SYSTEM DYNAMICS APPLIED TO RAILROAD PLANNING

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Introduction

Since World War II, the market share of most railroads has been declining. Both passenger and freight traffic has been captured by competing modes of transportation. This trend now seems to have come to an end. Before the turn of this century, we may see a real comeback of railroad traffic.

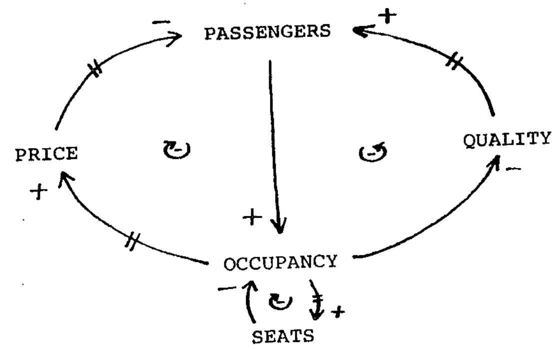
Several system dynamics models have been developed to study railroad performance. In 1979 the author was involved in a system dynamics modelling effort at Pugh-Roberts Associates to study track-caused accidents for the United States Transportation System Center. In 1980 the author developed a system dynamics model for Consolidated Rail Corporation in the US to study policies which can lead to self-sustainability for the railroad. This model was presented at the 1981 System Dynamics Research Conference in Renselaerville.

In 1981 a preliminary system dynamics model was developed for the Norwegian State Railways to study passenger and freight traffic for the complete network. In addition, a particular model was developed to study commuter traffic in Oslo. This paper describes modelling work done for the Norwegian State Railways (NSB).

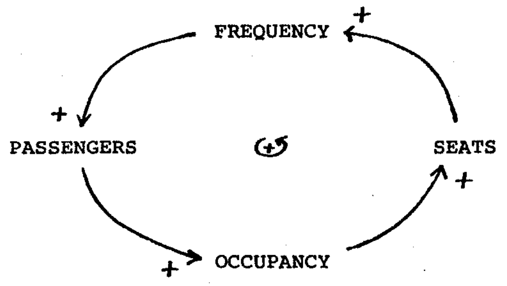
Model

Key variables in the transportation sector are price, travel time and quality. Price is determined by competition, operating costs and Government subsidies. Travel time is determined by track and equipment condition. Quality is determined by train frequency and occupancy.

The variable occupancy represents the ratio between number of passengers and number of seats for passenger traffic. It is part of several feedback loops. First, increasing occupancy reduces the quality which causes reductions in traffic, which in turn reduces occupancy. Second, increasing occupancy causes prices to go up, which causes reductions in traffic which in turn reduces occupancy. Finally, increasing occupancy causes investments in equipment to go up, thereby reducing occupancy. These feedback loops are shown below.



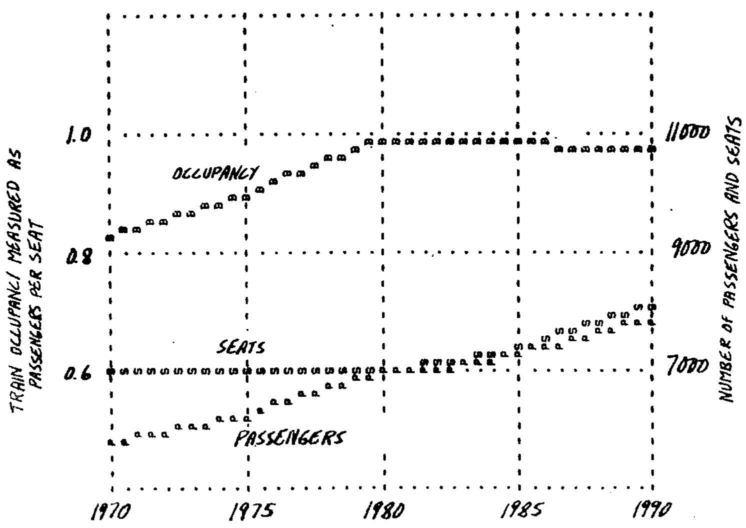
All loops shown in the figure above are negative feedback loops. As an example of a positive feedback loop in the model developed for the Norwegian State Railways, some variables relating train frequency to occupancy are shown on the next page. This loop can trigger growth. Increased train occupancy causes investments in equipment to go up (i.e. seats), leading to increased train frequency. Higher train frequency attracts more passengers, thereby increasing train occupancy.



Results

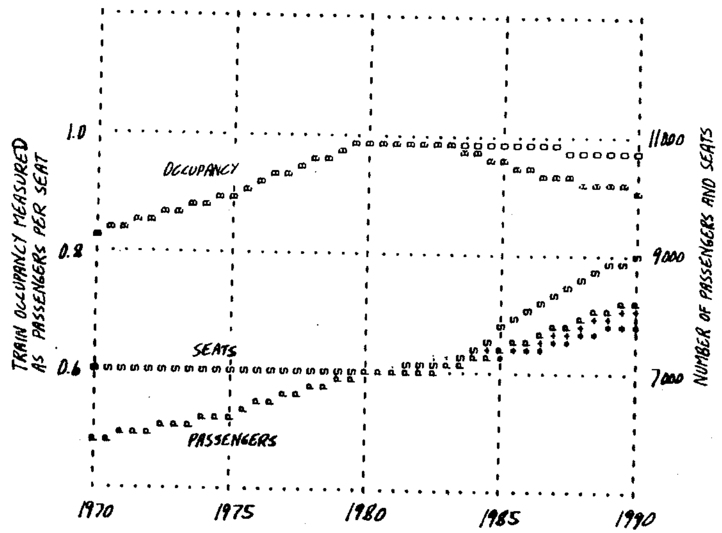
As mentioned in the introduction, a particular model was developed to study commuter traffic in Oslo. Simulation results based on this model will be presented here.

The base run is shown below. Historical behavior from 1970 to 1980 is roughly reproduced by the model. In that decade, the number of seats remained constant. The number of passengers, however, rose steadily, causing occupancy to go up. The numerical value - 7000 passengers in 1980 - represents the number of passengers travelling from the town of Lillestrøm to the city of Oslo in the morning between 6AM and 9AM.



From 1980 to 1990, the model predicts a steeper rise in the number of seats than in the number of passengers, causing occupancy to go down. The reason for this behavior can be seen in the negative feedback loop presented earlier relating occupancy to seats. Increasing occupancy in the 1970s caused a rise in investment backlog. After a delay of some years, the Norwegian State Railways ordered new equipment. After another delay of some years, the equipment was delivered and put into operation.

NSB is interested in reducing the occupancy faster than in the base simulation. One way of achieving this goal is to increase the lifetime of existing equipment. This requires extensive maintenance, but it can be done. In the simulation run shown below, it is assumed that only 10 percent of the planned scrapping of existing equipment is implemented from 1980 to 1990. A faster growth in the supply of seats is achieved, causing occupancy to drop quicker.



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