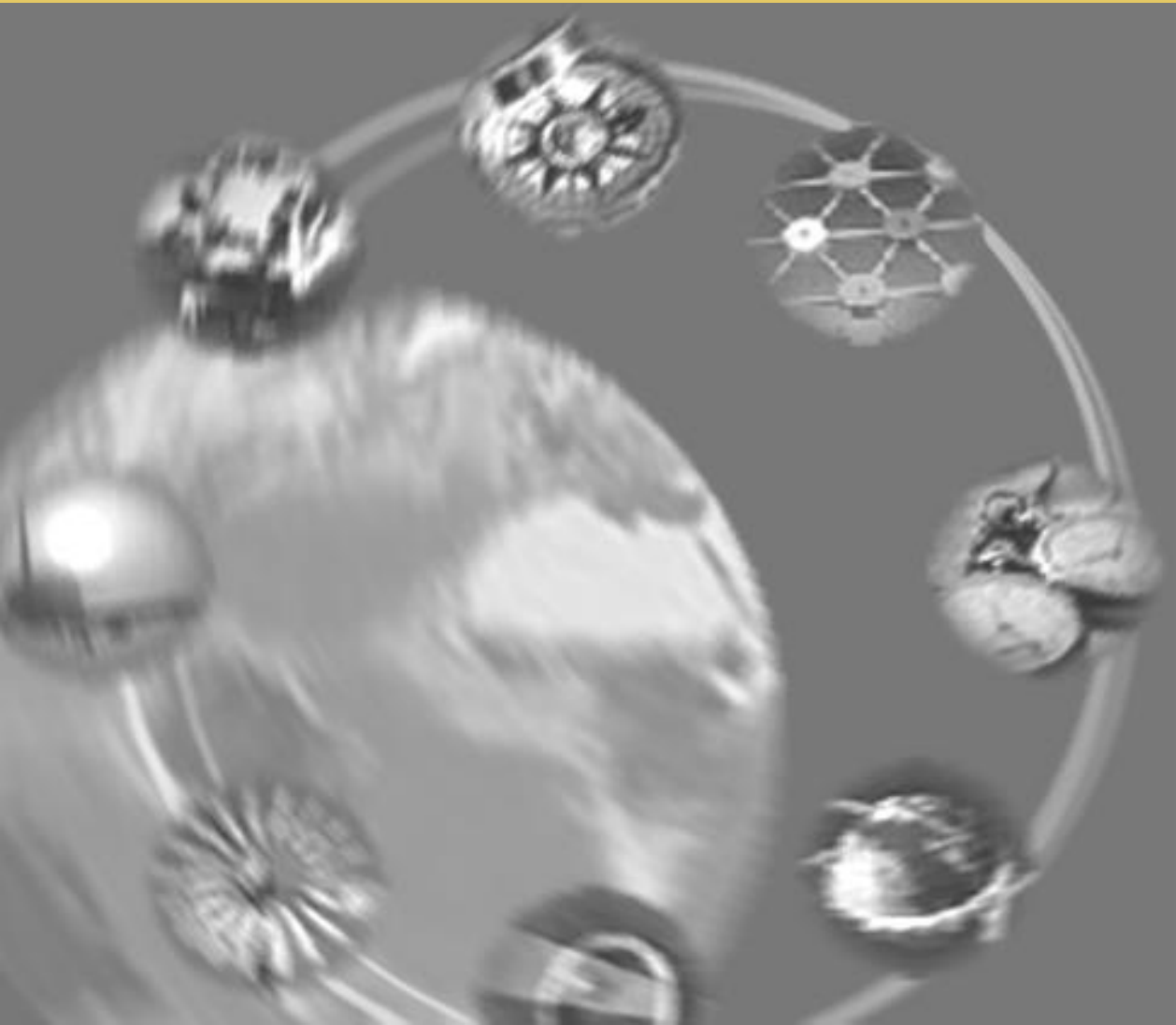
Pay or not to pay

Modelling Process

401.661 Advanced Construction Technology



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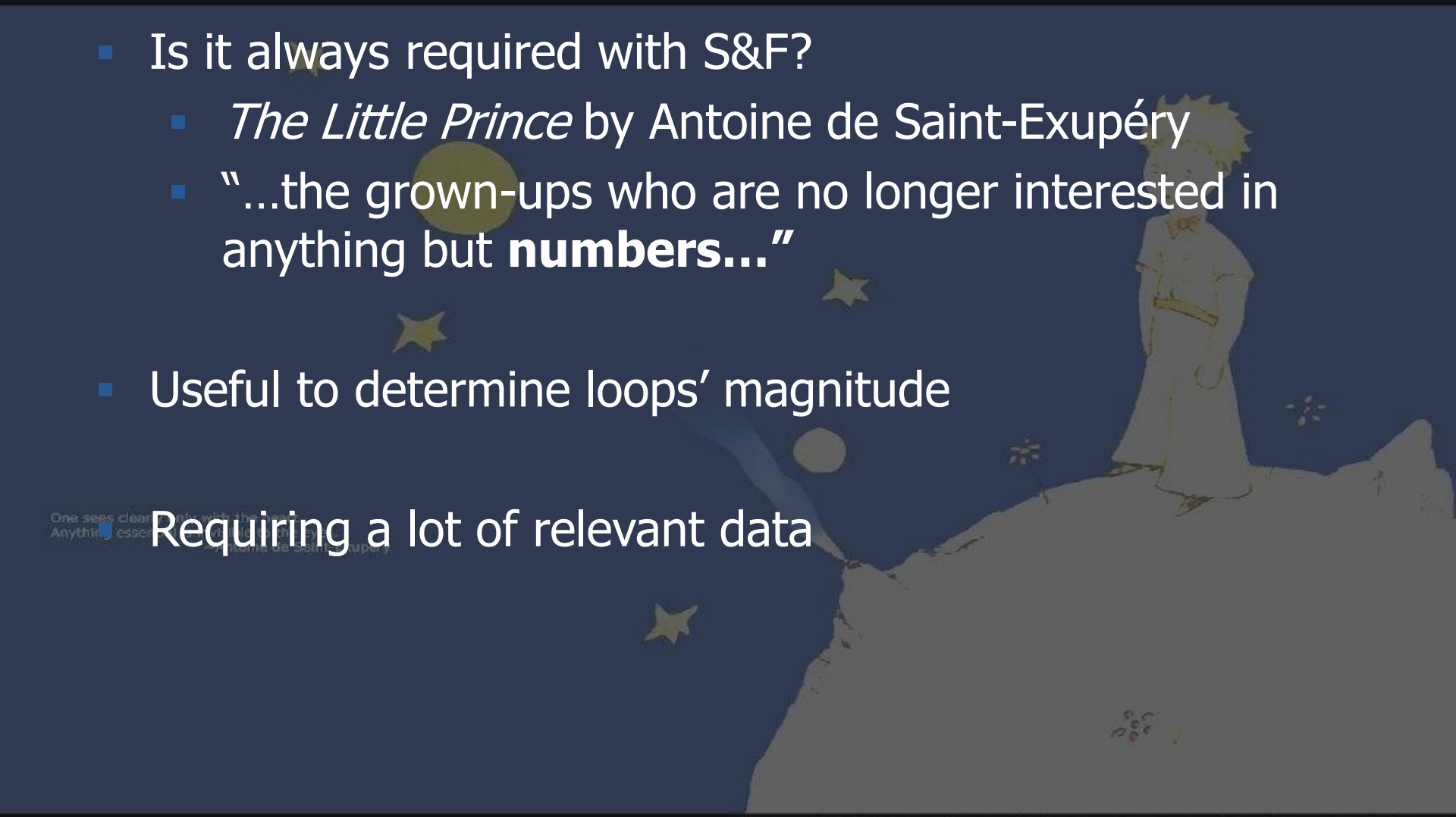
Model Quantification

- Is it always required with S&F?
  - *The Little Prince* by Antoine de Saint-Exupéry
  - "…the grown-ups who are no longer interested in anything but **numbers…**"
- Useful to determine loops' magnitude
- Requiring a lot of relevant data

