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The Cairns Tilt-Train Derailment in Queensland

An Overview and Partial Analysis

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Scope of This Commentary

- I do not propose a full analysis of the accident here
- After performing a WBA from the information in the accident report, I raise questions concerning
  - the incomplete consideration of all possible causes of the driver's failing to slow the train
  - The adequacy of the existing protection systems, in particular for the accident location

The Brisbane-Cairns Tilt Train

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The Cairns Tilt Train

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A (Prototype?) Power Car

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The Cairns Tilt Train

- Narrow gauge
  - 1067 mm gauge, similar to that of many streetcar systems
- Takes just over 25 hours for the 1,681 km journey
  - Previous journey time 32 hours
- „High speed“
  - 160 kph maximum speed
- Diesel
  - DMU sets: *City of Cairns* and *City of Townsville*
  - Two EMU sets also operate Brisbane-Rockhampton, which is electrified
  - **Note:** the EMUs have lower C of G (CoG) than the DMUs!

The Route

The Tilt Train Underway

The Tilt Train Underway

Whoops! (November 2004)

The Berajondo Derailment

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What Happened, in Brief 1

- Acronym soup ahead! All that I use are defined here
  - The Cairns Tilt Train (**CTT**) *City of Townsville* (***CoT***), a Diesel Multiple Unit (**DMU**), derailed at Cabbage Tree Creek (**CTC**) at 23:55 Australian Eastern Standard Time (**EST**) on 15.11.2004 between Berajondo (**BO**) and Baffle (**BA**) on the Bundaberg-to-Gladstone part of the route from Brisbane to Cairns.

What Happened, In Brief 2

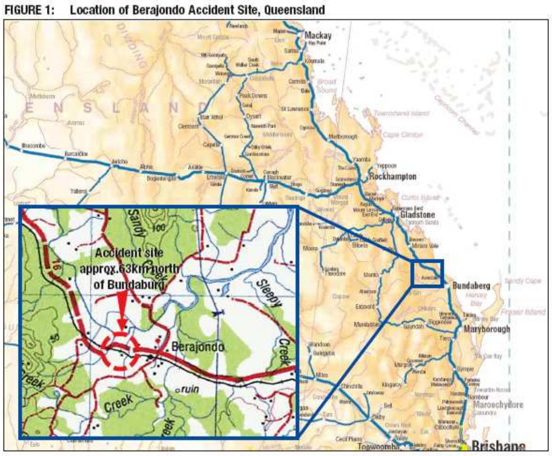
- Point of Derailment (**POD**) was 83 **m** beyond the Speed Board (**SPB**) restricting the **CTT** to 60 **kph**. It was travelling at 112 **kph** at the **POD**.
- This 60-kph **SPB** was 415 **m** beyond the Mid-Section Magnet (**MSM**)
- The **MSM** lies 1.212 **km** beyond a 150-kph **SPB**.
- The **MSM** lies 3.525 **km** beyond the Station Protection Magnet (**SPM**) at **BO** and 3.014 **km** before the **SPM** at **BA**.
- On the 1.6 **km** stretch from the 150-kph **SPB** to the 60-kph **SPB,** the **CTT** had accelerated from 80 **kph** to 111 **kph** under steady power.

Derailment and Harm (people)

- The train derailed
  - close to midnight
  - dark night (no moon)
  - single-track line (as most of the way)
  - block („section“) ran between the stations BO and BA
    - Light signals at stations: in particular for entry and departure
- 0 killed; 18 severe, 10 moderate, many light, injuries
- Problems during evacuation
  - Train collided with electrification infrastructure
  - Not knowable what was „live“ and what not

Derailment Location

FIGURE 1: Location of Berajondo Accident Site, Queensland



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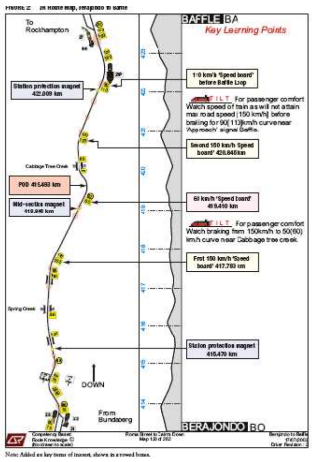
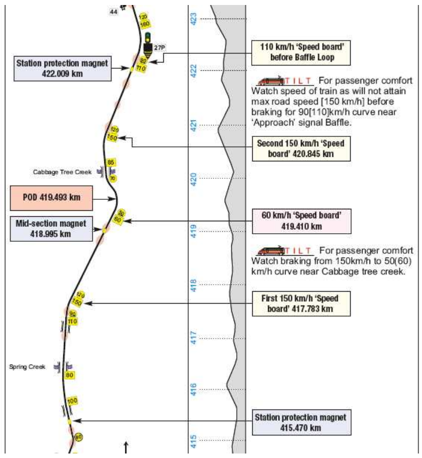
The Berajondo to Baffle Route Map



