Safety in the Railway Industry

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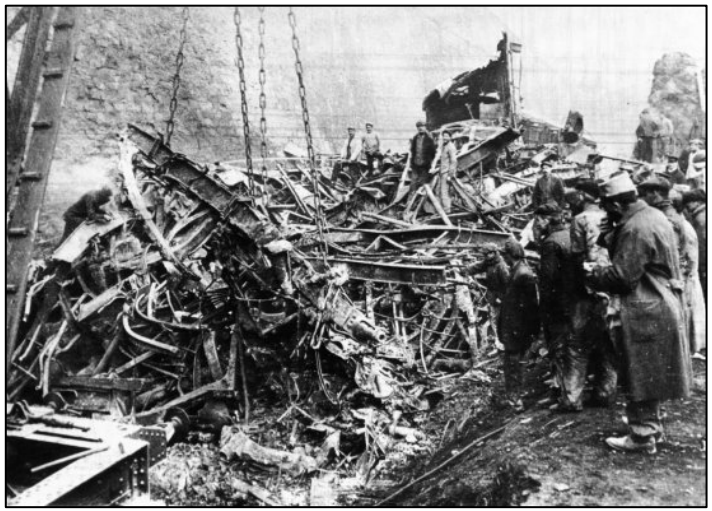
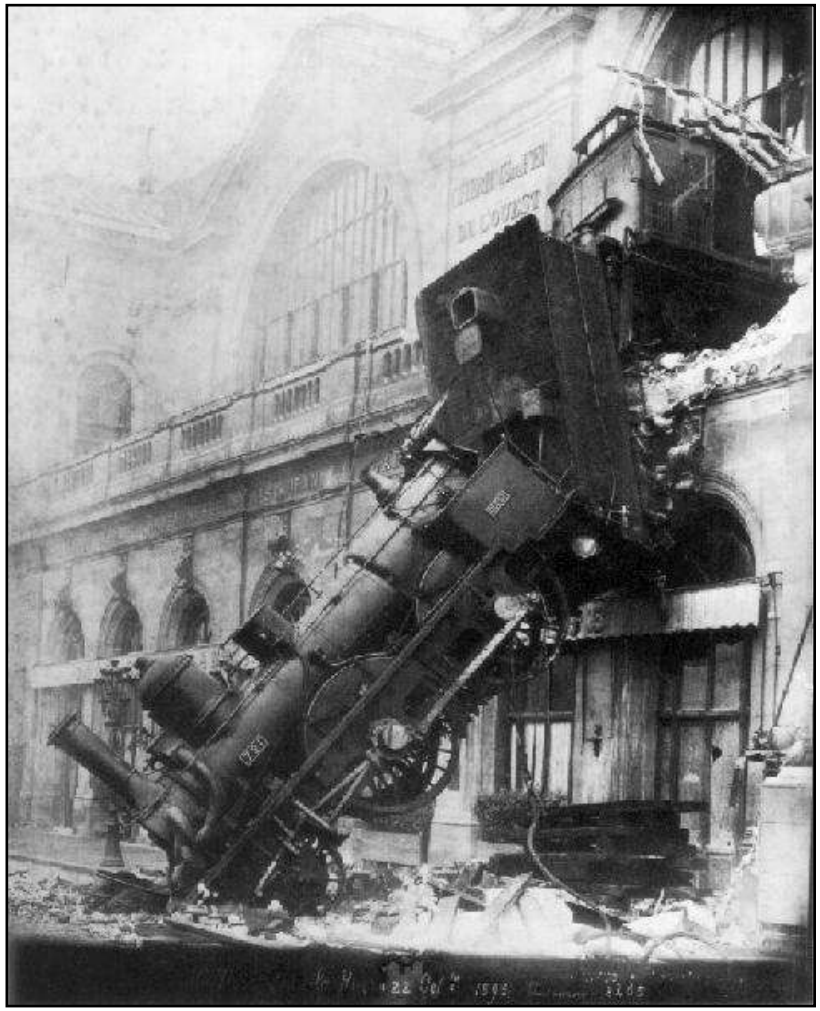
Preamble

A gentle disclaimer

This presentation is based on the author's knowledge and 30 years' experience in the railway industry, which only represents one point of view and might not be the full fact. It does not necessarily represent the Corporate view of the MTR. The majority of the material are searched from the web and the author would take this opportunity to thank all those who share their works in the public domain.

Since we have Railways we have Accidents





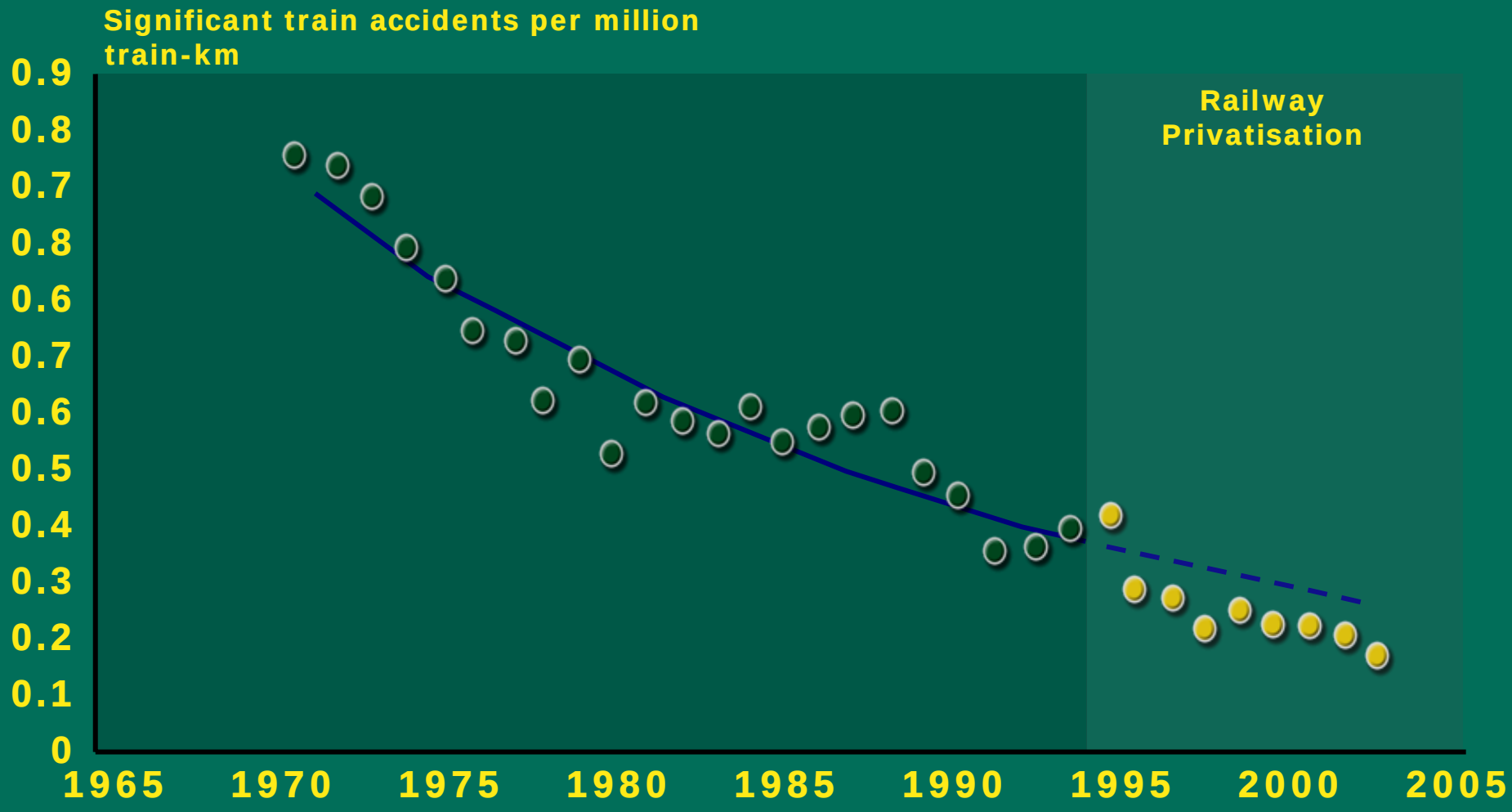
Why are we so concerned about Safety

- Railways in Hong Kong carry over 4M passengers a day. Their well beings and those behind whom they support are our responsibility
- Hong Kong has a population of around 7M implying high reliance on railway transport. So, any accident would become a political crisis
- Heavy tangible and intangible prices would be paid by the industry for any accident

So, Hong Kong pushes railway technology and safety management to the limits

A Safe UK Railway

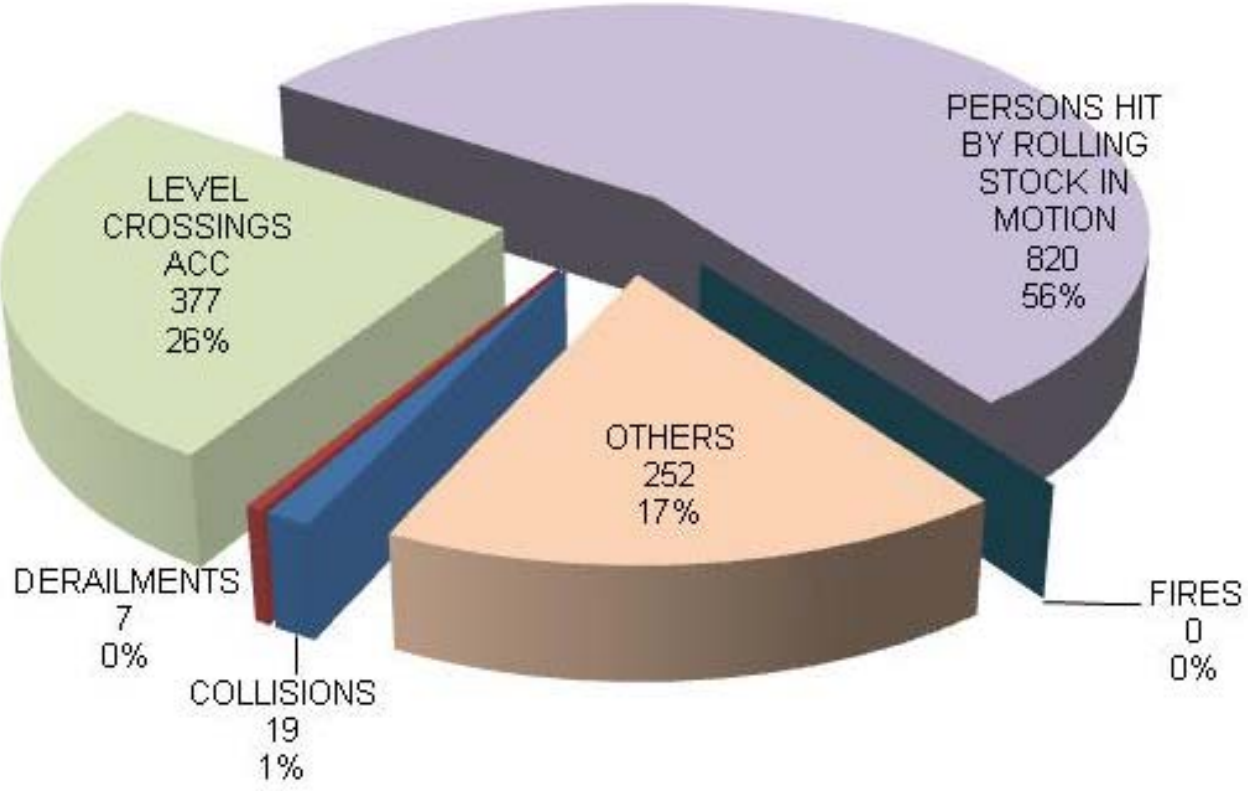
Department for Transport



ERA Biennial Report - key facts and figures

The first analysis provides some clear feedback regarding serious accidents and fatalities on the European railways

2006 Deaths by type of accident



The Global Trend

- Globally, safety in railways has improved dramatically
- Railway safety becoming more high profile and sometimes political
- More stringent legislation and monitoring of railway operation – Corporate Manslaughter Bill 2007
- Public often mixed up Operation Safety, Personal Safety, Equipment Reliability and media interests
- Public often amplifies minor safety issues and indirect consequences
- Public has no Fail-safe concept

THE WORLD HAS CHANGED

The World has Changed

Old coaches do not have doors. Now, a train even roll back for a few inches with doors opened is a serious accident.

In developed lines, all works during traffic hours require possessions

The World has Changed

Is it safe to walk in front of a Loco? Certainly NOT in developed countries.

Traditionally, the railway is the shortest walking route. Now, restricted track access handicaps failure recovery.

The World has Changed

This Bridge certainly cannot pass the latest safety standards.

Capital investment of modern railways is very high.