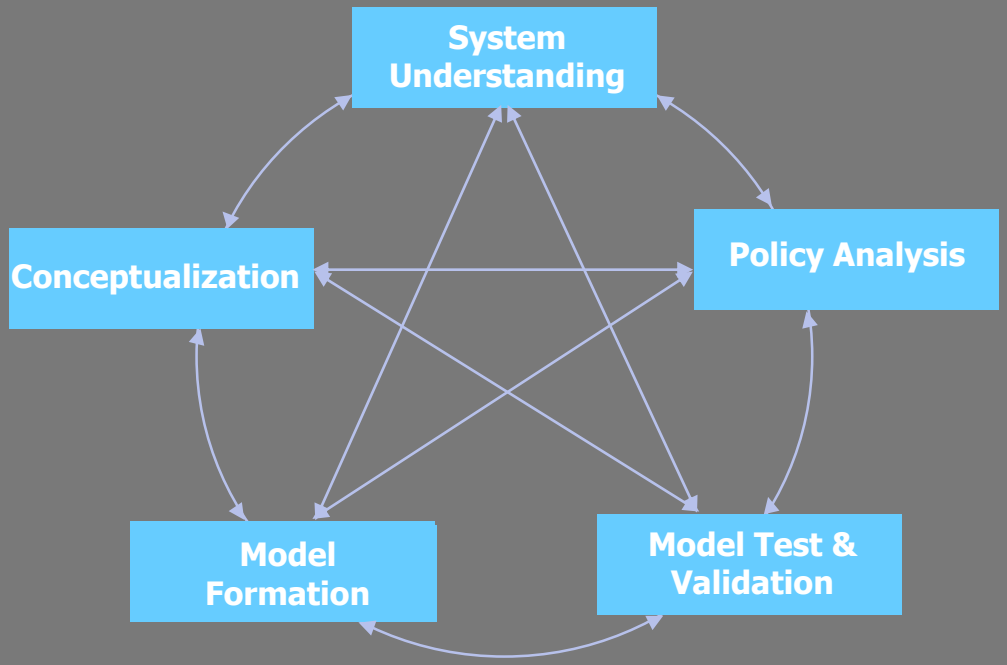


Lecture Outline

- Typical Modeling Method
- Background of the Case Project
- Dynamic Modeling Process

Modeling Process

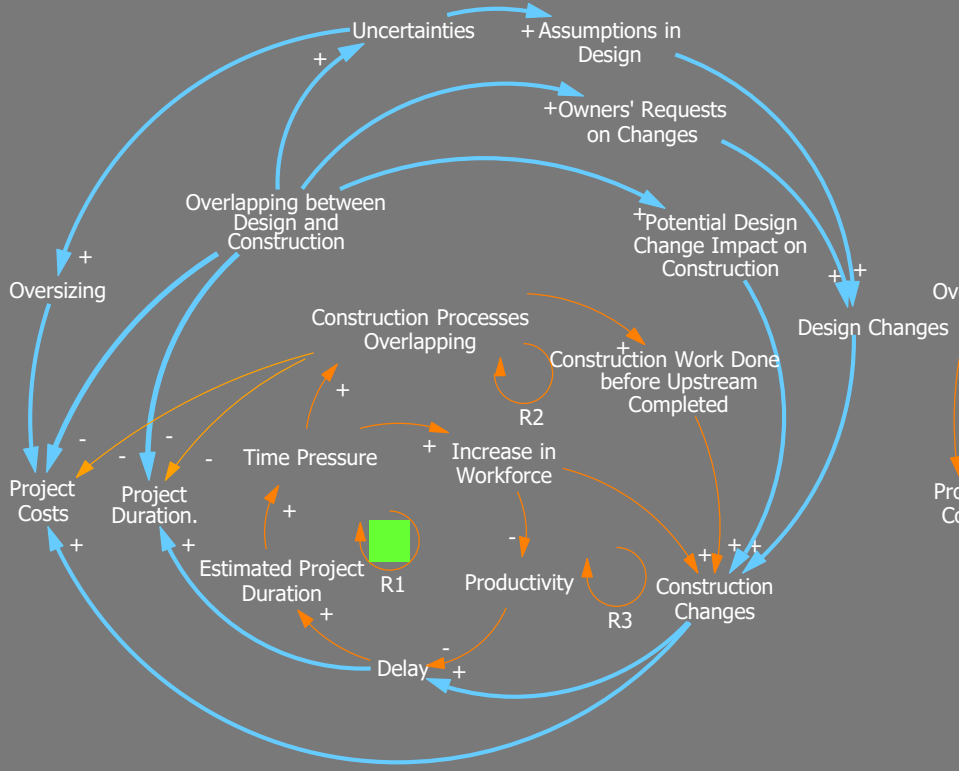
- Learning can happen across ALL stages of modeling.
- Involving continuous iterations among the modeling steps.



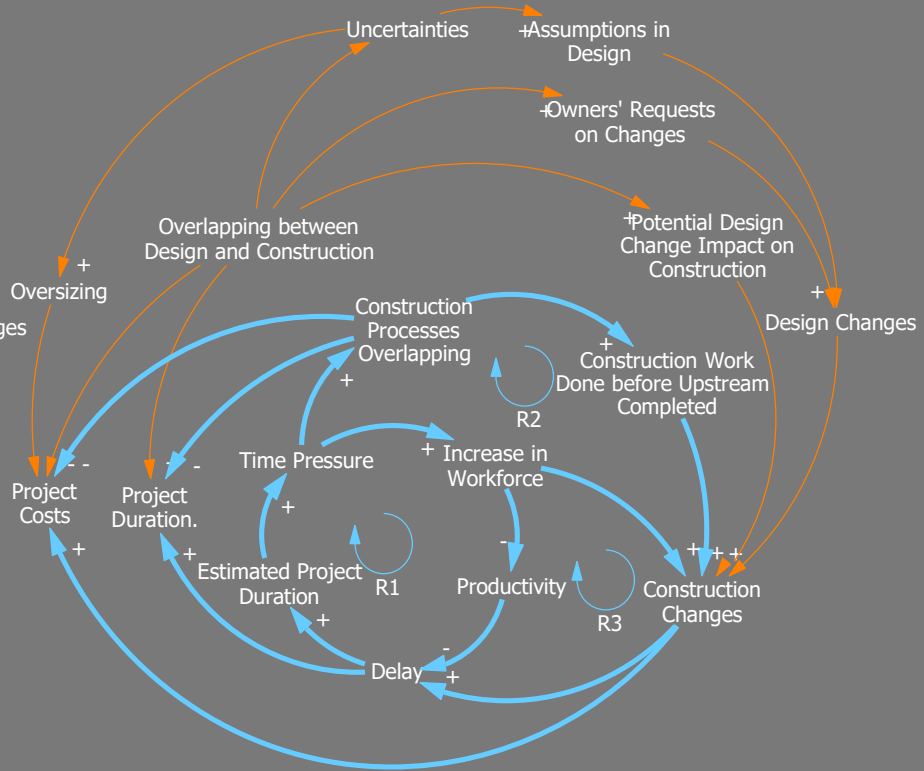
- System Understanding: the process of deepening the modeler's understanding of the system with relevant information, usually including problem statement, list of variables, and reference modes

- Conceptualization: conceptual model structures are described in the form of a causal loop diagram to show the dynamics of variables involved in the system (also, called dynamic hypotheses)

