OSMA R & M Enterprise Data Sharing Survey Report

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Introduction

"At the intersection of mission, technology, and place is NASA's need to modernize for a digital-forward future. Digitalization, the process of moving toward digital business, is occurring everywhere and remains an ongoing process across the federal government."[1] Whereas, Digital Transformation is "employing digitization/digital technologies (e.g., Artificial Intelligence (AI), mobile, cloud, data) to change a process, product, or capability so dramatically (e.g., real-time, intelligent, personalized, anywhere, anytime) that it is unrecognizable compared to its traditional form." [2] In order to facilitate a digital transformation it is essential for NASA to understand and identify where data exists today and which data are value-needed in the future, understand where there are unfulfilled data needs that limit the advancement of NASA work, and ensure NASA efficiency through Findable, Accessible, Interoperable, and Reusable (FAIR) digital assets in the future.

Therefore, NASA's Reliability & Maintainability (R&M) Enterprise Data Sharing team is working to leverage both Digitization and Digital Transformation to achieve their vision of developing an R&M data discovery framework that enables our community, our partners, and our stakeholders with the ability to efficiently, robustly, and seamlessly access information that enables real-time knowledge and model-based, analytics driven, decision-making impacting R&M.[3] As a result the R&M Enterprise Data Sharing team: Laurel Dye (GRC), Timothy Adams (KSC), Roger Boyer (JSC), Richard Stutts (MSFC), Warren Grant (JSC), Bruce Reistle (JSC), Matthew Williamson (GRC), Steven Cornford (JPL), Christine Kilmer (GRC), Edward Zampino (GRC), Teri Hamlin (JSC), Todd Paulos (JPL), Irene Wirkus (GRC), and Warren Grant (JSC), working in coordination with the NASA R&M Technical Fellow (Anthony Diventi), Deputy Technical Fellow (Nancy Lindsey), and NASA Safety Center (NSC), has conducted a survey of its Reliability, Maintainability, and Availability (RMA) community members to identify data existence (created or used) and where there are corresponding barriers to data acquisition and/or R&M or other issues as its Phase 1 efforts.

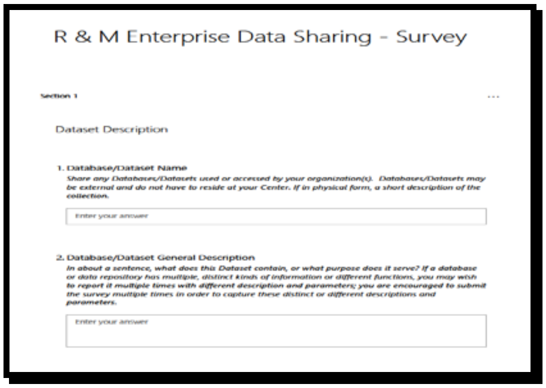
The intent of this report is to summarize the results of that R&M survey, *R & M Enterprise Data Sharing - Survey*, as well as to provide insights and corresponding recommendations for future work needed to address data sharing, data mining, and barrier mitigation opportunities.

Discussion

I. Survey

The *R & M Enterprise Data Sharing - Survey* focused on determining what and how data sets were created, used, and referenced by Reliability, Maintainability, and Availability (RMA) teams across NASA. This was done by asking the questions (multiple choice and fill-in) shown in the Figure 1 embedded file, which were intended to draw out not only data lists but the barriers to performing specific analyses and the depth and breadth of each data set. The respondents encompassed Armstrong Flight Research Center (AFRC), Ames Research Center (ARC), Glenn Research

Center (GRC), Goddard Space Flight Center (GSFC), Johnson Space Center (JSC), Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC), Stennis Space Center (SSC), and Jet Propulsion Laboratory (JPL) as shown in Figure 2. While respondents provided the data requested there were follow-up interviews to clarify and gather additional data for interpreting results for further action.


R & M Enterprise Data Sharing - Survey

Section 1

Dataset Description

1. Database/Dataset Name

Share any Databases/Datasets used or accessed by your organization(s). Databases/Datasets may be external and do not have to reside at your Center. If in physical form, a short description of the collection.

