Electrifying the future Irish railway

Abigail Palmer & Nora Balfe

Iarnród Éireann Irish Rail, Ireland

SUMMARY

This paper describes the baselining of current electrical controller operations on the Irish rail network, and the ongoing work to assess the human factors risks and issues associated with an increase in the level of railway electrification and move to a new operational control centre including new equipment. To support decarbonisation, there are plans to increase the electrified network from 50km of track to at least 150km in the greater Dublin area, with possible further increases in other areas. To understand current work, the existing role was baselined to document the sources of information used, the tasks undertaken, and the current workload. A series of workshops are ongoing to explore the role of new systems and interfaces to be used in future and the expected increase in ECO workload and how this will be managed.

KEYWORDS

Railway electrical control, rail human factors, task analysis, workload assessment

Introduction

Iarnród Éireann Irish Rail owns and operates the railway network in the Irish Republic, including 49km of electrified line around Dublin. The organisation plans to triple the electrification of the railway in the greater Dublin area over the coming decades to support a more sustainable and efficient train service. Simultaneously, the organisation is preparing a move to a new national control centre which will include the control of the electricity lines supplying power to the electric trains. These plans present a number of human factors challenges, including changes to the electrical control operator (ECO) role being made as part of the move to the new control centre, predicting the workload and hence the required number of workstations for future operations, and ensuring that the human machine interfaces used to control the electrical supply are fit for purpose.

Similar to UK operations (Kaul, Smyth & Patrick, 2022), the Irish ECO role is responsible for managing the control and supply of electricity to the overhead line equipment (OHLE) from which electric trains draw their traction power. In normal operations, the ECO predominantly monitors the system and responds to any faults or alarms. The alarms can be complex and are an area of study in their own right (e.g. Dadashi et al., 2013). The busy periods for ECOs are at night when the OHLE must have electrical supply removed (known as an ‘isolation’) in order to allow track, signal and OHLE maintenance work to safely take place. These maintenance isolations are planned in advance, but there is a level of communication and coordination with the track staff for each one, as well as actions to operate the Supervisory Control and Data Acquisition (SCADA) system to remove the electrical supply. At the end of the night, the process works in reverse to confirm the track staff are finished and clear of the track before returning the electrical supply. Emergency isolations may also be necessary in the exceptional event of faults and failures, or trespassers in the vicinity of the OHLE.

Electrical control room operators are recognised as key safety critical workers whose actions are crucial for avoiding serious consequences (Goncalves et al., 2014). This paper outlines the work done to baseline current ECO operations and describes the planned work to assure that the human factors risks of the future changes are identified and mitigated.

Baselining

The current ECO role is a single workstation controlling the electrical supply in the Dublin area. However, at night the role is shared with a 'regulator' workstation which is responsible for making decisions on train running. The ECOs are therefore competent as both ECOs and regulators. Three strands of work were undertaken to baseline the current ECO operations:

1. Information audit of the current control room
2. ECO baseline task analysis
3. ECO baseline workload assessment

Information audit

As part of the preparation for the move from the existing control centre to the new control centre, an information audit was conducted to identify the different sources of information used in the current control centre and assure that equivalents were included in the design of the new centre. This audit was undertaken on all roles in the control centre, but only the results for the ECO role are presented here. The audit was conducted via a site visit which collected data on the number of screens in each operational position, and their normal display, other hardware at each operational position, frequently used paperwork at each position, and reference information. The findings are described in Table 1.

The ECOs use the SCADA system to monitor and control the supply of electricity of overhead lines. They have three screens for this system and use them to display three different views: an event list, a schematic, and an alarm screen. They also have a general PC with internet access on their workstation. There were four sets of keyboards and mice, one attached to each screen. Three are to provide redundancy on the SCADA system (one set for each screen), and as the general PC is separate, it requires its own peripherals. There is a Frequentis Dicora unit for making railway related calls and a separate landline on the ECO desk for non-work related calls. The final hardware on the desk was an emergency shutdown button which is intended to cut off the electricity supply in an emergency without needing to go through the SCADA system. The frequently used paperwork included a logbook for any events during the shift, temporary notices sent to the ECO on changes to plans or procedures, contact details for maintenance support for the SCADA system and for the OHLE system, and forms for isolating the OHLE to facilitate maintenance work on track. In addition, there the workstation held a number of reference documents, including the rulebook containing all the procedures for the SCADA system, updates to this book, and documents showing the OHLE line drawings.