Examples of Causal Loop Diagram



Design-Driven Feedbacks



Construction-Driven Feedbacks

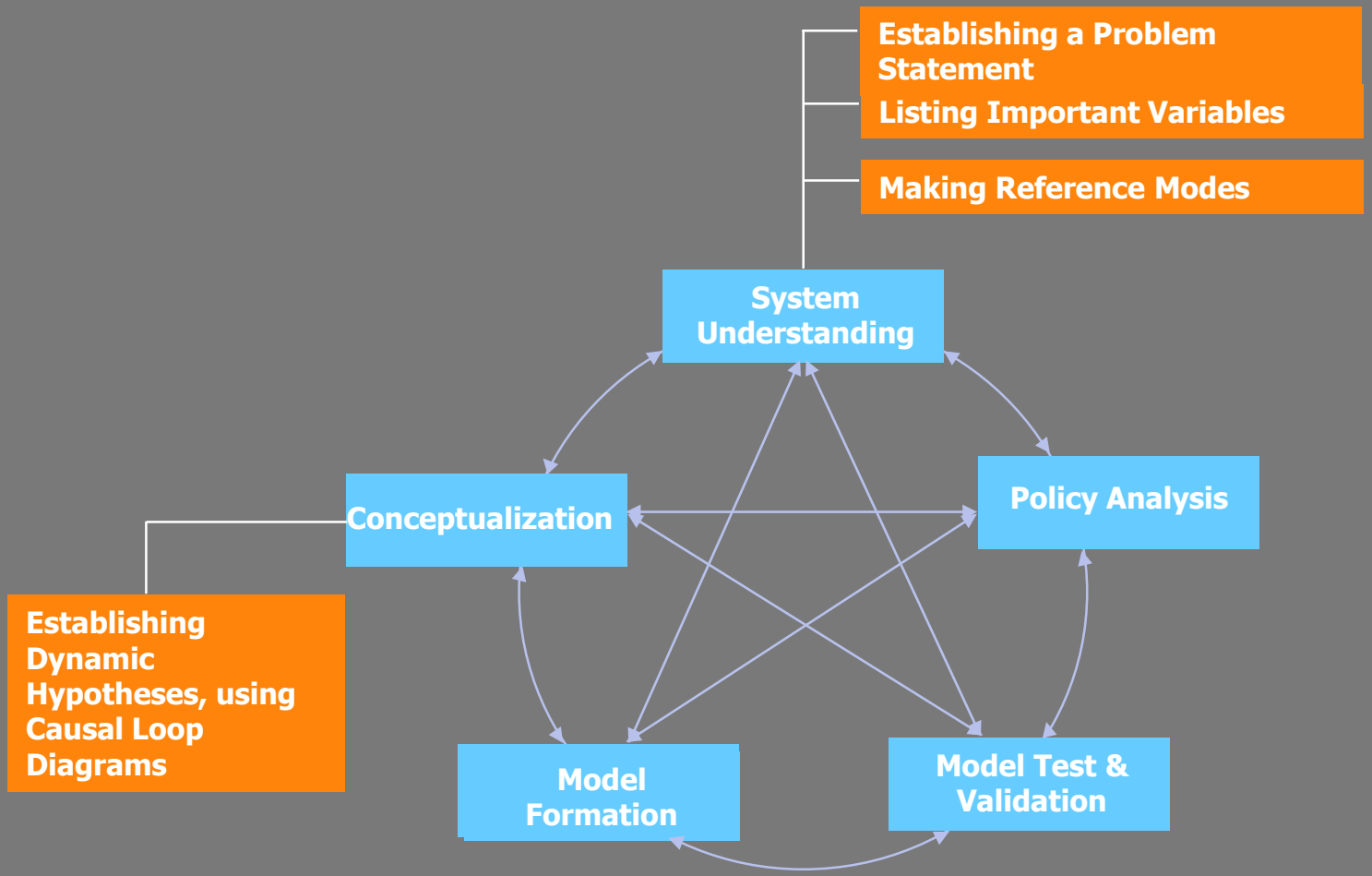
- Model Formation: having a causal loop constructed, variables in the model structures come to have quantitative attributes through building mathematical equations for variables.

This step also includes the identification of stock and flow structures, which characterize the state of the system and generate the information, upon which decisions and actions are based, by giving the system inertia and memory [Sterman, 2000]

- Model Validation: tested and validated in accordance with the purpose of the modeling

- Policy Analysis: the validated model is applied to solving the given problems

One Typical Modeling Method is ...



Lecture Outline

- ✓ Typical Modeling Method
- ➢ Background of the Case Project
- ➢ Dynamic Modeling Process

Background of the Case Project

Strategic Decisions for Highway Operation

"A construction company has recently completed their highway construction project, which has been awarded with a BOT contract".

"The highway runs from City A to City B in a more direct way than the existing road, and has service facilities for drivers".

"A discounted cash flow analysis shows some numbers for toll charges that can return their investment within the operation period".

"However, the top management of the company won't believe the numbers, thinking that highway operation might not be a simple mathematics".

"According to their experience, drivers choose a drive road depending on cost-convenience tradeoffs, having the following two options:"

- A highway with a lot of services and toll
- An old road without services

"Because of such a recognition, the top management wants to understand dynamics caused by drivers' tendency in choosing a drive road and to know how to maximize their profits, while keeping an acceptable level of service".

Lecture Outline

- ✓ Typical Modeling Method
- ✓ Background of the Case Project
- ➢ Dynamic Modeling Process

Problem Statements

- Figuring out the dynamics involved in highway operations including tradeoffs among toll charges, service level, volume of traffic, and congestion level.

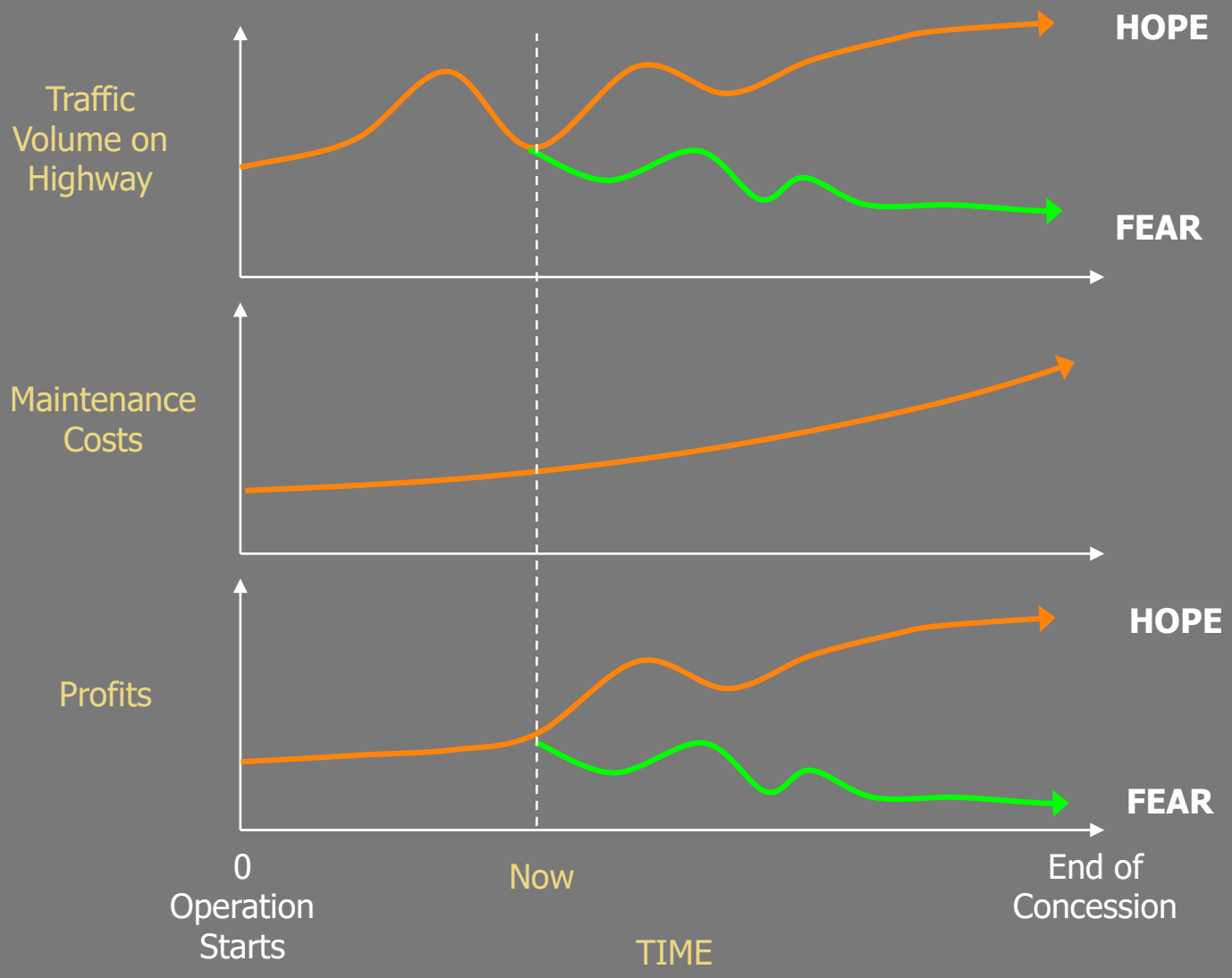
- Finding an optimal level of toll charges and maintenance costs, which can maximize their profits, keeping an acceptable level of service.