Enter your answer

2. Database/Dataset General Description

In about a sentence, what does this Dataset contain, or what purpose does it serve? If a database or data repository has multiple, distinct kinds of information or different functions, you may wish to report it multiple times with different description and parameters; you are encouraged to submit the survey multiple times in order to capture these distinct or different descriptions and parameters.

Enter your answer

Figure 1: R&M Data Survey Questionnaire (embedded pdf)

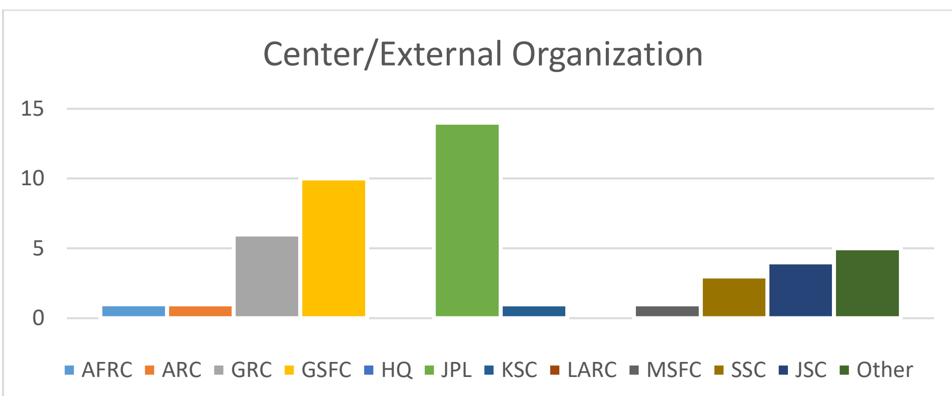


Figure 2: Responses by Center

(“Other” indicates at another NASA location other than AFRC, ARC, GRC, GSFC, HQ, JPL, KSC, LARC, MSFC, SSC, or JSC; or a non-NASA center location such as a supplier/vendor.)

II. Results

R&M survey results indicated that RMA efforts across NASA are dependent on a variety of raw data (see Figure 3) but generally start early in the mission life cycle (See Figure 7) and tend to wane prematurely in later lifecycle phases. Further, it was seen that the breadth of data types used by RMA practitioners is extensive, while the depth of data may be limited since the survey results show more dispersed and inferred data than comprehensive or limited raw data usage (see Figure 3).

