Science and Technology Advances Affecting Transportation

Results of Scan of Future Science and Technology Advances

Hyun-A Park
Innovation in Transportation

- Innovation can be a powerful force in getting greater results with the available resources
- As transportation agencies face greater pressures to perform while funding resources continue to be limited, the need to increase innovation is of growing importance
- The future holds lots of promise with new technologies and new ways of delivering transportation services
- How can organization best foster and adopt innovation?

Spy Pond Partners, LLC
But first, a look into the past!
20th Century Predictions — 50 Year Horizon
Drive-in Market 1959?
Super Chef - 1965?
WEATHER MADE TO ORDER?

By NAVY CAPT. H.T. ORVILLE

Ike’s Adviser Reports
Man’s Progress in Weather Control
20th Century Predictions — Transportation
Europe in Two Hours

By Col. Bernt Balchen
Will atomic energy power tomorrow's railroads?

Some day you may see a train like this—powered by the energy locked up in the atom.

Possibly the locomotive will have its own nuclear reactor. Or perhaps it will use electricity generated at atomic power stations. But this much is certain. Of all forms of land transportation, railroads offer the greatest opportunities for the efficient use of nuclear energy.

Railroads are constantly exploring exciting possibilities like this. Such progressive thinking is important to all of us—for we're going to need railroads more than ever in the boom years ahead.

Clearly, it's in the national interest to give railroads equal opportunity and treatment with other forms of transportation. America's railroads—the lifeline of the nation—are the main line to your future.
• Why did some predictions become reality and others did not?

• Could there have been actions taken that could have accelerated the benefits of the science and technology advancement of the past?

• Were there future predictions that could have been realities with some assistance that did not materialize?
Agenda

• Scan Findings
  1. Society and Demographics
  2. Resource Scarcity
  3. Globalization and Mobility
  4. Climate Change
  5. Useful Information
  6. Technology

• Implications for Transportation

• Additional Insights
Summary Observations

- Broad agreement among experts regarding emerging technologies
- Substantial disagreement on key risk areas
  - Climate change
  - Resource scarcity
- Many noted the difficulty of predicting the future
Society and Demographics

Current State
- Global population is still growing - greatest growth in poorest areas
  - Wealthier countries have stable or shrinking populations
- Life spans are longest they have ever been
- Economic disparity is growing

Predictions
- S1: Aging Population
  - Infrastructure changed to support older population and longer lifespans
- S2: Share More, Own Less
  - Resource efficiency
  - Resource pools
- S3: Social & Econ. Inequality
  - Growing disparity between the haves and the have nots
  - Fewer percentage of the global population can enjoy the current middle class lifestyle

Implications
- The obstacle to progress is no longer technological
  - It’s societal
- Focus needs to be on what technology can help us achieve, not just on improving technology
- Need to evaluate and adjust what a “good” quality of life is - not everyone can live the current average
- Need to accept that less is better
Emerging U.S. Megaregions
Resource Scarcity

**Current State**
- **Fossil Fuels**
  - Global supply able to meet current demand
  - Steady rise in fuel prices but still low
  - Auto ownership & cheap freight
- **Rare Earth Elements**
  - Plentiful but concentrated
  - Politics drives supply
- **Land & Water**
  - Increasingly limited resource
  - Growing water disputes
  - Cities w/o water source

**Predictions**
- **Fossil Fuels**
  - S1: We run out
  - S2: We have plenty
- **Rare Earth Elements**
  - S1: We run out
  - S2: We have plenty
- **Land & Water**
  - Land will become increasingly valuable
  - Support larger population on a given land area
  - Water supply strained
  - Desalination insufficient to meet demand

**Implications**
- Disagreement amongst experts on availability of critical resources
- Lack of social & political will to mitigate risk
- If there is resource scarcity, shift will be toward alternatives to scarce resources
- Politics will drive access to resource supplies
Globalization and Mobility

**Current State**
- Global interconnectivity greater than ever before
  - Individuals & businesses are mobile
  - Greater dependence on others
- Economic relationships are intertwined
  - Icelandic bank failure impacts countries globally
- Regional connectivity has weakened due to focus on global
  - Intra-region travel more difficult & costly than inter-region

