



Rail Accident Investigation Branch

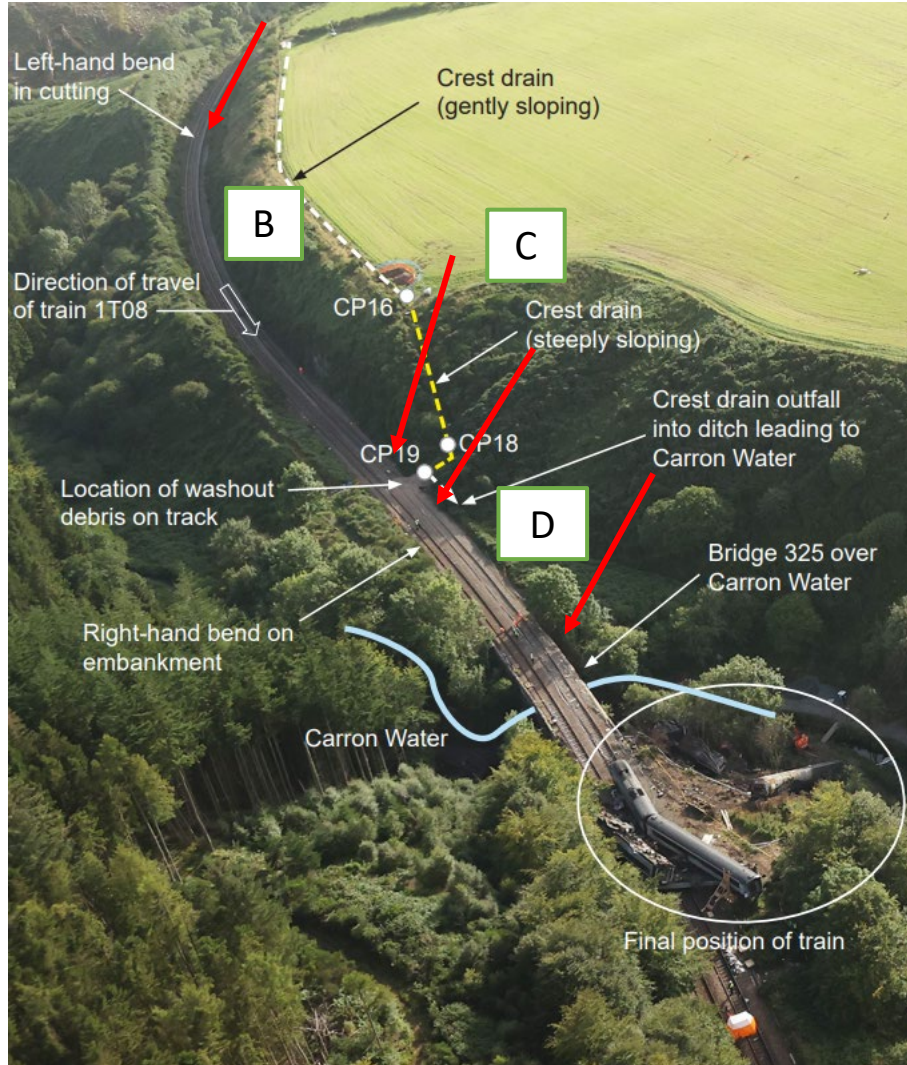
Derailment Mechanism

Rail Accident Investigator's Seminar

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Inspector

15th November 2023

Carmont derailment site



Relevant zones	
Zone B	Down line on approach to washout debris
Zone C	Washout debris
Zone D	Down line north of debris on approach to bridge