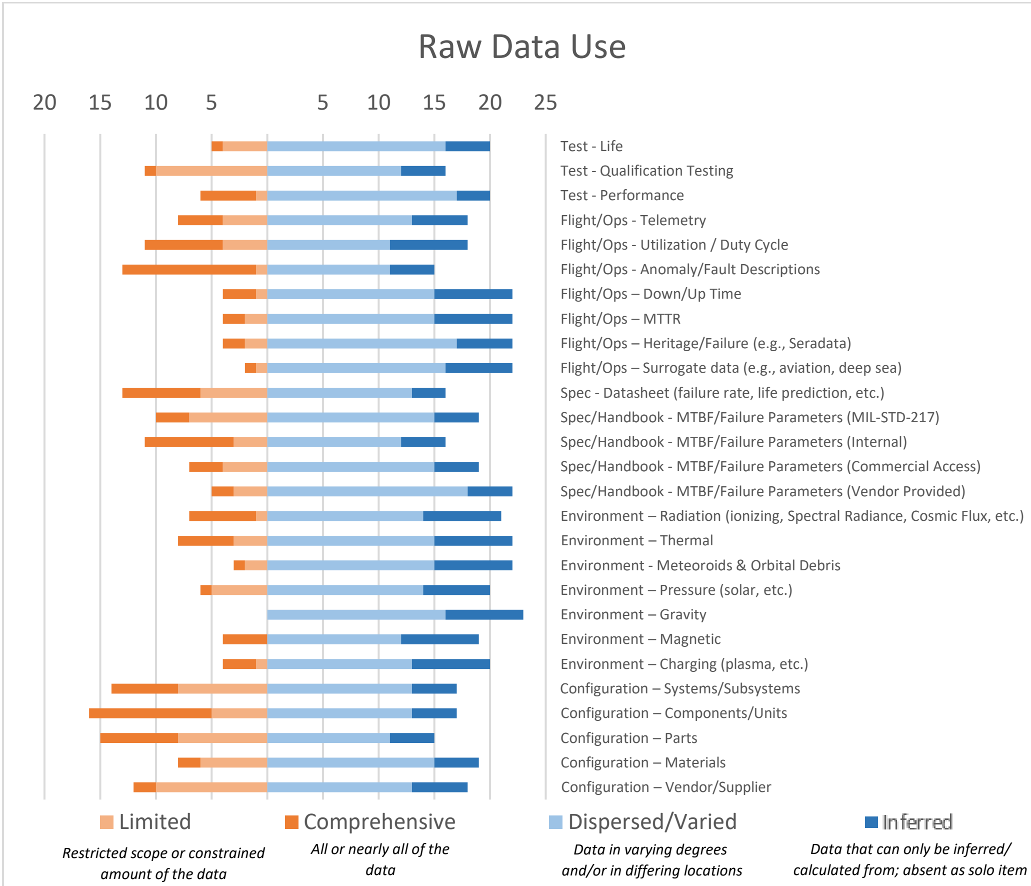


Figure 3: Raw Data Usage

R&M survey results (see Figure 4) also indicate that RMA teams create data in the form of analyses. It is assumed that the variation in analysis content across the respondents is based on mission needs. In particular, the survey results seems to indicate that maintainability and availability analyses are not being performed in a formal or deterministic sense, but more in a collateral manner as recommendation from other analyses. Conversely, responses seem show that life, stress, and trade studies are predominantly being performed deterministically, whereas the amount of inferred content in analyses indicated in the survey (dark blue lines on Figure 4) seems to show that traditional RMA analysis techniques (Failure Modes and Effects Analysis (FMEA/FMECA), Fault Tree Analysis (FTA), Probabilistic Risk Assessment (PRA)) are not being uniformly applied. For example, the survey shows that some respondents' analyses are only inferring failure modes, effects, and causes. That likely implies that traditional Failure Modes and Effects techniques are not necessarily being applied. However, all of the technique indications will need further investigation to identify the true limitation to employing traditional RMA techniques.

Taking a deeper look, failure probability and failure rate derivation survey results (See Bayesian, Statistics, and modeling line items of Figure 4) are showing abundant use of modeling and statistical analysis, but the use of handbook data is still dominating RMA models/analyses. In deriving the probability of any cause (e.g., stress, physics, radiation) of a failure incident, models and statistical methods are normally used. Therefore it is assumed that RMA teams are only relying on handbook data out of necessity due to lack of data, guidance, direction, or support. This assumption will need to be confirmed with further investigation in order to reduce barriers to failure probability and failure rate derivation and sharing.

