

**INSTITUTION OF RAILWAY SIGNAL ENGINEERS
2018 EXAMINATION**

MODULE 7 - SYSTEM MANAGEMENT AND ENGINEERING

TIME ALLOWED - 1 1/2 HOURS

ANSWER **THREE** QUESTIONS, ALL QUESTIONS CARRY EQUAL MARKS

WRITE ON ONE SIDE OF THE PAPER ONLY, AND NUMBER EACH SHEET THAT
YOU USE CONSECUTIVELY

COMMENCE YOUR ANSWER TO EACH QUESTION ON A NEW SHEET OF PAPER

ANSWER SHEETS WILL BE PHOTOCOPIED – PLEASE USE ONLY BLACK INK

Question 1

Listed below are five classes of factors which can affect human performance.

For each of these classes, identify two examples of specific factors which tend to have an adverse effect on performance. For each example you identify, explain how that specific factor tends to increase the probability of human error and suggest what measures might be taken to counteract it.

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|----|--|-----------|
| a) | Ambient environmental factors | [5 marks] |
| b) | Ergonomic factors | [5 marks] |
| c) | Factors relating to task design | [5 marks] |
| d) | Factors relating to equipment and tools | [5 marks] |
| e) | Factors relating to the individual who performs the task | [5 marks] |

Question 2

Discuss the problems, opportunities, costs and benefits of applying full automatic train operation to a mixed traffic mainline railway. You should consider technical, operational, economic and social aspects, taking account of safety requirements and the need to manage disturbances, failures and emergencies. [25 marks]

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Question 3

A train control and protection system which transmits movement authorities to trains by radio has recently been installed on an existing railway. The system provides continuous speed supervision and includes a new type of computer-based interlocking. The trains are manually driven and use tachometry to measure their speed. Following the commissioning of the system, drivers have been reporting that it occasionally triggers unnecessary brake applications which are leading to train delays.

- a) Draw an overall schematic diagram of the system, showing the interfaces between its subsystems. [5 marks]
- b) Describe the possible causes of the unnecessary brake applications. [10 marks]
- c) For one of these possible causes, explain what evidence you would need in order to determine whether this is the actual cause and describe how you would gather this evidence. [10 marks]

Question 4

It is much more difficult for signalling or telecommunications systems to achieve electromagnetic compatibility with a railway electric traction system than with national power distribution lines running parallel to the railway.

- a) Explain the characteristics of a typical railway electric traction system, including trains and fixed equipment, which cause particular difficulties for the compatibility of signalling or telecommunication systems, or both. [10 marks]
- b) For a lineside signalling or telecommunications system of your choice, describe the measures that should be taken in system design and installation to ensure electromagnetic compatibility when the system is installed on a railway electrified at 25kV 50Hz. Include a brief description of the system of your choice and state any assumptions you have made about the electric traction system and the trains that run on it. [15 marks]

Question 5

Considering the whole lifecycle of a signalling or telecommunications system based on programmable electronic equipment:

- a) What can be done to enhance the reliability of the system? [6 marks]
- b) What can be done to enhance the availability of the system? [6 marks]
- c) What can be done to enhance the maintainability of the system? [6 marks]
- d) Explain how the software of the system can affect its reliability, availability and maintainability. [7 marks]

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Question 6

A data transmission network is to be provided as part of the upgrade of an existing railway to CBTC operation. The network will be used as the bearer for all signalling, control and communications functions required by the railway.

- a) Outline those functions needed to ensure safe, efficient and reliable operation of the railway which will depend upon the data transmission network. You should take account of operations in normal and degraded situations, together with the need to manage emergencies. The needs of all operational and engineering disciplines should be included. Identify which of these functions are related to safety. [10 marks]
- b) What principal features should be incorporated into the design of the data transmission network to ensure suitable levels of performance availability? [8 marks]
- c) How would functional safety requirements influence the design of the data transmission network? [7 marks]

Question 7

It is essential that the specification of a safety-critical system should be correct, but specification errors can be difficult to eliminate.

- a) Describe a scenario where a specification error can remain dormant for a long time. [8 marks]

One approach to eliminate specification errors is to apply formal methods which make use of abstraction, refinement and proof to mathematically demonstrate that a set of requirements is coherent.

- b) Propose two typical top level safety requirements and then break each of them down into a series of formal specification statements. [14 marks]
- c) Suggest one type of specification error which might not be detected by the use of formal methods. [3 marks]

Question 8

- a) Draw a system architecture boundary for a level crossing with obstacle detection and with automatic, remote manually controlled and local manually controlled modes of operation. Considering train detection, signal interlocking, and the level crossing as related sub-systems, define the functions allocated to each of them. [8 marks]
- b) Identify all the interfaces that are required for the safe operation of the level crossing. [6 marks]
- c) Describe two possible means of automatically initiating the barrier lowering. [3 marks]
- d) Draw an event flow chart for a complete cycle of operation for the passage of a single train, starting from the crossing being open to road traffic through to reopening after the train has passed. [8 marks]

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Question 9

- a) Draw a V lifecycle and identify the design phase, the installation and testing phase and the operation phase. Show how verification and validation relate to the stages on the drawing. [5 marks]
- b) You have been tasked to write a signalling test plan for a new Automatic Train Control (ATC) system before it can be tested. Write a list of headings that you will include in the test plan and show how you can achieve the verification and validation of the lifecycle phases through this test plan. [10 marks]
- c) Explain how you will manage the various activities as you progress the testing. [10 marks]

Question 10

- a) Explain the role of the Hazard Log in the development of a signalling or safety-related telecommunications system, and show how it should relate to the project Safety Management System and the system Safety Case. [10 marks]
- b) Suggest three sources of entries for the Hazard Log. [5 marks]
- c) Explain three risk acceptance criteria by which a given risk is mitigated and managed. [10 marks]

End of paper