



# **Developing a Testable Reliability Requirement for F-15E Radar Modernization Program (RMP) IOT&E**

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# Testable Requirements



- **Testable requirements must be**
  - **Realistic**
  - **Measurable**
  - **Possible to evaluate**
- **Sometimes requirements are stated as a future need**
  - **We can't evaluate to a point in the future**
  - **The decision authority must decide now if the system should be acquired**
- **AFI 10-601**
  - **“If the production threshold value is planned to be achieved following completion of IOT&E, include a testable value to be achieved/demonstrated for evaluation during the IOT&E.”**



# Why Reliability Growth?



- **Reliability is the ability of a system to perform required functions for a specified period of time**
  - Ex: mean time between critical failures (MTBCF) for RMP
- **Reliability growth is an increase in system reliability as a result of corrective actions**
- **Time between IOT&E and when the system must demonstrate reliability allows for growth**
- **Reliability growth plans improve:**
  - Investment decisions
  - Operations and maintenance posturing
  - Assessment of progress over time



# Reliability Growth Models



- **Duane Model – 1964**
  - Logarithmic growth
  - Formalized “test, analyze, and fix” process
- **Crow-AMSAA Model – 1974**
  - Failures as a stochastic process
  - Allows for statistical evaluation of growth
- **MIL-HDBK-189 – 1981**
  - DoD-specific guidelines for planning
  - Yardsticks for assessing growth
- **Planning Model based on Projection Methodology – 2006**
  - Introduces parameters based on programmatic
  - Combines programmatic and statistics



# PM2 - Assumptions



- **The number of failure modes present in the system at the beginning of the time period is inherently unknown**
- **Individual failure mode occurrences are independent of all other failure mode occurrences**
- **System usage and environment can be predicted throughout the reliability growth cycle**
- **Failures follow a nonhomogenous Poisson process**
  - **For a defined period of time, a certain number of failures are expected**
  - **Failures can happen at any time**
  - **Time between failures is independent**
  - **As reliability improves, the failure rate decreases**



# PM2 – Parameters



- **Define:**

- **What is the required end-state of the system?**
  - **$M_G$ : goal reliability**
- **What proportion of fixes can you make?**
  - **MS: management strategy**
- **How effective will implemented fixes be?**
  - **FEF: fix effectiveness factor**
- **What is the best possible state the system can achieve?**
  - **K: ratio of goal reliability to growth potential reliability**
- **How much operating time will the system accumulate?**
  - **T: total time**



# PM2 – Under the Hood



- **Determine:**

- $M_I$ : The initial reliability that enables reaching  $M_G$

$$M_I \geq (1 - \text{FEF} * \text{MS}) * \frac{M_G}{K}$$

- $\beta$ : The planning curve shape parameter

$$\beta = \frac{1}{T} \left( \frac{1 - \frac{M_I}{M_G}}{\text{MS} * \text{FEF} - \left(1 - \frac{M_I}{M_G}\right)} \right)$$

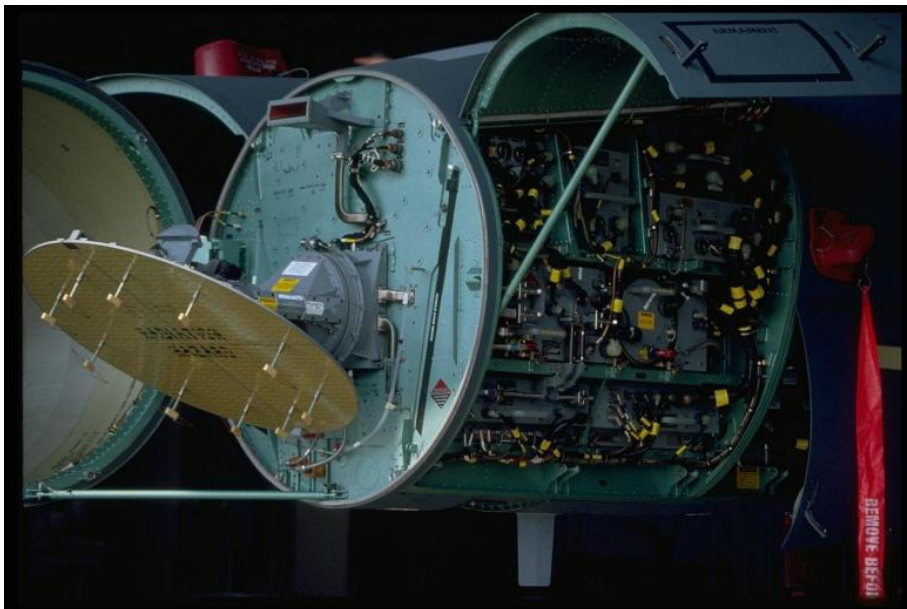
- $M(t)$ : The expected reliability, in terms of cumulative time

$$M(t) = \frac{M_I(1 + \beta * t)}{1 + \beta * t * (1 - \text{MS} * \text{FEF})}$$





