Electronic Virtual Trainstops

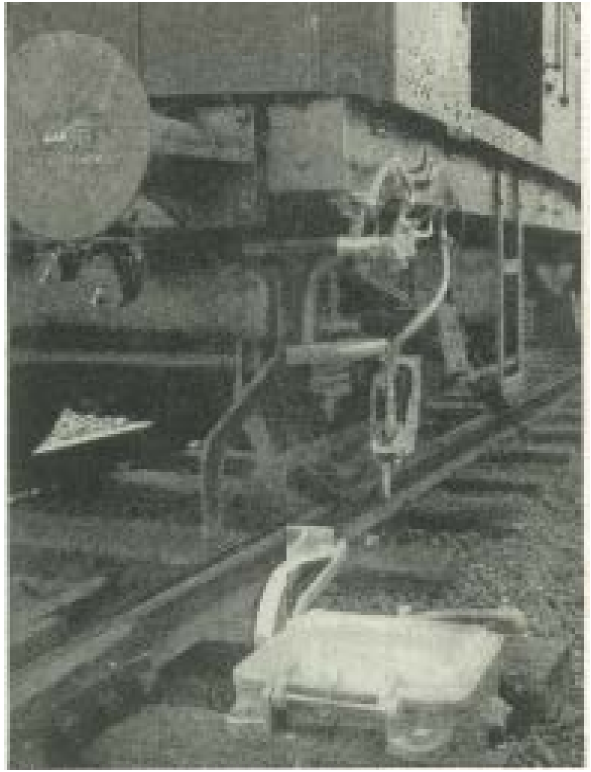
Peter Burns, PYB Consulting

Overview

- System view of cab
  - 1922 updated to 2022
- CBTC requirement for open access
  - Location/identity
  - Speed
  - Trainstop
- Trainstop application
  - Big Red Button
  - Electronic Virtual Trainstop (options)
- Challenges to Interoperability

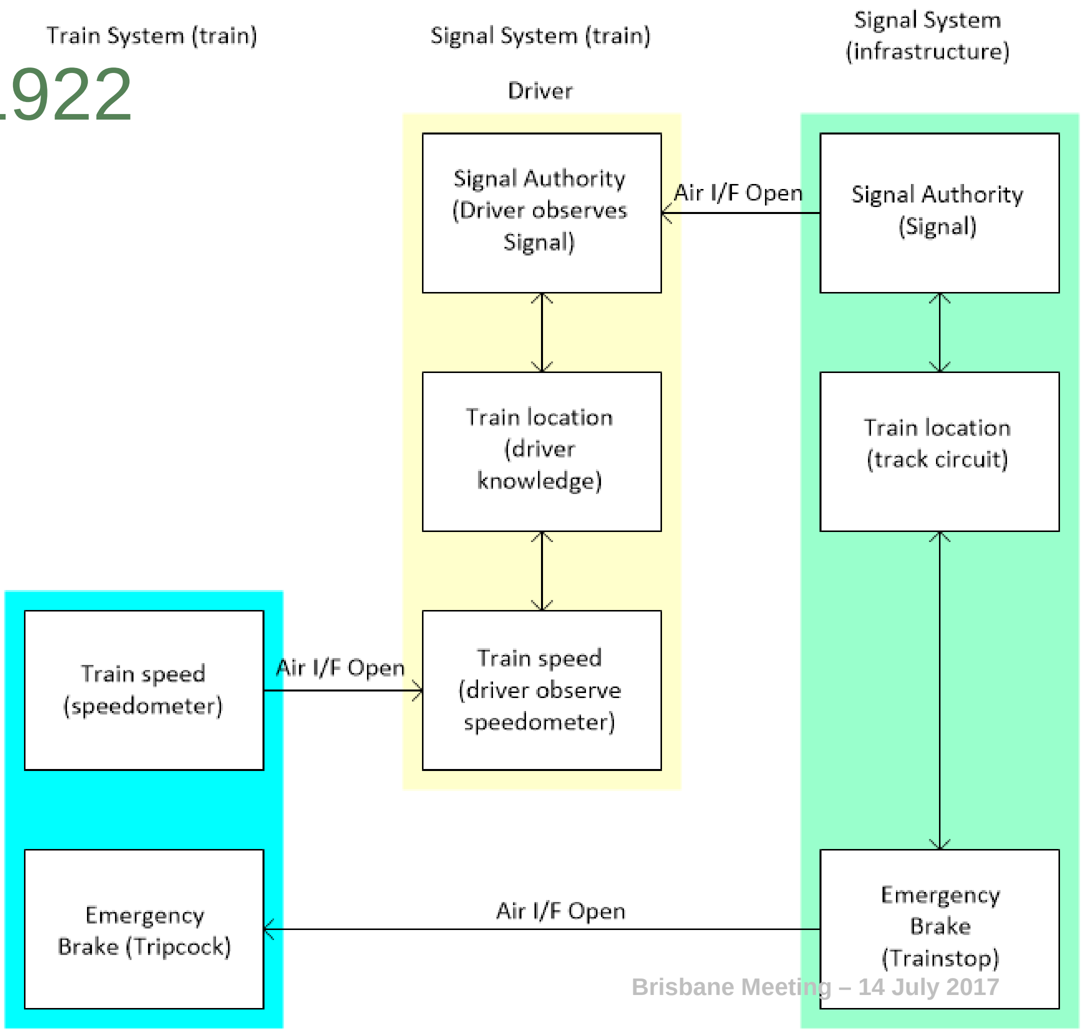
Where did we come from?