Derailment mechanism

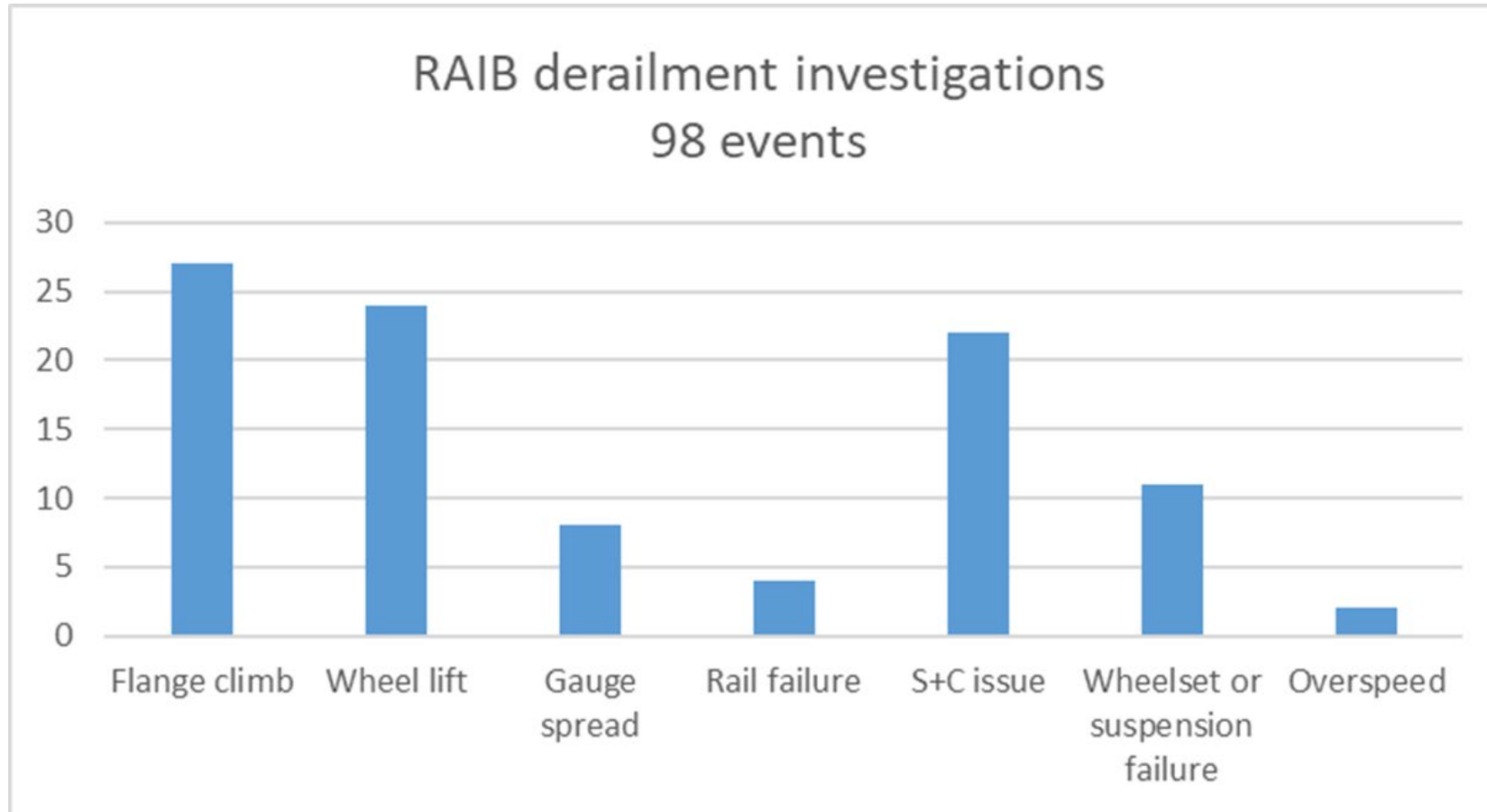
- How did the wheels lose guidance?
- Early understanding is key:
 - effective/timely site evidence collection
- A frequent challenge:
 - the complex interaction at the vehicle-track interface

Typical classification

1. Wheel flange climb
2. Wheel lift
3. Gauge spread
4. Rail failure
5. Switch and crossing malfunction and degradation
6. Wheelset and suspension failure
7. Overspeed

