PARSONS

Implications of Increasing Grade of Automation

APTA Rail Conference 2017
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Agenda

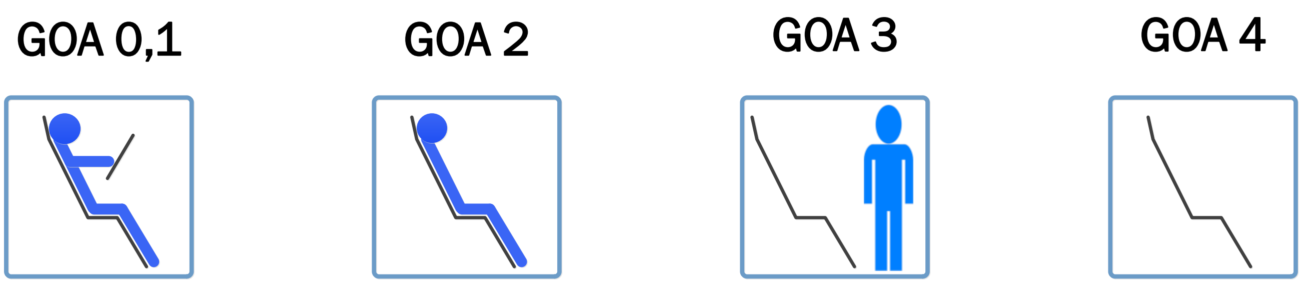
1. Definition of GOA
2. Benefits of Increasing GOA
3. Obstacles to Increasing GOA
4. Trends of Automation in Transit
5. Concluding Thoughts & Questions

What is Grade of Automation?

- Defined in IEC 62267 – Railway applications – Automated Urban Guided Transport (AUGT) – Safety Requirements

Specified Grades of Automation (GOAs)

- GOA 0: Manual operation with no automatic train protection
- GOA 1: Manual operation with automatic train protection (like PTC)
- GOA 2: Semi-automatic train operation (STO)
- GOA 3: Driverless train operation (DTO)
- GOA 4: Unattended train operation (UTO)



GOA0 – Manual Driving, no ATP or ATO

- GOA 0: Manual operation with no automatic train protection
  - Safety and efficiency of train movements are fully under the control of the Train Operator
  - Movement authority, including route locking and maximum speeds, may be granted by a variety of means, including:
    - Wayside signals and line-of-sight conditions
    - Permanent operating rules
    - Verbal instructions in person or by radio voice communications
- GOA 1: Manual operation with automatic train protection
- GOA 2: Semi-automatic train operation (STO)
- GOA 3: Driverless train operation (DTO)
- GOA 4: Unattended train operation (UTO)

GOA1 – Manual Driving with ATP

- GOA 0: Manual operation with no automatic train protection
- GOA 1: Manual operation with automatic train protection
  - ATP protects train from specified hazards, typically by applying brakes to a stop
  - ATP may provide protections associated with any combination of (refer to IEEE 1474.1):
    - Route interlocking, train spacing, end-of-line, travel against the authorized direction
    - Train integrity, overspeed, door operation and travel in the vicinity of trackside work crews
  - Train Operator is responsible to command train acceleration, deceleration and door opening/closing, and to monitor track conditions ahead of the train
- GOA 2: Semi-automatic train operation (STO)
- GOA 3: Driverless train operation (DTO)
- GOA 4: Unattended train operation (UTO)

GOA2 – ATO with Driver in the Control Cab

- GOA 0: Manual operation with no automatic train protection
- GOA 1: Manual operation with automatic train protection
- GOA 2: Semi-automatic train operation (STO)
  - System provides full ATP and ATO, with a Train Operator stationed at the control cab
  - Train Operator monitors trackside conditions ahead of the train and typically triggers door closure and train departure
- GOA 3: Driverless train operation (DTO)
- GOA 4: Unattended train operation (UTO)

GOA3 – ATO with Roving Attendant

- GOA 0: Manual operation with no automatic train protection
- GOA 1: Manual operation with automatic train protection
- GOA 2: Semi-automatic train operation (STO)
- GOA 3: Driverless train operation (DTO)
  - System provides full ATO and ATP
  - Attendant (aka Train Captain) is stationed on-board the train to support recovery operations and attend to passengers as required
  - As Attendant is free to move about the train, they are not necessarily available at the control cab to detect the presence of hazards ahead of the train
  - These hazards must either be rendered sufficiently remote to preclude the need for Train Operator vigilance at the control cab or be detected by supplementary systems
- GOA 4: Unattended train operation (UTO)