- Automatic signalling
  - A H Rudd paper IRSE 1914
    - Proposed 3 & 4 position light signals
  - A F Bound paper IRSE 1915
    - Proposed automatic trainstops
  - Melbourne 1919
    - Essendon line opened with both
  - IRSE response
    - Set up committee 1921 - 1924
  - F Raynor Wilson 1922
    - Published book on Automatic Signalling



System Diagram 1922

- System Architecture for signalling
  - Infrastructure Subsystem
    - Light signal
    - Trainstop Mech
  - Driver Subsystem
    - Observes signal
    - Obeys
  - Train Subsystem
    - Responds to driver
    - Tripcock Mech



System Requirements

- System's Required Functions
  - The driver needs a method to get an authority to allow the train to go forward into the section
  - The driver needs to know how far he/she can safely drive the train before needing to stop or change speed
  - The train needs a way to stop or control itself safely if the driver can't or doesn't

Modern System Requirements

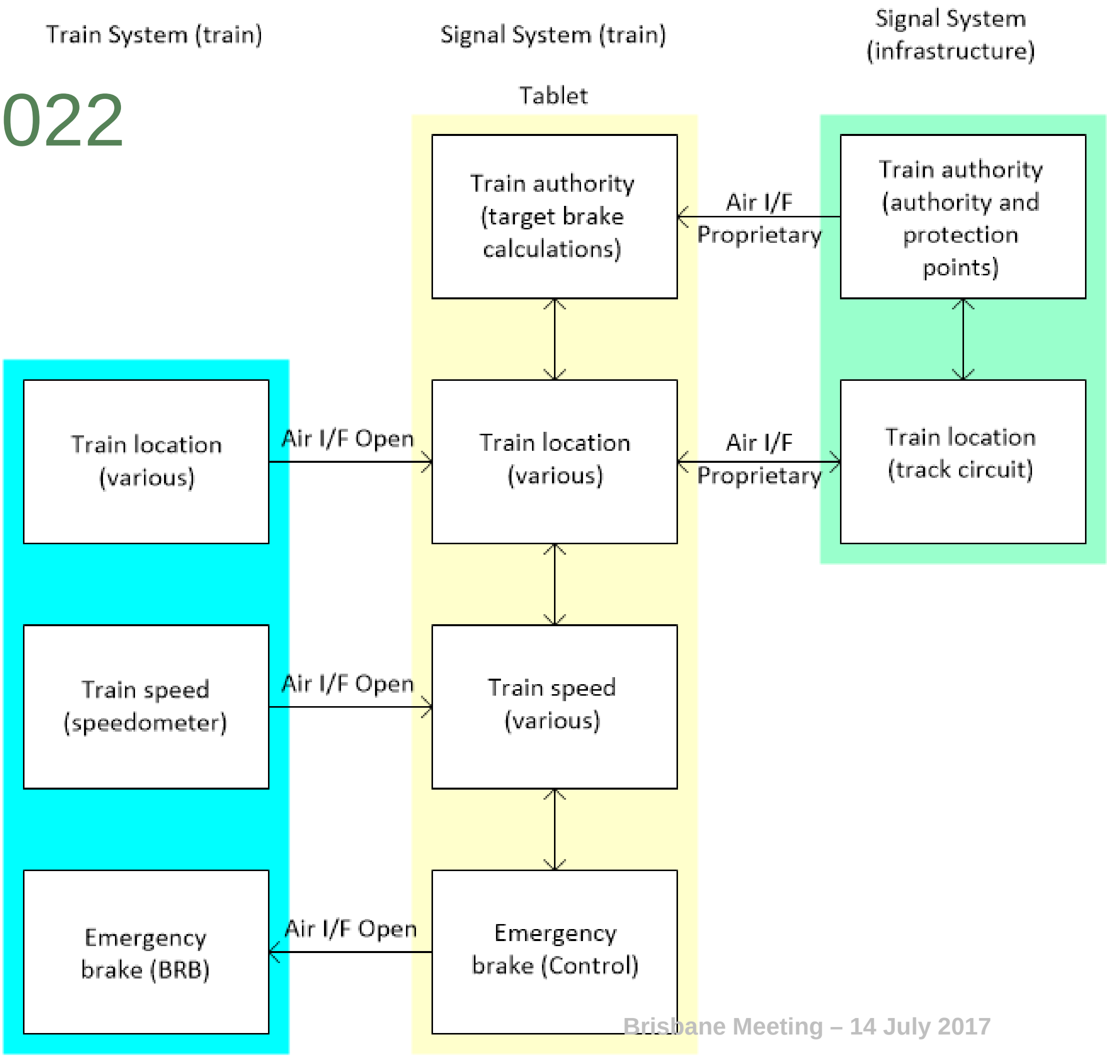
- System needs:
  - An interface to the driver (DMI)
  - Knowledge if train ID and Type
  - Knowledge of train location
  - Knowledge of train speed
  - Ability to operate the train's emergency brake
- Can we show that this is sufficient?

Vital Tablet Computer (VTC)

- VTC System Comprises
  - A tablet computer (+ possible other)
  - Sensors to acquire information (eg)
    - Cameras
    - GPS sensor
  - An interface to an emergency brake control

