Small Satellite Reliability Initiative (SSRI)

A Public-Private Effort Addressing SmallSat Mission Confidence

Technical Interchange Meeting-4

7-8 November 2018, Laboratory for Atmospheric and Space Physics (LASP), Boulder, CO

DAY 1

* Welcome- Neil White- LASP
* TIM-4 Objectives, Day 1 and Day 2 Plans, SSRI Status and Next Steps
  + Michael Johnson/ NASA Goddard Space Flight Center
* Lessons Learned from SmallSat Missions (30-minute presentations/discussions)- What should we learn from SmallSat missions that have flown and from missions in development to inform the success of future missions?
* John Baker-JPL: MarCO (Mars Cube One) **[pg. 4]**
* Kyle Kemble- AFRL/RVEP: SHARC (Satellite for High Accuracy Radar Calibration) **[pg. 5]**

Steve Diamond- Airbus-OneWeb **[pg. 7]**

* Will Mast- Goddard Space Flight Center/WFF: IceCube **[pg. 8]**
* Ken Hyatt- Adcole Maryland Aerospace: Kestrel Eye (KE-IIM) **[pg. 10]**
* Working Lunch- Lessons Learned from SmallSat Missions, cont.
* Patrick Phelan- Southwest Research Institute: CYGNSS (Cyclone Global Navigation Satellite System) **[pg. 11]**
* Amanda Donner-JPL- ASTERIA (Arcsecond Space Telescope Enabling Research in Astrophysics) **[pg. 12]**

Afternoon Session

* SSRI Best Practices/ Design Development Guidelines Working Group- Status and Plans Presentations and Discussions (5 sections)- What is the status of, and what is TIM-4 attendee feedback on the sub-team effort to define design/development guidance and best practices consistent with confidence levels ranging from “do no harm” missions to those whose failure would result in loss or delay of key national objectives?
* Working Group Section Leads **[pg. 14]**
* Best Practices/ Design Development Guidelines Software Framework- What type of software-based framework can allow a range of users to most efficiently and effectively benefit from knowledge captured by this initiative? What are plans for developing it?
* Harald Schone- JPL **[pg. 16]**
* Open Discussion **[pg. 18]**
* Day 1 Debrief, Day 2 Plans
* Adjourn

Group Dinner

DAY 2

* Day 1 Debrief, Day 2 Plans, Open Discussion **[pg. 19]**
* Other Efforts Relevant to SmallSat Mission Confidence (30-minute presentations, 15-minute discussions)- What activities related to SmallSat mission success are being executed by the NASA Electronic Parts and Packaging and the NASA Academy of Aerospace Quality and the NASA Academy of Aerospace Quality? Can we leverage each other’s activities?
* Michael Campola- Goddard Space Flight Center: NASA Electronic Parts and Packaging (NEPP) **[pg. 20]**
* Jeanette Plante- NASA HQ: NASA Academy of Aerospace Quality **[pg. 21]**

Break

* Knowledge Sharing- What is the status of knowledge sharing activities? What information and resources should the SmallSat community exchange to increase mission success and reduce overall development costs? And importantly, what systems and processes can we establish to facilitate knowledge sharing among organizations that may compete against each other? [11:00 -11:30]
* Craig Burkhard- NASA Ames Research Center **[pg. 22]**
* Allyson Yarbrough, Craig Langford- The Aerospace Corp: Alternative Parts Database **[pg. 23]**

LASP Tour, Lunch

* Knowledge Sharing, cont**. [**released by the presenters **[pg. 24]**
* Open Discussion, TIM-5 Plans **[pg. 24]**
* Adjourn

The organizers convey special thanks to Neil White and his colleagues at LASP for hosting TIM-4. Everyone, thank you for making it a productive event.

Safe travels.

Day 1 – Wednesday, November 7, 2018

TIM-4 Objectives, Day 1 and Day 2 Plans, SSRI Status and Next Steps

Key Speaker: Michael Johnson/ NASA Goddard Space Flight Center

The objectives of this technical interchange meeting are to catalyze thoughts about SmallSat mission confidence and to share thoughts regarding where we are on best practices and guidelines. Over next couple of days we will start with lessons learned from project managers who have flown missions to stimulate some discussion on the best practices and design guidelines that we should apply to SmallSats from the standpoint of ‘do no harm’, from single nodes to constellations, and from durations of a few months to several years.

The second day’s discussion will focus on activities that aren’t directly involved in the Small Satellite Reliability Initiative (SSRI), but that have tentacles into SSRI. We are trying to break down walls - smart people are within the walls and outside the walls so how do we push the boundaries of how we work with each other?

We will wrap up the meeting with discussions with the primary objective of sharing where are and getting feedback. We need some ideas on what we should be doing, and course corrections. There isn’t a lot of love for gathering information and hosting it in a file just to let it sit. We need to determine how we wrap this in a framework that people will use and make it useful to a broad audience, from procurement staff to those developing systems.

Discussion, Questions and Answers

Q: What is the planned outcome by the end of the meeting? Is it concurrence? What is the target?

A: Looking for concurrence on the best practices and guidelines for the framework that we wrap around them. Knowledge sharing is important here. Answers are needed to the question on whether the approach that the SSRI is taking is adding value. If there is no value add, what should we be doing? What we are doing needs arms and legs. We are also looking for folks to volunteer to help with the committees. What aren’t we doing that we should be doing?

Q: Is there a written mission statement on the goal of the working group and outcomes?

A: Yes there is. It is kind of captured in the TIM-4 invitation. Given the growing potential of SmallSats what is the approach we should be taking to realize mission confidence for these misisons, without breaking the SmallSat paradigm.

Action Item: When you say mission confidence that really speaks to how and what you satisfy. Safety group, technical authority, folks regulating space debris? We need a confidence matrix that shows these different groups.

Q: Does the ‘we’ include just NASA or is it more inclusive?

A: It is more inclusive and we want to include Class A, B, and C SmallSat classes. We want this working group to be intergovernmental and open. We don’t want scaled down big satellites to be SmallSats. We want to talk about which practices we should avoid. There’s a lot of low hanging fruit that would greatly increase the approach to reliability that can be used by the university programs and commercial entities.

Lessons Learned from SmallSat Missions (30-minute presentations/discussions)- What should we learn from SmallSat missions that have flown and from missions in development to inform the success of future missions?

Key Speaker: John Baker-JPL: MarCO (Mars Cube One)

Four years ago Dr. Elachi (JPL) had the idea to develop two relay CubeSats within 14 months to support InSight communications during landing. During development, InSight had a payload issue that was resolved. InSight launched with MarCO A and B.

Currently, Insight and the two MarCO’s are set to arrive at Mars in three weeks.

* Insight is carrying a seismometer
* MarCO will be realtime communications relay capability
* MarCO requirements were to launch with InSight, demonstrate / attempt 8Kb/s during Insight entry, decent, and landing.
* Separation from the primary payload was important.

