

# LOGM 634 - Homework Set #4

Due 20 January 2017

## From the Ebeling text - Exercise 8.2

In the design of a space station, four major subsystems have been identified, each having a Weibull failure distribution with parameter values as given here

Subsystem	Scale Parameter	Shape Parameter
Computer	3.50	0.91
Avionics	4.00	0.80
Structures	5.00	1.80
Life Support	6.00	1.00

The reliability of the station must be 0.995 at the end of the first year. Determine the percentage increase in reliability for each major subsystem needed to reach the system goal. Assign equal reliability goals to all subsystems.

While not clearly stated, these subsystems operate in series – where the failure of any subsystem results in system failure. Therefore, the system reliability will be expressed as

$$R_{sys}(1) = 0.995 = R_C(1) \times R_A(1) \times R_S(1) \times R_{LS}(1).$$

We are also asked to assign an equal reliability goal to every subsystem, meaning that

$$R_C^*(1) = R_A^*(1) = R_S^*(1) = R_{LS}^*(1)$$

$$= \sqrt[4]{R_{sys}(1)}$$

$$= \sqrt[4]{0.995} = 0.9987476$$

The increase in reliability would then be the difference between the goal reliability 0.9987476 and the reliability of each subsystem at  $t = 1$ . These values, computed using the information in the table, are shown below

$$R_C(1) = \exp \left[ - \left( \frac{1}{3.5} \right)^{0.91} \right] = 0.7263$$

$$R_A(1) = \exp \left[ - \left( \frac{1}{4.0} \right)^{0.80} \right] = 0.7190$$

$$R_S(1) = \exp \left[ - \left( \frac{1}{5.0} \right)^{1.80} \right] = 0.9463$$

$$R_{LS}(1) = \exp \left[ - \left( \frac{1}{6.0} \right)^{1.00} \right] = 0.8465.$$

Thus, the increase in reliability for each subsystem is found as follows

$$\Delta R_C = \frac{R_C^*(1) - R_C(1)}{R_C(1)} = \frac{0.998748 - 0.7263}{0.7263} = .3751$$

$$\Delta R_A = \frac{R_A^*(1) - R_A(1)}{R_A(1)} = \frac{0.998748 - 0.7190}{0.7190} = .3891$$

$$\Delta R_S = \frac{R_S^*(1) - R_S(1)}{R_S(1)} = \frac{0.998748 - 0.9463}{0.9463} = .0554$$

$$\Delta R_{LS} = \frac{R_{LS}^*(1) - R_{LS}(1)}{R_{LS}(1)} = \frac{0.998748 - 0.8465}{0.8465} = .1799$$

## From the Ebeling text - Exercise 8.14

Nether Fales, a reliability engineer, must decide which of two components to use in the design of a new product. According to the supplier, component A has a unit cost of \$225 and a Weibull failure distribution with a shape parameter of 1.7 and a characteristic life of 12 yr. Component B has a unit cost of \$245 and a constant failure rate of 0.11 failures per year, according to the manufacturer's specifications. A failure of either component results primarily in the replacement of a comparable (same age) part. The average part cost of component A is \$40 and that of component B is \$35. In addition, if component A is selected a special test unit must be purchased at a cost of \$4300 to be used in identifying the failed part. The product will have a 10-yr design life, at the end of which component A has a salvage value of \$60 and component B has a salvage value of \$40. Operating costs and other support costs are the same for either component. If 100 units of the product are to be manufactured, determine which component to use in the design of the product by comparing the life-cycle costs. Assume a 5% effective discount rate.

We are asked to choose between two component options on the basis of the lower total life cycle cost  $LCC$ .

## From the Ebeling text - Exercise 9.1

The time to repair a power generator is best described by the following probability density function

$$f(t) = \frac{t^2}{333} \quad 1 \leq t \leq 10$$

Determine the probability that a repair will be completed in 6 hr. What is the *MTTR*? What is the median time to repair.

The probability that a repair can be accomplished in 6 hr is  $P(T \leq 6) = F(6)$ , which is expressed as

$$F(t) = \int_1^t \frac{t^2}{333} dt = \frac{t^3}{3(333)} \Big|_1^t = \frac{t^3 - 1}{999}.$$

The requested value is then

$$F(6) = \frac{6^3 - 1}{999} = 0.215.$$

## From the Ebeling text - Exercise 10.4

An aircraft consists of the following subsystems having the reliability parameters shown

Subsystem	Failure Distribution	Parameters
Propulsion	Weibull	$\theta = 1000, \beta = 1.7$
Avionics	Exponential	$\lambda = 0.003$
Structures	Weibull	$\theta = 2000, \beta = 2.1$
Electrical	Weibull	$\theta = 870, \beta = 1.8$
Environmental	Exponential	$\lambda = 0.001$

A system *MTTR* of 5 hr based on the average number of failures over 50,000 hr of operation is desired. Allocate the *MTTR* to the above subsystems. Assume that a repair will restore the system to as good as new.

## From the Ebeling text - Exercise 11.5

A critical communications relay has a constant failure rate of 0.1 per day. Once it has failed, the mean time to repair is 2.5 days (the repair rate is constant).

- a. Compute the steady-state availability.
- b. Compute the interval availability over a 2-day mission (starting at time zero).
- c. What is the point-availability at the end of the 2 days?
- d. If two communications relays must operate in series, compute the availability in parts a - c.
- e. If the two communication relays operate in parallel, compute the availability in parts a - c.