

# Crashworthiness

Railway Accident Investigation Seminar 2018

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# The fundamental questions we try to answer when looking at crashworthiness ...

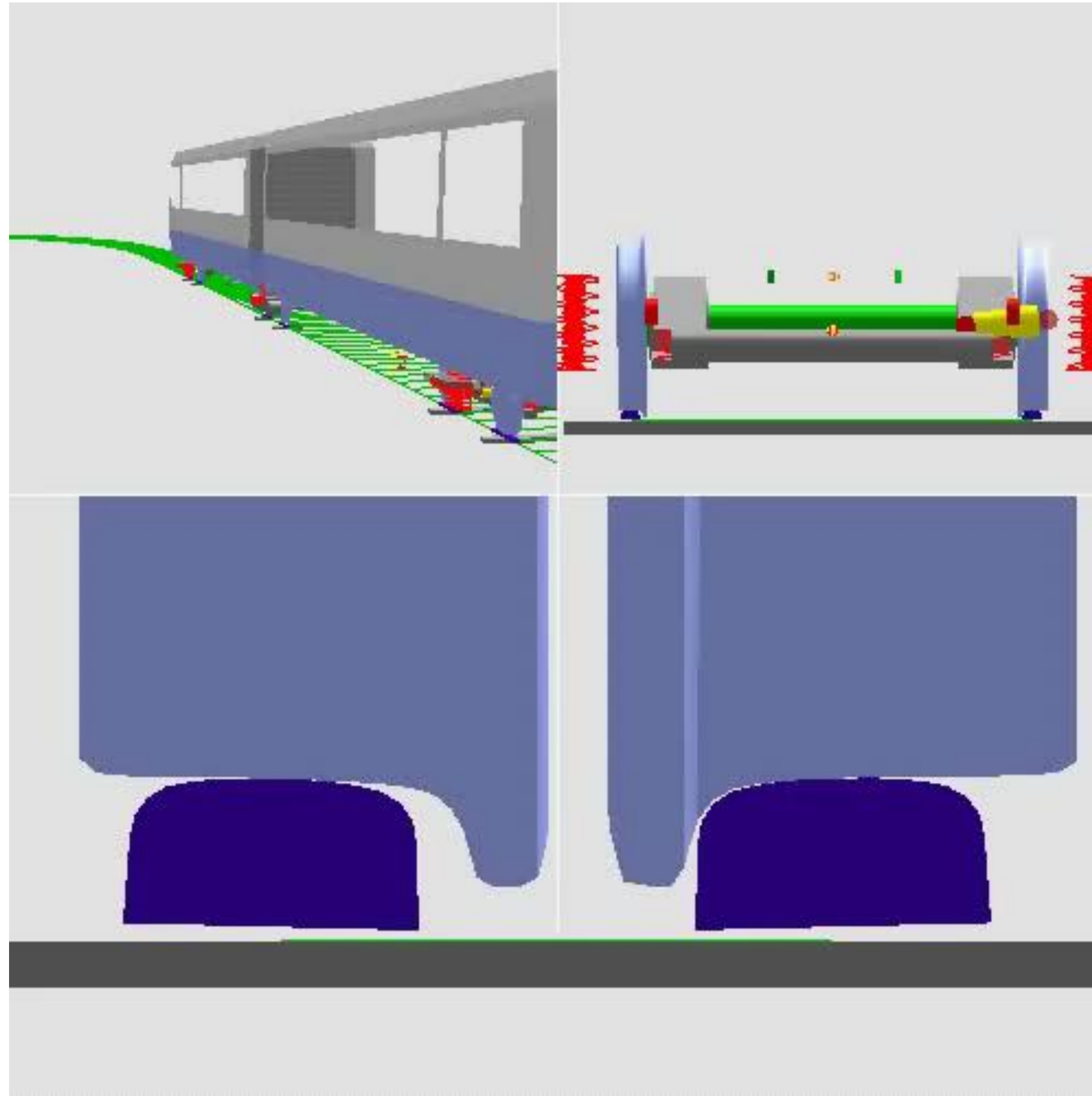
- ▶ How severe was the accident?
- ▶ How did the vehicle structure perform considering the severity of the accident?
- ▶ How did the vehicle interior perform considering the severity of the accident?
- ▶ What was the final injury count and classification of the injuries?
- ▶ What were the main injury causation mechanisms?
- ▶ Was the casualty toll consistent with the severity of the accident?
- ▶ Did any vehicle feature contribute excessively to the casualty toll?