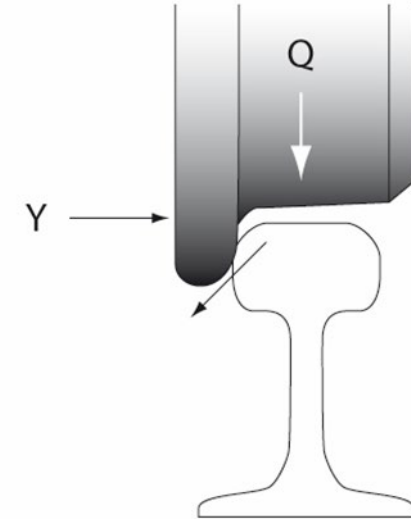


RAIB derailment investigations



Wheel flange climb

High lateral to vertical force ratio enables the wheel flange to progressively climb onto and over the rail head



Lewisham - 24 January 2017



Combination of track twist and probable offset load resulted in significant wheel unloading on a bogie hopper wagon when traversing newly-laid S&C

Wheel lift

Large vertical forces lift the wheel flange over the rail head

Moy 26 November 2005



First Scotrail



First Scotrail



Landslide debris accumulated under cab lifting the wheels, resulting in leading vehicle immediately deviating from the track

Identification of derailment mechanism

- Interpretation of the site witness evidence will help early identification of derailment mechanism
- Helps to focus site work and avoid unnecessary evidence collection/survey tasks



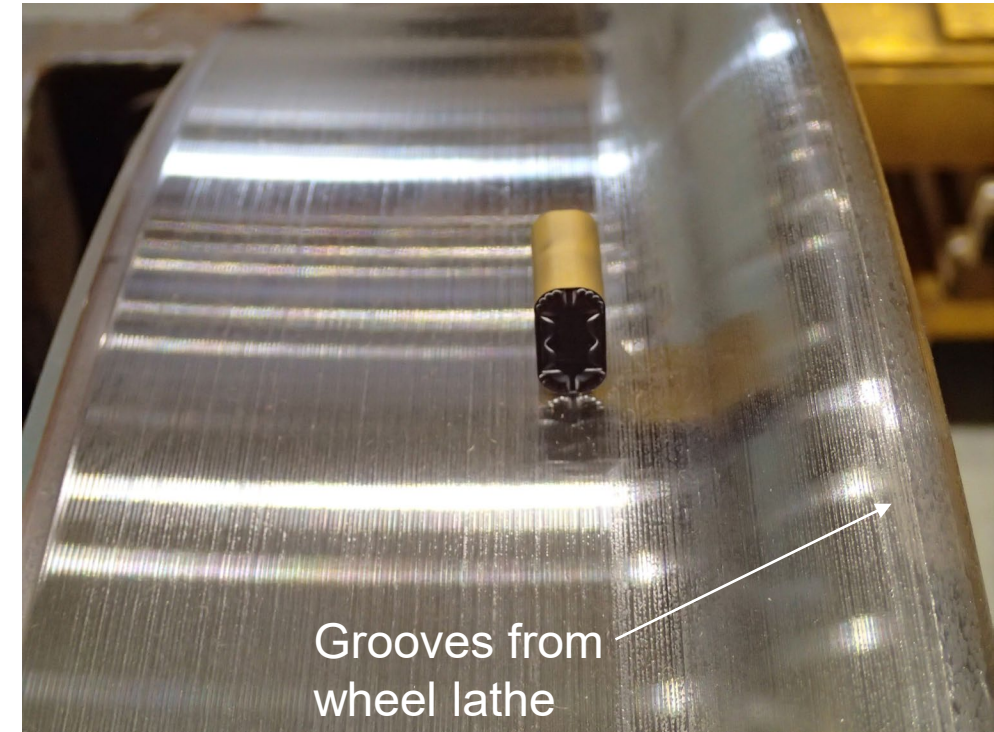
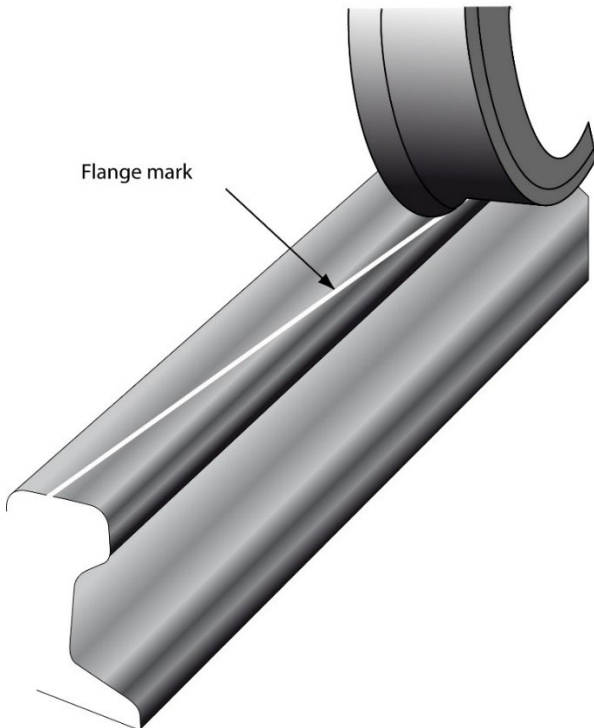
Wheel path