GOA4 – ATO Unattended

- GOA 0: Manual operation with no automatic train protection
- GOA 1: Manual operation with automatic train protection
- GOA 2: Semi-automatic train operation (STO)
- GOA 3: Driverless train operation (DTO)

- GOA 4: Unattended train operation (UTO)
  - No driver or attendant required on-board the train for normal operation
  - Rolling stock does not require a control cab, per se: a hostling panel is deemed sufficient for rare manual movements
  - System reliability needs to be sufficiently high to preclude the need for Train Operator intervention, except for extremely low probability failures
  - Manual movements typically limited to maintenance and storage facilities, or for failure recovery
  - May be applied by territory (e.g. full system, only mainline, only core areas, only reversal locations)

Grade of Automation Definition Summary

With Increasing GOA

Basic functions of train operation		On-sight GOA0	Non-Automated GOA1	Semi-Automated GOA2	Driverless GOA3	Unattended GOA4
Ensure safe movement of trains	Ensure safe route	Ops Staff (route by systems)	Systems	Systems	Systems	Systems
	Ensure safe separation of trains	Ops Staff	Systems	Systems	Systems	Systems
	Ensure safe speed	Ops Staff	Ops Staff (partial by system)	Systems	Systems	Systems
Drive train	Control acceleration and braking	Ops Staff	Ops Staff	Systems	Systems	Systems
Supervise guideway	Prevent collision with obstacles	Ops Staff	Ops Staff	Ops Staff	Systems	Systems
	Prevent collision with persons on tracks	Ops Staff	Ops Staff	Ops Staff	Systems	Systems
Supervise passenger transfer	Control passengers doors	Ops Staff	Ops Staff	Ops Staff	Ops Staff	Systems
	Prevent injuries to persons between cars or between platform and train	Ops Staff	Ops Staff	Ops Staff	Ops Staff	Systems
	Ensure safe starting conditions	Ops Staff	Ops Staff	Ops Staff	Ops Staff	Systems
Operate a train	Put in or take out of operation	Ops Staff	Ops Staff	Ops Staff	Ops Staff	Systems
	Supervise the status of the train	Ops Staff	Ops Staff	Ops Staff	Ops Staff	Systems
Ensure detection and management of emergency situations	Detect fire/smoke and detect derailment, detect loss of train integrity, manage passenger requests (call/evacuation, supervision)	Ops Staff	Ops Staff	Ops Staff	Ops Staff	Systems and/or staff in OCC

Systems (including CBTC) assume responsibility for more functions

Table source: IEC 62290-1, Ed. 2.0, 2014

Benefits of increasing GOA

Safety Benefits of Higher GOA

- Elimination of adverse effects of driver inattention / distraction
  - Professional Engineers are obligated to view public welfare as “paramount,” not just one of a series of equal factors
  - The human cost of incidents adversely affects the industry and society as a whole
  - Lawsuits resulting from incidents, especially where negligence or incompetence is involved, are extremely costly

