

Exam

Infrastructure Management

Course : Infrastructure Management
Code : 582040
Date : 22-06-2017
Time : 13:45-14:45

The exam consists of multiple-choice questions.

Read each question and all alternatives carefully.

For answering the questions use the extra sheet handed out.
Blacken the letter that corresponds to the one best answer.

Make sure you understand each question before you attempt to answer it. If you have questions about the items on the exam, ask for clarification.

Much success!!!

Ind	Group	Cor:
1 B 8	B 8	B
2 A 8	A 8	A
3 A /	A /	B
4 A 8	A 8	A
5 A 8	A 8	A
6 C 8	C 8	C
7 B 8	B 8	B
8 D 8	D 8	D
9 C 8	C 8	C
10 A 8	A 8	~~B~~ → A

1. A railway agency is responsible for the management of a wider railway network consisting of several assets including switches, catenaries, signals and electrical installations. In recent years the number of switch failures has increased which often led to a decrease of track availability. The infrastructure manager of the railway agency decides to investigate the problem further. He discovers that particularly after cold nights with snowfall the tongues of the switches could not be moved due to ice and snow. When further looking into the switch components, he detects that many switch heating systems do not provide enough heating capacity to melt ice and snow. The reason is that the technical specification used by the agency for the switch heating system does not consider the combination of ice and snow. Based on the infrastructure manager's level of analysis the loss of the ability of a switch to move its tongues during cold nights with snowfall is a:

- a. Failure mode
- ☒ b. Failure effect
- ☒ c. Failure cause ?
- ☒ d. Failure occurrence

2. After the blocked railway switches the railway agency has the impression that many failures are induced by weather-related incidents and wants to determine the risk of weather-related failures. An investigation of all weather-related failures between 2013 and 2016 showed that:

- 65% of failures occurred during winter time and are caused by a combination of low temperature and snowfall.
- The number of failures is drastically increasing if temperatures are under -10 degrees or snowfall is above 20mm.
- There are only a few failures recorded if temperature is around 0 degrees (without snowfall) or snowfall is under 5mm.
- The most vulnerable component of the railway infrastructure is the switch. The switch is not working due to ice between the tongues or a broken heating system.
- 10% of all failures cause some safety issues, 70% of all failures lead to train delays, but all failures need some maintenance work.
- Due to the longer maintenance work the delay time is higher when the heating system is broken. Safety is more affected when there is ice between the tongues.

The responsible infrastructure manager needs to evaluate the probability that a switch failure will occur during winter. Which scale do you suggest him to use?

- a. unlikely – temperature >0 degree / snowfall <5 mm
possible – temperature 0 to -10 / snowfall 5 to 20mm
certain – temperature <-10 / snowfall >20 mm
- b. unlikely – safety issues $<10\%$
possible – train delays >10 -70%
certain – maintenance >70 -100%
- c. unlikely – no ice between tongues and heating is working
possible – ice between tongues or heating is not working
certain – ice between tongues and heating is not working
- d. unlikely – No maintenance and delays due to working heating
possible – Safety issues due to ice between tongues
certain – Longer maintenance and delays due to not working heating

3. For prediction reasons the infrastructure manager asks a colleague to do an analysis of the switch failure data. The infrastructure manager is particularly interested in whether the number of switch failures depends on the age of the switch and the type of the switch. The colleague conducts a regression analysis and includes 4 types of switches that were prone to failure in the past 2 years. The switches in the sample cover almost the entire service life of the 4 switch types. The colleague runs the analysis and provides the infrastructure manager with the following results:

	<i>Coefficient</i>	<i>Standard error</i>	<i>T-Statistic</i>	<i>P-Value</i>
Constant	5,016	0,147	34,019	0,000
SwitchType 1	0,295	0,149	1,933	0,057
SwitchType 2	0,328	0,152	2,203	0,031
SwitchType 3	0,084	0,149	0,561	0,576
Age	0,369	0,160	2,308	0,024

The infrastructure manager is wondering how he should interpret the results and ask you to tell him how often a switch of type 4 with an age of 18 years would fail within two years. What do you answer to the infrastructure manager?

- a. The number of failures for a switch of type 4 cannot be calculated, since the colleague forgot to include the type 4 switches in the analysis.
- b. The number of failures for a switch of type 4 with an age of 18 years is 11.7 within two years.
- c. The number of failures for a switch of type 4 cannot be calculated, since not all factors are significant.
- d. The number of failures for a switch of type 4 with an age of 18 years is 12.4 within two years.

