Understanding the Dynamic Effects of Lightweight Materials in Cars

Key Features of the Dynamical Model
Investigate/understand how the various impacts of a material change over time in order to determine the optimal material.

Variables
- Cost of material
- Availability of material
- Embodied energy of material
- Ecological impacts (various) of material
- Recyclability of material
- Mass of material, which dictates:
  - Car fuel consumption/emissions
  - Opportunities for innovation in other car components
- Market appeal of car
- Rate of diffusion of new innovations

Dynamical effects
- Lightweight materials leading opportunities to use efficient energy technologies
- Technology diffusion
- Market supply and demand
- Rebound effects
- ‘Limits to growth’ of material/energy availability

Research Challenge
Investigate/understand how the various environmental and economic impacts of a material change over time in order to determine the optimal material.

Focus on the Australian context, but the process should be adaptable in the international context.

Proposed Solution
Use a system dynamics approach to:
- investigate how changes in the social-environmental system affect material selection
- investigate the impact of using various materials for vehicle components
- suggest the optimal material(s) to use for vehicle components

Case study: Car
Focus on alternatives to conventional steel.

Methodology
1. Investigate system dynamics and materials science
   - Verify that a system dynamics approach is appropriate
   - Investigate materials that can potentially be used for vehicles
2. Develop a dynamical model
   - Identify the key variables that influence materials performance
   - Identify the key dynamical effects (feedbacks and accumulations) that determine system behaviour
   - Determine that appropriate range of values that each variable can take
3. Test the dynamical model
   - Ensure that the model exhibits realistic behaviour

Expected Outcomes
- A list of the most beneficial materials, or
- A set of scenarios for which certain materials are most beneficial

Industry relevance
The outcomes can inform decisions in the Australian automotive industry regarding research and development into new materials applications.

Introduction
The primary material in cars is steel, which is dense and requires a lot of fuel to move.

Materials composition of vehicles
- Mostly sent to landfill
- Mostly recycled

Static Analysis vs Dynamic Analysis
Materials selection for components based on near- and long-term impacts:
- Linear assessment: static, snapshot
- System dynamics: dynamically complex, non-linear

Eg. Ecological impact
Production → Operation → End of life

Expected Outcomes
- Cars made from virgin material
- Cars made from recycled material
- Cars retired

Recycled material

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