The Route Map Around the Derailment



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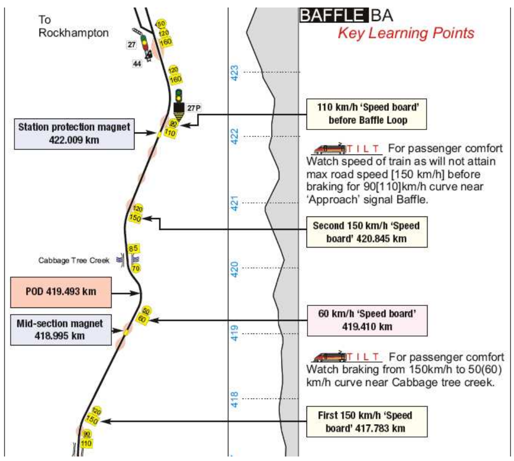
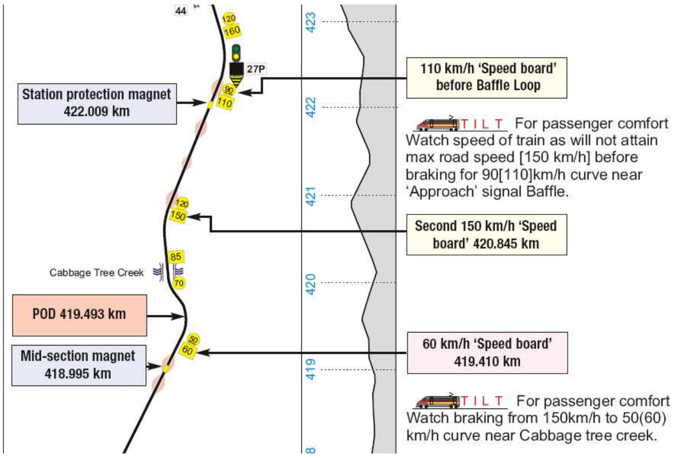
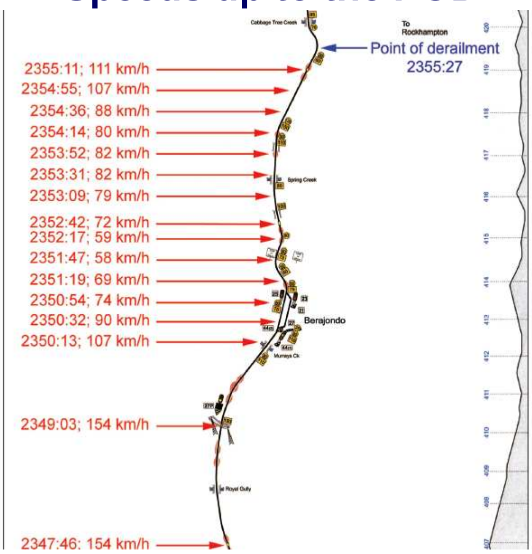
The Route Map at the Point of Derailment



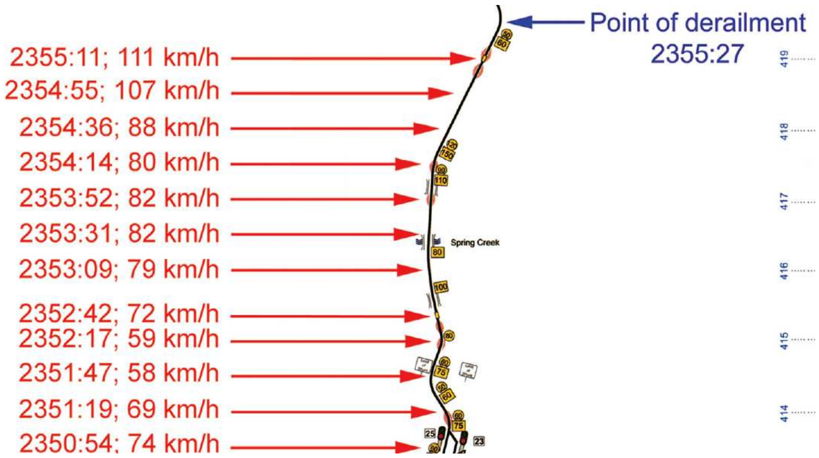
The Point of Derailment



Speeds up to the POD



Speeds Immediately Before Derailment



Derailment Dynamics

- The train was travelling at 112 kph at POD
- The left-hand curve at CTC was posted for 60 kph for the Tilt Train (50 kph for others)
- Tipover: full wheel unloading for lead power car of DMU at CTC would have occurred at about 97 kph
  - post-accident modelling with *Vampire* (Sec 2.6)

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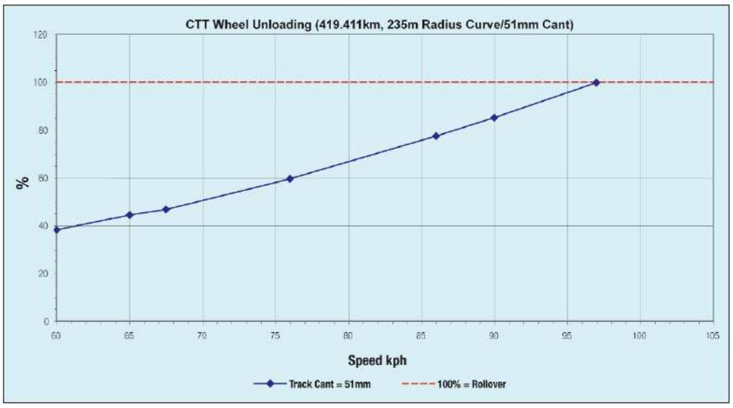
Tilt Train Tips

