SaRS Making the world safer and more reliable for

everyone

SAFETY & RELIABILITY SOCIETY ASIA-PACIFIC BRANCH

## DIGITAL MAINTENANCE FOR ROLLING STOCK: EMERGING CHALLENGES IN SAFETY, CYBERSECURITY AND DATA

## DR. EMMA TAYLOR RAZORSECURE

4<sup>TH</sup> MAY 2022

The Safety & Reliability Society is a Licensed Member of the Engineering Council for CEng and IEng Professional Registration



click to find out how

# Programme

- Introduction
- Presentation by Dr Emma Taylor
- Q&A session
- Accessing the webinar and upcoming webinars
- Feedback

Note: the Webinar is being recorded









## **VIEWING IN FULLSCREEN AND Q&A FACILITY**

SaRS= My event ENGLISH | C FULL SCREEN | A EVENT BOARD





May 22

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## Digital Maintenance for Rolling Stock: Emerging Challenges

Dr Emma Taylor, Head of Digital Safety

v1.0

## 1. Team Overview

## FUNDING SOURCE FOR DIGITAL MAINTENANCE

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Today we are proud to announce alongside @transportgovuk the winners of the 2021 Transport Research and Innovation Grants (TRIG 2021). Hear from Transport Minister Trudy Harrison as she shares the 51 project winners: cp.catapult.org.uk/news/1-95m-wil... #TRIG2021 #transport #innovation #SME



cp.catapult.org.uk  $\pounds$ 1.95m will fund 51 projects to improve the UK's transport system - TRIG 2021

Department

for Transport



Transport Research and Innovation Grants
Department for Transport

"Bold, innovative, proof of concept projects"

#### The TRIG fund purpose is to:

- reduce barriers to innovation and advance technology in transport
- enable a better transport system in the UK
- exploit smart ideas that have the potential to develop further
- fund early stage innovations to take to the next stage of development

## DIGITAL MAINTENANCE PROJECT TEAM







## UNIVERSITY<sup>OF</sup> BIRMINGHAM



## UNIVERSITY OF BIRMINGHAM (BCRRE)



- > Recipient of the Queen's Anniversary Award for Higher Education
- > 100+ Masters students/year, industry Connected-Leaders and Digital Leaders programmes
- > Trusted partner internationally e.g. Network Rail, HS2, SMRT and Siemens
- > Assurance of digital signalling systems
- > Founding member of the NCSC/UKRI-funded RITICS Research Institute
- > Founding Member and Lead of UKRRIN (rail research), with an industry-appointed remit for rail cyber security

### **RAZORSECURE - RAIL CYBER SECURITY SPECIALISTS**



Cyber Security At The Edge, Powered by Machine Learning

#### **IN FIGURES**

26+/Employees

1600+/Rail Vehicles Protected

50M+/Passengers Protected

9/ Active Operators

#### OUR CUSTOMERS

TRAIN BUILDER A TRAIN BUILDER **ICOMPORO**  SIEMENS Ingenuity for life





A company of engle



West Midlands Railway



## CURRENT PRODUCTION DEPLOYMENTS





- > 197 trainsets
- > Siemens, CAF & BT Rolling Stock



WiFi/Media Server and operational systems

- RazorSecure *Delta* on Icomera router for WiFi and operational VLANs via wired backbone
- > 157 trainsets live
- BT & CAF Rolling Stock





Extension to Altamont Corridor Express in

acting as router for WiFi and PIS

2021

19 trainsets



## A DEFINITION OF DIGITAL MAINTENANCE



- > Any corrective or preventive action on electronic systems
- > Electronic equipment to connect to the on-board system
- > Can be for viewing data, diagnosis, testing, updates
- > In person or remote
- > Implemented to ensure operational availability and compliance with regulatory and standards requirements

- > Digital Maintenance is part of "safety" <u>and</u> "cybersecurity" <u>and</u> "data (asset) management"
- > Effective digital maintenance needs multi-disciplinary teams, multi-disciplinary perspectives
- > An emerging (and under appreciated ?) challenge