Less exposure for roadside workers

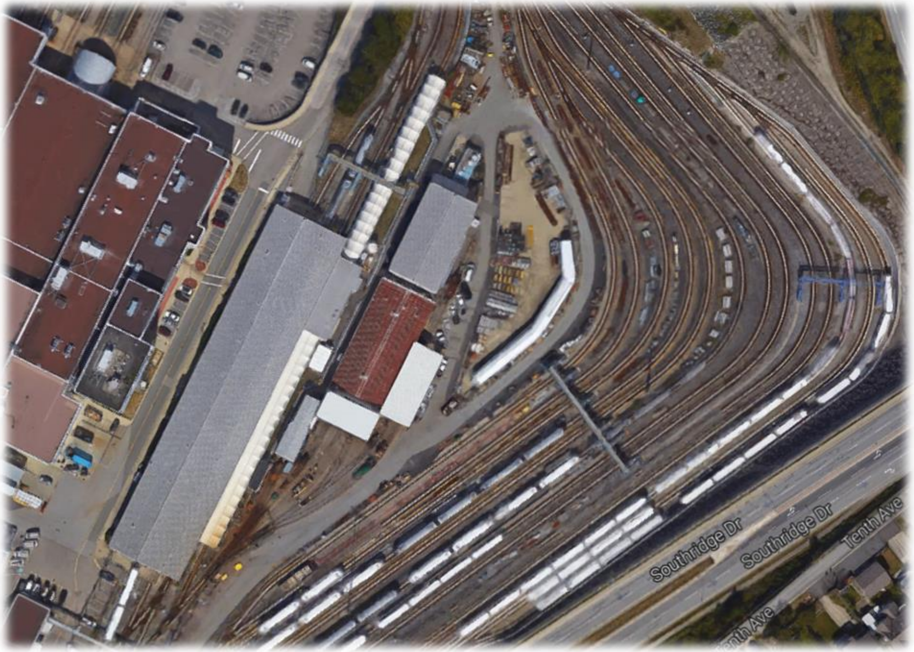
  - Less reliance on trackside devices (e.g. track circuits) that need to be maintained
  - System features to protect roadside workers during maintenance.

Service Benefits of Higher GOA (1/2)

- **Repeatability:** speed profiles and station dwells
  - More accurate **prediction of arrival** times, for optimization of schedule and service regularity
  - **Coordinated arrivals** at a common station of trains on different operational routes (e.g. express/local), to improve the efficiency of passenger transfers
  - **Energy Conservation** through coasting and by coordinating arrivals and departures within a traction power section, to maximize the benefits of regenerative braking (one train feeds energy to another)
- Improved **passenger comfort**
  - Smoother, more **comfortable, repeatable** ride, closer to the ideal speed profile with jerk and acceleration limiting

- **Simpler and more flexible** operations
  - Immediate, automatic responses to incidents / blockages
  - Enhanced failure reporting capabilities, to provide more data to Control staff, for faster response

Service Benefits of Higher GOA (2/2)



- Reduced dependence on staff **availability** for operations
  - Easier satisfaction of **planned demand**
    (complexities of coordinating staff schedules with service schedules)
  - Easier satisfaction of **unplanned demand**
    (possible to deploy a train without waiting for a driver to attend)
- Potential for unmanned storage yards

Capacity Benefits of Higher GOA

Potential for shorter-headway operation to reduce passenger wait-time at stations and maximize the use of existing infrastructure, due to:

- Enhanced repeatability
- Elimination of Train Operator to shorten terminal station dwells
- Reduction in reaction delays
- Increase in train service frequency (i.e. capacity) with CBTC, to reduce platform wait times and crowding

Cost Benefits of Higher GOA

Lower costs for staffing:

- Train Operators reassigned to other jobs
- …but there are also additional staffing requirements that reduce this benefit:
  - Roving station attendants, to assist passengers
  - Additional security staff
  - Additional maintenance functions
- Generally a significant overall cost reduction

Obstacles to increasing GOA

Obstacle: Upgrade/Replace Multiple Systems

- Signal systems need to be expanded to support higher GoAs
- Fleet retrofits and additional systems may be required to replace driver functions:
  - On-board CCTV
  - Intercom to Central Control
  - Guideway detection / Platform Doors
  - Frontal train impact detection (cow catcher sensors)