FIGURE 14: Wheel Unloading vs Speed



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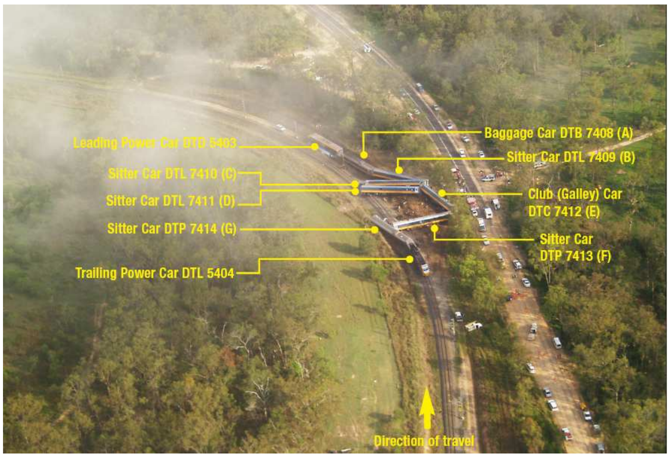
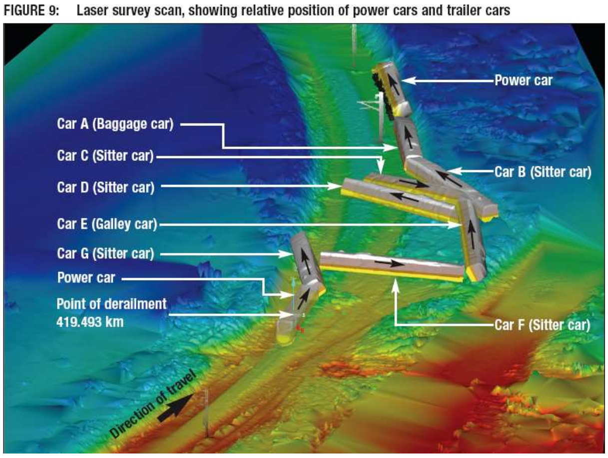
The Result

An Aerial View

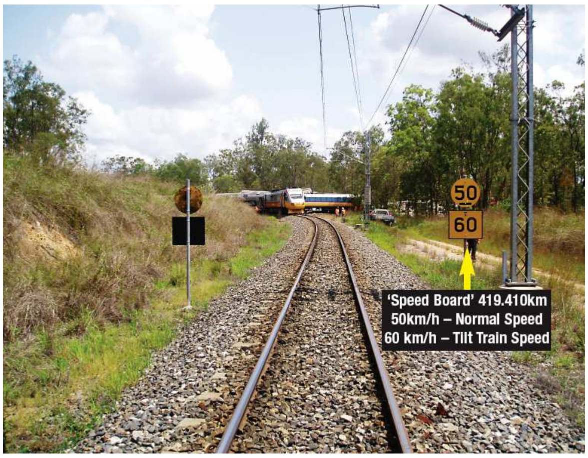


A Laser-Measurement Reconstruction

FIGURE 9: Laser survey scan, showing relative position of power cars and trailer cars



Rear View Showing Speedboard



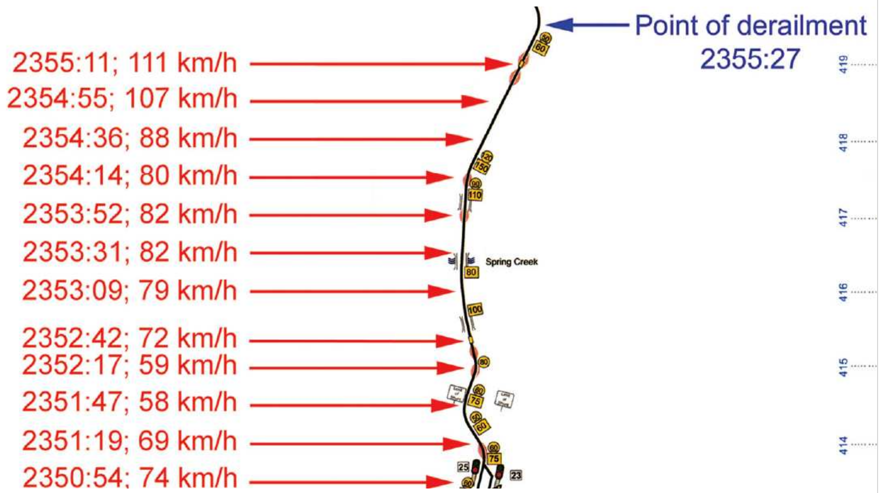
Selected Pertinent Facts 1

- No technical problem with train or infrastructure
- Two drivers; one had left cab to prepare coffee
  - Operationally allowed for non-driving driver to leave cab
- Signals
  - Light signals at Berajondo and Baffle stations
  - Speed boards, at which the train has already to be at or below indicated speed
- Other indicators
  - Station protection magnets at BO and BA
  - Mid-section magnet 498 m before POD
    - triggers a cab alarm which must be acknowledged, and was!

