MOTT MACDONALD

Tramway Vehicle/ Infrastructure Interfaces

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Gauging and Clearances

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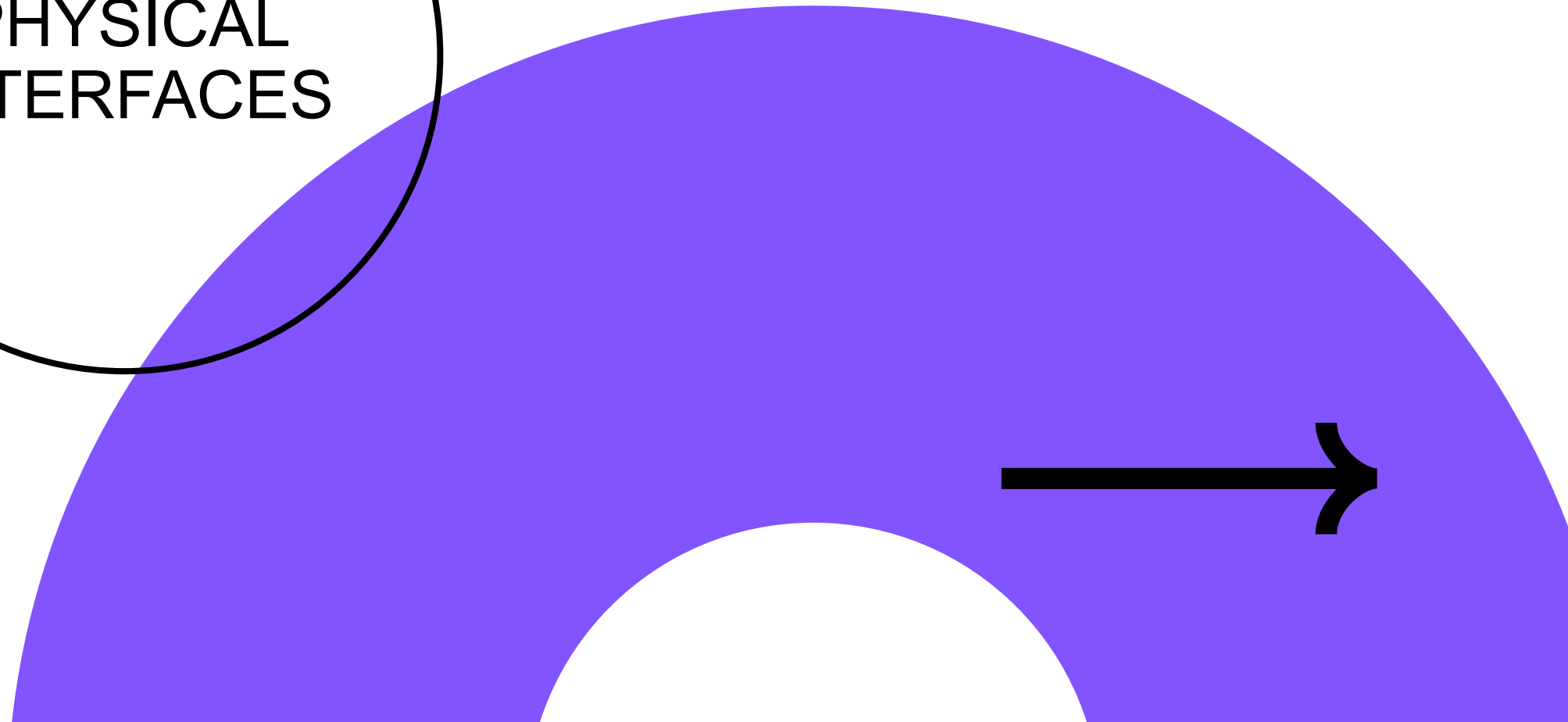
Platform/ Vehicle

Vehicle/ Infrastructure Communications

Vehicle/Road Users

PHYSICAL INTERFACES



Wheel / Rail

Wheel/Rail Interface needs to provide:

Support – Distribute load from the vehicle to the ground

Transmit – Transmit and distribute traction and braking forces from the vehicle

Guide – Guides the vehicle along the track

Detection – Provide the means of using track circuits/axle counters to detect vehicles