Table 1: Results of ECO information audit

Screens	Hardware	Frequently used paperwork, sticky notes & others	Reference paperwork
SCADA screen 1: used to display event list	Keyboard and mouse	ECO logbook	SCADA Rulebook (4 parts)
SCADA screen 2: used to display schematic	Keyboard and mouse	Temporary notices	Permanent notices (updates to SCADA rulebook)

SCADA screen 3: used to display alarms	Keyboard and mouse	Contact details for SCADA maintenance support	Long term isolations
General PC	Keyboard and mouse	Electrician on-call list (changes every 12 hours)	OHLE line drawing diagrams (laminated book)
	Frequentis	Isolation forms	Types of substation (list)
	'House phone' – used for non work calls		
	Emergency Shutdown Button		
	Bag of tags for keys		

Baseline task analysis

The task analysis was developed through a series of site visits to the existing ECO control room, and analysis of SCADA alarms and phone logs. The high-level tasks identified were:

- Conduct daily tasks – sign in, handover, log on to system, configure SCADA set-up, run daily tests on SCADA
- Prepare daily running sheets (note, this is a task related to the traffic regulation role)
- Answer phone calls relating to managing the electrification
- Manage isolations – prepare forms, coordinate with track staff, and operate SCADA to switch on/off the electricity to facilitate maintenance work
- Respond to alarms
- Isolate electricity in emergencies

Of these, only the conducting of daily tasks is predictable and stable. All other task categories will vary depending on the state of the railway. Communications and alarms will go up when there are faults and issues, while isolating the electrical supply tends to be a planned activity but the number and complexity of planned isolations can vary considerably from day-to-day.

Baseline workload assessment

The final piece of baselining work was a workload assessment of current operations. Four techniques were applied in the workload assessment: quantification of metrics, observations of ECOs, analysis of phone logs, and alarm analysis.

The assessment identified a number of infrastructure features that could be quantified in order to estimate the demand created on the operator. These included: the number of substations, track paralleling huts (TPHs), kilometres of track, breakers (feeders, rectifiers and high voltage), number of long term isolations in place, and average number of isolations taken on a weekday and on a weekend. Table 2 gives a description and quantity of each.

Table 2: Quantification of metrics for ECO workstation

Asset Type	Description	Quantity
Substations	Installations which convert the voltage from 38kV AC to 1500DC to supply the OHLE	13
Track Paralleling Huts	TPHs contain DC switchgear which electrically connect a number of different sections of the OHLE	7

Electrified Track		Length of track where electrically powered trains can operate	49km
Breakers	Track Feeder	Breakers controlling the power from the substations/TPHs to the track	76
	Rectifier	Breakers controlling the swap of power from 38kV AC to 1500V DC in the substations	25
	38kV AV	Breakers controlling the electricity connection from the national supplier to the substations	23

Four observations were conducted during night shifts, when ECOs are typically most busy as they are required to give and take back isolations to facilitate maintenance access. One of the observations was not included in the workload assessment, as it was scheduled during the Christmas period when fewer isolations are taken and therefore was not representative of typical ECO workload. Of the three observations analysed, two were undertaken on weekdays between 2300 and 0500 and one at a weekend between 2300 and 0700. The results for one observation are shown in Figure 1.

