Small Satellite Industrial Base Study: An Overview and Interim Update

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Objectives of the Study

- Understand the types of EEEE (electrical, electronic, electromechanical, electro-optical) part requirements that are flowed to sub-tier suppliers from small satellite programs
  - *Gather data through interviews and data surveys*
  - *Exclude CubeSats*

- Examine similarities and differences between part selection and testing practices for emerging “mid-space” parts vs traditional space-grade parts
  - *Identify trends in the perceived “rush to the middle”*

- Determine potential effects on the larger space industrial base
  - *Enable use of alternate-grade parts without impacting the health of the space-grade supply chain*
  - *Reiterate that alternate-grade parts are not appropriate for some missions*

- Deliverable: Final Report
  - *Foundational findings to expand upon as a community*

Status

- Inputs collected from selected SmallSat Parts Suppliers, Subsystem Builders, Spacecraft Builders. Interviews with SmallSat procurers under way

- Coordinating with JPL, NASA/GSFC and leveraging other concurrent initiatives
  - *Small Satellite Reliability Initiative*
  - *Collaborations with academia*
  - *Feb 2019 Small Satellite Symposium insights*

- Compiling, analyzing, and formatting data. What are we trying to say?
  - *Need a way to effectively interpret and communicate the qualitative interview results*
  - *Determine what is the same and what is different about the mid-grade offerings*
  - *Identify themes and trends*
  - *Reiterate that alternate-grade parts are simply not options for some missions*

- Draft outline for final report prepared

Final Report – Draft Outline

- Executive Summary
- How the study was conducted
- Identify common themes in responses regarding
- Status of traditional satellite industrial base
- Recommendations for the Government and other SmallSat procurers
- Conclusion and Options for Future Work
- Appendix
  - *Interviewee responses in raw form (anonymized)*

SmallSat Piece Part Suppliers: Selected Interview Questions/Responses

- What data do you provide to customers for the various types of parts you supply and is there a cost for the data?
  - *Commercial product shipments receive no data. Standard Military grade product shipments receive QCI (Quality Conformance Inspection) attributes data. Aerospace product shipments receive an expanded C of C (Certificate of Compliance - with wafer lot & wafer no. ID) and a full data package is available for a purchase order upcharge. If required by the automotive customer, a PPAP (Production Part Approval Package) is generated documenting the product design, assembly and qualification*
  - *…no unit level or lot level data to any customer or market at this time. For space grade devices, a summary of processing attributes, 3rd Party DPA (Destructive Physical Analysis) report, and TID (Total Ionizing Dose)) test summary are provided… at no cost*

- What basic requirements do you see flowed down to you from the contractor (technical and quality)?
  - *We produce COTS devices, and as such we rarely accept additional flow downs that would modify our current processes or controls*
  - *That is dependent on the customer and application. It includes full MIL-PRF-38535 QML Class V, NASA PEM-INST-001, standard automotive, and commercial. In some cases radiation performance is specified.*

The comments expressed here are quotes from the Interviewees and do not represent the opinions of The Aerospace Corporation

SmallSat Sub-system Providers: Selected Interview Questions/Responses

- What available information and measures does your organization, subcontractors or vendors offer in lieu of the heritage management approach and military specifications?
  - *It is very customer-driven and relies on a detailed agreement between us and the customer to determine the system requirements….*
  - *Apart from space-grade suppliers, we base it on experience with the vendor …If the part is not available NOW for immediate delivery, we will likely not consider it, and strike it from our list of approved components.*

- How does your organization quantify or estimate reliability or risk?
  - *Reliability is estimated using MIL-HDBK-217 methods, for lack of a better option. Technical and programmatic risks are identified using a traditional 5x5 "Risk-impact Matrix", along with mitigation plans. Funding is allocated as appropriate to retire [risk] if possible.*
  - *We don't, apart from our selection process... Our 20+ years of flight heritage has shown that our approach yields very reliable and long-lived systems.*

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SmallSat Spacecraft / Launch Vehicle Builders: Selected Interview Questions/Responses

- How have you incorporated COTS EEE parts in your vehicle design?
  - *Our designs are milestone and cost driven. We have a very aggressive schedule to our first launch therefore we interrogate the use of EEE COTS hardware based on a). meeting performance requirements b). Cost c). heritage (where used) not focused on space heritage*

- *What standards do you often reference for inhouse builds or suppliers?*
  - *PEM – INST001, ECSS-QST-6013b, AEC-Q101*
  - *MIL-STD with lower assurance levels, NASA EEE-INST-002*

- What outside-the-box, agile measures can the gov't take to help the COTS community (i.e., manufacturers, providers and parts suppliers) adapt to new demands for satellite systems and services?
  - *Lots of luck on that. We have limited experience with COTS. Space is too small a buyer to have influence.*
  - *Develop a standard for what a "construction analysis" shall contain*
  - *Develop a standalone reliability document for automotive parts*

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Honorable Mention

- Certain DoD and NASA standards or test methods, e.g., those for electronic parts management and reliability assessments, are often referenced by the SmallSat community. Some standards need to be updated to reflect advanced technologies and mass production quality improvements achieved since the original documents were published. What approach would you take to do this?

