Automated Metro Operations:
Challenges and Opportunities

ASCE International Conference on Urban Public Transportation Systems

Conservatoire National Des Arts et Métiers

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National Conservatoire National des Arts et Metiers

- 1794: Created by decree after the fall of Louis XVI
- 1819: First course in Mechanics, Applied Chemistry and Industrial Economics
- 2013: 85,000 students at 28 campuses
- Offices in 12 countries with 42 partner countries
- Seeking cooperative arrangements in transport and logistics education with US institutions
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Agenda

- Introduction
- Unattended Train Operations
- Future Trends
- Opportunities
- Challenges
- Conclusions

Agenda

Introduction

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Introduction: 30 years of exponential growth

30 years of remarkable progress developing and deploying fully automated passenger rail systems

- 48 lines in 32 cities
- No onboard staff
- Provide general public transit service with high capacity (100+ passenger) trains.

Introduction: Unattended Train Operation

Unattended Train Operation

Modern technologies automatically control train functions, including:

- propulsion,
- brakes,
- doors and
- train spacing.

Automated barriers and/or sophisticated intrusion detection systems prevent passengers and trespassers from entering the train's guideway space

Introduction: **Conversions!!**

2009 Nuremburg U-Bahn converts U2 Line to fully automated operations

2012 **Paris**

Converts oldest and busiest line to UTO!

Second UTO conversion underway

2013 Sao Paulo Brazil Metro converting to UTO

Introduction: Sources and Objectives

Sources

- reported experiences of many UTO metros and
- onsite visits to interview management operating or building several UTO lines.

Objectives

- introduce UTO metro operations to the American public transit community,
- highlight the benefits
- review the challenges

Agenda

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UITP Observatory of Automated Metros

International Association of Public Transport

- 3,400 members from 92 countries
- most active in research and information sharing concerning UTO Metros.

OBSERVATORY OF AUTOMATED METROS

- Based in Barcelona
- Hosts regular global seminars
- Maintains Atlas of Automated Metros

Observatory of Automated Metros recognizes an automated Metro when three criteria are met.

1. Trains must operate without any staff onboard.
2. Trains must operate with a minimum capacity of 100 passengers/train.
3. Trains must be part of the public transport network.

Private lines including airport services and people movers are discarded.

UTO's Technological Building Blocks

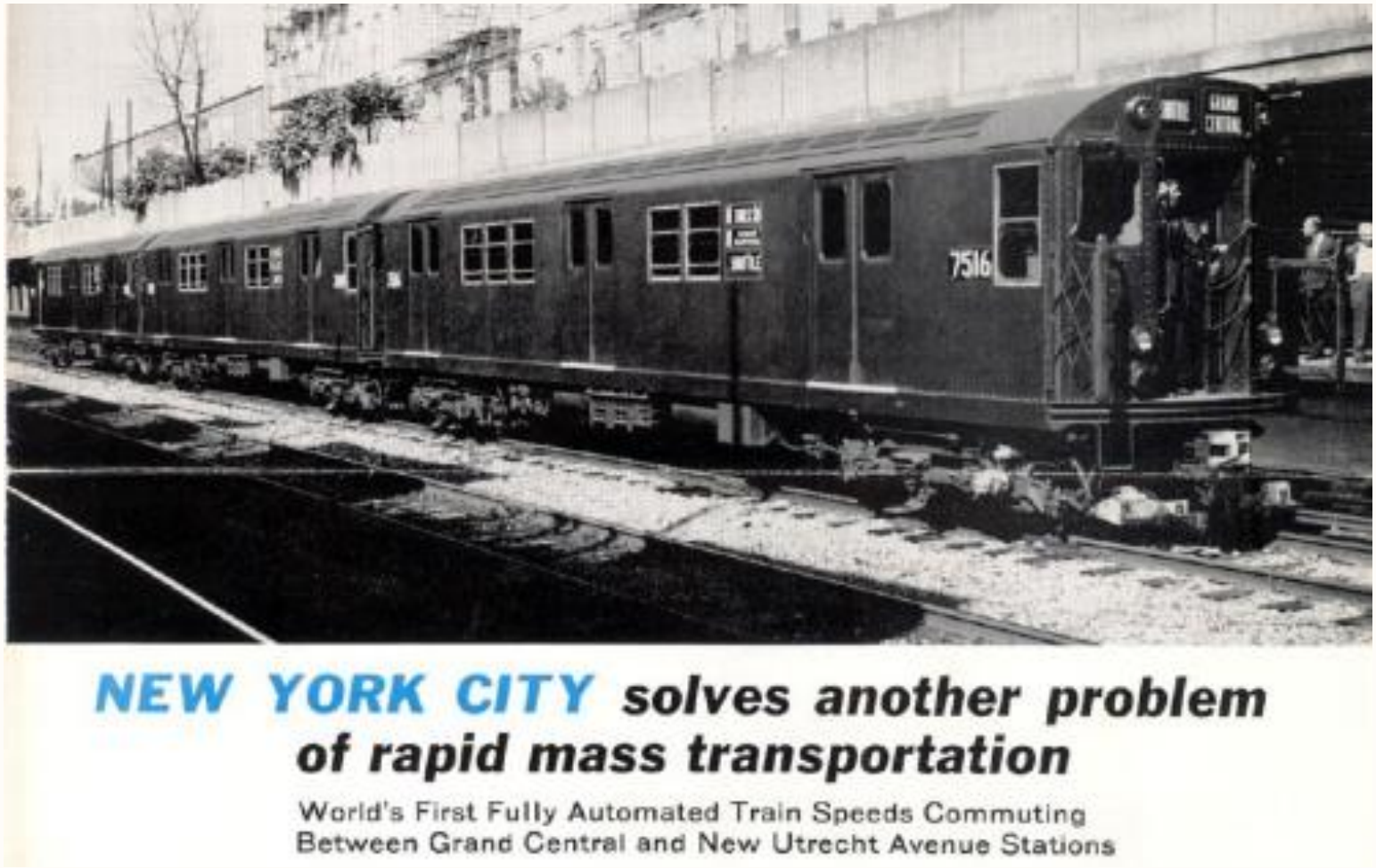
ATP **Automatic Train Protection** ensures safety making certain that trains avoid collisions, respect signals and operate within speed limits;

ATO **Automatic Train Operation** runs the trains as it provides for train piloting and driverless functionalities

ATC **Automatic Train Control** coordinates service delivery with route setting, headway regulation, schedule adherence and service management.

Pioneers of Automated Operations

The first modern driverless trains ran between Times Square and Grand Central Station from January 1962 until April 1964



Pioneers of Automated Operations

Westinghouse demonstrated its “Skybus” system on fairgrounds in Pittsburgh from 1965 to 1975

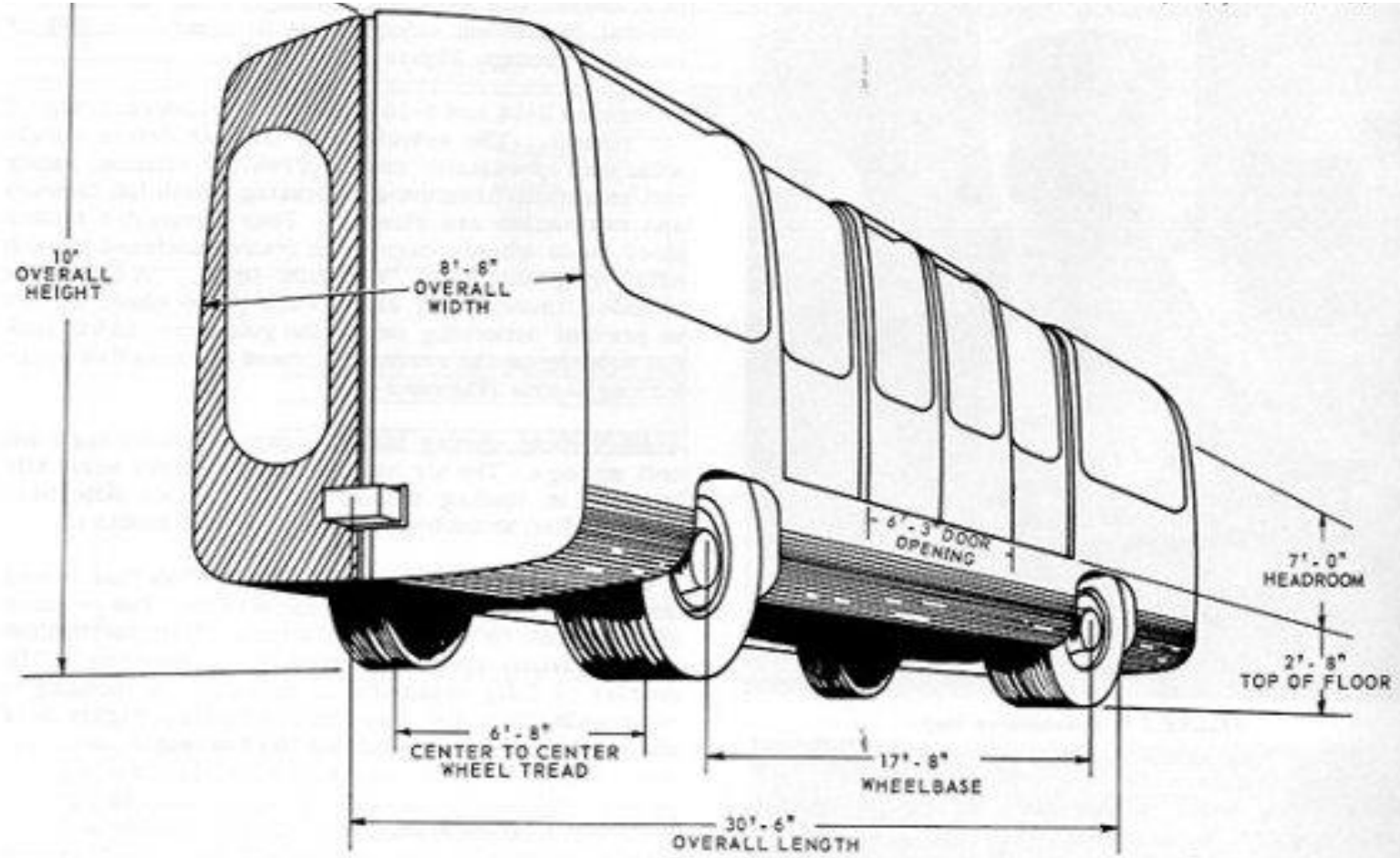


FIGURE 2-10 Vehicle Dimensions

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Pioneers of Automated Operations

West Virginia University opened a fully automated system in 1975

This system is still operating 38 years later.