List of Variables

- Toll Charges
- Highway Capacity
- Travel Time
- Traffic Volume
- Service Quality
- Trip Frequency
- Road Attractiveness
- Degree of Congestion
- Time Reduction through Highway
- GDP*
- Population*
- Price of Gasoline per Mile*

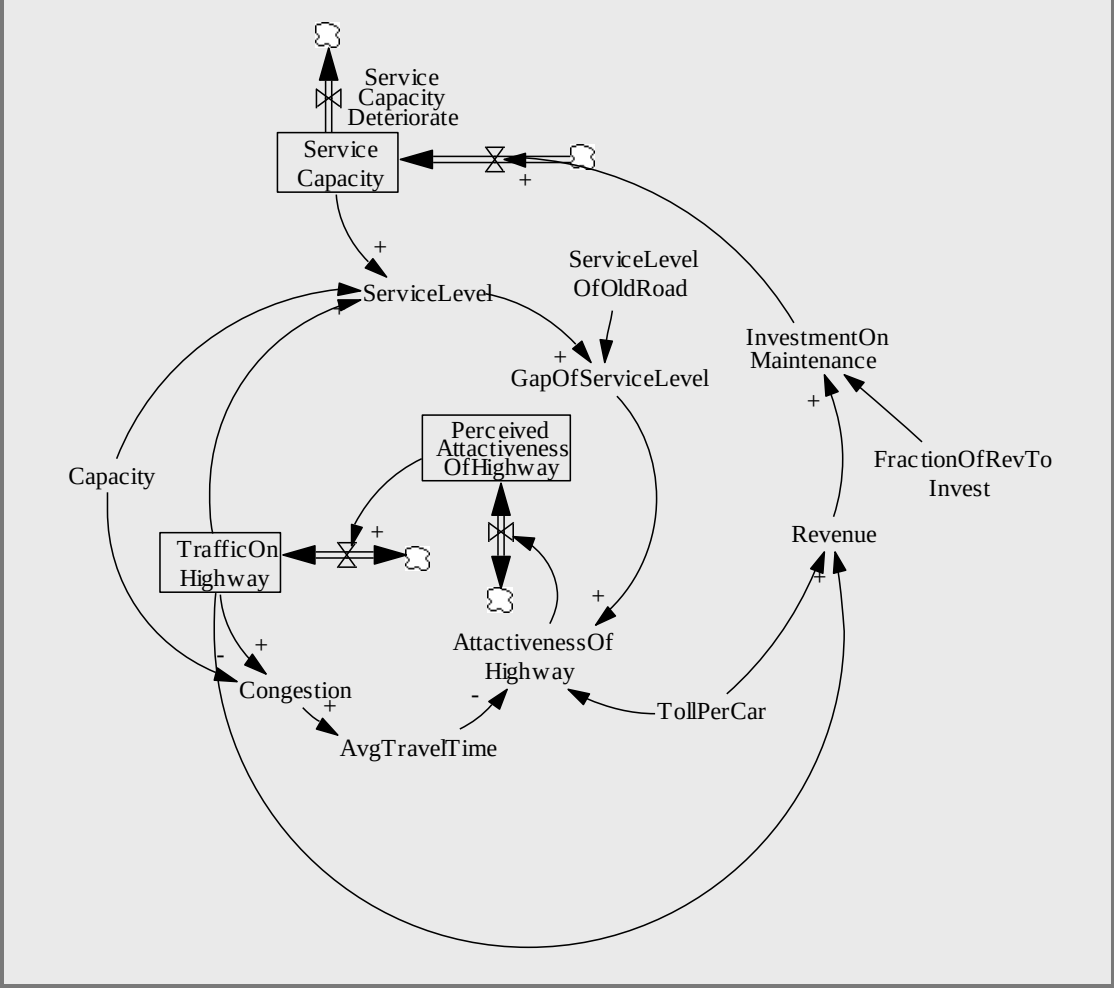
*Exogenous Variables

Reference Mode



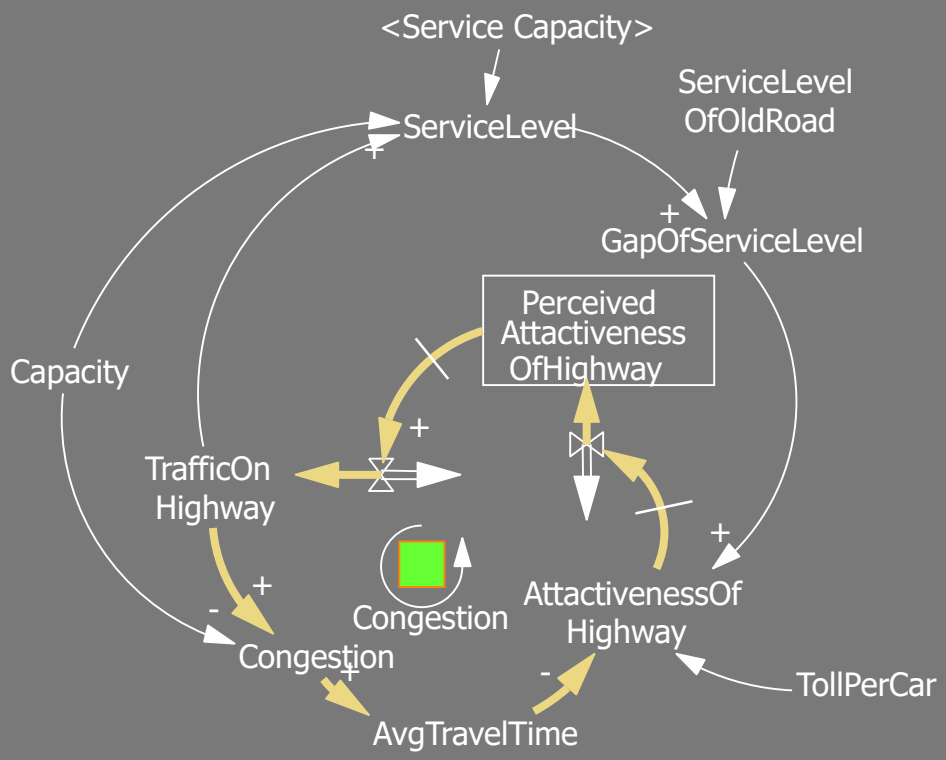
Dynamic Hypotheses

The Spaghetti



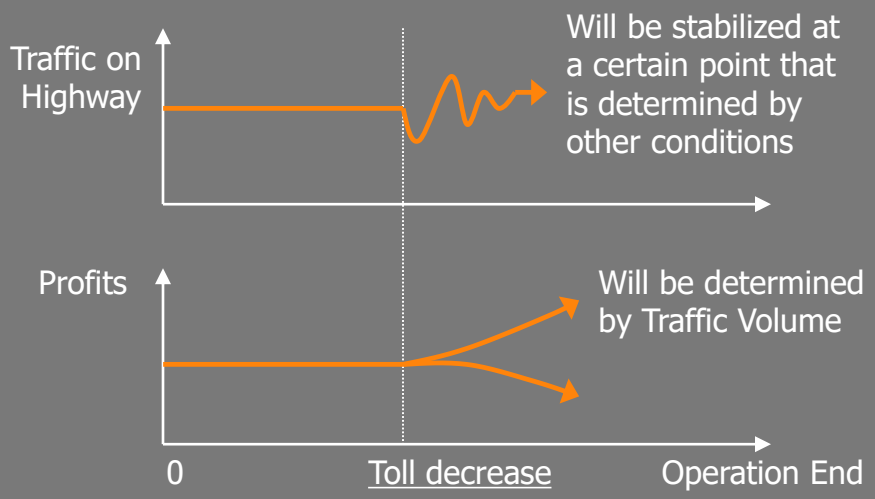
For the first stage of the development, one needs to analyze feedback loops that have the most significant impacts on the system and established dynamic hypotheses of them.