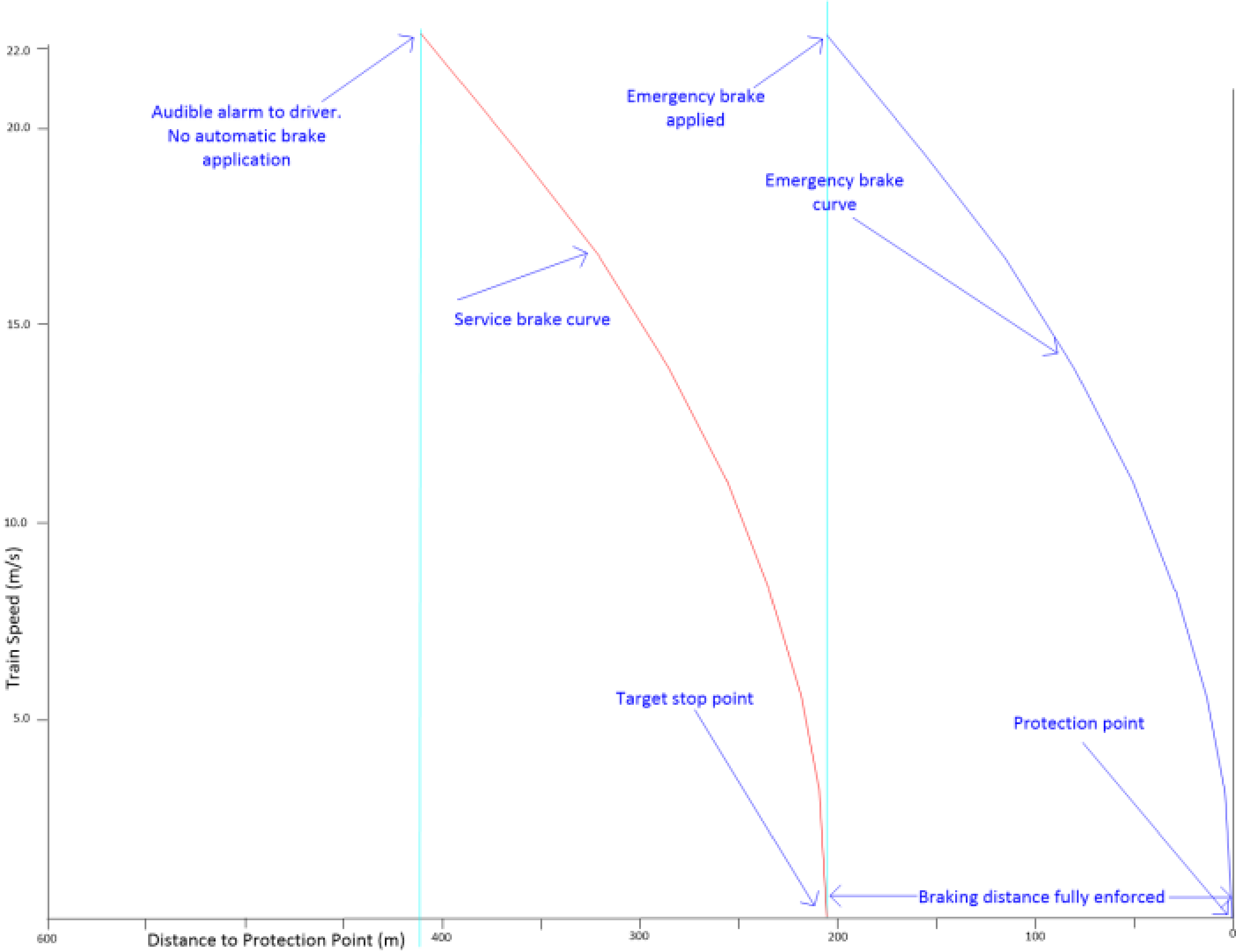
System Diagram 2022

- System Architecture for signalling
  - Infrastructure Subsystem
    - Train authority
  - VTC Subsystem
    - Advises driver
    - Issues alarms
    - Controls brake
  - Train Subsystem
    - Responds to driver
    - Brake mechanism



