Hydrogen-Powered Railway Vehicles (Hydrail): A Vision

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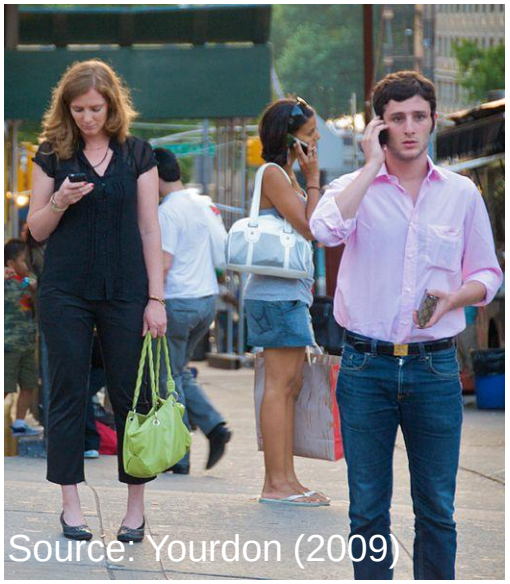
Millennials (or Generation Y)

- Born early1980s to mid1990s (~37-20 years old)
- Largest generation in America, now larger than baby boomers
- Largest generation in U.S. labor force
- Grew up or living through difficult economic times and technological change
- Prefer urban areas, often central city, mixed-use communities with access to mix of shops
- Being connected to digital resources very important
  - Working while travelling
  - Engaging in social media
- Socially and environmentally conscious
- Willing to spend more for products of responsible companies, including environmental causes


Source: Yourdon (2009)

Millennials and Transportation

- 66% of millennials have high quality transportation as one of the top three criteria to decide where to live
- They like mobility choice, with preference for public transportation on many routes, especially commuting
  - Prefer public transportation
  - Multi-modal, e.g., walking, transit, Uber
- Automotive
  - Less Americans licensed to drive now than in 1960s
  - Prefer environmentally friendly cars – hybrid and electric
- Environment
  - Important consideration
  - Supporting rather than leading role for transportation choice
- Transportation preference similar in younger than millennial generation (Generation Z)

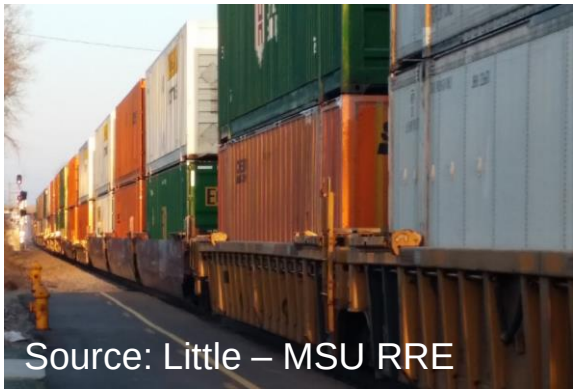

Source: Hoffrichter – MSU RRE

Millennials and Railways

- Higher demand for transportation by rail
  - Convenient end-to-end journey essential, e.g., walk to station/stops
  - Wi-Fi, 3/4/5G supported and stable on rail routes important
- Rail connection of suburbs important
  - Millennials buying homes for starting a family but still would like to retain urban feel and connection to city center
  - Opportunities for redevelopment of "industrial" belts of cities
- Environmental performance a marketing advantage
  - But rail needs to stay ahead
  - Electric "green" car has potential to negatively impact imagine of rail "dirty diesel trains" or "dirty electric trains" (supplied by coal power plants)

Millennials and Impact on Freight: More Online Shopping

- More purchases online
  - Short delivery times preferred
  - More frequent but smaller grocery quantity shopping (Millennial preference for fresh, local foods)
- Integration with supply chain essential
  - Opportunities for rail and transit exist, e.g., package pick up at station, grocery ordering at station or online, pick up at destination station or delivered to home
  - Pick up points on the train? - Amazon patent filled
  - Stations become distribution centers? E.g., for package deliver, maybe by drones?
- Part of passenger train that can be easily converted to carry freight in off peak – demonstration project started


Source: Little – MSU RRE


Source: Derksen (2011).

