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A Mission and Quality Assurance Perspective on Radio Amateur CubeSat's

There is a false impression and a fabricated perception that building, launching, deploying and operating a CubeSat is easy, a proverbial walk in the park and that any person or institution can achieve it.

This fabricated view of designing, building and deploying an amateur radio CubeSat is completely false and incorrect. It takes a dedicated team of technical talented individuals following an appropriate planning and execution process to accomplish it.

In addition to the traditional system engineering processes, there is an emerging discipline defined as Mission Assurance. Mission Assurance includes a disciplined application of a combination of risk management, quality assurance and management principles to achieve a desired outcome and success.

Mission Assurance Overview

The definition of Mission Assurance is the disciplined application of proven scientific, engineering, quality, and program management principles toward the goal of achieving mission success.

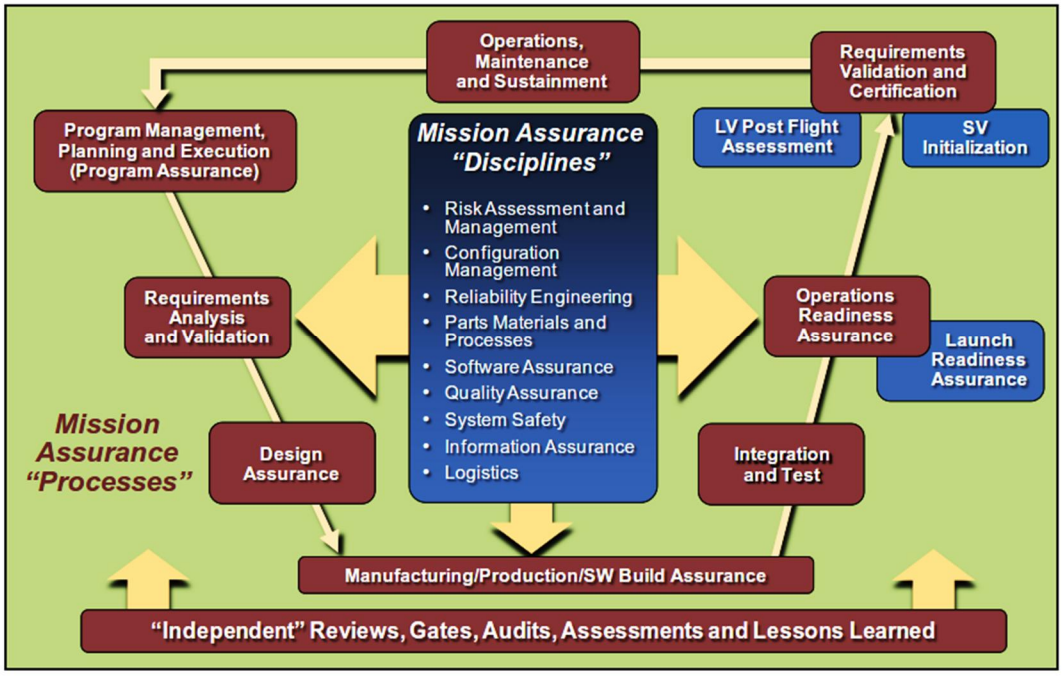

Fig 1 – Mission Assurance from a System Engineering Perspective

There are undisputed advantages and many documented case studies of success achieved in following a Mission Assurance process. Unfortunately such a process is completely out of scope for small organization and individuals designing an amateur radio CubeSat from a time and cost perspective.

Looking at various standards, it is a known fact that there are currently many commercial aerospace and military standards including specifications available for Satellites. Except for the standardised dimensions for CubeSat's and some guideline documents for developers available no dedicated test and qualification standard is available for amateur radio CubeSat's.

This highlights that there are some challenges for small amateur radio design teams and individuals, to identify the right amount of Mission Assurance aspects and best practices to be applied in order to determine if these activities are likely to have a big payoff.

Mission Assurance Considerations

In light of the above, there is considerable pressure to achieve mission success while lowering lifecycle costs in designing launching and operating amateur radio CubeSat's. Design teams have to seek the optimal balance between these two challenges.

In defining a CubeSat mission the mission requirements should be clear. The following three areas as a minimum must be considered:

- Defining the objectives of the CubeSat mission
- Tailoring the design process to achieve the mission requirements
- Defining potential problems and conflicts including possible solutions to reach the above goals being the mission assurance aspect of the mission.