Congestion

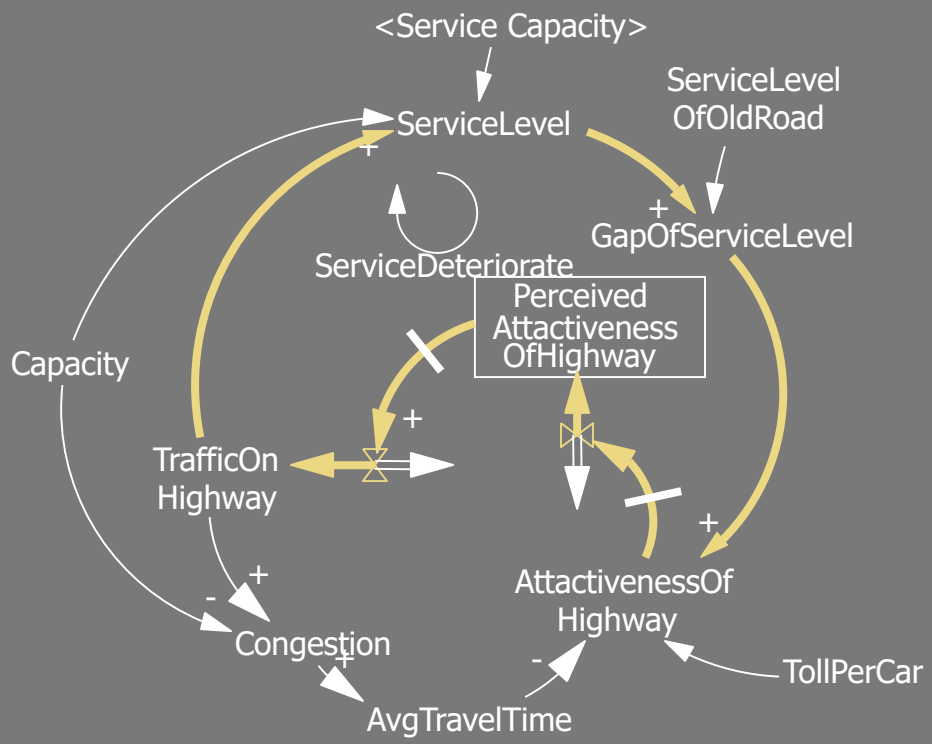


If toll becomes cheaper, traffic goes up, congestion becomes more, and drivers have a higher average travel time. That affects negatively on the Attractiveness of Highway with the consequent reduction in traffic.

The following hypotheses on the system's behaviors are established when toll is decreased.



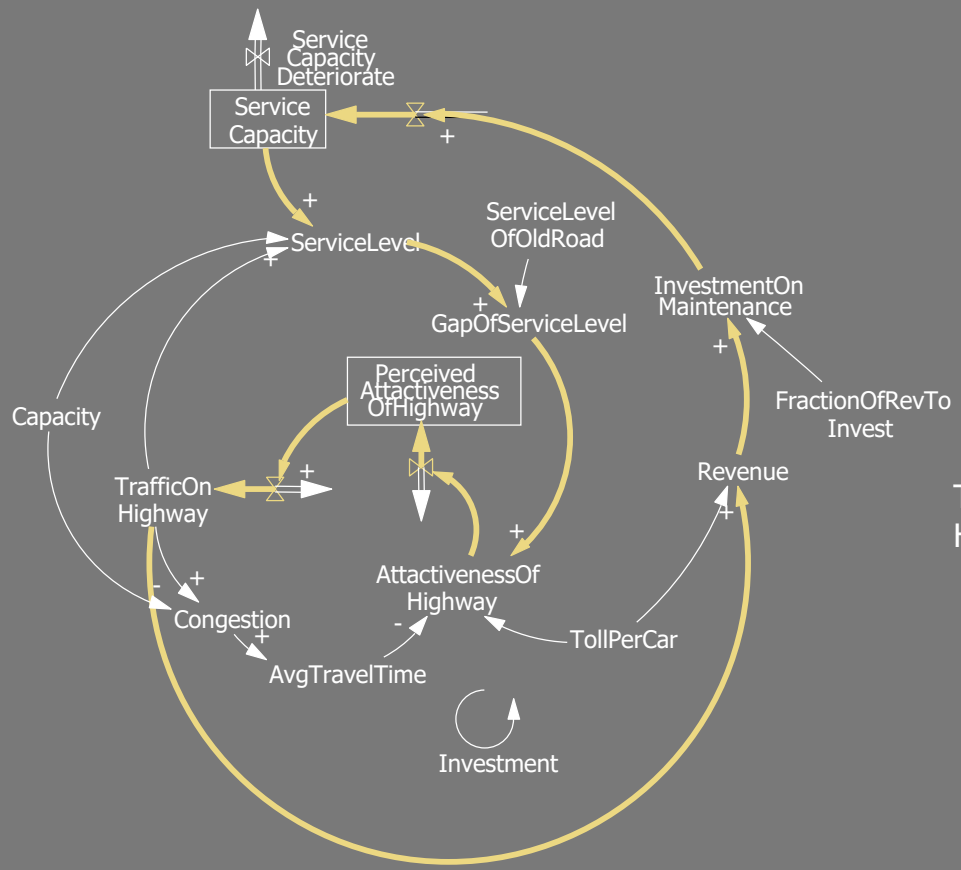
Service



The attractiveness of the Highway with respect to the service level depends on both the service on highway and in the alternative route. As an increase in traffic deteriorate the Highway's service level and in turn its attractiveness.

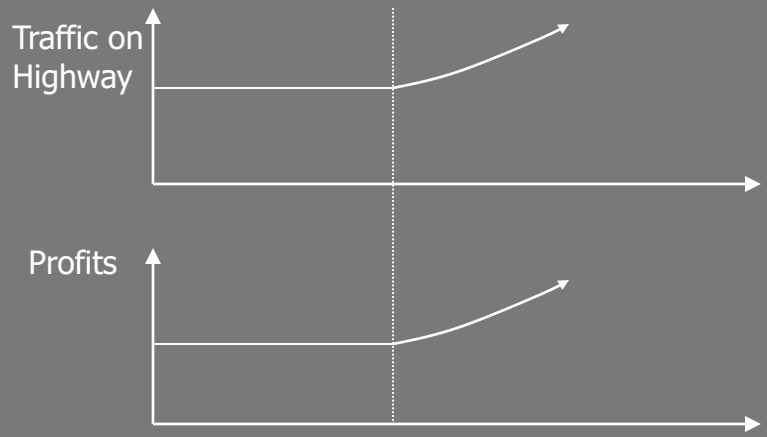
The same hypotheses on the system's behaviors as Congestion Loop are established when toll is decreased.

Investment

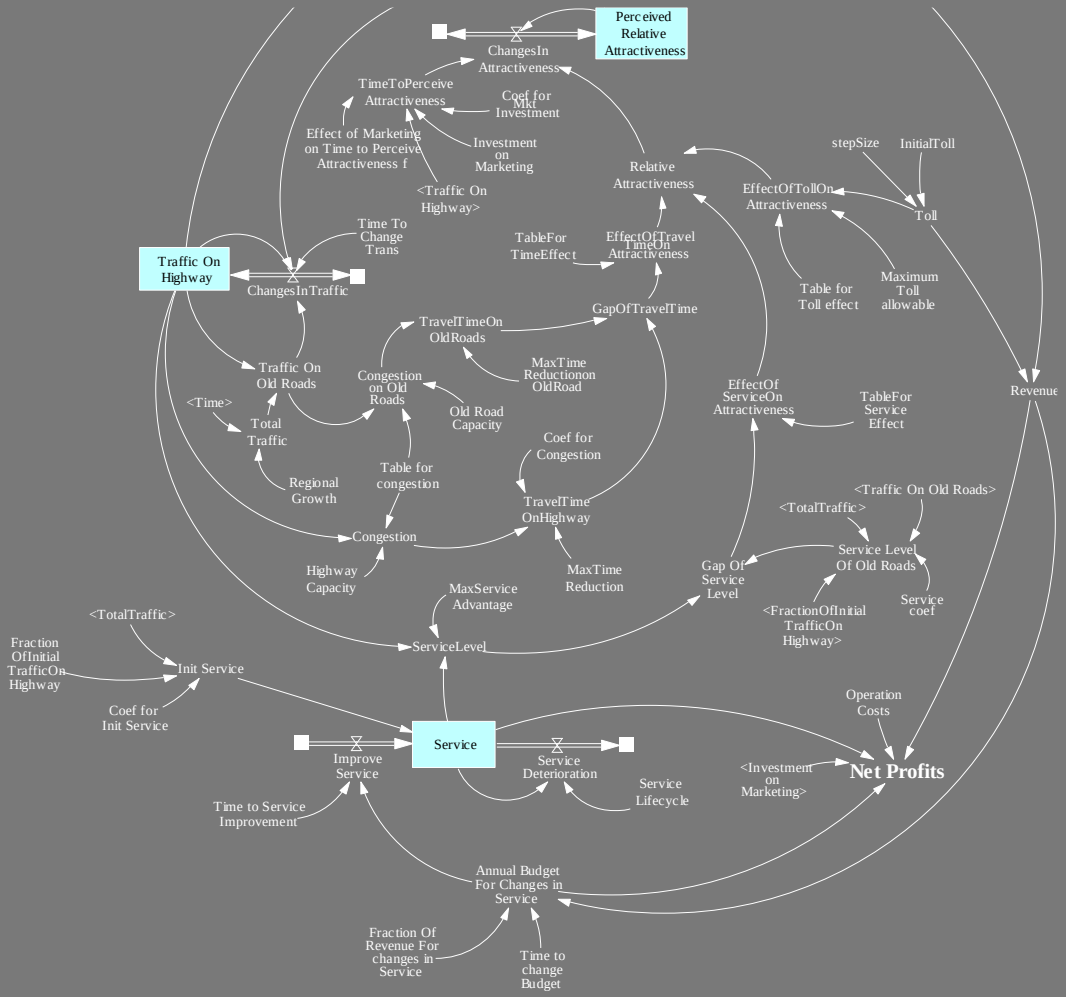


As traffic goes up, the company can spend more money on services. And better services increase the attractiveness of the highway.

