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Mission Quality Assurance Virtual Training and Certification Using the NASA Academy of Aerospace Quality

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ABSTRACT

Many educational entities are involved in developing space bound payloads. These payloads are designed, constructed and tested under diverse conditions and by largely "amateur" teams. The Academy of Aerospace Quality (AAQ) is an open-access online resource that provides quality assurance training to students and faculty involved in payload projects. AAQ's goal is to provide assistance in assuring that payloads are "successful" from a quality standpoint. The NASA AAQ is also being used by other, non-academic entities. This paper describes the resources and functions available on the AAQ website and how they can be used by project teams to support the training of their members on quality assurance topics.

INTRODUCTION

The number of small space payload projects by academic institutions has grown significantly over the past several years, and the trends seem to indicate that this growth will continue for the foreseeable future[1]. This growth has also been fueled by the support provided by rideshare programs such as NASA's ELaNa program[2]. These academic projects have characteristics unique to them, such that Swartwout has proposed placing them in a category of their own: "University-class spacecraft."[3] He identifies the following features:

1. It is a functional spacecraft, rather than merely a payload instrument or component.

2. Untrained personnel such as students perform a significant amount of design decisions, integration and testing, and flight operations.

3. The training of students is as important (if not more) than the mission itself.

From these features it becomes quickly apparent that the teams involved in these types of projects are often composed mostly of "amateurs" with little, if any, quality assurance training. In addition, these payload projects are designed, constructed, and tested under very diverse conditions, many of which are not favorable to supporting quality assurance. And though the vast majority of such projects are developed in universities by undergraduate and graduate students, they are now being developed in high schools and even middle and elementary schools.[4]

Swartwout's analyses about the success and failure rates of university-class spacecraft reveal a mission failure rate close to 40%[5]. He suggests that these failures are often due to underestimating the complexity of even "simple" spacecraft which leads to schedule slips in development and inadequate allocation of resources for testing. Additionally, there is a lack of knowledge of critical best-practices for design, assembly, integration and testing that are known to more seasoned spacecraft developers.[6]

In response to these issues, NASA proposed an open-access training platform developed and run by an academic team (namely, the authors of this paper at Auburn University) that facilitates and supports academic teams learning about quality assurance and the best-practices used in the aerospace industry. The result is the NASA Academy of Aerospace Quality (AAQ). This paper introduces the NASA AAQ and briefly describes the resources available through it.

WHAT IS THE NASA ACADEMY OF AEROSPACE QUALITY (AAQ)?

The NASA AAQ is an open-access internet-based academy providing quality assurance training aimed at students and faculty at all educational levels involved in planning, designing, building, launching and operating payload projects for space. These include Cube Sats, Small Sats, Nano Sats, International Space Station, high altitude balloons, rockets, and more. The NASA AAQ URL is http://aaq.auburn.edu.

The academy comprises 50+ interactive, multi-media educational courses for all aspects of quality assurance necessary to ensure mission success. Furthermore, there is a comprehensive list of acronyms and terms, and a searchable list of relevant standards with their links.

NASA AAQ also provides a forum and community for networking and sharing of events, lessons-learned and case studies, and sponsors annual workshops.

The most recent development of the site adds a virtual training and certification system. Using this system, users of the site can obtain a certificate of completion for the courses and/or curricula they register for and successfully complete. Both the content and the passing criteria for the courses and curricula will be discussed in the section describing the Academy in greater detail.

THE NASA AAQ TEAM

The NASA AAQ is sponsored and led by NASA Headquarters Office of Safety and Mission Assurance (OSMA), with participation from the NASA Safety Center and from Marshall Space Flight Center. The project is directed from NASA headquarters by Jeannette Plante, from Glenn by Mike Kelly, and from Marshall by Julie Bilbrey.

Auburn University leads development and deployment of the website. Dr. Alice E. Smith and Dr. Jeffrey S. Smith are the principal investigators from Auburn.

AAQ Expert User group

A group of experts from a variety of academic and non-academic institutions, all of whom work in space payload projects, offers guidance and expertise to NASA AAQ. They are expert users who evaluate and give feedback on the content of the site. The current NASA AAQ expert users are listed in Table 1:

Table 1: AAQ Expert Users

Name	Institution
Alex “Sandy” Antunes	Capitol Technology University
Luke Becker	Johns Hopkins University
Jonathan Black	Virginia Tech
Paul Darby	University of Louisiana – Lafayette
Derek Garcia	Jet Propulsion Lab
Andy Hollerman	University of Louisiana - Lafayette
Iqbal Shareef	Bradley University
Bob Vermillion	RMV Technology Group LLC

The group also meets about once a year to discuss future directions for the project.