The following depicts the *Kletskous* design, test, qualification and acceptance process as a minimum to achieve the design goals.

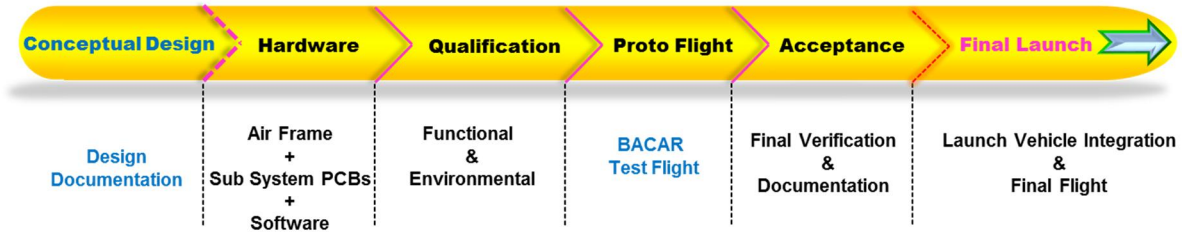

Fig 2 – Tailored System Engineering Process

Design Reviews

Design reviews are one of the oldest known techniques for identifying design challenges and problem areas. The advantage of implementing such reviews is that it identifies design weaknesses, allows for alternative approaches to the design and improves the overall quality of a design.

Model Opinion

In order to be able to perform the necessary integration, test and qualification work the following three models as a minimum are required:

- Engineering Model - typically a Fatsat (integration set-up), which is flight representative in functionality being the various subsystems in a workbench configuration.
- Qualification Model – an updated model from the Flatsat environment which is in fit, form and function the final product, being hardware & software tested and environmentally qualified,
- Flight Model – being the final model completed for flight.

Functional and Operational Testing

As part of the Mission Assurance aspect of the design of *Kletskous*, qualification is of the most importance. Test and qualification standards for CubeSat's are currently non-existent. The only way is to study large satellite standards and derive some requirements from there.

Functional testing of hardware in an environmental chamber is most ideal including the ability to perform software testing with automated test equipment to test sub and full systems. This kind of environment is costly and out of reach for small teams and individuals.

Alternative ways needs to be found and design teams need to be creative in order to be able to test to the best of their ability to ensure that identified hardware and software risks are mitigated.

Environmental Testing

The space environment is unforgiving and apart from the functional testing required, proper environmental testing is of most importance.

As a minimum, the following environmental testing is required to ensure that the CubeSat will survive during launch and operationally in outer space:

- Vibration
- Shock
- Acoustic
- Temperature

Documentation

The Kletskous design philosophy pertaining to documentation is to keep documentation to an absolute minimum to execute the mission successfully and safely.

The following criteria was identified in order to achieve this objective:

- A Specification and Interface Control Document (ICD)
- Generate plan including results for hardware, software and environmental tests for the CubeSat
- A complete Master Record Index (MRI)
- Additional documentation as required by the launch agency

In generating the above list of documentation, the following requirements as a minimum should be used as a guideline for completeness purposes:

- Objective evidence in the form of identified documentation required
- Traceability from requirements through testing and results obtained
- Should be auditable without difficulty

In conclusion

In the Aerospace industry the disciplined application of proven scientific, system engineering management, quality assurance, and program management principles toward the goal of achieving mission success have been proven without doubt.

Mission Assurance entails by far more than the traditional project management, quality control and quality assurance aspects in the engineering environment.

This overview is by no means conclusive and offers a general viewpoint only in order to obtain an insight into the challenges that faces amateur radio design teams or individuals and how Mission Assurance aspects could contribute to the overall success of building a CubeSat.

It should be clear from some of the basic Mission Assurance aspects covered in this paper that CubeSat design teams could learn a significant amount from these principals to achieve success in building, launching, deploying and operating an amateur radio CubeSat.

Further Reading

1. Mission Assurance Guide. The Aerospace Corporation, Technical Operating Report TOR-2007(8546)-6018 Rev.B
2. CubeSat 101: Basic Concepts and Processes for First-Time CubeSat Developers. Rev dated Oct 2017
3. The Challenge of Assuring Space Mission Success. William F. Tosney and Gail A. Johnson Rot, April 11, 2016