The results across all observations showed a similar trend of a reduction of regulator duties from the first hour of the shift as the train service comes to an end. In the second hour, communications and actions on SCADA ramp up as isolations are given out for that night's maintenance work. This hour tends to exceed the typical best practice of 70% time occupancy (leaving a threshold of 18 min in each hour for exceptional events and short breaks) and in some observations it reached 100% time occupancy. There is then a lull over three-four hours as the maintenance work is carried out on track until shortly before the start of train service when activity ramps back up to re-energise the OHLE.

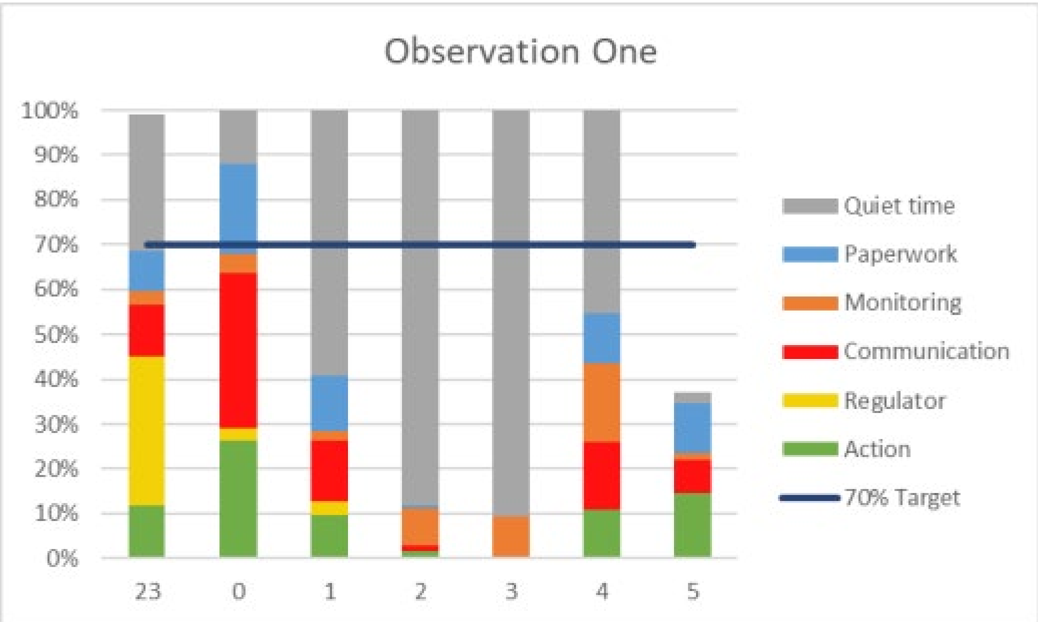

Figure 1: Results for Observation 1

Daytime work is more focussed on responding to alarms and is less predictable. The communications and alarms analyses were used to give some insight to the workload during the day. The call logger was analysed and the overall, daily, and hourly averages were calculated. The analysis also included the origin and purpose of the call where possible. The alarm analysis was complex due to the number of different categories of alarms and alerts and difficulty in establishing the ECO required response to each type of alarm. However, the main categories of alarms and alerts were established with operations and the logger was analysed over a seven day period.

The communications analysis found an average of 52.5 calls per day over the week analysed, with a maximum of 80 in one day. Typically, calls lasted less than 1 min and the greatest percentage occurred between 0000-0559, corresponding with the period when isolations are taken. Incoming calls were more than double outgoing, indicating a lack of control by the ECO over when their communications workload will occur. The majority of calls were to/from OHLE maintenance staff, with a lesser number to the signaller controlling trains running over the electrified infrastructure.

There were 2443 alarm instances found over the seven day period analysed. These were spread over three categories of alarms, with 75 different names and 16 different states. The majority (1860) occurred during the nightly isolation window with 983 generated as a result of isolation activities, 696 as a result of maintenance activities, 128 as a result of faults, and 53 as a result of testing. On average, there were approximately 40 alarms per hour between 0000-0500, while there were approximately six per hour from 0600-2300.