MarCO details:

* MMA solar arrays used (Boulder, CO company)
* 60cm high gain antenna
* Software defined radio called IRIS
* Cell phone cameras on gum sticks (8GB of RAM). Image quality is comparable to early cell phone cameras.
* Thrusters are all at one end.
* First MarCO spacecraft is named Wally, had a leaky thruster and went wherever it wanted to go, hence its name. Since then, Wally has been working well
* Second MarCO spacecraft is named is EVA.
* Older processor was used - MSP430, limited memory
* Much flight heritage
* Selective radiation testing was performed on MarCO.

The radio used on MarCO had commercial up streamed parts. A buck converter was used for which the radiation tolerance was unknown. Needed to do a better analysis so they found that there was a 60% chance the radio would make it.

The MarCO team didn’t do a lot of the fault tree analysis that is often done. These analyses are typically performed to understand how long certain spacecraft parts will last over a period of time, but since MarCO was only planned for a 6-month mission much of the analysis wasn’t done.

Stress analysis was not done either. $10M was the cost of the mission including development, $5M on testing, and none on analysis.

Could the MarCO team have done a little analysis and enhanced the mission assurance? JPL choose not to because they were on a 14-month development schedule. The team really didn’t have good evidence what activities have more risk than others and they had to prioritize the analysis. Some analysis was done on the ISIS radio, some parts are d-rated.

An important issue / point of discussion is what is the trade off between testing and analysis? With analysis you see what might be, and with testing you see what is.

An end-of life analysis wasn’t done, as well as other analyses. The tolerances stack up. Even a small amount of analysis helps. It’s also about the learning process. Even a $100K of analyses could have impacts on the design. Is there ratio of funds used for testing versus analysis? You can still understand weakness and systems functional issues and functional design by testing, even if you don’t do analysis. There was no requirement for MarCO to make it to Mars.

Q: Was the schedule constraint that made the team take the testing route? Was there any ability to change the design? Was funding a major constraint?

A: The schedule was the major constraint. There is always a conversation about the life time of the parts, and the radiation susceptibility was always part of the discussion. The MarCO team did place the more sensitive parts in the center of the spacecraft to shield them a bit. Turns out that the radiation challenge on the way to Mars isn’t that much of a challenge .

JPL assurance did perform a triage process to meet the mission timeline.

MarCO results so far:

* Zero radiation upsets
* ADCS has had a number of operational anomalies
* Vacco valve failures
* Lessons learned: perhaps reliability may not require class A parts, but redundant subsystems.

For small satellites (for short missions) the amount of reliability work can be done by the designers, not by an independent group.

How much reliability analysis was performed by the vendors versus in-house by JPL? Often vendors supply a parts list. (XACT is an example).

Q: What is the heritage of the Vacco valve? Was it custom design?

A: Unknown. They are developing other units for other customers.

Q: Is there a plan to do a post mission case study on MarCO? Redundancy at the system level, and common failure would need to be addressed. Would the Vacco value problem be found through analysis? A short duration mission with a short development schedule would make for a good lessons learned document.

A: SMD funds MarCO, so they would fund a case study if it was wanted.

Key Speaker: Kyle Kemble- AFRL/RVEP: SHARC (Satellite for High Accuracy Radar Calibration)

SHARC Case Study:

* Radar performance mission – satellites are good tools for RADAR calibration
* SatComm communications capability
* HaWK deployable solar array unit from MMA
* Launch timeline: to ISS, deployed May 2017
* Team was able to operate in several different modes. Three different communications.
* NAND Memory – major anomaly

Major lessons:

* Path agnostic communications – both good and a failure at the same time
* Programmed at the wrong frequency, which meant conus only
* Could still get a third of the world
* Really changed how many folks are really needed to support operations. From a mission assurance profile – you have focused problems and don’t need all the engineers in the room.

Pass Transactions –

* + Planning activity – how do you coordinate when things should occur? When is it too late to submit a command and how do you build that into your ground segment? Human in the loop was included until the end.
  + SHARC C-band Macros – focus on things like having the C-band transponder warm up.
  + 4 (5) Core Tests – is the spacecraft responding appropriately? Understand how fault rejections put you back into the solid state.
* Day in the Life – how do you set up a testing structure to observe minimal success?

Building 595 houses soup to nuts development through operations.

Normative Behavior – the community should engage in this more. The SmallSat community is scrappy.

Satellite Mode Lexicon: safe mode, sun safe mode, operations mode. A system reset doesn’t have to be a bad thing. It allows you to come back to a known state that is safe. Relieves the stigma of failure.

Summary: tight integration of the operational and test environment; connectivity to the spacecraft is key; design elements to have safe modes.

Q: Ground RF testing with the dish with GlobalStar?

A: Yes, worked out of their hibay. Located at Kirkland so was in conus. Could only see a third of the world due to their frequency.

Q: 5 tests – where these the only tests done?

A: Yes, and they all paid large dividends.

Q: Full environmental screening?

A: Mostly in the vehicle environment. ISS is very smooth ride. TVAC and vibration facilities are available at Kirkland.

**Key Speaker: Steve Diamond- Airbus-OneWeb**

Company started as a joint venture about 3 years ago for LEO constellations. Airbus-OneWeb is located in Toulouse, France and soon in Florida.

You need to think about how you do missions when you are turning things around at the cadence Airbus-OneWeb does. STP Sat 2 and 3: spacecraft capabilities at less than a third the cost.

Airbus-OneWeb wants to help start the conversation about access to space. It’s about the backend of what we are doing. What is unique is how we are able to deliver the spacecraft for the cost and reduced timeframe.

What is the definition of reliability? Google definition – defined outcome and consistent performance.

Airbus-OneWeb stripped out 95% of touch labor. They highly automated the manufacturing process. They can build up to 1000 spacecraft a year. The whole paradigm changes regarding reliability methods from design to manufacturing when you are building this many spacecraft. Everything is focused and integrated from the beginning. One Web is a LEO constellation. How you fly 1000 spacecraft and how you fly one and two are very different.

OneWeb Satellite Industrial Model: 1 for 1 comparison of what you could spend within the space industry today and what you could get now with OneWeb.

Incorporate in your future design, COTS with heritage. The more you can reuse heritage hardware the more you will benefit. As much as you can reuse the better you’ll be.

Are you in the spacecraft business or the mission business? NASA / others don’t want to be in the spacecraft business because spacecraft are becoming commodities. They (NASA) should be in the mission and science business.

Every mission we design has a payload. OneWeb is trying to create an ecosystem, a payload users guide to reduce on the mission side, the amount of customization. It won’t fit everything, but it’s a start. There is a lot of opportunity for standardization. It’s a mission discussion, not just reliability.

Airbus-OneWeb is starting with 12 flight articles and getting ready to launch on a Soyuz in February. Launching 10 with propulsion to polar 1200KM orbit. Could pull them out of orbit. Hall effect thrusters will be used for orbit raising.

The Florida facility is across from Blue Origin. Engages in serial production of spacecraft.

