Small Satellite Industrial Base Study: Foundational Findings

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Executive Summary of Foundational Findings (1 of 2)

- Study objective
  - *Gain better understanding of the SmallSat community's*
    - Technical practices, engineering approaches and common processes
    - Requirements flow-downs
  - *Glean recommendations for how the government can further capitalize on the strengths and capabilities of SmallSat offerings*
- Stakeholders across the SmallSat ecosystem interviewed
- 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.*

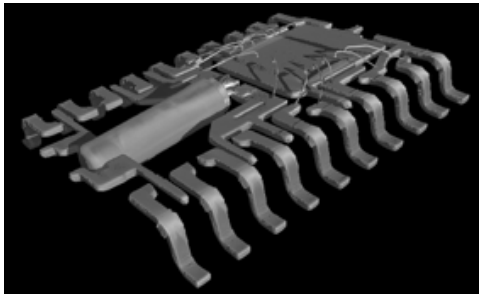
Executive Summary of Foundational Findings (2 of 2)

- Study captured the rich diversity of perspectives and identified common themes in the hope that they sharpen insight as new norms are established
- To accelerate progress, the SmallSat industry requests
  - *Signal from the government that COTS can be considered*
  - *Aerospace publish guidelines for how COTS can be accepted for space applications*
  - *Product a standard for what a "construction analysis" shall contain*
  - *Generate a standalone reliability document for automotive parts*
  - *Government to use any flexibility available to reduce the overhead burden on small space companies associated with contracting and performance monitoring*
  - *Government to enter into engagements that more closely resemble collaborative, trusted partnerships vs strictly contractual engagements*

Study Approach

- Team reviewed conference and workshop proceedings, reports and recommendations from colleagues and the study's sponsors
- Prepared a list of four stakeholder groups representing the relevant SmallSat ecosystem
  - *Electronics Piece-Parts Suppliers*
  - *Card, Assembly and Subsystem Providers*
  - *Spacecraft Builders*
  - *Procurers of SmallSat vehicles or missions*
- Questions specific to each stakeholder group were prepared to support 30-minute interviews
  - *Due to scheduling constraints, some interviewees chose to respond by e-mail*
  - *All responses will be included on a non-attribution basis*
- Sincere thanks to stakeholder entities who agreed to participate in the study
- Coordinated with JPL, NASA/GSFC, Air Force Space and Missile Systems Center and leveraged knowledge of other concurrent initiatives
  - *NASA's Small Satellite Reliability Initiative*
  - *Collaborations with academia*
  - *Feb 2019 Small Satellite Symposium insights*

SmallSat Electronics Piece-Part Suppliers: Interview Questions



1. What types of parts do you provide (e.g., space, military, medical, automotive, commercial)?

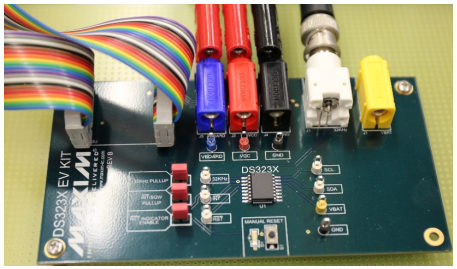
2. What hurdles do you see in meeting requirements for traceability and homogeneity primarily for automotive and commercial?

3. What basic requirements do you see flowed down to you from the contractor (technical and quality)?

4. What data do you provide to customers for the various types of parts you supply and is there a cost for the data?

5. What types of tests and validation do you perform for the various part types you provide?

SmallSat Circuit Card, Assembly, and Subsystem Suppliers: Interview Questions



1. Does your organization use a quality management system?

2. Estimate the percentage for each category of COTS parts used in your product line (e.g., commercial, industrial, aviation, up-screened)

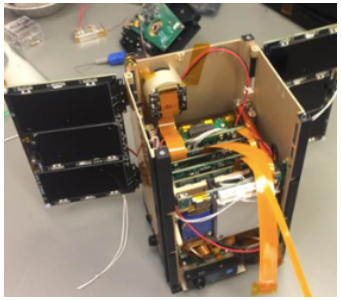
3. What available information and measures does your organization or subcontractors or vendors offer in lieu of the heritage management approach and military specifications?