4. Due to a changed train schedule, the railway agency has to reduce the possession time available for railway interventions from 6hrs to 5hrs. The infrastructure manager of the railway agency is asked to reconsider the planned intervention strategy for 3 components of one of the railway lines (see Figure 1). He knows the individual intervention cost – c_i , the service-life shortening cost – c_s , the intervention time - t_m , and the possession cost - c_p (Table 1).

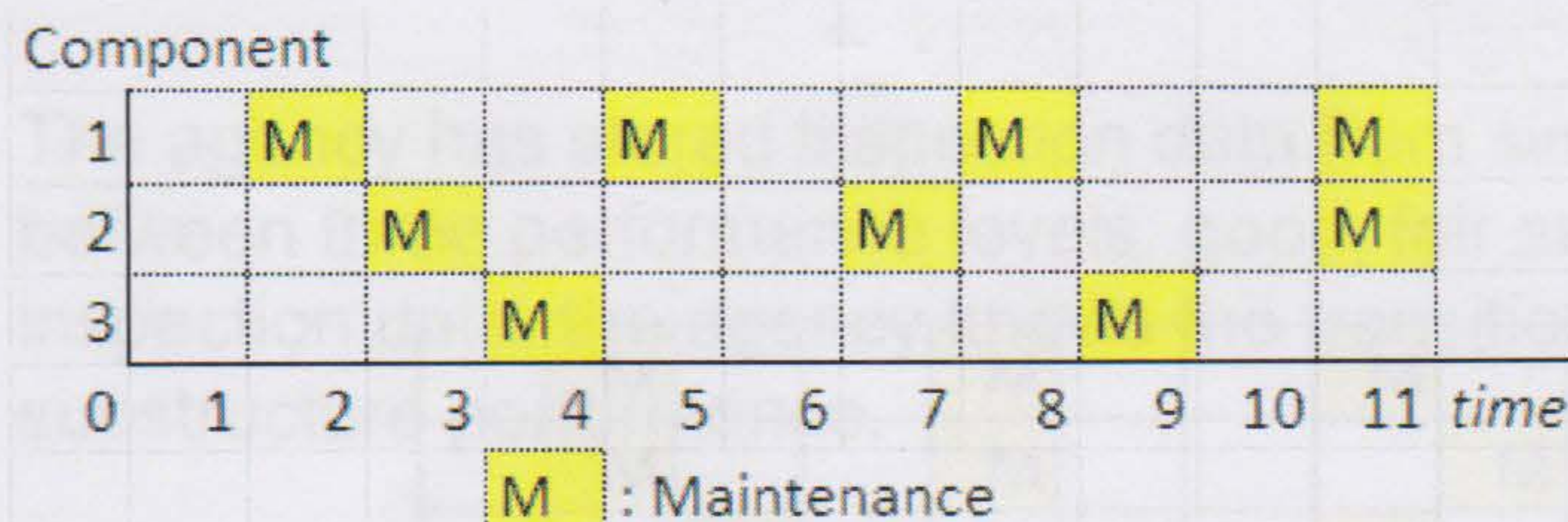


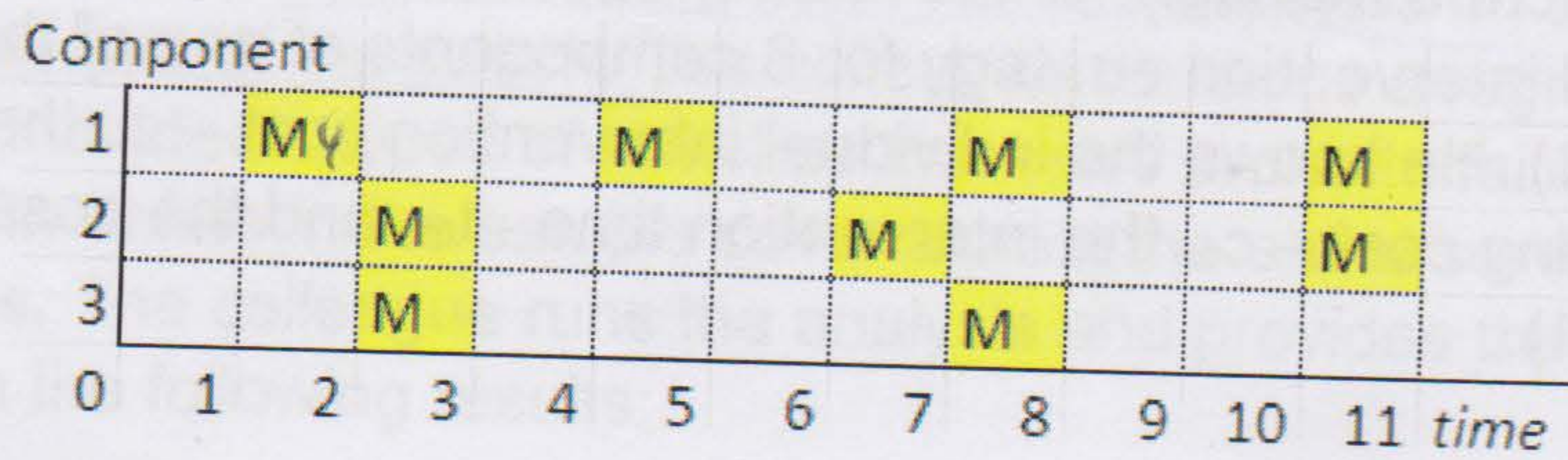
Figure 1 Planned intervention strategy

Component	c_i	c_s	t_m (hrs)	c_p
1	4	0,5	2	1,5
2	2	0,5	2	
3	3	0,4	3	

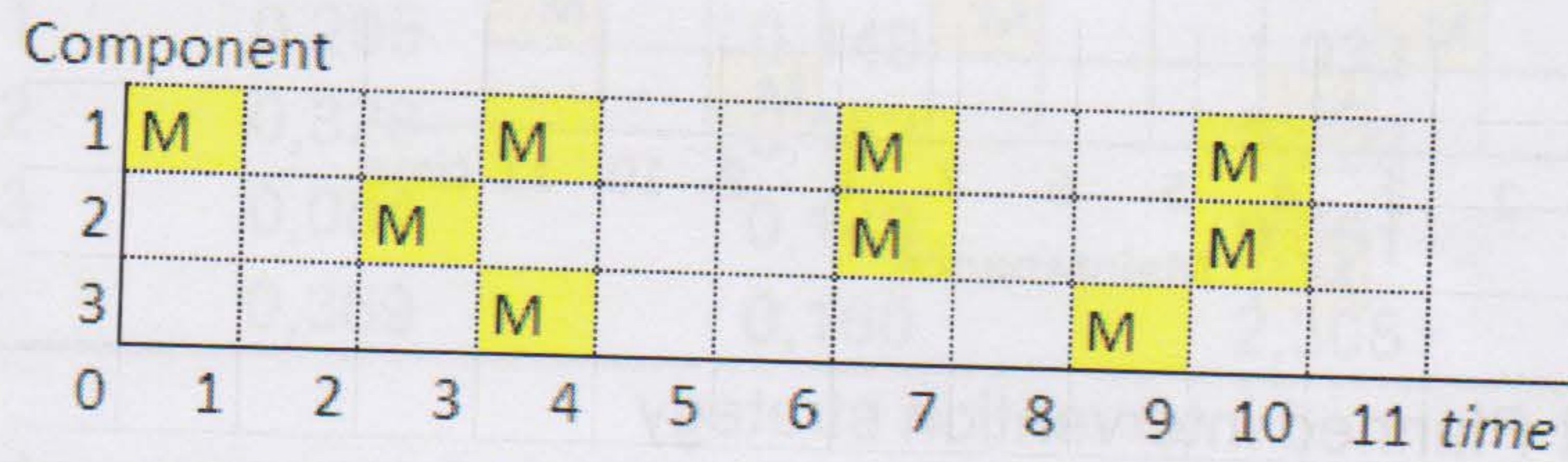
Table 1 Intervention cost, intervention time, and possession cost

Based on that, the infrastructure manager comes up with 4 strategies. Which one should be selected for the railway line?

