Question 1

You are the systems engineer for a new signalling or telecommunications project that will involve the introduction of new technology into existing systems.

a) Describe the Systems Engineering Management Plan that you should put into place for this project. Your plan should identify all systems engineering activities that you wish to be carried out in order to support timely and efficient project delivery. [20 marks]

b) Identify the key stakeholders who should endorse this Systems Engineering Management Plan and explain why. [5 marks]

Question 2

a) Write down an equation which expresses Availability in terms of Mean Time To Failure and Mean Time To Repair. [5 marks]

b) The Mean Time To Repair is the sum of the times taken by each of the activities which must be completed between the occurrence of a failure and the restoration of normal operation. Draw a timeline showing the sequence of these events and actions. [5 marks]

c) For each activity on the timeline, identify likely causes of delay and suggest what steps might be taken to reduce the time involved. [15 marks]
**Question 3**

An automatic level crossing on a mixed traffic line has a history of motorists disobeying the road traffic lights. The level crossing in question features a station stop within one of the strike-ins. The design of the level crossing does not take this into account. With particular attention to human factors:

a) Explain ways in which the design of the level crossing may contribute to motorist misuse of the level crossing. [5 marks]

b) How could the design be altered to reduce the problem? [10 marks]

c) What measures could be taken in order to deter motorists from disobeying the road traffic signals? [5 marks]

d) If you are tasked to carry out a risk analysis of the level crossing, what factors will you consider in order to carry out the task? [5 marks]

**Question 4**

a) In an underground mass-transit railway, what functions need to be provided by monitoring, communication and control systems to manage the safe and convenient movement of people between the street and the trains? You should take account of the effects of disruption to train services and of emergency situations. [10 marks]

b) If the trains are driverless, what monitoring, communication and control functions should be provided to meet the needs of passengers in the trains? You should take account of incidents in the trains, prolonged dwell times in tunnels, and the possible need to evacuate trains stranded in tunnels. [10 marks]

c) How should these systems interface with the control of train movements? [5 marks]

**Question 5**

a) How would you define the reliability of a given railway both from the users’ perspective and the maintainer’s perspective? [5 marks]

b) What are the factors that can affect the reliability of a signalling system on a long-term basis? [10 marks]

c) Draw and explain a Reliability Block Diagram which can be used to calculate the overall reliability of a railway. [10 marks]

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**Question 6**

ETCS Level 1 is to be applied to the trains and signalling of an existing railway.

a) What are the main engineering problems and major costs of retrofitting ETCS on-board equipment to an existing train? [7 marks]

b) What are the vital interfaces for the new on-board signalling system with the existing rolling stock? [3 marks]

c) Identify the main interfaces to consider while designing and implementing ETCS Level 1 on an existing piece of railway. [5 marks]

d) Identify the risks and related mitigating measures associated with all of the interfaces in b) and c). [10 marks]

**Question 7**

[Diagram of system lifecycle]

Note: The broken lines indicate that some lifecycle stages have been omitted

a) For each of the stages shown in the abbreviated lifecycle diagram above, suggest a type of software tool which might be used to perform or to support an activity which forms part of that stage. Explain what each tool contributes to the output of that stage. [20 marks]

b) Where a software tool generates outputs which can directly or indirectly affect the behaviour of the system, for example where the tool generates executable software code or configuration data, what measures can be taken to ensure that an error in the design of the tool will not cause the system to malfunction in service? [5 marks]

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Question 8

A safety case for a safety-related electronic system should contain:

- Evidence of quality management
- Evidence of safety management
- Evidence of functional and technical safety

The following questions relate to this evidence:

a) What does quality management contribute to ensuring safety? [4 marks]
b) What does safety management contribute to ensuring safety? [4 marks]
c) What is the difference between functional safety and technical safety? [3 marks]
d) Describe what evidence is needed to demonstrate functional safety. [7 marks]
e) Describe what evidence is needed to demonstrate technical safety. [7 marks]

Question 9

You have been tasked to produce an outline design for the train control, traffic management and communication systems for a new mass transit railway which is to be equipped with CBTC.

a) Draw a block diagram identifying the various systems that comprise the complete railway for which you need to consider before starting your design. [10 marks]

b) Identify the various sub-systems that you are designing in this complete rail system. [5 marks]
c) Identify the key system issues to consider while designing the railway. [5 marks]
d) What are the measures that you would consider in order to resolve these issues? [5 marks]
Question 10

a) Sketch a fault tree for either:

i. A train equipped with an automatic train protection system failing to stop at a red signal; or

ii. Loss of radio communication with a train running in ETCS Level 3. [12 marks]

b) Explain how such a fault tree could be used to estimate the likelihood of the failure occurring. [5 marks]

c) Based on your fault tree, identify measures that could be taken to reduce this likelihood. [8 marks]