component weights, the spreadsheet uses the specified component *cg* range as detailed in Chapter Two to calculate the maximum permissible aircraft *cg* range.

The primary task for program CONFIG is to develop a landing gear model that can be used as the baseline configuration. Given the aircraft weight, configuration characteristics, and the number of struts and tires, the program determines the loads on the tires and the

total braking energy to be absorbed by the brakes. Suitable tires, wheels, and brakes are either selected from manufacturers' catalogs or sized statistically as detailed in Chapters Four and Five. The length of the structural components, *e.g.*, axles, truck beam, piston, cylinder, and trunnion, are determined based on the attachment scheme and clearance requirements. As for the linkages, a generic attachment scheme derived from existing commercial transports is used to determine the arrangement and required length of the drag and side struts. Based on this information, the program establishes a mathematical model of the notional landing gear in three-dimensional space, which is to be used by the remaining programs for detailed analysis.

Program LIMIT is used to examine the design and kinematic characteristics of the landing gear. Given the configuration characteristics of the aircraft and the model of the notional landing gear, turnover angle, pitch and roll angles during takeoff and landing, ground clearance, and turning radii are calculated using procedures as detailed in Chapter Three. The calculated values are then compared with a list of specified requirements to identify possible constraint violations. From the dimension and arrangement of the landing gear and the allocated stowage space, pivot axis and retraction angle are determined using mathematical kinematic analysis as detailed in Chapter Six. In addition, retraction path, swept volume, and stowed position are established and compared with stowage boundaries for possible structural interference.

The flotation characteristics of the aircraft are determined by program PAVE. Flexible and rigid pavement bearing stresses associated with specified loading conditions are calculated using pavement design procedures as detailed in Chapter Seven. The required pavement thickness is converted to the standard pavement bearing strength reporting system and tabulated for comparison purposes.

The component and group weights of the landing gear are calculated by program GEARWEI. As detailed in Chapter Eight, the structural weight of the landing gear is determined analytically from the notional landing model, while the weight of the non-structural components is determined from a statistical database. These weights are combined to arrive at the landing gear group weight.

9.3. Organization of Analyses

The programs are organized as shown in Figure 9.1 for use in an iterative fashion to study the global effects of variations in the landing gear design parameters. Aircraft weight and configuration characteristics, as well as a limited number of landing gear-related design parameters, enter the package through program CONFIG. The former set of data is obtained either from existing aircraft sizing codes or disciplinary analyses, *e.g.*, ACSYNT and FLOPS, whereas the latter is user-specified or is set up as defaults. Using this information as a starting point, program CONFIG generates a notional landing gear model, as well as data sets to be used as inputs for programs PAVE, LIMIT, and GEARWEI. The first two programs then assess flotation, operational stability, maneuverability, and stowage aspects of the aircraft/landing gear concept are examined. If all the design constraints are satisfied, landing gear weight is then estimated in program GEARWEI. Note that if any of the design constraints cannot be satisfied by the current configuration, user-specified modifications to the model or design parameters will be needed to resolve the violations through an iterative process. The execution of all the programs is essentially instantaneous.

The current state of the analysis package is a compilation of a number of separate analysis codes. The package does not have the capability to generate the required landing gear-related parameters, *e.g.*, the number of tires and struts, attachment location, and stowage space, based on imported aircraft configuration characteristics. Thus, starting values, or “guesstimates”, must be provided for these design parameters. The parameters can then easily be varied by the user, or an optimizer, for parametric study purposes and the information used to select the optimum design.