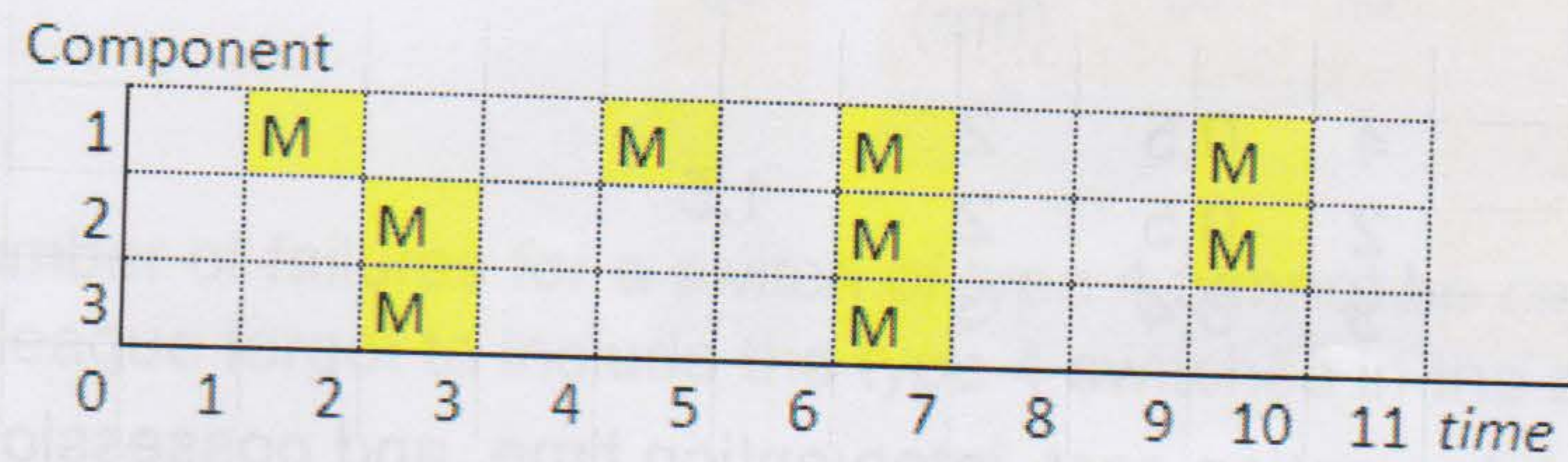
a.



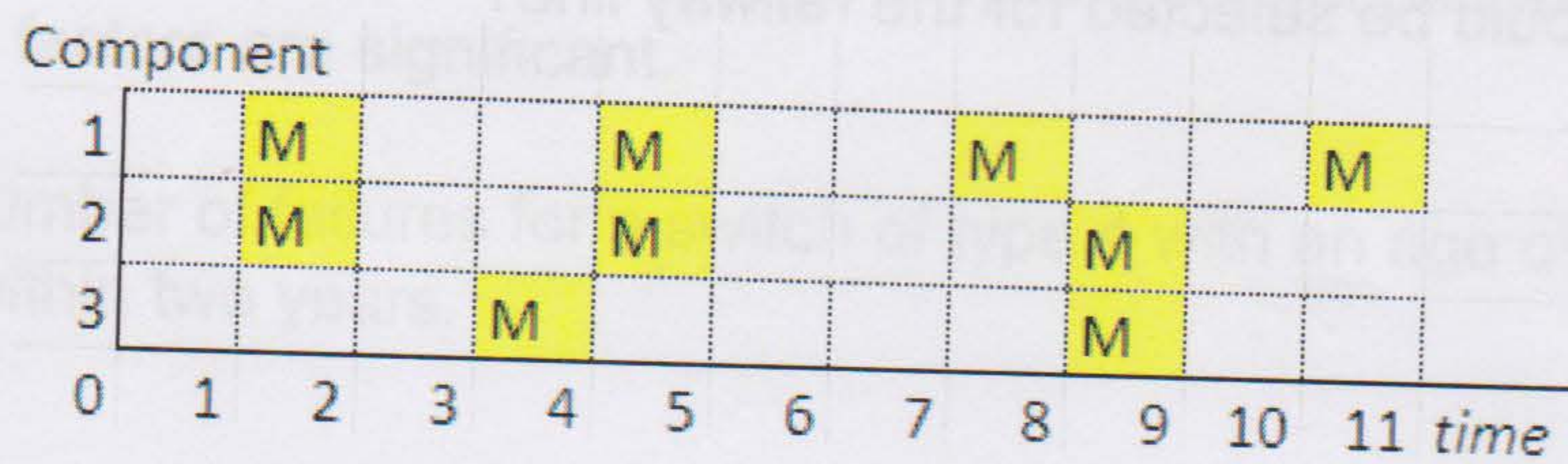
b.



c.



d.



5. A road agency needs to decide on the intervention strategy for a bridge and the infrastructure manager is considering two strategies for the substructure of the bridge:

Strategy 1: The substructure will be only maintained after the expected life time of 30 years.

Strategy 2: The substructure will get a first intervention after 15 years to slow down the deterioration and a second intervention after 30 years.

The agency has stored inspection data from similar bridges and distinguishes between three performance levels: good, fair and poor. From the stored inspection data, the agency knows the transition probabilities for the substructure performance.