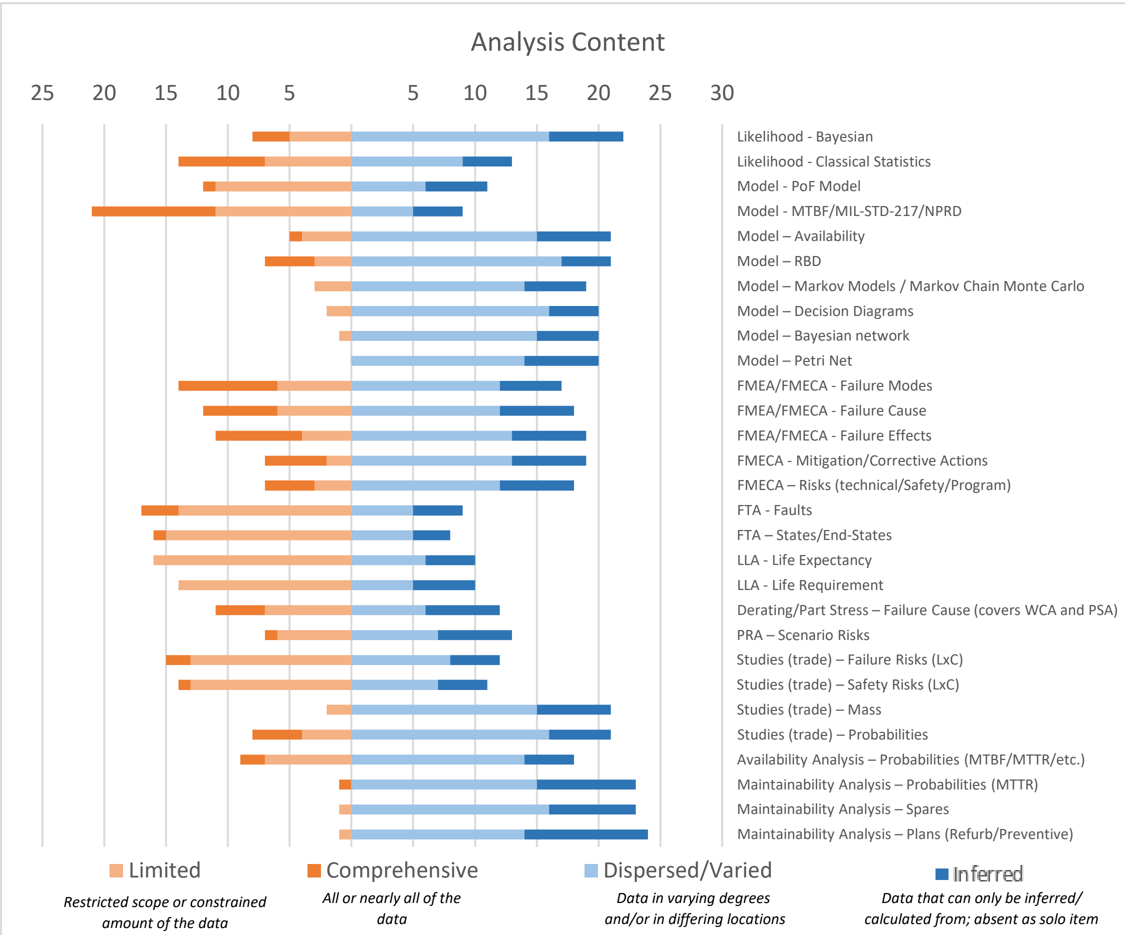


Figure 4: Analysis Types and Contents

These variations and limitations have not stopped NASA teams from employing these data to support NASA missions through their application to a wide variety of analysis and support efforts (See Figure 5). But survey results indicate that there may be additional opportunities to use either the raw data (shown in Figure 3) or created data (i.e., analyses – shown in Figure 4) for additional NASA endeavors and increase the use of data, especially RMA analyses, collaboratively. While survey results indicate that logistics, failure analysis, and risk assessment are well supported by the RMA data sets, there are only a few ($\leq$ 5) data sets being used to support de-orbit/extended mission, life expectancy, readiness, testing, and cyber risk. This seems to imply either a lack of understanding of the potential use/value of the data, a lack of timeliness or accuracy of the data, or a lack of access/findability to the data.