Traction Return – For electric vehicles provide the negative return path

Steel Wheel on Steel Rail

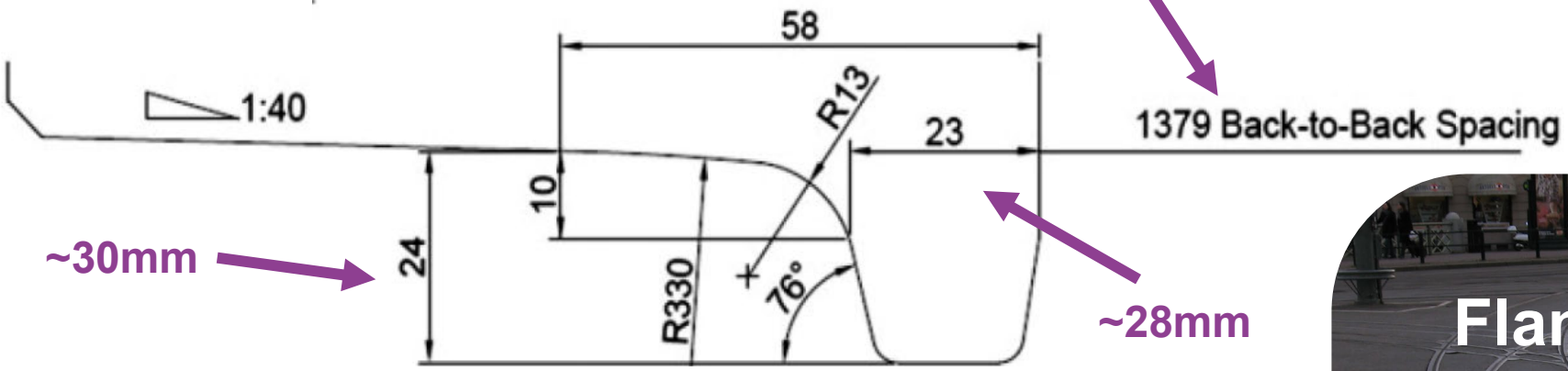
Low friction

Low energy consumption

But lower ability to withstand traction and braking forces

Vulnerable to contamination

Tramway Wheel/Rail Interaction

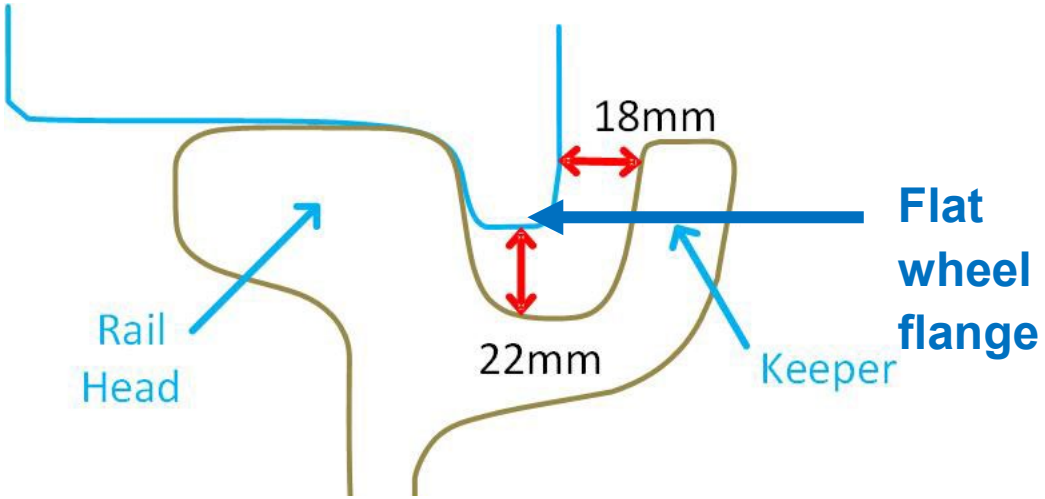


~1362mm

1379 Back-to-Back Spacing

~30mm

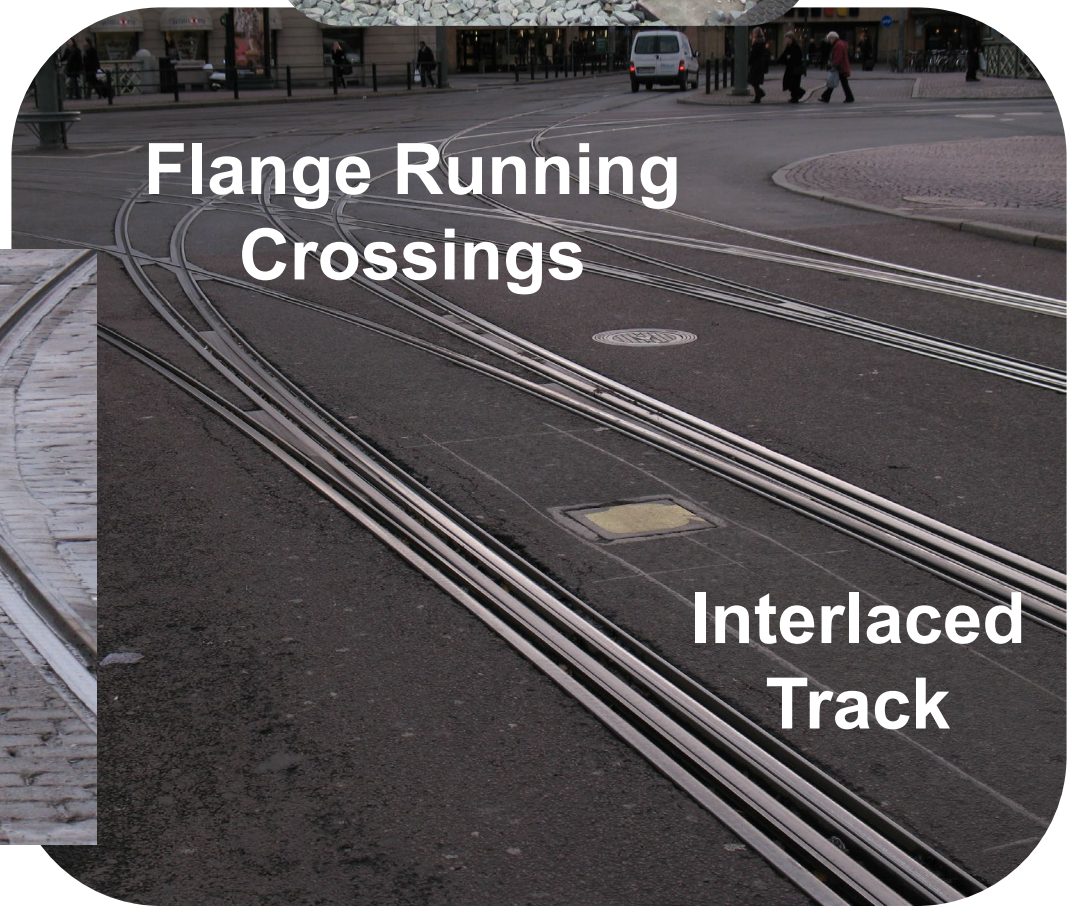
~28mm



Flat wheel flange

Check Rails Flange Way ~ 22-32mm

~38-44mm



D. Crosbee, P. Allen and R. Carroll, “Analysis of design and performance of tram-train profiles for dual-operation running,” Proc IMechE Part F: Journal of Rail and Rapid Transit, vol. 231, no. 5, pp. 578-597, 2017.

Clearances

All need to be considered:

- Contact wire to structures
- Pantograph to structures
- Roof mounted equipment to structures
- Pantograph to people
- Roof mounted equipment to people
- Height above highway
- Compliance with legislation and BS EN50122-1

Pantograph / OLE

Pantograph/Contact Wire

Stagger – tight radius curves

Wind loading

→ Pantograph width and dynamic sway

Wire height (typically ~3.8 to 6.7m)

Gradient (wire and track)

