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

1st Lt Andrew J. Passey

AFOTEC Detachment 6

(702) 404-4120

andrew.passey@nellis.af.mil

Release Date: 15 Mar 11

Overview

- Testable Requirements
- Why Reliability Growth?
- Reliability Growth Models
- PM2 – Assumptions
- PM2 – Parameters
- PM2 – Under the Hood
- F-15E Radar Modernization Program (RMP) Example
- Conclusions

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 programmatics
  - Combines programmatics 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**

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

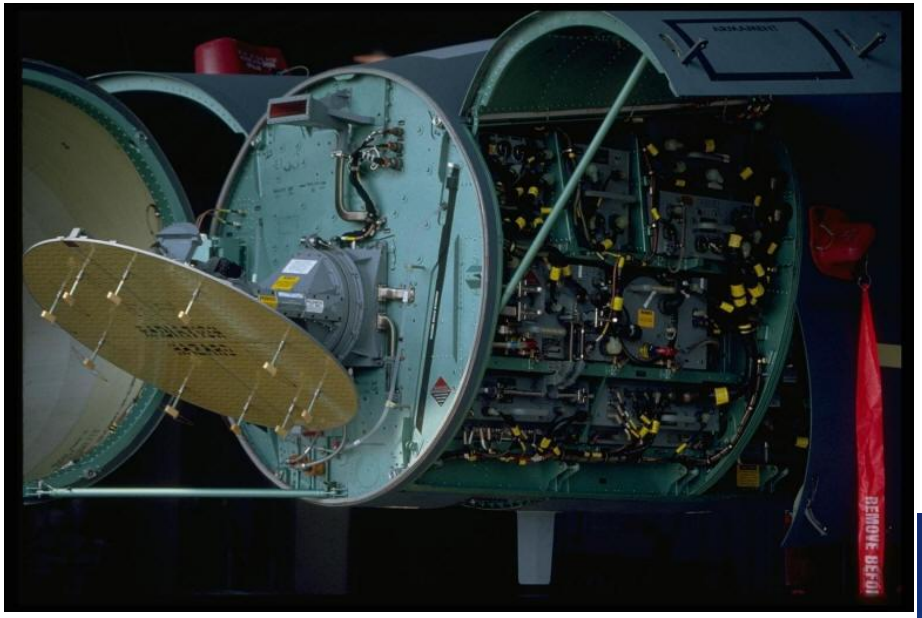
  - **β: The planning curve shape parameter**

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

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

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

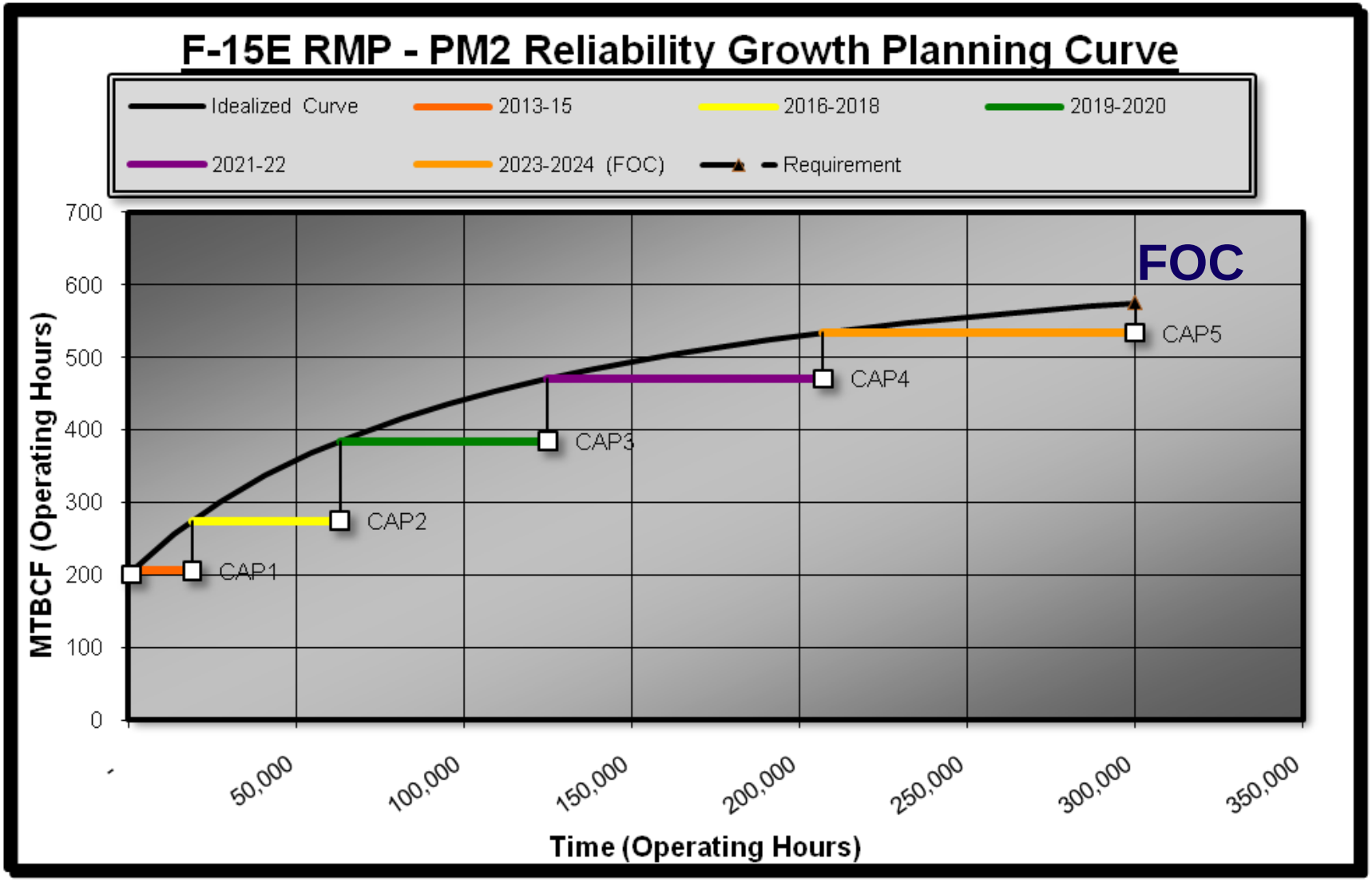
F-15E RMP Example



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 ~ 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

- Air Force Instruction 10-601 (July 2010). *Operational Capability Requirements Development*. Washington, DC: HQ USAF.
- Army Evaluation Center/AMSAA (29 June – 1 July 2010). *Reliability Short Course.* Nellis AFB, NV: AFOTEC Detachment 6.
- Ellner, P. M. and Hall, B. J. (May 2006). AMSAA Technical Report No. TR-2006-9, *"Planning Model Based on Projection Methodology (PM2)."* Aberdeen Proving Grounds, MD: AMSAA.
- F-15E RMP SPO (February 2007). *Capability Development Document*. WPAFB, OH: AFMC/WWQE. (Original document is classified).
- Wackerly, D. D., Mendenhall III, W., & Schaeffer R. L. (2008). *Mathematical Statistics with Applications, 7th Edition*. Belmont, CA: Thomson Higher Education.