**Predictions**
- S1: “Earth Culture”
  - Borderless economy
  - Global currency
  - Global laws
  - Virtual nations
- S2: Decreasing Mobility
  - Virtual contact
  - Improved short distance mobility
- S3: Quick and Easy Travel
  - Faster travel w/new technologies
  - Go anywhere in 90-min.
  - Multi-modal travel
  - Airships for freight

**Implications**
- Disagreement about increase or decrease in mobility
  - Higher energy costs
  - Improved technology
- Both economic & technology forces are likely to exist
- Faster travel in the future
  - Scramjets
- S1 not likely in near future
  - Europe is moving in that direction
Climate Change

**Current State**
- World’s science community generally agrees that climate change is real
  - Caused by people
- Lack of political will globally to halt, reverse, or slow down change
- Uncertainty exists about the implications of climate change

**Predictions**
- S1: A Non-Issue
  - Impact of CC will not be significant
- S2: A Decision Driver
  - CC impact significant
  - Political will created to make change
  - Long-term impacts mitigated
- S3: Reactive Adaptation
  - CC impact significant
  - No political will to change
  - Have to adapt to the serious impacts of CC

**Implications**
- Some progress has been made in dialogue about CC
- Lack of clear policy suggests that averting the serious impacts of CC is not likely
- Optimistic view: create payoff matrix comparing the cost of acting when
- Reality is not so simple
  - Most actions have multiple drivers
- Take actions that solve multiple problems
### Useful Information

#### Current State
- Exponential increase in available information over the last few decades
  - Google searches yields an overwhelming list of links
- DRIP (Data Rich Information Poor) syndrome a common curse
- Distinguishing what is important from what is not is a challenge
  - Filtering information and analyzing it a growing service

#### Predictions
- S1: “Personal Brain”
  - Spreadsheets and Google
  - Help us make sense of the overwhelming amount of information
  - Intelligent information systems
- S2: The Internet of Things
  - Interconnectedness extends to things
  - RFID
- S3: Interfaces
  - Windshield displays
  - Eyeglass displays
  - Telecom advancements

#### Implications
- Growing reliance on intelligent information systems
- Success at getting to useful information frees up time to do “real” tasks
- Who/what do we trust in information filtering services?
  - Distinguishing underlying business interest
- What happens when the computer makes a mistake?
R.C. Central Park
50 Central Park South, New York
The R.C. New York, Central Park
is a luxurious haven in the heart of
the city.
apple

54 kcal

- water 84.9%
- carbohydrates 14.6%
- fiber 1.5%
- protein 0.2%
- sugar 0.2%
- ash 0.2%
- vitamin C
- K
- Ca
- Mg
- P
<table>
<thead>
<tr>
<th>Current State</th>
<th>Predictions</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Computers are everywhere and increasingly interconnected</td>
<td>- Nanotechnology will dramatically improve to deliver targeted medicine and diagnostics</td>
<td></td>
</tr>
<tr>
<td>- Nanotechnology is emerging</td>
<td>- AI will have computers have greater power to reason and analyze - mimic humans</td>
<td></td>
</tr>
<tr>
<td>- AI has improved but not to human power</td>
<td>- Biotech, Genetics, &amp; Medicine will advance due to increased computing power combined with biology advancement</td>
<td></td>
</tr>
<tr>
<td>- Dramatic improvements in medicine - longer life</td>
<td>- Cloud Computing will able cross industry power</td>
<td></td>
</tr>
<tr>
<td>- Cloud computing reemerging</td>
<td>- Robotics will increase in everyday use - automated vehicles</td>
<td></td>
</tr>
<tr>
<td>- Robots are moving from commercial to individual applications</td>
<td></td>
<td>- Poised for breakthroughs imagined by sci-fi years ago</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Integrative power of cross tech and org activities will deliver to breakthroughs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- New ethical dilemmas and dealing with existing ones will be an issue</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Genetic selection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Unemployment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Nanotech contamination</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Privacy of data</td>
</tr>
</tbody>
</table>
Implication for Transportation - Technology

• Propulsion
  - Battery technology improvements
  - Commercialization of scramjets/ramjets

• Seamless Connectivity
  - Multi-modal travel
  - Crowd sourcing, tracking and real-time data analysis

• Autonomy
  - Advancements in sensor technology, AI, and robotics
  - Semi or fully automated vehicles
    - Efficient travel (safety, congestion mgt, etc.)
    - Cheaper resource sharing
Implication for Transportation - Lifestyle

- Reaching mobility peak

- Continued increase in energy prices:
  - Move towards compact, urban communities with less need for personal vehicles
  - Technology advancements creating less travel needs

- Affordable energy prices continues:
  - Greater focus on faster modes of transportation
  - Increasing mobility is the focus
Implications for Transportation - Infrastructure

• Need for new road infrastructure is decreasing
  - Focus on operations: ITS, Intellidrive/vehicle sensors, etc.