Pioneers of Automated Operations

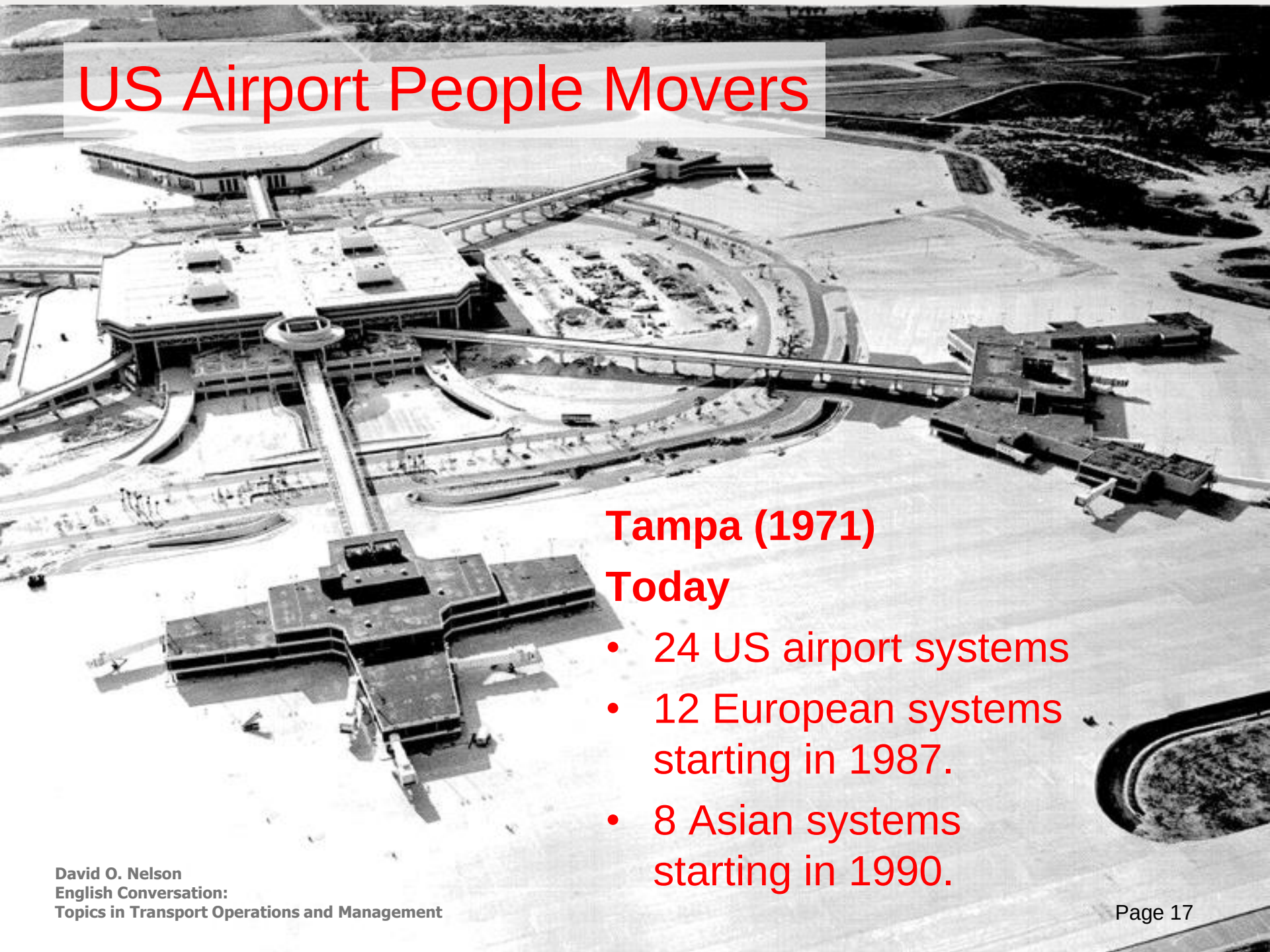
1974 Downtown People Mover Program

U.S. Department of Transportation
Urban Mass Transportation Administration

Low volume systems eventually built in:

- Miami
- Detroit
- Jacksonville

US Airport People Movers



Tampa (1971)

Today

- 24 US airport systems
- 12 European systems starting in 1987.
- 8 Asian systems starting in 1990.

Pioneers of Automated Operations

The newest US Metros including lines in

- Philadelphia,
- San Francisco,
- Atlanta,
- Miami and
- Washington DC

employ many (or most) of the technological building blocks necessary for driverless operation

but all employ operators on every train.

The rest of the world wasn't standing still

1983: First Full Scale Automated Metro opens in Lille

- 45 route kilometers (28 miles)
- 60 stations
- 270,000 weekday riders.

Four more cities were added in the 80's

Source: Ramon Malla Atlas of Automated Metros 2013

1990's Three new French systems
Four new Asian Systems

Source: Ramon Malla Atlas of Automated Metros 2013

Today: 48 UTO lines in 32 cities.

Source: Ramon Malla Atlas of Automated Metros 2013

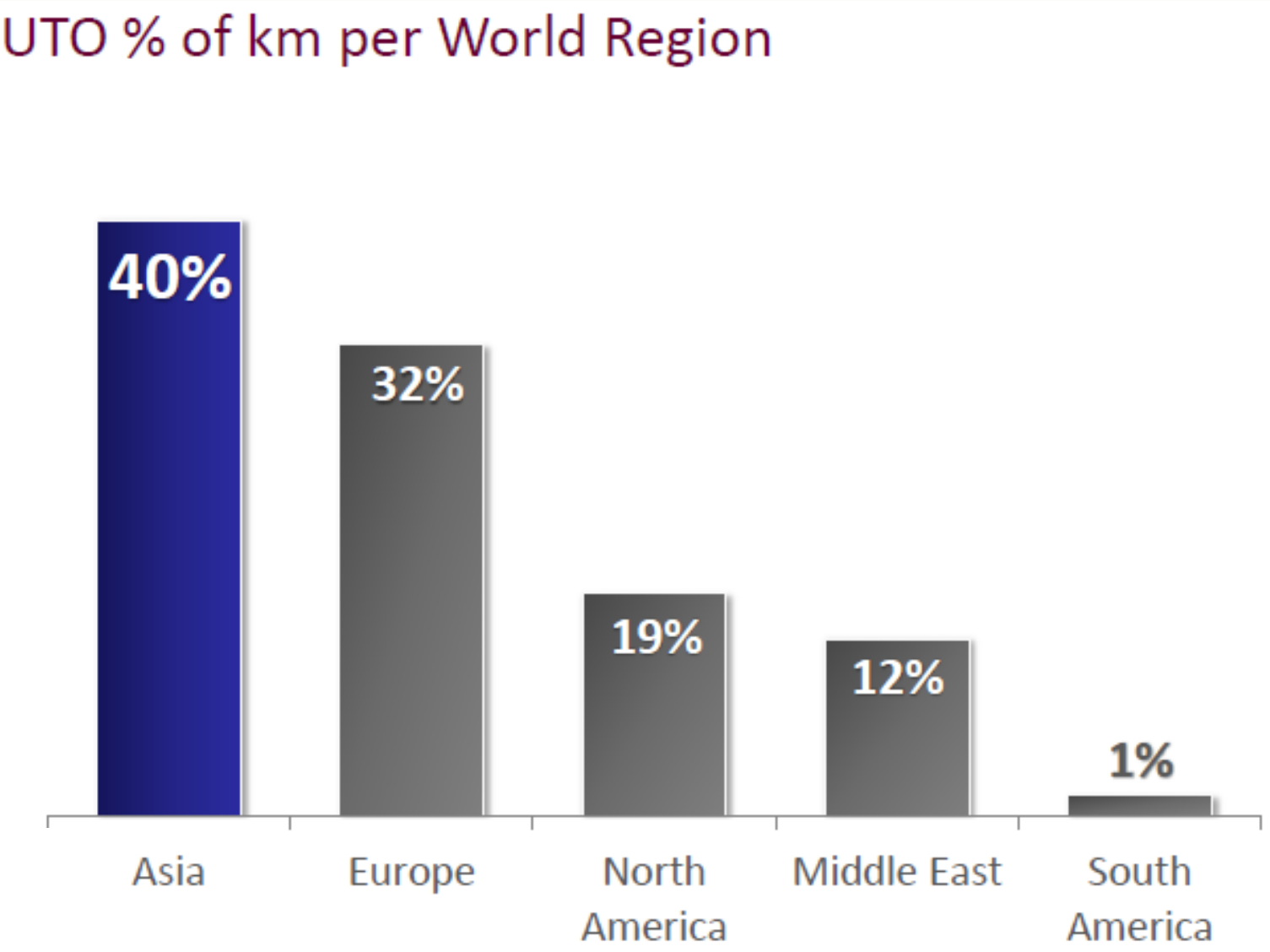
Progress continues in this decade

- Two new systems have opened in Korea,
- South America opened its first UTO line (Sao Paulo)
- Two existing legacy lines in Europe have been converted to driverless operation.
- Conversion of a third legacy line is underway

