Chapter 5

Direct Operating Cost Model

The direct operating cost model calculates the direct operating costs as a function of the mission profile, vehicle gross weight, energy costs, and aerodynamic coefficients. Excluded are the costs associated with operating personnel, support infrastructure, charges on the guideway installation cost , maintenance, and terminal operations, since these costs are fixed with respect to changes in the vehicle shape design. Costs associated with longitudinal trim and guidance are also excluded. All of the assumed parameters involved in this model were taken from feasibility studies on MAGLEV vehicles [3] [6].

The operating cost model calculates the force required to levitate and propel the vehicle for the duration of its mission. The vehicle weight is provided by the structures model, and the aerodynamic coefficients are provided by the aerodynamics model. The required magnetic lift is the aerodynamic lift subtracted from the vehicle weight. The force to be put out by the magnets is this term divided by the $\cos 35^o$ since the magnets are angled to provide both lift and lateral guidance. The levitation power required is calculated as the product of the system current and voltage. The current is given as a function of levitation force in the final report of the government MAGLEV system assessment team [6]. The voltage is a constant. The power required to overcome the aerodynamic drag is the product of the drag force and the vehicle speed. This value is divided by the system efficiency which is nearly 1.0 for the linear synchronous motor and 0.82 for the converter station. Magnetic drag is not accounted for here, since it is small compared to aerodynamic drag at cruise speed [6]. Magnetic drag becomes predominate at lower speeds. The total power required is the combined power for propulsion, levitation, and auxiliary power. The auxiliary power is that for the superconducting magnets, cooling system, HVAC, and lighting. The total power is multiplied by the trip time to give the energy requirements for the trip. The energy costs are calculated using the consumption charges and demand charges used in the feasibility studies [3] [17] [27].

The vehicle mission profile is that of an 800 kilometer trip at $134\frac{m}{s}$ ($300mph$). There are no intermediate stops, and it is assumed that the vehicle travels at its cruise speed over the entire trip distance (no acceleration or deceleration). The system is operational 16 hours per day, 365 days per year. Fifty person vehicles are used with an average passenger load of 2000 per hour. The auxiliary power required is 85 kw and is constant over the entire speed range. The assumed electric charges are $\$0.05/kwh$. The assumed electric demand charges are $\$7.50/kw$ and are accrued monthly.

The inclusion of energy costs in the multidisciplinary conceptual and preliminary designs is important for several reasons. Analyzing technical performance may lead the designer to designs with lower energy consumption, although no consideration is given to the efficiency of the energy source. Herbst [64] cites an example pertaining to the comparison of MAGLEV vehicles to aircraft. A MAGLEV vehicle might require less energy to complete a similar mission as an aircraft although its energy source (Rankine cycle power plant) operates at a lower efficiency than the energy source for the aircraft (Brayton cycle engine). The use of operating cost as a figure of merit for these vehicle designs accounts for this efficiency and serves as a uniform measure for operating performance. As for the fixed operating costs which this model ignores, Deutsch [3] estimates the personnel and material costs to be $49 million per year and $48 million per year respectively. Deutsch also estimates the energy costs (variable) to be $172 million per year. This number is very close to the yearly energy costs calculated by this operating cost model for typical designs. The subroutine for the direct operating cost model can be found in Appendix E.