# Accident reconstruction

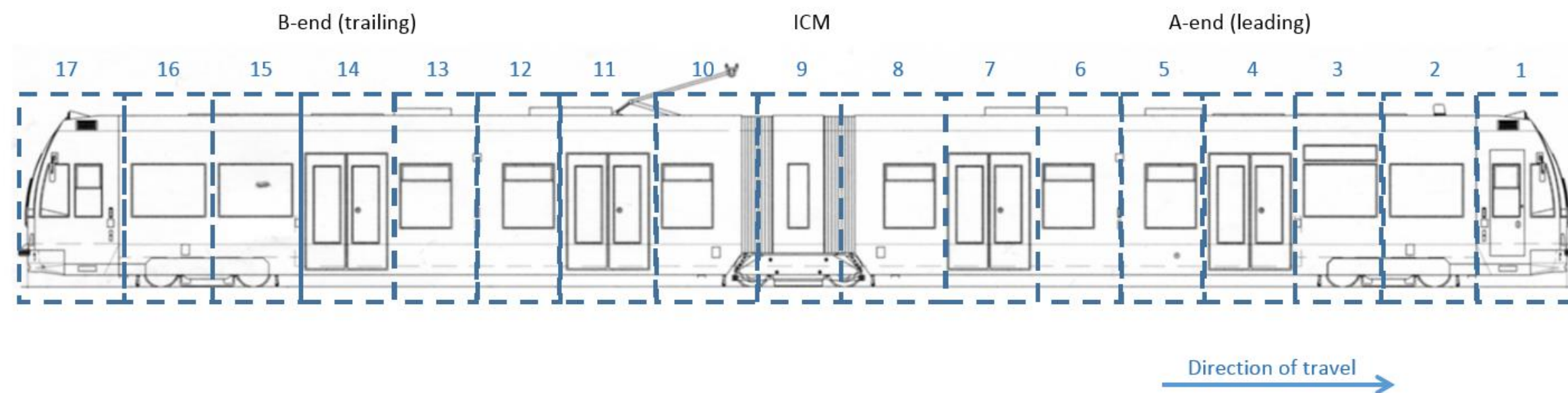
- ▶ To understand severity, one needs to understand the sequence of events
- ▶ At Sandilands, the sequence of events was divided into two phases
  - ▶ Up to point of derailment: Bombardier Transportation simulation
  - ▶ Beyond point of derailment: visual representation using computer model
    - ▶ Bombardier's derailment simulation
    - ▶ External examination of tram identifying contact marks
    - ▶ Site evidence (eg: POD, OLE dropper contact, location cabinet, marker lights, paint marks, etc)
    - ▶ Physical model to test hypothesis
    - ▶ Computer model to represent the output

# Derailment simulation



# Examination approach

- ▶ Examination needs to be carefully planned so as to satisfy the requirements of all agencies and the Police
- ▶ Essential to work collaboratively with other agencies and Police
- ▶ Divide the tram in zones
- ▶ Four separate waves of examination:
  - ▶ Interior (for physical evidence first and then detailed examination)
  - ▶ Exterior (detailed examination)
  - ▶ DNA recovery
- ▶ Detailed joint examinations of tram started in January 2017 (2 months after the accident) and was completed in April 2017