信號系統遭雷擊 8小時3度延誤

西鐵故障阻7萬人上班

罕見狂雷

受高密度雷電影響，西鐵信號系統亦遭雷擊損毀，8個多小時內先後出現3次故障影響7萬多人，全程行車時間由原來30分鐘一度延誤至超過1小時10分鐘，西鐵雖「事先張揚」列車服務會受阻，但在4個多小時的「搶修」過程期間，只不斷修改列車延誤時間，沒有向乘客提供接駁巴士疏導乘客，令大量被困月台和車廂的市民極為鼓譟，其間3名乘客不適，部分需送院。環境運輸及工務局已要求西鐵提交報告。

搶修逾4小時 無接駁巴士

民主黨及民建聯都批評九鐵，要求徹查。而**西鐵客運總經理徐偉強**就列車延誤爲乘客帶來不便致歉，但並無回應是否低估了信號故障對市民的影響，只解釋已評估列車受阻情況，認爲市民如常乘搭受延誤的列車，仍較轉乘接駁巴士方便。鐵路系統專家梁廣灝相信，事故與密集雷電造成電波大干擾有關（見另稿）。

西鐵回應指出，鐵路系統已設有避雷裝置，但並未有就信號系統防雷擊保護及具體損毀情況等提供任何資料，亦未交代整體列車的延誤時間。西鐵列車最後在昨晨10時15分全線回復正常，約7萬名乘客受影響。

前晚通宵搶修 昨晨再現問題

前晚新界西北區雷電多[illegible]西鐵[illegible]隧道的信號系統和架空電纜先後[illegible]晚上[illegible]11時[illegible]生故障。徐偉強相信，信號[illegible]前晚[illegible]密雷擊有關，前晚工程人[illegible]作通宵[illegible]修，[illegible]現部分信號系統有組件[illegible]員，並將[illegible]更換，至凌晨12時前已搶修完畢，列車亦全面回復正常。

但昨晨5時34分開出頭班車時，工程人員又再發現大欖隧道北段信號系統組件出現「間歇性」問題。徐說，他們已即時透過傳媒、車站廣播及車廂廣播通知市民列車延誤的消息，並已通知運輸署。

30分鐘車程延誤40分鐘

但歷時4個多小時的搶修過程中，西鐵沒有安排接駁巴士疏導乘客，市民繼續入閘擠在月台等車，列車開至即一湧而上，車程時間卻嚴重

列車延誤 [illegible]信號系統故障[illegible]在[illegible]班[illegible]列車[illegible]現達[illegible]分鐘的延[illegible]車上乘客唯有看報[illegible]（樂銳昌攝）

[illegible]成[illegible]小時[illegible]時間受阻，繁忙時間班次由每3分鐘一班車，延誤至10分鐘一班，全程行車時間由30分鐘延長多30至40分鐘，跟西鐵最初預告的延誤15分鐘相差甚遠。

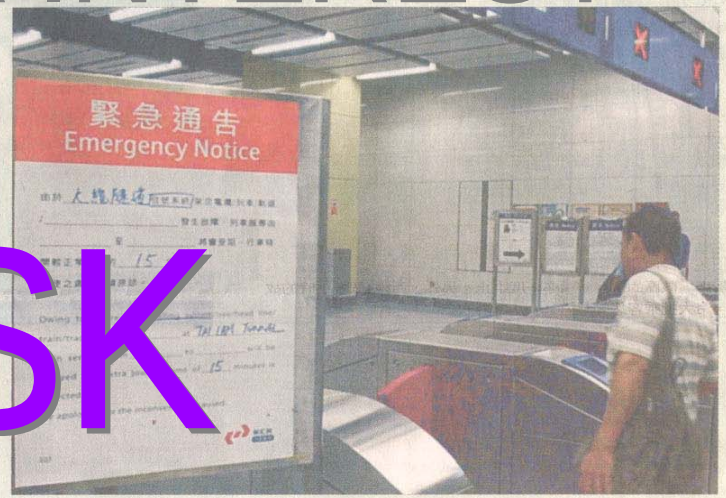
九鐵主席田北辰指出，九鐵員工在搶修時，是跟時間競賽找出問題，內部亦預備了接駁巴士在車站，但考慮到市民上落巴士加車程的時間，由錦上路站往荃灣西要20至30分鐘，與初時評估的列車時間差不多，而當時亦預計當列車延誤超過30分鐘，即會提供巴士，但最後延誤時間不過30分鐘，故決定不提供接駁巴士。

發言人補充，另有一個巴士接駁方案是由屯門駛往南昌並途經各站，但所需時間達1.5小時。

田北辰續稱，昨日的雷電實在罕見，九鐵會汲取教訓，研究信號系統的防干擾措施。另外，亦可考慮日後遇上列車延誤時，提供接駁巴士供乘客選擇。九鐵發言人又表示，除車程延誤時間外，日後會考慮一併公布乘客候車時間。

環運局促提交調查報告

運輸署表示，昨晨5時半收到西鐵通知，已即時通報其他交通機構加強服務，巴士公司表示，昨晨等車客沒有明顯增加，毋須增加班次。**環境運輸及工務局發言人**表示，已要求九鐵提交詳細調查報告。



早上7時左右，西鐵在大堂貼上列車車程將會延長15分鐘的告示，但實際上，有乘客被延誤了30分鐘。（樂銳昌攝）

西鐵昨晨因大欖隧道信號系統故障，全線列車服務受阻，西鐵起初公布會有15分鐘的延誤，但其後改為20分鐘，最後更改為30至40分鐘。（郭慧嫻攝）

Are we loosing focus? The Bridge out seems more dangerous!

Adaptive Survival vs. Stress Injury

Stress injuries can heal

Bent by stress

Could we be changing the course of railway development into adaptive survival instead of healthy growth?

Major Railway Safety Concerns

- FIRE
- Level Crossings
- Maintenance Error
- Equipment Breakdown
- Signal Passed at Danger
- Operation Error
- Object near Track
- Adverse Weather
- Terrorist Attacks
- Others

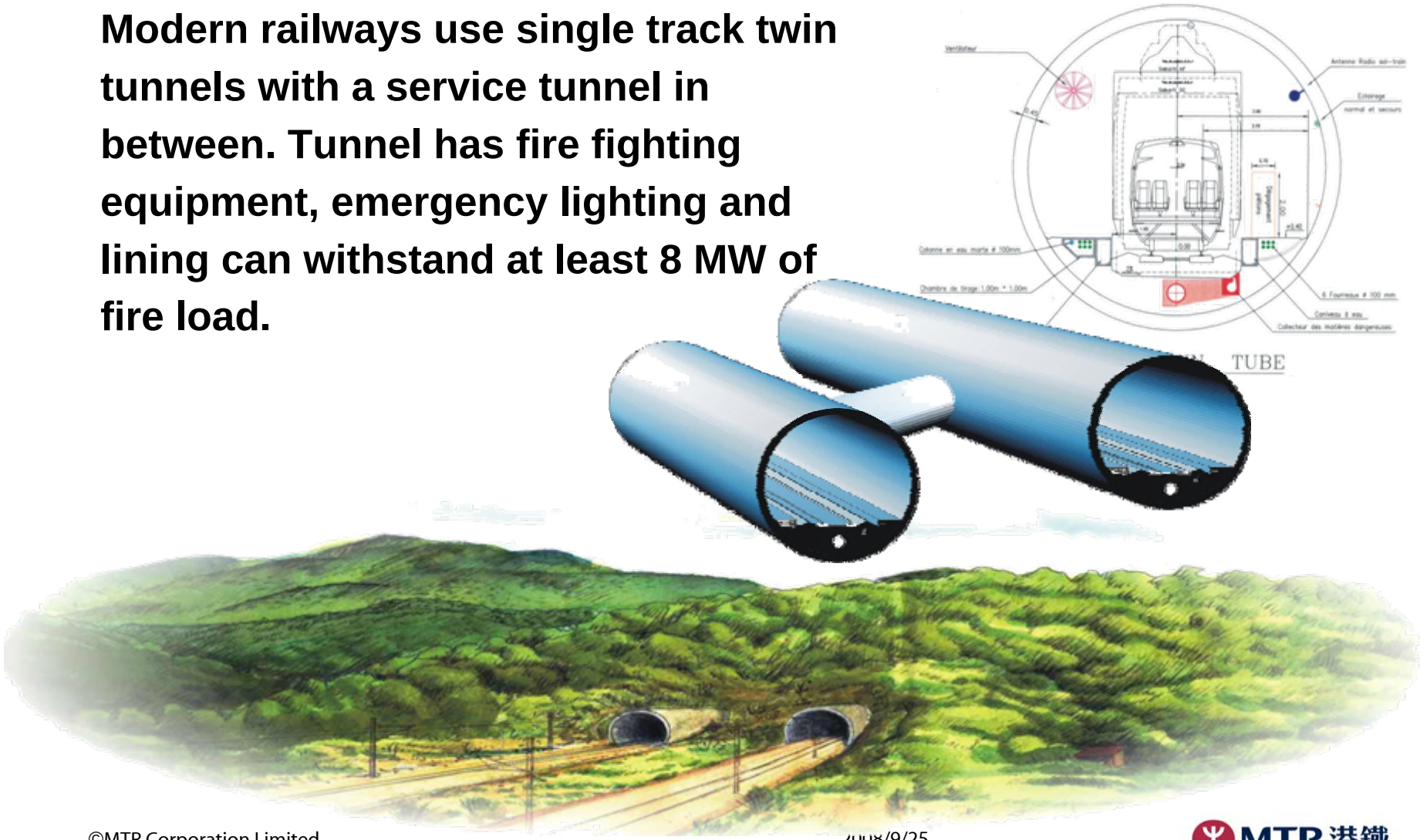
Fire - Tunnel Fire due to Freight Trains

The Summit Tunnel fire occurred at 5.50 a.m. on 20 December 1984 when a goods train carrying more than a million litres (835 tonnes) of petrol in 13 tankers entered the tunnel on the Yorkshire side .

Tanker 9, crowned with glassy deposits formed by bricks in the shaft above; the bricks melted, dripped down and solidified on top of the tanker. .

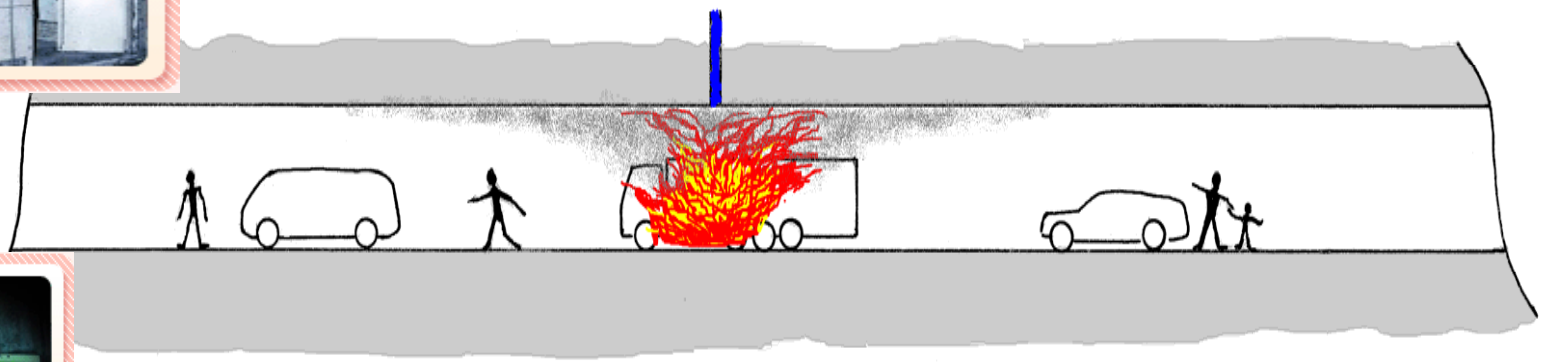
Fire - Tunnel Fire – lesson learnt

Modern railways use single track twin tunnels with a service tunnel in between. Tunnel has fire fighting equipment, emergency lighting and lining can withstand at least 8 MW of fire load.



Fire - Tunnel Fire – lesson learnt

For passenger trains, Tunnel Ventilation System to extract smoke in one direction, clear exit signs, Cross Passage Doors are installed. Number of trains inside the tunnel will be restricted to lower the risk.



Fire - Tunnel Fire – lesson learnt

On 21 August 2006 a fire broke out in the load compartment of a lorry on HGV *Shuttle Mission* 7370 from the UK terminal to France. The shuttle train was brought to a controlled stop at PK3050, 20.5 km from the UK portal, at 13:40 hrs.

All 34 persons on board (30 lorry drivers and 4 Eurotunnel staff) were evacuated into the *service tunnel* by 13:49 hrs without injury.

Fire - Train Fire

Usually caused by de-railed Freight Trains after collision or over speed. Apart from the excessive damage the toxic fume is deadly.

Fire - Train Fire – lesson learnt

Freight Trains normally have ample separation from passenger trains especially in Tunnels. Special procedures in handling DG.

Fire - Train Fire – lesson learnt

Passenger Trains are designed with high fire resistant rating and easy evacuation. Smoke vents, intercom and portable fire extinguishing equipment are carried.

Fire - Station Fire

At 0955 hours on 18 February 2003, a train was set on fire by a 56 year old mentally disordered man in an underground station in Korea causing 140 dead and over 136 injured.

Fire - Station Fire – lesson learnt

The famous King's Cross Station fire in 1987 killed 31 people.

After this, station designs are improved with fault tolerant Public Addressing, Help Point, C&C Systems, Low Smoke and Halogen free cables.

Level Crossing – collide with cars

On 13 November 2005, a passenger train collided with a road vehicle at a level crossing in Norfolk killing the driver.

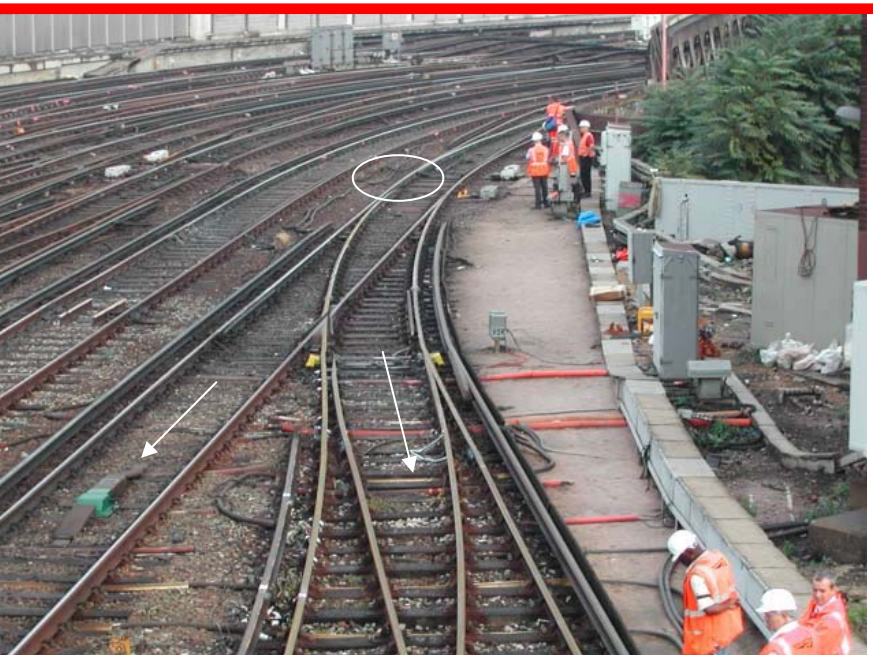
Level Crossing – lesson learnt

New lines over 120kph will not have level crossings. Crossings are designed with lots of warnings and final escape for vehicles.

Despite wide public awareness, people and drivers still want to beat it. Is your time budget really so tight?

MTR港鐵

Maintenance Error - Turnout



At 22:48 hrs on 11 September 2006, a train formed of two class 455 EMU derailed on 1565 points, which were traversed in the *facing direction when* moving into Waterloo south sidings.

At 18:27 hrs on 24 October 2006, a loaded passenger train derailed on 1507 points in the facing direction as the train was approaching Waterloo station. These points had been subject to recent unplanned maintenance.

Maintenance Error - Turnout

The derailment was caused by the flange of the left-hand wheel on the leading axle of coach 7 climbing the left-hand switch blade, before progressing to the stock rail/switch blade interface, splitting the points and running into derailment.

Maintenance Error – Track

Four people were killed and 30 injured in the derailment occurred on 17 October 2000.

The 12:10 London to Leeds train left the rails near Hatfield station about 16 miles north of London at the line speed of 115 mph due to a fractured rail.

July 10 2003
Two rail companies and six of their executives and staff have been charged with manslaughter

Maintenance Error – lesson leant

The Corporate Manslaughter Bill

"An organisation… is guilty of the offence of corporate manslaughter if the way in which any of the organisation's activities are managed or organised by its senior managers:-

(a) Causes a person's death, and

(b) Amounts to a gross breach of a relevant duty of care owed by the organisation to be deceased."