Airbus-OneWeb deals with suppliers differently. OneWeb is imbedded in the design effort directly. They are highly integrated and collaborative with the supply chain on how things go along. They are always getting data. If there is an anomaly they have probably already mitigated it at the factory.

Q: When do we start breaking even?

A: There are a lot of non-recurring elements.

Q: How can you apply the lessons OneWeb has learned to folks building onsies-twosies?

Mass production and other approaches exist because they make sense, so which ones that OneWeb uses can be applied to NASA, for example, without going to mass production?

A: Steve to take a list of questions for others at OneWeb who can help answer what lessons learned are appropriate for developers developing spacecraft on a onesy and twosy basis.

Current constellation is using Iridium (70 or 80 spacecraft). OneWeb didn’t constrain themselves on what others had done first. Wanted to figure out the point of doing something, what is their value add? Their facility allows them to change spacecraft on the fly. Their facilities weren’t built as a one trick pony.

Q: SmallSats will eventually become commodities, what is relevant to your process that allows spacecraft to last n years, that you don’t have excess margin for 8 or 10 years?

A: Airbus-OneWeb spacecraft are built for 5 years. They are fully tested for the environment. As production rates go up, lot testing will be done and not individual testing. 1 out of 1, then 1 out of 2, 1 out of 100, 1 out of all eventually. Tracking every component and sub-assembly. They are big data advocates and are always monitoring so they know right away when a problem arises.

Q: What is in your process – working closely with vendors is a key comment.

A: Supply chain risk management. Could Steve get back with us on other lessons learned that can transfer to onsey and twoseys. Being aware of what makes suppliers change their products (materials, factory moves and different staff, ect) is an important thing. OneWeb is broken if they are not in touch with their suppliers. Its not just a sale to these vendors, there is a financial benefit.

**Key Speaker: Will Mast- Goddard Space Flight Center/WFF: IceCube**

A skunkworks approach was used for IceCube. It was GSFC’s first science mission on a CubeSat. The team had a lot of experience on other aspects like adapting and integrating COTS and low-TRL hardware, but not for CubeSats.

Recommendations for improving mission success:

1. Build an experienced team

How do you give people experience? You follow the model of the sounding rocket office. Over 10 years got a supply chain going and standardized rocket I&T. In 2000 I&T got outsourced to contractors and they are over the learning curve. Need a multi-disciplinary team that handles multiple missions is key.

2. Define your scope, goals, success criteria

Got away from standard formats. Everything they did was on a spreadsheet or on NTBS (?)

No SEMP, no S&MA plan and these could have been helpful. They had many unanticipated development efforts (interface issues). CubeSats need much larger reserves percentage-wise than larger projects. Also FTE to hardware ratio will be higher for the cost of the hardware. The cheaper the hardware parts are, the more labor you need to spend. 10 to 1 for a 6U.

3. Conduct risk-based mission assurance

Racked and tracked top 10 issues

Q: How did you make your decisions on the worry list? Some are technical issues, some are issues that you can’t pay for. You can only test for so much so how do we capture this?

A: Every engineer has a list of things that would have helped if they knew at the start of the project. How do we capture these things at this workshop without voiding IP? Will has many lessons learned from LADEE. A lot of decisions had to be made on LADEE. NASA has a lessons learned database. This is the 4th TIM and this question always comes up.

Q: Did they do a lessons learned review at the start of this mission?

A: No, there wasn’t time.

Q: We have a lot of natural language tools, can we use open source lessons learned tools?

A: It’s hard because the mission requirements and conditions are different. Could be more confusing.

Q: What is the purpose of the group? To help someone start something? How do we start a reliable mission, for instance?

A: How do we extract what everyone has learned and apply it moving forward? This is what we are trying to do at this workshop. Don’t want to repeat mistakes.

Different lessons are applied in different situations. There are three parts to a lessons learned: the lesson, the target (what you are applying the lesson to), and the condition under which the lesson is useful (environment for instance).

System lessons learned is another kind of lesson. So many lessons learned are not actionable, or are squishy. Then there are some common things that are coming out that are best practices for multiple groups. We need to mine what we are hearing today to figure out how to organize going forward.

4. Design for Simplicity and Robustness

No redundant systems – robustness is driven by risk mitigation. To make things actionable, you need to add some numbers to the lessons (for instance, you can go down to 10% to fully recharge).

5. Maintain a healthy skepticism on vendor subsystem data sheet

Acceptance testing is where you’ll find the issues

6. Plan for ample IV&T time

MAIW paper recommends that I&T should be 1/3 to ½ of the schedule. Bad commands were found that would have ended the IceCube mission.

7. Perform four mission assurance plans

Lessons learned: don’t skimp on documentation and formulation……

Apply lessons learned to planetary SmallSats.

Suggestion is to spend the last week of the mission to take stock of what is working and do some more testing of the systems and spacecraft to get more end-of-mission data.

**Key Speaker: Ken Hyatt- Adcole Maryland Aerospace: Kestrel Eye (KE-IIM)**

Worked for the last 4 years on Kestral. Army closed it out with an ops demonstration to validate the original objectives of the mission. They have over 200 lessons learned.

Originally designed as low cost program to get a dedicated asset available at the brigade level. Biggest drawback was the tasking. Looking for more real time tasking downlink.

Originally the design and parts selection was cost driven (do it cheap and fast). Then went to a ‘don’t fail’ risk posture. Had to redo the design due to parts failures. Deployed out of the JEM module on ISS. Had to redesign the cold gas system. Redesign was needed for the battery system as well.

Lessons learned: the idea is to have a more structured framework. How do you get the parts while keeping costs down? They were used to large teams of Aerospace staff, but went to 5 folks throughout. There were no resources to tap back into. Needed common frameworks. How do you capture reasons for not performing certain testing/analysis and how do tell your customer why? Especially customers who are used to big space.

Not static lessons learned. How do you go back and reassess the original baseline when things like the vehicle change? Like turbotax, you want to be able to go back in to change a variable to reassess risk.

Include the risk process in with the best practices and other guidelines. How can we provide the framework to assess risk? Risk is mission dependent.

The hard part isn’t grabbing lessons learned from these missions, but how do we make them useful to this community?

Be flexible and find creative ways to keep costs down.

Tried to do Kestral in a very module way. Needed to allow adaptation to change. No control over the parts selected, but could control the testing of the parts.

Experienced a latch valve failure so did full testing. At 4500 psi, gas permeated into the seals so went back to swap out seal materials. You find differences in commercial products when you use them in space.

The framework can’t be focused on just parts. What is a good philosophy to buy down risk?

Batteries:

* Compatible to ISS
* Challenging redesign
* Battery heater was COTS
* One failed in TVAC. Went back and had some spare batteries. Implemented another control circuit and software that allowed them to turn off the heater.

Another change was going to a Nanoracks deployer.

Human factor comes into it. After two and half years everyone was tired. Is the human factor issue youth? On Kestral there were two fresh outs, Ken who has a different background, and a couple other senior engineers. But the day-to-day engineers were younger engineers. It was a combination of factors. Need to mix in people with experience with inexperienced people.

