

Space Systems Engineering

Topic: Maintainability

HOMEWORK

Due: One week from assigned for individual work and two weeks for group work.

Individual Work (40%)

1. (15%) There are four major subsystems in one system design. Their failure rates and mean corrective maintenance times are as follows:

Subsystem i	λ_i (per days)	$M_{CT i}$ (days)
1	1/2000	1
2	1/1000	2
3	1/800	0.5
4	1/5000	1

Mean preventive maintenance time $M_{pt} = 0.5$ hours at the frequency of $f_{pt} = 1/600$ per hour. Each maintenance task, no matter corrective or preventive, on average takes 0.4 hours of logistics delay time and 0.3 hours of administration delay time. Please calculate the mean maintenance downtime for one maintenance task.

2. (10%) Given the following data, calculate the achieved availability

- $M_{ct} = 0.5$ hour
- $MTBM_u = 2$ hours
- $M_{pt} = 2$ hours
- $MTBM_s = 1,000$ hours

3. (15%) The requirement M_{ct} for an equipment item is 65 minutes. A maintainability demonstration is accomplished and yields the results given in the table for 50 tasks demonstrated (Task time in minutes).

Task 1-10	39	57	70	51	74	63	66	42	85	75
Task 11-20	42	43	54	65	47	40	53	32	50	73
Task 21-30	64	82	36	63	68	70	52	48	86	36
Task 31-40	74	67	71	96	45	58	82	32	56	58
Task 41-50	92	91	75	74	67	73	49	62	64	62

- Did the equipment pass the maintainability demonstration?
- In reality, after which task can the conclusion be drawn?

The acceptance and rejection table for Demonstration method introduced on lecture slides is as follows.

Maintenance Demonstration Table for Mean

Maint Task No.	Accept /When Cum \leq	Reject /When Cum $>$	Maint Task No.	Accept /When Cum \leq	Reject /When Cum $>$
1	-	-	26	4	12
2	-	-	27	4	12
3	-	-	28	4	12
4	-	-	29	5	12
5	-	5	30	5	13
6	-	6	31	5	13
7	-	6	32	6	13
8	-	6	33	6	14
9	-	7	34	6	14
10	-	7	35	7	14
11	-	7	36	7	15
12	0	7	37	7	15
13	0	8	38	7	15
14	0	8	39	8	15
15	1	8	40	8	16
16	1	9	41	8	16
17	1	9	42	9	16
18	1	9	43	9	17
19	2	9	44	9	17
20	2	10	45	9	17
21	2	10	46	10	17
22	3	10	47	10	18
23	3	11	48	10	18
24	3	11	49	11	18
25	4	11	50	11	19

Group Assignment (60%)

Documents to use in this assignment:

Maintainability_Columbia_Case.pdf

Maintainability lecture notes

- a. Please read the document of *Maintainability Issues in the Disaster of Space Shuttle "Columbia"* as the file of "Maintainability_Columbia_Case.pdf" in the reading material.
- b. Please prepare a report to discuss the importance of maintainability in system design and operations. Specifically, please discuss whether maintainability was well addressed in the original design of Columbia and during its operations. The discussion should include three maintainability measures mentioned in the lecture notes such as maintenance times, maintenance frequency factors, and maintenance cost.