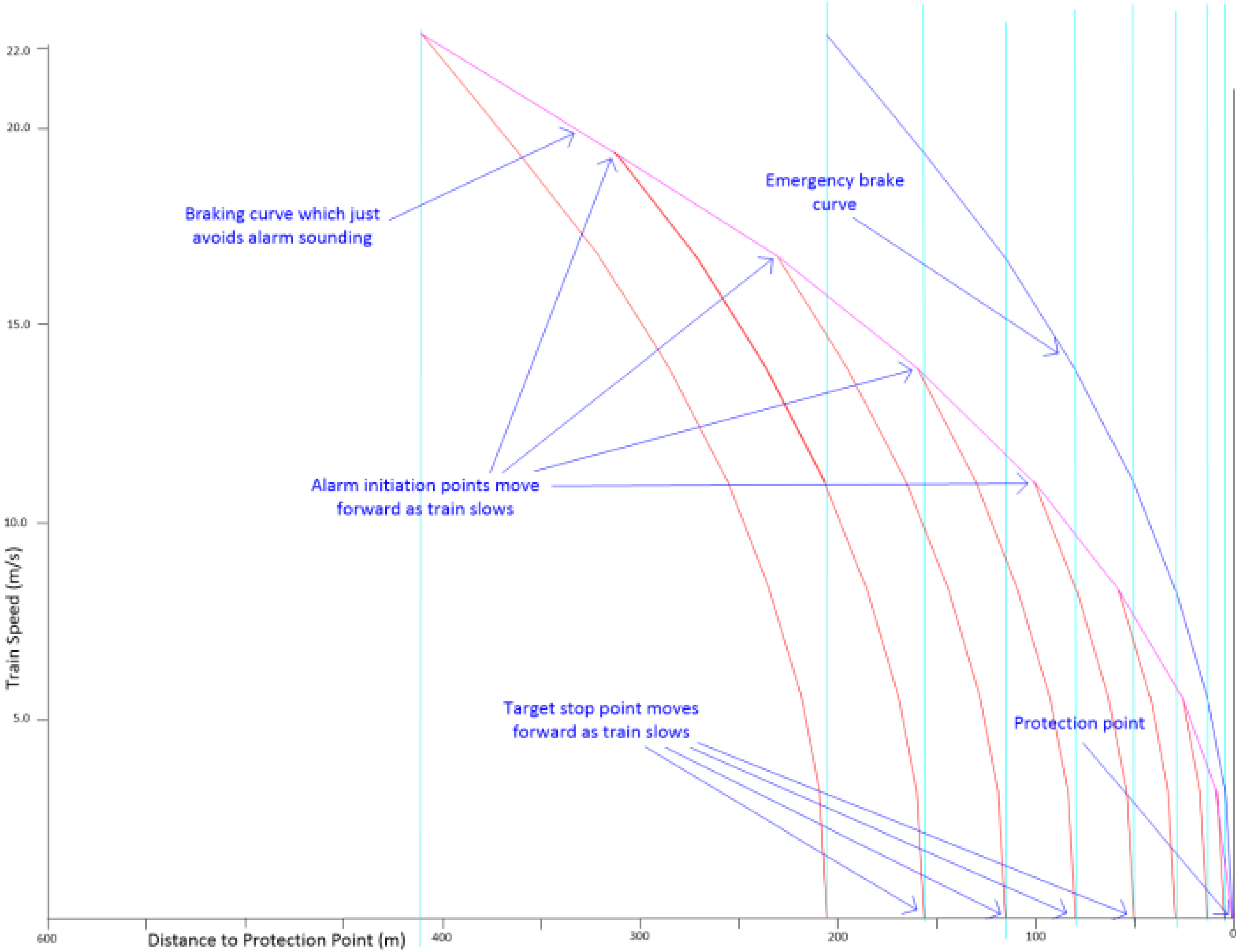
Stopping

- Demonstration of adequacy:
  - Enforced “overlap” beyond stop point
  - Alarmed (non vital) management of slowing to stop point



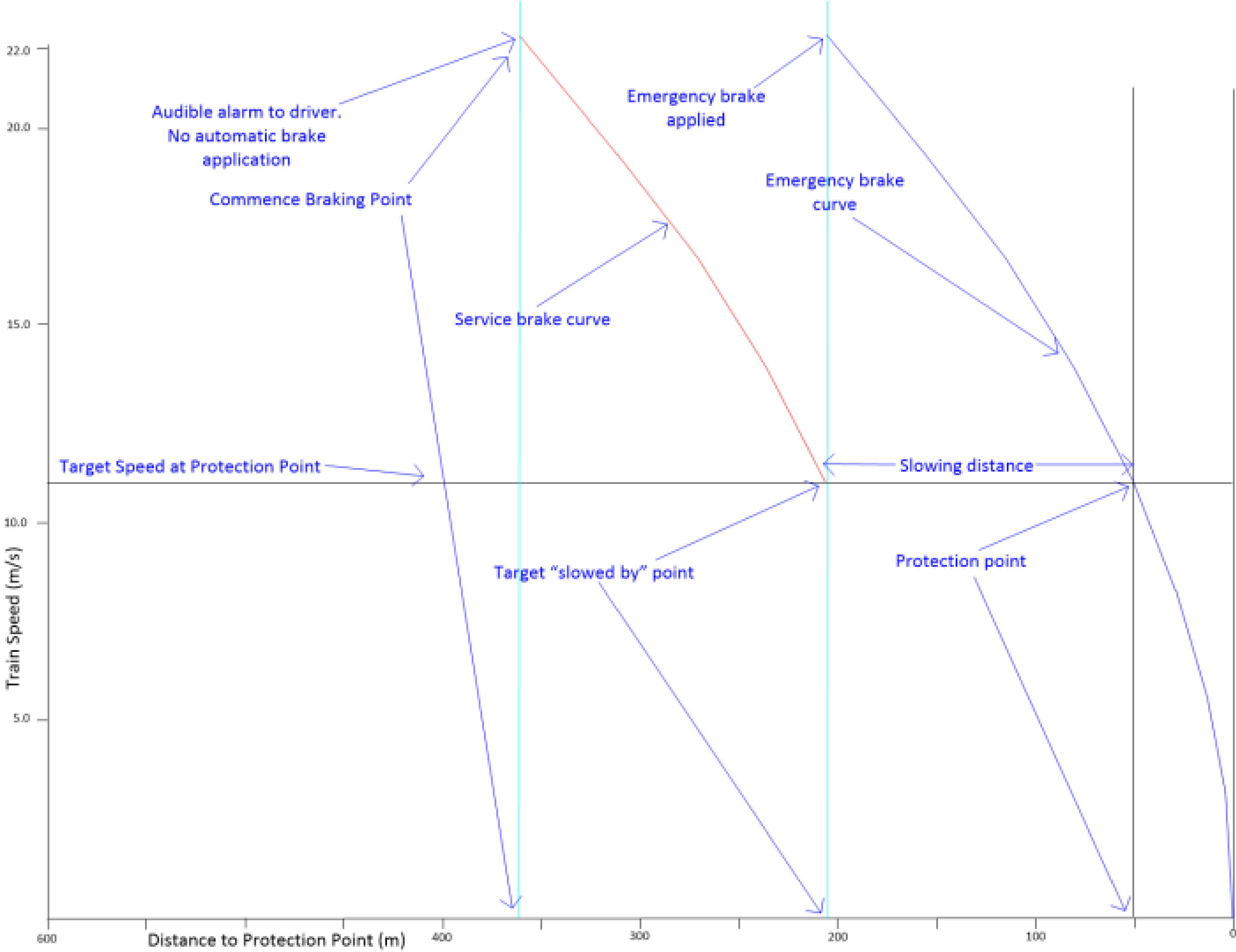
Stopping

- Demonstration of adequacy:
  - As train slows, “overlap” length reduces
  - Target stop point moves closer to protection point as train slows