Selected Pertinent Facts 2

- One block from BO to BA
  - block occupied by the CTT at the time
- Before BO, CTT had attained 154 kph and then slowed as required
- Driver had maintained at or below posted speed up to (83 m before) POD
  - after BO, 74 kph → 58 kph → 111 kph
  - After BO SPM, 72 kph → 111 kph
  - After 150-kph speed board, 80+ kph → 111 kph
    - Note: train is physically unable to attain 150 kph in this short 1.627-km segment before the CTC 60-kph speed board
  - did not slow at MSM

Speeds up to POD



Causes?

- Pretty clear: cause was derailment at excessive speed (Report Sec 2.8, 3.1 Major Factor 1)
- That means, in the absence of automatic protection systems, that for better or for worse the driver is causally implicated
- So what on earth was going on?
  - We shall consider this after seeing the WBG

Report Conclusions

Report Conclusions: Major Factors

- 1. Accident principally caused by excessive speed
- 2. The driver did not reduce the train to a safe speed before entering the Cabbage Tree Creek curve
- 3. The train was in steady power „virtually up to“ derailment [*PBL note: to 3 secs before derailment*]
- 4. It is possible that the driver became disoriented and/or distracted from his principal task in this section
- 5. There is no technical system that detects very short periods of driver inactivity/distraction

Report Conclusions: Underlying Factors 1

- 1. At 417.783 km (23:54.26 hours), posted speed increases to 150 kph
- 2. Possible that driver mistook mid-section alarm for station protection magnet before Baffle
- 3. Possible that driver momentarily left driving position, either shortly before or after passing mid-section magnet

Report Conclusions: Underlying Factors 2

- 4. Safe driving of CTT largely depended on
  - driver responding to external prompts
    - speed boards, vigilance-system warnings, station magnet system
  - driver's track knowledge and competency
  - two-driver mode of operation
- 5. Co-driver absent from his seat, not in a position to check driver's ops (operational procedures did not preclude this)
- 6. Train's headlight would only have provided limited visual detail (of distant SPB or CTC curve)

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Report Conclusions: Underlying Factors 3

- 7. External darkness may have contributed to loss of geographical awareness
- 8. MSM is primarily used for providing tilt train geographical reference information. It provides no indication of location or next speed limit. A driver who incorrectly assumes the location of the train is not aided by the alarm.
- 9. [Monitoring of driver's return to duties after absence]

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The Why-Because Graph

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The Why-Because Graph

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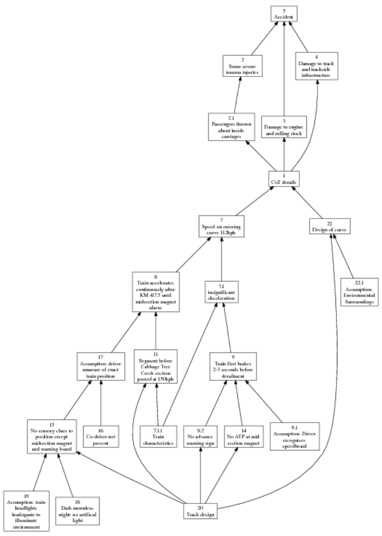
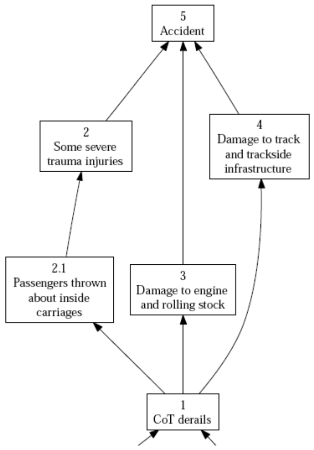
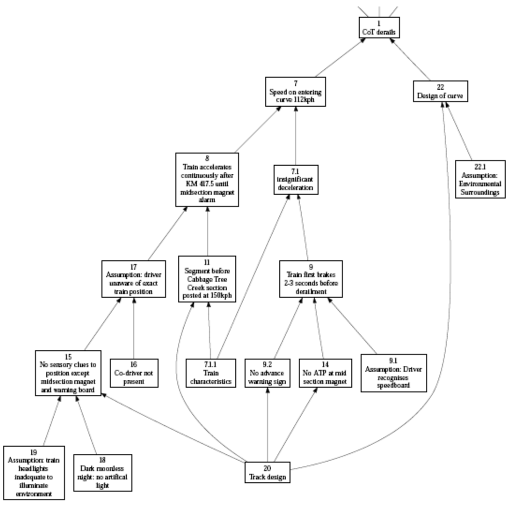