# F-15E RMP Example





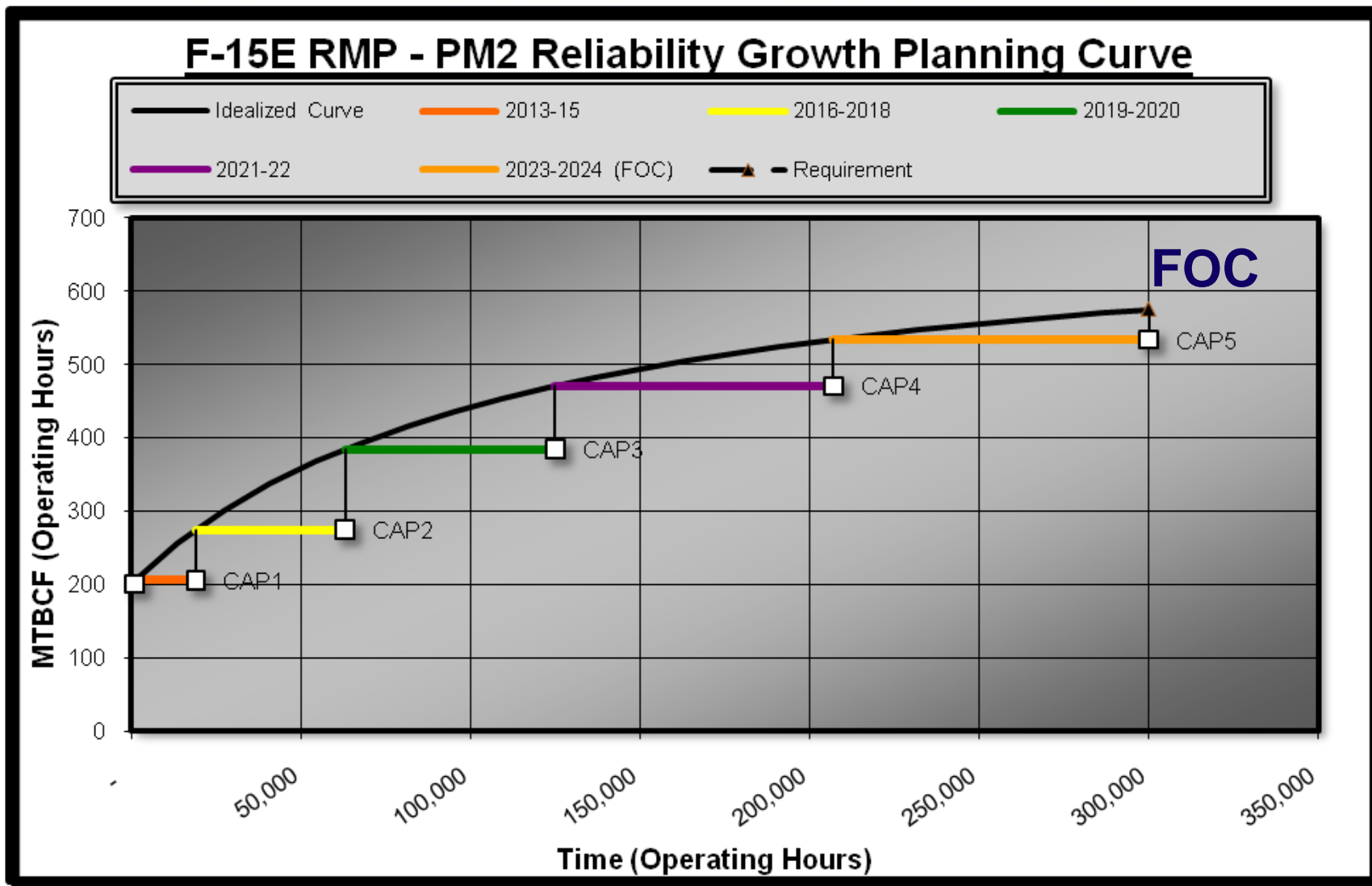
# F-15E RMP Example



- Key performance parameter: radar MTBCF of 575 operating hours at full operational capability (FOC)
- 12-year gap between IOT&E and FOC
- 5 jets/1200 hours for IOT&E
- Parameters
  - $M_G = 575$  operating hours
  - $MS = 0.9$
  - $FEF = 0.8$
  - $K = 0.8$
  - $T = 300K$  operating hours
- $M_I \sim 200$  operating hours



# RMP Growth Curve





# Conclusions



- **Creating a reliability growth plan allows improved:**
  - User planning for manpower and sustainment
  - Program office programming and budgeting activities
  - Test team evaluation of realistic and measurable metrics
  - System performance assessment in a transparent and objective manner
- **The earlier the planning process takes place, the better**
- **Using rigorous statistical methods provides:**
  - Credible and defensible results
  - Powerful techniques to assess progress
  - Quick “what-if” analysis



# Questions





# References



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