Challenges for Transport Geography

CHAPTER 10

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Future Transportation Systems
The Prediction of Future Outcomes

Forecasting | Scenarios | Speculations

5 years | Major Project

Uncertainty

Predictability

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Common Flaws in Forecasting

A. Early stage forecasting (under-estimation)
B. Late stage forecasting (over-estimation)
C. “Return to normal” bias
Elements of Transport Technology

- Transport Technology
- Propulsion
- Vehicle
- Infrastructure
- Operations
Evolution of Transport Technology since the 18th Century

**Maritime**
- **1800:** Steam engine
- **1900:** ICE
- **1950:** Automation
  - Docks
  - Steamships
  - Iron hulls
  - Liners
  - Bulk ships
  - Supertankers
  - Containerships

**Road**
- **1800:** Omnibus
- **1900:** Automobiles
- **1950:** Electric cars
- **2000:** Self-driving vehicles
  - Surfed roads
  - Bicycles
  - Trucks
  - Highways

**Rail**
- **1800:** Steam Locomotives
- **1900:** Tramways
- **1950:** High speed rail
  - Subways
  - Tramways

**Air**
- **1800:** Balloons
- **1900:** Airships
- **1950:** Jet engines
- **2000:** Drones
  - Helicopters
  - Jet planes
  - Wide body jets
  - Supersonic jets
## Major Technological Improvements in Transportation, Second Half of the 20th Century

<table>
<thead>
<tr>
<th>Innovation</th>
<th>Characteristics</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superships (1960-)</td>
<td>Bulk and tank vessels with a mass up to half a million deadweight tons.</td>
<td>Reduce transport costs through massive economies of scale.</td>
</tr>
<tr>
<td>Container vessels (1968-)</td>
<td>Vessel specifically designed to carry containers.</td>
<td>Carry primarily manufactured goods with the capacity to interface with major land transport systems.</td>
</tr>
<tr>
<td>Jet aircraft (1958-)</td>
<td>Fast non-stop services between major urban centers.</td>
<td>Linked with the development of service activities such as banking, finance and tourism.</td>
</tr>
<tr>
<td>Fuel-efficient vehicles (1970-)</td>
<td>Reduction in fuel consumption due to lower weight and more efficient engines.</td>
<td>Enabled highway transport to increase its share of urban intercity transport.</td>
</tr>
<tr>
<td>High-speed trains (1964-)</td>
<td>Trains capable of moving at speed higher than 200 km/hr.</td>
<td>Effective competition between intercity air and road transport in high density areas.</td>
</tr>
</tbody>
</table>
Development of the UK Transport System, 1750-1990
Development of Operational Speed for Major Transport Modes, 1750-2010 (km per hour)
Operational Speed of Contemporary Transport Modes

- Air
- High Speed Train
- Containerships
- Poly. (Air)
Drivers of Change for Future Transportation

**Transport System**

- **Policy**
  - Governance
  - Security
  - Regulation / taxation

- **Finance**
  - Finance mechanisms
  - Pricing and returns
  - Public / private partnerships

- **Demography & Society**
  - Population growth
  - Aging / retirement
  - Urbanization
  - Changing work patterns

- **Economics**
  - Economic growth
  - Global trade
  - Economic integration
  - Transportation costs

- **Energy & Environment**
  - Energy availability
  - Alternative fuels
  - Climate change

- **Technology**
  - Information technologies
  - Materials technology
  - Engine technology
## General Impacts of Transport Innovations

<table>
<thead>
<tr>
<th>Field</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel time</td>
<td>Lower time and higher reliability</td>
</tr>
<tr>
<td>Trip planning</td>
<td>Easier to book and monitor</td>
</tr>
<tr>
<td>Environment</td>
<td>Less environmental impacts and noise</td>
</tr>
<tr>
<td>Energy</td>
<td>Lower energy consumption per unit carried</td>
</tr>
<tr>
<td>Assets</td>
<td>Higher level of utilization of modes and infrastructure</td>
</tr>
<tr>
<td>Safety</td>
<td>Reduced number of accidents, fatalities and injuries</td>
</tr>
<tr>
<td>Accessibility</td>
<td>Improved accessibility; reduced friction of distance</td>
</tr>
<tr>
<td>Cross-border</td>
<td>Improved throughput and security</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Longer life cycle, improved maintenance and reliability</td>
</tr>
<tr>
<td>Materials</td>
<td>New and recycled materials</td>
</tr>
<tr>
<td>Intermodal</td>
<td>Improved connections between modes</td>
</tr>
</tbody>
</table>

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Forces Shaping the Diffusion of Information and Communication Technologies in Transportation