Extracted from the Home Secretary's foreword to the draft Corporate Manslaughter Bill (March 2005)

Maintenance Error – Track Circuit

Errors by the technician:

- Failure to cut back old wire
- Failure to tie old wire out of the way
- Old insulating tape used instead of new
- Disconnection of only one end of a wire
- Failure to insulate bare end of wire

The famous Clapham Junction Accident occurred in 1988 where a wrong sided Track Circuit failure caused three commuter trains to collide with 35 killed and 100 injured. Two loose wires took out from T&C touched a battery terminal causing a Track Circuit to pick up in the Signal Box. Railway *Safety Case regulations* was then introduced in 1994.

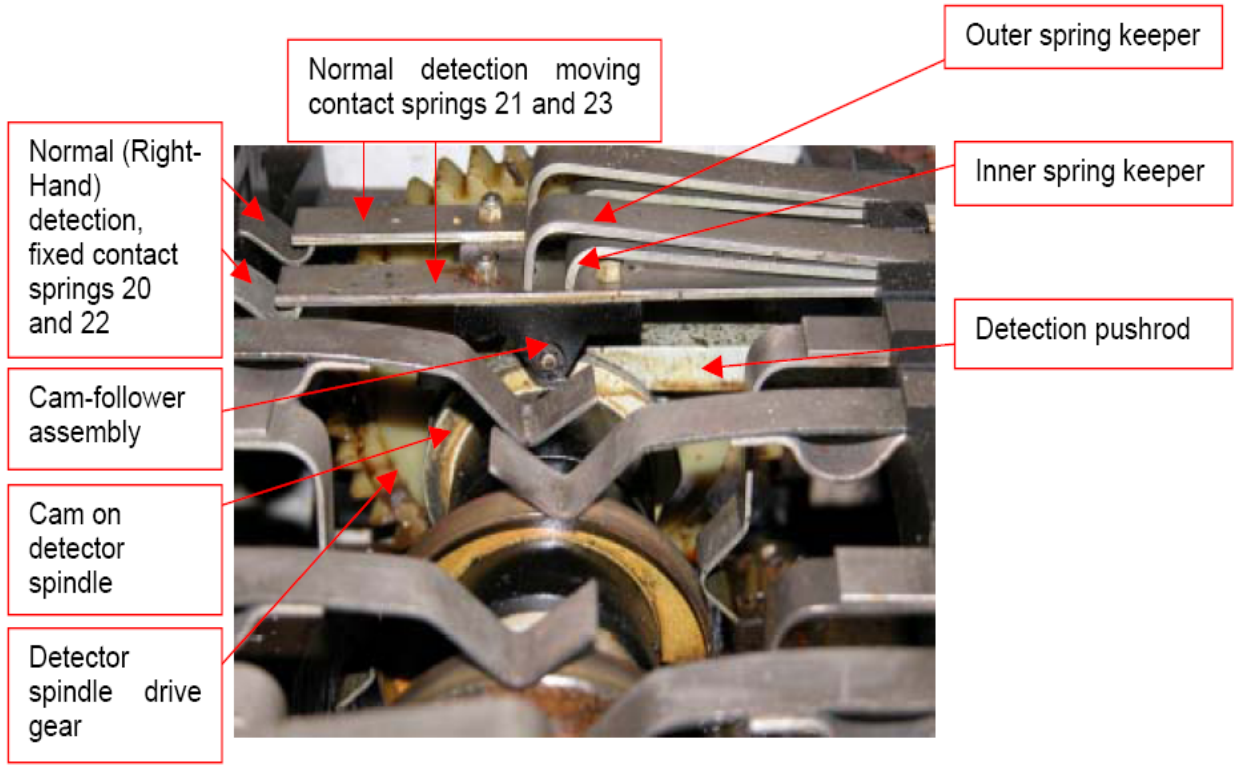
Basic Components of a Safety Case

1. Preliminary Hazard Analysis (PHA)
2. Failure Mode, Effects & Criticality Analysis (FMECA)
3. Subsystem Hazard Analysis (SSHA)
4. System Hazard Analysis (SHA)
5. Interface Hazard Analysis (IHA)
6. Operating & Support Hazard Analysis (O&SHA)
7. System Safety Assessment
8. Design Safety Review (DSR)
9. System Safety Audit
10. Reliability Demonstration
11. Maintainability Demonstration
12. System Integration and Commissioning Demonstration (SICD)
13. Fit for Service Certificate

Maintenance Error – Point Machine

On 27 May 2005, train 2N80 derailed at point 354 of Leigham Junction due to Signal Technician used wrong tool in adjusting the Circuit Controller of a Style 63 Point Machine.

To prevent further occurrences the concept of Safety Critical Tasks is introduced.

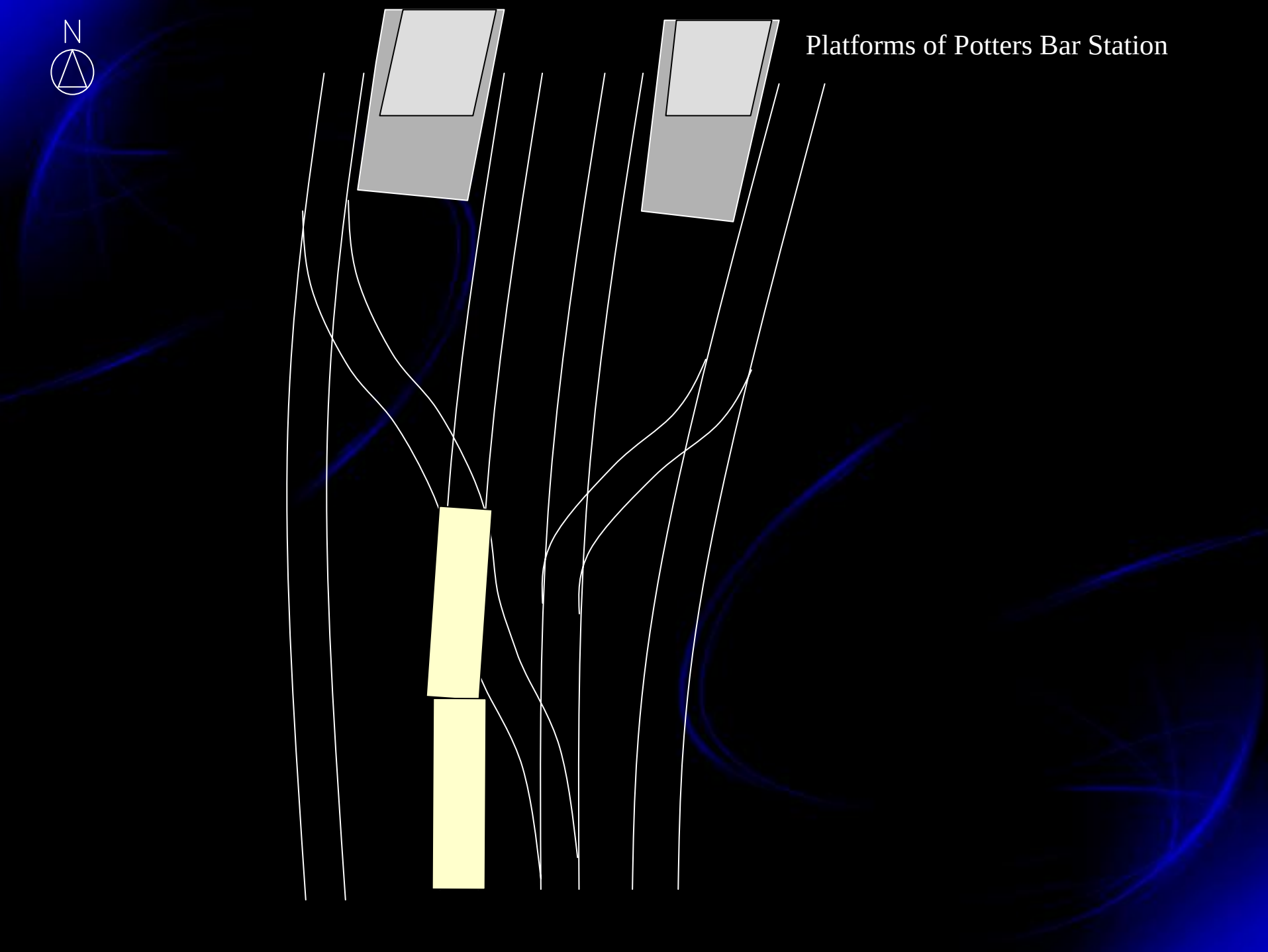


Safety Critical Tasks

- Staff MUST be competent on these tasks
- Independent checks are essential
- Regular review of situational risks
- Detailed procedure essential
- System limitations and technical tolerances MUST be make known to all staff
- Clear approval / operation procedure and contingency plan for sub-standard performance (especially on False Feeding)

Maintenance Error – Point

At 12:58 hrs on 10 May 2002, high speed train 1T60 from King's Cross to King's Lynn derailed just south of Potters Bar Station killing 7 people with over 70 injured. It was due to loose bolts from the turnout causing the 4th coach rolled to the platform.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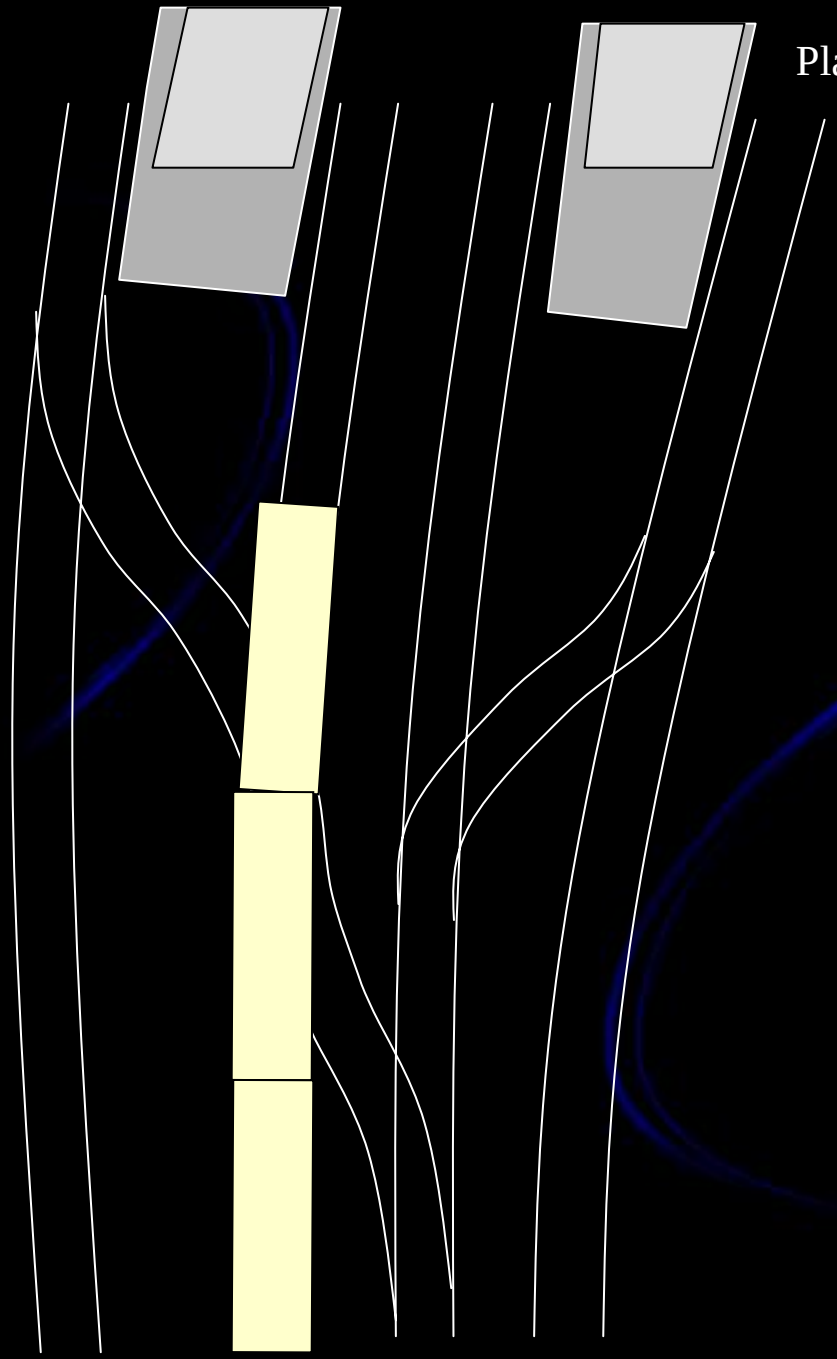
Platforms of Potters Bar Station