Obstacle: Rolling Stock Adaptation

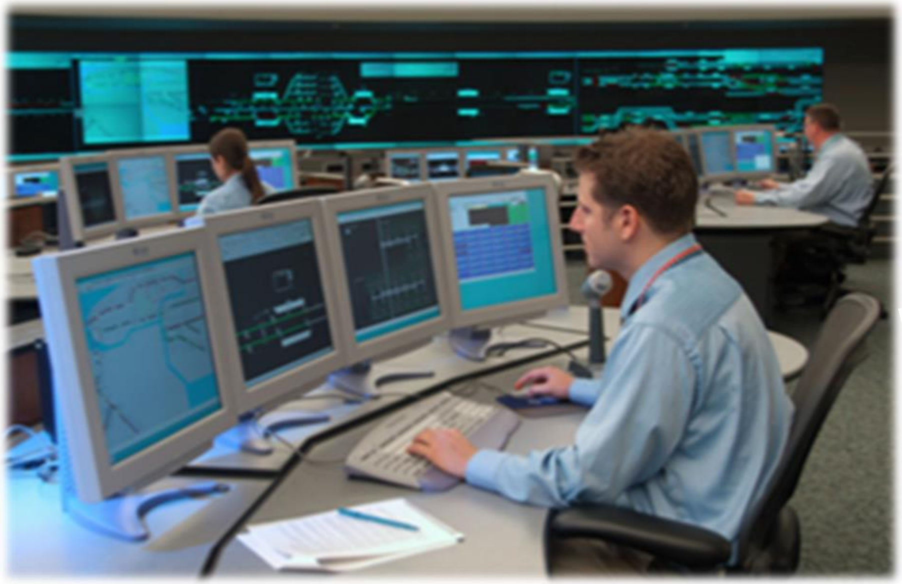
Rolling stock has to be adapted or procured to:

- Allow ATO control
- Remove constraints associated with driver inputs
- Provide remote feed for passenger information and announcements
- Detect hazards (e.g. smoke/fire, impact with object on the guideway), etc.

Obstacle: Communications Upgrades

Communications systems have to be implemented:

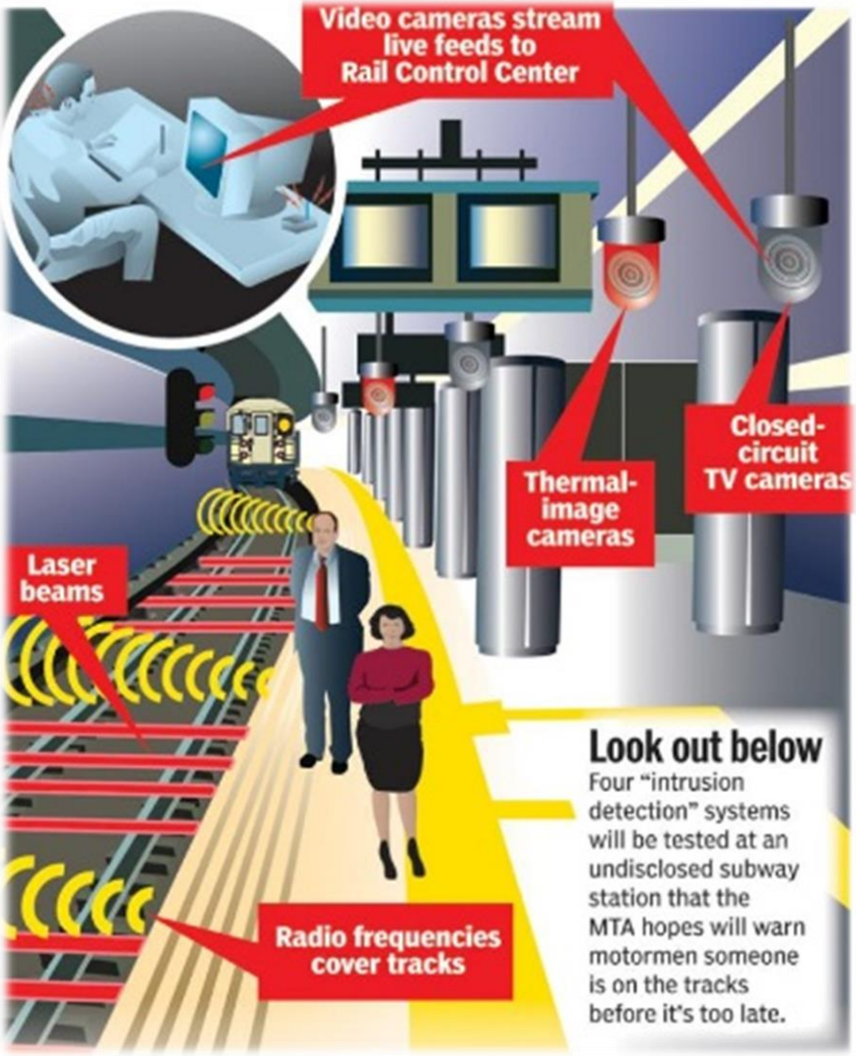
- **Voice radio** to support dialogue between passengers on trains and central control staff
- It may be considered necessary to augment this with **CCTV feeds** from train cabins to central