WBG Upper Part: Derailment Consequences



WBG Lower Part: Causes of Derailment



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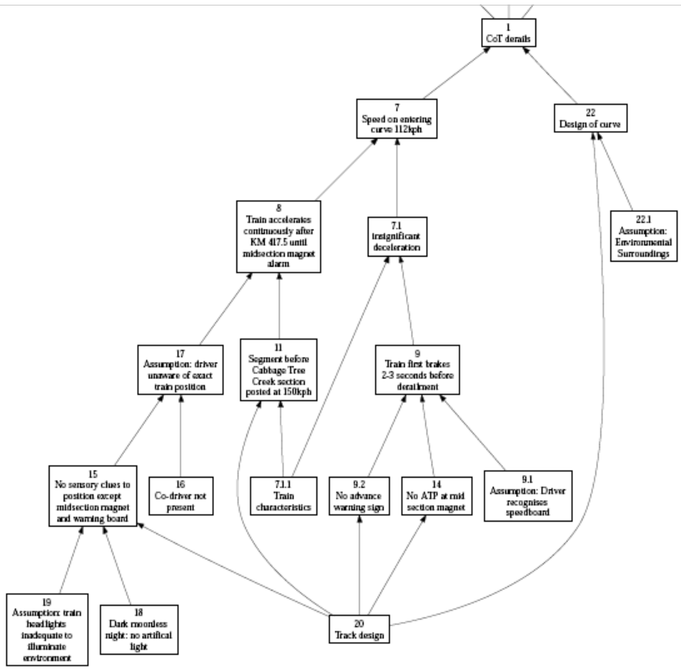

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Observations on the WBG

- The WBG is sparse
  - 23 nodes altogether, 18 nodes precursory to derailment
- However, it does identify significant issues
  - Track design: 5 out-edges!
    - Design of curve (general topography of track in vicinity)
    - 1.627 km segment posted 150 kph followed by posted-60-kph curve
    - MSM 0.415 km before 60-kph SPB
  - Few sensory clues to position
    - SPB and MSM
    - Moonless night. Headlights inadequate?
  - Train
    - accelerated continuously for 4+ km previous to POD
    - braked 2-3 sec before derailment (driver saw 60-kph SPB?)

General Observations

- Note that this WBG is derived from the report
  - It was not produced through our interpretation of events
- It identifies significant issues
  - Explaining why driver accelerated and failed to slow
    - Acceleration? Obvious: he could accelerate while remaining under posted limits, so why not?
    - Failing to slow? Not so obvious
  - Design of protection systems: adequate?

Observations and Partial Analysis

Two Main Issues from WBG

- 1. Why did driver fail to slow?
- 2. Are the protection systems adequate?

Disclaimer

- Please note: in what follows, I am deriving individual factors
- These factors are not to be thought of as mutually exclusive. It is possible, even likely, that, of the potential factors I identify, more than one of them played a role in the accident
- My purpose in Issue 1 is to enumerate potential factors, and note how (whether) they are handled in the accident report; it is not to propose my own explanation of the accident
- My purpose in Issue 2 is to assess countermeasures

Issue 1: Driver Failed to Slow

Potential Causes of Failing to Slow 1

- Driver distracted, fatigued or incapacitated?
  - Distracted? Maybe (maybe left his seat, Sec 2.8)
  - Fatigued? Probably not (Sec 2.12)
  - Mentally or physically incapacitated? Probably not (Secs 2.8, 2.13)
- Driver mistook geographic position of train?
  - Thought he was in different block? **Not addressed**
  - Thought he was further along the block? „*Real possibility*" (Sec 2.8)
- Driver wasn't aware of impending sharp curve
  - misread/misremembered Route Map? **Not addressed**
  - ... or lapsed in understanding route? **Not addressed**
  - ... or left his driving position and missed cues? Possibly (Sec 2.8, also Conclusions 3.2: Underlying Factors 3)

Potential Causes of Failing to Slow 2

- Driver intentionally caused derailment
  - No evidence (Sec 2.8)
- Driver intentionally driving fast
  - .... and misjudged braking? „*Unlikely*“ (Sec 2.8)
  - .... and misjudged stability? **Not addressed**
    - Note: DMU has higher CoG than EMU and he drove both
    - Note: He has no other traffic to worry about, just the track geometry

Potential Causes Not Addressed by Report

- Driver mistook geographic position of train?
  - Thought he was in different block?
  - Thought he was further along the block? **Partially addressed only**
- Driver wasn't aware of impending sharp curve
  - misread/misremembered Route Map?
  - ... and lapsed in understanding route?
- Driver intentionally driving fast
  - .... and misjudged stability?

Mistook Geographic Position 1

- Did he mistake the block and think he was somewhere else than between BO and BA?
  - Signals at BO clearly marked „BO xy“, where x and y are each decimal digits
  - Signal marker boards „very visible“
  - With two drivers in cab, driver driving must call out signal ID when passing and driver not driving must confirm
  - One could conclude it is unlikely that the driver mistook the block he was in
  - Nevertheless, this issue is not addressed in the report: **an incompleteness**

Mistook Geographic Position: At BA SPM? 1

- Did he think he was at BA SPM, just before the 110-kph-posted curve? A „*real possibility*“ (Sec 2.8, also Conclusions: 3.2 Underlying Factor 2)
- Consider the facts about the route ....