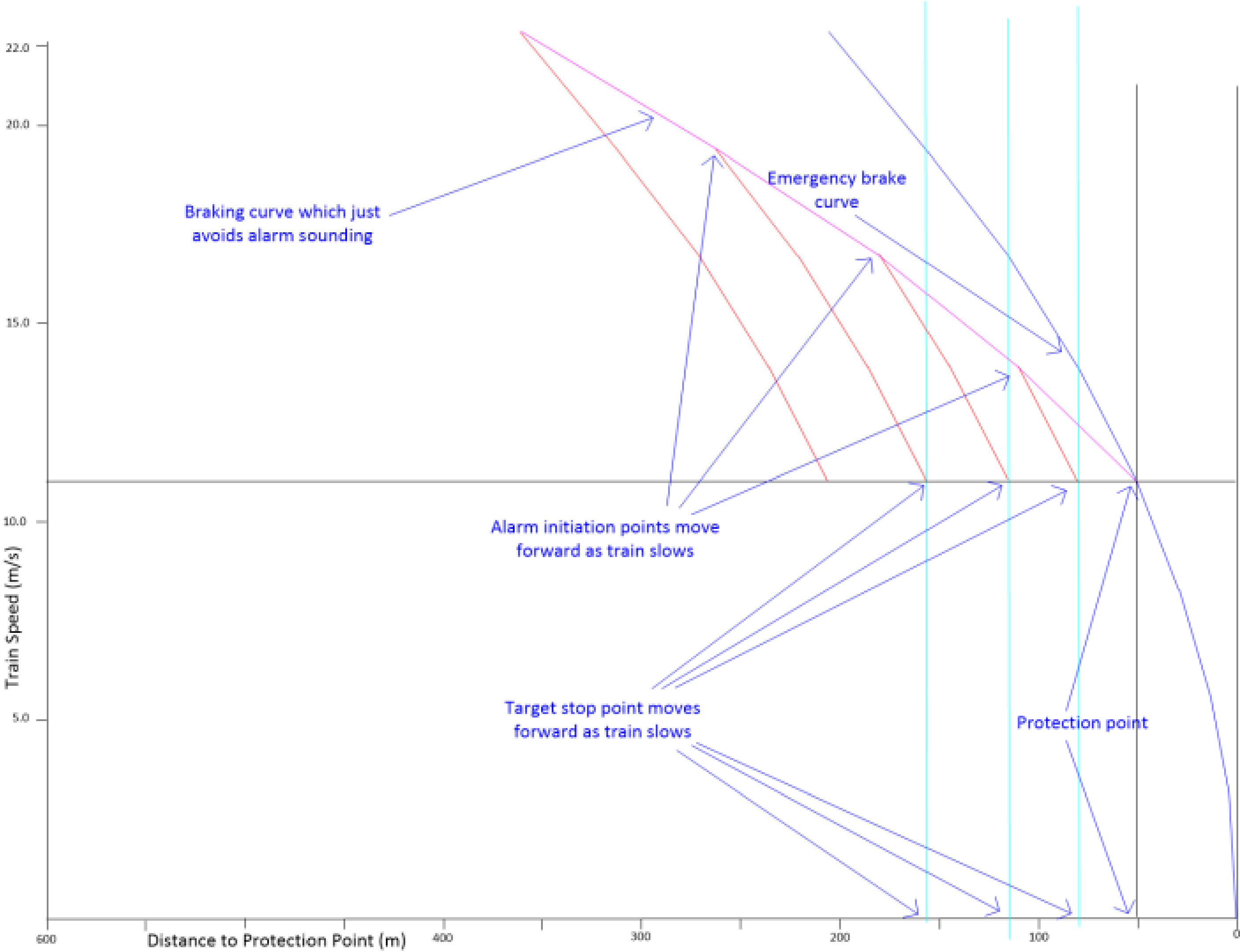
Slowing

- Demonstration of adequacy:
  - Target speed protected by “overlap” which enforced that train does not exceed speed at protected location
  - Target “slowed by” point managed by non vital alarm



Slowing

- Demonstration of adequacy:
  - As train slows, "overlap" length reduces
  - Target "slowed by" point moves closer to protection point as train slows



Concept of “non-fitted” train

- Train may be fitted with no relevant equipment
- Train may be fully fitted with CBTC equipment for another system
- Train may be fitted with common equipment which can be interfaced to

A place in the cab

DMI & Train ID

- Required components
  - Train Identity
    - Bar Code
    - Electronic Tag
  - Train Type
    - Included in train ID
    - Informs braking and authority
  - Train Weight
    - Informs braking
  - Train Length
    - Various methods
    - Default to “longest of class”

Speed – Using estimates for signalling

- Estimate of current value (incl latency affects)
- Use tolerance to set error bars
- Probability actual value is outside error bars (safety criteria)

Speed

Method	Signalling System?	VTC itself?	Train System?
GPS	No	Feasible. A tablet can have GPS functionality provided it can see satellites	Feasible. The train may be fitted with GPS functionality. An interface to the VTC is needed.
Speedometer	No	No	Feasible. All modern trains are fitted with speedometers. An interface to the VTC is needed.
Inertial Navigation	No	Feasible. The tablet can have Inertial Navigation Sensors and capability.	Feasible. The train may be fitted with Inertial Navigation Sensors and capability. An interface to the VTC is needed.
Doppler Radar	No	No	Feasible. The train may be fitted with Doppler radar either separately or as part of a separate on-board signalling system. An interface to the VTC is needed.