  – *The notion that NASA or the DoD can match the reliability of consumer devices (e.g. 25,000,000 iPhones per quarter) at a reasonable cost is simply laughable. Instead, a combination of good design and using the latest, mass-produced consumer parts in industrial and automotive grades is the key to minimizing cost while piggybacking on a much larger market, and the quality performance of the suppliers in that market.*

  – *Need a better way to estimate reliability. …Utilize the methods of MIL-HDBK-217, but with the manufacturer's failure rate data. (Most COTS manufacturers develop failure rate estimates based upon life testing, and many of them publish the data). This method needs to be coupled with thermal management requirements, derating, and radiation testing programs.*

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Heatmap Visualization of Qualitative Findings

(Notional Practices and Data – for illustration purposes only)

Respondent / Practices Used	A	B	C	D	E	F
Standards Documents						
Qualification Screening, Derating, Reliability						
Insight into Supplier Processes						
Customer Insight Provided						
Top Priority	Cost & Sched	Capability	Cost & Sched	Resiliency	Capability	Cost

Strong	Moderate	Weak	Minimal

To make progress, industry requests…

- Signal from Gov't that COTS can be considered
  - *General feeling that customer and Aerospace will not buy off on COTS parts*
- Aerospace publish guidelines for how COTS can be accepted for space applications
  - *Minimum requirements, path to use in space applications*
- Standard for what a "construction analysis" shall contain
- Standalone reliability document for automotive parts

Key Messages and Themes

- To Be Determined

Invitation to Collaborate

- Share your feedback on our approach
- Point us to your completed study findings as references
- Recommend POCs within the SmallSat ecosystem for interviews
- Share your first-hand experiences, lessons learned, and best practices

Today's Take-Aways

- In this period of burgeoning opportunity and transition, norms are being challenged.
- Requirements flowed to suppliers are fragmented and are not easily categorized.
  - *Widely variable and dependent upon what suppliers and procurers at various levels are willing to agree to, rather than a codified set of standards adopted across the ecosystem.*
- Study will capture the rich diversity of perspectives and identify common themes in the hope that they sharpen insight as new norms are established

Questions and Discussion

Backup

Abstract

- This report documents a study of the Small Satellite (SmallSat) related industrial base. The primary objectives are to understand the types of requirements flowed to tiers of suppliers, explore the emerging intermediate grades of electronic parts and examine SmallSat programs' parts usage to determine the potential effects on the traditional space industrial base.
- The authors gathered data through written surveys and interviews with entities that provide electronic piece parts, subsystems or entire spacecraft, as well as procurers of SmallSats. They also utilized online research, publications on SmallSat technology, and participation in workshops, focus groups and conferences.
- In this period of burgeoning opportunity and transition, norms are being challenged. The authors found that the requirements flowed to suppliers are fragmented and are not easily categorized. They vary widely and depend upon what suppliers and procurers at various levels are willing to agree to, rather than a codified set of standards adopted across the ecosystem.
- Therefore, the authors have chosen to capture the rich diversity of perspectives and identify common themes in the hope that they sharpen insight as new norms are established.

Speaker Bio

- Dr. Allyson Yarbrough is a Principal Engineer at The Aerospace Corporation in El Segundo, CA, a non- profit, Federally Funded Research and Development Center that delivers independent space systems engineering and technical support to diverse government and civil agencies.

- She focuses on innovations for satellite and space-related applications. She also researches ways to apply space-related technology for the public good and enhancing industrial competitiveness. She holds five patents and is active in outreach and professional activities, a few examples of which include membership in the Society of Women Engineers, serving on university Industrial Advisory Boards, and advocating for STEAM (science, technology, engineering, arts, math) excellence in under-served communities.

- Dr. Yarbrough earned the B.S. Degree in Electrical Engineering at New Mexico State University and the M.S. and PhD Degrees in Electrical Engineering at Cornell University.