Level of asset accumulation

Innovation

Competitive advantage

Information control

Path Dependency

Asymmetry

Internalization

Firm
## Potential of Some Transport Innovations

<table>
<thead>
<tr>
<th>Innovation</th>
<th>Perceived Benefits</th>
<th>Potential Beneficiaries</th>
<th>Cost Burden</th>
<th>Potential Supporters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Rail</td>
<td>Accessibility to CBD; Reduced emissions and energy used per pass. – km; Safety</td>
<td>New users; Developers; Landed interests along paths</td>
<td>Tax payers; Nearby residents</td>
<td>Transit industry; Drivers; Environmental groups; Passengers</td>
</tr>
<tr>
<td>Road Pricing</td>
<td>Reduced congestion and emissions</td>
<td>Drivers with high time value</td>
<td>Drivers</td>
<td>Environmental groups; Collecting institutions</td>
</tr>
<tr>
<td>Telecommuting</td>
<td>Reduced congestion and emissions; Time savings</td>
<td>Telecommuters; Commuters</td>
<td>Employers; Tax payers (if subsidized)</td>
<td>Environmental groups; IT industry; Commuters</td>
</tr>
<tr>
<td>Shared / on demand vehicles</td>
<td>Lower costs; Increased mobility, better usage of existing vehicle assets</td>
<td>Commuters; Users; People without vehicles</td>
<td>Taxi industry; Transit industry</td>
<td>Passengers; IT industry</td>
</tr>
</tbody>
</table>
Potential Benefits of On Demand Vehicles Compared with Conventional Taxi Services

- Driver / Passenger Matching
- Scale Effect
- Regulatory Setting
- Supply and Fare Flexibility

Legend:
- On-demand service
- Conventional taxi (company)
Number of Monthly Trips by for Hire Services, New York City, 2015-2019
# Forms of Transport Automation

<table>
<thead>
<tr>
<th>Automation Level</th>
<th>Modes</th>
<th>Terminals (Loading / Unloading / Storage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None (Level 0)</td>
<td>All driving functions assumed by user.</td>
<td>All functions assumed by manually operated equipment.</td>
</tr>
<tr>
<td>Basic (Level 1)</td>
<td>Driving assistance (e.g. cruise control), but user responsible for core driving functions.</td>
<td>Operation assistance (location of drop-off, storage and pick up), but manually operated equipment.</td>
</tr>
<tr>
<td>Partial (Level 2)</td>
<td>Some driving tasks (e.g. steering, acceleration, deceleration). User monitors environment and ready to take control.</td>
<td>Planning and managing the use of equipment and storage space (Warehouse and yard management systems).</td>
</tr>
<tr>
<td>Conditional (Level 3)</td>
<td>Perform most driving tasks and monitors driving environment. User must be ready to take control at request.</td>
<td>Semi-automatic equipment (cranes, gantries, storage stacks). Automated access to facilities (automated gates).</td>
</tr>
<tr>
<td>High (Level 4)</td>
<td>Performs all driving tasks and monitors controlled driving environment. User does not need to take control.</td>
<td>Integration between automated handling and storage systems (Fully automated terminal or warehouse). Automated pick-up and deliveries.</td>
</tr>
<tr>
<td>Full (Level 5)</td>
<td>Autonomous vehicle; Performs all driving functions under all environments. User provides destination, but does not control vehicle.</td>
<td>Autonomous terminal; responds to demand (modal, intermodal, flows).</td>
</tr>
</tbody>
</table>
# Forms of Transport Automation

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<th>Automation Level</th>
<th>Modes</th>
<th>Terminals</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>None</td>
<td>All functions assumed by manually operated equipment.</td>
</tr>
<tr>
<td>1</td>
<td>Basic</td>
<td>Operation assistance (location of drop-off, storage and pick up), but manually operated equipment.</td>
</tr>
<tr>
<td>2</td>
<td>Partial</td>
<td>Planning and managing the use of equipment and storage space (Warehouse and yard management systems).</td>
</tr>
<tr>
<td>3</td>
<td>Conditional</td>
<td>Semi-automatic equipment (cranes, gantries, storage stacks). Automated access to facilities (automated gates).</td>
</tr>
<tr>
<td>4</td>
<td>High</td>
<td>Integration between automated handling and storage systems (Fully automated terminal or warehouse). Automated pick-up and deliveries.</td>
</tr>
<tr>
<td>5</td>
<td>Full</td>
<td>Autonomous terminal; responds to demand (modal, intermodal, flows).</td>
</tr>
</tbody>
</table>

All driving functions assumed by user.

Driving assistance (e.g. adaptive cruise control), but user responsible for core driving functions.

Some driving tasks (e.g. steering, acceleration, deceleration). User monitors environment and ready to take control.

Perform most driving tasks and monitors driving environment. User must be ready to take control at request.

Performs all driving tasks and monitors controlled driving environment. User does not need to take control.