Uplift – Tension

→ Pantograph Mechanism

Degradation of Both

Carbon Pads wear, spalling and failures

Contact Wire wear

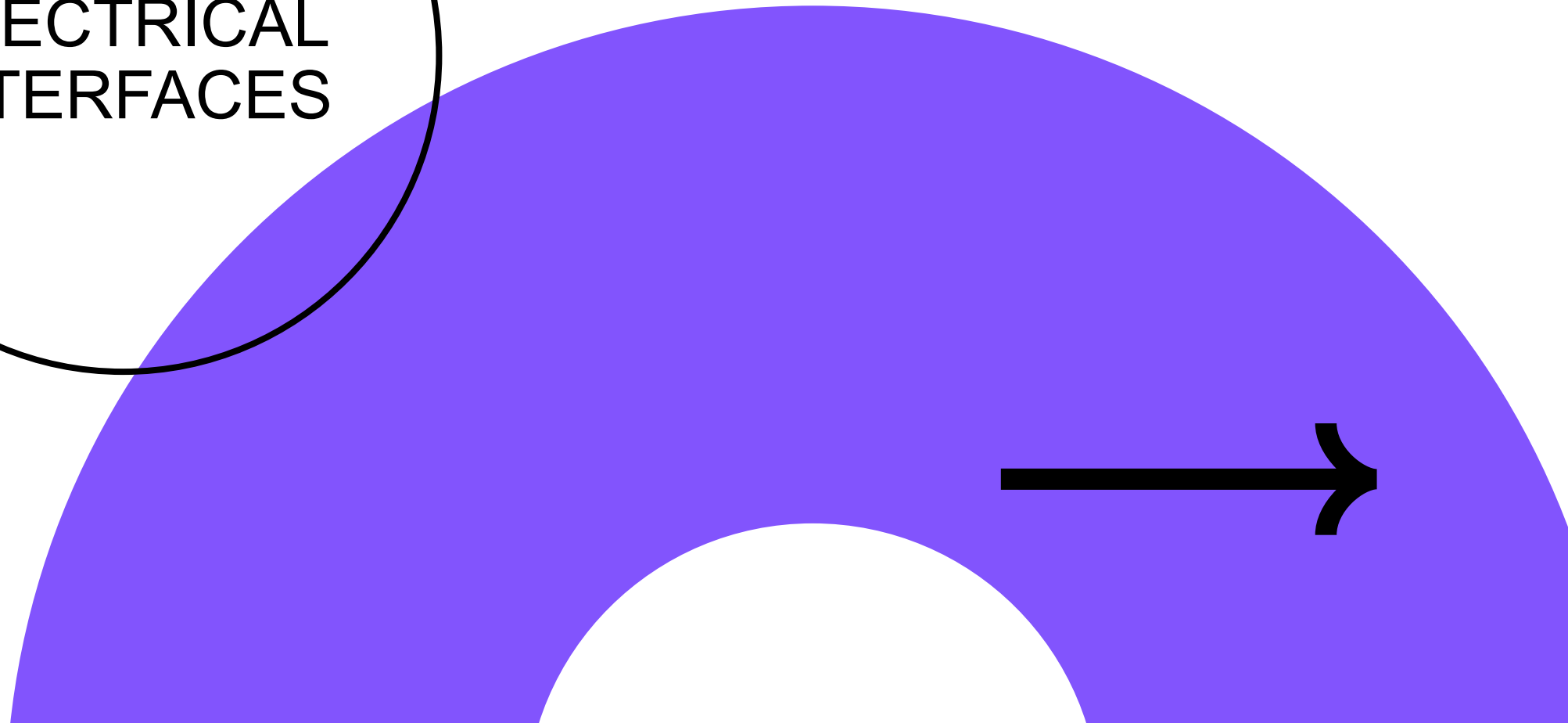
Impact of Weather – rain, ice

Heating of OLE and Pantograph

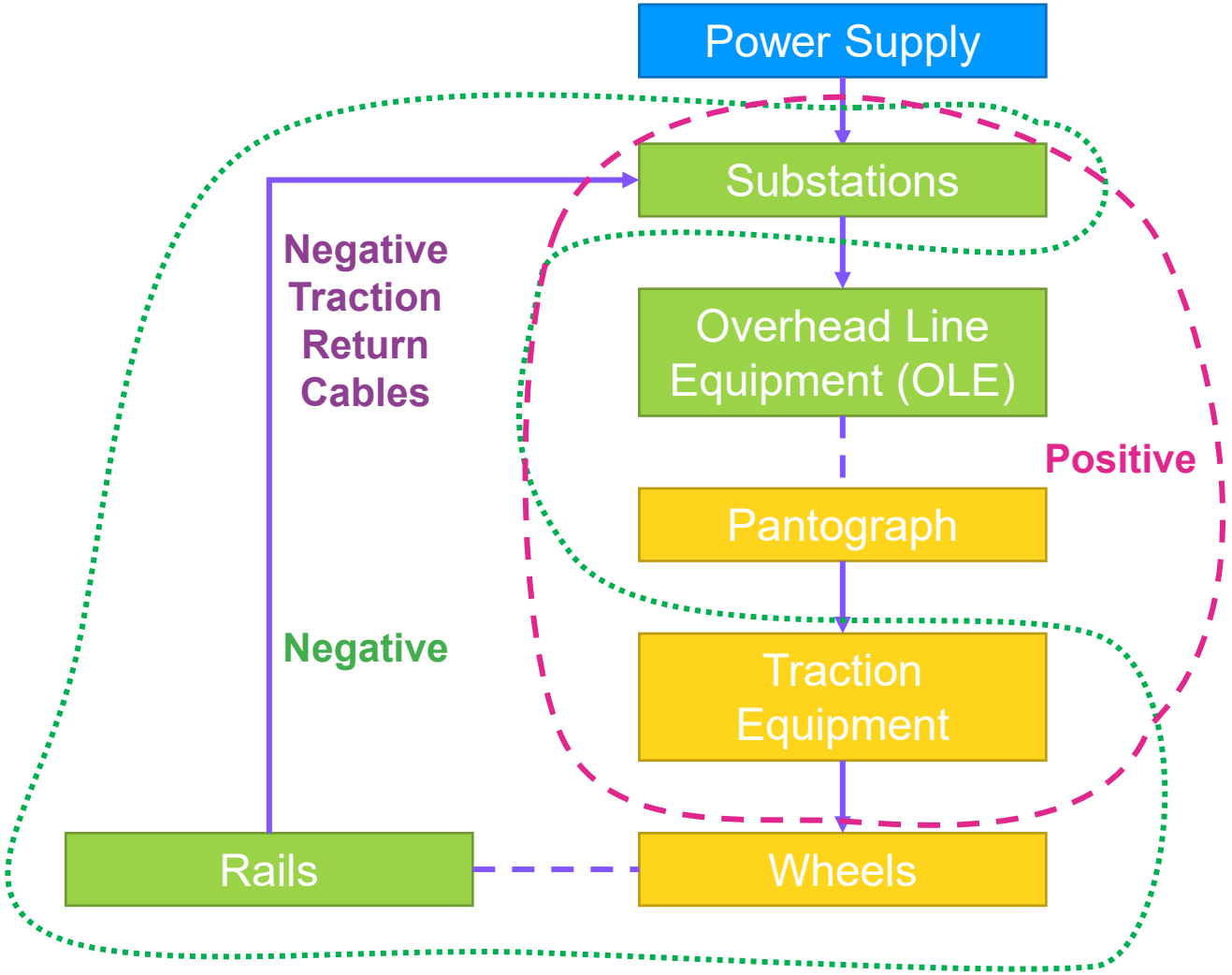
Increased wear from discontinuities e.g. section insulators

.

ELECTRICAL INTERFACES



Traction Power Demand / Capacity



System needs to be capable of planned operation

750V DC Commonly Used

Max. and Min. Voltages
Current
Substation capacity
Number of vehicles in section
Regenerative braking – return to OLE

