Surrogate Data for Risk Informed Decision Making

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Problem Statement and Introduction

- **Problem statement**: When no project specific test data is available and there is no historical data for the systems' individual parts – especially during early design phases, how can Reliability & Maintainability (R&M) engineers present helpful results to a project that aid in the Risk Informed Decision Making (RIDM) process?
- A lack of data can be present early in the design cycle or on single launch mission or missions using newer technology.
- Reliability input is crucial even when there is no data. It is up to us as R&M engineers to create and apply analysis. Surrogate Data allows us to do this.
- Topics
  - What
  - How
  - Why
  - Example

What is Surrogate Data

- Any sort of reliability data that is not direct test data for the system specific part.
  - MIL-HDBK-217, EPRD, NPRD, FMD, GIDEP reports, and many other sources can be applicable depending on your employer.
  - Heritage programs with similar systems.
  - Expert input from subsystem leads, e.g. Reach out to your avionics lead for insight into similar avionics card layouts/reliability data.
  - Program CAD physics models like 6DOF/Loads Analysis that are also based on surrogate data.

How to use Surrogate Data

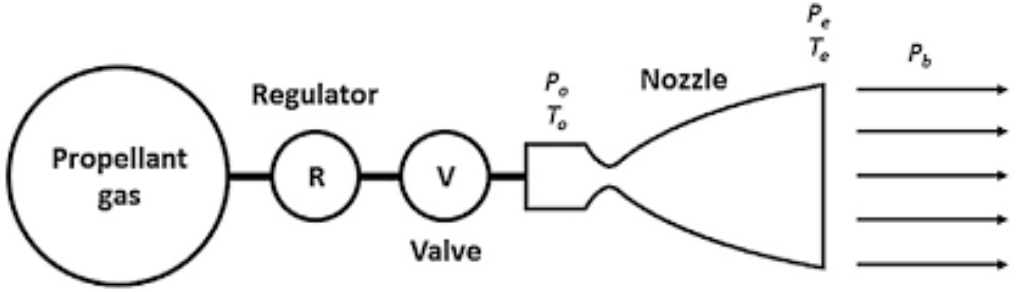
- Error factors
  - Use distributions instead of point estimates when applying surrogate data.
- Conservative estimates
  - Tend to the conservative side of any distributions and conflicting data.
- GR&A
  - Make it clear what stand in data you are using and why. Remember, the project trusts you to present on reliability, so your judgment on what data to use drives reliability.
- Get subsystem owners to review the way you have modeled their systems to make sure surrogate data is applicable.

Why use Surrogate Data

- Shortened schedule may not allow part testing.
- Early design phase trade studies may need reliability comparisons.
- Helps establish requirements and verification.
  - Reliability results can sometimes tell how likely a requirement is to be met using methods like PRA.
- Can help communicate risks to subsystem owners early on, so they know what to expect during middle phase risk analysis.
- Helps manage project management expectations.

Hypothetical

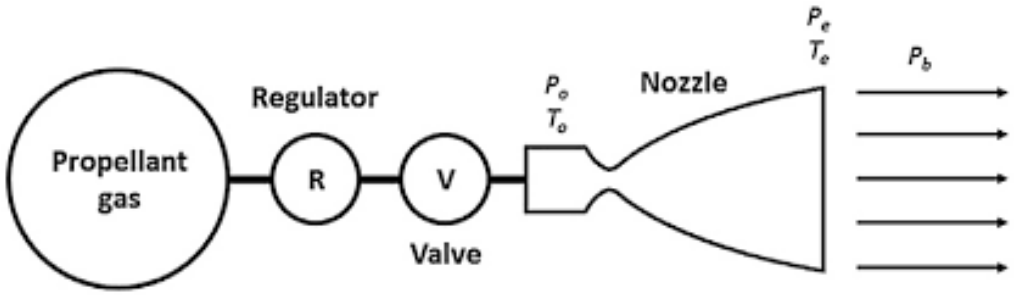
- Take a simple RCS system:



- Let's look at the valve
  - The program has no specific test data on the material of the valve you are using.
  - The program has used a similar RCS system in the past on a different project but not identical.
  - Use engineering judgment, expert input, and like component surrogate data to deduce how to model the valve.

Hypothetical Cont.

- Take a simple RCS system:



- Using Engineering judgment, you assign the valve 3 failure modes. A demand failure to open, a demand failure to close, and a rate leakage failure.
  - Work with your RCS lead to determine when these demand failures should be modeled.
- Looking at the past system, a demand failure rate to open/close of 5E-6 is found, then compare this to similar rates online and approve it and similarly use 4E-6 for the leakage failure rate.
  - It is later decided that the leakage rate should be more conservative after comparing to other database results, so it is adjusted using a normal distribution and setting 4E-6 as the 5^{th} percentile and 5E-6 as the 95^{th} percentile and end with a mean of around 4.5E-6. This makes the results worse but is worth switching if it is made clear how and why the switch was made in the notes and assumptions.
- Document the results and make sure to note as an assumption that the results are using surrogate data.

MAV example

- Shortened Program Timeline
  - Quick turnaround on trade study results and hardware updates.
  - Many design cycles in short time meant lots of project visibility.
  - Pre-PDR level, so reliability normally would just be starting, but instead was able to aid in design decisions by use of surrogate data.
- Make clear GR&A to establish where certain surrogate data came from.
  - Ex. For a certain TVC part, SLS failure rate data and modes were used despite not being identical part.
  - Setting the scene helps everyone understand the fidelity of your results.
- Developed products in tandem that normally would happen separately.
  - FMEA and FTA/PRA were developed at the same time rather than having FMEA as a source for FTA. This was due to shortened timeline and required using failure modes from other hardware tests and engineering judgment rather than testing.