You could spend a lot on quality groups to create procedures, record keeping, and checks on what will be a defect. But if you can’t afford them, you have to take the risk.

Kestral had a FOB process, spreadsheets. They had someone coming in to help with pre-safety.

There are pros and cons of having someone who is truly independent versus someone who is assigned from within to make sure assurance is maintained for the project.

The expectations and guidelines need to be set up front so that everyone understands them.

Kestral had issues with their flat sat environment. Errors weren’t seen in the flat sat environment until they were seen on orbit. Would have like to spend more resources on flat sat environment.

Working Lunch- Lessons Learned from SmallSat Missions, cont.

**Key Speaker: Patrick Phelan- Southwest Research Institute: CYGNSS (Cyclone Global Navigation Satellite System)**

CYGNSS has a 3-year mission cycle, a constellation of 8 satellites.

Lessons learned Themes:

Risks with vendors: vendors go out of business so you need flexibility, and a vetting process. Processes are not often well established. Datasheets may not share all the information. Some still use ‘old space’ practices.

Constellations and SE: SwRI mostly did onsey and twoseys. Constellations are new for them. Automate test and ops. Not the best way to get people experienced (oversubscribed staff)

NASA Standard Process: margin and reserve requirements; EVM light was done; standing review boards (backfill staff required to support these requirements).

Launch Vehicle and Testing: launch schedule and project schedule are sometimes in conflict. Contractual reporting can sometimes be an awkward communications chain.

Project Relationships and PI Engagement: Earth Venture program wasn’t the best way to give junior people leadership roles. Things aren’t disclosed until too late sometimes.

Recommendations on the team and growing people into leadership roles: mentoring is a part of it. Its tough when you are on a fast paced project. Success came from mentorships between experienced staff and fresh outs. If you turn them (fresh-outs) lose they’ll go down a rabbit hole.

They have 70 pages of lessons learned and 40 of them are the actual lessons learned forms that the engineers filled out. Is this document on the SharePoint site? Maybe not but can put it on the SharePoint site and SSRI site.

**Key Speaker: Amanda Donner-JPL- ASTERIA (Arcsecond Space Telescope Enabling Research in Astrophysics)**

ASTERIA is a tech demonstration mission:

* Pointing stability
* Precision thermal control
* Detected a transiting exoplanet (existing one)
* GPS capability - Takes the TLE and then tells XACT where ASTERIA is.
* Radio and two patch antennas.

Lessons Learned:

There are a lot of trades in the CubeSat world.

Vendor interactions: its important to describe requirements. Many vendors are small startups and don’t have a QMS. Verify system behaviors of delivered products via testing.

Hardware design decisions: thermal model accuracy is critical; staking and conformal coating (too much overhead at JPL as they are targeted to Class B); latch up issues

System design decisions: value in designing in flexibility and extensibility into the systems with an eye toward operations; incorporated a radio duty cycle to achieve positive power margin; FSW is a significant driver for system cost and complexity.

Tailored approach to ASTERIA: hardware quality assurance, environment assurance, reliability assurance, system safety, software quality assurance. Running software static analysis (like on their radio) is an important lesson. Can tailor as issues are recognized, whereas here they over-mitigated and under-mitigated in some cases.

Integration and Test: mission scenario tests are critical to understanding system behavior; long duration system test is critical; overlap Cog-E and technician roles; make multiple testbeds available to FSW team.

Mission scenario test: this test was done close to the end and had to fix some things as issues came up. Final release was 7.1 and most testing was done on version 7.0.

Operations: Many of the development team transferred to operations. Spent all the money to get to launch then had to beg for pennies for operations. Takes two passes a day. Value of full system testbed; single ground station is at Morehead University. It is student run and they are interested in being part of the DSN. Haven’t gone longer than a couple of days of no contact. Not a NASA mission so couldn’t get NEN for free. They found the station at Morehead, but its just 1 station and no backup.

JPL has quality compliance so that was why they had trouble to get the conformal coating done. JPL would have gone against their own procedures. JPL found a vendor that could do this quickly and efficiently.

One thing about these lessons learned, all these things would have been prevented if done the big space way. But we don’t have the money, time. The problem is all gut when you don’t have the money. How much do you give up, how much do you gain by doing CubeSats? What is the risk, what is the reward? We aren’t hearing any numbers here.

Its hard to do the risk analysis with this. For tailoring approaches done by JPL, someone tried to do a value assessment to come up with these. The ability to define risk and communicate it accurately is important. If there are too many unknowns you need to do more.

FORMECA requires a stress analysis. WICA communicates with FORMECA.

As a group at TIM-2, we got an estimate of what the most important test are. It’s a data mining issue. The data is out there. It’s a processing and data analysis issue. Even if we have the money, we don’t have the manpower to do this. We need to find volunteers to build and mine this data. The industry is moving very fast. Should we continuously figure out the lessons learned for new starters? Or move onto the next missions? Should we go through all the lessons learned or figure out what we need to do for the next mission?

For the tech demo, you are satisfying yourself. The highest value is still supporting meaningful science. Do we leave it to the vendor? We have to work within the SmallSat constraints, but as soon as we start saying you need to have this and that done, it gets expensive. Can we use MarCO’s processes for validating certain systems, and use ASTERIA processes for other systems?

We should focus on what works and what doesn’t. We have an industrial base and should look at demonstrated hardware that’s worked. What has worked with Blue Canyon? Use that. Start building that way. We want to build a community where we all talk. We had Blue Canyon and Planet here.

But then you are limiting yourself to heritage components. Yes, but there is always development going on and there are families of products to consider.

JPL has no interest in building CubeSats, but buying them. MarCO and ASTERIA were the first CubeSats built and operated by JPL. It’s been a challenge sharing what we want to do. Having a tech demo before you do the mission can prove out the technology as well as the relationships.

Q: Is it common practice to write lessons learned at the end of the mission?

A: Sometimes it’s a contract deliverable, sometimes there is no money or staff to do the lessons learned at the end of the mission. Start writing lessons learned as you go along. Can we list a set of functional capabilities, and a list of functions common to missions?

Q: Can you do anything useful on a platform of this size?

A: For a certain FTE and development schedule the answer seems to be yes, but were we lucky? Will we run into a string of bad missions since we’ve been lucky?

Tyvak and BCT – they are in the mode of selling the next version. For our missions we could use a tried and true fixed version, and let Tyvak go on and do their development? That is one approach. The SmallSats are an opportunity to do something different. Are we leaving capability on the table? Does this move us back to the big satellite model? How do we articulate certain elements that are common to all of us? That will be a very valuable thing to have.

SSRI Best Practices/ Design Development Guidelines Working Group- Status and Plans Presentations and Discussions (5 sections)- What is the status of, and what is TIM-4 attendee feedback on the sub-team effort to define design/development guidance and best practices consistent with confidence levels ranging from “do no harm” missions to those whose failure would result in loss or delay of key national objectives?