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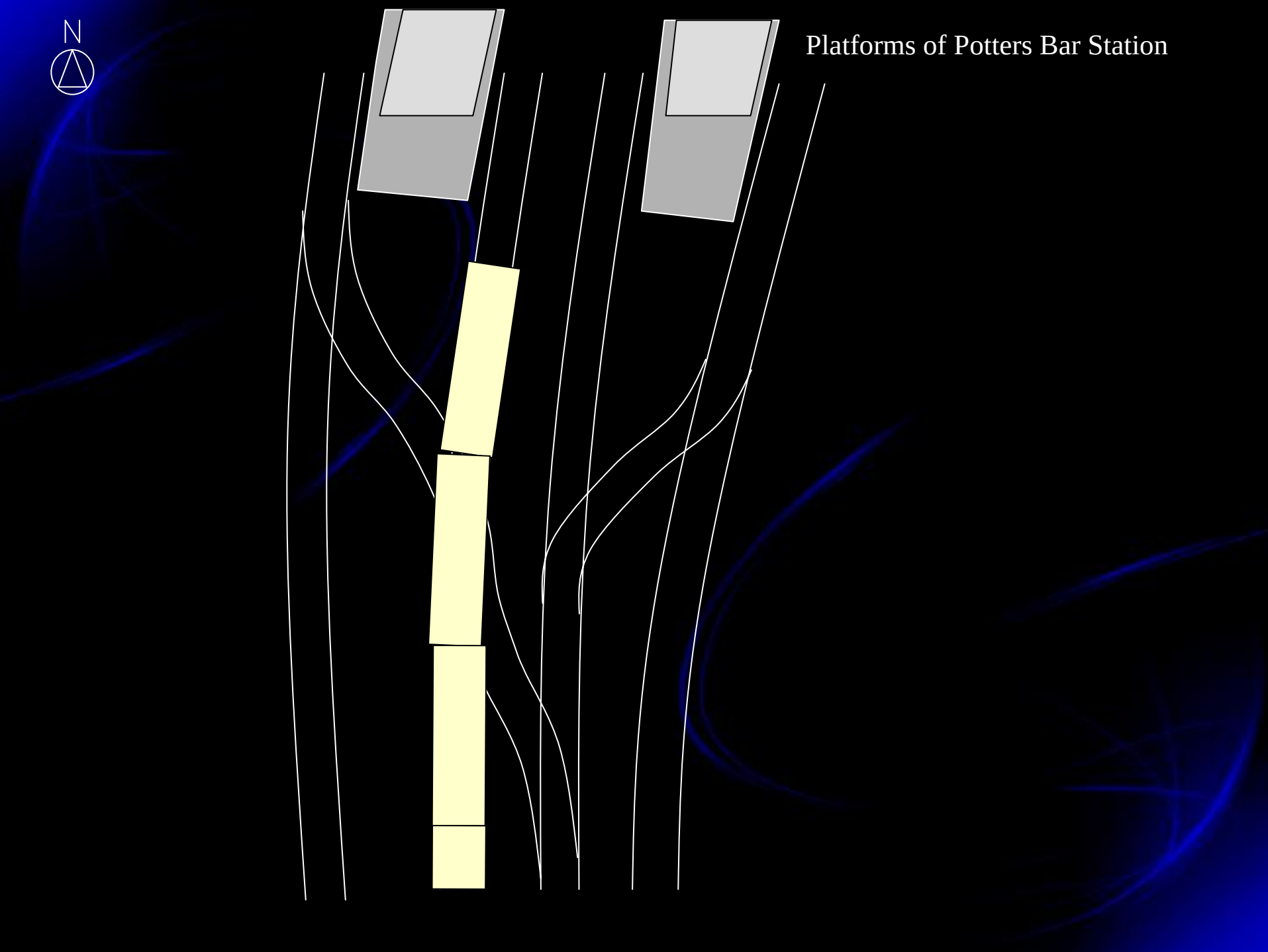
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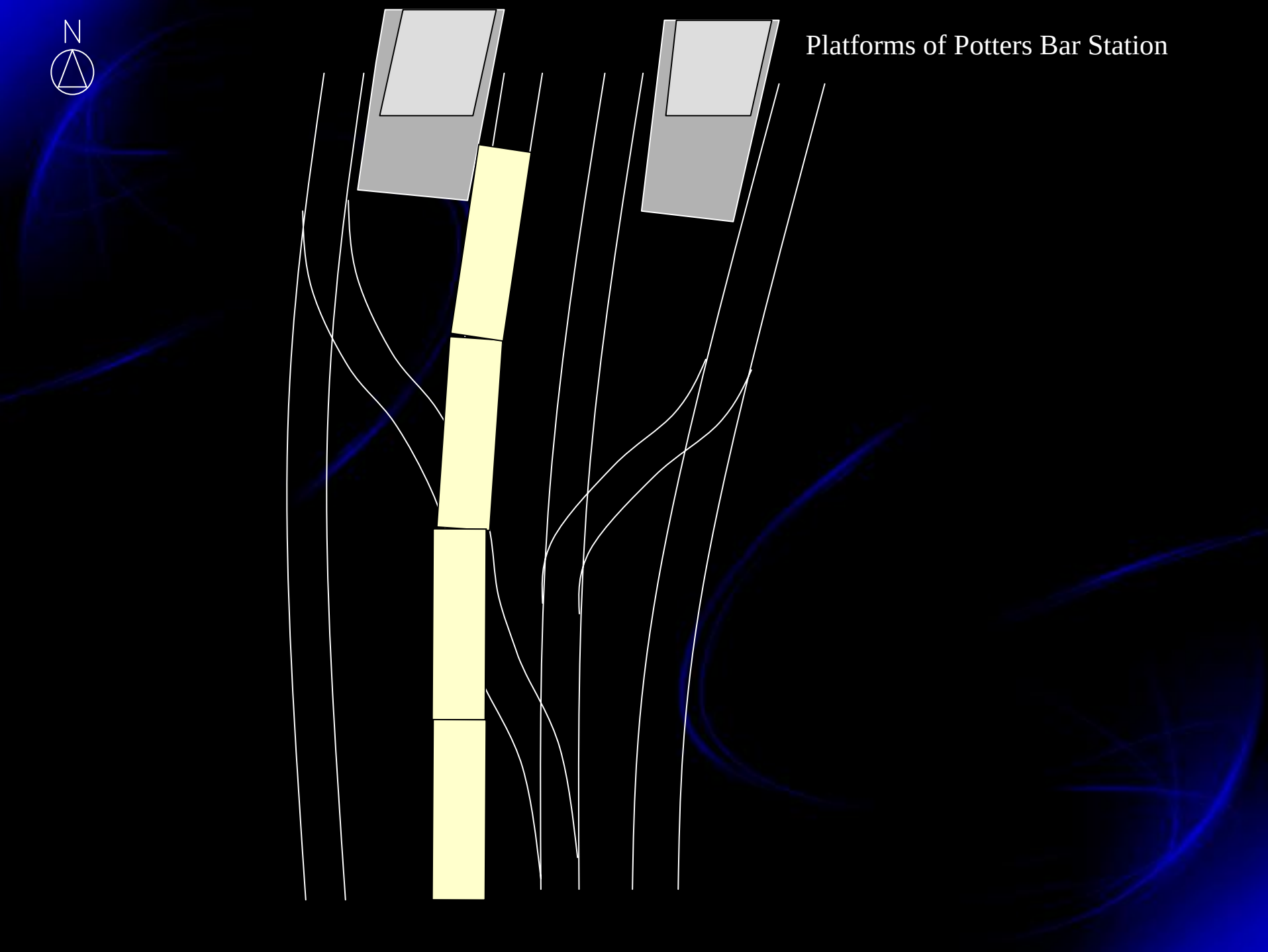
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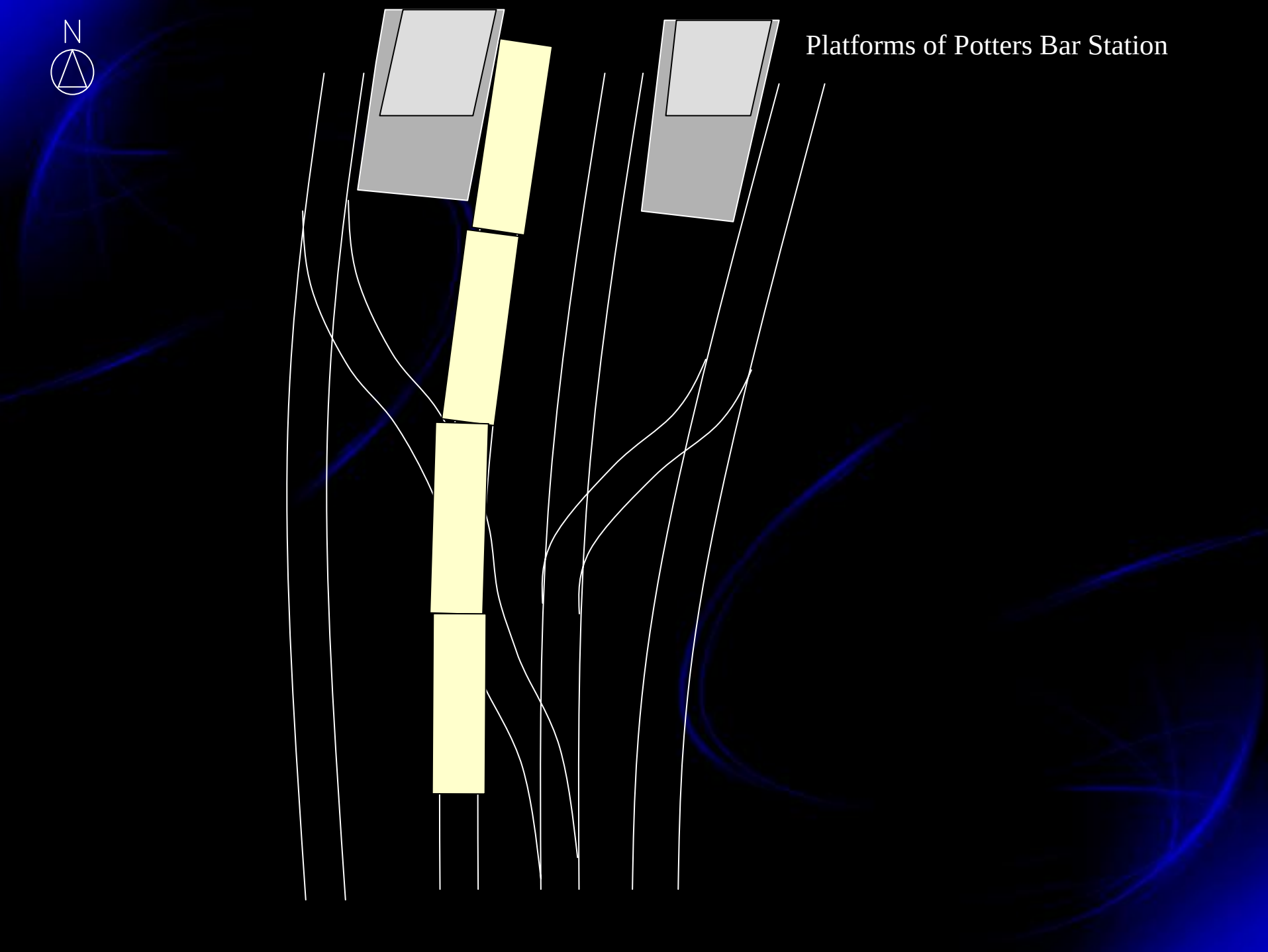
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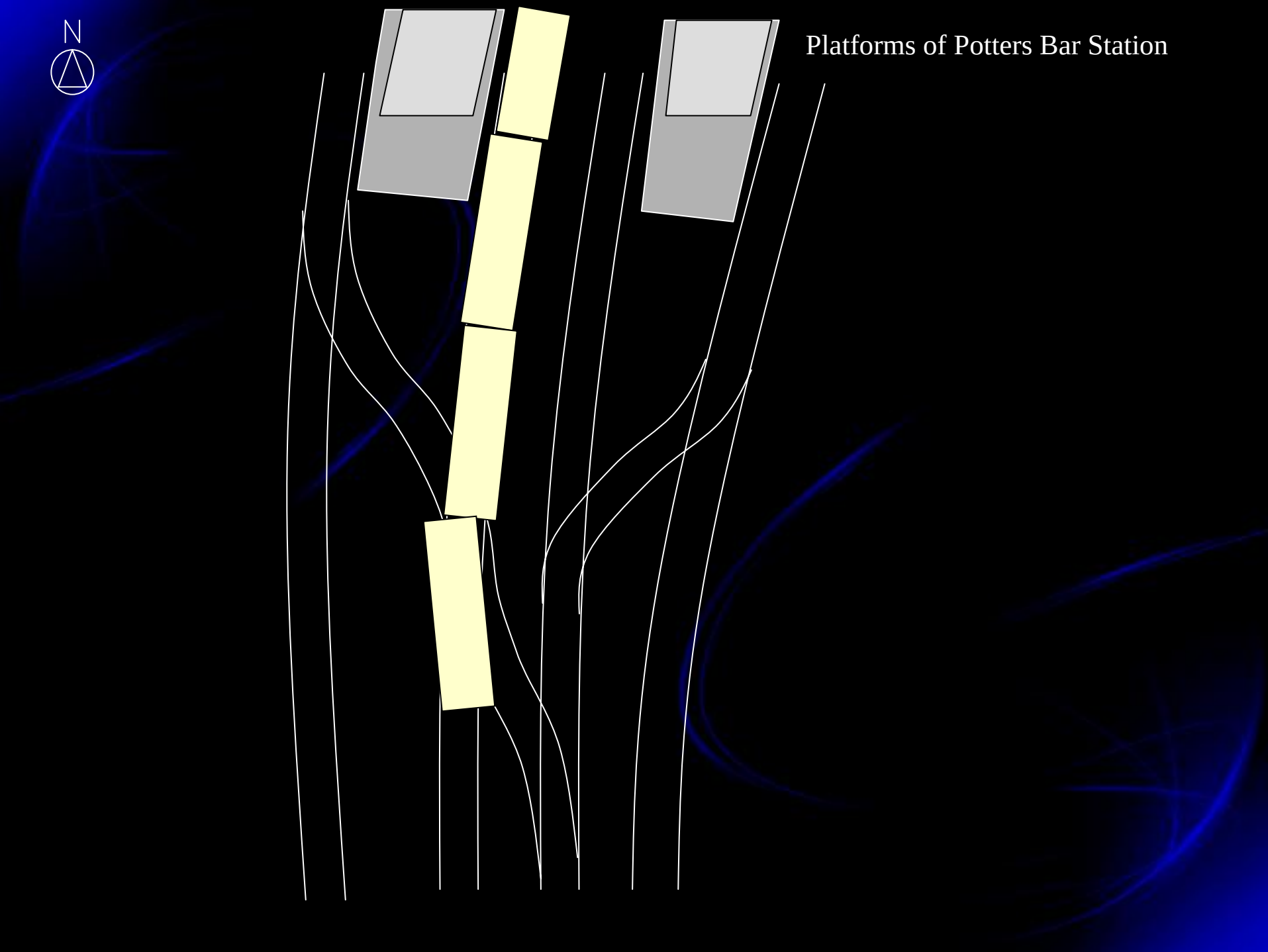
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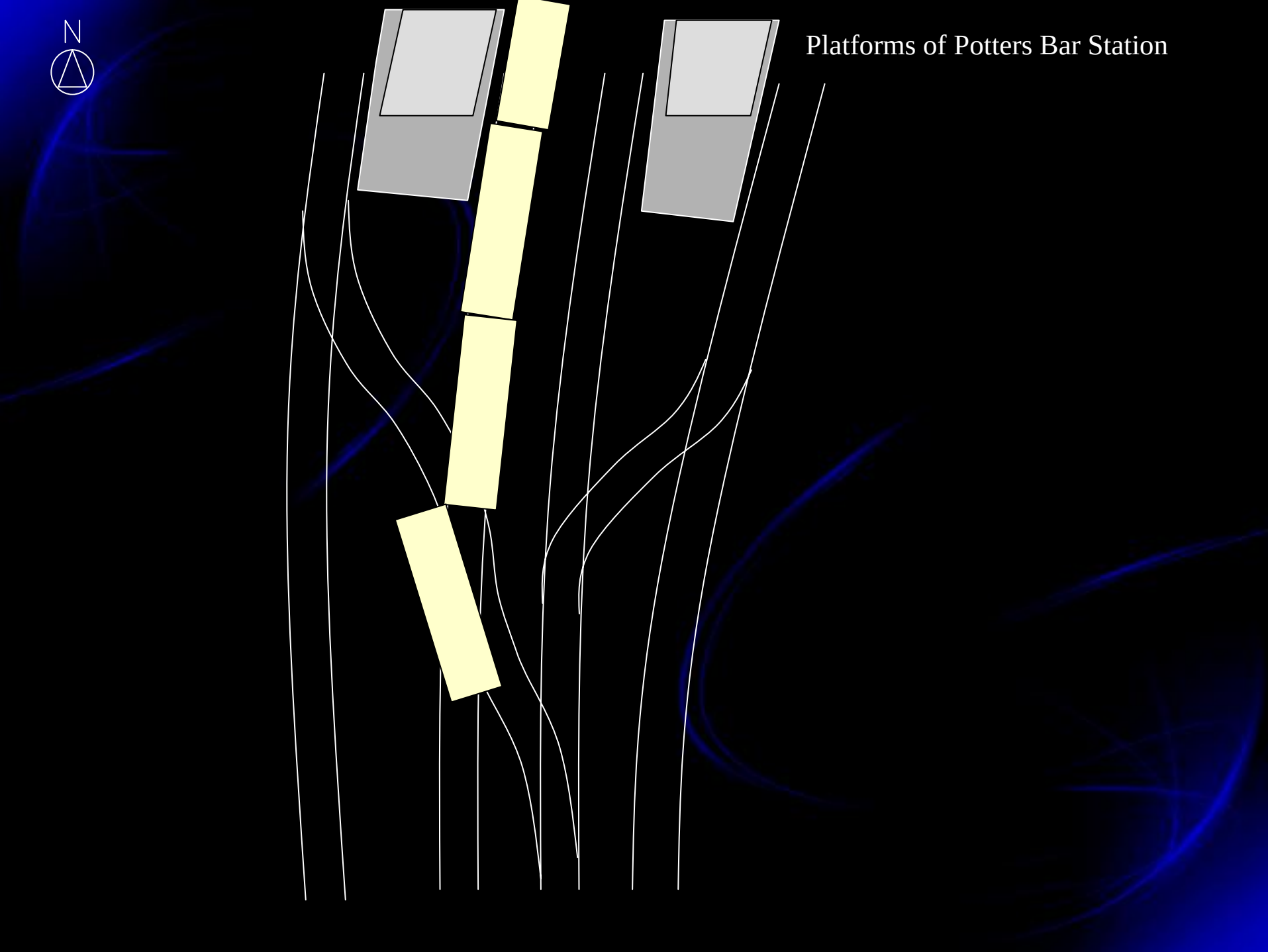
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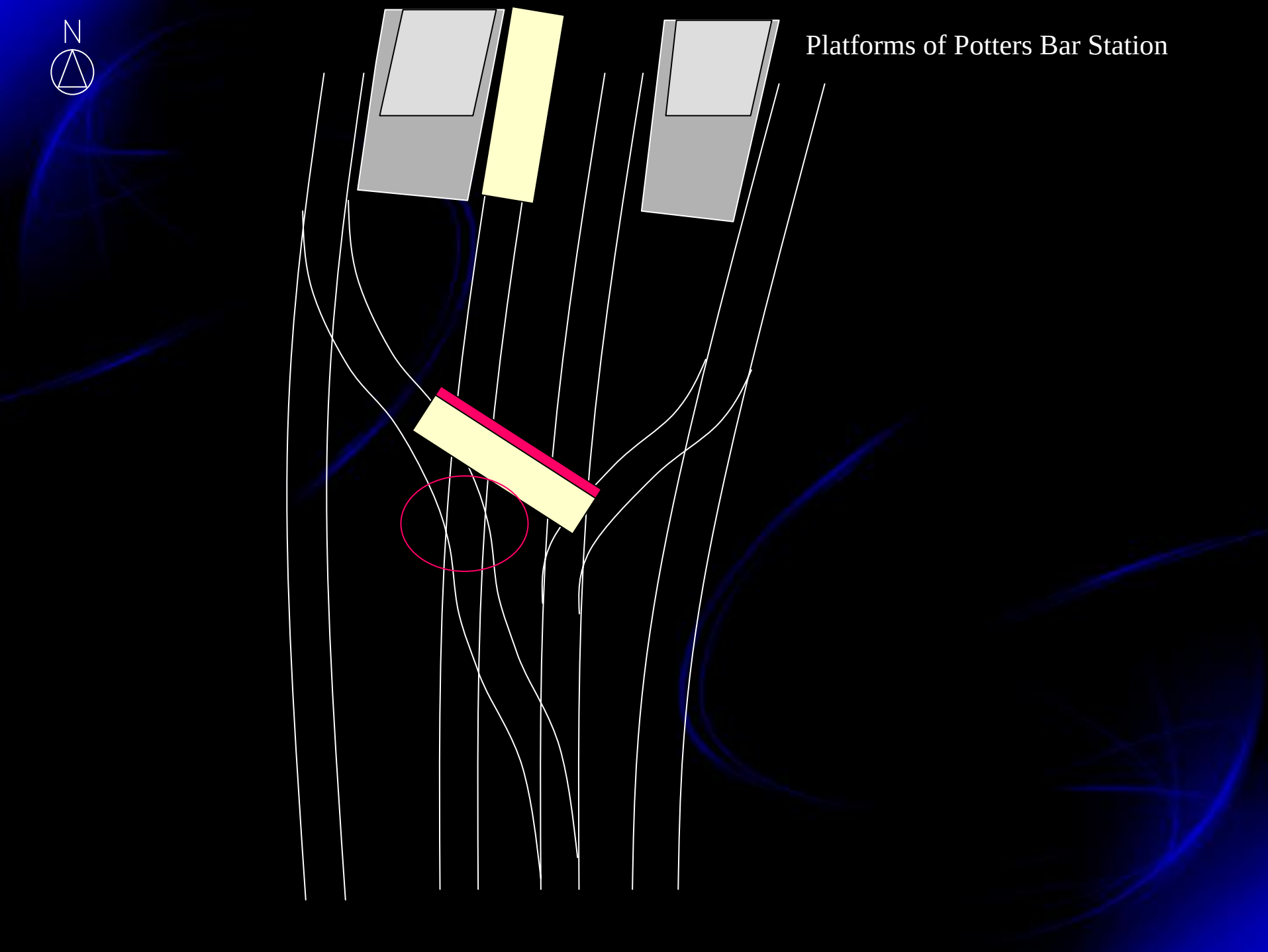
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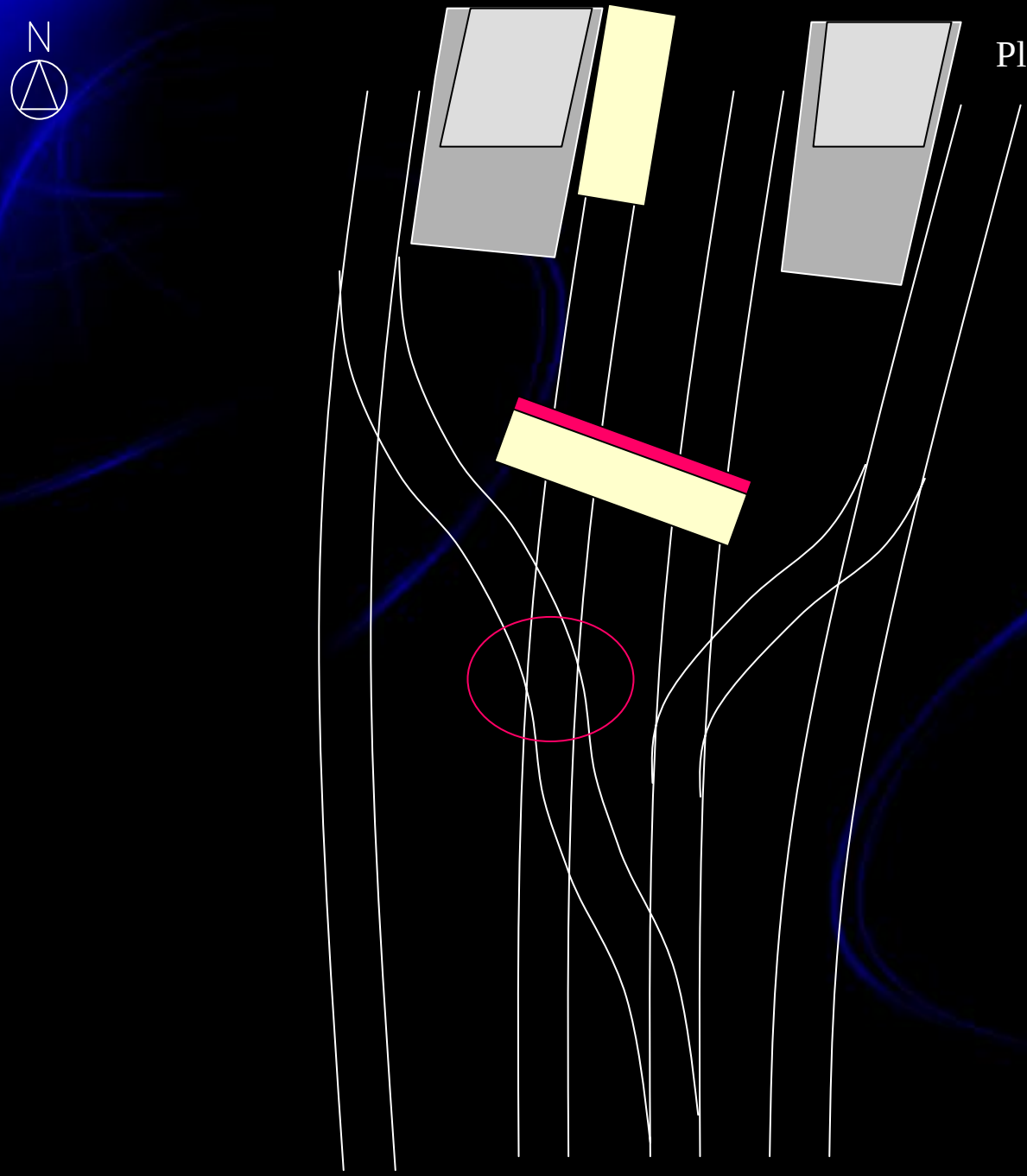

