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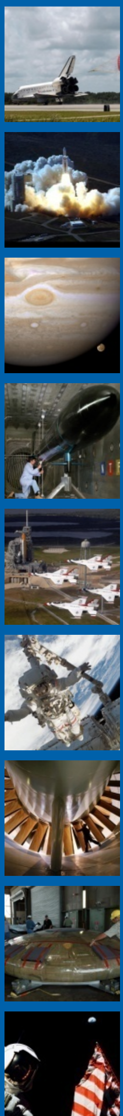

Red Light:

Trains Collide at Ladbroke Grove

(A Lesson in Human Factors Design)

Leadership ViTS Meeting

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THE MISHAP

During London's morning rush hour on October 5th, 1999, a commuter train (known as the 165) passed a red signal at Ladbroke Grove Junction and collided with a High Speed Train (HST). Thirty-one people died in the crash and subsequent fires. Although the incident could be attributed to driver negligence—all available safety features were functioning properly, and there were no technical or mechanical problems—the Health and Safety Executive investigation saw the incident as a "system-wide failure." Careful consideration in design of the human-machine interface and associated training could have prevented the collision.

Note: When a train goes through a red light, the event is referred to as a **Signal Passed At Danger (SPAD)**. The critical signal, SN109, had experienced seven SPADs within the past five years and was one of Great Britain's twenty-two most dangerous signals.

Automatic Warning System (AWS):

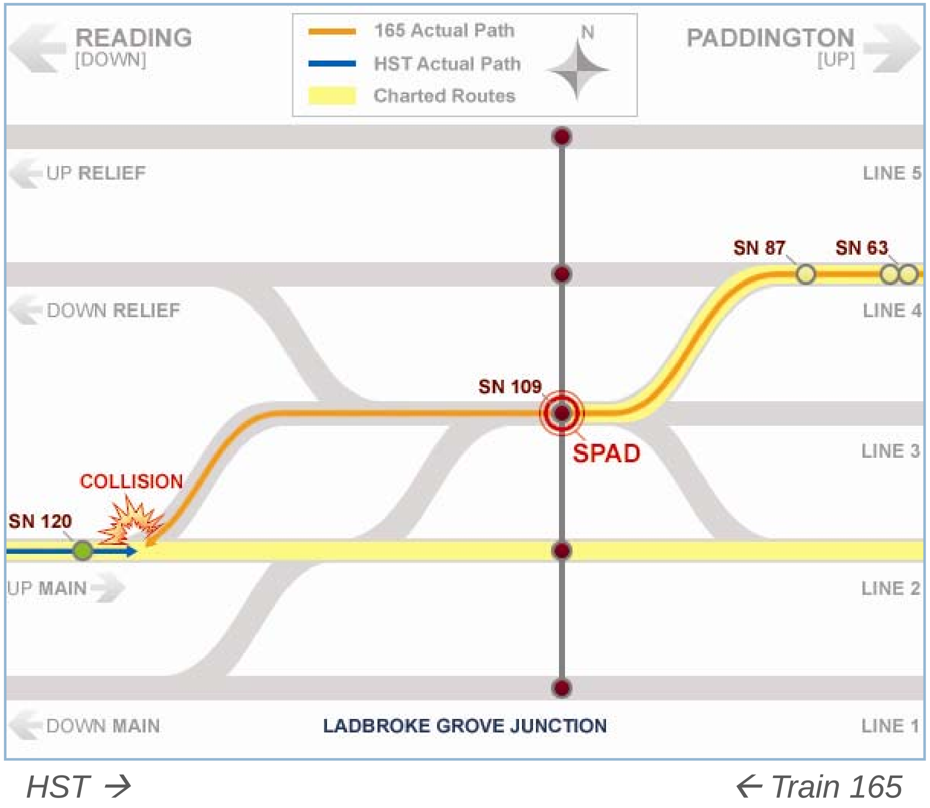
- To protect against SPADs, both trains carried Automatic Warning Systems. An AWS gives both a visual and an audible warning or alarm when a train approaches a red or yellow signal. If the driver does not slow down the train, the AWS automatically applies the brakes and stops the train.
- Standard practice by operators was to cancel the AWS audible alarm, then respond to the signal as appropriate, based on the situation.
- Cancelling the alarm disabled the AWS's braking feature.