4. How does your organization quantify or estimate reliability or risk?

5. What are the most important technical requirements your organization provides to suppliers of subsystems, assemblies and piece parts?

6. What standards do you often reference for in-house builds or suppliers?

SmallSat Spacecraft / Launch Vehicle Builders: Interview Questions



1. What standards do you often reference for in-house builds or suppliers?
2. What are the most important technical requirements you flow to your suppliers of piece parts, assemblies or subsystems?
3. What do you accept as proof of meeting any of the requirements you have levied, i.e., is it analysis or is it testing of parts or subsystems?
4. What measures do you employ to ensure the likelihood of a successful mission (e.g., redundancy units or functionality, part up-screening, application-specific characterization)?
5. What can the COTS community (i.e., manufacturers, providers and parts suppliers) do to make it easier for the gov't to gain objective insight into the relative strengths and challenges of COTS?
6. What outside-the-box, agile measures can the government take to help the COTS community (i.e., manufacturers, providers and parts suppliers) adapt to new demands for satellite systems and services?

Heatmap: Electronic Piece-Part Suppliers

Respondent / Practices Used	A	B	C	D	E
Part categories / grades provided	COTS, Enhanced Product, Automotive, Military, Space	COTS, Medical, Aircraft Military, Space	COTS, Rad Tolerant, Automotive, Military, Space	COTS, Industrial, Automotive, Medical, Military, Space	COTS, used in Automotive, Medical, Military, Space applications
Traceability & homogeneity					
Basic requirements flowed					
Data provided to customers					
Tests & validation performed					

General Alignment with Gov't Specs/Stds:	Strong	Moderate	Weak	Minimal

Heatmap: Card, Assembly, SubSystem Suppliers

Respondent / Practices Used	A Driver(s): Cost & Sched	B Driver(s): Capability & Cost	C Driver(s): Capability & Cost	D Driver(s): Sched
Amount of alternate-grade parts usage	Very little. Space-grade parts preferred.	COTS is most-used part grade	COTS ~50%, Auto/Indus ~25%, Space/Rad Hard ~25%	Industrial 90%, COTS 5%, Aviation/Auto 5%
Data provided to customers	Depends on customer	Functional tests for custom parts. Mil std tests when required.	Determined by customer spec and Statement of Work.	
Basic requirements flowed				
Standards referenced	Not available			
Estimating reliability or risk				

General Alignment with Gov't Specs/Stds:	Strong	Moderate	Weak	Minimal	None

Heatmap: Vehicle Builders

Respondent / Practices Used	A Driver(s): Capability	B Driver(s): Capability	C Driver(s): Schedule	D Driver(s): Capability	E Driver(s): Resiliency
Standards referenced			Not available		
Basic requirements flowed to subs			Not available		
Tests & validation performed					

General Alignment with Gov't Specs/Stds:	**Strong**	**Moderate**	**Weak**	**Minimal**	**None**

Gov't SmallSat Procurer Interview Questions

1. What design life (mission life?) are you targeting for your SmallSats?
   - *One yr design life. That said, our vehicles last much longer. 5 yrs is easy. Our experience is that if we get through infant mortality, our vehicles last a LOT longer. Some last 15 yrs. In most cases, they last until it's no longer possible to maintain the orbit OR the gov't runs out of funding to maintain operations.*

2. Do you flow down a system reliability target to your contractor or supplier? If so, what is it and how did you arrive at it?
   - *We don't flow down a reliability number. We flow down mission objectives. Example: 90% chance of success for the 1st yr. We do not ask vendors to perform a reliability analysis. For one SmallSat, the goal was 0.85 at 1 yr.*

3. What technical requirements do you flow to your contractor(s) or supplier(s)? E.g., reliability at the spacecraft level, reliability at the constellation level, mission (comm/imaging/sensing/ science…) capabilities?
   - *Experiment Requirements Documents, Technical Requirements Documents. These contain high level requirements and are negotiable.*

The comments expressed here are quotes from the Interviewees and do not represent the opinions of NASA, the Air Force Space and Missile Systems Center or The Aerospace Corporation