Location

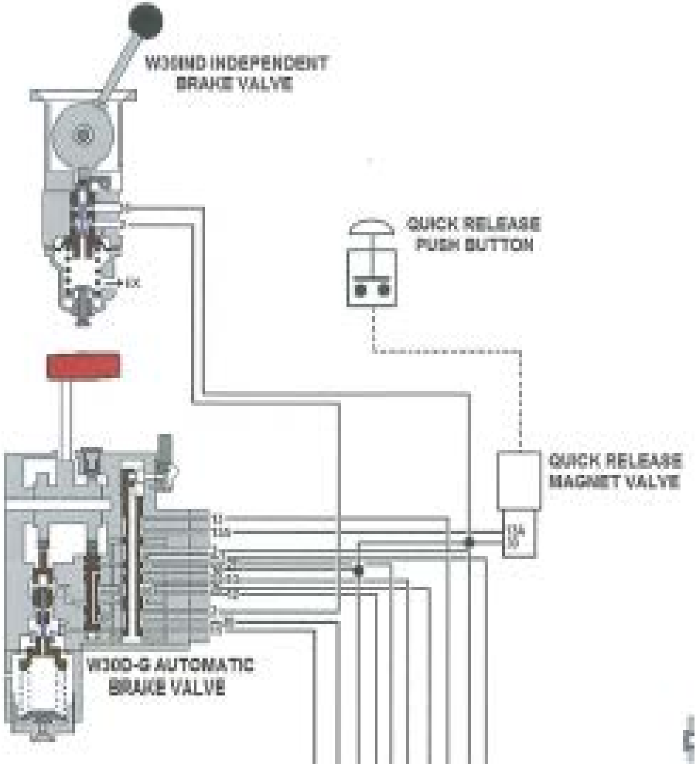
Method	Signalling System?	VTC itself?	Train System?
GPS	No	Feasible. A tablet can have GPS functionality provided it can see satellites	Feasible. The train may be fitted with GPS functionality. An interface to the VTC is needed.
Inertial Navigation	No	Feasible. The tablet can have Inertial Navigation Sensors and capability.	Feasible. The train may be fitted with Inertial Navigation Sensors and capability. An interface to the VTC is needed.
Electronic Tag	No	No	Feasible. The train may be fitted with one or more tag reader systems either separately or as part of a separate on-board signalling system. An interface to the VTC is needed.
Signalling System	Feasible. Track circuit and Axle Counter transitions are available sources. Other sources may also be available.	No	No
Odometer	No	No	Feasible. A train fitted with a tag reader system will often use an odometer for infill purposes.

Big Red Button

- Methods for operating the emergency brake
  - Normal brake lever
    - Set to “emergency”
  - Tripcock mechanism
    - Operated by infrastructure
  - Big Red Button (driver accessible)
    - Releases air from brake pipe
  - Driver vigilance system
    - Electronic smart “watchdog”

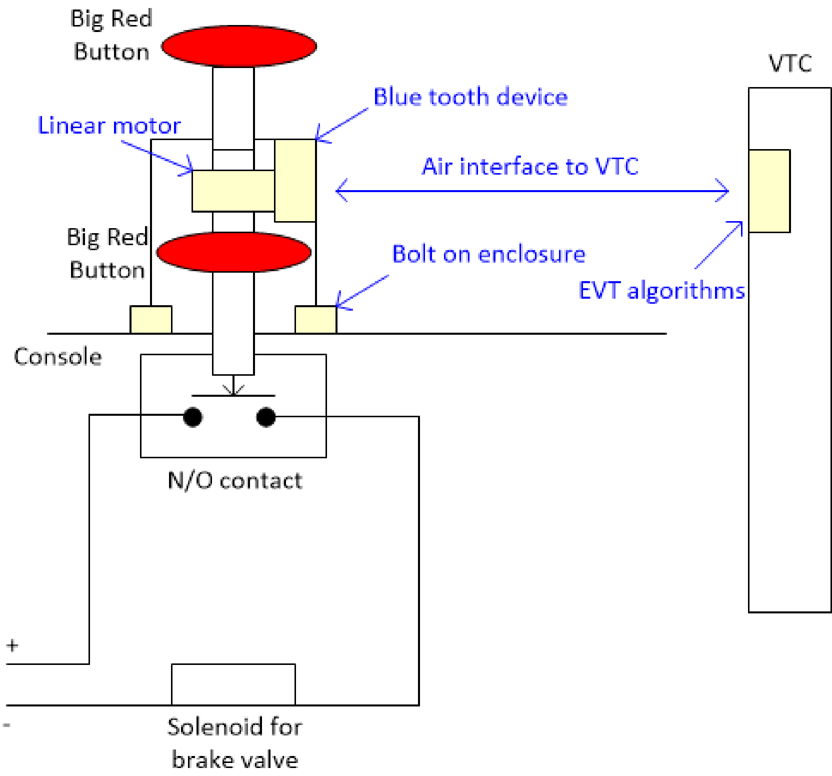
Trainstop Interface

- "Under the bonnet" brake activation
  - Buttons and levers can interface to electric contacts and solenoid valves
  - Standards used are those applicable to train wiring (not signal infrastructure)
  - Systems are regarded as secondary protection (vis TPWS)
  - SIL rating required aligns with the usual requirement for such systems



