The Future of Transportation Networks and Their Financing

David Levinson
University of Minnesota
Department of Civil Engineering

The Need for Speed

Speed (km per hour)

S-Curves (Japan)

Gaps: Speed in Context

The Rise and Fall of Technologies (US)

Strategies for Maturity

- Tune products to markets and specialize
- Manage demand and supply
- Shun standardized one-size-fits-all but still try to achieve economies of scale
- Avoid risky high capital cost projects: Exploit cash cows and fat cows, reinvest profits in new technologies
Profits?

• Question: Roads aren’t profitable, are they?
• Answer: They could be, we charge (approximately) enough to cover costs of construction and maintenance of major roads through the gas tax. We could charge more through tolls or gas taxes.
• We dedicate some gas tax to transit.
• We could do the same by increasing revenue and using it for new modes ...
• But what should we invest in?

How to Prosper in the Coming Collapse of the Gas Tax

• The rising price of gasoline along with environmental regulations is increasing the adoption of alternative fuels and engines.
  - Hybrid Gas/Electric Cars
  - Ethanol
  - Ultimately Hydrogen Power

The Collapse ...

• Less Gasoline purchased implies less gas tax revenue.
• To maintain revenue, governments raise gas tax rate
• This increases switch away from gasoline.
• It is a vicious circle

We Could Charge More

• Before we ask for more money though, we should have an effective way of using it.
• We need to understand facilities before we can decide what is effective.

Different Roads Warrant Different Financing

Limited Access Roads: Principal Arterials
Linking Roads: Minor Arterials
Locals: Residential Street Rural Roads

Local Roads

• Owned and operated by most local units of governments (homeowners associations, townships, cities, counties)
• Serve land access to and from those residences
• Are unused (underused) almost all of the time
• In economic jargon: Excludable but non-Rivalrous ... “Club goods”. Initial construction paid by landowners (developers) and deeded to local government
• Operations and maintenance paid for with an “access” charge, much like a club. E.g. property tax, road utility fee
**Local Roads ... Future**

- We have had local roads since the beginning of history and will continue to do so until universal adoption of flying cars (and trucks, and bicycles, etc.) make them obsolete.
- In short, we will continue to have local roads for a long time.
- There is no “crisis” in the funding of local roads, the property tax, (or impact fees, or transportation utility fees) will continue into the future.

---

**Linking Roads**

(Collectors, Minor Arterials)

- Owned and operated by local or state governments
- Connect local roads with each other and with limited access roads
- Are sometimes congested, suffer delay at intersections
- Often less congested than before the interstate.
- In economic jargon: non-Excludable but Rivalrous ... “Congestion goods”
- Initial construction paid by local or state government
- Operations and maintenance paid for with a mix of gas taxes and access charges (property taxes)

---

**A Strategy for Linking Roads**

- Area or Cordon charging
- Demonstrated to reduce congestion
- Popular in London, being considered elsewhere.
- Collection costs are high, and will be until transponders or other technologies are ubiquitous

---

**Limited Access Roads**

(Principal Arterials, Freeways)

- Owned and operated by higher units of governments (states)
- Serve movement between places
- Are fairly well used and many suffer congestion when unpriced
- In economic jargon: Excludable and Rivalrous ... “Private goods”
- Initial construction typically paid by federal government (90/10) and deeded to states or by states themselves (or by turnpike authority in some cases)
- Operations and maintenance generally paid for with a per-use gas tax a weak form of user fee that does not affect time-of-day of use (or by a toll)

---

**Beyond Maturity**

- Senility
  - More “free” pavement
  - More congestion
  - More pollution
  - More energy consumption
  - More of the same
- Rebirth
  - Systems for reliability
  - Systems with flexibility
  - Systems with adaptability
  - Systems with affordability

---

**Limited Access Roads ... Rebirth**

- The limited access freeway system is mature, the interstates are built out, very few additional center-line miles of new roads will be built

- Apply strategies for maturity
- Breakout
**Strategies for Maturity?**

**Differenitiated Level of Service**
- Most goods we consume give us choices between "good, but cheap", "better, but costlier", and "best, but expensive" alternatives, just witness the “Wall of toothpaste” at a large supermarket.

**Differentiation by Value**
- There are proposals for a new and reliable layer of tolled limited access roads (HOT Networks) that will be faster than untolled freeways and guarantee point-to-point travel times (much like Federal Express guarantees overnight delivery), allowing those with a high value of time to buy their way out of congestion.

  **Costs**
  - Lose economies of scale
  - Higher construction costs
  - Lose "equality" — "we are all in this together"

  **Benefits**
  - Gives users choices
  - While the rich can buy themselves out of congestion, in fact everyone is in a hurry sometimes.
  - Improves efficiency
  - Increases system revenue

**One Path to Differentiation**
- Underutilized High Occupancy Vehicle (HOV) Lanes -> High Occupancy/Toll (HOT) Lanes
- Connected HOT Lanes -> HOT Networks (transponder become common if not ubiquitous)
- Infill the network to add capacity in other congested areas.
- Convert existing general purpose capacity from "free" to "toll", though the tolls need not be as high as on premium HOT networks.

**Differentiation by Type**
- A second differentiation strategy is separate truck and automobile highways (Just as high-speed rail separates passengers from slower freight trains).

  **Costs**
  - New right of way
  - New construction

  **Benefits**
  - Specialization (car-only roads are cheaper to build, can have steeper grades, and require less pavement)
  - Safety - minimizes car-truck crashes, which are much more dangerous

**Breakout?**
Vehicles/Infrastructure Interaction

Trains
- Tracks steer trains
- Centralized Intelligence in infrastructure
- Each track committed to one train, with one origin and one destination
- Limited flexibility
- Potentially high capacity

Cars
- Cars steer themselves
- Decentralized Intelligence in vehicle (we hope)
- Each road section has many cars, with different origins and destinations
- High flexibility
- Limited capacity

One vision of the future hopes to get best of both worlds

That vision failed
- Classic chicken and egg problem
  - no one would buy special vehicles without a network of special roads.
  - no organization would build special roads without a fleet of special vehicles
- There is no deployment path
- The vision succeeded from a technology standpoint, but failed from an economic one

Smart Vehicles ... "Dumb" Roads
- Is a promising development path -> solves problems of transportation disadvantaged and safety, not by itself congestion
- Must be led by vehicle manufacturers
- Enables vehicles to drive themselves in mixed traffic
  - Already can follow (Adaptive cruise control) (Note: Cruise control was introduced in 1958 Chrysler Imperial, stay within lanes, parallel park. Harder tasks include lane changing
- Assisted by infrastructure (e.g. magnets where there are lane markings, signs that provide information in form vehicles can grasp, GPS), but the vehicle technology cannot depend on the infrastructure

The Next Revolutionary Mode
- Revolutionary modes allow us to do not only the same things faster or better, but allow us to do new things.
- Turnpikes -> Canals -> Railroads -> Automobiles -> Airplanes ->
- Some contenders include Information/Communications Technologies (ICT), Intelligent Transportation Systems (ITS), and other Three-Letter Acronyms (TLA).
- Still, it is unclear what the next mode will be, but history suggests we are overdue

Joining Hard & Soft

Hard Transportation
- Vehicles
- Infrastructure

Soft Transportation
- Operations
- Policies
- Finances

Transportation
- Vehicles
- Infrastructure

Transportationism

Soft Hard Transportation