WHAT HAPPENED?

Position of 165 Train	Action taken by the 165 Operator
SN 63: Double Yellow (AWS horn sounds)	Cancels AWS horn; applies brakes and proceeds with caution
SN 87: Yellow (AWS horn sounds)	Cancels AWS horn; coasts
239 Meters before SN109: all signals are red, but SN109 is not visible at this point on the track. All other signals are visibly red.	Applies power without seeing SN109
107 Meters before SN109: (AWS horn sounds)	Cancels AWS horn; increases power
SN109: Red	Continues to accelerate: SPAD
100 Meters Before Collision: oncoming HST is visible	Applies emergency brakes upon seeing the HST

Collision: the 165 collides with the approaching HST with a closing speed of approximately 130mph

Track Diagram



PROXIMATE CAUSE

A diesel commuter train (the 165) passed a red signal at Ladbroke Grove crossing. It continued approximately 700m into the path of the approaching high speed train before the two trains collided with a closing speed of approximately 130 mph.

ROOT CAUSE / UNDERLYING ISSUES

A complicated British gantry with multiple signals (not SN109)

Complicated Signal Layout

- The gantry supporting SN109 was frequently obscured by transverse girders and overhead line equipment.
- SN109 was visible 60 meters after the other signals on the gantry.

Ambiguous Alarms

- Alarms did not distinguish between minor warnings and critical events.
- The control room monitoring system did not have a unique alert for SPADs.

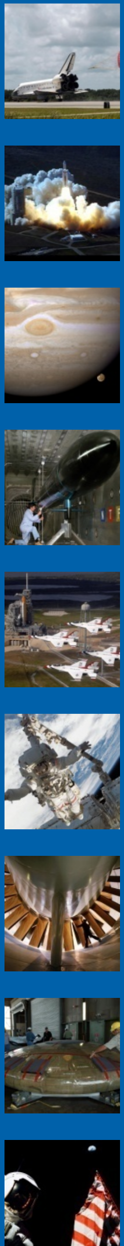
Training and Experience

- Train165's driver completed his training only thirteen days before the incident.
- A recent review of the driver training course called for re-structured training and increased practice time. The driver's course had not yet been updated to meet these requirements.
- Signalers only received on-the-job training on how to handle SPAD's if they happened to be on shift when an actual SPAD occurred.

System Design

- The AWS system was designed to provide a warning and emergency braking if the driver did not acknowledge the alarm.
- Cancelling the AWS warning alarm gave the driver complete control of the train and eliminated a layer of protection.

  [Note: the 165 Train was scheduled to be fitted with a Train Protection and Warning System which would have identified the SPAD and automatically applied brakes.]



FOR FUTURE NASA MISSIONS

Human Action

- Design engineering control measures to minimize required human action or conscious effort.
- When human interaction is required, design with people in mind. Consider:
  - Human capability and limitations
  - Human expectations and logic
  - Performance shaping factors
- Streamline the human-machine interface to reduce error in:
  - Perception
  - Data interpretation
  - Decision-making
  - Action execution

Human Capability and Limitations

- Keep displays simple.
  - Errors are more likely when interfaces are complex or cluttered.
  - A simple display is usually more effective than one that communicates a lot of information all at once.
- Develop consistent and structured training to increase the likelihood that personnel comprehend the information needed to accomplish their assigned responsibilities.

Human Expectations and Logic

- Humans develop expectations based on experience.
  - Anticipate normal warning progression (from green, to yellow, to red)
- Training through repetition makes proper actions second nature .
- Repetition can also reinforce negative behaviors.
  - In this case, the driver had learned to automatically cancel the AWS horn.

Ref: "The Ladbroke Grove Rail Inquiry" 2001; and others - see System Failure Case Study