**Working Group Section Leads**

How can we package some of these thoughts so that they are helpful to the community? We need to take a holistic approach mixed with an analytical approach.

Two major components:

* Best practices and guidelines
* Knowledge Sharing

This package of information would be for anyone who needs to know, whether they are building or buying. Do we offer it by Class A, B, C, D? No. What about gold, silver, and bronze and then by certain attributes? No to that as well.

What we are talking about now, whether you are a single node or constellation, certain things will be more important to you. It’s a constraints level approach. It has 5 different constraints and based on where you are, you are somewhere on the cube. It’s an optimization issue. Maybe fill in each box with an example mission. Having example missions in the cubes can help establish the basis for each block/cube.

The approach is to divide into 5 sections. We would wrap this with a software framework to help the user get to where they need to be.

How do the guidelines and best practices get to this? Each block informs trade studies. But if you don’t have enough funds you need to decide what tests you will do and can’t do. You have to set up your program initially, then go back to the cube over time to go over the higher value trades.

A lot of folks don’t tailor. There are people who don’t want to make the hard decisions. A lot of programs want a sincere discussion and handshake on what is agreed upon up front. This cube could help articulate what the expectation is from the customer level. This may help the contractor and customer base get agreement. Can you tie the risk management process to the cube to support the risk discussion? Papers (Swartwout and Aerospace) have been written on how mission confidence increases by the number of satellites an organization develops.

1. Getting Started

Try to define what the confidence levels are and what they should be. (Do no harm to very high). What are the unique lessons to SmallSats? How do we capture those lessons learned?

How do we design a mission that is resilient to failure? It takes a lot more thought to design a spacecraft to where if you were to poke a hole, the system still survives.

To understand lessons learned (and take advantage of the cube), you need to understand your mission, including constraints. You need this to scope out your own program. This is how the Getting Started section is envisioned being used.

2. Expected Mission Lifetime

Q: What is the target audience for this section? Not JPL as they have their own process.

A: If you are building to an environment you aren’t used to, this is where you can find lessons to help you. Where Mike sees GSFC and JPL helpful in this section is to contribute mission content/lessons. How can you help Blue Canyon and others without handholding? The vendors do use some of the lessons and requirements we give to them to build into their product lines.

This isn’t a static document, but a framework for information that can evolve. The intent is it to be a knowledge base that drives you to a certain cube depending on what you need. Right now you have a bunch of MIL specs and NASA documents, but this summarizes and focuses information to share with the customer.

Q: Section 2 is an index into the cube. What is the content inside one of these elements?

A: They could be best practices, other referenced standards, maybe. They could be best practices that could be tailored for certain missions. You will find relevant information based on certain coordinates.

Presenting users with too much information is overwhelming. Best to show them a simple GUI, but not get too much into the weeds.

3. Space Environment/Orbital Constraints

Having ability to give realistic metrics. Functional block is the biggest driver.

4. Programmatic Constraints

This part is on logistics, which often gets overlooked.

* Are they going FedEx? How is the integrator shipping it?
* Team experience is a consideration. How do you do a self-assessment of your team and how do you backfill if needed? Can you leverage from other teams?
* What documentation is needed? Vendors are washing out their level of experience due to growth. They sometimes can’t transfer philosophy to new teams.

5. Mission Architecture Constraints

A lot of this information isn’t written. The team is trying to capture what is unique for SmallSats and CubeSats. Would like folks to give an hour of time for an interview with Tony or Catherine to pick brains on this segment.

One thing we are seeing from some new companies is that they are one trick ponies. They don’t understand the space business. It would be nice if we could prioritize for the vendor base the best practices of working in space.

JPL, APL and others don’t know how to design for reliability. Even after 15 years JPL’rs don’t know many of these things.

Why does Planet need help from us? We can focus on interplanetary.

This is a dangerous comment. SmallSats still aren’t a commodity. People are still producing bricks if they don’t know what they are doing.

One thing with SmallSats is that if folks have a cool idea, they can use a SmallSat as a low barrier platform.

How much demand is there for SmallSats on top of what we are already doing? How do you put the SmallSat paradigm on these big space companies?

We still don’t even know what our product is for this workshop. This tool cube could help answer questions for us that could lead us to a product. We could share this cube with users to get their feedback.

Q: In terms of those who we think this tool will help, some people just want to cut to the quick. Is there a way to weave that into this capability, the turbo tax model, the ability to ask a few key questions/attributes (supported by machine learning and natural language tools) to push out the level of support you need?

A: Yes, we’ve thought about that a bit so that it’s tenable to user time and experience (express lane for example). If the user is the stakeholder, that requires them to go through this tool to identify more of their needs up front to give to the developers which helps the communications channel.

Best Practices/ Design Development Guidelines Software Framework- What type of software-based framework can allow a range of users to most efficiently and effectively benefit from knowledge captured by this initiative? What are plans for developing it?

**Key Speaker: Harald Schone- JPL**

Should we collect the lessons learned for everything out there, or just the most important things? What kind of information are we willing to accept? If we have to wade through a thousand emails and documents, this is very inefficient. It is very hard to communicate information that way.

They have worked with Vanderbilt University to figure out what information to use to build out the lessons.

1. Modeling approach means that you understand the systems and the fault tree to go through the steps. Are the faults re-usable?
2. UCLA predictive tool: expert system tool. There is an operator whether you need to connect one piece of information with another piece of information. Has outputs: Bayesian Estimation, Processing factors, SPICE, (and one more)

Purpose of the session:

Q: If you are developing a certain class mission, you have to follow the traditional model? JPL has flight practices for a given mission. What is unique about the SmallSat mission is what we should focus on.

A: We will not be able to rely on the hardware with the current components and we can’t survive in some environments and some science and return missions with SmallSats as they are now. We can’t answer some of these questions. We can’t even evaluate the radiation issues – too complex.

Q: Who will pass TEMCO using the SmallSats?

A: Right now we can’t find radiation-approved parts inside NASA, have to rely on commercial.

[From white board]

* Connect people, not data
* What is the nature of the lessons learned
* Can we use existing data mining tools to harvest lessons learned
* We need a vetted bank of information (process?)
* Compliance matrix (state intended and how have they retired it)

How to collect lessons learned:

* Symptoms
* State of the system
* Mitigation
* Can it be generalized?
* Vague lessons learned can be transformed into implementable action with interviews

How to collect lessons learned:

* Templates
* Self-assessment questionnaire
* Large database require search capability

The first step is to understand the nature of the kind of conditions the spacecraft will find itself in. There is some information available in the public domain (Google scholar, papers). Low hanging fruit. Apply these to the NASA database.

Different tools provide different information. Make a space where we know the information can be trusted. These can be the different documents that we are pulling from different disciplines. Also need someway of peer reviewing each other. We don’t know which ones are useful. Once you get the data how do you vet that its true? What is the vetting process for this?

Need effective communication with the supply chain. This is difficult to figure how it instructs the user.

Q: Different mission developers have their own way of flying successful parts. Are we saying that if a certain vendor isn’t using our process, we aren’t going to use their part?