Highlights from the 2013 UTO Atlas

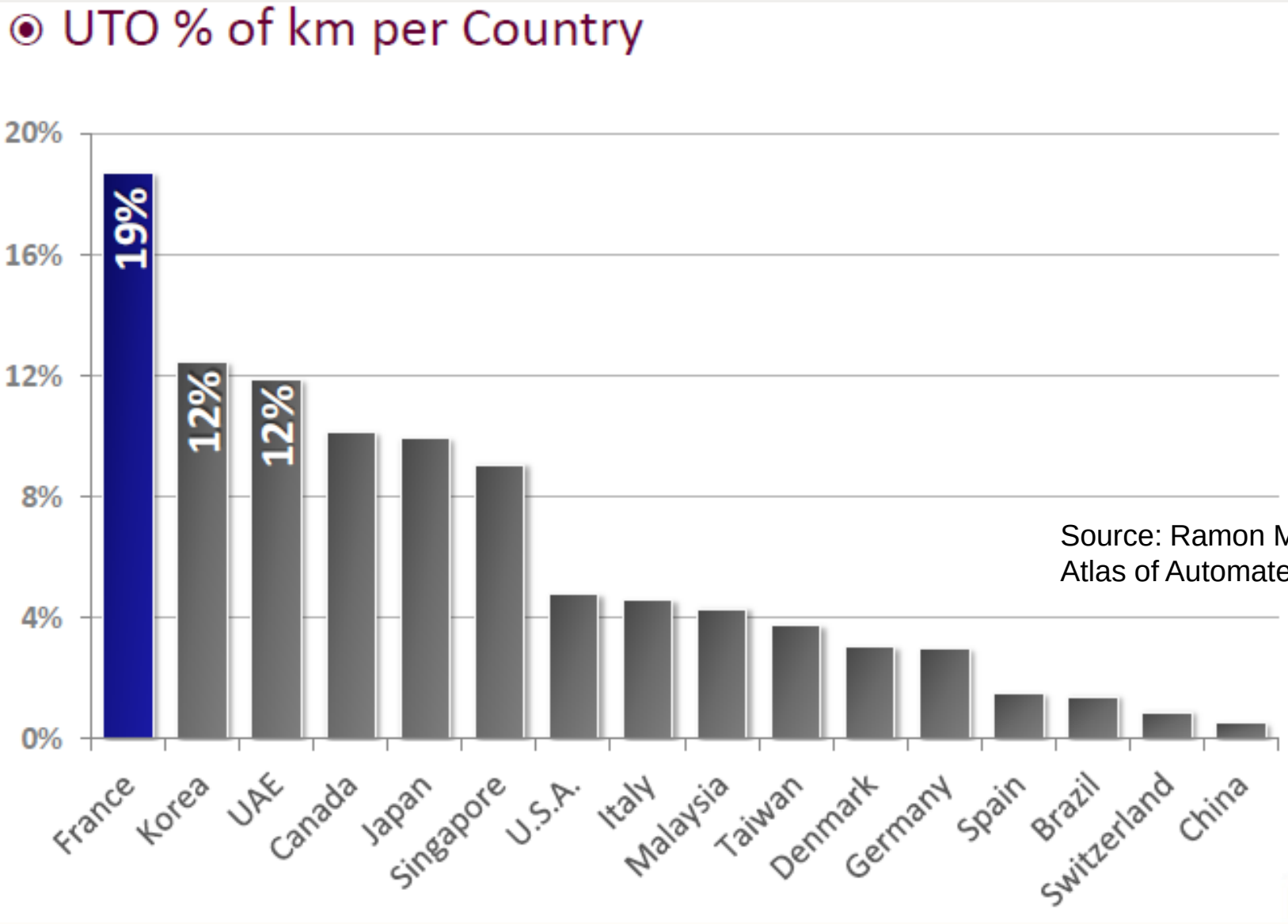
- **48 lines in 32 cities.**
- **674 route kilometers servicing 700 stations.**
- 40% of all UTO kilometers are in Asia, 32% in Europe.
- 19% of all UTO kilometers are in France!
- All UTO routes are grade separated, with the route kilometers of UTO almost exactly split 50/50 between underground and elevated construction.
- More than 2/3rds of UTO trains are designed to carry more than 300 passengers per train.
- 86% of new UTO stations use Platform Screen Doors (PSDs) to keep passengers and trespassers off the guideway.

