Chapter 02, Simulation Examples in a Spreadsheet
Example 09: Replacing Bearings in a Milling Machine
By Mohammad Abubakar Atiq, BSIE, F2022031002, To Sir Rehan Ashraf

Table 22 Distribution for Bearing Life

Distribution of Bearing-Life

Bearing Life	Probability	Cumulative Probability
1000	0.100	0.100
1100	0.130	0.230
1200	0.250	0.480
1300	0.130	0.610
1400	0.090	0.700
1500	0.120	0.820
1600	0.020	0.840
1700	0.060	0.900
1800	0.050	0.950
1900	0.050	1.000

Table 23 Distribution of Delay until Mechanic Arrives

Distribution of Delay Time

Delay Time	Proability	Cumulative Probability
5	0.600	0.600
10	0.300	0.900
15	0.100	1.000

page 65, Chapter 02: Simulation Examples in a Spreadsheet
Example 9: Replacing Bearings in a Milling Machine

A milling machine has three different bearings that fail in service. The distribution of the life of each bearing is identical, as shown in Table 22. When a bearing fails, the mill stops, a mechanic is called, and he or she installs a new bearing (costing $32 per bearing). The delay time for the mechanic to arrive varies randomly, having the distribution given in Table 23. Downtime for the mill is estimated to cost $10 per minute. The direct on-site cost of the mechanic is $30 per hour. The mechanic takes 20 minutes to change one bearing, 30 minutes to change two bearings, and 40 minutes to change three bearings. The engineering staff has proposed a new policy to replace all three bearings whenever one bearing fails. Management needs an evaluation of the proposal, using total cost per 10,000 bearing-hours as the measure of performance.

Current Method

Bearing 1			
Step	Random#	Life (Hours)	Delay (minutes)
1	0.431	1200	5
2	0.617	1400	10
3	0.307	1200	5
4	0.379	1200	5
5	0.601	1300	10
6	0.509	1300	5
7	0.222	1100	5
8	0.545	1300	5
9	0.891	1700	10
10	0.692	1400	10
11	0.862	1700	10
12	0.676	1400	10
13	0.362	1200	5
14	0.053	1000	5
15	0.672	1400	10
TOTAL		19800	110

Bearing 2			
Step	Random#	Life (Hours)	Delay (minutes)
1	0.509	1300	5
2	0.989	1900	15
3	0.522	1300	5
4	0.924	1800	15
5	0.783	1500	10
6	0.398	1200	5
7	0.689	1400	10
8	0.597	1300	5
9	0.385	1200	5
10	0.620	1400	10
11	0.897	1700	10
12	0.514	1300	5
13	0.947	1800	15
14	0.843	1700	10
15	0.966	1900	15
		22700	140

Bearing 3			
Step	Random#	Life (Hours)	Delay (minutes)
1	0.671	1400	10
2	0.554	1300	5
3	0.611	1400	10
4	0.472	1200	5
5	0.513	1300	5
6	0.523	1300	5
7	0.823	1600	10
8	0.299	1200	5
9	0.143	1100	5
10	0.231	1200	5
11	0.426	1200	5
12	0.546	1300	5
13	0.543	1300	5
14	0.817	1500	10
15	0.215	1100	5
		19400	95

Costs of Bearing= $ 32.00 per bearing
Downtime cost= $ 10.00 per minute
Mechanic cost= $ 30.00 per hour $ 0.50 per min
Replacement Time by Mechanic
Replacement Time 20 minute
2 Bearing 30 minute
3 Bearing 40 minute

The total life of all 45 bearings is = 61900
Hours / 10,000 Bearings = 6.190
The Total cost per 10,000 bearing - Hours is = $ 2,316.64

For Single Trial of the simulation, the cost of the current system is estimated as follows:

Cost of Bearing = $ 1,440.00
Cost of delay time = $ 3,450.00
Cost of downtime during repair = $ 9,000.00
Cost of Mechanics = $ 450.00
Total Cost = $ 14,340.00

Proposed Method

	Bearing 1		Bearing 2		Bearing 3		First Failure (Hours)	Random#	Delay (minutes)
Step	Random#	Life (Hours)	Random#	Life (Hours)	Random#	Life (Hours)			
1	0.599	1300	0.653	1400	0.265	1200	1200	0.859	10
2	0.054	1000	0.882	1700	0.708	1500	1000	0.904	15
3	0.899	1700	0.996	1900	0.171	1100	1100	0.557	5
4	0.314	1200	0.938	1800	0.982	1900	1200	0.030	5
5	0.882	1700	0.649	1400	0.958	1900	1400	0.778	10
6	0.259	1200	0.596	1300	0.636	1400	1200	0.252	5
7	0.834	1600	0.216	1100	0.658	1400	1100	0.311	5
8	0.027	1000	0.798	1500	0.184	1100	1000	0.333	5
9	0.948	1800	0.061	1000	0.735	1500	1000	0.576	5
10	0.368	1200	0.441	1200	0.478	1200	1200	0.325	5
11	0.799	1500	0.103	1100	0.603	1300	1100	0.788	10
12	0.237	1200	0.283	1200	0.684	1400	1200	0.516	5
13	0.982	1900	0.593	1300	0.311	1200	1200	0.682	10
14	0.325	1200	0.074	1000	0.860	1700	1000	0.187	5
15	0.807	1500	0.970	1900	0.174	1100	1100	0.977	15
Total							17000		115

Costs of Bearing= $ 32.00 per bearing
Downtime cost= $ 10.00 per minute
Mechanic cost= $ 30.00 per hour $ 0.50 per min
Replacement Time by Mechanic
1 Bearing 20 minute
2 Bearing 30 minute
3 Bearing 40 minute

The total life of all 45 bearings is = 17000
Hours / 10,000 Bearings = 1.700
The Total cost per 10,000 bearing - Hours is = $ 5,229.41

For Single Trial of the simulation, the cost of the current system is estimated as follows:

Cost of Bearing = $ 1,440.00
Cost of delay time = $ 1,150.00
Cost of downtime during repair = $ 6,000.00
Cost of Mechanics = $ 300.00
Total Cost = $ 8,890.00