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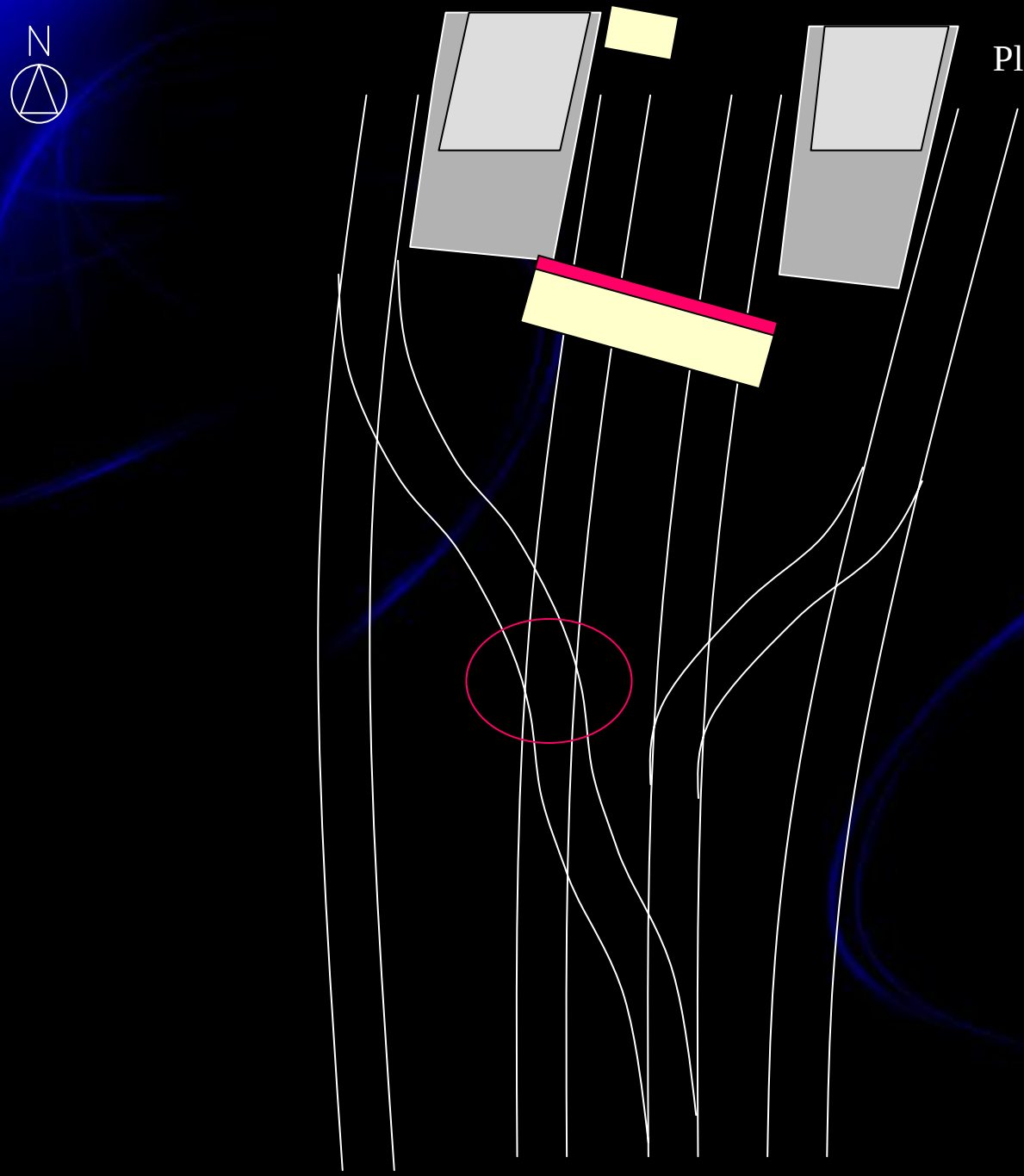