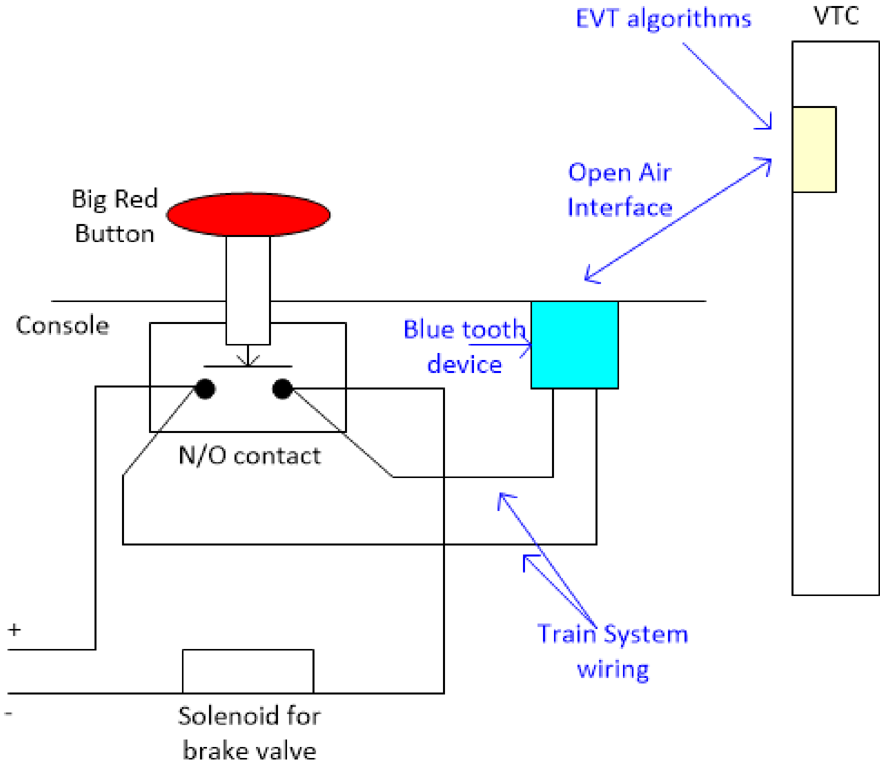
Electronic Virtual Trainstop option 1

- Direct mechanical actuator for button
  - Simplest option?
  - Activation box is “bolted on” on top of existing button
- Plus
  - No need to look “under bonnet”
- Minus
  - No common standard for button position, dimensions, operation
  - May interfere with normal button operation



Electronic Virtual Trainstop option 2

- Electrical switch in parallel with switch for existing button
  - Use standard “air interface”
  - Makes use of standard feature of all Big Red Buttons
- Plus
  - Uses standard open interface
  - Fits with standard interface for location and speed
- Minus
  - Blue tooth “standard” device requires development
  - Future proofing is challenging

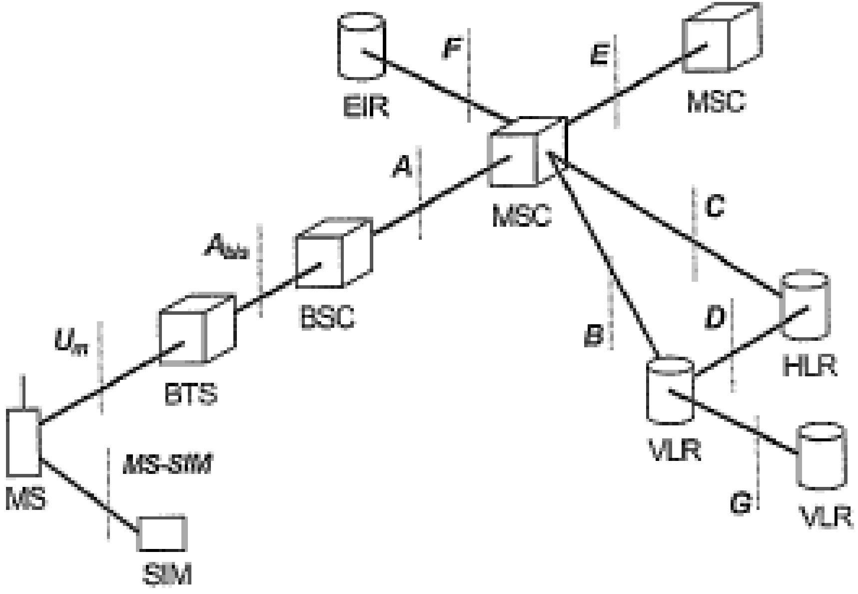


Interoperability – GSM Drivers

- 1981: NMT-450 analogue network opened to public (Televerket)
  - Ericsson product, included Roaming
  - Deployed Scandinavia, The Low Countries & Austria
  - France and Germany not happy
- 1982: GSM (Groupe Spécial Mobile) established
  - Under Thomas Haug (Televerket) - set EU digital mobile standard
  - French & German Govt R&D in CD-900 (via SEL, ATR, SAT)
  - Competition held to select base product to standardise
  - Ericsson selected with narrowband TDMA product (1987)

