

UNIT 1.5

Engineering Challenges in Incorporating Life Sciences Experiments into Flight Hardware

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What do project engineers need to understand besides engineering?

- Engineering is only part of the project.
- Engineers need to understand all parts of the project in order to be able to perform their function.
- Life science flight projects have many parts that are all required to work together seamlessly in order to be successful.



What are the functional parts of a life sciences flight project?

- Science
- Engineering
- Contracts
- Verification
- Operations
- Safety & Maintenance
- Configuration control
- Risk assessment/tracking
- Budget assessment/tracking
- Schedule assessment/tracking
- Export control
- Management

What does an engineer need to know about each of the project functions?

NOTE: This presentation is focused on science and will only touch briefly on other subjects

- Contracts – Need to Understand:
 - Requirements – must be written so they are understandable and verifiable
 - Statement of work – how they are written and what deliverables are required
 - How direction is given to a contractor
 - How long it takes to put a contract into place
 - What it takes to modify a contract and what the consequences are of changes to the contract
- Verification
 - How verification is done
 - Who does verification
 - Who approves verification
- Operations
 - Many aspects of crew operations can not be found in requirements documents
 - Must interact with operations/crew early and often in order to provide a product that is useable
- Safety and Maintenance
 - Safety is more a process than a set of requirements, need to understand the process and the resulting requirements
 - It is the responsibility of every member of the project team to prove that it is safe regardless of what the requirements say.
 - Reliability is much more important on ISS than in the past.
- Configuration Control
 - We must understand the system and use it.
 - Getting behind and losing the documentation of what is being done will cause huge problems.
- Risk Assessment and Tracking
 - Not tracking risks and assessing them leads to surprises and embarrassing failures.
 - Need to understand how to assess, document and address risk with mitigation plans, MRB.
- Budget/Schedule Assessment and Tracking – Need to Understand:
 - How the financial system works
 - The task planning, cost prediction process
 - How to create, read, and assess schedules
- Export Control
 - Need to understand the laws, processes, and limitations
- Management – Need to Understand:
 - Who controls what in the project
 - Who you take an issue to for resolution

What is the science requirement for the project?

The entire project team is responsible for insuring that the final product, the science data, has a good chance of answering the research question being asked.

Who in the project is responsible for science?

Everyone is responsible for science. Engineers on the project need to better understand the science mission.

Who should you go to for science help in the project?

- At the highest project level is the Project Scientist or Principal Investigator
 - The PS works on a daily basis with the project manager on all aspects of the project.
 - The PS typically chairs or co-chairs the external science advisory groups.
 - The PS reports to senior management with the project manager.
 - The PS cosigns the science and technical requirements document with the project manager.
 - The PS gives direction to the project same as the project manager.
- At the working level there are typically:
 - Assigned civil servant scientists (science lead)
 - External consultants
 - Contracted scientists

What do the scientists do?

- Develop science requirements
- Oversee all development work (both internal and external)
- Set up and conduct all experiments related to the flight
- Science performance approval
- Consultation and assistance in crew training
- Consult with and provide assistance and direction to flight operations



Training to use the air sampler before flight

INTRODUCTION

What is different about life science from other science that is flown?

Research using living specimens is very complex with a very large number of influencing factors that are hard to quantify and can have very large effects on the outcome of an experiment.

- Very small amounts of seemingly benign chemicals can have large deleterious effects on the living specimens.
- Chamber configurations can have unexpected effects.
- What is done on the ground can be very difficult to repeat on orbit.
- Both hazardous and non-hazardous chemicals can require special containment and handling.
- Environments taken for granted on the ground result in undefined flight requirements.
- Experimental procedures can be complex and require extensive crew training and/or experience.
- The crew must be isolated from the specimens and the specimens must be isolated from the crew.



Space flight specimens and typical ground experimental equipment can have difficulty in the space flight environment.

- The launch environment can cause problems with specimens and mask the experimental results being sought
- Microgravity can cause not only the effects that the experimenter is looking for but also effects that are detrimental to the experiment
 - Inability to feed, sleep, drink
 - Unwanted bubbles in fluid systems
 - Unwanted air flow patterns
 - Unwanted hot or cold areas



How does a flight project (including engineering) deal with the added complexity and uncertainty with flying life science experiments?

- Experienced science oversight of project to the detailed level
 - Engineering needs to work side by side at the detailed level with the science oversight groups
 - Internal project scientist
 - External project scientists
 - NASA science advisory panels
- Engineering must understand that using new designs and techniques on flight hardware, no matter how simple, exposes the project to risk if not previously used on the ground.
- Life science testing is a statistical process requiring multiple specimens and tests. Do not assume a single test will resolve an issue.
- Must develop and test the specimen interface as soon as possible
 - Science Evaluation Units developed that bring the specimen interface to flight level and tested with specimens prior to CDR
 - Qualification unit developed and tested with specimens prior to flight unit delivery
 - Mission verification tests performed with flight unit, flight specimens, and flight procedures prior to flight
- When the effects of microgravity can not be tested or predicted on the ground, a validation flight must be conducted prior to science
- Performing experimental procedures with specimens requires high quality training hardware
 - Life Science Glovebox
 - Unique Experiment-Specific Equipment
- Train all parts of the project team (including engineering and contractors) to understand science issues and processes
 - The purpose of this course is to help achieve this goal
 - Everyone needs to understand all aspects of the project