A: No.

Should there be a vetting rating for parts?

Consider a compliance matrix form to facilitate how to specify quality requirements for classes B, C, D. For the quality portion of this you might have why you decided to put your resources in to a certain part or why you selected another part.

We need specific information from the people who had the experience with the vendor on where the relationship went wrong so that the lessons learned becomes actionable. Provide test results, etc.

We need to identify why this thing happened, what wasn’t done that could have mitigated the problem.

What is the description of the lesson (what are the symptoms), when should I look for the lesson (are there precursors), and is there a mitigation?

How can you generalize specific lessons learned that can help more people? University and small companies might not be so willing to give up their secret sauce. Think about a consortium that will have a stake in this. Information sharing is a discussion topic – how to protect it, how to capture it.

Will an open source document be created? Creating a standard versus guidelines? A standard is probably not the way for SmallSats. Will there be NDAs and liability issues?

Are templates the way to go to collect lessons learned? Need to make it searchable, customizable, and searchable for large databases.

We should search around to see if someone has solved the complex search issue.

Are we committed to putting resources behind this? Spend a couple of hours a week on this to see if we can figure out what kind of system this can be? Expert system or predictive system? They are very different systems.

**Closing thoughts and comments for Day 1**

We need an orderly way to figure out how to capture the lessons and share them. And we need input from the users of the tool or whatever it is we come up with. It’s a pretty diverse group. Probably too early to present what we are thinking about. We need a description of the lessons learned tool that we are thinking about before we send it out to users.

Can lessons learned information be captured on the fly? This will guarantee that mission teams capture everything.

Are there too many facets to this activity? Need to make it into a manageable slice. GFSC Gold Rules captured Apollo lessons, we have SPOON, and an SE doc.JPL has flight project practices that are like the Gold rules. Daunting for SmallSats.

People who use this tool/document we come up with - people don’t want to go through a huge document line by line.

Q: Is going through the flight project practices useful to other SmallSat missions may do?

A: Yes, probably.

Don’t we want to accept higher risk to control cost? We are being told to get our costs down. If you go down to Class D you can use a level 3 part. You can mix parts levels.

Part classes aren’t relevant now. They are detached now. For radiation it’s harder to meet that number. It’s easier to buy the rad hard part. Some of our COTS lessons learned haven’t been captured from earlier days of using COTS. We’re mixing everything together, but all the procedures are still the same.

There were areas where they didn’t use the standard documentation system for ASTERIA. Always incurring risk since that is normally not what they do. On big teams, its more important to have that documentation. On ASTERIA they could communicate easier using

SharePoint and spreadsheets. Whose spreadsheet is the most current spreadsheet? It’s not always easier to toss out the old processes.

We have Google docs now for collaborative things and it comes in handy. SharePoint is used as well and has been made such that there is configuration management for documents.

**Day 2 – Thursday, November 8, 2018**

**Day 1 Debrief, Day 2 Plans, Open Discussion**

The key take home is that we have general agreement that we need an approach to try to take design and development best practices and given mission constraints, zero in on a user friendly framework. How do we make this happen? We need to make it consistent.

It’s important to start with lessons learned that we try out on processes like the cube. We need sample lessons learned. How do you vet the lessons, investigate them so that they are actionable, and take them a step further and try to make them general for other users. Are we putting the cart before the horse? Do we have lessons learned? We need to capture the lessons learned now if only as a sample to figure out a process/tool to share.

SwRI lessons learned for IceCube is a good start. Having a format to capture lessons learned in the right way will help. There are probably templates available.

If the presenters from yesterday (a lot of successful CubeSat missions out there) capture their lessons learned that will be good. Also include the GSFC Gold Rules and JPL’s Flight Systems Practices.

Send recommendations on temples and places to refer to capture lessons from our past/current missions. (Action for MikeJ)

Other Efforts Relevant to SmallSat Mission Confidence (30-minute presentations, 15-minute discussions)- What activities related to SmallSat mission success are being executed by the NASA Electronic Parts and Packaging and the NASA Academy of Aerospace Quality and the NASA Academy of Aerospace Quality? Can we leverage each other’s activities?

**Key Speaker: Michael Campola- Goddard Space Flight Center: NASA Electronic Parts and Packaging (NEPP)**

Ongoing work at NEPP will be presented and how these activities play into efforts from an agency perspective.

Commercial space and small missions are driving the use of non-traditional electronic parts.

If you are trying to manage your risks you need to consider programmatics, technical design, radiation (reliability).

Need to understand a device’s failure modes and that causes you to understand your confidence level.

Dealing with modern electronics – need new capabilities to win work

People want success and to ensure that things work. Need to know how you are using the part and in what environment. Can we skip the Application/Environment black cloud?

EEE parts are available in “grades” based on how are you using the part. $900M dollar industry, only 1 % is based on military applications.

Is the fab manufacturer will to work with us to determine the variation then call it quits or throw in some margin? Trade margin for knowledge. Changing the process leads to a new approach.

Can you live with the system actually working, we cannot calculate risks – failure is an option.

How do you accurately predict fault tolerance? Where is this fault tolerance being implemented? Need to validate it in different ways. Maybe too much for us to afford, so do we need to validate our own fault tolerance? Is losing memory tolerance alright for short missions?

We are taking the 5x5 matrix and giving it depth.

During the design cycle there is an additional component – highly variable in the selection guideline. Make a notional EEE Parts Selection for each application. Provide a shopping list for the particular application, a preferred parts list.

Each agency has a list of shared parts that need to be shared with the community. How do we share information across the community, not only lessons learned?

GSFC is working to classify class 2 parts. We do not want to be in the business of telling what parts are correct for you. NEPP is not responsible for how the parts are implemented.

Take all the decision risks upon ourselves. It is in the government’s interest to share this information with the world. People do not have the funds to figure everything out for themselves. Key to know who the vendor is, so we could leverage from them.

Regarding relationships with suppliers, can you pay a little more for a given board and that gives us the opportunity to participate in bi-weekly meetings, being given more insight into change notifications, opportunities to make recommendations for future versions (controlled variance). The vendor would look out for us more. Not sure how much this subscription service works or how much it costs.

Model based mission assurance lets you document assumptions and models for systems responses. It also lets you track availability and reliability.

The document needs to be alive, and useful to new people and people who have built many spacecraft but who may be using new electronic parts.

There are opportunities to propose things to NEPP.

<https://Modelbasedassurance>.org (at Vanderbilt)

**Key Speaker: Jeanette Plante- NASA HQ: NASA Academy of Aerospace Quality**

Alice Smith manages the NASA Academy of Aerospace Quality program at Auburn University. The program provides training on quality assurance topics. There are now over 50 modules and they try to align the NASA lessons learned and case studies with their modules. They are currently trying to arrange a curriculum from their modules.

NASA QA Policy model being proposed by Jeanette:

* Things not to do that could get us in trouble (prohibited materials or other design features and technical specs
* Process controls: best practices around production processes
* Quality verification methods: how do we know something achieved our intent. What kind of tests can we do for this?
* Quality limits: these are negotiable, depends on what your pass/fail criteria are.