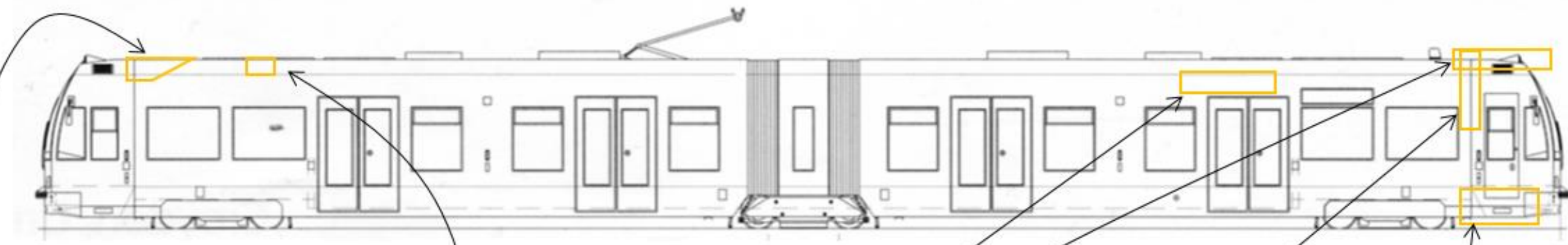



# Exterior examination

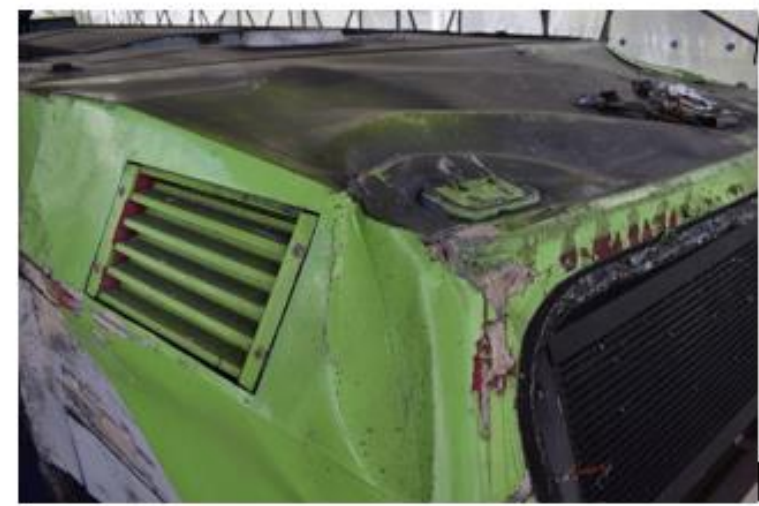
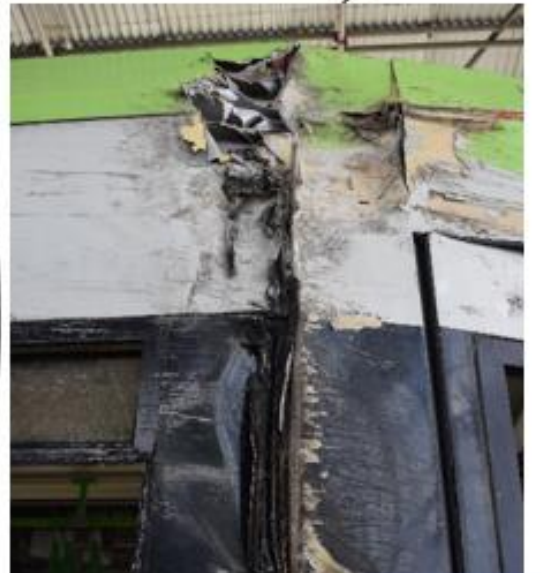


# Exterior examination - Example

**Damage to body structure (not glazing or doors and not scrape marks)**



Legend:  Outer skin pierced/noteworthy damage

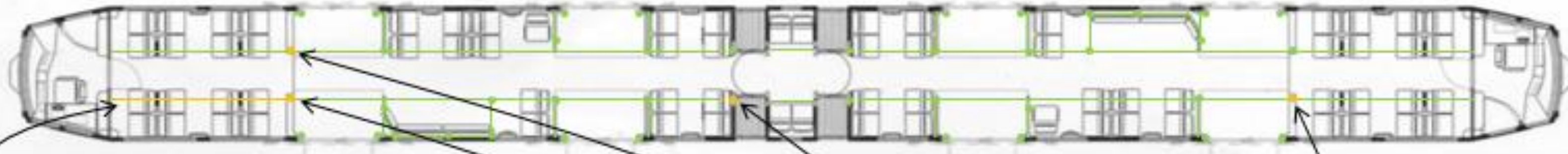


# Interior examination





# Interior Examination - Example



- Legend:
- Grabpole detached during accident (none)
  - Grabpole deformed during accident
  - Grabpole intact