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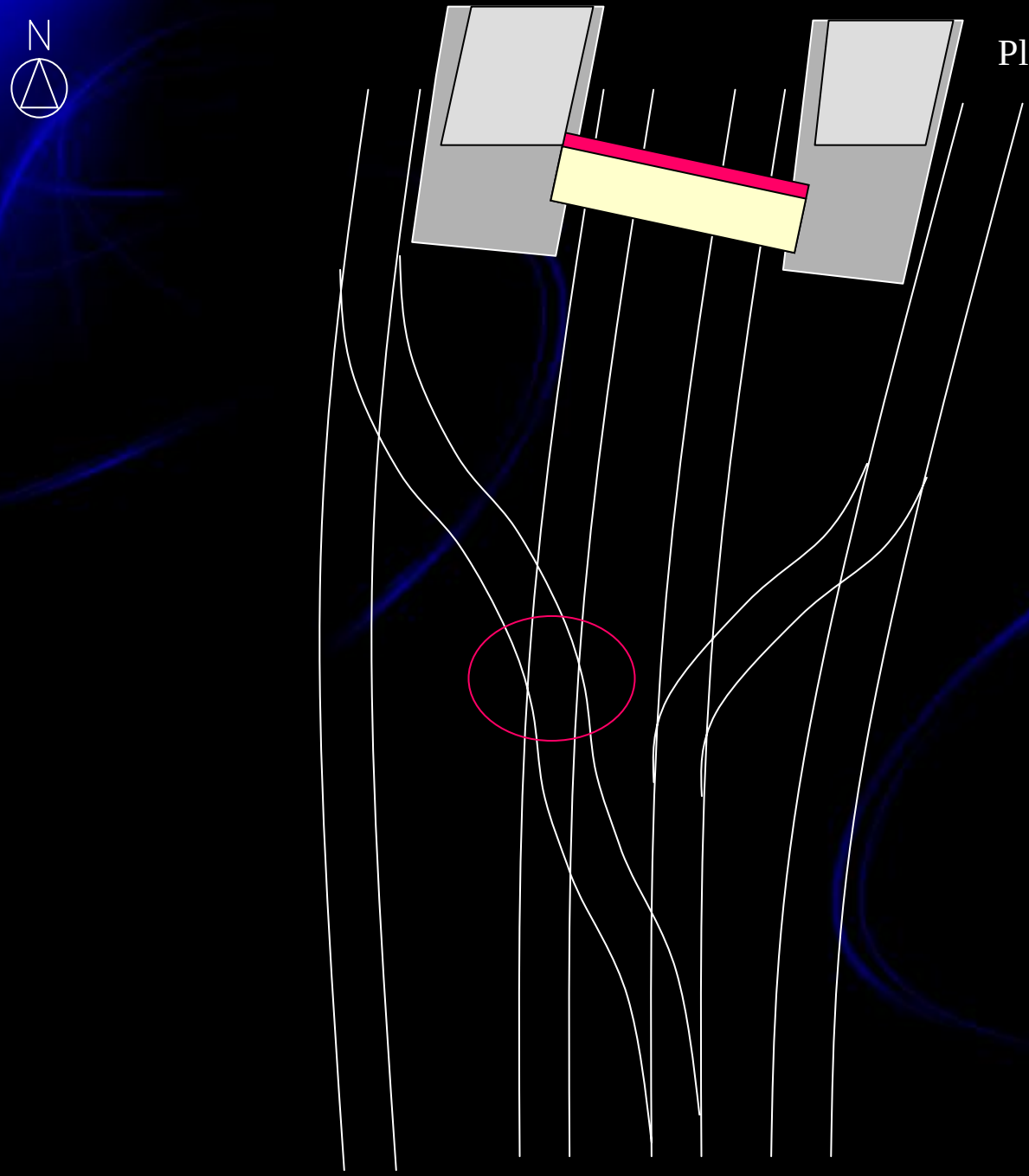

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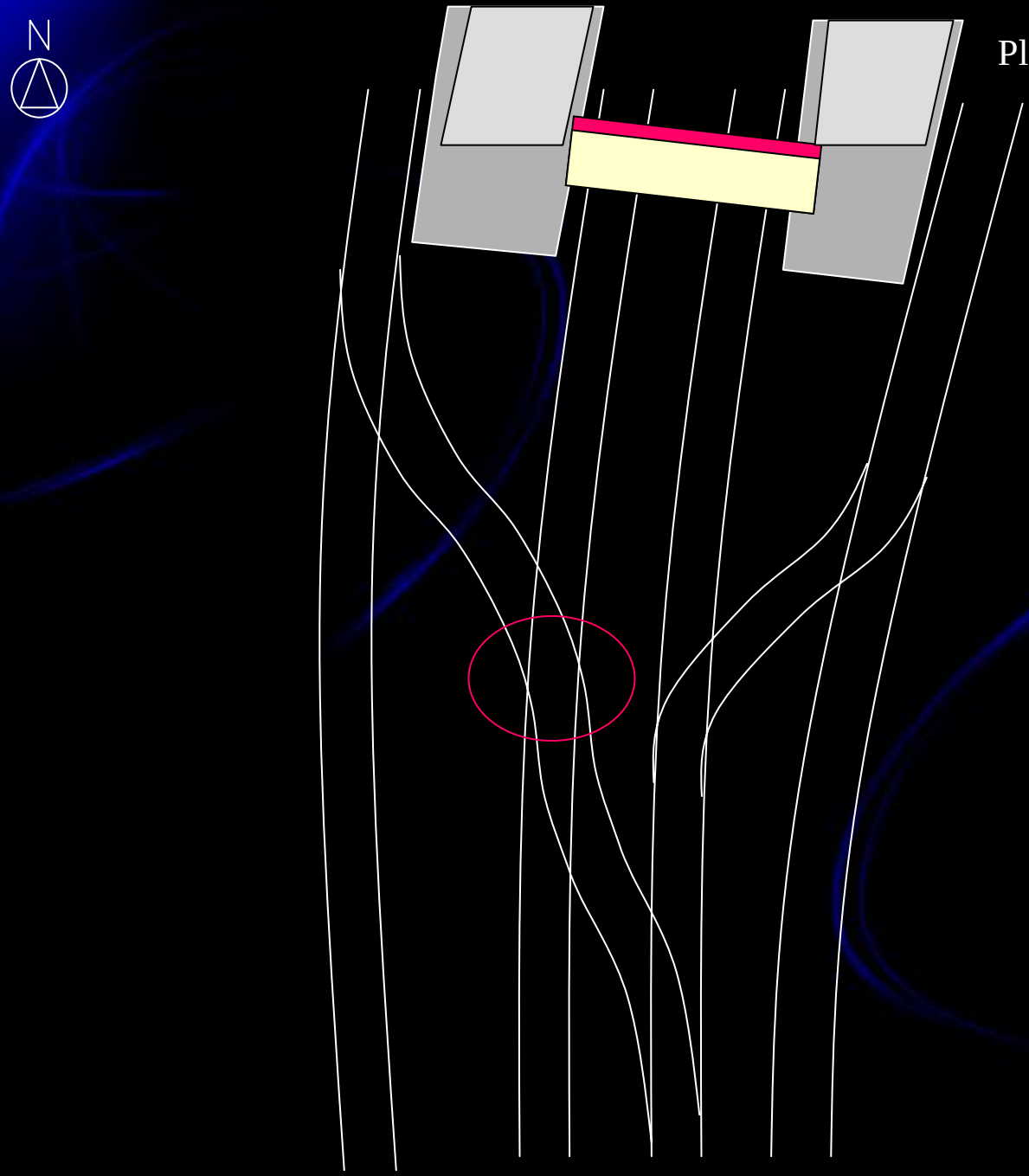
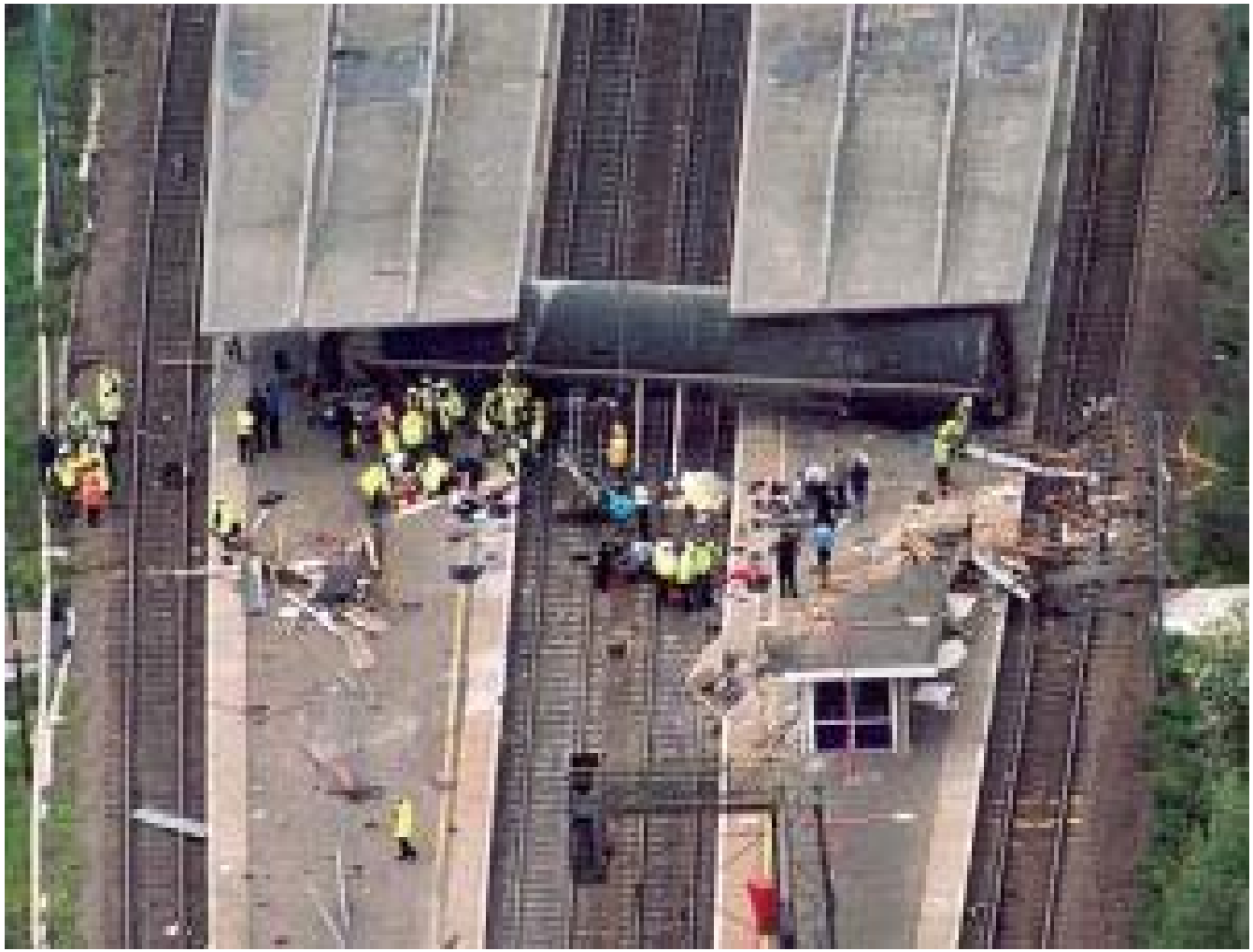


Platforms of Potters Bar Station

Maintenance Error – Point



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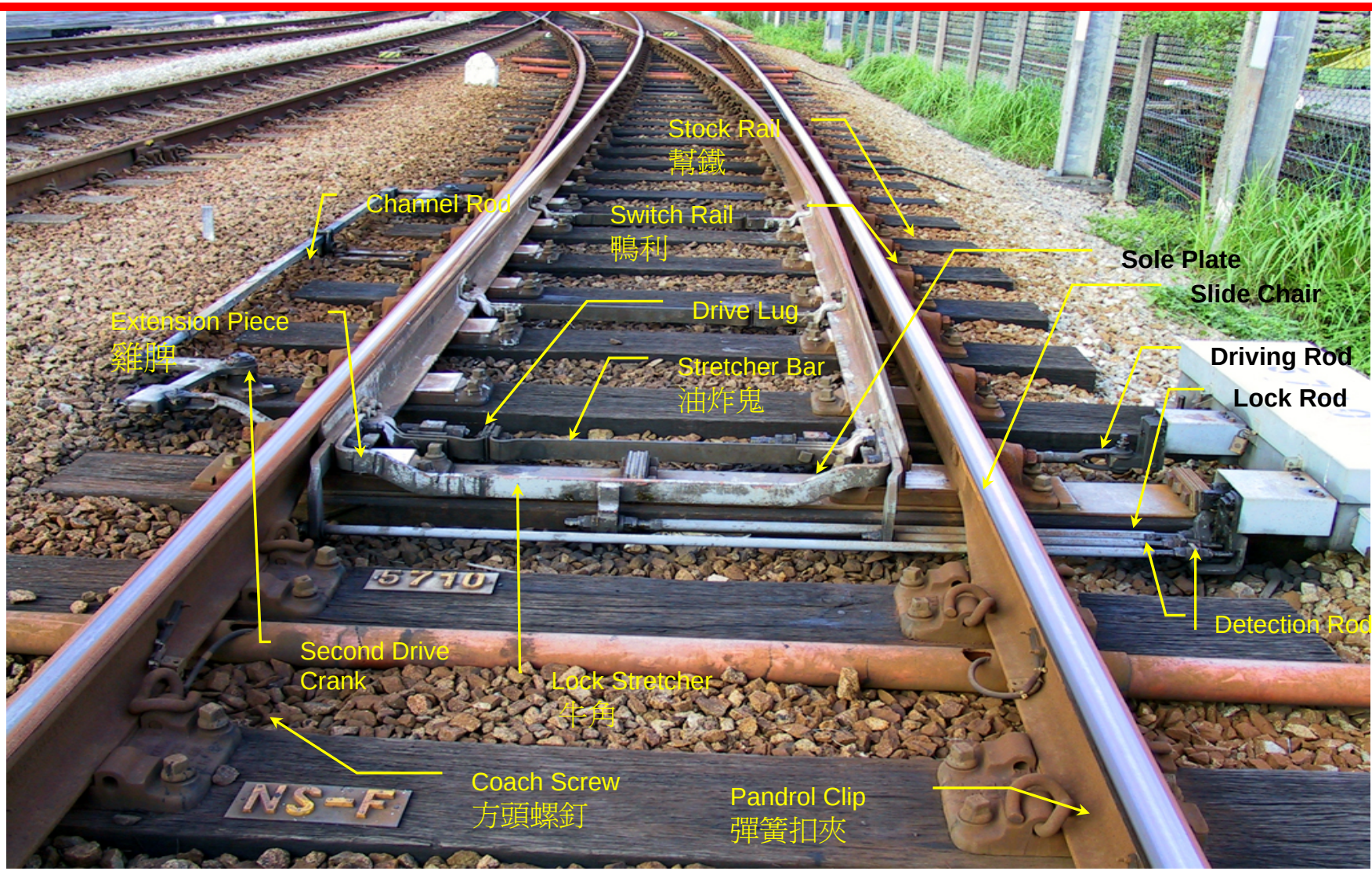
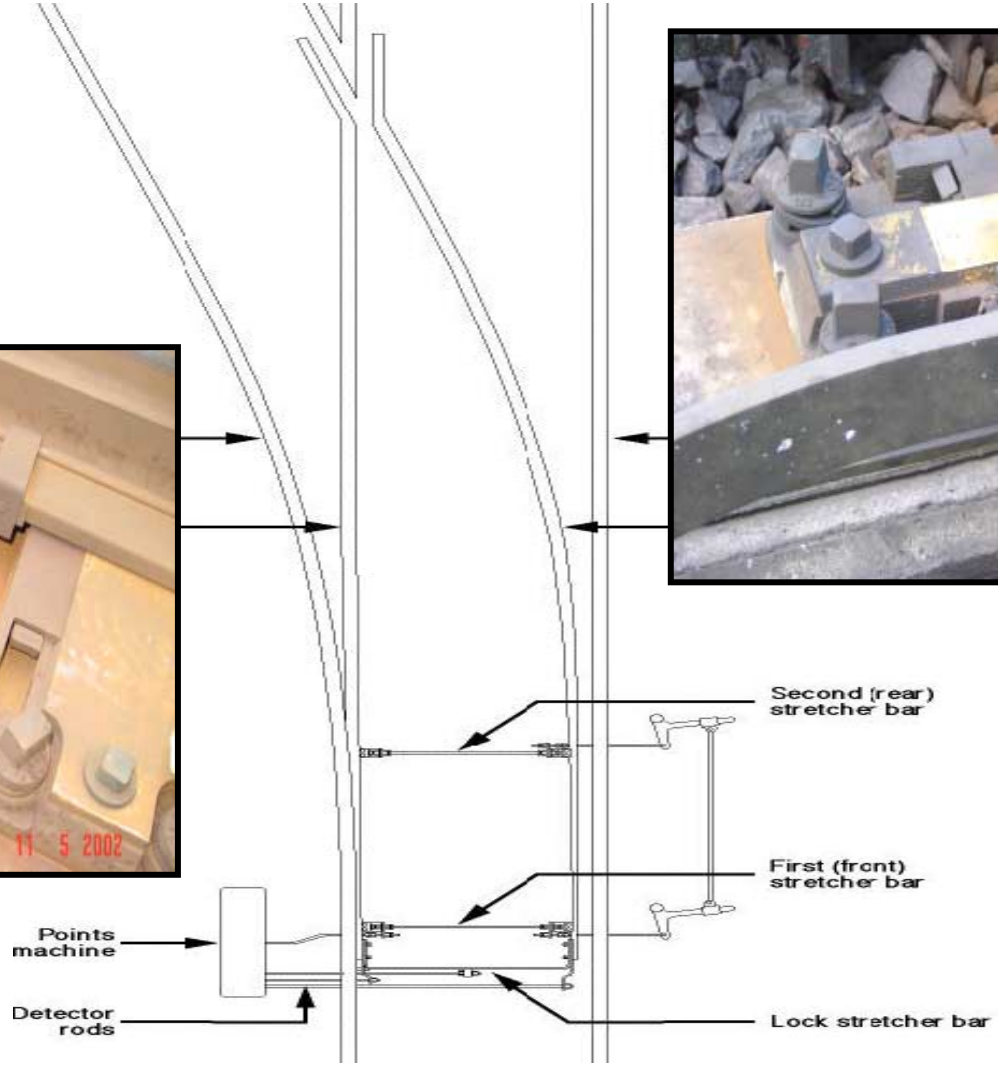
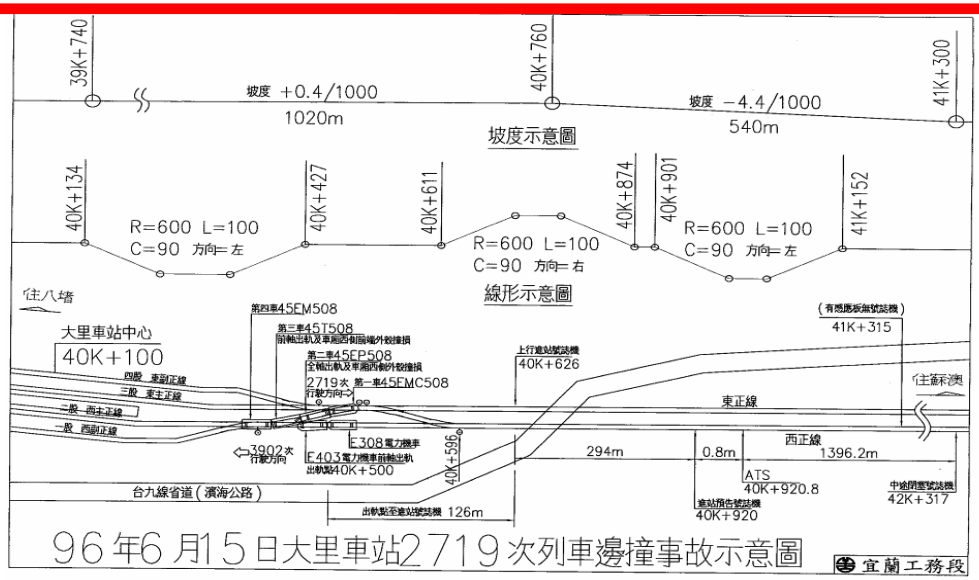