Highlights from the 2013 UTO Atlas



Source: Ramon Malla Atlas of Automated Metros 2013

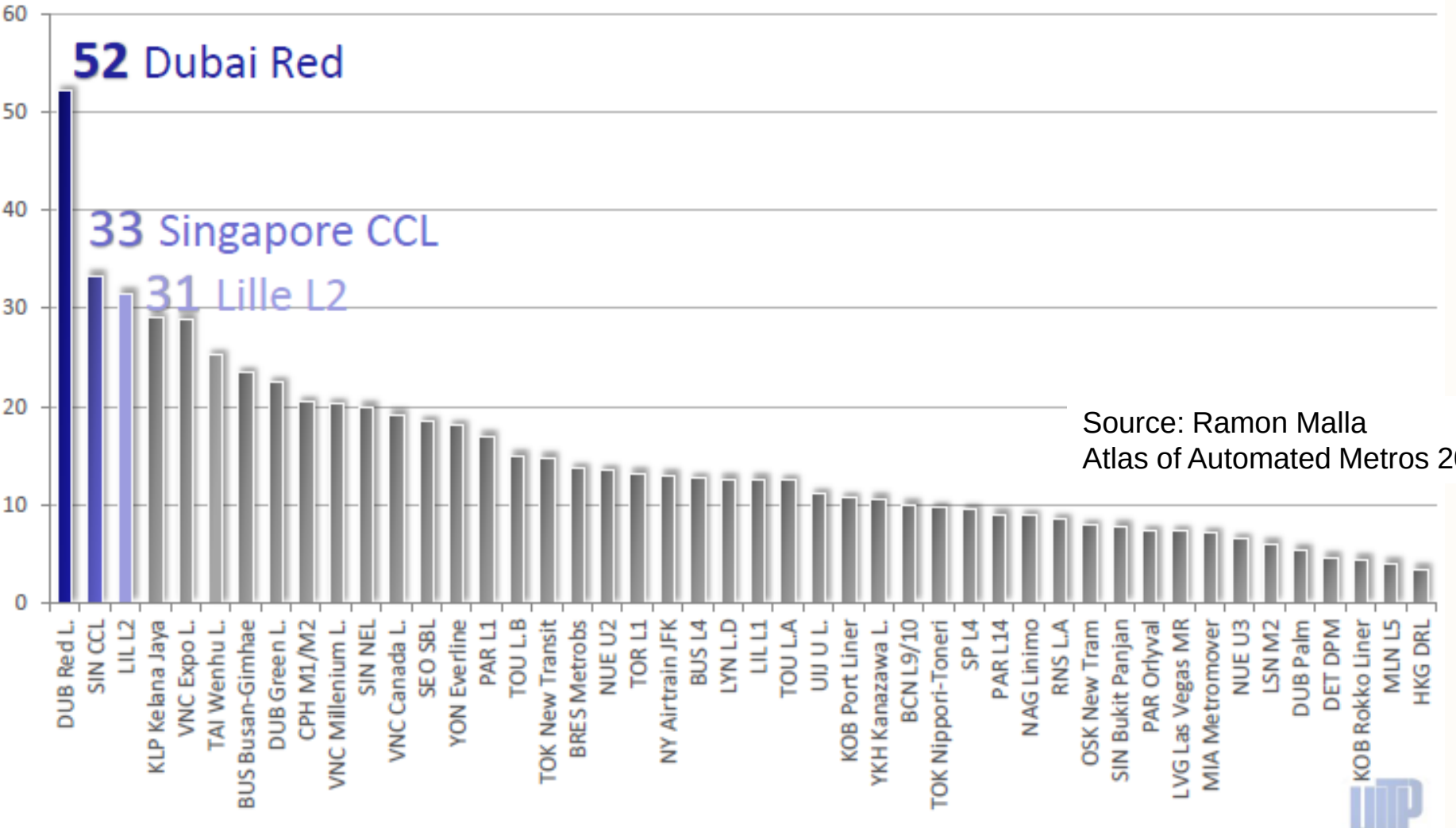
Highlights from the 2013 UTO Atlas



Source: Ramon Malla
Atlas of Automated Metros 2013

Highlights from the 2013 UTO Atlas

UTO lines length *(in km)*



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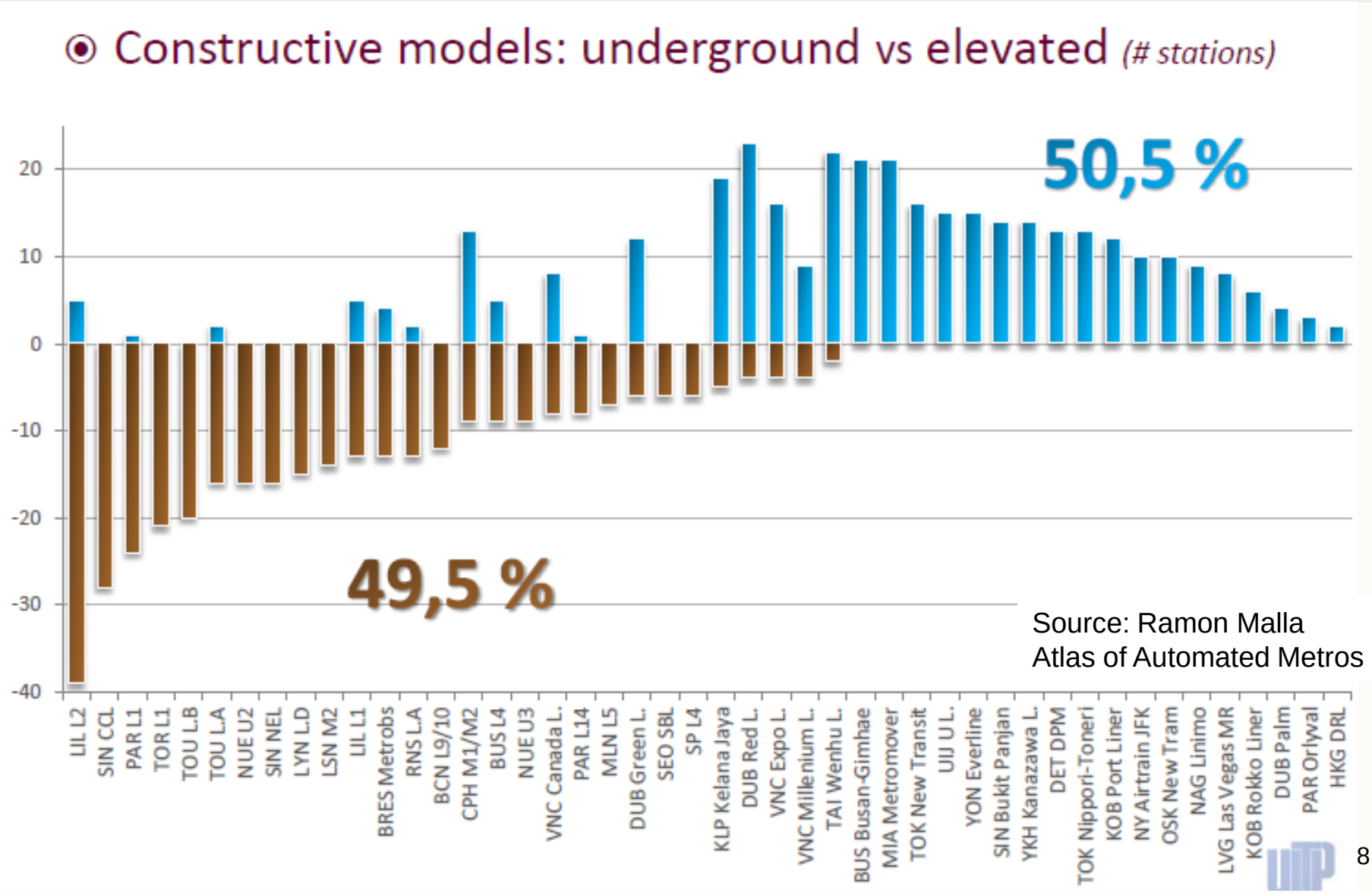
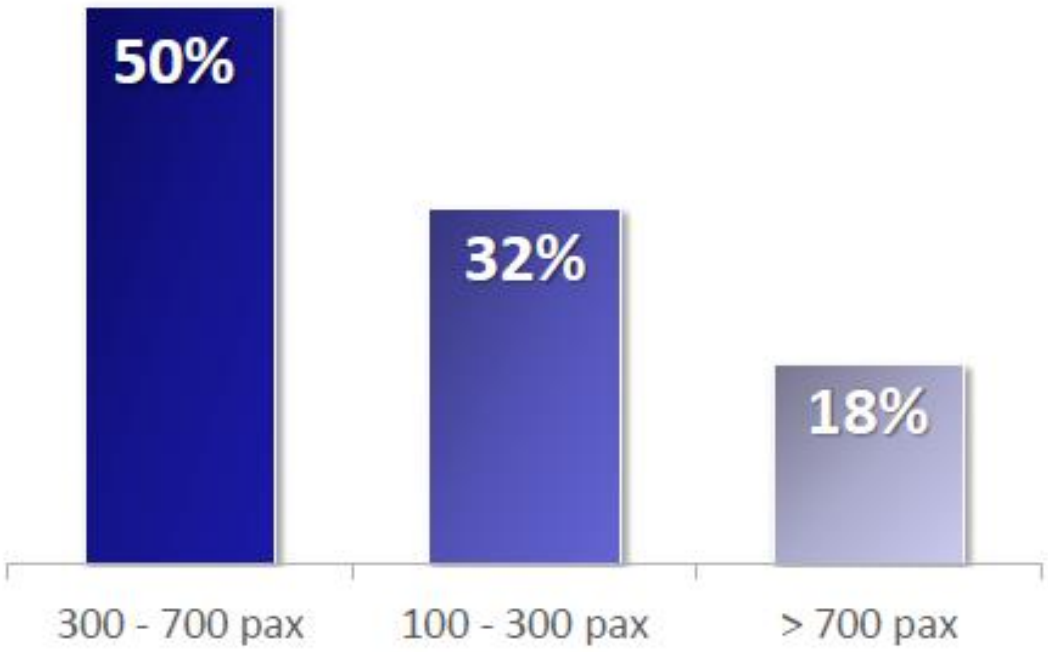


Source: Ramon Malla
Atlas of Automated Metros 2013

Highlights from the 2013 UTO Atlas

Line Capacity: passengers per train *(as a % of km)*

< 300 pax/train



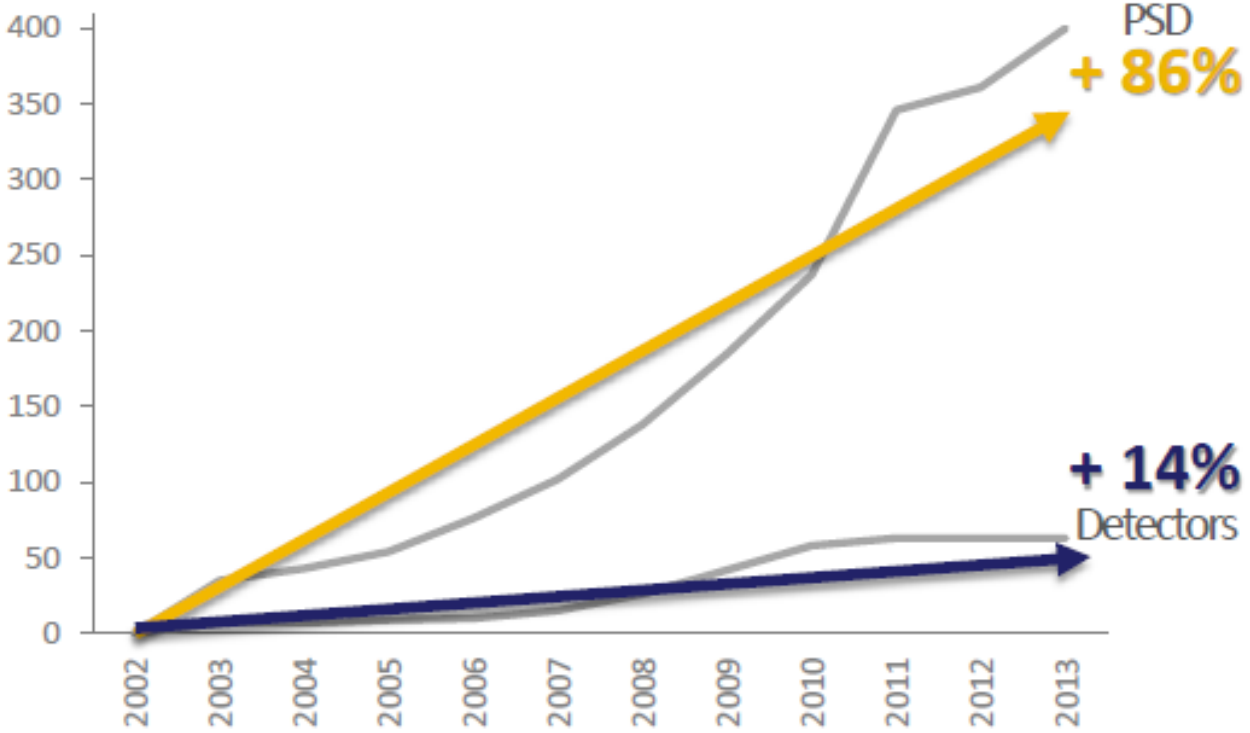
Source: Ramon Malla
Atlas of Automated Metros 2013

Highlights from the 2013 UTO Atlas

- Track Protection Systems: Platform Screen Doors vs Intrusion Detection Systems *(as a % of last decade new stations)*

Platform Screen Doors

Intrusion Detectors



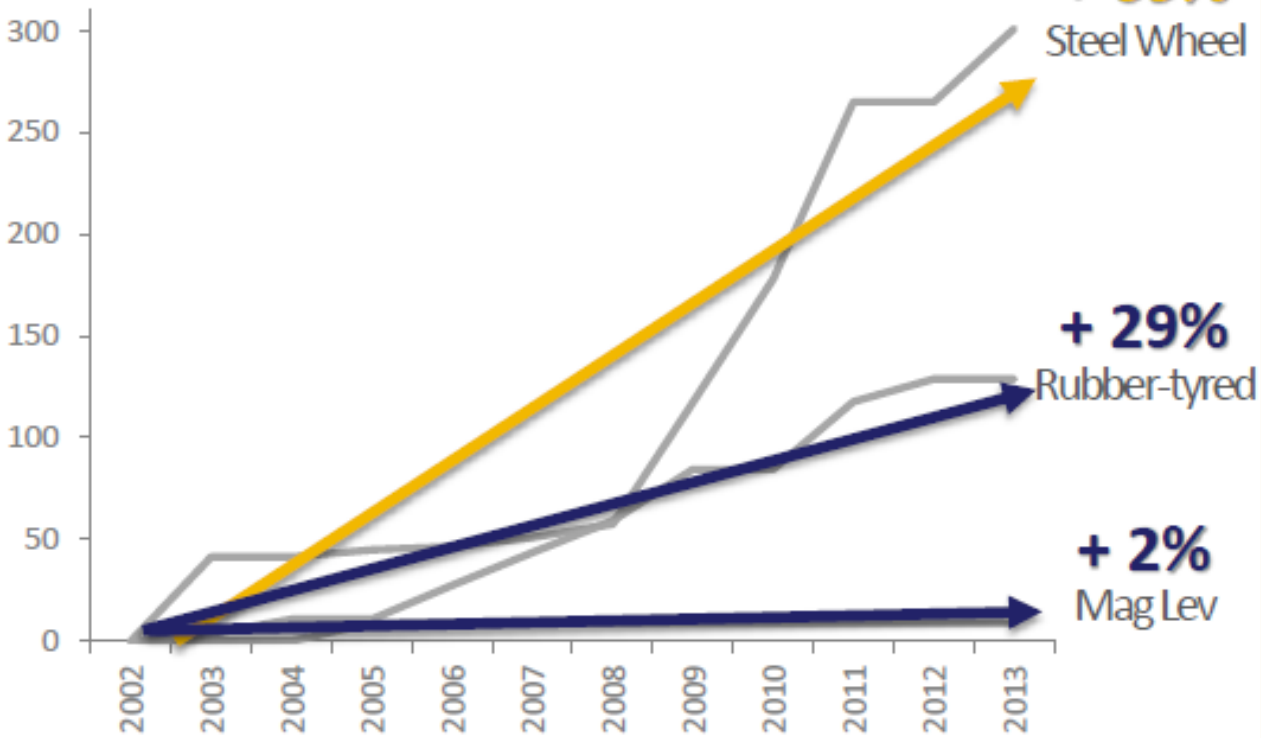
Source: Ramon Malla
Atlas of Automated Metros 2013

Highlights from the 2013 UTO Atlas

Wheel Systems: Rubber vs Steel *(as a % of last decade new km's)*

Rubber tyred

Steel Wheel



Source: Ramon Malla
Atlas of Automated Metros 2013

- UTO Metros are no longer an exotic innovation.

