Geographic Information Systems for Transportation in the 21st Century

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Introduction

A product of the 20th century

Some thoughts on an update for the 21st century*

*Oxford University Press does not seem interested in a second edition...
“We are witnessing a revolution in the human sciences, including transportation and urban sciences, fueled by a stunning advancement in capabilities to capture, store and process data, as well as communicate information and knowledge derived from these data.”

20th versus 21st century GIS-T

What elements of 20th century GIS-T endure?
• Transportation data modeling
• Routes and flows within spatial networks
• Spatial analysis and modeling

What is new about 21st century GIS-T?
• Changing context for transportation
• Cross-cutting developments in GIScience and technologies
• Grand challenge: Collaborative mobility
21st century GIS-T

Changing policy context for GIS-T

• The world is more crowded
• Space-time dynamics are becoming speedier and more complex
• Shift to sustainable mobility

Capabilities for collecting and generating space-time data are increasing

• Geospatial technologies, GIScience, smart cities, Internet of Things, big simulations
The future is urban

- In 2008 (+/-), the world became majority urban for the first time in history
- By end of 21st century, 70% - 80% urban

- Urban problems are humanity’s problems
The world is speedier

Space-adjusting technologies Ron Abler
- Transportation and Information/Communication Technologies (ICTs)
- Change the nature of space with respect to the time, cost and effort

Space-time convergence Donald Janelle
- Decreases in apparent distance over time
- Redistribute human activities in space and time
Speedy world challenges

Higher urban metabolism
• A hyper-coordinated city: Nonlinear dynamics, more intensive resource use
• Contrast with urban management: Slow, incremental, linear

Increasing shearing forces
• Mismatched system dynamics
• Human systems are speedier
• Physical, biological systems still slow
Collective action failures
Individually rational but collectively irrational behaviors

Example: Mobility
• Individually rational
• Collectively irrational
• Collective outcomes: congestion, resource depletion, damaged environments, loss of community
Sustainable mobility

Humanity is urbanizing
Cities are sustainable settlements
Cities must facilitate sustainable mobility

Four major strategies

1. Substitution: Mobility → Telecom
2. Modal shift: Private → Public, Shared
3. Distance reduction: Sprawl → Density
4. Improve efficiency: Vehicles, infrastructure, systems
## Conventional versus sustainable transportation planning

<table>
<thead>
<tr>
<th>Conventional</th>
<th>Sustainable</th>
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</thead>
<tbody>
<tr>
<td>Physical</td>
<td>Social</td>
</tr>
<tr>
<td>Mobility</td>
<td>Accessibility</td>
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<tr>
<td>Traffic focus</td>
<td>People focus</td>
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<tr>
<td>Technocratic</td>
<td>Community-based</td>
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<tr>
<td>Economic</td>
<td>Multidimensional</td>
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<tr>
<td>Large scale</td>
<td>Local scale</td>
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<tr>
<td>Street as road</td>
<td>Street as space</td>
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<tr>
<td>Speed traffic up</td>
<td>Slow movement down</td>
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<tr>
<td>Time minimized</td>
<td>Time reasonable and reliable</td>
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<tr>
<td>Modal-specific</td>
<td>Integrated modes</td>
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</tbody>
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21st century: So much data!
Cross-cutting developments in GIScience and technologies

1) High resolution environmental monitoring
- satellite, airborne remote sensing and geosensor networks

2) Location-aware technologies
- that can report their precise geo-location densely with respect to time
3) Spatio-temporal and moving objects databases

4) Geosensor networks

5) Tools to explore massive spatio-temporal data

6) Tools for simulating systems from “bottom-up”
Mobility data

Moving Across Places Study (MAPS): Built environment and activity in Salt Lake City, Utah.

GPS data for 900 people
Plus:
- Walkability measures
- Transit schedules
- Transit usage
- Traffic counts
- Parcel-level data
- Census data
- Weather data
- …
Visualizing 5 million bicycle journeys in London
Jo Wood (City University London)
Connected vehicles

Billions of sensors
People, vehicles, infrastructure

Wireless communication
Infrastructure, peers

Vehicle to vehicle (V2V)
Vehicle to infrastructure (V2I)

Vehicles and infrastructure in constant communication
USER-GENERATED CONTENT

Proactive (Primary) UGC
- Idea-Generation, Co-Creation, Feedback, Problem-Solving
- Sensing
  - Participatory Sensing
  - Opportunistic Sensing
  - Ad-hoc Sensing

Retroactive (Secondary) UGC
- Human Computation and "Volunteered" Work
- Web, microblog, Q&A database and other social media submissions

UGC Mode
- Volunteered
- Not Volunteered

UGC Type
- Volunteered
- Not Volunteered
Smart cities

- Enhance *hard* infrastructure with *soft* infrastructure

- *Leverage* administrative data with sensors, user generated content (UGC) and synthetic data

- Generate new *capabilities* not just greater efficiency
“Billions to trillions of everyday objects and the surrounding environment are connected and managed through a range of devices, communication networks, and cloud-based servers”

(Gu et. al. 2011)
Big simulations

21st century GIS-T

TRANSIMS model of Chicago
http://avl-test.ncsa.illinois.edu/
Open data

International Open Government Data Conference 2012

A Global Movement to Democratize Data

DATA.GOV / CITIES

WE CAN DO IT!
Build a better America with civic hacking!

Get Involved

21st century GIS-T
A vision: Transport 2.0

Seamless, multimodal system
- Web of integrated transport services
- More providers and stakeholders
- Multifaceted public sector

Collaborative mobility
- A way to solve collective action failures
- Navigate, solve problems, explore, engage, share mobility resources

Mobility services
- Real-time geographic information is the foundation
Why cooperative transport? (a partial list)

Improve private transportation
• Wasted capacity

Improve public transportation
• “Last mile,” quasi-public transportation

Coordinate multi-modal transportation
• Currently: loosely-coupled systems

Crowdsourcing and self-organization
• The crowd can be wiser than the few

Inclusive planning
• Engaged citizens = less NIMBYism?
Self-driving vehicles?  
Important, since humans are terrible drivers!

Beyond ownership  
Private vehicles are a terrible waste of energy and space  
Private vehicles are empty and idle > 90% of their existence  
Ownership is inequitable

**Self-driving vehicles + collaborative mobility → fewer vehicles → a better transportation future**