MTR港鐵

Maintenance Error – Point



Equipment Failure – ATP + Driver Action



於頭城站折返轉向駕駛原次位迴送機車E403號，司機員應依規定起動次位機車並啓用ATP系統後行駛，列車開動後自動切斷牽引馬達電流無法續行，司機員即以操作隔離ATP系統行車，列車行駛至龜山站通過後，因司機員疏忽未注意龜山~大里站間第一閉塞號誌機顯示「注意號誌」應依規定減速，持續以約90km/hr之速度行駛，至發現大里站「進站號誌預告機」顯示「險阻號誌」及進站號誌機外方之「列車自動停車裝置標誌（ATS）燈」顯示紅燈時始採取緊急緊軔措施，雖當時第2719次列車司機員發現第3902次列車高速接近鳴笛示警但已不及，致邊撞正由大里站西正線開出之第2719次列車。

Equipment Failure – ATP + Driver Action – lesson learnt

On 5 October 1999 a commuter train passed Signal 109 at red after ATP cutout near Paddington.

After the Paddington accident HM HSI recommend the decommissioning of AWS after the ATP system is proved operating reliably. A second man will be post onboard of an ATP failed train.

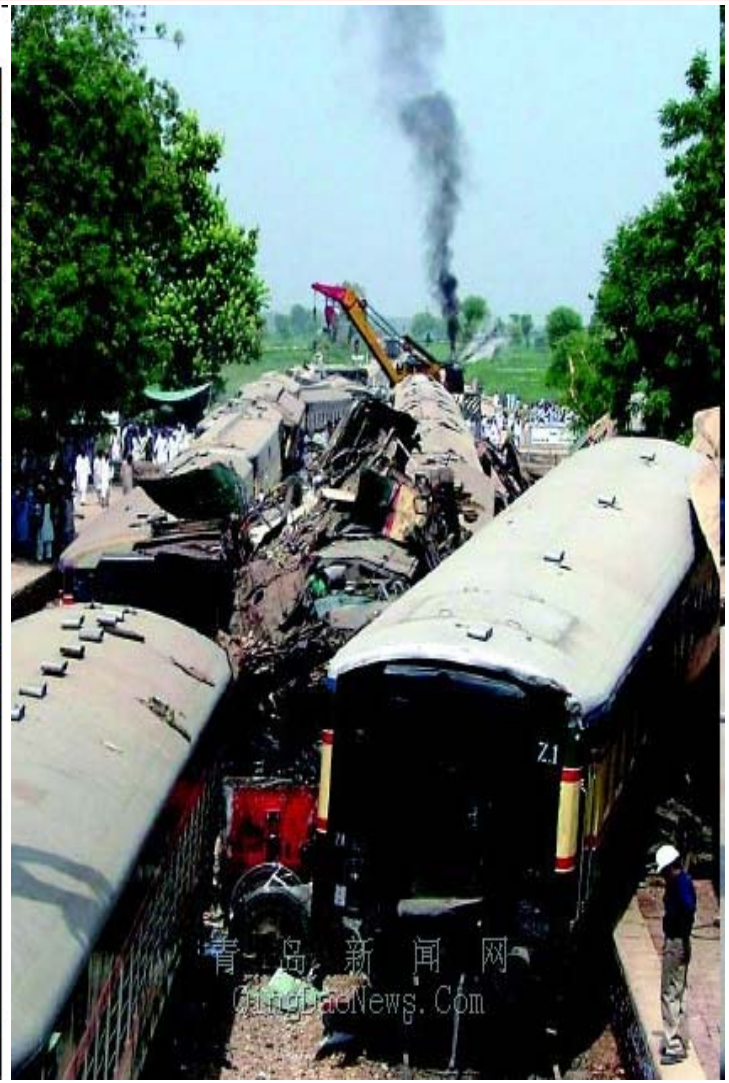
Equipment Failure – Metal Fatigue

At 11.00am 3 June 1998, an Inter City Express (ICE) was travelling at 200km/h derailed and struck an over bridge just outside of the town of Eschede. The power-car passed under the bridge safely, but the following carriages struck the bridge bringing it down on top of them. The remaining carriages then crashed into a wreckage with 101 people died and 88 injured. The cause of the accident was a wheel rim which broke and damaged the train 6Km south of the accident site.

Signal Passed at Danger – Head-on Collision

Head-on collision is not the worst case. It is the second collision on the fouled carriages that causes most injuries.

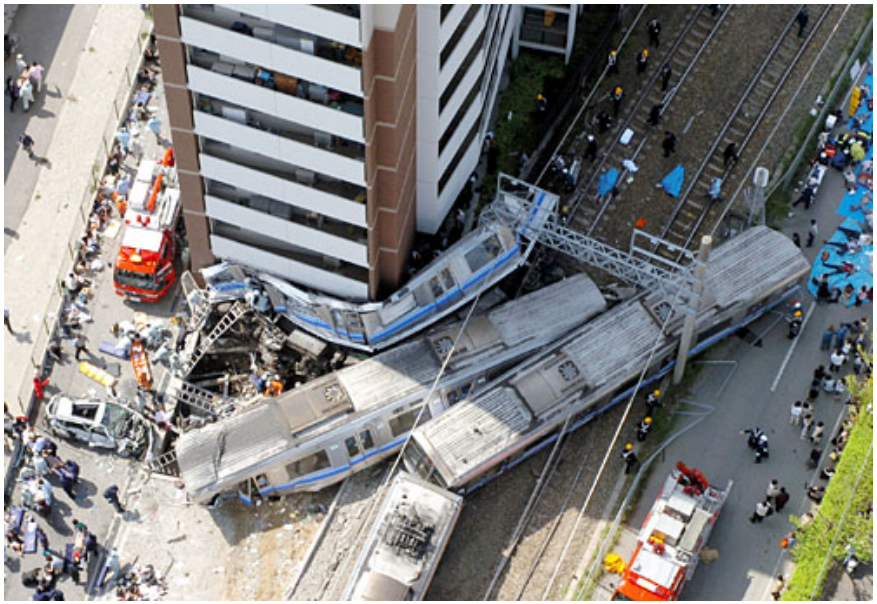
Signal Passed at Danger – Second Collision

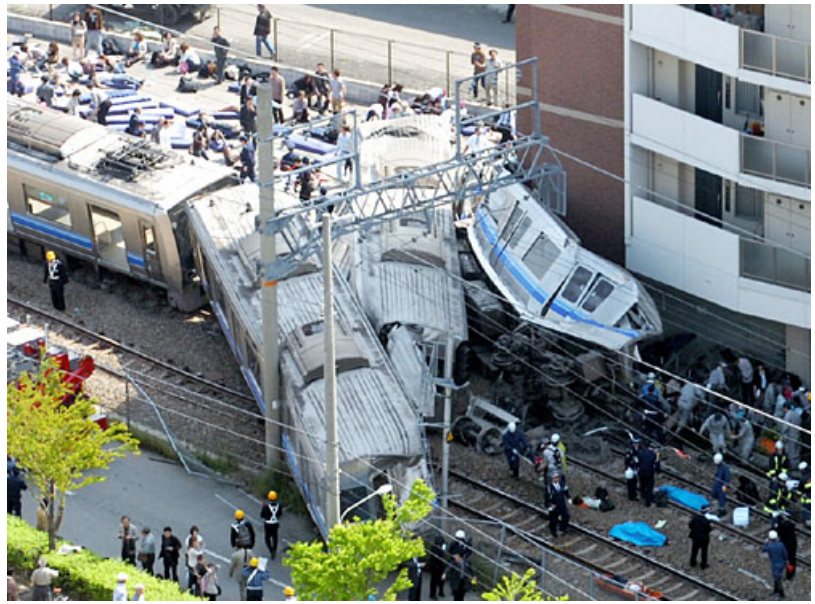


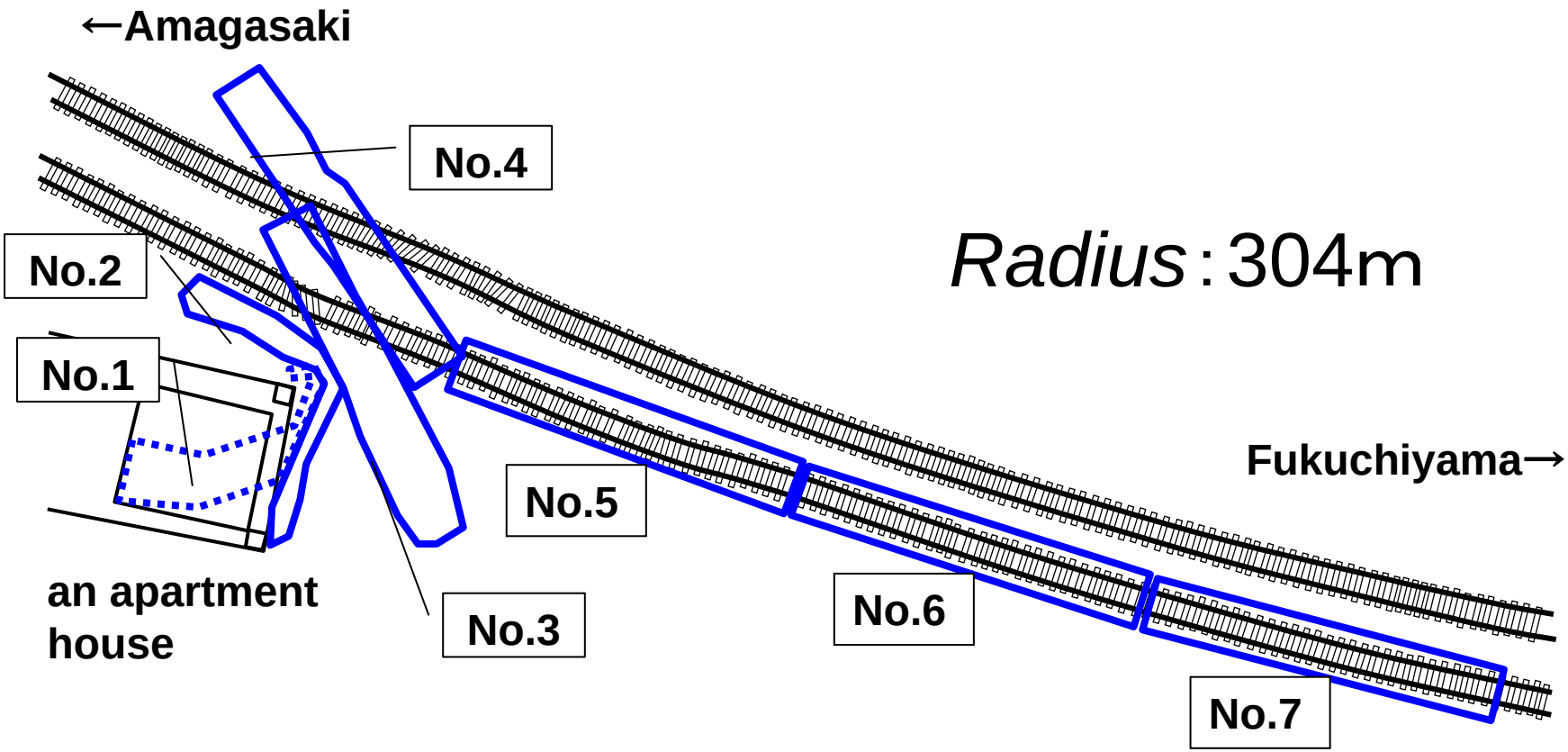
MTR港鐵

Operation Error- over speed derailment at curve

At 9:19am on April 25 in 2005, an EMU from the Fukuchiyama Line of JR West derailed near Osaka killing 106 passengers and injuring 562. At a previous station, the train overran by 70 meters causing a one minute delay. The driver was explaining to the conductor at the time when the train entered the 304-meter-radius curve at 116km/h, against a 70km/h speed limit. The first car tilted to the left, causing derailment.