Gov't SmallSat Procurer Interview Questions

4. Do you have the ability and authority to trade technical, cost, schedule, risk and resiliency priorities? If so, how do you typically go about trading these priorities?
   - *Depends on the funding. We can adjust the Requirements and Risk "knobs" but not the Cost and Schedule knobs.*

5. What are the primary drivers of your program and the mission assurance you apply? Are they your requirements? Constraints? Risk and probability of mission success? Something else?
   - *We focus on Constraints (Lane Dividers) and Mission Objectives (Vision)*
   - *What is good enough?*
   - *Is it still worth it to launch, despite the risk?*
   - *Sometimes 50 / 50 is chance of success is good enough.*

6. What contract types do you typically use?
   - *Everything from Cost Plus Incentive Fee to Firm Fixed Price*
   - *Other Transactional Authority*
   - *Whatever the last one wasn't*

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Gov't SmallSat Procurer Interview Questions

7. What do you accept as proof of meeting any of the requirements you have levied, i.e. is it analysis or is it testing of parts or subsystems?\
   - *We take what artifacts we can get. These may be printouts of a response spectrum to random vibe test, for example. We extrapolate from little to no info to a risk assessment. We "reverse engineer" a risk assessment.*
   - *Focus is on a Robust Design up front. Our subject matter experts are embedded. We know Pass / Fail in real time.*
   - *We personally witness and participate in system test with the Contractor. Includes an Acceptance Level Random Vibe Acoustic Flow.*
   - *Don't break the hardware on the ground.*

8. How do you define, assess, monitor and mitigate risk?
   - *Robust risk management process is in place, including a monthly Risk Management Board. By our definition an Issue = Risk realized.*
   - *30 – 40 risks are monitored during the life of the program.*
   - *Cannot mitigate all risks. We decide what we can / cannot live with.*
   - *Gov't owns the risk process across Ground, Spacecraft, Launch.*

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To accelerate progress, industry requests … (1 of 2)

- Signal from Gov't that COTS can be considered
  - *General feeling that Customer and their support team 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*
- Aerospace create a keyword search list
- Standard for what a "construction analysis" shall contain
- Standalone reliability document for automotive parts
- Make contracting much easier. Gov't wants to buy commercial but levies FAR and other requirements that do not match with commercial
- Gov't needs to buy more and buy more often, like the aircraft industry does. Look for frequently-used commodities and buy in volume to gain price advantage
- Update Mil-Std-1547 "Military Standard, Electronic Parts, Materials, and Processes for Space and Launch Vehicles", which does not address new technologies such as plastic encapsulated devices

To accelerate progress, industry requests … (2 of 2)

- Create an approach to utilize the methods of MIL-HDBK-217 “Military Handbook: Reliability Prediction of Electronic Equipment”, but with manufacturer’s failure rate data
- Conduct an empirical study, see how performance/flight data aligns with predictions, and analyze the trends. Current reliability assessments are far too conservative, applying things that don’t really make sense
- Gov’t is way too hung up on automotive grade parts. Need to take a closer look at aviation grade parts, which are very high tech
- Gov’t could buy needed components and provide them to their contractors
- Be more realistic: If an item is COTs, then treat it as COTS. Gov’t tends to over-analyze. Instead, should focus on mission-critical issues
- Do not try to control every single little thing. Use incentives instead or maybe make disincentives work better.
- SmallSats are not $B satellites, they are cheap. Gov’t needs to scale the oversight accordingly
- Create a base system document to which requirements could be added based on the mission objective, rather than starting with the highest level system requirements documents

To accelerate progress, industry could …

- Create one giant catalog for COTS
- Create a good Web site with specs and information
- Attend conferences with Gov't in attendance
- Deploy better key word searchability of Web sites and documents (e.g., use common terminology)

Study's Key Messages

- 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 captures the rich diversity of perspectives and identifies common themes in the hope that they sharpen insight as new norms are established

Recommended Follow-on Work

- Complete at least two additional Small Satellite Procurer interviews
- Assemble Small Satellite Industrial Base results with those of other studies and apply data analytics techniques to identify additional themes and trends of assistance to the Government in procuring Small Satellites
  - *Coordinating with*
    - NASA's Small Satellite Reliability Initiative
    - University Small Satellite researchers
    - 2019 Small Satellite Symposium insights
    - Industry working groups, task forces, councils, trade groups

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