

Predicted Availability & Reliability Formulas¹

	At a particular point in time (t)	During the time interval [t ₁ , t ₂]	During the time interval [t ₁ , t ₂] when t ₁ = 0 and t ₂ → ∞
Availability²	$A(t)_{sys} = \left[\frac{\mu}{\lambda + \mu} + \frac{\lambda}{\lambda + \mu} e^{-(\lambda + \mu)t} \right]^N$ <p>This is referred to as “point availability.”</p>	$A(t_1, t_2)_{sys} = \left[\frac{\mu}{\lambda + \mu} + \frac{\lambda}{(\lambda + \mu)^2 (t_2 - t_1)} [e^{-(\lambda + \mu)t_1} - e^{-(\lambda + \mu)t_2}] \right]^N$ <p>This is point availability averaged over the time interval from t₁ to t₂.</p>	$A_{inherent-sys} = \left[\frac{\mu}{\lambda + \mu} \right]^N$ $= \left[\frac{MTBF}{MTBF + MTTR} \right]^N$
Reliability³ (Availability = Reliability when μ = 0)	NA	$R(t_2 t_1)_{sys} = [e^{-(\lambda)(\Delta t)}]^N = e^{-N\lambda\Delta t}$ where Δt = t ₂ - t ₁ , or written as: $R(t)_{sys} = [e^{-\lambda t}]^N = e^{-N\lambda t}$ when t ₁ = 0 and t ₂ = t.	$R(t_2 t_1) \rightarrow 0$ as $t_2 \rightarrow \infty$
Probability of r or less events⁴	NA	$P = \sum_{n=0}^r \frac{e^{-N\lambda t} (N\lambda t)^n}{n!}$ where t is from 0 to t.	$P \rightarrow 0$ as $t_2 \rightarrow \infty$
Probability of element cycle time is more than c time units⁵	NA	$G(c) = \frac{\mu e^{-\lambda c} - \lambda e^{-\mu c}}{\mu - \lambda}$ where c is the lower bound for predicted time for element operation, failure, and repair.	$G(c) \rightarrow 0$ as $c \rightarrow \infty$

Notes:

- 1 - **Nomenclature:** **N** is the number of elements in a series configuration; **MTBF** is element mean time between failure; **MTTR** is element mean time to repair; **λ** = 1/MTBF; **μ** = 1/MTTR; **t** is mission time; and **c** is cycle time. **Notes:** λ and μ are constant rates over time (thus, the exponential distribution models the failure and repair distributions). λ, μ, t, and c have the same unit of time (e.g., hours). For design purposes, MTBF is a lower-bound parameter and MTTR is an upper-bound parameter.
- 2 - **A** is Availability, the probability of mission readiness at a particular point in time or during a time interval from t₁ to t₂. Steady-State Availability is asymptotic as t → ∞. Inherent Availability, a type of Steady-State Availability, occurs at the 6th decimal place when (λ+μ)t is approximately 10 or more.
- 3 - **R** is Reliability, the probability of no failures during a time interval from t₁ to t₂. R is 0.3679 or less when Nλt is 1.0 or more. The notation R(t₂ | t₁) means the “reliability from t₁ to t₂ given the system has operated during the time interval from 0 to t₁ with no failures.”
- 4 - **P** is the probability of r or less number of events (e.g., failures, repairs, etc) during the time period from 0 to t. This probability is determined by the cumulative Poisson distribution. The Poisson process assumes failures are immediately repaired or replaced—thus, there is no accounting for repair time.
- 5 - **G** is the probability that element (not system) cycle time is more than c time units in length. Cycle time, a convolution, accounts for element operation, failure, and repair.