Took the AS9100 QMS model (adopted by NASA and our supply chain) and overlayed the SE documents onto it so that it aligns with reviews. This gets the quality community to the table with the project earlier. This is an industrial level model and doesn’t apply to the SmallSat model. However, a lot of what we do early on in I&T and other process might be applicable to the SmallSat community though.

AAQ is a list of topics, and doesn’t really reflect where we are going.

Amateur users: those with very little corporate knowledge, little awareness of quality engineering. Learning everything the first time. They can benefit from plug and play.

NASA Partners: harder requirements ‘must deliver’; low turn over

There are concerns about how the AAQ modules are written and for what audience.

The earlier lead for the AAQ activity provided seed money to Auburn University. The content comes from inside and outside of NASA. Whoever could provide content was invited, so it’s all volunteer. No one has really reviewed if the content is appropriate for the level of the user. Jeannette needs to review the AAQ more and figure out how to better get it reviewed. Need to make sure that someone with not a lot of time can read it and get something from it.

Technical review of the AAQ is a priority.

Would this group be interested in participating in the AAQ Workshop for next year? It could be more of an SE workshop and have quality be a smaller part.

Going forward, would there be more utility if the content addressed the 7120.5 community?

Q: Is the SE / QA model that Jeanette is proposing, new?

A: Yes. Just recently brought on a quality person from LaRC who is also an SE. This will also work with MBMA.

Initially it was said that SE over QA wouldn’t scale down to CubeSats, but now the thought is that the good ideas can scale down to SmallSats. Does depend on how much corporate knowledge you can retain.

Looking at expanding the SE portion of this, so let her know if you want to participate.

Knowledge Sharing- What is the status of knowledge sharing activities? What information and resources should the SmallSat community exchange to increase mission success and reduce overall development costs? And importantly, what systems and processes can we establish to facilitate knowledge sharing among organizations that may compete against each other?

**Key Speaker: Craig Burkhard-NASA Ames Research Center**

The S3VI is managed from Ames, sponsored by SMD and STMD.

S3VI charter is to:

* Advance communications on small spacecraft work across the agency
* Provide US SmallSat research community with mission enabling information
* Maintain engagement

Q: Are there any access controls with the databases?

A: No, it’s all publicly available.

From the NASA SmallSat Missions database, we could link the mission with blocks inside the Cube as mission examples.

Q: Is there any place where we can capture sub-systems level success stories?

A: Yes, SPOON captures that information.

Request that C. Norton be in touch with Mike Johnson on how the SSRI can help with the PI lessons learned workshop.

Recommendation from this group is to make it a required deliverable that each funded project deliver a lessons learned document. Talk with C Norton, C Baker, A Martinez.

Consider a Yelp or Google review type app to rate parts. Yes, the team is working on integrating this into the SPOON records.

Key Speaker: James Cockrell NASA Ames Research Center CubeSat 201

Spent two years in the CubeQuest Challenge ground completion. 13 original competitors that self eliminated based on standing with their competitors.

Wanted to disseminate how to propagate NASA best practices and how to build a higher quality CubeSat for those not with NASA. What can we do to propagate NASA lessons learned and disseminate them to universities and commercial entities who are promoting small spacecraft?

CubeSat 101: shows ho to get your SmallSat onto a CLSI launch

CubeSat 201: covers Pre-phase A to

A lot of low-hanging-fruit can be applied to SmallSats that can be shared with universities. Is there a way to quantify what you can most expediently and cost effectively for SmallSats?

Need to identify the existing bodies of knowledge first!

Cost benefit analysis? Where are they (universities STPs, CubeSats) are putting their money and into what categories? Knowing how much they spend on their SmallSat will be helpful. We haven’t asked for that information yet and it might be spotty. Universities don’t track labor.

Can we scale recommendations/ lessons learned to the SmallSat level? If we can quantify this a little by figuring out what we spend on analysis, we gain somewhere else. This might not be possible. Student turn over affects the university projects.

Harvesting the low-hanging-fruit will have some immediate beneficial affects. Will report out at next SSRI TIM.

**Key Speaker: Allyson Yarbrough, Craig Langford- The Aerospace Corp: Alternative Parts Database**

There is a lot of knowledge base to this community since the Class A community doesn’t take risks. Need to figure out a way to better understand the reliability of these parts. Working with LASP.

There is a lot of duplication of effort and the government pays for testing of these parts many times over. Aerospace has a relationship with multiple government organizations. They want to migrate this alternative parts database to a larger forum. Hope to go live the first quarter of next year. Their goal is to form a consortium of people who want to contribute parts data. If there are parts that people want to use, Aerospace can test them in their chambers.

Q: How will you handle recalls, software bugs, if someone learns something negative about the part or company?

A: Aerospace would list a forum where people can post their experiences with a particular part or vendor.

Allison has gone to The Aerospace Corporation general council to ask if there is an issue once they have the results what can be done. They just need to state their observations, but don’t make an assessment and recommendation on whether or not to use the part.

Q: What kind of radiation?

A: Looking at high-energy protons. Looking for single event upset and degradation. No heavy ion testing has been done yet.

For alternate grade – their definition is anything that is not a mil or space upgrade part.

Talked about different classes, but you can find different parts (Diodes) that outclass class A parts.

Total dose testing has been done. Didn’t see any failures yet in comm parts so far. Total does not monotonic, depends on the technology.

Sometimes its easy to process to approve a part – trying to bin things. Just don’t want to discount things.

Aerospace will seed with their data, TID or single event will be captured. Some parts of the database will be small, but would like the community to share test data. The website is the moderating forum which could be more tutorial and discussions. The first priority will be to get the data out there. Also interested in parts to let the team know that they have flown, but that no radiation testing has been done.

The EEE parts data goes past the SmallSat community and they’ll share with multiple organizations. If the SmallSat community will share their data, then Aerospace will figure out a way to share the other community data (large sats).

There are small companies that look at Aerospace as a competitor since they compete for small sat work from NASA.

LASP Tour, Lunch

**Knowledge Sharing, continued**

**Open Discussion, TIM-5 Plans**

JPL checks with their vendors on whether they have reviewed for reliability.

The Aerospace Corporation has found that some of the JPL data can’t be shared because of propriety issues. To promote sharing of knowledge maybe JPL can sanitize lessons to share them.

Doug Sheldon was the TAC host. (To be taken off line.)

Some of the data that the Air Force paid for - how can it be shared with others? Aerospace to check on this.

JPL has an FTE invested in translating 50K parts to sanitize and share them.

Are all the Aerospace parts being tested published in the same place? Is Aerospace capturing these? It’s all IEEE RAD home. These are compendium posters that are already sanitized. This comes from GSFC/NEPP.

The off-set voltage and other background data is available, but can’t be published. Need to figure how to incorporate the raw data with it. Does NEPP have raw data? It has the full test reports, what changed and what didn’t. Some background data wouldn’t make sense to everyone. You need more information to understand why certain things were done. RAD Central can tell you how some of these tests were done.