• Need for greater focus on maintaining existing infrastructure continues to grow
  - Nanotechnology is likely to help develop materials that are easier to maintain and longer lasting

• Robotics and other technology advancements will help with less resource intensive and safer construction

• New fuel delivery infrastructure will emerge to replace gas stations

• Infrastructure is no longer bricks and mortar but a system of systems
  - IT as new transportation infrastructure
Implication for Transportation - Governance and Organizations

- Institutional Structures/Organizations
  - Transportation organizations need to be poised to deal with an increasing complex world
  - Transportation decisions need to connect with a wider set of sectors, disciplines, and policy areas
    - Need to include telecommunications, innovation, business, economic development & labor, social services, privacy, etc.
  - Earlier collaboration a must
  - Government, policy, and legislation needs to provide broader, more flexible frameworks to address unpredictability and complexity
  - Greater focus on knowledge sharing and collaborative decision-making
  - New brand of decision-maker will emerge - versed in complex systems thinking and complex program management
Implication for Transportation - Governance and Organizations (cont.)

- Institutional Structures/Organizations (cont.)
  - Realignment of transportation planning and operating agency structures to better match geographic mobility and travel demand patterns
  - Repurpose MPOs to be metropolitan-level agencies that plan, fund, build, and operate transportation networks
  - Integrate transportation, land use, urban development, and economic development function

- Public Investment Policy
  - Likely to mirror the implications above
  - Spending flatter to support wider range of modes & services
  - Focus on system-wide, integrated solutions
Implication for Transportation - Governance and Organizations (cont.)

- Public Investment Policy (cont.)
  - Support growth of emerging industry clusters that supply next generation transportation systems and infrastructure
  - Potential examples of transition include:
    - Planning and management of logistics/transport of local food supplies
    - Balance calls for accountability with enabling more nimble and resilient public policy and agencies
    - Replace motor fuel taxes with other revenue sources
    - Consider strategic disinvestment/abandonment
    - Accelerate development and regulation of nationwide Smart Grid
Multiple Modes, Multiple Sectors
Smart Grid
New Revenue Streams
Urban Agriculture
Strategic Abandonment
Additional Insights

• Predictability
  - Skepticism about ability to predict the future
    · Especially 30-50 years out
  - Experience tells us that we are unable to accurately and completely predict the future
  - Predictions are extrapolated on what we know now
  - Hard to determine the disruptors that will fundamentally change the technological landscape
  - How do we better guide transportation into the future?
  - Use the past and measurement tools to better assess degree of accuracy of predictions in given timeframes
    · USPS peaked in 1979
Additional Insights (cont.)

- Adaptation
  - Neo-Darwinism suggests period of stasis, followed by period of rapid change, followed by a new order
    - Move from agrarian society to industrialization
    - We are now settling out of the rapid change of the information age
  - Desynchronization suggests that different parts of society move through change at different rates
    - New technologies are first adopted by business, military, industry, then by individuals/families, and then by governments/institutions - regulatory/legal is last adopter
    - Need to be careful about responding to broad trends and look at what is happening in transportation
Business As Usual Scenario???
KAIST Inductive Propulsion
Terrafugia - “Flying Car”
Star Trek Transporter
Innovation is Important!!!

HOW CAN WE FOSTER INNOVATION AND ITS POTENTIAL TO ADD VALUE MORE QUICKLY?

- Innovations come in lots of different ways
  - A simple tool to quickly clean out culverts
  - A process change to improve the accuracy of vendor payments
  - A new data application that improves the budgeting process
  - Etc.

- A culture of innovation can lead to cost savings, increased employee satisfaction, efficiency gains and the organizational confidence to meet challenging times.
Questions

- How can the transportation community best promote and improve innovation results?
- What are the ingredients of success for getting innovation results?
- How can leading organizations help lagging organizations get more innovative?
- What is the balance of organization and leadership strengths versus technology and tool availability?