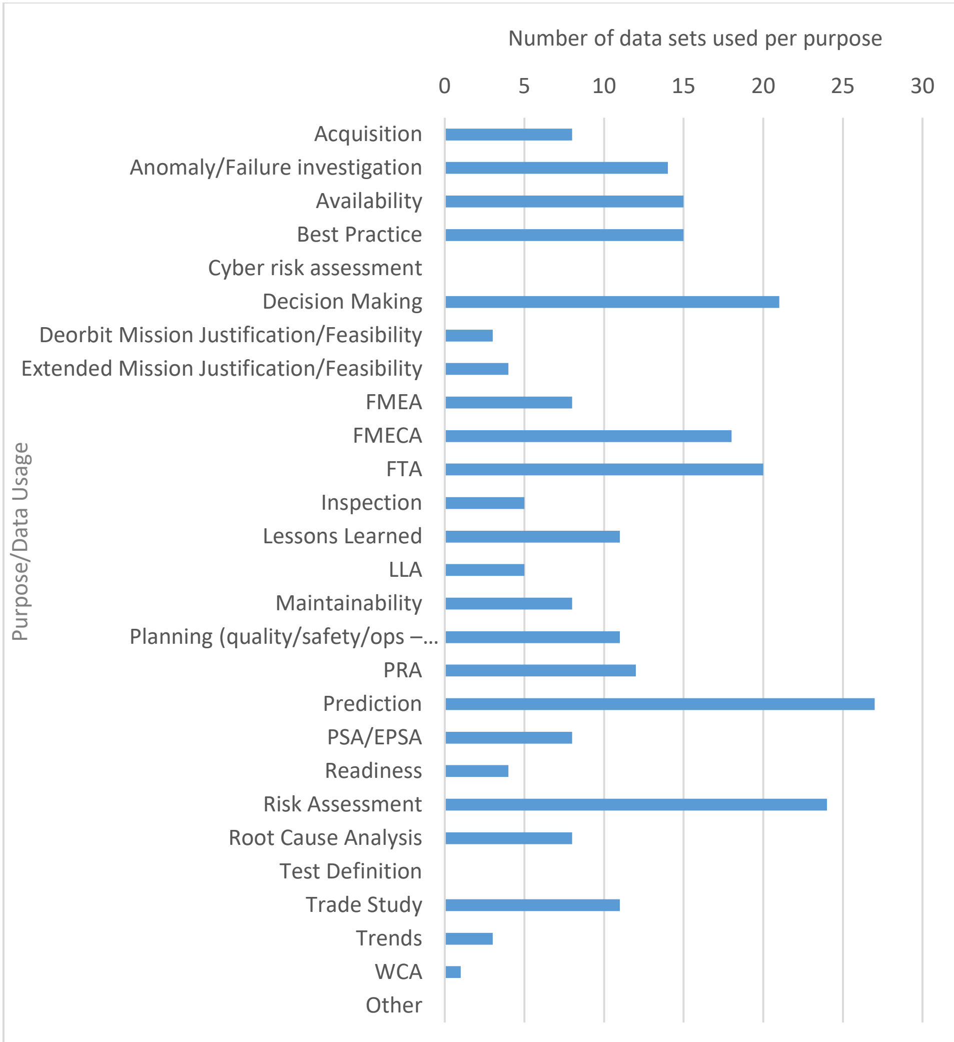


Figure 5: Data Usage

However, collaborative use of RMA data is dependent on if the data is FAIR - Findable, Accessible, Interoperable, and Reusable. Findable data (created or used) must be discoverable through inherent knowledge of its existence or through standard searching processes. The results of this survey show that the majority of the data is either with individuals or within center/ program internal systems and repositories. Therefore, RMA data findability will need to depend on knowledge of its existence. Individual centers could gain this knowledge if the survey data (Attached) and/or this report are shared via R&M Technical Discipline Team (TDT). Once the RMA data is findable by RMA teams across NASA, it will require access for use. Accessibility may be another issue since survey and interview responses indicated that the data is kept in a manner that will need program/project approval for sharing inside or outside of the source program/ project. This access challenge will need understanding of access purposes well beyond the RMA community and may need TDT or Office of Safety and Mission Assurance (OSMA) advocacy to solve. Further, all data users (internal to the prject/program and across NASA) must also remain cognizant of when the data is available from or in regard to any program/project, which is at PDR or at non-NASA-project-life-cycle times for most teams (see Figure 7).