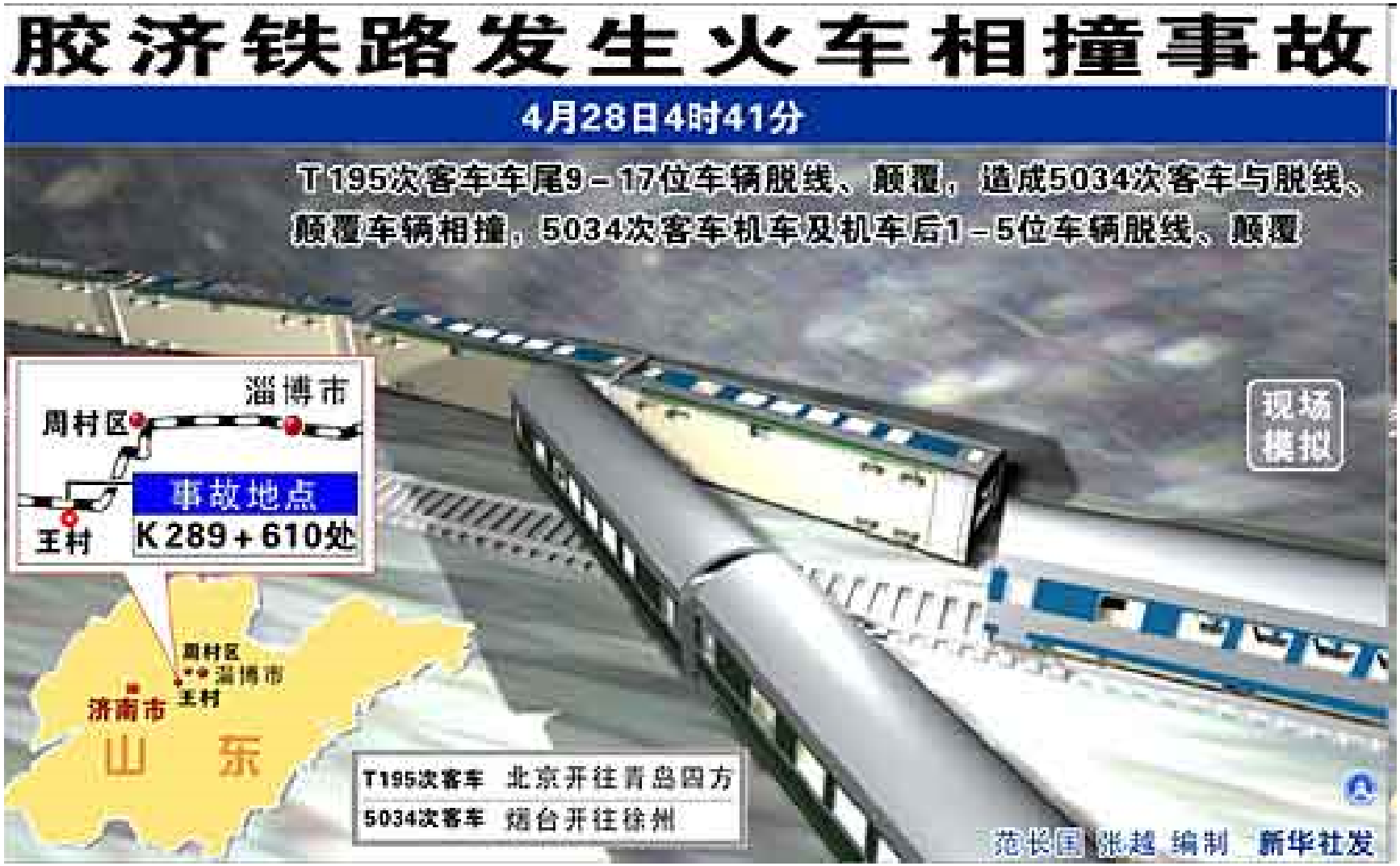




Killed：106 passengers and the motorman

Injured：562 passengers

Operation Error- over speed derailment at curve



Operation Error- over speed derailment at curve

MTR港鐵

Operation Error- over speed – lesson learnt

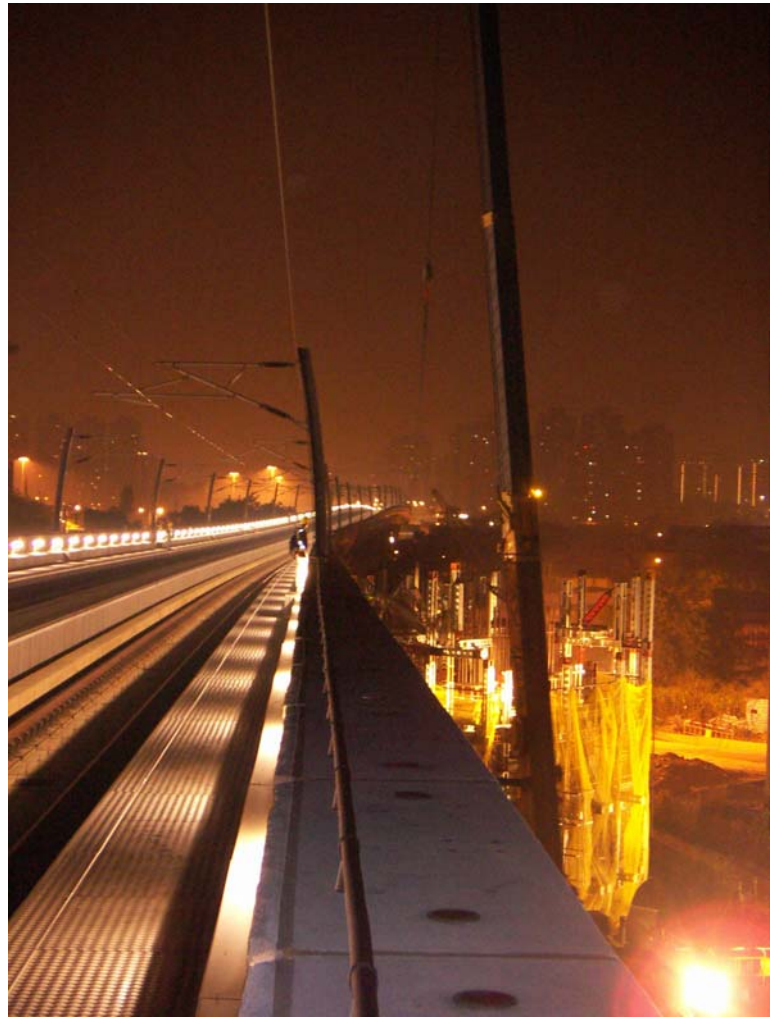
Which you want to survive, the Buffer Stop or the train. Good lesson learnt for Buffer Stops designers.

To prevent over speeding & SPAD, some countries legislated the requirement of ATP as essential for passenger trains.

Object near Track - railway protection

At 10am on 22 September 2006, a Maglev on trial was travelling at 200kph from Lathen to Doerpen in Germany. Due to Control Centre unable to recognize the existence of works close to the viaduct, it crashed with a works vehicle killing 23 people with 10 injured.

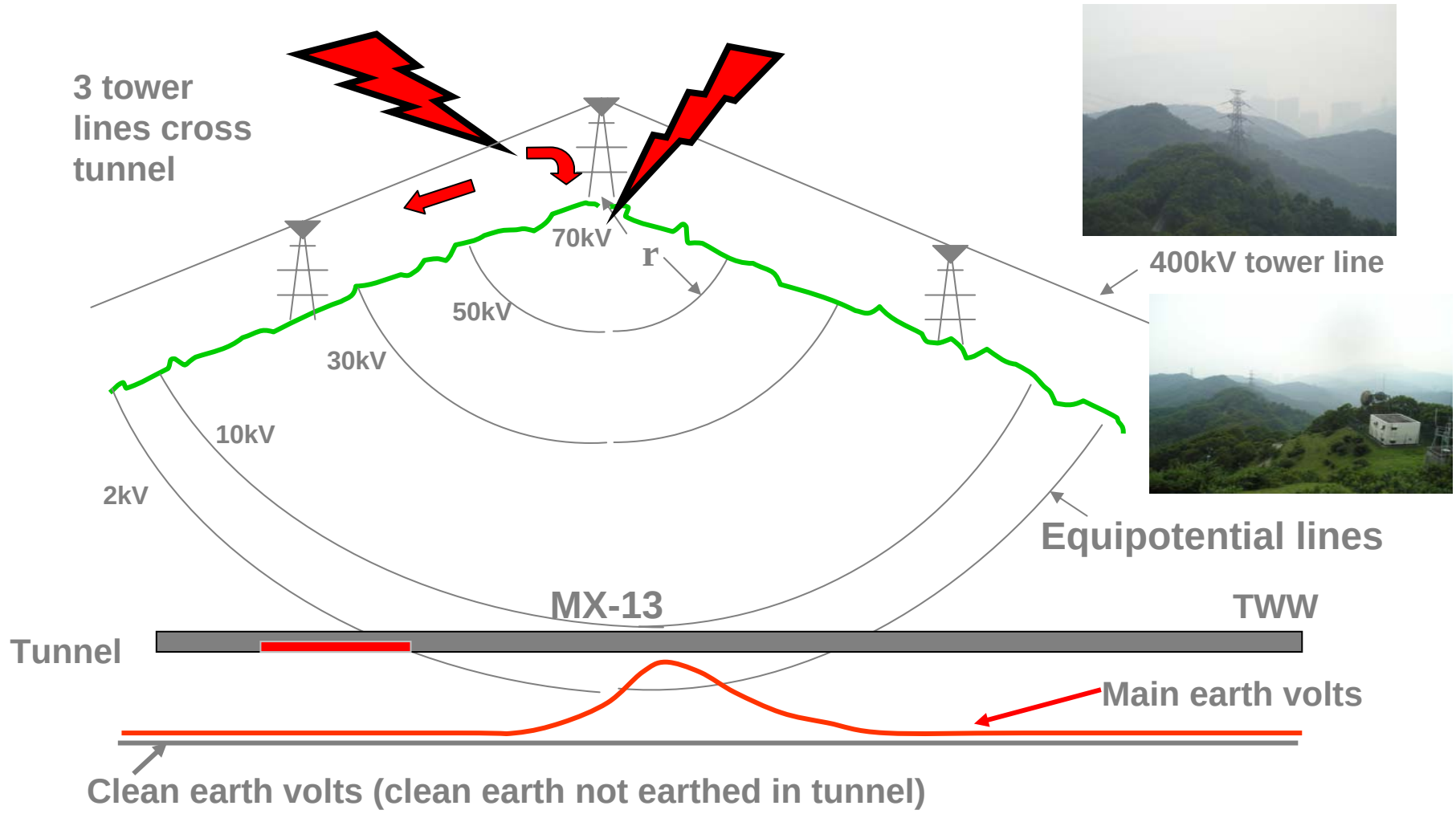
Railway Protection is often legislated in the Railway Ordinance.



Adverse Weather - Lightning

Lightning damages equipment and can be deadly to staff who need to work in the open under such bad weather conditions.

Problem in Tai Lam Tunnel



Adverse Weather – Fallen Trees

Anything that falls into the Structural Gauge can be deadly.

Anything that falls into the Electrical Gauge causes more trouble.

Adverse Weather - Flooding

Flooding of viaducts can cause much trouble and damage.

Flooding of plain tracks normally will not cause much trouble, only service impact.

Adverse Weather – Soil Lost

Under heavy rain a bridge or large volumes of soil can be washed away

Adverse Weather - Landslide

2006年11月19日清晨5時35分, 一列津山線列車行經牧山站至玉柏站的途中, 一段約20米長路軌被山上滾落的碎石擊中而變形, 更令其中一條路軌斷裂, 引致該列車出軌, 25名乘客連同司機受傷.

Terrorist Attack - Explosives

At morning peak of March 11, 2004, Madrid suffered the worst-ever terrorist attacks on railway systems with a total of 10 explosions.

The Atocha, Santa Eugenia, and El Pozo stations were all involved. According to early news reports, the explosions killed more than 180 people and wounded over 1,000.

Terrorist Attack - CBRNE

After numerous failed attempts to disseminate anthrax spores and botulinum toxin, in and around Tokyo, on March 20, 1995, members of the Aum Shinrikyo cult, led by Shoko Asahara succeeded in releasing sarin in 5 trains running on three major subway lines converging in downtown Tokyo.

More than 5,500 people were affected. There were 641 casualties resulting from sarin inhalation that required medical treatment and 12 deaths.

Terrorist Attack

The railway occupies a vast terrain with so many blind spots and trespassers. It is rather impossible to say 100% that we can prevent Terrorist Attacks. In the main line, our only defence is metal fences. We can only provide surveillance, diversity and redundancy to reduce risk.

Other Railway Safety Concerns

- Trespassers hit by train
- People commit suicide
- Object on track
- Escalator accidents
- Passengers slip and fall in stations
- Platform Gap incidents
- Staff injuries
- Theft of metal along track

How to Maintain Safety

- Maintain the Safety Case
- Ensure O&M readiness before taking over the system
- Make sure which are Safety Critical Systems and separate from Operation Critical Systems
- Draw a line between Operation Safety and Personal Safety to remain focused
- Identify which are really Safety Critical Tasks
- Know the Operation Limits and System constraints
- Know the psychology, limits and working culture of your staff

Man is the Most Safety Critical System

- Make sure that they are well trained and competent
- Make sure that they have most updated information about the systems
- Make sure that they are not over loaded
- Make sure that they feel being treated fairly
- Make sure that they are proud of their work

BUILT A SAFETY CULTURE

Be Prepared - Tunnel Evacuation

Tunnel evacuation procedures and equipment are constantly drilled and tested with rescue forces.

Be Prepared - Incident Drills

Train and Station incident scenarios are regularly drilled with rescue forces.

Review will be conducted after every drill to look for improvement measures.

Be Prepared - Incident Handling Drills

Drills can be hands on by really derailed a wagon for staff familiarization.

Even the mostly unlikely scenario of attack by CBRNE will be drilled.

Pushing to the Limits

Increasing expectations, Media brings tragic scenes home, Political demand

Decreasing Resources and flexibility, Increasing Operation capacity and Government intervention

My Message for this Presentation

There are thousands of equipment, men and women who did millions of right things a day to make the railway safe and efficient. However, one slight error could be deadly with a price tag that nobody can pay.


谢 谢