- Derailed wheels leave damage on the track.
- Use to identify point of derailment (PoD).



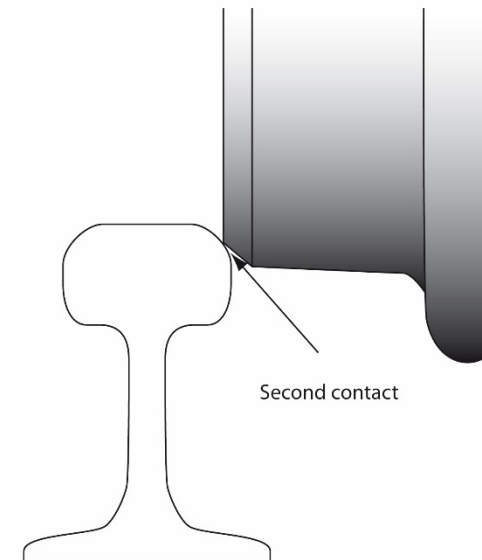
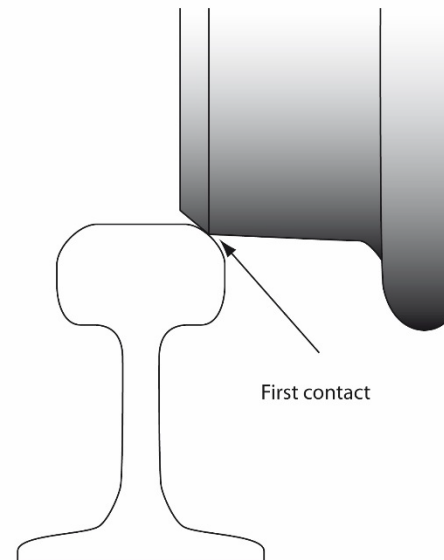
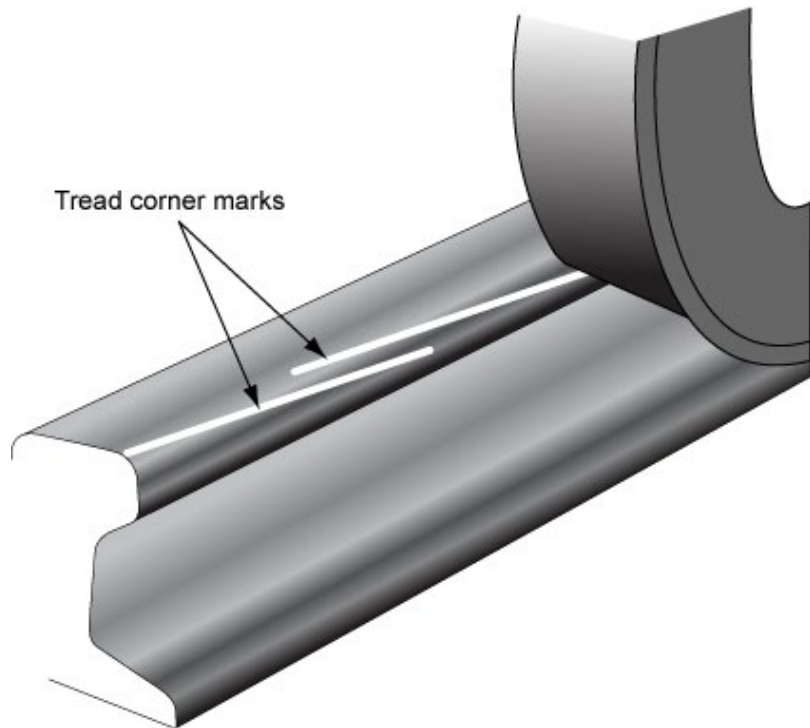
Flange marks