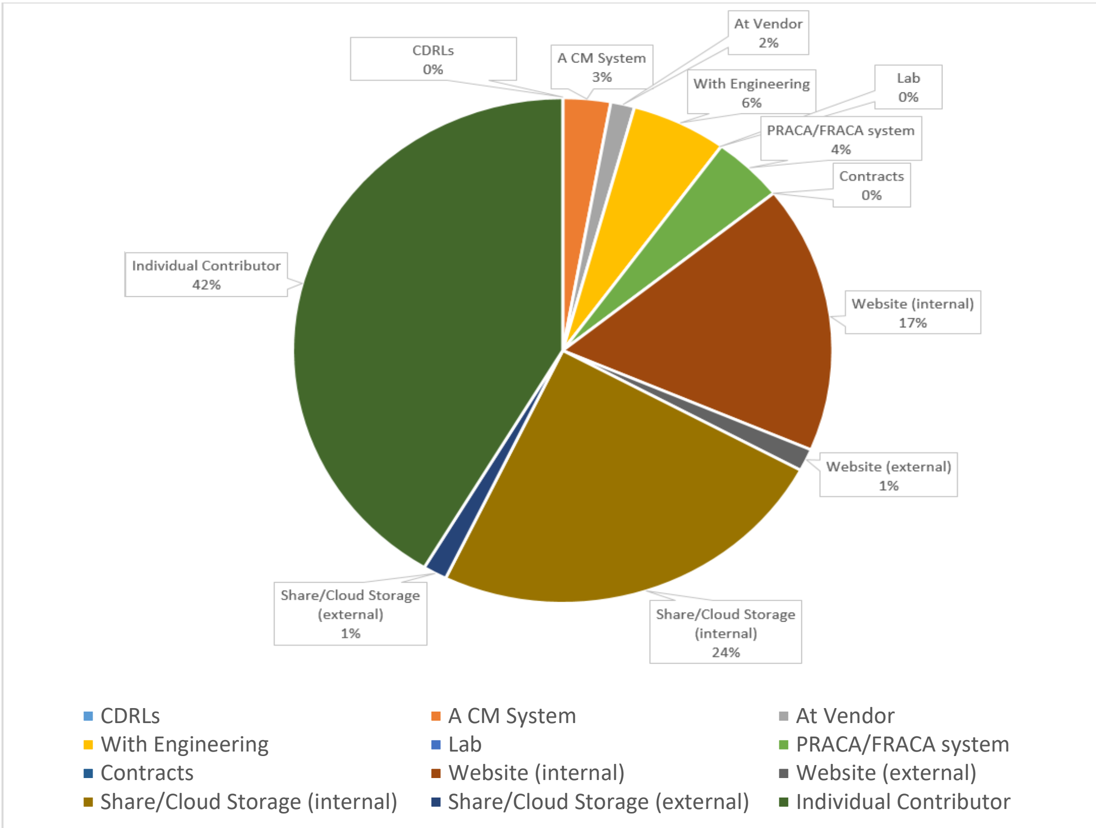


Figure 6: Data Location

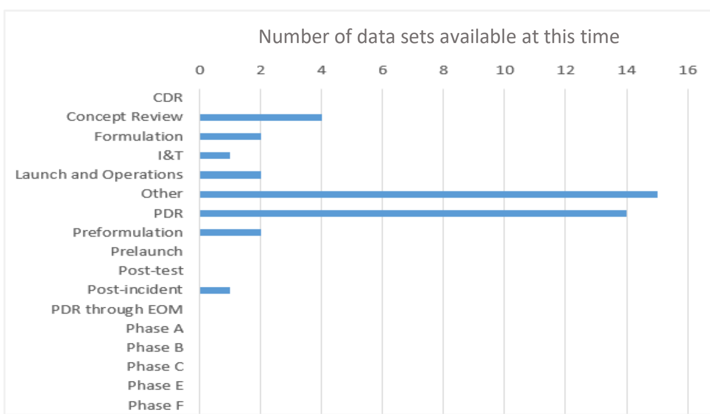


Figure 7: Data Timing

While the survey results indicate that data created and used in analyses, across the gamut of configuration item types (Figure 8), is used to support life, failure, and safety risk assessment (Figure 4), they also show that the majority of the data sets are very project/program specific (see attached survey data set descriptions). Therefore, the applicability of many data sets across NASA may be limited, while the generic part/component data sets (e.g., Non-electronic Parts Reliability Data (NPRD), Electronic Parts Reliability Data (EPRD), GRADS (Generic Risk Analysis Data Set), Failure Interrogation and Analysis Tool (FIAT) Data) may be able to be further utilized across all of NASA today. However, with sufficient data mining, structuring, and packaging, data users across NASA (e.g., RMA teams or Systems Engineers or Project/ Program Mangers) may be able to use/understand and exchange/share (Data Interoperability) each other's project/program-specific data and expand generic data to support future/current missions as well as exchange/share reference libraries or dictionaries and model development for data/knowledge reuse (reusability).

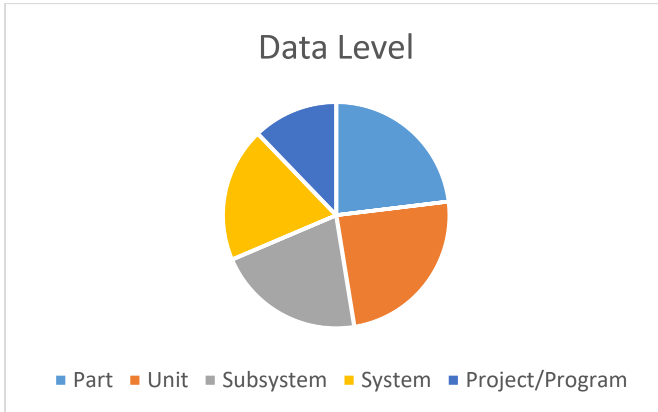


Figure 8: Data Across Configuration Types

While the results of the survey will help formulate the NASA RMA community's digital transformation path forward, the survey itself should not be considered a comprehensive depiction of the entirety of R&M data, since follow-up interviews identified that there are at least thirteen significant additional data sets that will need further investigation:

- AFRC Project and Centralized CM systems
- AMES Electrical Power Reliability Office dbase - https://dev qspress.ndc.nasa.gov:8443/EPRO/Frontpage.cfm