It’s hard to know what you’re going to get when you search RAD Central.

Does it make sense to figure out what kind of data you need to have? Johnny (NEPP PM) is trying to get to the point of what kind of information you need. There are commercial parts in NEPP. Really need to look at the compendium, which tells the name of the person who performed the test so you can reach out.

Are we just reinventing the wheel here or should we expand the NEPP database and have them host some of this?

Path of acquiring government data is ok, but how do we share private data? Never a huge urge to really keep parts data private. System level data is different. Could be that we’ll work these commercial entities one by one to get them to share their data. If companies knew that there is a place to share their data, they would be interested.

There probably has to be an incentive for companies to share their data. This is probably a closed community. A tiered structure where universities just need to share a few pieces of data as their pay in. In the last 10 years Harold tried to get people to contribute to RAD Central and no one wanted to contribute.

Working with LASP on a place to post it. How would the tool work for hobbiest to professional people?

It’s not reinventing the wheel to put data into your fields. NEPP is trying to push out everything that can get approved on NEPP.

AI: M Campola will send C Langford a list of links where radiation is being shared. Mike will also note where there are hurdles to entry and will try to overcome them.

AI: Harold will see about sanitizing content in JPL databases.

AI: Allison to pull some thoughts together on how to initiate a crowd sourcing (citizen science kind of work) opportunity that puts this issue out to the community to help get some momentum behind it.

Should we coordinate a survey? Should we send out a survey about data sharing with questions such as: what are your concerns; under what conditions would you want this to be an initially closed group; what memberships would you want to be part of.

Can NASA set up a CRATA or something to do testing for people at a discounted rate as long as the data is shared with NASA? Good idea, but we probably don’t have any bandwidth with NASA’s own testing. NASA test facilities are closing down. National Academies - ‘Testing at the Speed of Light’

OneWeb: What is the ask? What do we want out of this? Can we distill this down to 4 or 5 bullet points? Still not clear about what is being asked. OneWeb can take this back to the industry community. Need to think about these points but one might be:

What type of process do we need to spin up to get the test data that you have?

AI: MikeJ to work with Catherine, Pat, and Harald to go through the meeting minutes from the TIM’s and extract these 4 or 5 questions to industry.

The quid pro quo is straight forward in that wikipedia could be an example of what this sharing could result in.

Since test facilities closing down can we leverage more of the universities? Could we incentivize them to do some of the testing? (University of Maryland, Center for Advanced Life Cycle).

Knowledge Sharing, continued

There is concern about how unstructured the existing lessons learned data is. The NEN is difficult to wade through and some TIM-4 participants are pretty sure that they’ll never use the NEN lessons learned the way they are. We need a way to navigate them and cut down the unnecessary chatter. 1) We should figure out if we can capture certain metadata within the lessons to enable people to get to the data faster and 2) determine under which phase of the project can we accomplish this - formulation or operations.

If we put some thought behind it we can find some categories in which to bin lessons. Can we come up with orthogonal categories? Its possible to teach a user to search by categories, and not by whatever comes into their head. Aerospace has lessons learned database, but sometimes its quicker to just talk with someone.

There are a few distillations of lessons learned like the Gold Rules. Tailoring matrices make a judgment call on what is more important than others. Consider the use of natural language processes to help better inform results of searches that are returned to a user so that they are more applicable to the user. Ian Coldwell is the person to contact regarding the natural language tool.

We found that the fidelity of the information isn’t there. If we have a natural language query system, users still need to be trained. You have to ask for the system to be trained for the query. Its very powerful and they have a high degree of accuracy in their results, but its not like Google. There is a huge amount of work behind the scenes. LaRC is working on this kind of thing with IBM Watson, but we aren’t sure of the status. If its the right tool we might have to have 10 FTEs engaged in the natural language activity to get the lessons learned out.

We don’t have a situation where we have big data, at least in radiation. When you look though the lessons learned, a human can figure out a few things, but machine learning can’t take a person’s name for example, and find information. Data mining is much easier with machine learning. At least as a necessary step, we should get some guidelines from diverse sources as candidate lessons learned, throw a sample set out on the table, then that will help us to identify patterns like key words and algorithms.

AI: Jim Cockrell to take an action to see how these fit into a template and what kind of sorting can be done. Jim to find lessons learned sources for the group.

Has anyone spoken with a professional category person?

In addition to the lessons learned environment, it would be useful if the lessons learned could be tied into the Cube.

We should set up a sub-group on how to mine the data. How do you make all the data that is out there easily accessible? (J Cockrell, D Perry, M Johnson, C Burkhard, C Venturini)

How do we tap into a larger group that is collecting and organizing lessons learned?

Q: Has GSFC small satellite group done a GSFC CubeSat lessons learned?

A: Yes, but the value was so so. Was so so because the activity was organized by someone not associated with the small satellite activity and they didn’t talk to the right people.

At JPL, Young Lee, runs a small satellite lessons learned forum and its coming up in a month. Maybe they can try something there. Would want to get Earth science, RainCube, and others to participate.

What will help is if we all speak the same language on these lessons learned.

Are we proposing that the next CubeSat missions fill out a template that Pam Clark (JPL) put together that is being passed around? Allison to ask if the lessons learned theme can be added.

Is what is going on at JPL, something that can be shared with the whole community? Student projects might also be able to use the JPL lessons learned template.

AI: A Donner to ask about sharing the template outside JPL.

Lessons learned can be collected throughout the life cycle.

The study committee for the N-Cube design needs help. Volunteers? M Swartout, A Yarbrough to help.

We could start to identify typical missions with different parameters.

AI: M Campola to attempt to categorize different missions into the Cube. Consider a check box on what 3 parameters you want to look at once.

AI: OneWeb will offer to be a liaison with industry.

AI: J Plante will create a compliance matrix and get more content on AAQ.

Closing thoughts:

* Good to hear all the lessons learned. Better perspective now.
* Good idea to try to solve common problems by getting the information into one place.
* There is a lot going on all over that we need to take advantage of.
* Never know whom you’ll run into. Its priceless to meet different people.
* OneWeb extends an invitation to visit its Toulouse or Florida facility.
* Until the government incentivizes their contractors, identify some specific topics, it will be slim to have support.
* Some groups want to share their lessons, but want others to share in return.
* We need assistance from HQ to define what the order of our task is.
* Will JPL try to internally make a useful, searchable database? If so can they share?
* Members are happy we didn’t revisit the same topics at this TIM. There is something new here. With the small size of this meeting everyone is heard.
* We all have the same struggles and want to do CubeSats better. We just got Class D, now we have sub-class D. Can this be captured in a SEMP template? 1) tailored SEMP for Cubesats , 2) tailored S&MA for Cubesats, and tactics to keep a sanity check.
* We need a database with the right parts, not all the parts. If we have 5 or 10 radios and computers that we can choose from is that a good number.
* Report out on the action items will occur at TIM-5.