The following hypotheses on the system's behaviors are established when fraction of revenue for investment on the service capacity is increased.

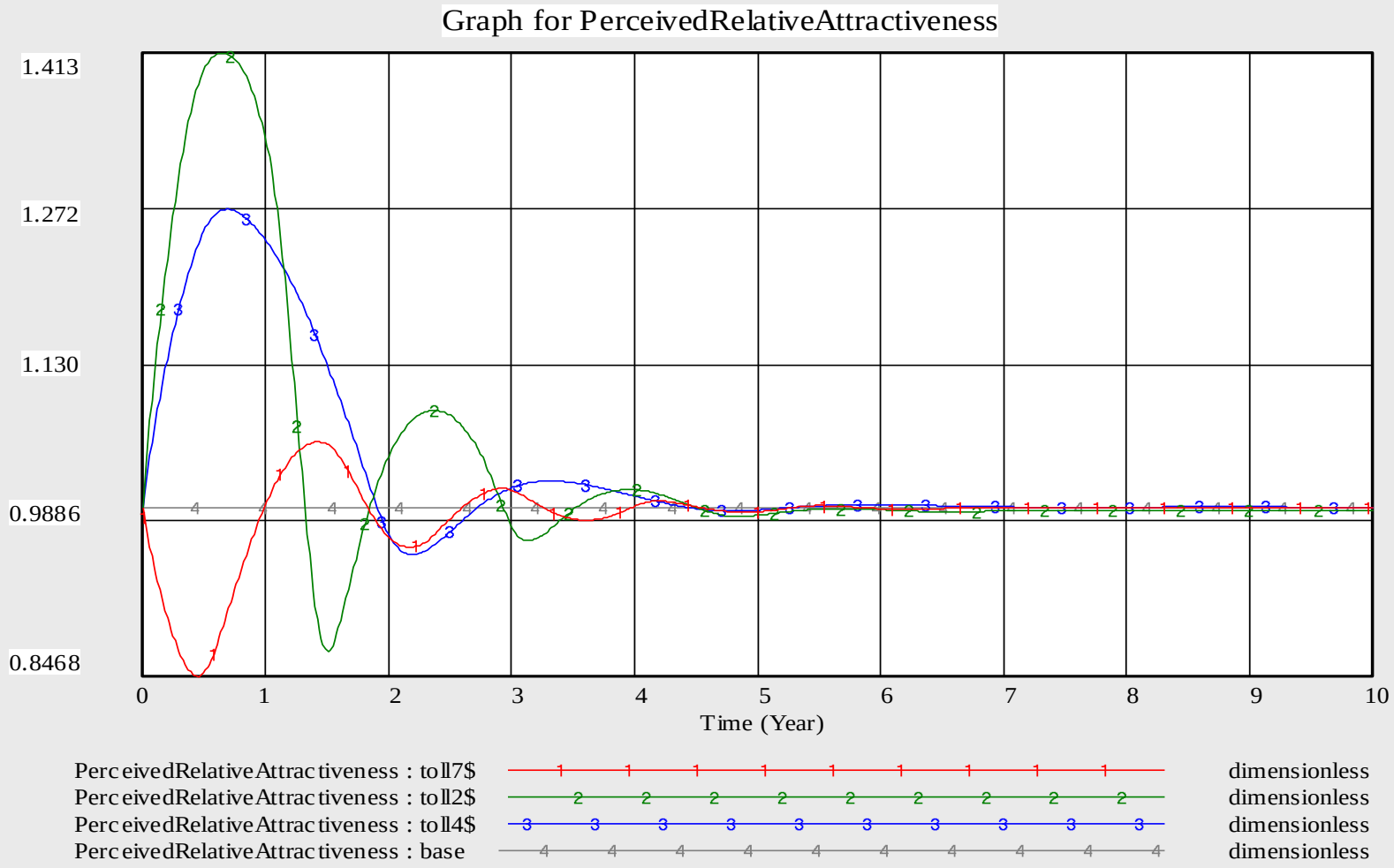


Model Formation



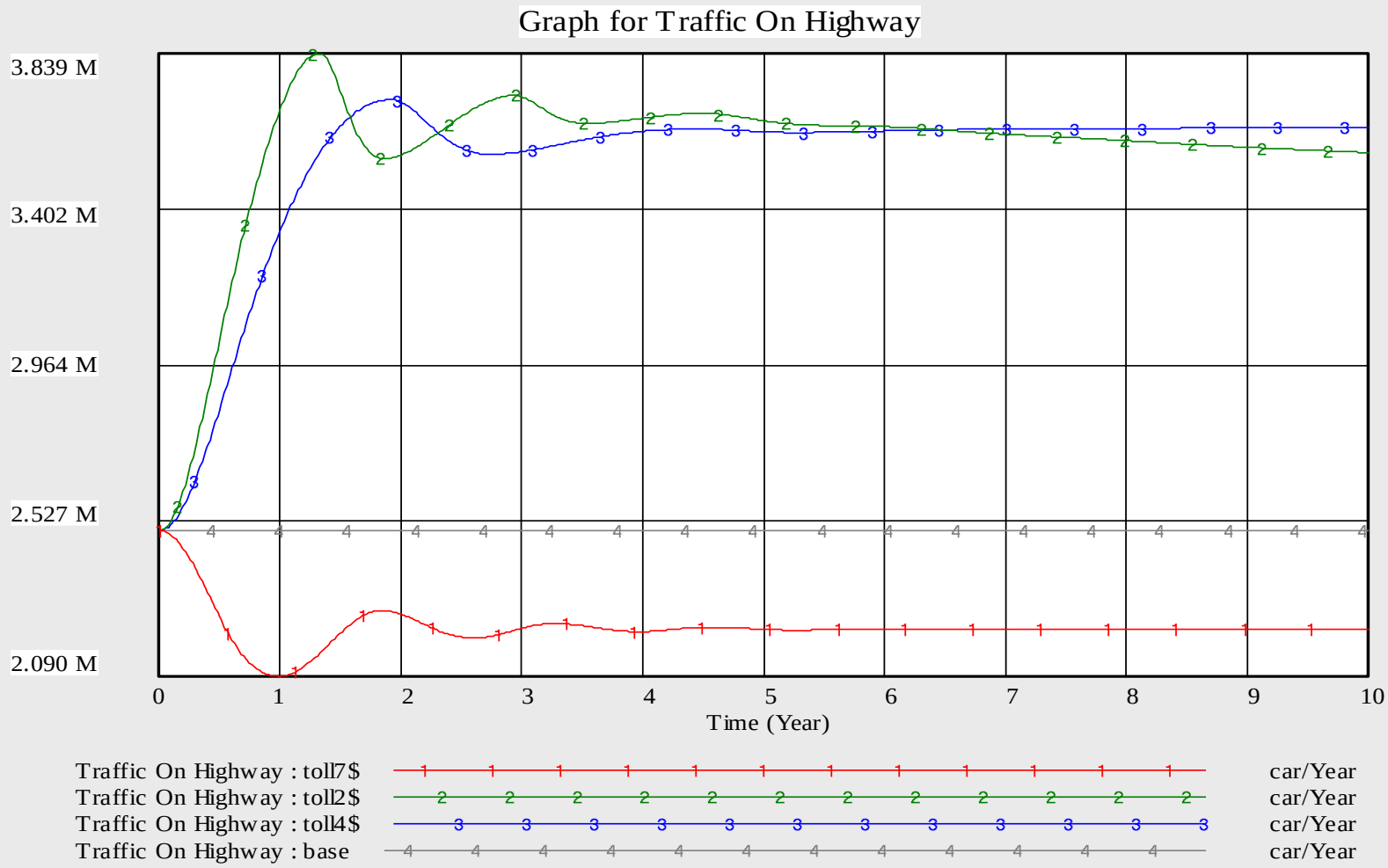
Model Analysis

Toll Impact



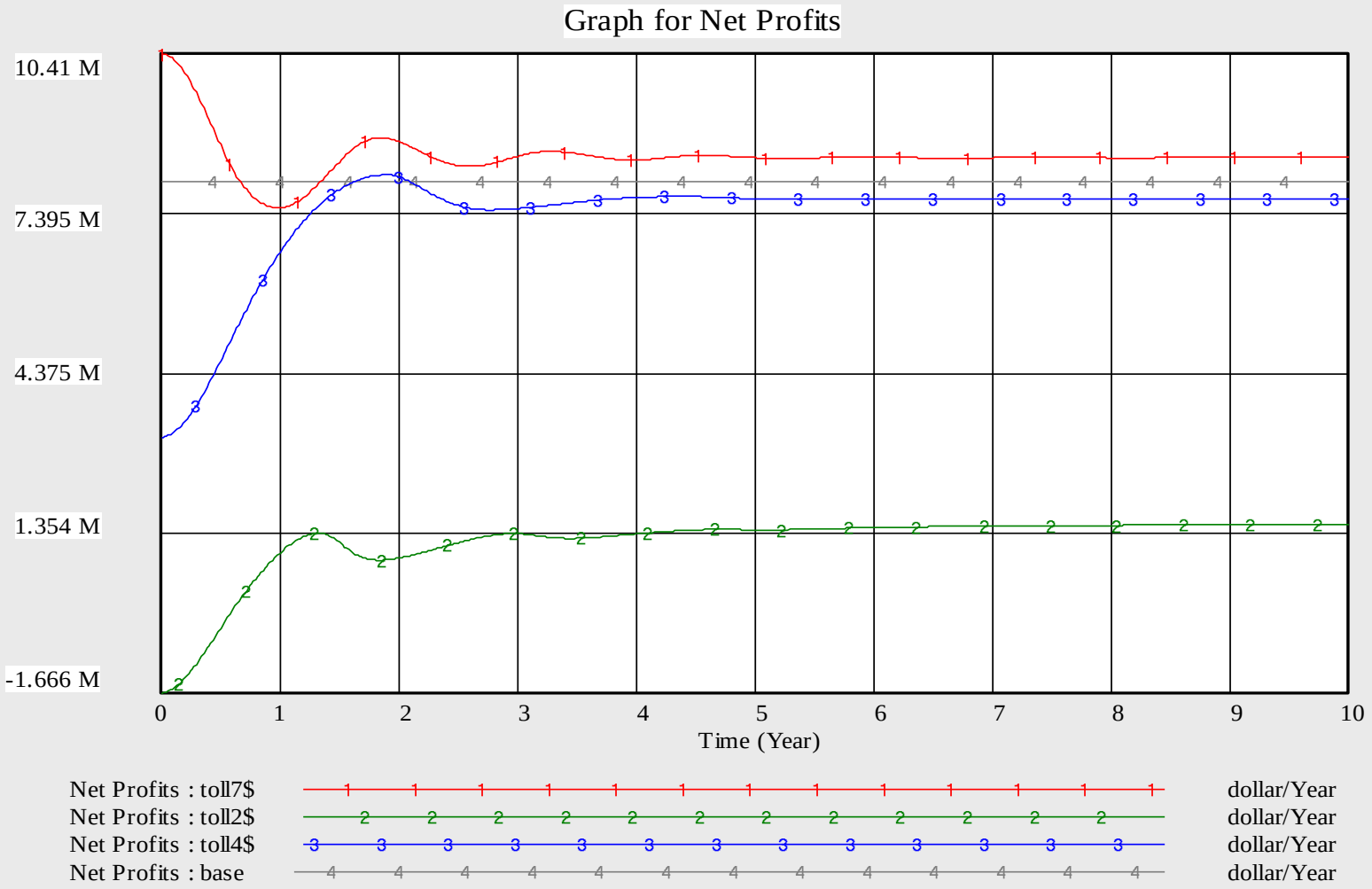
Model Analysis

Toll Impact



Model Analysis

Toll Impact