They are integral to the worldwide public transport landscape.

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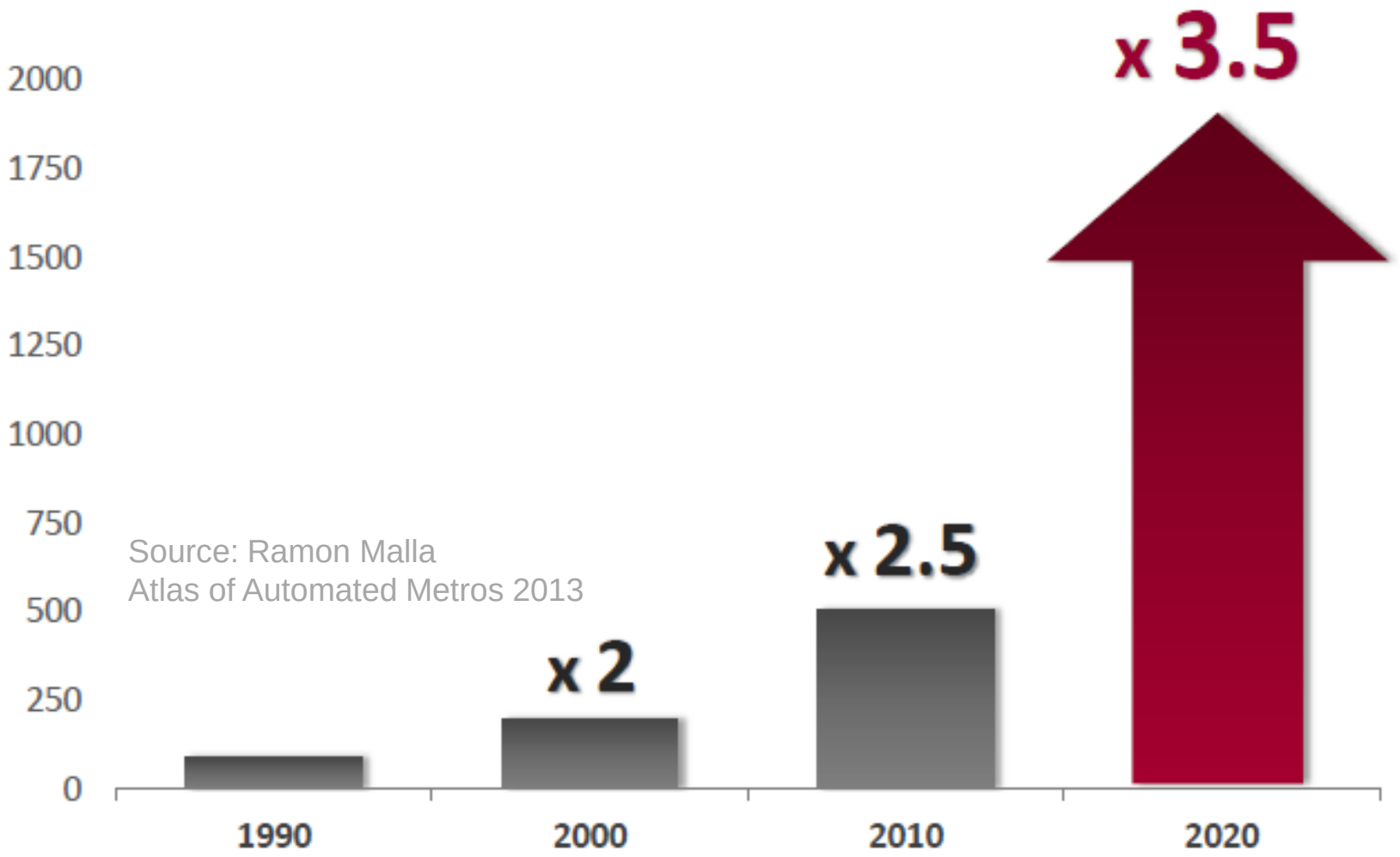
Future Trends from the 2013 UTO Atlas

- Exponential **growth!** relative to previous decade

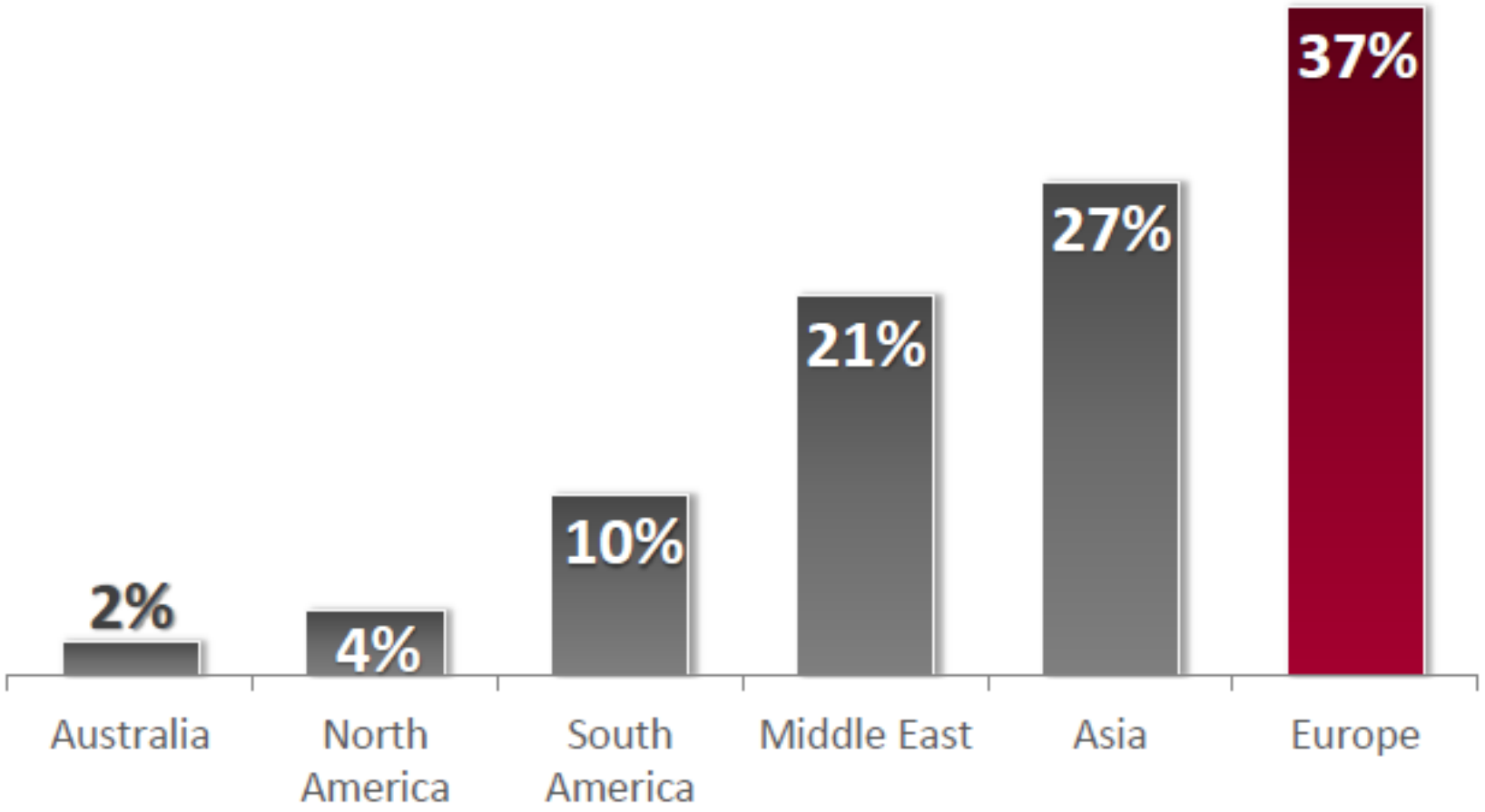


Source: Ramon Malla
Atlas of Automated Metros 2013

Future Trends from the 2013 UTO Atlas

- Worldwide **growth distribution** *(% of new km's 2014-25)*

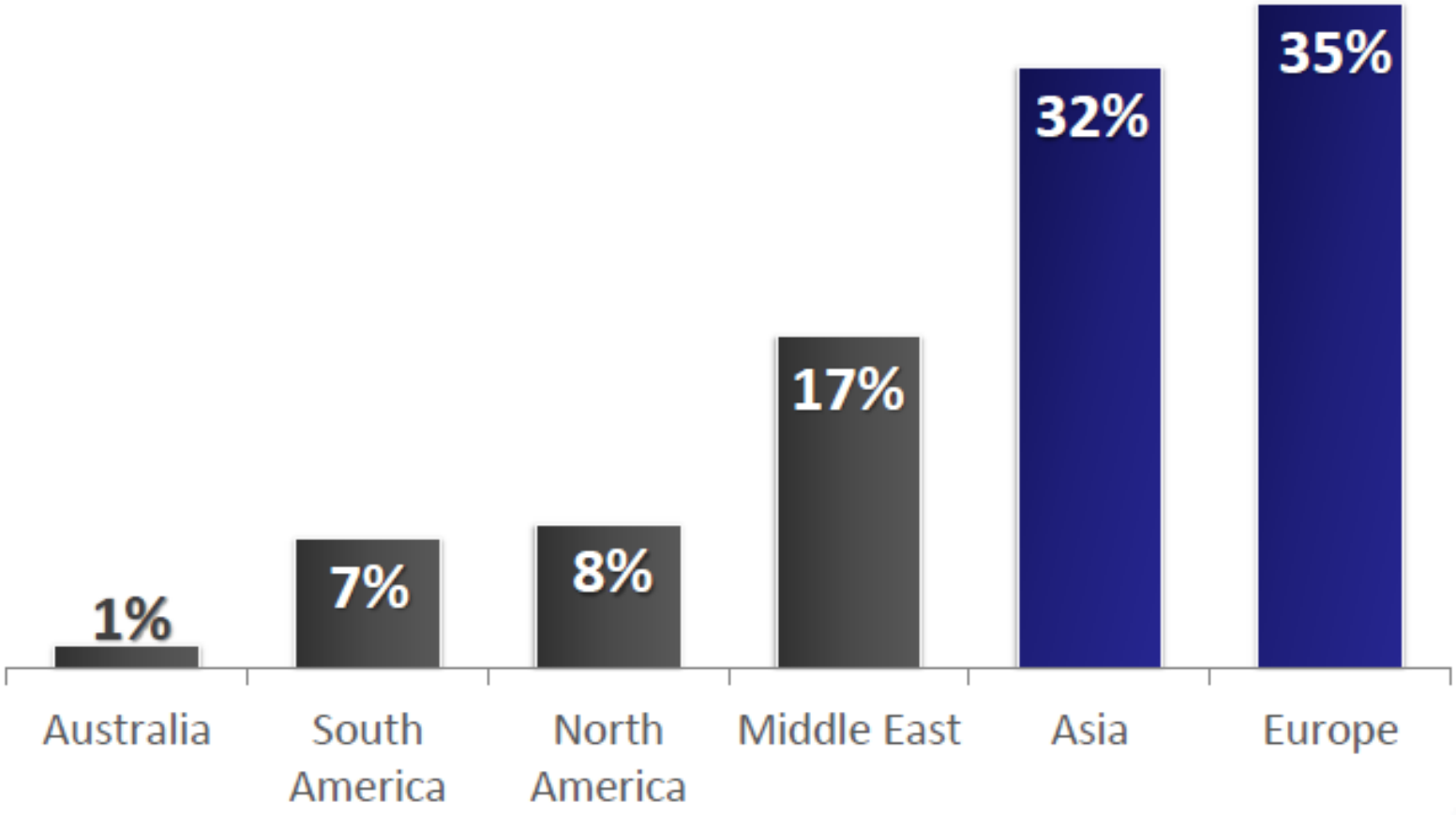
Source: Ramon Malla
Atlas of Automated Metros 2013