Final Report – Draft Outline

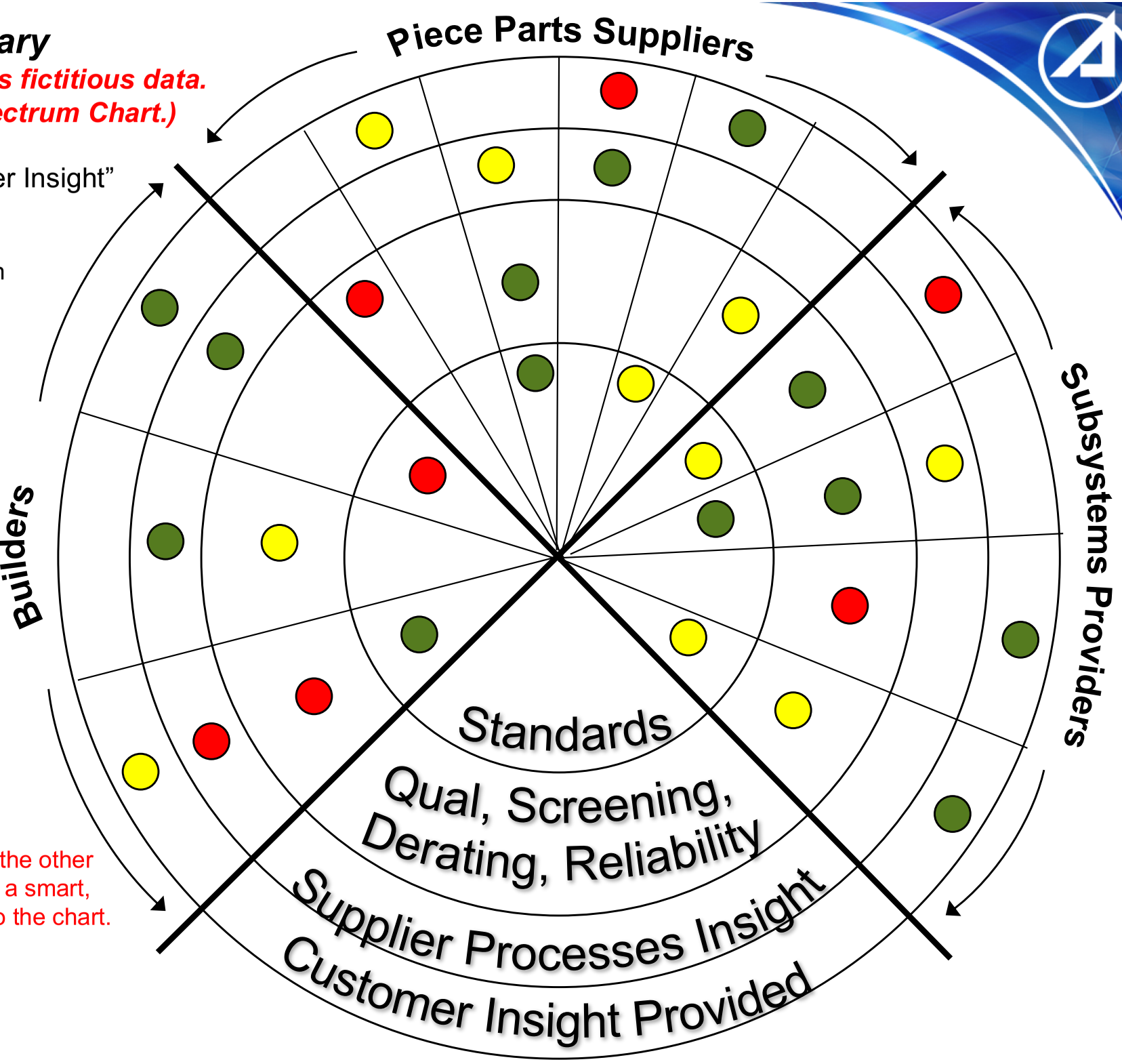
- How the study was conducted
  - *Literature review, survey of previous, related work*
  - *Four categories of Entities interviewed*
  - *List of questions posed to Interviewees*
  - *Leverage related concurrent work*
- Identify common themes in responses regarding
  - *Standards*
  - *Requirements flow*
  - *Approaches to Qualification, Screening, Derating, Reliability*
  - *Level of insight*
- Status of traditional satellite industrial base
  - *Potential impacts of the growing SmallSat market, with mitigation strategies (?)*
- Recommendations for the Government and other SmallSat procurers
  - *Evolve procurement practices to be more flexible*
  - *Innovative strategies for flexible, agile PMP (parts, materials, processes) management*
  - *Develop relationships with members of the SmallSat ecosystem*
  - *Consider suggestions and requests from industry that would facilitate progress*
- Conclusion and Options for Future work??
- Appendix
  - *Interviewee responses in raw form (anonymized)*

Results Summary

(Concept only. Uses fictitious data. This is called a Spectrum Chart.)

*Legend for "Customer Insight"

- Depending on customer, flow-down and part grade, willing to provide up to a complete data package
- Willing to provide up to wafer and lot-specific data
- Certificate of Conformance provided



*Need to add legends for the other variables. I'm working on a smart, legible way to add them to the chart. Any ideas are welcome!

"Builders" Results Summary *(Concept only)*

	Builder A	Builder B	Builder C
Standards	• PEM – NASA EEE INST-001 • ECSS-QST-6013b • AEC-Q101	• MIL-STD with lower assurance levels • NASA EEE-INST-002	Responsible design authority (REA) engineer
Qual, Screening, Derating, Reliability	• Uses few COTS parts	• Uses few COTS parts	
Insight into Supplier Processes	• EEE INST-002 Grade 1, 2 • COTS specified by customer • Periodic audits, spot checks	• Conservative derating • Up-screening • In-house radiation testing	• Study data sheets.
Customer Insight Provided	• Customer-dependent	• Customer-dependent	• Milestone, cost driven • Aggressive schedule to first launch