Mistook Geographic Position: At BA SPM? 2

- The train had passed no sharp curve after BO
- He would have sensed CTC curve, had CTT traversed it
  - The power car, where the driver is, does not tilt
- The magnet sequence
  - MSM is 2nd magnet after BO
  - BA SPM is 3rd magnet after BO
  - MSM is about 3.5 km from BO SPM
  - BA SPM is about 6.5 km from BO SPM
  - He was only 2.5 minutes from BO SPM
  - BA SPM is somewhere between 4-5 minutes from BO SPM
- The „freedom" sequence
  - 150-kph SPB gives the driver freedom to full-throttle
  - There are two „freedom" segments: one before CTC and one after
  - He'd opened up the throttle just once

Mistook Geographic Position: At BA SPM? 3

- In order for this „*real possibility*" to have occurred inadvertently, the driver would have had to
  - err in counting magnet alarms
  - err in counting his „freedoms"
  - mistake his 2.5-minute journey since BO SPM for a 4-5-minute period
  - be unaware that he had not sensed the sharp curve at CTC
  - be unaware of his speed profile since BO SPM of having maintained a speed at least 12 kph above that allowed at CTC
  - be unaware of having accelerated continuously under „steady power" for over 4 km, since the shunt limits/75-kph speed board at BO
- In my judgement, that would constitute a „lapse in concentration" of significant proportions
- One might well consider it to show cognitive impairment

Mistook Geographic Position: At BA SPM? 4

- So this „*real possibility*“ implies a multitude of significant lapses, to an extraordinarily high degree
- But the report considers the driver to have been in possession of the appropriate cognitive faculties (Secs 2.8, 2.12, 2.13 as noted)
- So it looks to this reader as though the report almost contradicts itself
  - One cannot speak of a literal contradiction here: these issues concern degrees to which cognitive properties manifest. Better to say **high tension**?
  - That leads us to consider dissolving the *high tension*

Resolving/Dissolving the *High Tension* 1

- One horn
  - The driver suffered a close series of significant cognitive lapses, both continual and punctual, over a period of three minutes or more
  - Neither the „soft“ protection systems (two-driver ops, speed boards, route knowledge and maps) nor the „hard“ protection system (BO SPM, MSM) sufficed to intrude into cognition
- Conclusion
  - The design of the protection systems on the route do not take into account the possibility of such significant lapses.
  - If one concludes that they did occur, protection systems **must** be adapted

Resolving/Dissolving the *High Tension* 2

- The other horn
  - Assume that the driver was indeed in possession at the time of appropriate cognitive faculties (such that a significant ongoing series of lapses likely did not occur)
  - Then he was aware that he was traversing/had traversed a section including a 60-kph restriction at speeds high (indeed, much higher) than 72 kph
  - That is, he was and had been prepared to bust speed limits where he thought it appropriate
- The report does not address this possibility: **another incompleteness** in the report

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Observations 1

- Observe that deliberate violation of the speed limit would be enough by itself to explain the accident
- Note that **I am not making the suggestion that this did happen**
  - I am not a policeman; I am not an investigator; I am not a lawyer; I am not expert in the sociology of railwaymen in Australia; <insert appropriate additional disclaimers>
- I am saying that a comprehensive analysis would address it; and that the report didn't do so

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Observations 2

- But is this horn of the high tension at all plausible?
  - **Yes, unequivocally**. See Scott Snook's Theory of Practical Drift in his analysis of the Operation Provide Comfort shootdown of two US Army Black Hawk helicopters by USAF F-15 fighter aircraft in the no-fly zone over Northern Iraq in 1994 (*Friendly Fire*, Princeton University Press, Princeton, N.J., 2000)
  - Interpretation of Practical Drift theory here:
    - Tensions between organisational goals ....
      - Prestigious „high-speed“ service
      - Safety requires low speeds at many points
    - ..... lead to dynamic adaptations of procedures and behavior
      - „Speeding“ by drivers where it is considered to be doable

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Observations 3

- The phenomenon whereby agents adapt behavior and procedures to resolve tensions in organisational goals (whether one calls it „practical drift“ or not) is widely recognised
- Some examples
  - „Get-home-itis“: corporate aircraft crews under pressure to take the boss where heshe wants, when heshe wants
    - Corporate aviation is significantly more susceptible to weather-related accidents than commercial aviation
  - Commercial aircraft crews under pressure to maintain schedule and destination
    - Landing at the goal airport, near to time, while conserving fuel

Observations 4

- An example closer to „home“:
  - December 1999 Glenbrook, NSW, rail accident
  - Analysed by Andrew Hopkins (Chs. 2-7 of *Safety, Culture and Risk*, CCH Australia, Sydney, NSW, 2005)
    - Commuter train passed a signal at „halt“...
    - ... after obtaining permission from signaller to do so...
    - ... after signaller indicated informally that track was clear...
    - ... commuter train driver accelerated ....
    - ... and ran into the rear of the *Indian Pacific* cross-country train that had been waiting at the next (halt) signal while obtaining permission to proceed
  - Hopkins discusses cultural tensions and adaptations to those tensions within NSW rail operations

Observations 5

- Besides ... dare I say this? ... isn't it sometimes just fun to exercise the capabilities of well-designed high-tech equipment?
- Possibly c.f. 1988 Airbus A320, Habsheim, France?
    - Air France pilot attempted to perform „standard“ Airbus airshow-pilot manoeuvre – steep climb-out from low-energy low pass
    - Without having experience with the manouevre
    - Without having scoped the airshow airport
    - Without having fulfilled the legal requirements for approval
    - With a plane load of uninformed passengers (illegal!)
    - From/in an unstabilised approach and unstable/unplanned state
    - With far too low engine speed („idle“ power instead of 60% N1)

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Observations 6

- The report suggests that the scenario in which the driver was intentionally driving „*to the limit*" and misjudged braking is „*unlikely*" (Sec 2.8)
- However, that he misjudged his braking is fact:
  - He applied full brakes 2-3 seconds before derailment
  - That suggests that he felt he needed emergency brakes
  - Full braking is not comfortable for (sleeping?) passengers
  - As far as anyone knows, there was no obstacle on the track to cause such a brake application
  - The full braking occurred at or near the CTC speed board
- Given the previous observations, one wonders which part of this scenario renders it „unlikely", and how?