Obstacle: Detection of Track Intrusion no Longer by Driver

Track intrusion detection systems have to be implemented:

- Especially in high-risk areas such as station approaches
- Replace driver vigilance responsibility to detect objects or persons in the track ahead of the train

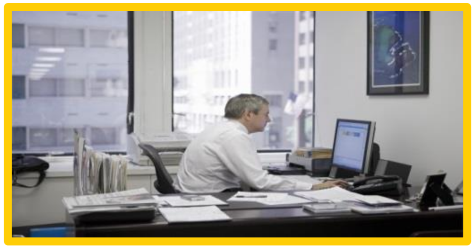


Obstacle: Detection of Track Intrusion no Longer by Driver

Platform Edge Door systems are even better alternative

- Almost a "must-have" for GOA4:
- Prevention of track intrusion, rather than just detection after-the-fact
- Containment of conditioned air at stations, especially in hotter climes (full-height, sealed PEDs required)
- PEDs are more costly than Track Intrusion systems
  - Especially for brownfield systems with multiple fleets for which door centerlines are inconsistent
  - For greenfield projects, costs can be offset by corresponding reduction in tunnel ventilation system costs

Obstacle: Expansion of Cyber Threats with Higher GoA



IT Systems

Smarter, more connected Signalling Systems

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Cyber Assets

Physical Assets

Cyber Threats

2006 Traffic engineers accessed Los Angeles' traffic control system, tampering with light sequences at 4 major intersections to create gridlocks during a labor union protest.

2011 Attack on a Northwest rail company's computer systems disrupted railway signals for 2 days, delaying operations and schedules.

2015 Muslim extremist group Arab Security Team hacked online TravelWest bus timetable in Bristol, United Kingdom, replacing content with Arabic text and music—the group has also previously infiltrated Philippine Airlines webpages.

2015 Cyber thieves hacked 10,000 American and United Airlines accounts from a third party, booking dozens of bogus trips and making mileage transactions.

2015 In a nondiscriminatory attack, Pro-Islamic hackers defaced the website of Hobart International Airport in Tasmania, Australia, to display a message supporting ISIS.

EMERGING/ FUTURE CHALLENGES

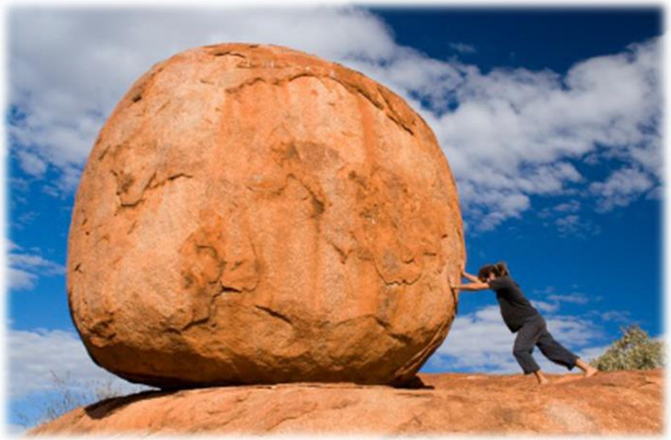
- Transit Interconnectivity
- Intermodal Operations Centers (US)
- Intelligent Transportation Systems
- Connected/Driverless Vehicles

Obstacle: Risks

- Risk perceived by the riding public
- Risk perceived by political decision-makers
- Risks of implementing a new type of signal system on an operating railroad, including safety, cost & schedule challenges

Obstacle: Culture

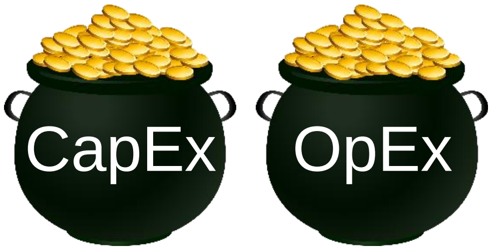
- Inertia / reluctance to change: *"Our staff is all used to the existing, manual system…"*
- Lack of long-term vision: *"Our manual system has worked fine for years; how can we justify spending the money to upgrade it?"*
- Organized labour unions may fear staff reductions