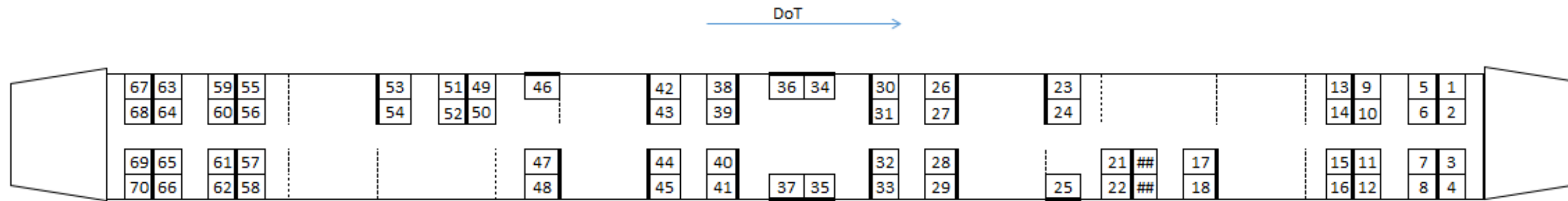


# Injury count and classification

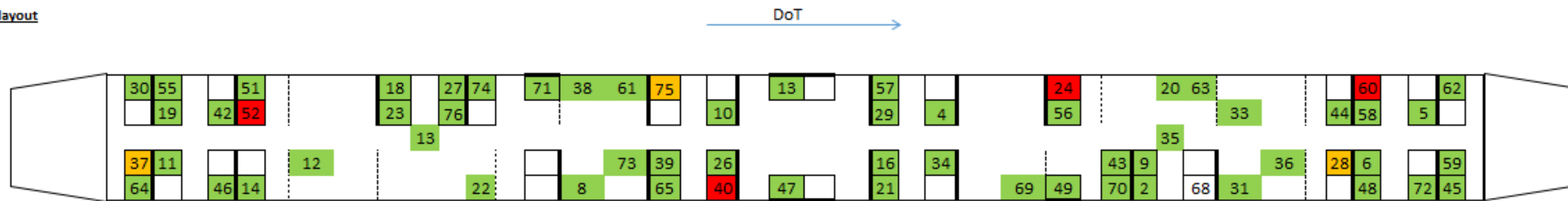
- ▶ Classification of injuries:
  - ▶ In accordance with the Railway (Accident Investigation and Reporting) Regulations 2005
  - ▶ Using AIS/ISS system
- ▶ Sources of evidence:
  - ▶ Passenger statements and questionnaires (BTP and RAIB)
  - ▶ Statements from medical professionals who treated the passengers at the various hospitals
  - ▶ DVI photos / Post-mortem reports
  - ▶ Site photos / Video walkthrough
  - ▶ DNA analysis report
  - ▶ Medical professional input for the deceased and most seriously injured passengers (Dr Angus Wallace)

# Classification (AIS/ISS) - For illustrative purposes only - NOT Sandilands

Seat numbers

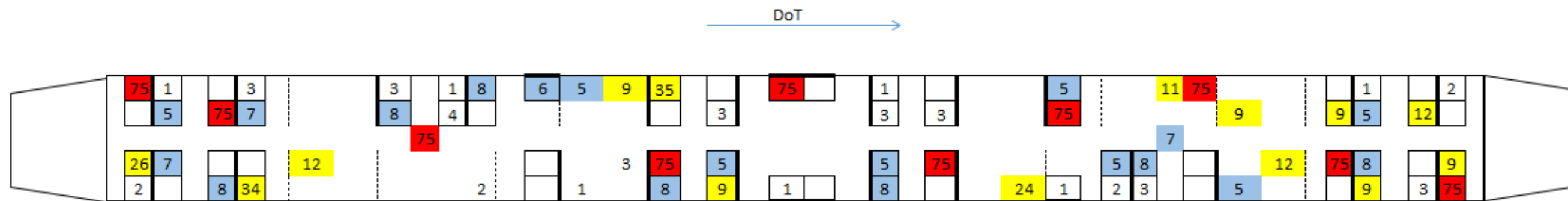


Finalised seating layout



- Positively confident about the position
- Some doubt over the position
- Low level of confidence in the position

ISS score



- Minor injury (ISS<5)
- ISS between 5 and 8
- ISS above 9
- Fatality (ISS=75)

# Injury causation

▶ Potential injury causation mechanisms:

▶ Crushing

Tram examination shows no gross deformation of bodyshell

▶ Ejection

▶ Penetration

Site and tram examinations show that detached equipment (pantograph, location cabinet, H&V unit) did not penetrate bodyshell

▶ Secondary impact

▶ Burns

No passenger reported any burns

▶ On exit

No passenger reported injury on exit

# Testing - Windows

- ▶ All 7 people who were fatally injured were either fully or partially ejected
- ▶ In total, 34 out of 69 passengers ended up partially or even fully ejected through windows and doors
- ▶ Questions we were trying to answer:
  - ▶ How strong were the windows?
    - ▶ Did any window break before the tram hit the ground?
    - ▶ Would the windows break when the tram hit the ground?
  - ▶ How much residual strength is there in a shattered window?

# Testing



Headform test - 210mm above window (corner)



Residual strength once shattered

# Tips

- ▶ Investigation starts from the point of notification
- ▶ Be methodical in your examinations
- ▶ Divide your site in smaller zones / Divide vehicle in smaller zones
- ▶ Remember evidence may be lying underneath your vehicle
- ▶ Good practice example:
  - ▶ Video walkthrough (BTP site and RAIB interior of tram) carried out shortly after walking wounded had left the tram
- ▶ Not so good practice example:
  - ▶ All window remains were tossed aside immediately after accident