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Unawareness of Impending Curve

- Such unawareness would imply that
  - either the driver was operating under significant cognitive impediment (ruled out: Secs 2.8, 2.13)
  - ... or he overlooked the CTC speed restriction on the Route Map (either through misattention or through not using the Route Map) and had forgotten about it (misapplied his route knowledge)
  - This second potential factor is not considered in the report: **an incompleteness**
  - Note that such a phenomenon has been seen already in the *first horn* of the *high tension*

Intentional Speeding

- Considered already as the *second horn* of the *high tension*
  - Reminder: the report does not consider it. This constitutes **an incompleteness** in the report

Failing to Slow: Summary

- The report considers some, but not all, of the causal possibilities of the driver failing adequately to slow
- The causal possibilities that it fails to consider are
  - Mistaking the block
  - Consequences of the scenario of thinking to be at BA-SPM
    - Significant cognitive lapses continuously for over 3 minutes, or
    - Intentionally speeding (or being prepared to do so)
    - Consideration of this scenario calls into question the judgement that scenario of „driving to the limit“ and misjudging braking „unlikely“
  - Unaware of curve/Misapplying Route Map/Knowledge
    - Scenario has much in common with above and analysis is similar
  - Intentional „speeding“
    - ... for understandable, indeed well-studied, sorts of reasons
    - Scenario also considered in above analysis

Issue 2: Adequacy of Protection Systems

Existing Protection Systems

- Route Knowledge & Maps
- Station-protection/mid-section magnets
- Speed boards
- Two drivers

Protection Systems 1: Route Knowledge

- Although route knowledge and competence is trained, training is regarded across many industries as insufficient to eliminate procedural errors fully
  - e.g., see comments above on why driver failed to slow
- Indeed, it may encourage them!
  - Intimate route knowledge may lead to overconfidence in the capabilities of the kit
  - Intimacy with operations may lead to violations of defined procedure
    - particularly to increase „efficiency“ or ameliorate tensions
    - again, as in Snook's Theory of Practical Drift

Protection Systems 2: Warning Magnets

- Positional warning systems of this simple kind are present on most railway systems in the developed world
- They give point-based, relative-positional information, and rely on a driver knowing within the resolution distance (less than or equal to one block) where heshe is
  - The mid-section magnet apparently did not suffice in this case to warn the driver that he needed to reduce speed
    - (something else did, 13-14 seconds later)

Protection Systems 3: Speed Boards

- These are speed-limiting signs, not advance warnings of speed restriction
  - They advise a driver of the current speed limit
  - They do not suffice to warn a driver sufficiently in advance to reduce speed

Protection Systems 4: Two Drivers

- In aviation (Pilot Flying and Pilot Not Flying) two operators can function as a team
  - there are flying tasks and non-flying tasks to perform
  - However, there are few non-driving operational tasks in the cab besides supervision – it is mostly „single driver"
  - Such so-called „supervisory control" is not always effective
    - This is well-known: see work of Thomas B. Sheridan
    - In air traffic control, supervision has been shown to be helpful
    - In other domains, a „group think" effect, whereby both parties tend to make the same mistaken assumptions about a state of their operation, can be/is often present (see especially Snook, *op. cit.*, concerning both the pilot-wingman team and the AWACS team)
    - It is not (yet) known in rail operations which mode dominates

Signalling Systems

- Light signals at stations
- Speed boards
- Station markers
  - station signals have reflective nameplates with unique ID
    - station unique-ID: Berajondo is BO; Baffle is BA
    - 2-digit number
  - readable from the cab
  - 2-driver ops requires call-out/confirmation when passing
    - ... when there are two drivers in the cab
- (Milestones? There, but not signals
  - reflective kilometer markers, but positioned away from the track and do not normally act as cues for the driver)

Existing Protection Systems: Analysis

- Had the driver
  - been aware that he was between BO and BA
  - correlated the MSM alarm with the Route Map and the time as well as his route knowledge
- .... then the MSM might have sufficed to allow sufficient speed reduction ....
  - ..... in the accident case (from 111 kph down to say 90 kph)
  - ..... but not in regular operations (from say 120 kph down to 60 kph)
  - ..... and not theoretically (from 150 kph down to 60 kph)
  - Proof follows

Braking from Mid-Section Magnet 1

- The dynamics of braking is as follows
  - Distance mid-section magnet to speed board = **415 m**
  - *$S = v_0.t + a.t^2/2 = (v^2 - v_0^2)/2.a$*
  - *@ $a = 1\ m/s^2$, v_0 = 150 kph/~42 m/s, v = 60 kph/~17 m/s*
    - *braking distance = 738 m + reaction distance*
  - *@ $a = 1\ m/s^2$, v_0 = 120 kph/~33 m/s, v = 60 kph/~17 m/s*
    - *braking distance = 400 m*
    - *reaction time = 2 s*
    - *reaction distance = 2 s x 33 m/s = 66 m*
    - *total distance from magnet to 60 kph =* ***466 m*** *!*