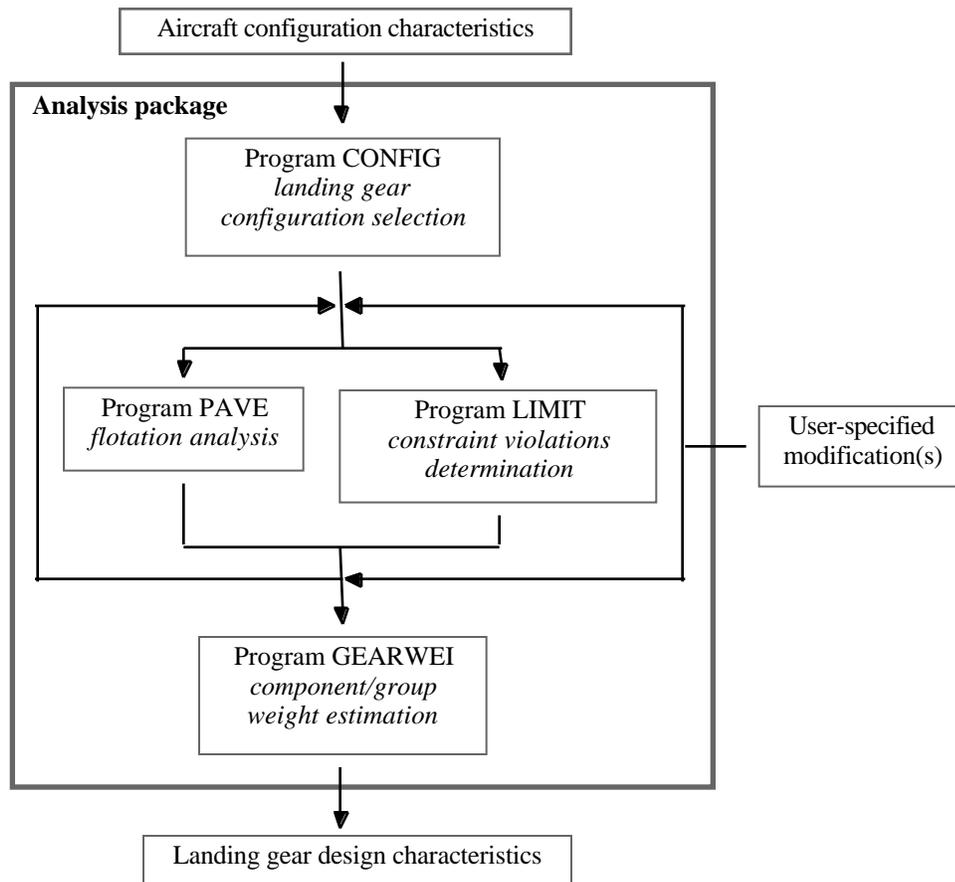


Figure 9.1 Organization of analyses

9.3.1. Input/Output Data

Data required by the analysis package are listed in Table 9.1. The majority of this information consists of geometric and weight characteristics associated with the aircraft: wing area and span, quarter chord sweep, fuselage length and width, maximum takeoff/landing weight, aircraft *cg* location, *etc.* These design parameters are readily available from existing aircraft sizing codes and can easily be rearranged into the “card-style” inputs used by the analyses. The remaining information consists of landing-gear related parameters, and as mentioned in the previous section, must be provided by the user or selected from defaults.

Table 9.1 Required input data

Parameter	Type	Description
Wing	Imported	Geometric characteristics; location
Fuselage	Imported	Geometric characteristics
Engine/Nacelle	Imported	Geometric characteristics; location
Weight	Imported	Takeoff/landing weights; weight distribution; aircraft <i>cg</i> location
Landing gear	User-specified or default	Design/selection criteria; number of tires/struts; location; clearance; stowage space

A description of the results generated by individual analysis is given in Table 9.2. It should be pointed out that these data only represent part of information that is produced by the analyses. Intermediate results, *e.g.*, constraint boundaries, landing gear loads and induced stresses, that might be of interest or importance to a particular discipline, are currently internal to the analyses. To access this information would require modification of the output section of the program(s) to extract these data. Sample input/output files for the four programs can be found in Appendix E.

Table 9.2 Analysis-generated output data

Program	Description
CONFIG	Selected tires/wheels data; strokes; load-stroke curve; mathematical landing gear model
LIMIT	Trunnion alignment; retracted landing gear position; stability/operational characteristics; constraint violations
PAVE	<i>ESWLs</i> ; concrete bearing stresses; pavement thickness; ACNs
GEARWEI	Structural member dimensions; landing gear component/group weight

9.4. Aircraft CG Estimation Spreadsheet

In addition to the four programs that made up the analysis package, a simple Microsoft Excel-based spreadsheet was created to establish the maximum permissible aircraft *cg* range for any given aircraft concept. Aircraft component identification was provided in the first column, while estimated component weights as obtained from existing sizing codes are entered into the second column. Given the aircraft geometric characteristics, the forward and aft component *cg* limits determined based on the generic aircraft layout developed in Chapter Three are entered into column three and four, respectively. The spreadsheet calculates the moments corresponding to the forward and aft component *cg* limits, and then divides the sums of the moments by the total component weight to arrive at the maximum forward and aft aircraft *cg* limits.