Presented to:

RAM X Training Summit

RAM Model and Simulation of U.S. Army Aviation Fleet

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Overview

- **Challenge**
  - **No in house model available in RAM**
  - **Existing models are built from top down**
    - Makes broad assumptions about individual part performance
    - Does not allow for precise what-if analysis
- **Benefit**
  - **Quick, detailed, accurate What-If analysis**
    - Accurately predict effect of part or maintenance improvements
  - **Holistic understanding of part reliability on fleet readiness**
  - **Improved mission planning**
  - **Completely customizable to desired metrics**
- **Approach**
  - **Probabilistic model of individual part reliability**
    - **Dynamically query part history for greatest accuracy and timeliness**
  - **Stochastic simulation of aircraft and fleet**
    - **Account for maintenance practices**
    - **Predict aircraft and fleet availability for specific mission parameters**
  - **Developed in the R programming language**
    - **100% in house, no proprietary software**
    - **The free open source R programming language**
- **Market**
  - **PM Fleet Management, Improvement project justification, system upgrade projections**

Primary data sources

- CAST
  - DA2410 - Component history (installation, removal, repair, overhaul)
  - LCF – System of record for part information
- ASAP
  - Maintenance downtime estimates based on repair
  - Opportunistic maintenance items
  - Component life estimates for non 2410 tracked items
- Rimfire
  - More accurate removal reason and failure mechanism for select parts

Model (reliability)

- Built from historic maintenance records
  - DA2410 via CAST for tracked items
  - ASAP when possible for non-tracked items
- Distribution is fit for each PN – Probability of removal vs. Flight Hours
  - Uses entire history for that PN
    - If sample sizes are too small, combine multiple PNs for the same WUC
  - Causable vs. Non-causable
    - Data is not true failure data, it is removal data, this obfuscates the 'why'
    - User will be provided a few choices on how removals are classified
    - Data will be considered censored or non-censored based on the classification

Model (reliability)

- Tail Number Specific Reliability Assessment
  - Live database connection allows for up to date data
    - Aircraft configuration – no two are identical
    - Near current hours on each part
  - Current data in conjunction with reliability function for each part yields up to date reliability assessment
    - Sub-systems, entire aircraft, unit, entire fleet
    - Very little component redundancy from a reliability perspective, simplifies roll up
- Stretch goals
  - Automatically select the best distribution to use
    - Model will compare goodness-of-fit metrics and select the appropriate distribution
  - Model individual removal reasons for parts

Simulation (Availability and Maintainability)

- For each iteration
  1. Start with current configuration and current flight hours on each part (initial conditions)
  2. Step forward in time – add step interval T to flight hours on each part
  3. Calculate reliability at new time for each part
  4. For each part compare updated reliability to random number to determine if part 'failed'
     - If the part did not 'fail' continue to step forward in time
     - If the part did 'fail'
       1. Reset the hours on that part to zero
       2. Add the likely downtime for that part to the downtime table
       3. Continue to step forward in time
  5. Continue to step forward in time until the desired simulated time is reached, this concludes one iteration
- Iterate a sufficient number of times based on the number of variables and computation time

$$\boldsymbol{t} = t_{i,j} = \begin{cases} t_{i-1,j} + T, & R_j\left(t_{i-1,j}\right) \geq U_{i-1,j} \\ 0, & R_j\left(t_{i-1,j}\right) < U_{i-1,j} \end{cases}$$

	0	1	2	3
Part 1	100	110	120	0
Part 2	50	60	0	10
Part 3	250	260	270	280

$$\boldsymbol{D} = D_{i,j} = \begin{cases} d_j, & R_j\left(t_{i-1,j}\right) \geq U_{i-1,j} \\ 0, & R_j\left(t_{i-1,j}\right) < U_{i-1,j} \end{cases}$$

	0	1	2	3
Part 1	0	0	0	48
Part 2	0	0	4	0
Part 3	0	0	0	0

Simulation (Availability and Maintainability)

- The simulation outputs a population equal to the number of iterations for each:
  - Accrued downtime over the simulated time
    - Availability
    - Total downtime
  - Components replaced
    - Identify problem components
    - Over the simulation time which parts are most likely to need replacement for that tail number
  - Reliability over time

Summary

- Live connection to data sources
  - Built for continuously changing data
  - Tail number specific analysis
- Model
  - Probabilistic reliability model for each part build from historic records
  - Specific reliability estimates for each part using current flight hours
  - Specific reliability estimates for each tail number using current flight hours and configuration
- Simulation
  - Predictive Monte Carlo simulation
  - Future availability estimates
  - Future downtime estimates
  - Components most likely to require replacement over time simulated

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