Obstacle: Cost-Benefit Assessment

- Sometimes the cost of automation may be perceived to outweigh the benefits…
  - Where labour is relatively inexpensive
  - Where political policies to grow the job market outweigh financial considerations

- Costs associated with other system upgrades
- Costs associated with customization, in the absence of standard methodologies and products
- Different pots of money for CapEx+Opex



- A cost-benefit analysis based on the agency's specific business objectives can be used to determine how far to go with automation, but
- Realistically, the decision whether or not to automate is often made outside of such objective considerations

Trends of Automation in Transit

Some Pioneering Transit Systems in Automation

- GOA2 (STO):
  - 1968 – LU Victoria Line
  - 1969 – PATCO (Philadelphia)
  - 1972 – BART (San Francisco)
  - 1976 – WMATA (Washington, DC)
  - 1979 – MARTA (Atlanta)
  - 1985 – Scarborough RT (Toronto)

    …
- GOA3 (DTO):
  - 1987 – London Docklands Light Railway
- GOA4 (UTO):
  - 1982 – Kobe (Japan)
  - 1983 – Lille (France)
  - 1986 – SkyTrain (Vancouver, Canada)

Trends of GOA4 in Rail Transit

- The following two charts may be familiar to you, if you have read the UITP Observatory of Automated Metros World Atlas Report, 2013
- The exponential trend of increasing GOA4 properties worldwide illustrates that many agencies are convinced of its merits
- The fact that this trend happens to match a corresponding trend in CBTC deployment is probably not a coincidence ☺