Traction Return
Accessible voltage in rails

Potential to use Onboard Energy Storage Systems

SEPARATED INTERFACES

Gauging

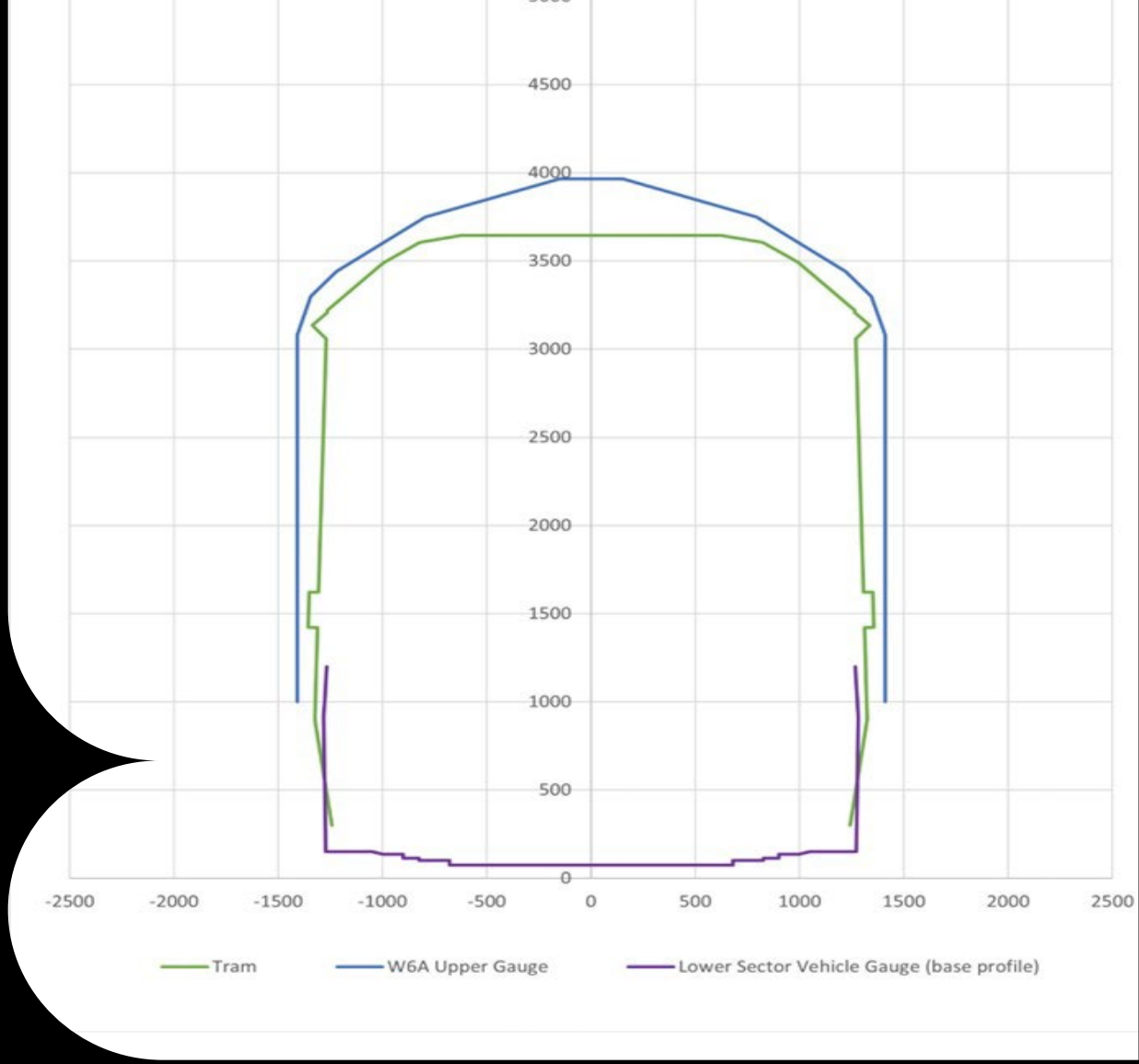
Vehicles need to clear all infrastructure and other passing vehicles

Track

- Alignment – horizontal and vertical
- Line speed
- Physical location of obstructions – poles, fences, bridges etc.
- Kerb edges and lane markings
- Installation and maintenance tolerances

Vehicle

- Length
- Static gauge
- Bogie type
- Articulation
- Bogie and wheelset spacing
- Underframe clearance
- Suspension characteristics
- Vehicle mass
- Manufacturing and maintenance tolerances



Platform | Vehicle

The Rail Vehicle Accessibility (Non-Interoperable Rail System) Regulations (RVAR) 2010