- Marks from wheel flange as it:
 - climbs the gauge face
 - runs over the rail head
 - drops down the field face



Tread corner marks

- As wheel flange drops down the field face, the wheel opposite drops into the four-foot forming a tread corner mark.



Matching wheel marks

...to determine wheelset
derailment paths



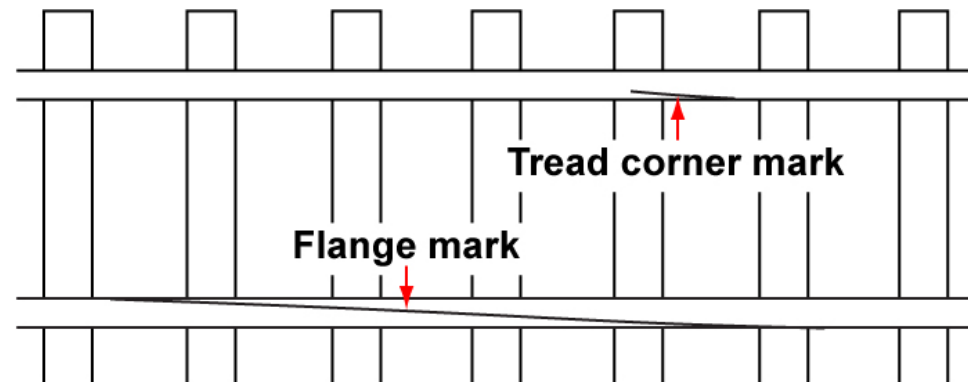
- RH flange drops down field face
- LH tread corner drops into four-foot



- RH flange runs on rail head



- RH flange climbs gauge face



No flange marks

- There may be no flange marks, for instance:
 - Wheel lift mechanism – although marks may appear on the rail head
 - Gauge spread – although tread corner marks will be present
 - Wheel/axle failure
 - Rail failure

Carmont – initial site reconnaissance

- Pattern of track damage and witness marks: Zones B to D
- First wheel mark (tread corner) on RH rail:
 - immediately north of washout material
- PoD nominated: Sleeper 0
- Sleepers numbered:
 - Approach to PoD = -ve
 - Leaving PoD = +ve



Carmont – Zone B observations

- Track walk (from beyond 200 sleepers) on the approach to PoD
- Systematic photographic record
- No wheel marks on rail head