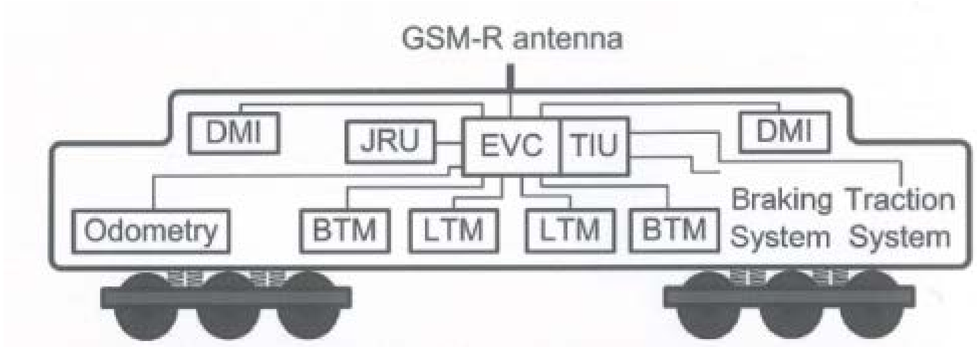
Interoperability – The GSM Experience

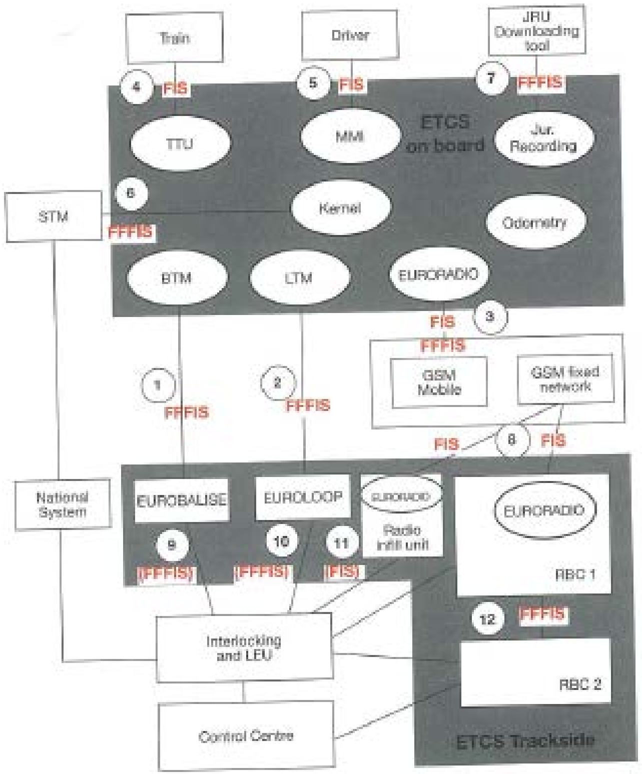
- Spec defined systems and interfaces
  - All interfaces open except A_{bis}
- Intellectual property challenges
  - EU suppliers agreed to non-discriminatory rights access (init)
  - Motorola (US) would only make rights available on “swap” basis
  - Result was to lock out US and Asian suppliers from GSM till rights expired



Interoperability – ETCS Practice

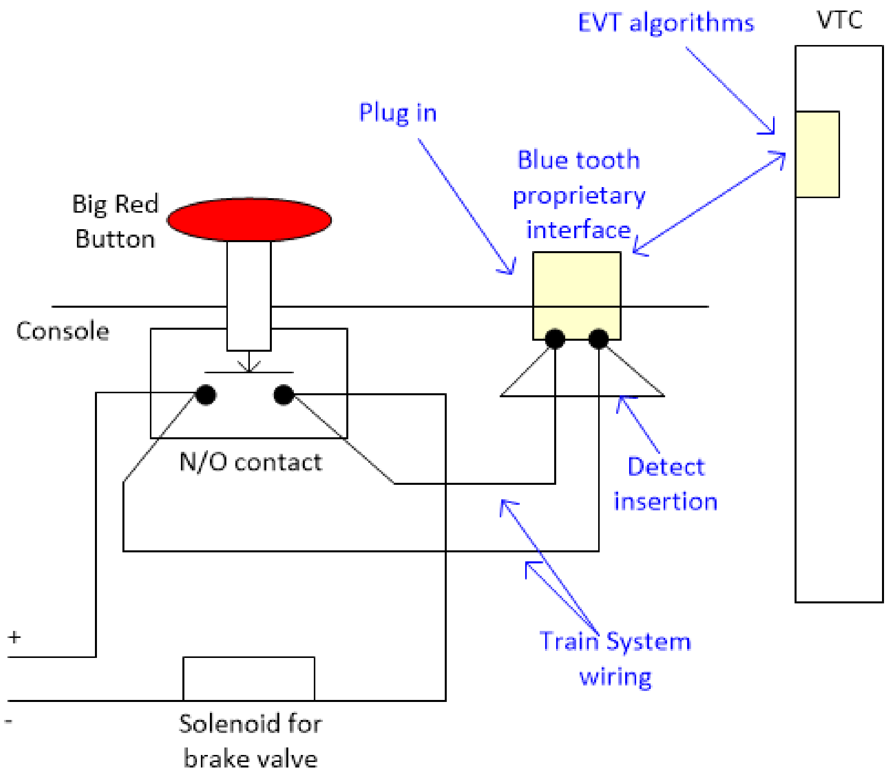
- Open interfaces:
  - GSM-R air i/f
  - Balise air i/f
  - Loop air i/f
- Other interfaces are proprietary or ignored





Electronic Virtual Trainstop option 3

- Electrical switch in parallel with switch for existing button
  - Plug in proprietary device.
  - Only mechanical form and electrical connection is standardised
- Plus
  - Easy to standardise
  - Minimum proprietary exposure
- Minus
  - Some wiring required on train ("minimal fitment")



EVT Form

- Features:
  - Simple, standard shell
  - Proprietary device inside
    - Air interface proprietary
    - Electrical contact standard
    - Standard “confirming” contact
  - Ticks “future-proof” box
- Requires agreements with AROs and train providers

Why choose this path?

- EVT represents “low hanging fruit”
  - Fully open interface for location and speed is some way off.
    - Not on anybody’s priority list
    - More complex
    - System concepts not yet mature
    - Stand-alone options available (VTC)
  - Simple interface for EVT
    - Practical method to achieve function not otherwise accessible
    - Cheap to use when provided
  - Provides safety and operations benefit to operators at low cost

Conclusion

- Interoperability is challenging
  - Can be high cost for a project
  - No regulatory authority in place
  - Industry can see as a threat
- Simple, open interfaces are a lesser step
  - Lower cost
  - Practical to implement
- Signal Engineer must understand trains

Questions?

- http://pybconsulting.com.au