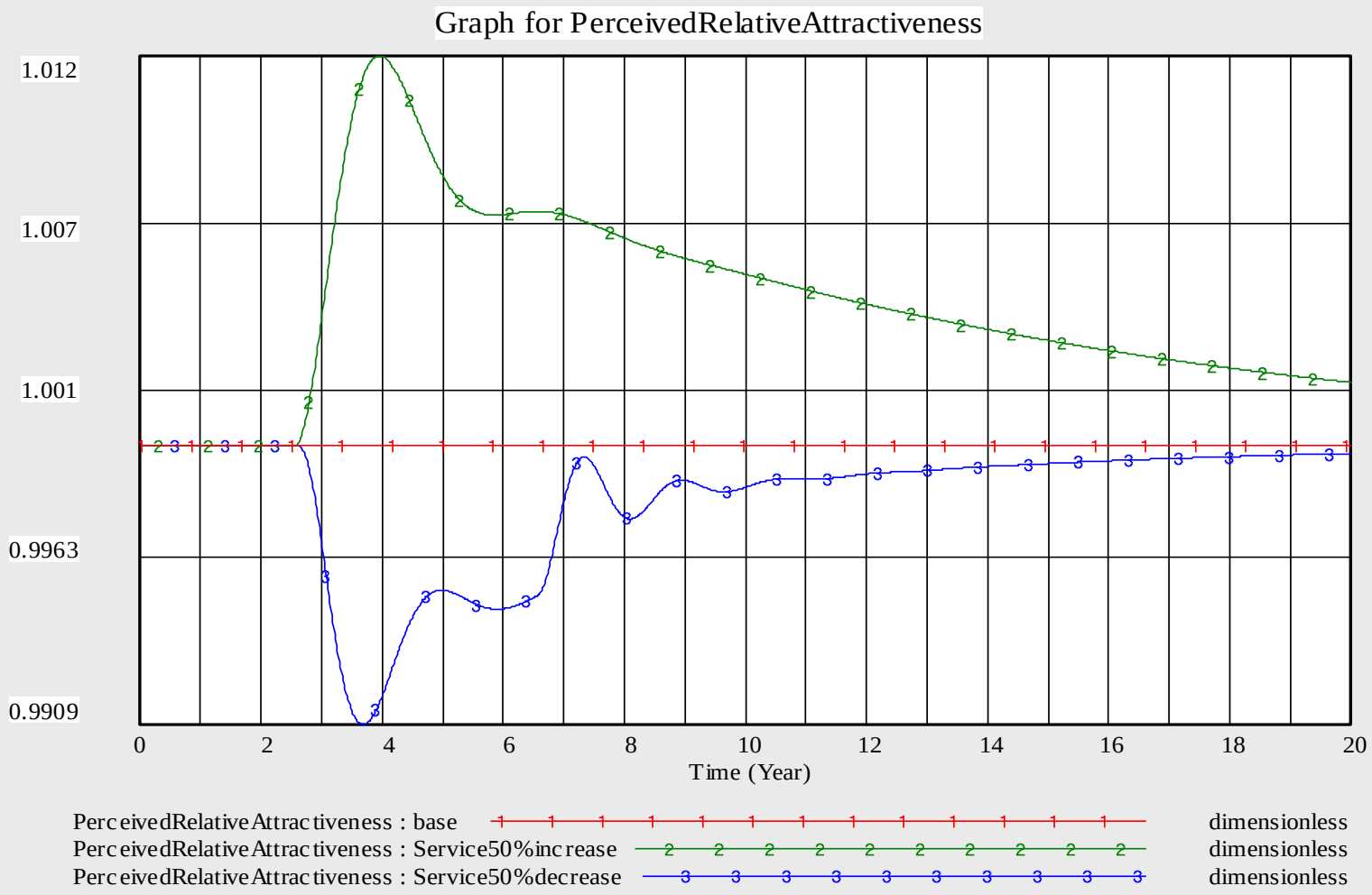
Policy Implications

- While the relative attractiveness always becomes stabilized at the initial equilibrium point, the traffic volume becomes stabilized at the point where there are no more changes in the attractiveness.

- Net profit from the highway operation may not be proportional either to toll amount or to traffic volume.

