



# ASQ CRE Prep course

Lesson IV. A. 2. c.

Reliability Block Diagrams  
and Models – Redundancy



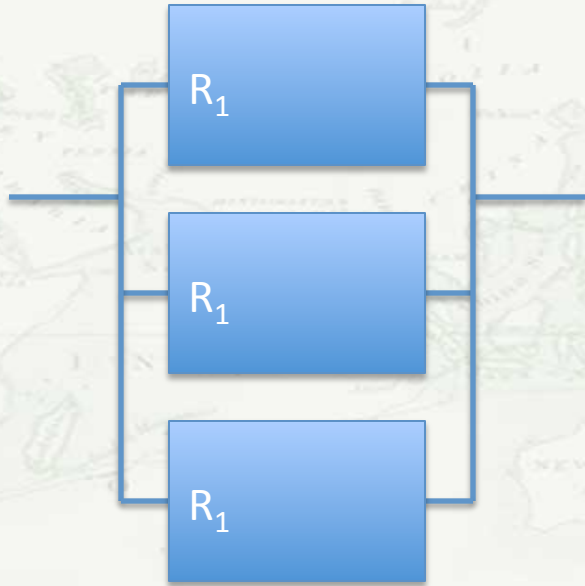
A photograph of a dense forest of evergreen trees heavily laden with snow. The trees are dark green, and the snow is a bright white, creating a high-contrast scene. The sky is a clear, pale blue. The trees are packed closely together, and their branches are covered in thick snow. The overall atmosphere is cold and serene.

Not fully redundant, fully

# RELIABILITY BLOCK DIAGRAM MORE THAN PARALLEL

# Other Types of Parallel

## k-out-of-n

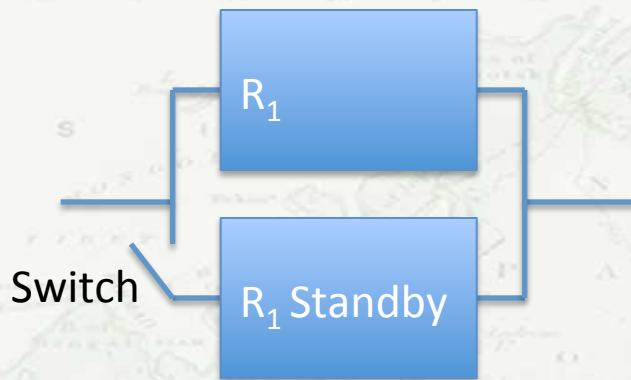


$$R_{system} = \sum_{i=k}^n \frac{n!}{i!(n-i)!} (e^{-\lambda t})^i (1 - e^{-\lambda t})^{(n-i)}$$



# Standby Redundancy

## Equal Failure Rates Perfect Switching

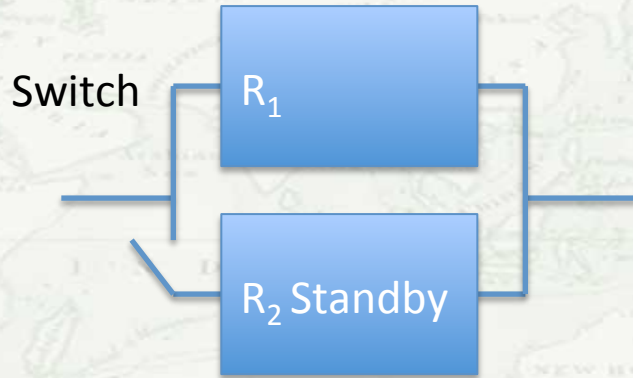


$$R(t) = e^{-\lambda t} (1 + \lambda t)$$

$$R(t) = e^{-\lambda t} \sum_{i=0}^{n-1} \frac{(\lambda t)^i}{i!}$$

# Standby Redundancy

## Unequal Failure Rates Perfect Switching

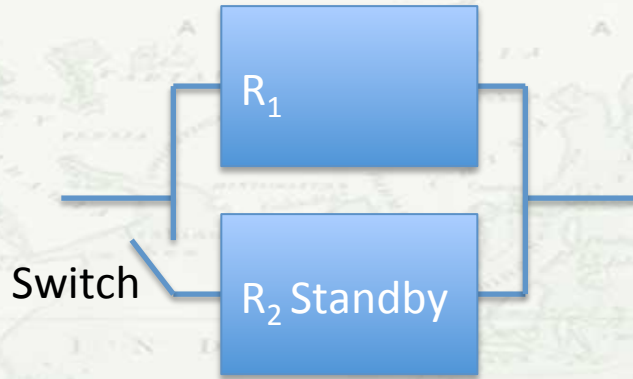


$$R(t) = e^{-\lambda_1 t} + \frac{\lambda_1}{\lambda_2 - \lambda_1} (e^{-\lambda_1 t} - e^{-\lambda_2 t})$$

$$R(t) = \sum_{i=1}^n \left[ e^{-\lambda_i t} \left( \sum_{\substack{j=1 \\ j \neq i}}^n \frac{\lambda_j}{\lambda_j - \lambda_i} \right) \right]$$

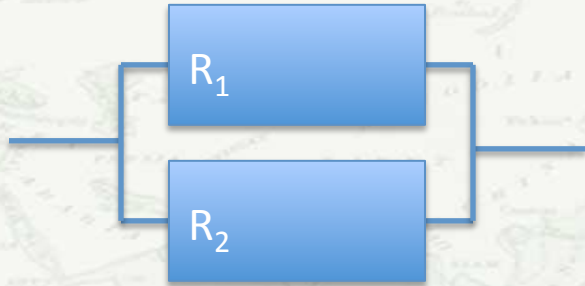
# Standby Redundancy

## Unequal Failure Rates Imperfect Switching



$$R(t) = e^{-\lambda_1 t} + R_{sw} \frac{\lambda_1}{\lambda_2 - \lambda_1} (e^{-\lambda_1 t} - e^{-\lambda_2 t})$$

# Shared Load Between 2 Elements



$$R(t) = e^{-2\lambda_1 t} + \frac{2\lambda_1}{2\lambda_1 - \lambda_2} (e^{-\lambda_2 t} - e^{-2\lambda_1 t})$$

Sometimes the  
switch is the  
problem





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Lesson IV. A. 2. d.

Reliability Block Diagrams  
and Models – Complex