THE ACADEMY

The AAQ is built around *courses* and *curricula*. A course corresponds to a quality assurance topic, while a curriculum encompasses multiple related courses.

The courses covered in the academy are listed in Table 2.

Table 2: AAQ Courses

Acceptance Data Package (ADP)
Additive Manufacturing
Commercial Off-the-Shelf (COTS)
Configuration Management
Connectors
Continuous Improvement
Control Charts and Process Capability
Corrective Action and Root Cause Analysis
Counterfeit Parts
Design of Experiments (DOE)
Documentation Management
Electrostatic Discharge (ESD)
Failure Mode and Effects Analysis (FMEA)
Fasteners
Fiber Optics
Flammability
Foreign Object Debris (FOD)
Fracture Critical
IEEE Parts
Inferential Statistics
Inspection Control
International Traffic in Arms Regulations (ITAR)
Introduction to the NASA Quality Program
Mechanical Joint Assembly
Mechanical Parts
Metrology
Micro-Electrical-Mechanical Parts (MEMs)
Non-Destructive Evaluation (NDE)
Offgassing
Packaging and Delivery
Parts Reuse
Plastic Encapsulated Microcircuits (PEMs)
Preloading
Problem Solving
Process Control
Quality Planning
Records Management
Regression Analysis
Risk Management for Quality Assurance

Robust Design
Shelf-Life Control
Software Assurance
Soldering
Staking, Bonding, and Conformal Coating
Standards
Statistics with Excel
Supplier Audit
Systems Engineering
Welding
Wire Crimping and Harness
Workmanship

There are currently two test curricula that were developed by the expert user group. These are listed in Table 3.

Table 3: AAQ Curricula

Curriculum	Courses Included
Project Management	• Configuration Management • Continuous Improvement • Inspection Control • International Traffic in Arms Regulations (ITAR) • Risk Management for Quality Assurance • Standards
Technical	• Additive Manufacturing • Commercial Off-the-Shelf (COTS) • Electrostatic Discharge (ESD) • Software Assurance • Soldering • Workmanship

WEBSITE OVERVIEW

Site Structure

The basic content structure of the site is as follows: for each quality assurance topic there is a course. A course contains different training resources. A curriculum groups multiple courses.

A course is comprised of different types of training resources. The course is completed when the student works through these resources. Courses are publicly available for any visitor to the AAQ site, though only those signed up for the course can receive a certificate of completion.

The available training resources include tutorials, quizzes, and other relevant materials such as standards and lessons learned.

Tutorials form the backbone of a course. They expose students to the topic and can be consulted as needed. Tutorials have been developed by the NASA AAQ team using information from NASA, from other subject matter experts and gathered from the public domain. References are included at the end of each tutorial, in case the student wishes to learn more about the topic.

Quizzes are used to test a user’s mastery of the topic. Quizzes include a variety of types of questions, including multiple choice questions, true and false, fill in the blank, among others. These are also developed by the NASA AAQ team in conjunction with the expert users and other subject matter experts.

A course can include other types of materials that are optional for the completion of the course. These include lessons learned, case studies, and relevant NASA standards.

A curriculum consists of a group of courses. Curricula can be developed by the NASA AAQ team and offered to the general public, or (in the future) they can be created by a team leader and offered only to his or her students. Visitors can access the publicly available curricula but only students can sign up for them and receive a certificate of completion.

User Categories

The NASA AAQ website has two broad categories of users: Non-registered and registered users. Non-registered users are casual visitors to the site. These have access to most of the content of the site, including the tutorials and quizzes that form part of a course, but they cannot sign up for courses and curricula and, hence, cannot receive certificates of completion. Registered users are further divided into two categories: students and team leaders. Students can sign up for courses and curricula and receive certificates. Team leaders can administer groups of students and consult their students’ performances in the courses and curricula they are signed up for. In a future iteration of the project, team leaders will also be able to create and administer their own curricula.

Website walkthrough

The main page for the NASA AAQ website is shown in Figure 1. From this page, users access all the publicly available content of the site. Registered users can sign into the NASA AAQ system to gain access to additional functionality.