UK Tramways provide level access

- Horizontal step ≤75mm
- Vertical Step +/-50mm

Traditional Approach | platforms designed to match vehicle

- High track fixity to stop track moving
- Allowance for maintenance tolerances
- Allowance for vehicle movements (suspension, wheelsets)
- Regular measurements of platform/vehicle interface or vehicle/track measurements

Modern Approach | door threshold strips or sliding steps

- Platform still needs to be correct height to allow RVAR compliant interface in all loading conditions
- Fixed or self levelling suspension

Vehicles need to clear all infrastructure – but at tram stops vehicles need to provide level access, to allow people to board and alight

Vehicle / Other Road Users

Visibility

Driver visibility

- Vehicle, driver ergonomics, and infrastructure (obstructions, vegetation etc.) need to be considered.

Vehicle visibility

- Livery, exterior lighting, as well as infrastructure design (obstructions, vegetation etc.) need to be considered.
- Doors need to meet RVAR 2011 requirements

Audibility

Audible warnings

- Audible to other road users and pedestrians taking into account environmental noise.
- Horn and bell.
- Distinct tones from other road users.

Additional Vehicle Design Considerations

- Human factors assessments and highly adjustable driver seating position
- All equipment shrouded to a low level
- No exposed running gear
- No locations for surfing
- High deceleration rate brakes
- Crashworthiness – safety for other road vehicles

Underrun Protection

Vehicle

- Bogie mounted obstacle deflectors.
- Require adjustment following tyre turning/replacement to be effective.

- Frontal mounted lifeguards.
- Modern examples regulate height relative to vertical curvature.
- Site based testing to demonstrate performance.
- Typical effective speed = <30km/h.

Infrastructure

- Embedded road surfaces.
- Embedded slab track through platforms.
- Track infill on ballasted track adjacent pedestrian areas.
- Risk assessment of locations required.

EM

ELECTROMAGNETIC
INTERFACES

Vehicle to Infrastructure Communication

What it does

- Highways signalling interface
- Route setting
- Points locking
- Passenger information triggers
- Audio 4G/5G communication
- Overspeed detection systems
- Onboard Energy Storage System transition control

Vehicle

- Cab equipment
- Transponder/reader on bogie/underframe
- Antenna on roof
- Low voltage power supplies
- Integration into vehicle main control systems

Infrastructure

- Loops/beacons
- Position – especially at platforms and stop lines
- Trackside controllers – integration into highways Road traffic controllers/points controllers
- Radio masts
- Control systems

Vehicle to Infrastructure Communication - Signalling

Human Machine Interface (HMI)

Vehicle Control Unit

Antenna (mounted under the vehicle)

Track Mounted Loops

Virtual Loop

Trackside Control Unit

Road Traffic Controllers (RTC)

Points Controllers

Control

Global Navigation Satellite Systems (GNSS)

Radio

Radio Base Station

Visibility and Signal/Sign Sighting

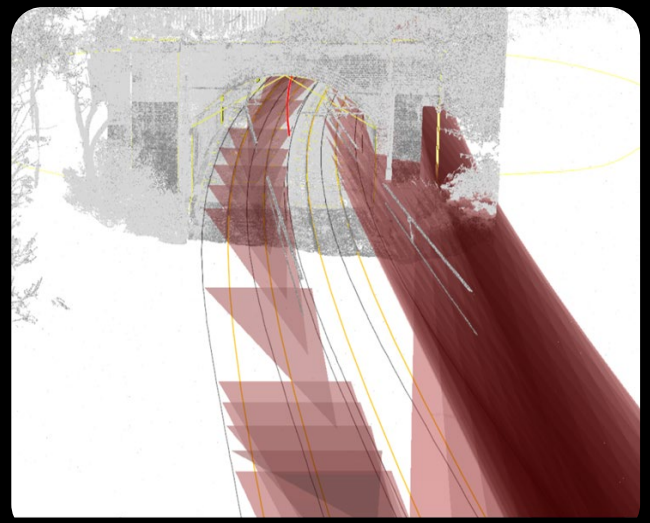
Line of Sight Operation –

Operated on the basis of being able to stop before an obstruction

- Distance
- Speed
- Forward sighting
- Buildings and structures
- Infrastructure – tramway, highway and third party
- Vegetation
- Braking performance