> Data is an information asset, it also requires physical and digital systems to "host" it, asset management is key

## DIGITAL MAINTENANCE PRACTICES



- > Updates to software
- > Management of onboard network equipment
- > Repair and replacement
- > Management of data files and configuration tools
- > Carried out by maintainers, working with manufacturers, OEMs (original equipment manufacturers) and asset owners
- Digital maintenance happens during the "maintenance" phase of the V-cycle, but the scope and implementation is defined earlier in the project phase
- What's the difference between BAU (business as usual) planned maintenance (periodic/risk-based/mileagebased) and remedial (ad-hoc in response to defects) for digital systems ?
- > Is a patch or software version update BAU or not ?

## V-CYCLE





## A Quick Poll !

## (1 question only)

#### Poll statistics:

#### APAC 4th May Q1\_Start:



#### Closed questions

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In your opinion, which aspect of digital maintenance requires the most improvement now ? Single choice

- 1. People (involved in digital maintenance, through connecting and updating software, gathering and analysing data)
- 2. Technology (for both wired and wireless networks, covering hardware, firmware,
- software, databases, sensors, gateways, firewalls, routers, laptops, removable media etc.)
- 3. Processes for managing digital maintenance (whether incorporated as part of management systems or local practices e.g. workpacks)



### DIGITAL MAINTENANCE IS AT EVERY LEVEL (TS50701)





## CONNECTIVITY AND DIGITALISATION IN RAIL





### MAINTENANCE KEY ACTIVITY FOR DIGITAL SYSTEMS





## ROLLING STOCK IS INCREASINGLY DIGITAL





Individual systems on board are digitally controlled, using both electronicmechanical systems and "computers"



The systems are connected by networks which control the flow of data and provide wired and wireless connection points

### TRAINS AT REST, DIGITAL MAINTENANCE IN DEPOTS





https://media.northernrailway.co.uk/news/gbp-6m-overhaulfor-allerton-train-depot

### LOCAL MAINTENANCE = DIRECT ACCESS TO TRAIN





#### REMOTE ACCESS CAN BE ENABLED (SYSTEMS, NETWORKS)





## 3. Project Overview

## **PROJECT TASKS**



- > Maintenance Survey and Depot Site Visits (closing out this week) WP1
- Generic Train Architecture, including Digital Safety and Security Requirements Specification (closing out soon) –
   WP2
- > Proof of Concept Safety Related Control Application Conditions (SRAC) (June/July) WP3
- > Verification, Assurance and Validation Independent Scrutiny (July/August) WP4
- Project management, including implementation of EDI (equality diversity and inclusion), stakeholder presentations (ongoing) – WP5

#### CONNECTIVITY AND DIGITALISATION ADDS VULNERABILITY



#### EN61375 Standard Network Design



## **GENERIC ARCHITECTURE (IN DEVELOPMENT)**





#### SIMPLIFIED GENERIC ARCHITECTURE (IN DEVELOPMENT)





For both ethernet networks, maintenance can be carried out in one of two ways:

1.An engineer can connect directly to the network from a central location and access all connected components to carry out maintenance from a single location.

2.An engineer connects directly to the specific subsystem/component (either by disconnecting the component, or connecting to a maintenance port)

#### PROVISIONAL SAFETY-RELATED APPLICATION CONDITIONS



- Maintenance Survey and Depot Site Visits (ongoing) WP1
- Generic Train Architecture, including Digital Safety and Security Requirements Specification WP2
- Proof of Concept Safety Related Control Application Conditions (SRAC) WP3. Identification and down selection ongoing, options include
  - No software updates while the trains are coupled
  - Maintenance (Service) PC shall be onboard
  - The train ID in safety critical systems shall only be updated when they are disconnected

## 4. Results to Date

Recap: these are preliminary results and are for information only

The percentage values on the graphics are indicative only, and should not be used as accurate statistics to predict the type and range of digital maintenance activities

#### DIVERSITY OF SYSTEMS REQUIRING DIGITAL MAINTENANCE



How many On-Board systems per unit do you have that require manual connections for digital maintenance? Examples of manual connections include retrieving logs or updating firmware on a device such as an Ethernet switch, control unit for Passenger Information Systems (PIS), Train Control Management System (TCMS), Closed-Circuit Television (CCTV), doors, braking systems, Heating, Ventilation and Air Conditioning (HVAC), Wheel Slide Protection (WSP) etc.)