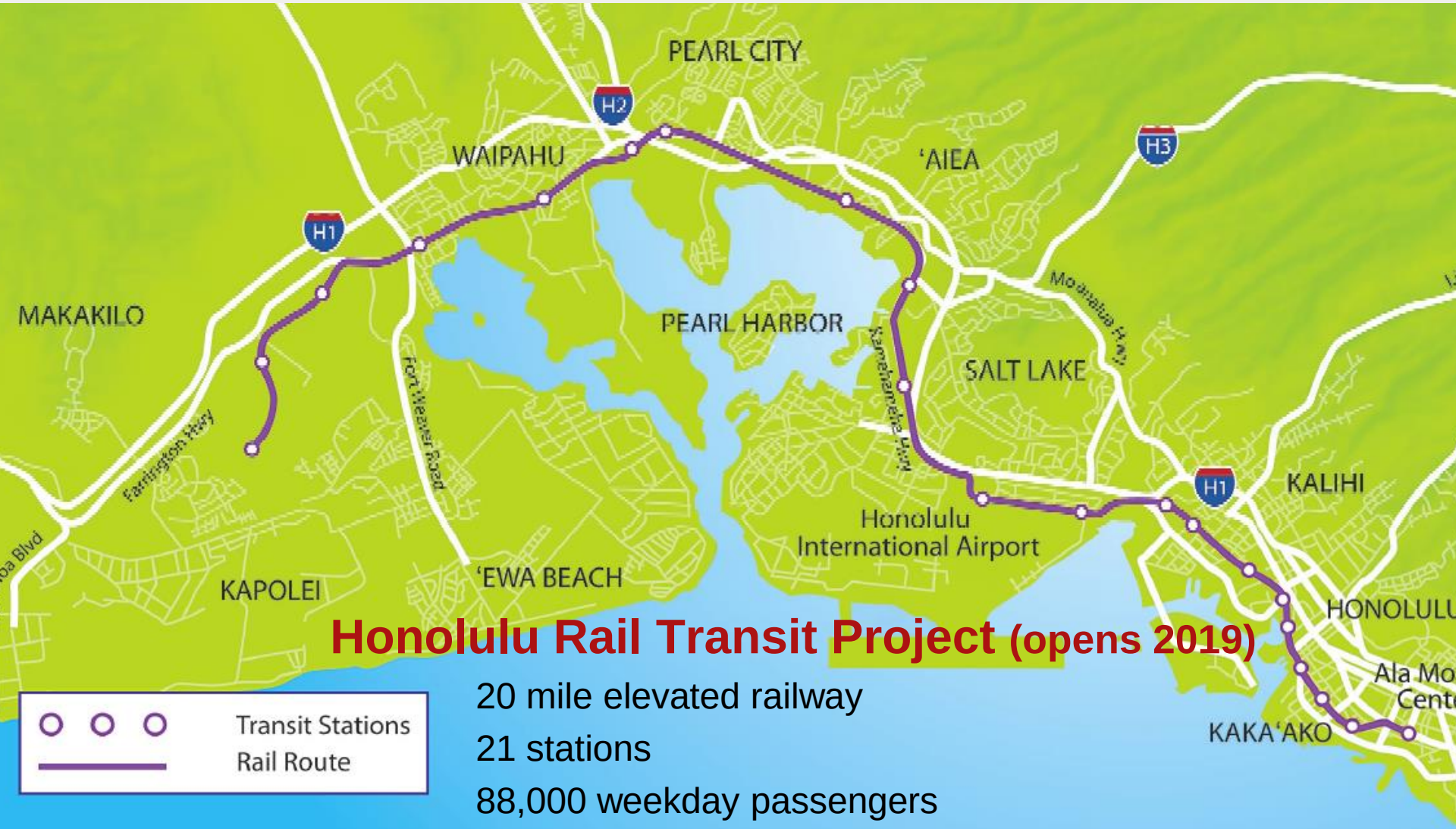
Future Trends from the 2013 UTO Atlas

- UTO km % per World Region in 2025

Source: Ramon Malla
Atlas of Automated Metros 2013



Honolulu: US first large scale UTO Metro



Honolulu Rail Transit Project (opens 2019)

20 mile elevated railway

21 stations

88,000 weekday passengers

Fully automated operations

Planned Future Developments Worldwide

Source: Ramon Malla
Atlas of Automated Metros 2013

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Opportunities from UTO Metro Operations

- Lower staffing costs.
- Shorter headways and passenger waiting times
- Shorter dwell times
- More reliable and robust operation
- High levels of safety and security
- Elimination of boring but stressful jobs
- Greater service flexibility
- Greater capacity and passenger space
- Smaller vehicle fleets.
- Lower energy consumption

Lower Staffing Costs

- Staff savings available from UTO are obvious.
- Paris transit managers reckon Line 1 payback is <10 years
- Line 1 saves 200 to 300 positions from the workforce.

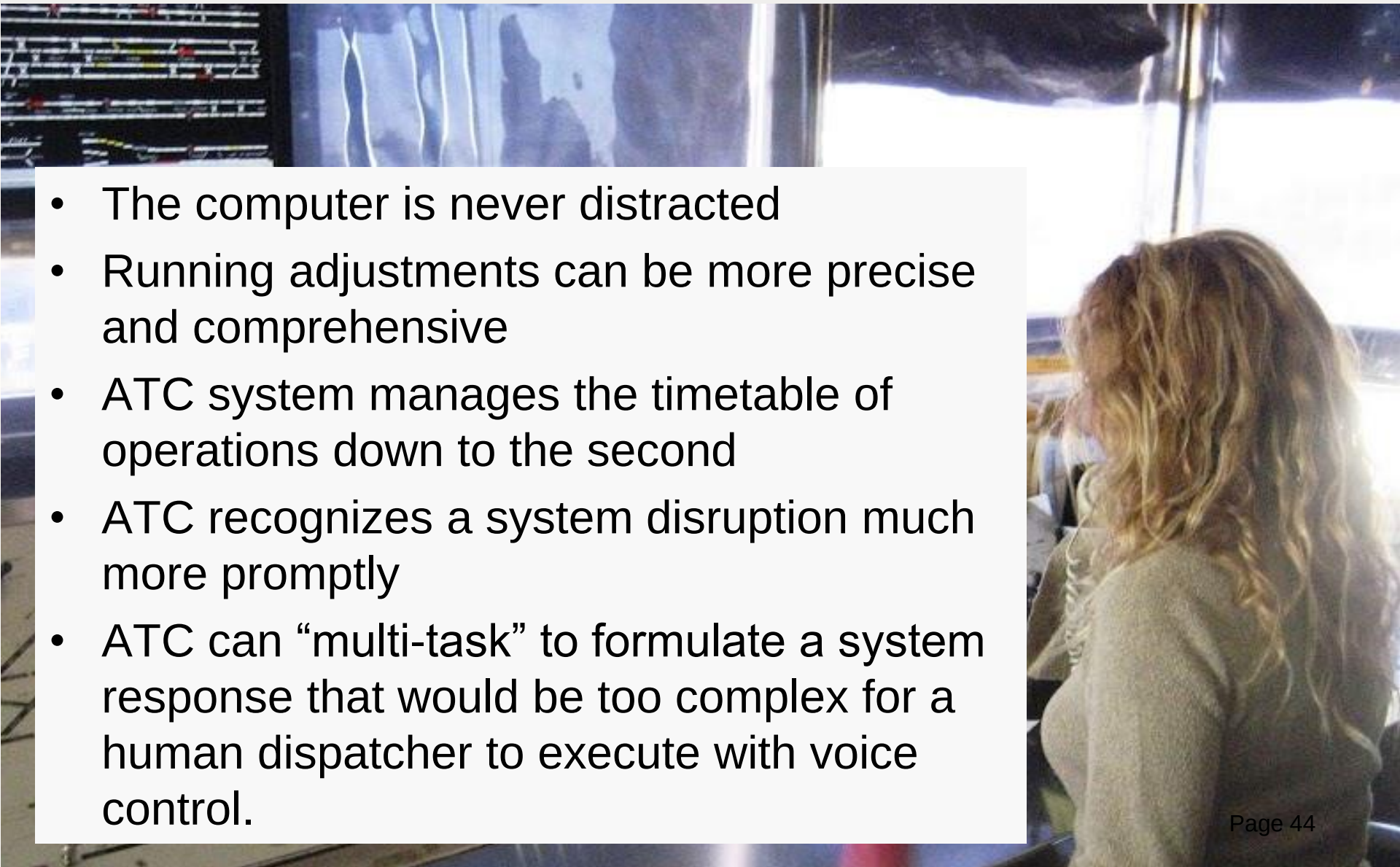
Shorter headways reduce waiting times

- Metro can run more trains without the operator’s salary.
- Shorter headways reduce passengers’ expected waiting times
- Precise train operation allows shorter minimum headways

Shorter dwell times

- More frequent arrivals reduce boardings & alightings per stop
- Less passenger activity shortens dwell times
- 42 second reduction between trains reduces dwell by ~3%.