Autonomous vehicle; Performs all driving functions under all environments. User provides destination but does not control vehicle.
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<tr>
<th>Mobility Transformations</th>
<th>Environment</th>
<th>Energy</th>
<th>Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility electrification</td>
<td>Reduced emissions and better air quality</td>
<td>Additional decentralized energy resources (smart charging)</td>
<td>Reduced total cost of ownership of vehicles</td>
</tr>
<tr>
<td>Grid Edge Transformations</td>
<td>Clean energy sources fuel electric miles</td>
<td>New resources for flexibility and stability of the electricity system</td>
<td>Earnings from electricity related services (V2X)</td>
</tr>
<tr>
<td>Mobility Transformations</td>
<td>Efficient use of resources</td>
<td>More options to aggregate and shape charging patterns</td>
<td>Optimized vehicles utilization, additional reduction of costs and congestion</td>
</tr>
</tbody>
</table>

**Value**
- **Greener cities**
- **Optimized energy system**
- **Cheaper urban mobility**
Emerging Transportation Technologies

• 1. Connected vehicle technologies;
• 2. Advanced aviation systems;
• 3. High-speed rail technologies;
• 4. Advanced propulsion, alternative fuels and related infrastructure;
• 5. The “Internet of Things”;
• 6. Advanced analytics and machine learning;
• 7. Automated vehicles;
• 8. Unmanned aircraft systems (UAS);
• 9. Maritime autonomous surface ships (MASS);
• 10. Infrastructure inspection robots;
• 11. On-demand ride services: Transportation network companies;
• 12. Innovative concepts for protecting pedestrians, bicyclists and motorcyclists;
• 13. Wireless power transfer;
• 14. Additive manufacturing (3D printing);
• 15. Materials science in infrastructure;
• 16. Hyperloop;
• 17. Big data and energy-efficient computing;
• 18. Satellites and commercial applications of space;
• 19. Robotics and autonomous systems;
• 20. Agri-science;
• 21. Blockchain;
• 22. Augmented/virtual reality;
• 23. Airline New Distribution Capability;
• 24. Sensors and screening technology;
• 25. Advanced materials and nanotechnology;
• 26. Modern airships;
• 27. Ice-phobic materials;
• 28. Intelligent transportation systems;
• 29. Wearable technology; and
• 30. Energy and its storage.
## Future Improvements in Maritime Transportation

<table>
<thead>
<tr>
<th>Sector</th>
<th>Category</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ports</td>
<td>Operations</td>
<td>Ship loading/unloading optimization, Stacking optimization, Gate access</td>
</tr>
<tr>
<td></td>
<td>Terminal design</td>
<td>Improved nautical profile, Yard design, Automation, Integration with inland transport systems (On-dock rail, barges)</td>
</tr>
<tr>
<td></td>
<td>Alternative Fuels and Power</td>
<td>Electrification of gantry cranes and portainers, Alternative fuels (CNG) for yard equipment and drayage</td>
</tr>
<tr>
<td>Maritime Shipping</td>
<td>Operations</td>
<td>Speed reduction, Optimized routing, Reduced port time</td>
</tr>
<tr>
<td></td>
<td>Ship Design and Propulsion</td>
<td>Novel hull coatings and propellers, Fuel efficiency optimization, Combined cycle operation, Multiple engines</td>
</tr>
<tr>
<td></td>
<td>Alternative Fuels and Power</td>
<td>Marine diesel oil (MDO), Liquefied natural gas (LNG), Wind power sails</td>
</tr>
</tbody>
</table>
The Four Industrial Revolutions

1.0 Mechanization

- Industrial cities
- Steam engine and mechanical production

2.0 Mass Production

- Industrial regions
- Scale economies
- Electricity and division of labor

3.0 Automation

- Global production networks
- Input costs
- Electronics and information technologies

4.0 Robotization

- Global value chains
- Added value
- Cyber-physical systems

Late 18th – early 19th Century

Late 19th - mid 20th Century

Second half of 20th Century

Early 21st Century
Value Chain Drivers of the Fourth Industrial Revolution

- **R&D**
  - Open innovation, Collaborative design
- **Procurement**
  - Flexibility and compliance, New materials
- **Fabrication**
  - 3D Printing and robotics, Distributed manufacturing
- **Distribution**
  - Automation (warehouses, terminals and vehicles)
- **Marketing**
  - Ecommerce, Omni facilities
- **Services**
  - ‘Internet of Things’, Shared services
<table>
<thead>
<tr>
<th>Phases of Development of the World Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>c1500-1780</td>
</tr>
<tr>
<td><strong>Mode of Accumulation</strong></td>
</tr>
<tr>
<td>Economic system</td>
</tr>
<tr>
<td>Source of growth</td>
</tr>
<tr>
<td>Production unit</td>
</tr>
<tr>
<td>Production system</td>
</tr>
<tr>
<td><strong>Functional Relations</strong></td>
</tr>
<tr>
<td>Spatial relations</td>
</tr>
<tr>
<td>Transport system</td>
</tr>
<tr>
<td>Supply system</td>
</tr>
<tr>
<td>Hegemonic structure</td>
</tr>
</tbody>
</table>