## FREQUENCY AND TRIGGERS FOR MAINTENANCE



How often do you carry out digital maintenance (e.g. manual updates or actions that require manual connections)?



This depends on defects being consistently identified and recorded. Are existing systems able to deliver this?

Service laptops used to carry out digital maintenance are majority issued by either company IT departments or train maintenance departments or equipment providers but their use needs to be triggered by other systems, asset databases or workflow management

#### WHO IS ALLOWED TO ACCESS SYSTEMS, HOW IS IT DONE ?



What access do suppliers and third-parties have to the on board systems and how are they involved in updates, maintenance and troubleshoot...shooting, System updates, Recovery of logs etc.)



### SOME SYSTEMS ARE AVAILABLE FOR REMOTE UPDATE



How many of these systems per unit can currently be updated remotely?







How many of these systems per unit require manual intervention once the remote update has completed?

## TYPES OF MAINTENANCE LAPTOPS PRESENT



How many different variants of maintenance Laptop are necessary to cover these systems? An example of a variant could be different types of ports, different types of operating systems, applications (32 or 64-bit), owned, updated or managed in different ways (internal IT department versus third party supplier)



## TOOLS TO ACCESS AND UPDATE SYSTEMS



What software/protocols are used during the update of on board systems?

·	SSH
---	-----

Telnet

Terminal emulator (e.g. PuTTY)



Proprietary software from manufacturers

Don't know

Prefer not to say

Other:

Which of these are more secure than the others ? What is "secure" ?

## WORKFLOW MANAGEMENT

-



What is the process used to request that a firmware update is carried out on a train by the maintainer?

Majority of answers in these two categories

- Electronic workflow management (e.g. asset management system, ticketing for process on train)
- Manual Electronic request (e.g. Email, Excel sheet)
- Paper form

What is the process used to record the details of what was updated, by whom, where & when etc?



## APPROACHES TO INITIATION OF MAINTENANCE



What is the process used to ensure that the train is in the correct state to receive an update?



This will need to be captured in workflow systems

## APPROACHES TO COMPLETION OF MAINTENANCE



What is the process used to determine that the update is successful?



This will need to be captured in workflow systems

## TRAINING AND SKILLS DEVELOPMENT



How are staff trained in digital maintenance? (select all that apply)

Balanced answers across these four categories

	In house	on	the	job	training
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Practical training on train equipment

Third	partv	supplier	provided
11111.04	party	oupplier	promace

Don't Know



Prefer not to say

Other:

Poll soon. Which category of control is most important ? People ? Processes ? Technology ?

## 4. Next steps

### PRELIMINARY RECOMMENDATIONS FROM SURVEY



- 1. Ensuring that competency, authority and permission to access and carry out digital maintenance is adhered to prior to gaining access to the asset
- 2. Activities undertaken by the supply chain and third parties are audited, logged and documented for duty holder transparency (NB: this includes use and management of maintenance laptops, system hygiene etc.)
- 3. Software, utilities and tools for digital maintenance are logged, documented and self-contained at the point of use (NB: vendor software lock-out, use of escrow in case of supplier failure may need more scrutiny)

## PRELIMINARY RECOMMENDATIONS FROM SURVEY



- 4. All digital maintenance activities must be carried out in a 'known', predictable state, and follow the agreed engineering change procedures, where any anomalies should be detected and reported (NB: software clashes between maintenance packages and access to components not in scope of maintenance may require scrutiny).
- 5. Any artefacts used as part of digital maintenance must have a clear provenance, and secure handling procedure (NB: this includes <u>all</u> artefacts, from signed certificates for updates, through to internal reverse engineering of third party systems)