GOA4 Transit Properties by Decade

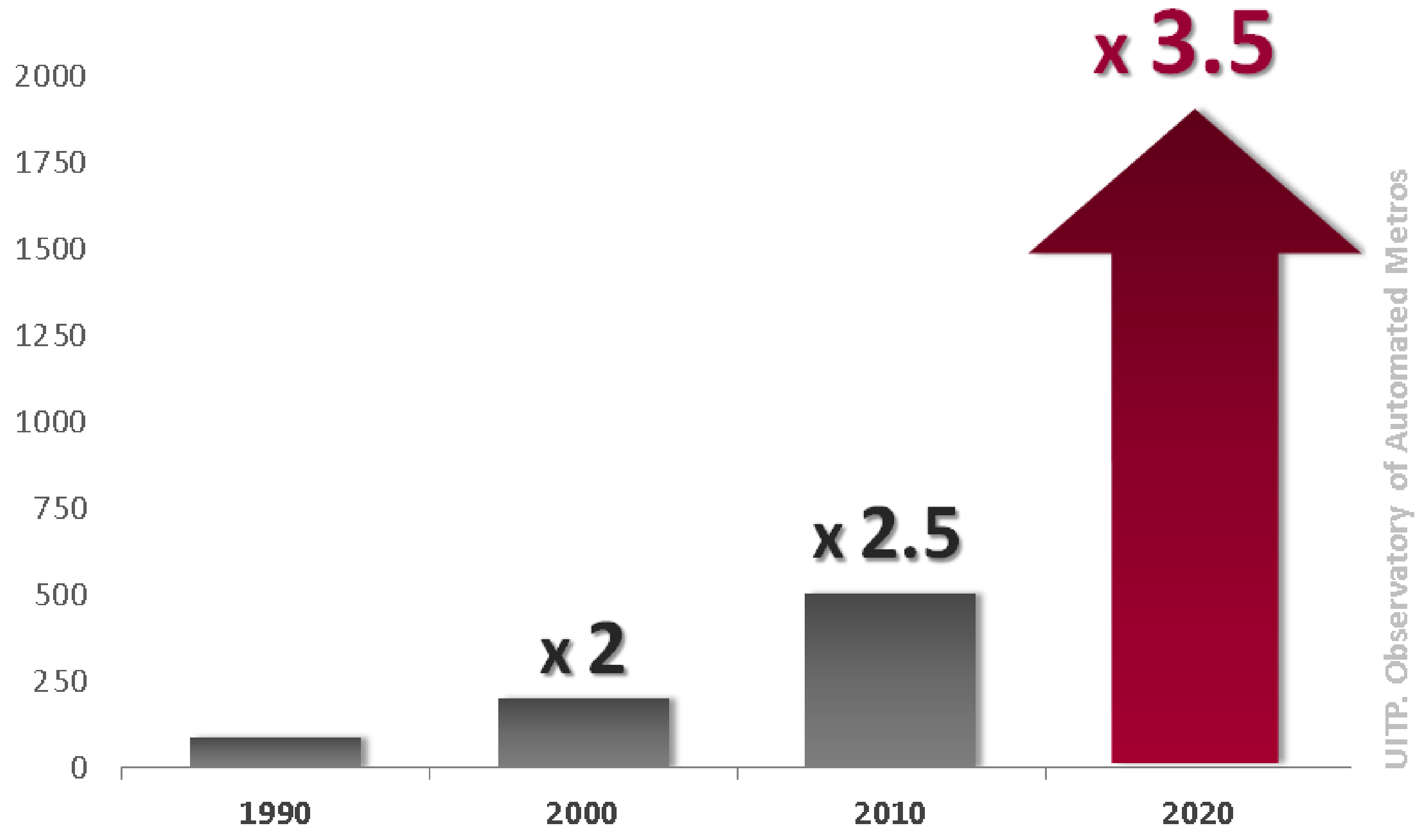
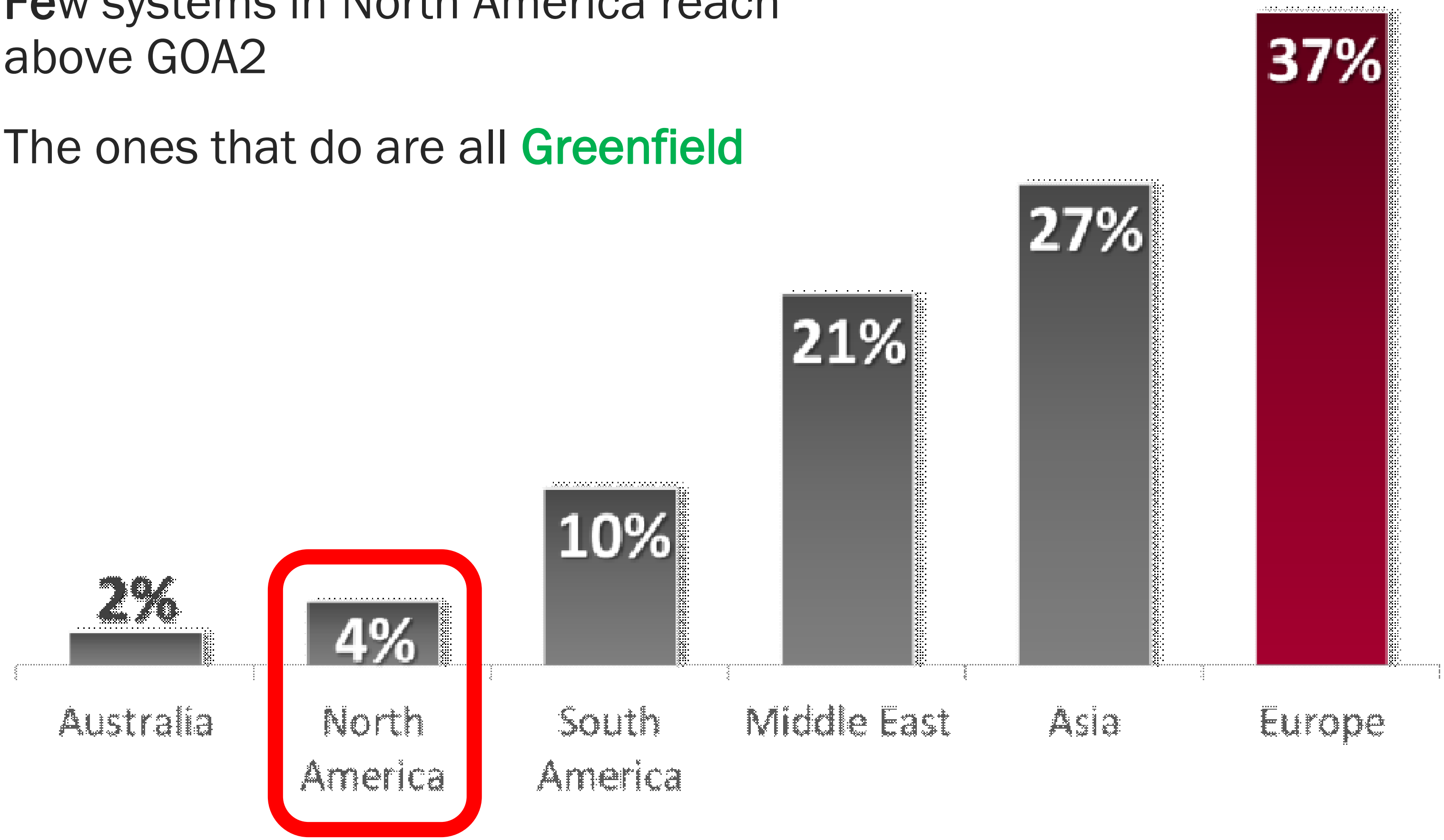