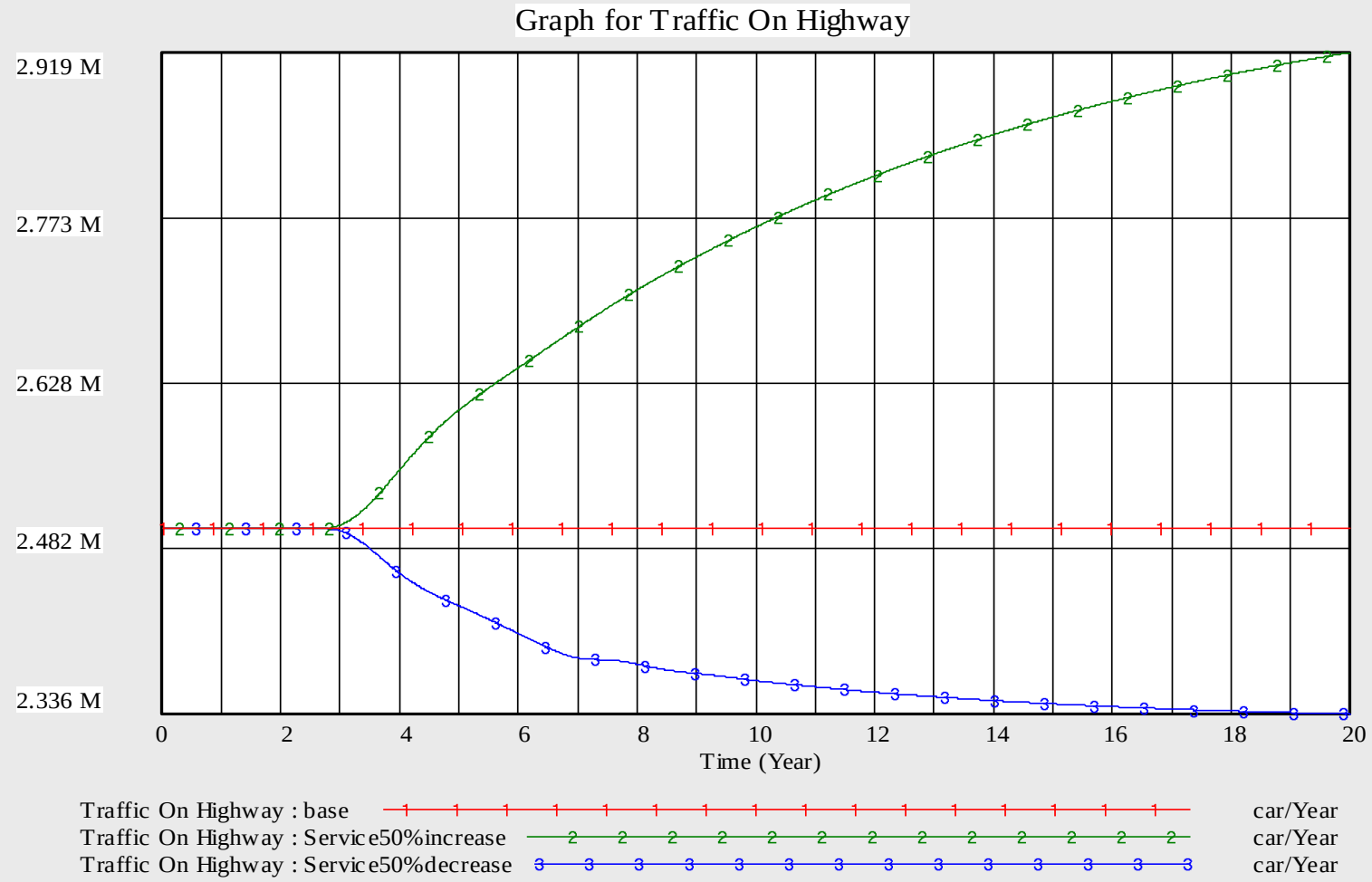
Model Analysis

Investment on Service



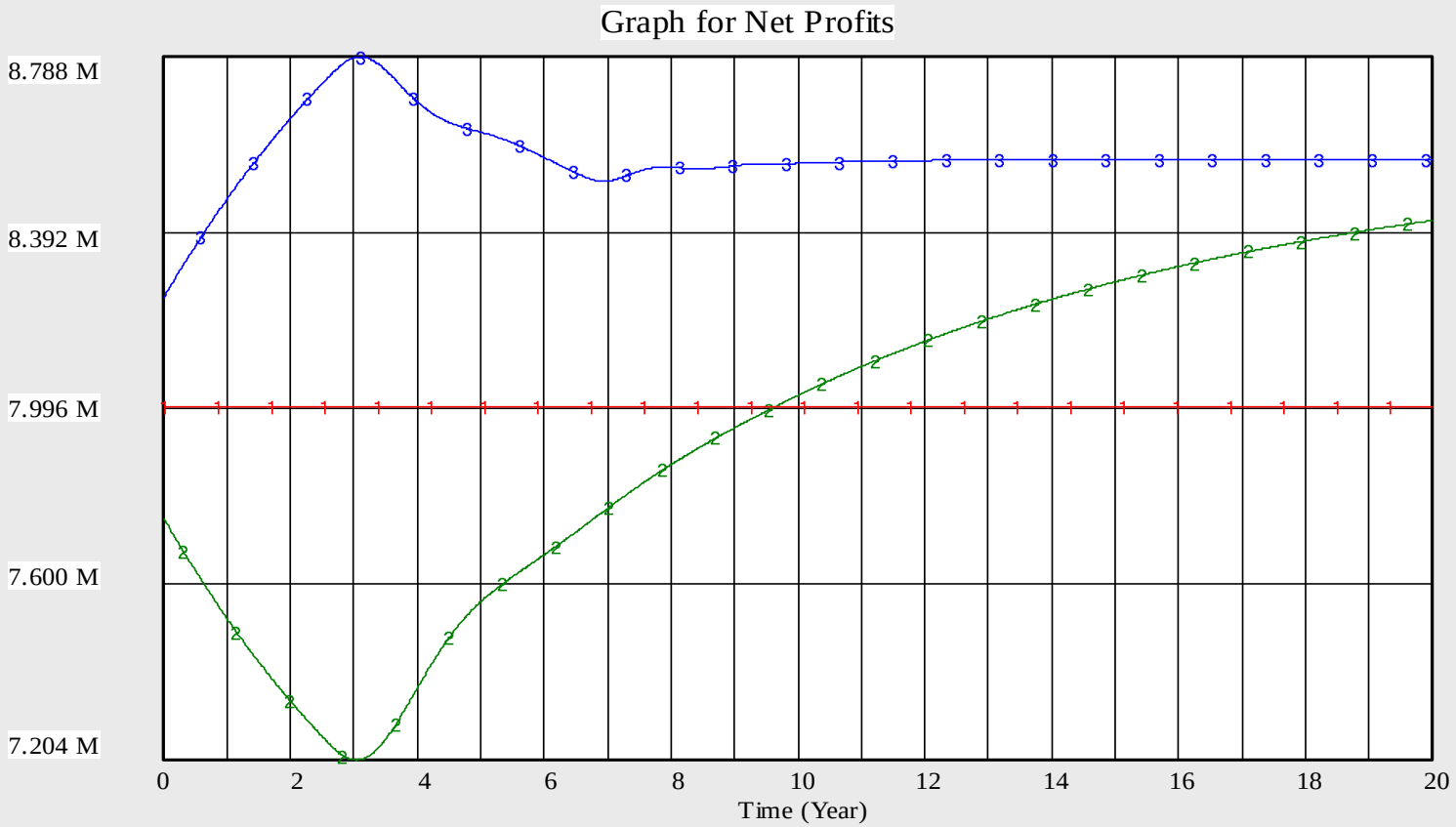
Model Analysis

Investment on Service



Model Analysis

Investment on Service



Policy Implications

- Investment on the service capacity can increase traffic volume and lowers annual net profits.

- However, the system also becomes stabilized, which implies that the long run, we can get almost same annual net profits regardless of the investment amount on service.

Policy Recommendations

- Set initial toll price a little bit higher than that of equilibrium case (say 7$ per car)
- Set the investment amount on service lower than that of equilibrium case (say 50% decrease)
- Invest on marketing for the initial period of operation (say the first 1.5 years)

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Term Project

Towards the world best consulting firm

Criteria for Consulting topics

- Problem
  - System understating: who are (Main) players?
  - At which level (industry, corporate, individual etc)?
  - To whom?
  - To be specific
  - Avoid physical or financial systems (this can be feasible only with a quantitative model)

- Tradeoff
  - Unexpected behaviors (sometimes side effects) caused by remedial actions, together with expected behaviors.
  - What did client do for solving the problem? This can be hints for finding tradeoffs
  - If feedbacks are involved, it would be super.
  - Problems and tradeoffs should have the same dimensions (to whom, at which level, type of behaviors)

    e.g., In S's call taxi model, government's policy to easy people's inconvenience worsened people's inconvenience.