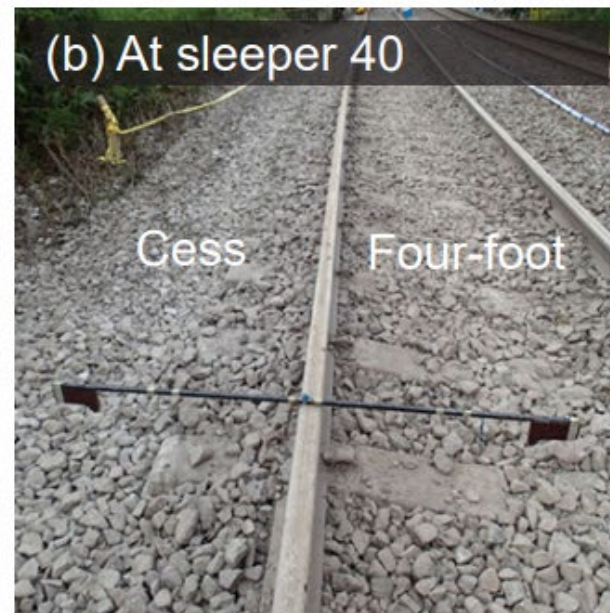
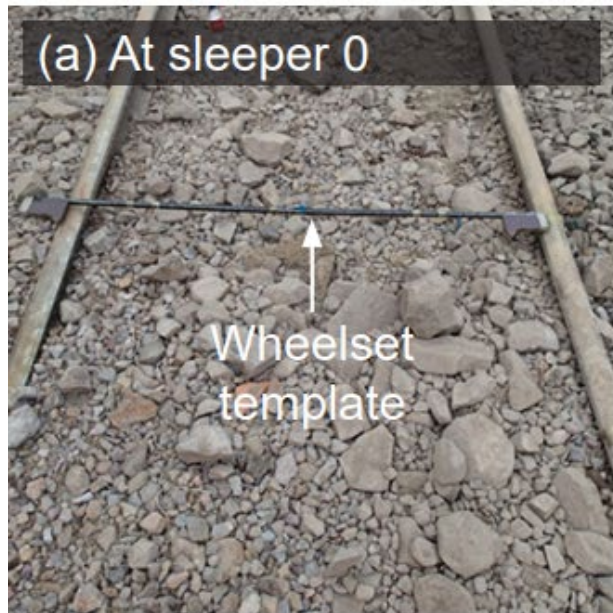
Carmont – Zone C observations

- systematic photography
- Washout debris covering the track – relatively low height
- Grooves cut by the passage of the train wheels



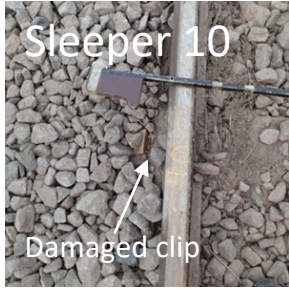
Carmont – Zone D observations

- Systematic photography using wheelset template
- Identified wheel marks consistent with LH wheels of four wheelsets climbing outside rail on the curve approaching bridge 325
- Sleeper damage and displaced ballast consistent with derailed wheelsets migrating to left

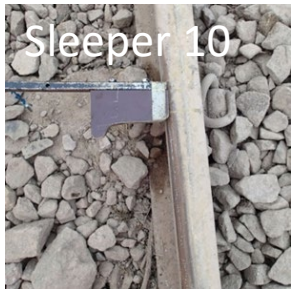


First derailed wheelset path

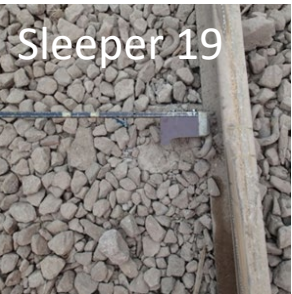
Carmont – Zone D observations



Second derailed wheelset path



Third derailed wheelset path



Fourth derailed wheelset path

Carmont – Vehicle examination

- Post-site examination of wheels and bogies on train
- Complex and extensive pattern of damage
- Evidence of leading bogie running through washout debris
- Evidence of wheels on leading power running over rail clips



Leading bogie



RH wheel – fourth wheelset

Carmont – some conclusions

- Absence of marks/damage to indicate derailment prior to washout
- Leading LH wheel was **lifted** onto head of cess rail by running over washout material. It deviated to left, RH wheel dropping into the four foot
- The following three wheelsets derailed by **flange climb** - bogie rotation increasing their angle of attack
- Absence of additional derailment marks on approach to bridge 325. Consistent with only the leading power car derailing as a direct result of encountering the washout material