Chapter 11 Costs

11.1. Introduction

The manufacturing cost of the landing gear cannot be treated simply as a function of weight or strut length. Instead, cost estimation must take into account the costs of development, certification, marketing, life-cycle, spares, *etc.* A typical program cost is roughly in the range of $10 to $12 million dollars, based on industry survey [App. A]. However, detailed information is considered proprietary and is difficult to obtain from the manufacturers. Thus, the cost issue will only be discussed in qualitative terms, while actual unit costs will be provided whenever available.

11.2. Maintenance and Overhaul

The maintenance costs associated with the landing gear represent a considerable item in the total maintenance bill [3]. The cost of the tires, wheels and brakes will remain relatively unchanged for new programs. The limiting factor is the size of the tire that can be constructed and tested without a major new investment in manufacturing and testing facilities. Current hardware limits the maximum diameter to 56 inches for the bias-ply tire and 58 inches for the radial-ply tire [App. A]. Dimensions and costs of several tires found on existing large aircraft are listed in Table **11.1**. For the aluminum wheel and carbon-carbon heat sink found on the Boeing Model 747-400, the unit price is valued at $70,000.

Table 11.1 Description of selected aircraft tires [App. A]

Tire	Type	Aircraft	Application	Cost, $
H49x19.0-22, 32-ply	Bias	Boeing Model 747	Main/Nose	2,100
42x17.0-18, 28-ply	Radial	Boeing Model 777	Nose	2,100
50x20.0-22, 32-ply	Radial	Boeing Model 777	Main	2,900

The landing gear overhaul interval varies between 33,000 to 42,000 flight hours, or roughly within six years [App. A]. Generally, the parts of a landing gear are given an ultimate ‘safe life’ beyond which they would, if still in service, be scrapped [57]. A justification of this approach is that deterioration in service can go unseen since corrosion and other process can occur in concealed areas which are only revealed when the assembly is completely stripped down.

The preferred method is to overhaul the entire set at the same time to minimize the down-time; however, it might be necessary to overhaul the set separately due to schedule, parts and facility constraints. Components may require extensive rework in the shops and thus it is difficult to quote a total throughput time. Given a supply of serviceable components to replace those sent shop-to-shop, it is possible to turn around a B747 assembly within five weeks [57]. Due to the length of time required to rectify each constituent part of a particular assembly, a unit nearly always loses its identity as such, and the end product may contain only a few parts of the original assembly. However, it is noted that when refurbished, the assembly may be better than a new one since it embodies modifications designed to increase the subsequent overhaul life [57]. For the B747 type landing gear, the overhaul cost is estimated at $400,000 [App. A]. Replacement of the carbon heat sink occurs every 1,200 to 1,500 landings, while only 300 landings are allowed for the wheel before replacement. The overhaul cost for the wheel and heat sink is pre-negotiated with the contractors and is known as cost-per-landing. Quoting the B747 figures, the cost for the wheel, including tire, is estimated at $5 per landing, while the cost for the carbon-carbon heat sink is estimated at $10 per landing [App. A].

11.3. Cost Reduction

With the financial challenges arising from the deregulation of the air-travel industry, the airlines are faced with the challenge of reducing operating costs to remain competitive. As a result, the airlines have demanded that the aircraft manufacturers produce new designs with high reliability and low maintenance requirements. In basic design, costs associated with the landing gear may be reduced by aiming at simplicity, compactness, and minimum weight and maintenance requirements. Simplified design and improved manufacturing techniques, *e.g.*, die-forging and three-dimensional machining [9], are being used to reduce the part-count associated with the landing gear system. In addition, recent technologies, *e.g.*, carbon-carbon heat sinks, radial tires, and high-strength steel, are being introduced. Potential savings associated with the application of these technologies have already been mentioned in Chapter Four.