Figure source: UITP Observatory of Automated Metros World Atlas Report, 2013

GOA4 Proportions by Continent

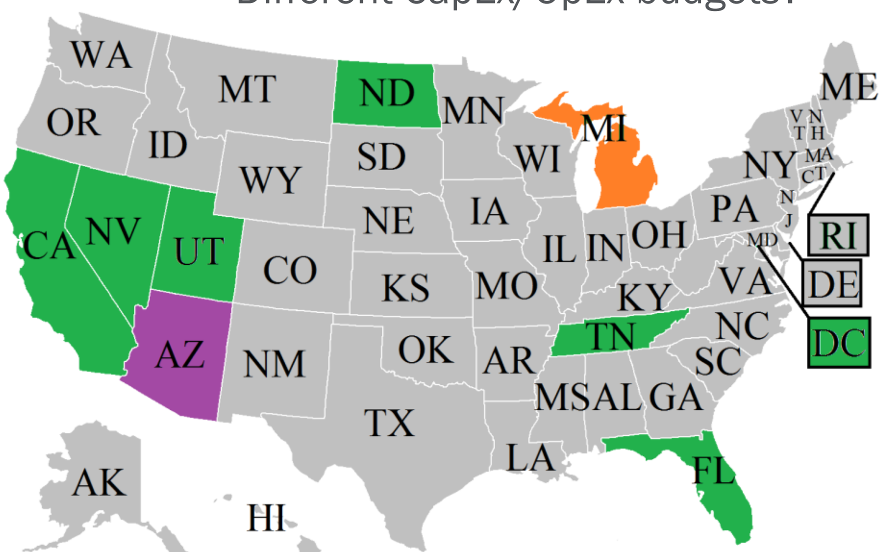
- Few systems in North America reach above GOA2
- The ones that do are all Greenfield



* Figure source: UITP Observatory of Automated Metros World Atlas Report, 2013

Main Obstacles to Automation in North America

- Why does North America lag behind most of the rest of the world in upgrading to GOA4?
- Why the reluctance in North America to embrace higher GOAs?
  - Impact of Rolling stock adaptation?
  - Additional systems to support?
  - Perceived risk (public, political, labour)?
  - Cost exceeds the anticipated benefits?
  - Different CapEx/OpEx budgets?



Future Considerations

- How do we ensure the relevance of our industry?
- BART Director asked me: if automation on a Google car only costs like 10k, why is CBTC so expensive?
  - Both Safety and Reliability need to be higher, given the larger impacts and number of people affected by a failure in large train systems…
  - …but how can transit system costs be reduced to approach smaller modes?
- Are we approaching the historical vision for Personal Rapid Transit?
- How will CBTC keep pace with the level of automation that is becoming mainstream?


Concluding Thoughts

Concluding Thoughts

- Increasing GOA transfers responsibility for safety and operational functions from humans to complex systems
- CBTC is the leading signalling technology that provides the opportunity for ATO, which is a characteristic of GOAs 2-4, so it is a common, although not universal, component of many systems having higher GOAs
- Other system capabilities, beyond Signalling, to support higher GOAs:
  - Carborne system interfaces
  - Train-to-wayside data transfer for voice, video
  - Track intrusion detection
  - etc.
- The decision to increase GOA should be based on a holistic approach that considers all associated Strengths, Weaknesses, Opportunities and Threats ("SWOT" Analysis)

Thanks for Your Attention!

- Questions?