Braking from Mid-Section Magnet 2

- For the existing situation:
  - *@ $a = 1\ m/s^2$, v_0 = 111 kph/~31 m/s, v = 90 kph/25 m/s*
    - *braking distance = 168 m*
    - *reaction time = 2 s*
    - *reaction distance = 2 s x 31 m/s = 62 m*
    - *total distance from magnet to 90 kph = 230 m*
- Conclusion: the driver could have slowed the DMU sufficiently to round the CTC curve without derailing, had he
  - had appropriate positional awareness
  - reacted with braking to the mid-section magnet alarm
- But this is not practical for the design of regular operations
  - exact wheel unloading dynamics not known beforehand

Braking from Mid-Section Magnet 3

- Deceleration of 1 m/s² is emergency braking
  - Normal braking on, say, the German railway is 0.5 m/s
- At normal braking (0.5 m/s²), the figures are
  - *@ $a = 0.5\ m/s^2$, $v_0 = 150$ kph/~42 m/s, $v = 60$ kph/~17 m/s*
    - *braking distance = 1,476 m + reaction distance !*
  - *@ $a = 0.5\ m/s^2$, $v_0 = 120$ kph/~33 m/s, $v = 60$ kph/~17 m/s*
    - *total distance from magnet to 90 kph = 866 m !*
  - *@ $a = 0.5\ m/s^2$, $v_0 = 111$ kph/~31 m/s, $v = 90$ kph/25 m/s*
    - *total distance from magnet to 90 kph = **398 m !***
- Normal braking would barely have sufficed !

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Braking from Mid-Section Magnet 3

- Conclusion: the mid-section magnet does not suffice to give appropriate operational indication of the approaching speed restriction to 60 kph
- It follows that, in absence of visual clues (this section is always passed at close to midnight by the CTT),
  - either route knowledge plus dead reckoning
  - or a preparatory speed restriction to below 120 kph, in anticipation of further slowing at the MSM
- ... is necessary to achieve the required 60 kph by the CTC SPB

Protections: Summary 1

- Route knowledge + dead reckoning is not reliable to the degree required to avoid all possible procedural errors over the operational life of the CTT
  - equally whether there is a driver team or single driver
  - This human phenomenon is unavoidable
- The speed restriction preparatory to CTC SPB is procedurally ineffective
  - Note this is consistent with intent: speed boards are not intended to guide operations, but to restrict them
  - Either there needs to be an appropriate speed restriction
  - .... or additional reliable protection mechanisms need to be installed at this point

Protections: Summary 2

- Note that no „soft“ protection (for example, an advance speed restriction, or an advance warning board) would suffice to preclude intentional speeding
- Only a „hard“ protection (ATP, say at an advance speed warning board and again at the MSM) would suffice rigorously to preclude deliberate speeding
- A „firm“ protection - say, data logging and post-trip evaluation - might help (see next slide)

„Firm“ Protection

- It may be that those drivers who might have been tempted to drive faster than posted have now been discouraged from traversing CTC at greater than, say, 90 kph :-)
  - Might one consider this cultural feature a form of „firm protection“? Or is it still „soft“?
- A driving operational-quality assurance program (DOQA) based on full-journey data loggers and (semi-automated) evaluations of each journey might suffice to identify common procedural infelicities (without needing to distinguish between inadvertent and deliberate actions)
  - FOQA (Flight Operational Quality Assurance) is proving its worth for many airlines, including Qantas I believe
  - There is now significant experience with FOQA which could be adapted to rail operations

Conclusion of Protection-System Analysis

- Additional protective mechanisms are required at (at least) CTC to ensure that normal operations can be pursued in darkness
  - even with a speed reduction to 110 kph over this segment
  - with normal braking performance
  - with adherence to all posted speeds
- Possible such mechanisms include
  - advance speed restriction at CTC
  - advance speed warning boards
  - ATP
  - a DOQA program

Protection Systems: Comment

- The analysis has concluded that the existing protection systems cannot have sufficed to ensure that the Cabbage Tree Creek curve would be successfully rounded under all foreseeable circumstances
  - This raises questions for the scope and conclusions of the „comprehensive risk assessment“ and „fully documented safety case“ which established that this line was „suitable for tilt train operations“ (QT/ATSB Report Sec 2.2)
  - One obvious response: of course the line was suitable, in the sense that one can just travel according to whatever procedures maintain the required safety level!
    - But what exactly were/are those procedures?

Conclusions

- This work
  - has performed a WBA of the Berajondo derailment
  - ... and has analysed therefrom the major causal factors identified by the WBA:
    - Possible causes of the driver's failing to slow
    - Adequacy of overspeed protection systems
  - ... and has concluded that
    - the consideration in the accident report of the possible causes of the driver's failing to slow is incomplete
    - the overspeed protection systems in the vicinity of Cabbage Tree Creek are inadequate
  - It demonstrates once again the value of performing a WBA

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The End

Thanks for listening!