More reliable and robust operation



- The computer is never distracted
- Running adjustments can be more precise and comprehensive
- ATC system manages the timetable of operations down to the second
- ATC recognizes a system disruption much more promptly
- ATC can “multi-task” to formulate a system response that would be too complex for a human dispatcher to execute with voice control.

High levels of safety and security

- UTO intrusion prevention and detection systems virtually eliminate suicides and trespasser fatalities
- 61% of US Metro fatalities
- UTO surveillance and customer communication systems deters criminal activity
- UTO computer is never fatigued or distracted.

UTO eliminates a boring, stressful job

- Operating a transit train is boring and repetitive
- Operating a transit train is unrelenting and stressful
- The transit train operator is isolated.
- UTO implementation eliminates this unattractive job
- UTO allows the transit agency to offer more interesting jobs

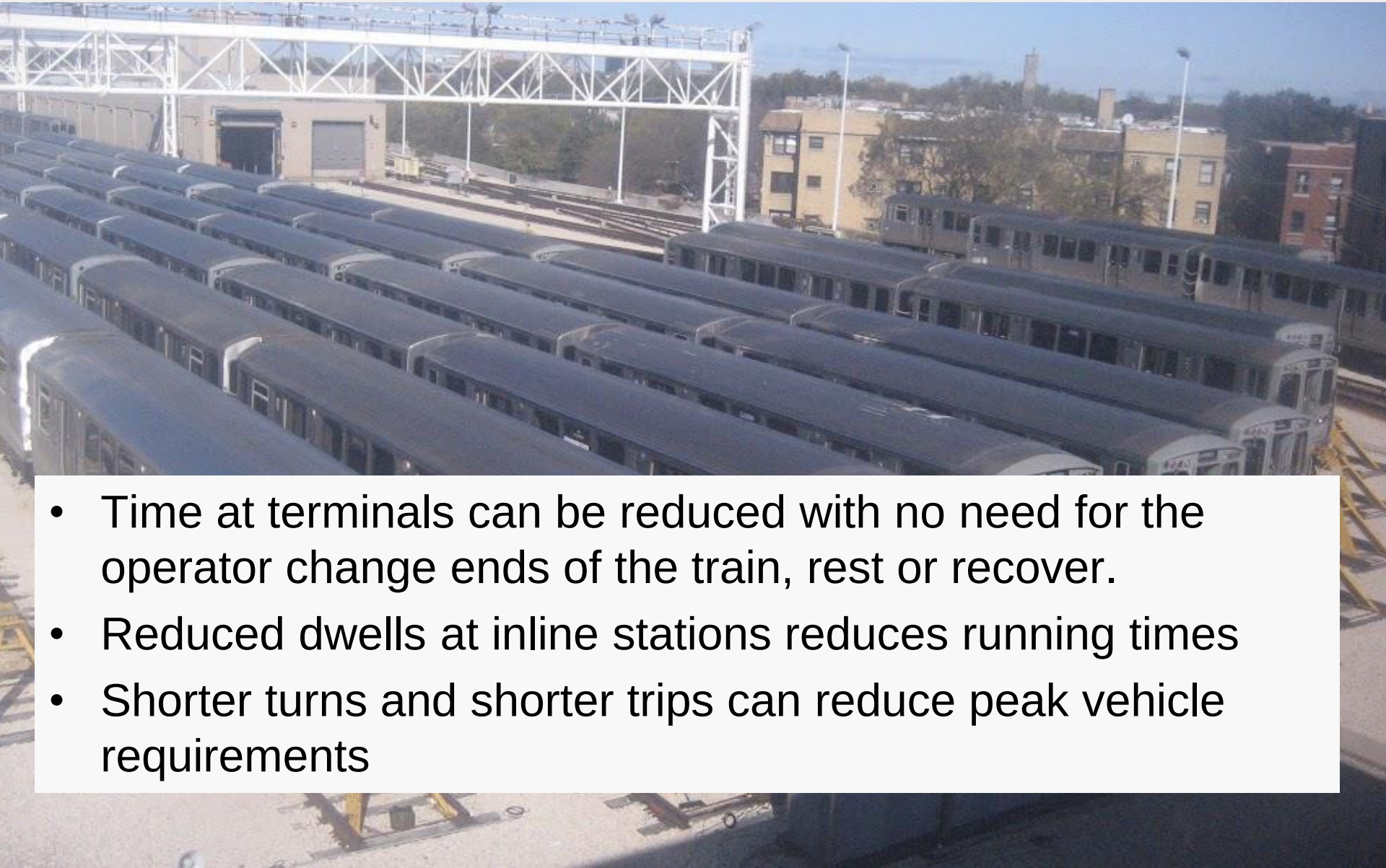
Greater service flexibility

- Ball games, festivals and school vacations get tailored service
- Dynamically adjusted service responds to market demands
- Extra service with no special pick or exorbitant overtime.
- Rush hour service can start early if a storm is coming

Greater capacity and passenger space

- Shorter headways and dwell times increase overall capacity
- More precise train control allows even shorter headways
- Elimination of the operator's cab adds passengers to end cars

Smaller vehicle fleets



- Time at terminals can be reduced with no need for the operator change ends of the train, rest or recover.
- Reduced dwells at inline stations reduces running times
- Shorter turns and shorter trips can reduce peak vehicle requirements

Lower Energy Consumption

Can UTO's be Greener?

- Coasting
- Lower Max Speeds
- Less deadheading
- Regenerative braking with coordinated stops and starts
- Staggered starts to reduce peak load

Lower Energy Consumption

UTO's can be Greener

But

- Public officials often reluctant to sacrifice speed for energy

- Day to day service adjustments can overrun coordination to reduce energy consumption

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Challenges facing UTO Metro Operations

- Safety concerns
- Workforce acceptance
- Guideway intrusions and door operations
- Staffing for unattended operation
- Terminal designs for short headways

Safety Concerns

- Some passengers and public officials can still have safety concerns about trains that seem to run by themselves.
- But citizens of the world are increasingly inured to technology

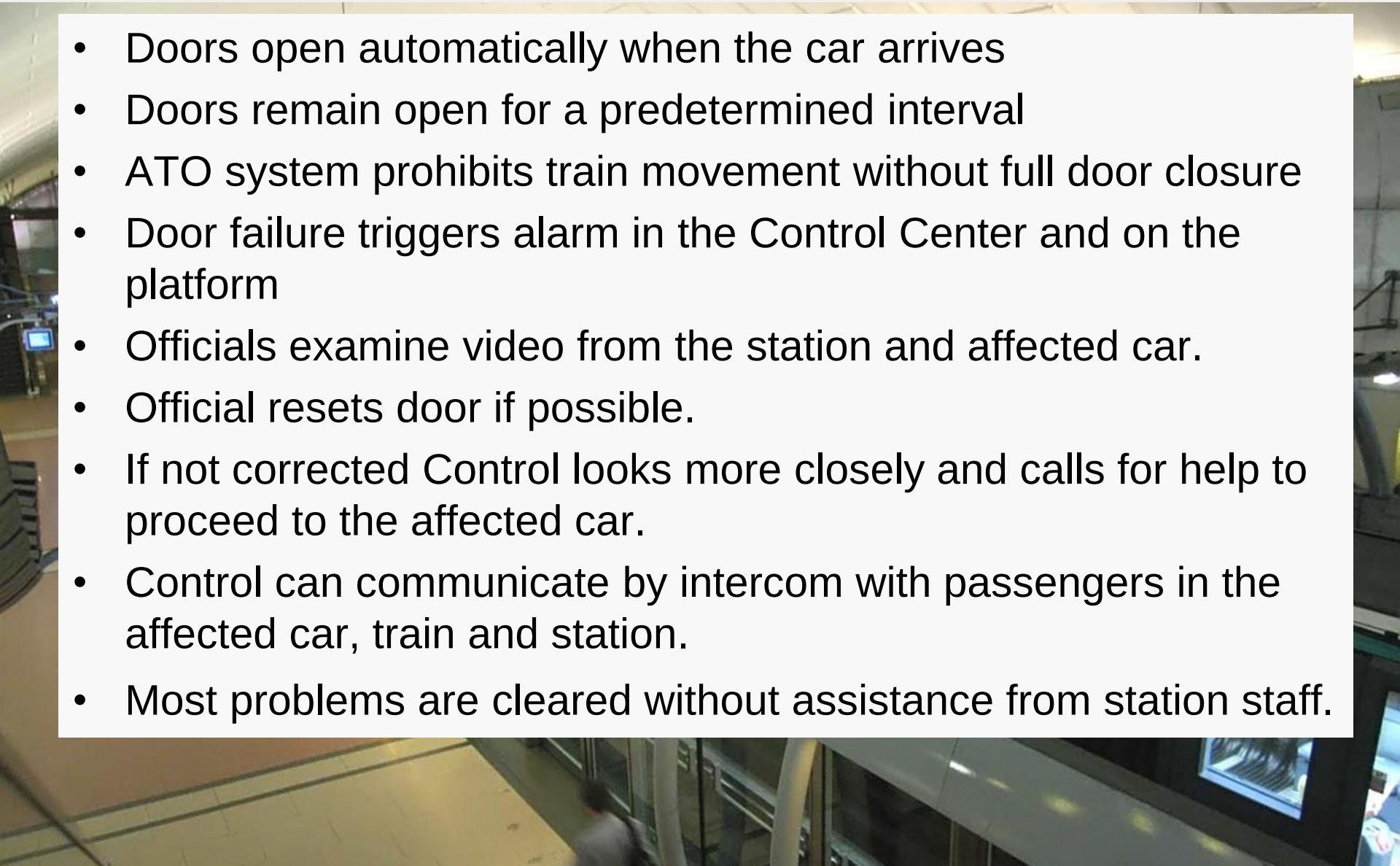
Workforce Acceptance

- Conversions can be difficult. Maybe less of a concern for new UTO lines
- Paris' Line 1 conversion started early with extensive consultation of drivers and their union representatives
- Automation characterized as part of a modernization program necessary to meet RATP's obligations to the public.
- UTO safety, capacity and service benefits align with fundamental values of drivers
- Productivity benefits were shared with labor and the trade unions.
- The most senior operators were offered early retirement.
- Redundant staff were absorbed elsewhere in Paris' extensive system.