Hydrail an Enabler

- Hydrail can fit well with preference of millennials and their values
  - A public transportation option
  - No emissions at the point-of-use
  - Lower visual impact than electrification
  - Possible very low total emissions
  - Possible to use 'green' energy sources
- Hydrail can help achieve government targets
  - Contribute to better local air quality
  - Contribute to reduce greenhouse gas emissions (Paris Agreement)
  - Contribute to energy security
- Hydrail can benefit railways
  - Possibly cheaper to implement than wayside electrification
  - Easier to achieve wider rail network reach than wayside electrification as not reliant on continuous wayside infrastructure ('go anywhere train')
  - Allows use of renewable energy independent of production time
  - Potential to reduce energy cost through higher efficiency compared to diesel
  - 'Green' hydrogen a possible marketing advantage vs improved combustion engines, or 'brown' electricity
  - No overhead electrification at freight loading facilities – easier loading/unloading of containers and swap bodies

Automated Railways

Source: Trowbridge Estate (2011)


Source: Lee (2012)

Source: Mabel (2011)

- 1967 London Underground: Victoria Line – automated between stations, but driver starts driving command and opens doors
- 1985 Vancouver Skytrain: Expo Line – fully automated ('leaky wire' technology)
  - Now largest autonomous rail network in the world
- Current systems rely on relatively expensive wayside infrastructure for full automation
- Development of radio-controlled systems, e.g., ERMTS Level 3, advanced PTC
  - Could reduce implementation cost
  - Potential for faster installation as multiple lines could be reached via radio
- Remote radio-controlled switch locomotives

Automated Passenger Vehicles: Possibilities

- Already, safely possible in dedicated, well-defined systems with similar train characteristics
  - Currently People Movers, Metros
  - Next, most likely Very High Speed (e.g., SNCF TGV project)
  - Many control and signaling systems already intervene if driver's concentration lapses
- Lower-speed urban / regional options
  - Technology transfer from automotive, e.g., instead of line-of-sight tram/streetcar operation
  - Radio-control plus on-board sensors on dedicated right-of-way – higher speeds possible compared to line-of-sight
  - Uber-type ordering of train car – formation of trains at peak time
  - Flexible interiors – quick, easy conversion for passenger or freight
- Automatic consist formation
  - At stops
  - In motion, individual coaches serve different destinations
  - Virtual coupling (no physical, mechanical connection)
- Mainline, mixed traffic
  - Most challenging
  - Moving block to increase capacity

Automated Rail Freight Vehicles: Possibilities

- Remote driving for less intensive service frequencies
  - Develop remote-controlled switcher technology further
  - Low-speed remote freight cars for local delivery
- Track Mobile for delivery of small consists
  - Eliminates need to equip freight cars with propulsion system
  - More flexible as does not exclusively rely on rail, e.g., sidings to turn around
- Fully automated driving
  - Track mobile or individual cars
  - Automatic train formation on route
  - Train formation while consist in motion

Source: Hoffrichter – MSU RRE

- Open access for shippers on local lines to reach switch yards
  - Railway concentrates on long distance
  - Shipper organizes and possibly operates last mile themselves

Hydrail and Automation

- No harmful emission / high voltage electrification hazard for freight railcars / trains possible
  - Direct delivery into warehouses for general merchandize and food
- Lower noise emission enabling deliveries late at night (no coasting or engine shut-off required)
- Reduced emissions at switch yards and industrial sites, which are often located close to disadvantaged neighborhoods
- Autonomous trains / vehicles possible while retaining environmental advantage on lines where electrification not feasible / affordable
- Longer range and faster refueling compared to battery options
- Urban / regional railway systems feasible through avoidance of expensive wayside power and signaling infrastructure
  - Particularly useful for lines / system with relatively low transportation capacity (e.g., people movers, very light rail, light rail)
  - 'Last mile' routes of freight cars from switch yards

Discussion

Contributions from attendees

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