Chapter 4

Acquisition Cost Model

The acquisition cost model calculates the investment cost involved in acquiring a MAGLEV vehicle. This should not be confused with the vehicle price which is the cost plus some mark-up value. This cost model does not deal with the other costs associated with this transportation system such as the cost of the guideway, electrical distribution, stations, maintenance, and facilities. A work breakdown structure for the entire transportation system was prepared by Parsons Brinckerhoff and can be seen in a paper by Deutsch [3]. It includes estimates of all of the capital costs of the transportation system. The design of the vehicles is of primary importance to the rail companies offering MAGLEV service. The overall system costs will be seen by these companies as user fees. The vehicle design does impact the cost of the system as a whole although these relationships are out of the scope of this work. For example, lower vehicle weight can impact the cost of the guideway structure. Bohlke [25] discusses guideway costs and shows some studies looking at the effect of span between guideway supports on the cost.

The acquisition cost of the MAGLEV vehicle is the total cost involved in creating the vehicles. This includes the cost of producing the vehicle structure, the furnishings, HVAC, levitation and guidance systems, propulsion, control systems, communications, breaking system, and on board power supply (APU). Information is not available on the costs of most of these components. Since they are present on any vehicle design, this model concerns itself with only the structural costs. The cost of the structure is a function of the vehicle shape and complexity, materials used, manufacturing processes chosen, and company procedures dealing with the use of different production facilities.

The different types of cost models are discussed in a paper by Rais-Rohani [32]. The two main categories of models are the Parametric Cost Models (PCM) and the Manufacturing Process Cost Model (MPCM). Parametric cost models are cost equations based on design variables as arguments. Weight engineering models fall into this category. These models are easy to use, although they are not very accurate. They ignore product and process complexity and depend upon a database of past cases. Cost accrued from cost drivers not present in the database cases will not be predicted by the model. These models are good to use in the conceptual design phase, since accuracy requirements are lower and not much is know about the vehicle in question.

Manufacturing process cost models include more detail about the materials and manufacturing processes used. They also address labor, time, and assembly. These models have higher accuracy than the PCM models, although they require much more information to build. This information may not be available at the conceptual or preliminary stages of a design process. Costs are accumulated on a process level giving these models the higher accuracy and sensitivity. Gutowski [65] refers to these types of models as primitive task models, since the whole manufacturing process is broken down to a collection of elementary activities which incur costs that add up to the whole. These activity based models require information from manufacturing process planning records, bills of material, and accounting records. This information is difficult to obtain for a company outsider since it is the source of a company's competitive advantage. Detailed knowledge of a company's cost is usually proprietary information, since it enables them to be competitive via aggressive pricing.

The optimization design undertaken in this work is a conceptual design so there is little detailed information available which would be necessary for the use of an MPCM. This information would include stringer and longeron spacing and surface skin panel size and shape. In addition to this, there have been no production level MAGLEV vehicles from which to construct a database for a PCM. As an interim model, this work employs RAND corporation's DACPA IV model for transport aircraft [66]. This model is a parametric cost model which describes the cost of an aircraft as a function of the vehicle size, structural materials, gross vehicle weight, and cruising speed. As was done for the structural weight model, we assume that the MAGLEV vehicle structure is similar to that of a transport aircraft. In addition to that, we assume that similar manufacturing processes will be used to build the MAGLEV vehicle as are used for transport aircraft. The database used to construct the DACPA IV model is constructed from aircraft with specifications shown below.

$$\begin{aligned} \text{Empty Weight} &: 9753 - 320085(lbf) \\ \text{Maximum Speed} &: 389 - 1250(kn) \\ \text{No. of Flight Test Vehicles} &: 10 - 33 \end{aligned}$$

The MAGLEV application is out of range for the maximum speed and the number of flight test vehicles (low for both categories).

The total acquisition cost predicted by the DACPA IV model includes the engineering cost, tooling cost, manufacturing cost, quality control cost, development cost, test cost, and materials cost. The engineering cost is a function of the empty weight, velocity, quantity of vehicles, and an engineering labor rate. The tooling cost is a function of the empty weight, velocity, quantity of vehicles, and a tooling labor rate. The manufacturing cost is a function of the empty weight, velocity, quantity of vehicles, and a manufacturing labor rate. The quality control cost is a function of the empty weight, velocity, quantity of vehicles, and a quality control labor rate. The development cost is a function of only the empty weight and velocity. The test cost is a function of the empty weight, velocity, and number of test vehicles, while the material cost is a function of empty weight, velocity and total number of vehicles. The actual aircraft cost model includes the engine and avionics cost. This part of the model was not used here. Replacement costs for MAGLEV specific items were not included, since this information is unavailable. All of the cost predictions are in 1986 dollars and are not adjusted. The model is run for a 100 vehicle fleet and 2 test vehicles. The labor rates are shown below.

$$\text{Engineering Labor Rate} = \$59.10/hr$$

$$\begin{aligned}
\text{Tooling Labor Rate} &= \$60.70/hr \\
\text{Quality Control Labor Rate} &= \$55.40/hr \\
\text{Manufacturing labor Rate} &= \$50.10/hr
\end{aligned}$$

Vehicle cost modifiers can be applied to account for materials. The cost modifier is 1.0 for an aluminum structure and 1.1 for composite structures. The acquisition cost model resides in the same subroutine that calculates the life cycle cost. This can be seen in Appendix E. As was previously mentioned, parametric models have low sensitivity and cannot predict outside of the realm of the vehicles used for the database. This analysis will, therefore, neglect costs incurred by some of the detailed MAGLEV design geometries. Acquisition cost will vary little from design to design.