Guideway Intrusions

- 86% of the world's newest UTO metros use Platform Screen Doors (PSD)
- 14% use intrusion detection systems
- All use a mix of surveillance and communication technologies to ensure passenger safety and security
- Managers in Paris feel their UTOs would be impossible without PSDs.
- Intrusion detections create frustrating false alarms

Door Operations

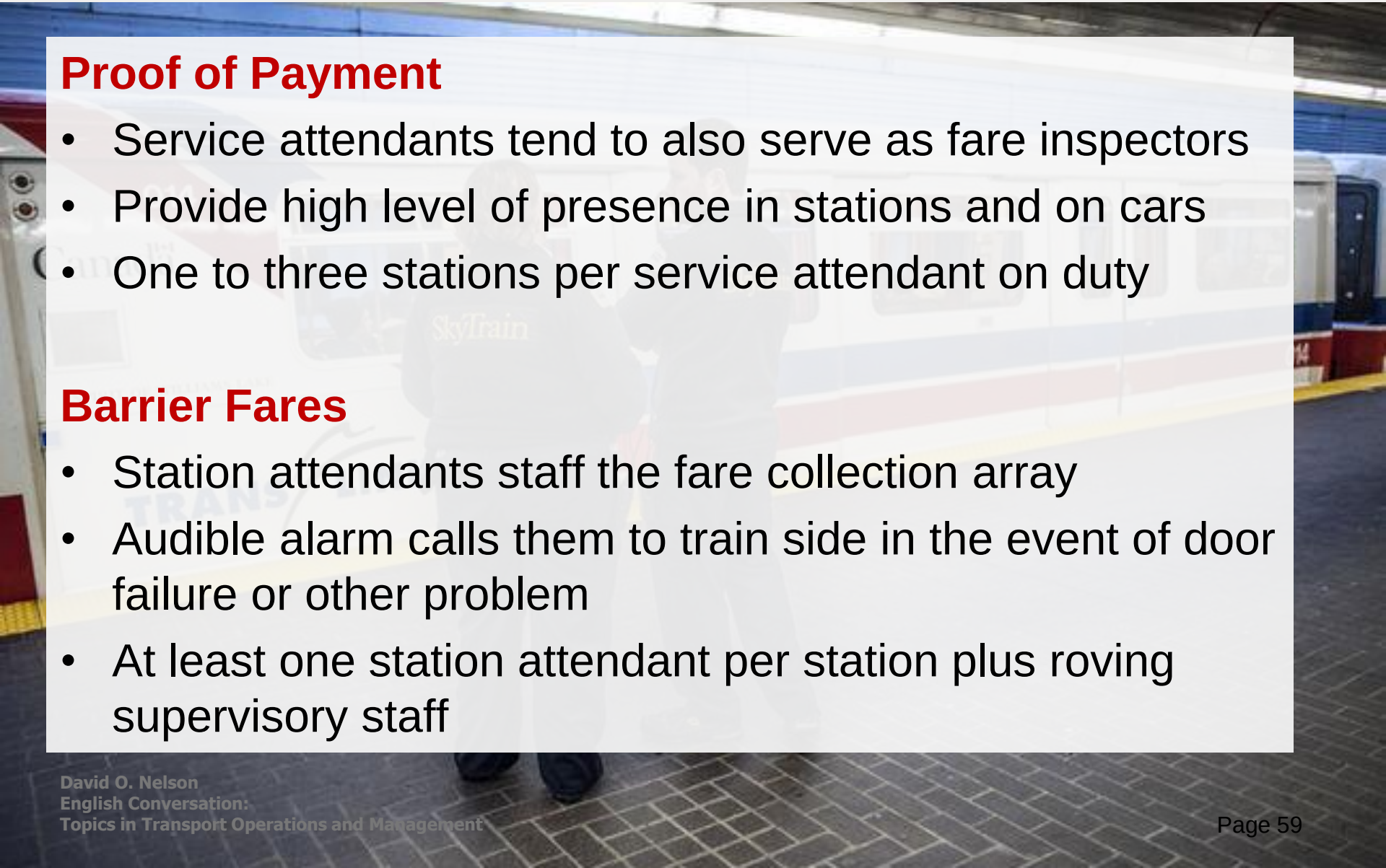


- Doors open automatically when the car arrives
- Doors remain open for a predetermined interval
- ATO system prohibits train movement without full door closure
- Door failure triggers alarm in the Control Center and on the platform
- Officials examine video from the station and affected car.
- Official resets door if possible.
- If not corrected Control looks more closely and calls for help to proceed to the affected car.
- Control can communicate by intercom with passengers in the affected car, train and station.
- Most problems are cleared without assistance from station staff.

Door Operations

- ATC sets interval between door opening and closing
- Interval varies from platform to platform and by time of day
- Some ATCs vary the station dwell time to even headways and avoid closing the doors on a standing train
- Door problems, often caused by passenger obstruction, are the most common, if not the most severe, cause of delays on UTO systems.

Staffing for Unattended Operation



Proof of Payment

- Service attendants tend to also serve as fare inspectors
- Provide high level of presence in stations and on cars
- One to three stations per service attendant on duty

Barrier Fares

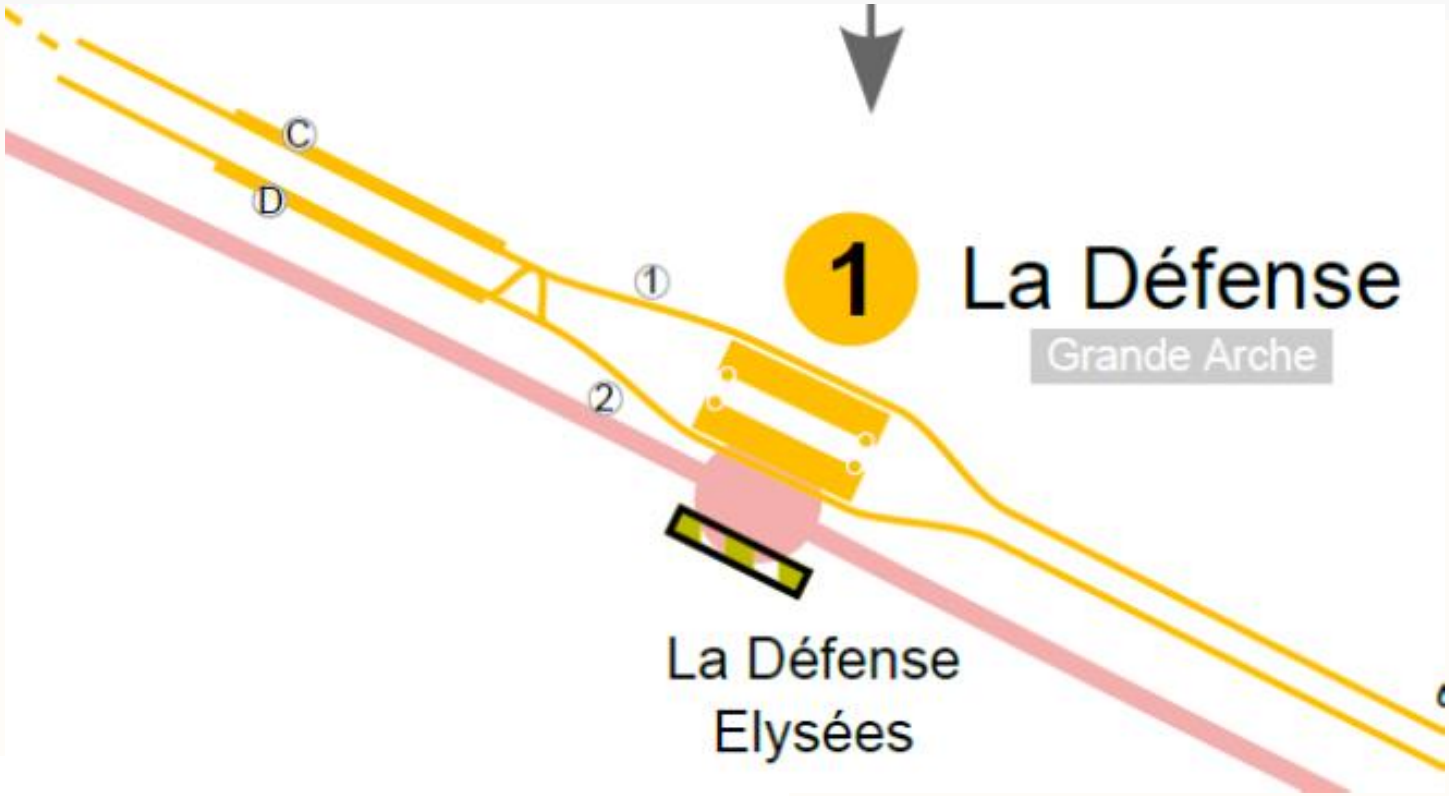
- Station attendants staff the fare collection array
- Audible alarm calls them to train side in the event of door failure or other problem
- At least one station attendant per station plus roving supervisory staff

Terminal Designs for Short Headways

- Short headways require special terminal designs
- With short headways following train can often approach the end of the line terminal before its leader has left.
- Unless the end of the line station is properly designed this can result in a recurring delay and suck capacity from the system.
- The problematic design puts the crossover between the inbound and outbound tracks on the mainline tracks.

Terminal Designs for Short Headways

The deadlock between the inbound and outbound train can be avoided with tail tracks and crossovers beyond the end of the line passenger station.



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Concluding Remarks

- Among the 54 nations with rapid transit Metro lines, the United States has the oldest and second longest network of route miles.
- UTO for rapid transit operations has gained wide acceptance around the world
- UTO provides numerous benefits in service delivery, safety and economic efficiency.

- As US transit officials consider new Metros and overhauls to legacy lines, the prospect of UTO for those lines should not be discounted or overlooked.

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