- AMES Pressure System dbase https://dev-qspress.ndc.nasa.gov:8443/General.cfm
- ORION/ISS Cross Program FMEA-CIL System - https://cxfmea-cil.nasa.gov/
- ORION/ISS Cross Program Hazard System - https://cxhazard.nasa.gov/home
- Code QS Document Management System (QSDMS) - https://qsdms.arc.nasa.gov/document/documents
- JSC Sharepoint - https://eisd.sp.jsc.nasa.gov/
- MARS - Mission Assurance Reporting System (KSC)
- MSFC Product/Project Data Management (Windchill) - https://nasa-ice.nasa.gov/windchill/
- KDDMS - Kennedy Design and Data Management System (Windchill) - https://kddms.ndc.nasa.gov/Windchill/app/
- KSC TIPS portal - https://adf-tosc.ksc.nasa.gov/TIPS/faces/home
- NASA Integrated Collaborative Environment (ICE/Windchill) - https://nasa-ice.nasa.gov/portal/
- NASA SMA Toolbox knowledge collection - https://nsc.nasa.gov/SMAToolbox/ui/search/default.aspx

Conclusion

The *R & M Enterprise Data Sharing - Survey* was successful in getting a preliminary snap-shot of the data created and used by the NASA RMA community. However, further research is needed into potential analysis barriers and the existence of additional data sets to develop a comprehensive strategy to maximize RMA digital transformation and project/program engagement. But data mining for data sharing that transcends ownership issues should be possible now.

Therefore the following recommendations are made for further efforts to realize each of the survey's goals:

Data Existence: Since it appears that there are additional repositories of data used by the RMA community, it is recommended that follow-up questionnaires be sent to the points-of-contact for the newly discovered data sets, as well as polling the community again to discover all the potential data for digital transition, sharing, and/or data mining.