- > These will feed into the proof-of-concept prototyping for the digital maintenance system happening Q2/Q3 2022
- > To achieve these, a broader cybersecurity perspective will likely need to be taken, this will include ensuring that malware cannot access via removal media/internet connection

## "SIMPLE" DIGITAL MAINTENANCE ACTIVITY



#### **BAU Maintenance**



The system will need to support asset management and access control

### DESIGNING FOR MORE COMPLEX SYSTEM UPGRADES



#### System Upgrade



The vehicle will need to be in a known "good state" before more complex system upgrades or non-standard maintenance are implemented. A digital "sandbox" may be needed. Asset management and access control will be even more important.

## SARS SURVEY – A CROSS SECTOR PERSPECTIVE



What is your job role? (this can be a current or previous role relevant to maintenance)



Engineering Safety team

Systems Engineer

75% in transport, rest in aviation, nuclear, defence, construction, railways, facility Wide range of roles and disciplines

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These results gathered from SaRS digital maintenance attendees Recap: these "snapshot" SaRS results are for information only

Their analysis as part of this presentation is for discussion only and should not be used as an authoritative report on the current level of digital maintenance in one or more industries

## MANAGING ACCESS IS KEY PRIORITY ?



What access do suppliers and third-parties have to the electronic systems and how are they involved in updates, maintenance and troubleshoot...shooting, System updates, Recovery of logs etc.)



These results gathered from SaRS digital maintenance attendees

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#### GREATER CLARITY NEEDED ON MAINTENANCE PROCESSES ?





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These results gathered from SaRS digital maintenance attendees

## MANAGING ACCESS IS KEY PRIORITY ?



How are login credentials and tokens (e.g. password) for the electronic systems managed and communicated?



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These results gathered from SaRS digital maintenance attendees

#### REMOTE ACCESS / DON'T KNOWS NEED MORE SCRUTINY ?



Are the majority of updates completed in person or remotely?





Do we have a clear definition of what is 'remote' and 'in person' ?

(Someone can be physically present with a laptop but the commands are being managed remotely by another technician)



These results gathered from SaRS digital maintenance attendees

## DON'T KNOWS REQUIRE FURTHER SCRUTINY ?



How often do you carry out digital maintenance (e.g. manual updates or actions that require manual connections)?



These results gathered from SaRS digital maintenance attendees

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## **OTHER FINDINGS**



- > Approximately half of service laptops are issued by company IT departments
- > A full range of approaches are taken for training in digital maintenance
- > There is no one dominant process used to determine that an update is successful (manual check of firmware version, manual test of equipment function, automated test of equipment function all present)

Where are the emerging challenges in digital maintenance ?

It depends... !

## Re-do the poll, then Q&A



#### Closed questions

In your opinion, which aspect of digital maintenance requires the most improvement now ? Single choice

- 1. People (involved in digital maintenance, through connecting and updating software, gathering and analysing data)
- 2. Technology (for both wired and wireless networks, covering hardware, firmware,
  software, databases, sensors, gateways, firewalls, routers, laptops, removable media etc.)
- Processes for managing digital maintenance (whether incorporated as part of management systems or local practices e.g. workpacks)



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- All webinar recordings are archived under the Resources Tab on the SaRS website
- SaRS members can access this archive as a member benefit:
  - You can join as a full member, or
  - The simplified **"Associate of the Society"** grade which gives you access to all the SaRS resources including the webinars.
  - See <u>www.sars.org.uk</u>
- This webinar recording will be available in a couple of days so keep an eye out if you want to see it again <u>SaRS</u>

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More information available at <u>www.sars.org.uk</u> SaRS

London Branch - The safety of low carbon hydrogen and its applications.
 26th May at 18:00 UK time. Presented by Dr. Gianluca Carigi (MES), Hassan Al Halwachi (Arup) and Ed Macfarlane (Abbott Risk Consulting)







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