Good Visibility for Driver

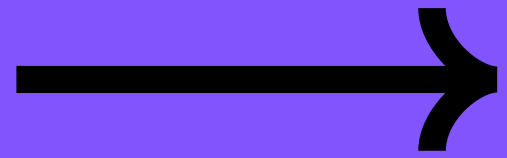
- Drivers position
- Seating adjustment
- Large windscreen – minimal obstructions
- Visibility, ergonomics and human factors assessment
- Rear view mirrors or cameras

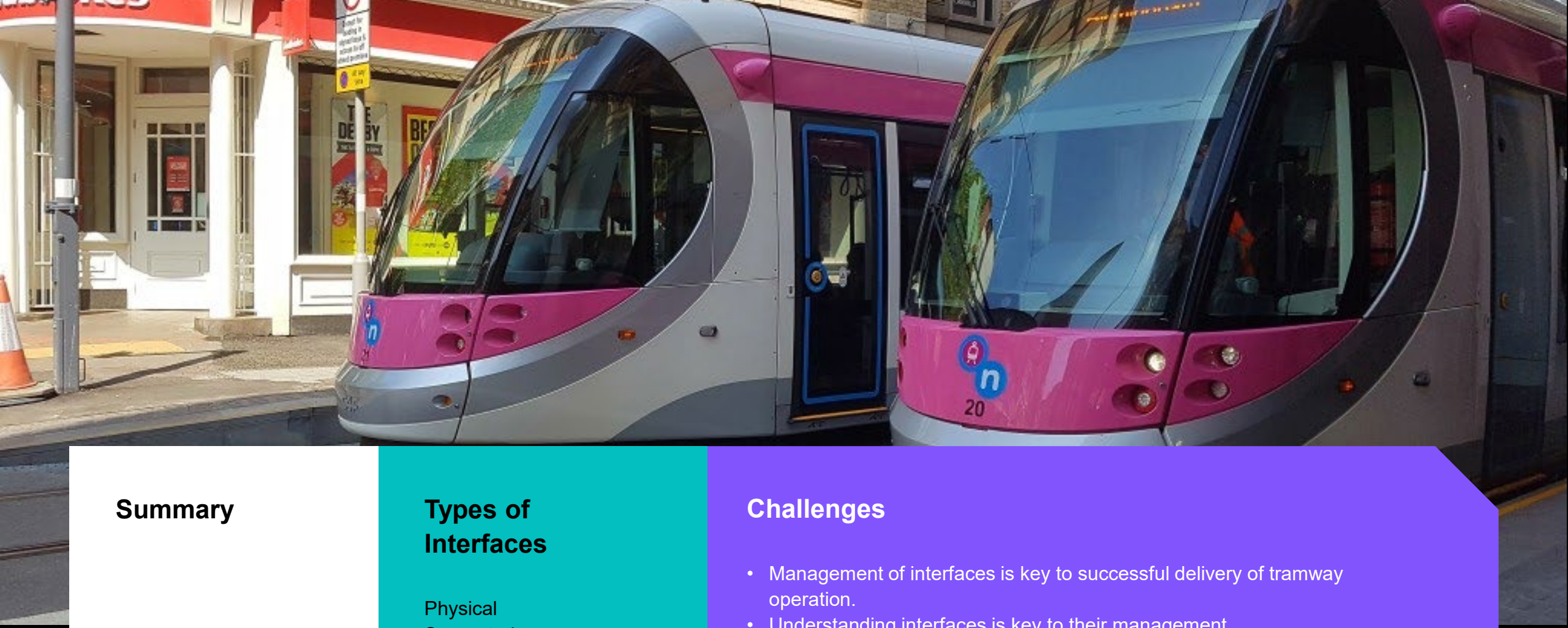


Signals and Signs

- Position
- Readability

SUMMARY





Summary

Types of Interfaces

Physical
Separated
Electromagnetic
Electrical/Comms

Challenges

- Management of interfaces is key to successful delivery of tramway operation.
- Understanding interfaces is key to their management.
- Active management of interfaces during project delivery is required.
- Ongoing monitoring/inspection and maintenance of both sides of each interface is required.
- Single Operator/Maintenance organisations can simplify interface management.

THANK YOU

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