Barriers: Since it appears that maintainability, availability, de-orbit/extended mission, life expectancy, readiness, testing, and cyber risk analyses are not being conducted commonly across NASA due to a lack of perceived value/need and/or funding, it is recommended that additional research into barriers be pursued to identify customer expectation/need gaps along with providing increased understanding of the value (e.g., failure risk assessment, anomaly triage/resolution, test planning/analysis, operations/maintenance planning, life limits, and sparing/redundancy/sensor optimization) of these analyses (and others) throughout project lifecycles, through customer discussion, training, and the planned R&M knowledge sharing portal.

In addition, while the survey did not specifically gather analysis tool information or usage, it became apparent in interviews and survey responses that there is a definite commonality in tool usage and that tool availability may cause analysis barriers as well. Currently each center must face the challenges of procuring/renewing each tool they use separately, which can create a resistance to tool acquisition and potentially create a barrier to analysis performance due to tool unavailability. Therefore, it is recommended that enterprise licensing of tools be assessed for feasibility. Note: additional data on each center's tool usage will need to be gathered/used to develop a final enterprise licensing plan.

Data Mining for Sharing: Since it was generally tolerable to most participants, based on interviews, to allow the mining of their data by a small team that would then develop a strategy to share globally applicable data, it is recommended that a catalogue of potential types of shareable data be formulated and a trial data mining effort be conducted. This trial effort is recommended to be the formulation of a digital Failure Mode Dictionary of commonly used items that can be shared with the TDT, on the R&M Portal, and incorporated into modeling tools and analyses. This would potentially increase the breadth and velocity for well-timed R&M artifacts to inform robust risk mitigation decisions and begin the transition of R&M from the as is digital state to a transitional digital state (see Figure 9). Note: the "Cross Program FMEA-CIL System" discovered in this survey effort may assist in this effort.

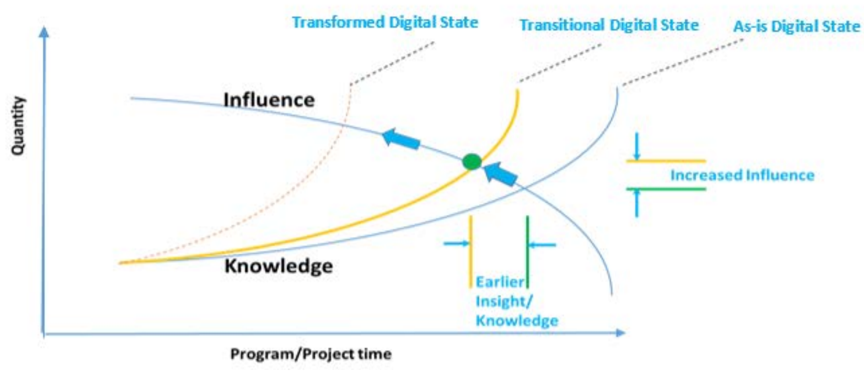


Figure 9: Digital Transformation Progression
More Timely Knowledge → More Influence → More Impact

The implementation of the above recommendations and continued R&M data/process innovation and improvement efforts, in close coordination with NASA's/SMA's data governance activities, will support NASA's digital transformation imperative and enable full utilization of RMA data and expertise across NASA.

Attachment

R & M Enterprise Data Sharing – Survey Data (embedded pdf)

References

[1] NASA blog on Future Work: Digital Transformation, Alicia Llewellyn, April 15 2019, https://blogs.nasa.gov/futureofwork/2019/04/15/digital-transformation/, Accessed 11/8/2020

[2] NASA OSMA/NSC SMA's DT101 Webinar, Tony DiVenti, November 3 2020, https://nsc.nasa.gov/events/detail/digital-transformation-101

[3] *Wilkinson, Mark D.; Dumontier, Michel; Aalbersberg, IJsbrand Jan; Appleton, Gabrielle; et al. (15 March 2016). "The FAIR Guiding Principles for scientific data management and stewardship".* Sci Data. 2016 Mar 15;3:160018. doi: 10.1038/sdata.2016.18. Erratum in: Sci Data. 2019 Mar 19;6(1):6. PMID: 26978244; PMCID: PMC4792175. https://pubmed.ncbi.nlm.nih.gov/26978244/