The observations found a peak of workload at the start of night shifts when ECOs are fully occupied with granting isolations, a lull during the middle of the night, and a smaller peak at the end of the shift as isolations are handed back. Daytime workload is more difficult to analyse, but has generally lower communications and lower alarm rates than nightwork. The ECO workload is therefore quite unbalanced as they are overloaded for a couple of hours at the start of the nightshift, and are relatively busy towards the end of the nightshift, but are likely to be underloaded at all other times. This may present difficulties in managing their workload when moving to the new control centre where they will not have additional duties.

Future operations

The move to the new control centre will create a new dedicated ECO role, where in the current operation the role is shared with a traffic regulation role (i.e. individuals hold both competencies). Additional equipment and information sources will be provided, and the ECOs will be co-located with signalling staff where they are presently co-located with regulation staff. The current human factors work is focussed on understanding how the ECOs will utilise the new equipment and develop a high-level task description for the role. A preliminary workshop was held with operations and engineering staff to review each piece of equipment, describe the goals and main tasks for the operator, and also identify whether the maintenance and procedures would be managed internally or externally. Table 3 summarises the outputs.

Table 3: Future system goals, tasks, and responsibilities

System / Equipment	Goal / Purpose	ECO main tasks	Maintenance responsibility	Standard operating procedure responsibility
SCADA	Monitor and control electricity supply to OHLE	• Run tests • Manage isolations • Monitor, acknowledge and resolve alarms • Diagnose faults	Irish Rail (software, PC workstation, server)	Irish Rail

		• Monitor voltage levels	External supplier (desk hardware)	
DMS	Support isolations and emergency access	• Validate isolations • Generate switching plans • Identify closest access points to faults and for emergencies	Irish Rail (software, PC workstation, server) External supplier (desk hardware)	Irish Rail
IESD	Emergency de-energisation of OHLE	• Run tests • Perform emergency de-energisation	Irish Rail	Irish Rail
TMS	Request isolations	• Request isolation from signaller • View train locations	External supplier	External supplier
Frequentis / Phone	Communications	• Make and answer calls	Irish Rail	Irish Rail
ICT PC	Access to IE ICT	• Access information on Sharepoint • Access emails to report faults • Access emails to receive isolation updates	Irish Rail	Irish Rail

The workshop also considered the workload of future ECOs. It was possible to estimate the effect of a major electrification programme in the greater Dublin area on the metrics detailing the assets to be managed. This is shown in Table 4 and describes approximately a tripling of assets to be managed.

Table 4: Future asset quantification

Asset Type	**Current**	**Additional from DART+**	**Total**
Substations	13	26	39
TPHs	7	Unknown	Unknown
Electrified track	49km	Approx. 94km	143km
Breakers	124	Approx. 260	384

The current design of the control room includes two ECO desks, but this may not be sufficient for the planned expansion. As sustainability initiatives are increasingly developed, there may also be further electrification of other routes in future. It is therefore necessary to consider how the additional workload will be managed in the future. This may be difficult, as ECOs are currently overloaded for a short period at the start of the night and are busy for another couple of hours at the end of the night due to giving out and taking back isolations. However, they are not as busy during the rest of the day and splitting the workload across multiple desks may result in underload. It is also necessary to consider whether the workload should be split geographically (i.e. different desks control different areas) or functionally (i.e. one ECO manages SCADA while another handles communications). There may also be benefits from considering changes to isolation procedures which could help reduce or stagger the workload for the ECO.

Further workshops are planned to analyse these issues in more depth, as well as finalising designs for the layout of equipment on the desks and analysis of proposed changes to the alarm system.

Conclusion

This paper has presented the approach taken in Irish Rail to analyse the current work and predict and analyse potential issues with future ECO operations, particularly given the expansion plans. The current operations were baselined through documentation of the information sources on the current workstation, a task analysis, and a workload assessment. The exploration of issues relating to future operations is being undertaken in a series of workshops with key stakeholders. To date, these have covered management of future workload and mapping out the functions and maintenance of future equipment. Future workshops will explore screen allocations and alarms analysis.

References

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