The current performance level of the substructure is regarded as good. Given the current performance level, the probabilities that the substructure will be at a certain performance level after 15 years without intervention are:

	Performance after 15 years		
	Good	Fair	Poor
Good	0.35	0.60	0.05
Fair	0	0.5	0.5
Poor	0	0	1

After 15 years the transition probabilities are changing due to deterioration. Given the performance level after 15 years without intervention, the probabilities that the substructure will be at a certain performance level at the end of the expected life time are:

	Performance after 30 years		
	Good	Fair	Poor
Good	0.15	0.80	0.05
Fair	0	0.3	0.7
Poor	0	0	1

The agency also knows the impact of the first intervention after 15 years on the transition probabilities. Given the current performance level, the probabilities that the substructure will be at certain performance level after 15 years with the intervention applied are:

	Performance after 15 years		
	Good	Fair	Poor
Good	0.95	0.05	0
Fair	0.7	0.3	0
Poor	0.3	0.6	0.1

The probabilities that the substructure will be at a certain performance level at the end of the expected life time are then:

		Performance after 30 years		
		Good	Fair	Poor
Good	0,95	0.35	0.60	0.05
Fair	0,05	0	0.5	0.5
Poor	0	0	0	1

What is the expected performance of the substructure after 30 years, if an intervention is done after 15 years?

a.

Good	Fair	Poor
0.33	0.60	0.07

b.

	Good	Fair	Poor
Good	0.05	0.46	0.49
Fair	0	0.15	0.85
Poor	0	0	1

c.

Good	Fair	Poor
0.15	0.37	0.48

d.

	Good	Fair	Poor
Good	0.33	0.24	0.10
Fair	0.60	0.60	0.48
Poor	0.07	0.18	0.42

6. The infrastructure manager also determines the optimal intervention strategies for a road network link for the next 20 years by calculating the return period of the rehabilitation intervention applied. The manager uses the net-present-value method and calculates agency and user costs. The calculation will show that the longer the intervention return period:

- a. The greater agency and user costs.
- b. The lower agency and user costs.
- ☒ c. The lower agency costs and the greater user costs.
- d. The greater agency costs and the lower user costs.

7. A colleague of the infrastructure manager suggests the uniform-annual-cost method for determining the optimal intervention strategies. He believes that this method is more appropriate for the analysis period of 20 years and that the net-present-value method will yield incorrect results. The colleague of the infrastructure manager is right:

- a. If the annual inflation is taken into account for the analysis period.
- ☒ b. If the return period of some interventions is larger than the analysis period.
- c. If only the costs incurred over the analysis period are considered and the benefits are not included.
- d. If the analysis period is so long that a reasonable forecast is not possible.

8. The rehabilitation intervention the infrastructure manager wants to apply for the road network link within the analysis period do not change the function of the road assets. In other words, the assets will provide the same services after the intervention. In order to determine the benefits of applying the intervention, the infrastructure manager needs to:

- a. Calculate agency and user costs over the analysis period.
- b. Determine at least two interventions for a road asset.
- c. Include technical and non-technical interventions.
- ☒ d. Compare the costs of at least two intervention strategies.

9. For executing the interventions on the road network link the infrastructure managers wants to contract a service provider. The work to be done on the road link mainly includes the mowing of grass, the cutting of trees, the cleaning of the road drainage, the cleaning of road signs, the removing of graffiti from objects, and the cleaning out of litter bins on parking areas. These services were already bought from other service providers in previous years. However, the infrastructure manager was not very satisfied with the delivered services. From the perspective of the infrastructure manager, the service providers were often too late in doing the contractually agreed tasks and there were constantly discussions with the service providers about the performance to be delivered, for example when the drainage needs to be cleaned. Furthermore, the service providers always tried to claim additional work that was not contractually specified. The infrastructure manager has also the impression that he had to do a lot of coordination among the service providers and that the agency's flexibility to change performance standards on the road link was relatively low.

Based on the experience of the infrastructure manager, which of the following contract designs for buying in the described services would you suggest?

- a. Discrete contract for single services with asset-related performance specifications, lump-sum price mechanism, and short-term duration.
- b. Integrated contract for multiple services with service-related performance specifications, cost-plus fee mechanisms, and long-term duration.
- c. Framework contract for multiple services with task-related performance specifications, unit price mechanism, and medium-term duration.
- d. Integrated contract for multiple services with asset-related performance specifications, lump-sum price mechanism, and medium-term duration.

10. In another intervention contract of the road agency the contractor is asked to deliver: "96% availability of the road". The contract describes:

- ☒ a. Asset-related performance.
- b. Service-related performance.
- c. Intervention-related performance.
- d. Process-related performance.