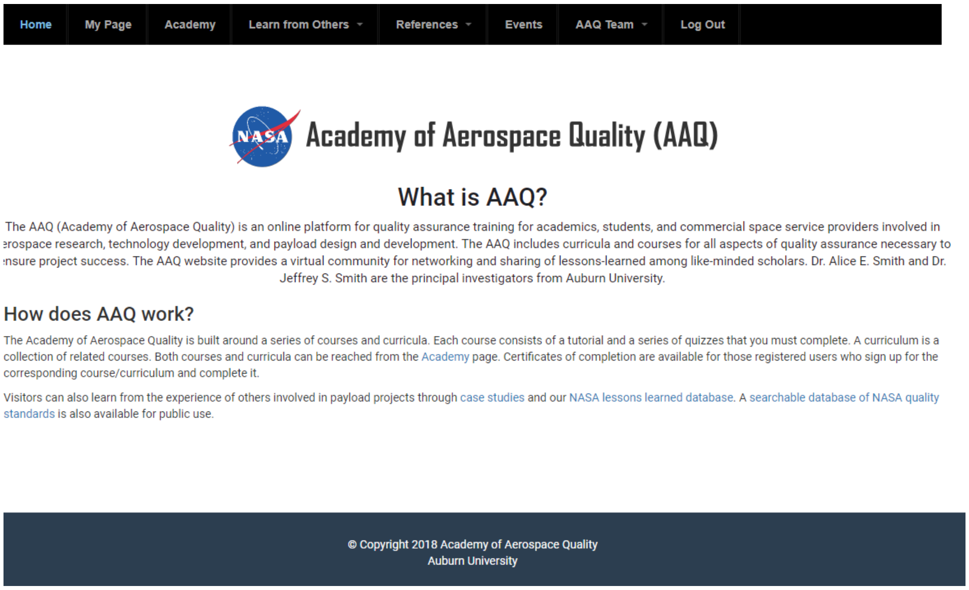

Figure 1: NASA AAQ Main Page

Signed in users also have access to a personalized "My Page" where they can view the courses and curricula they have signed up for, as well as consult their current progress and results. Team leaders, in addition to their own progress and results, can also view their students' results from this page.

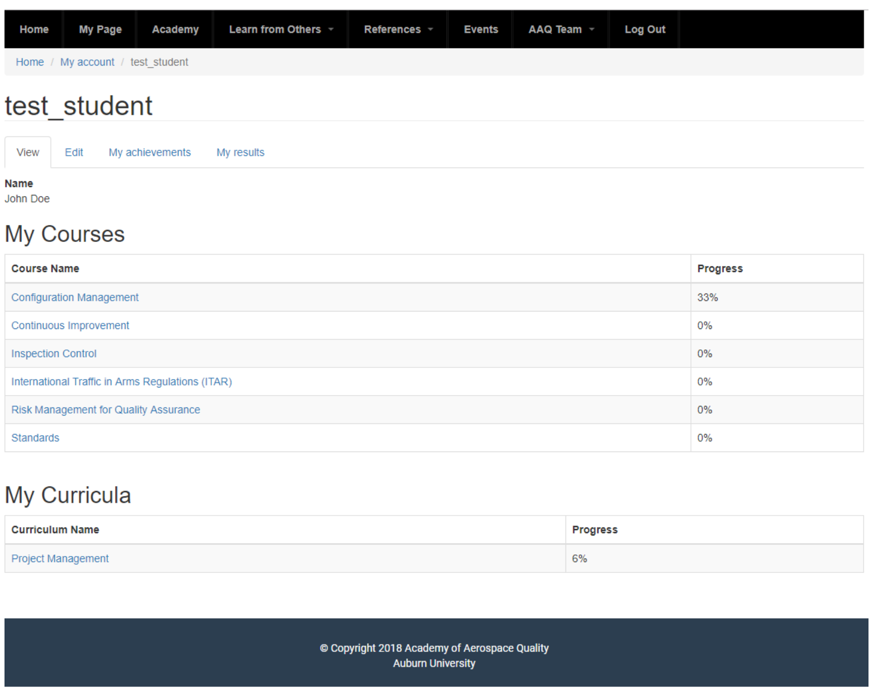

Figure 2: Personalized My Page

The Academy page (shown in Figure 3) lists all the courses and curricula available on the NASA AAQ website. Clicking on the name of a course or curriculum will take the user to the corresponding course/curriculum's main page.

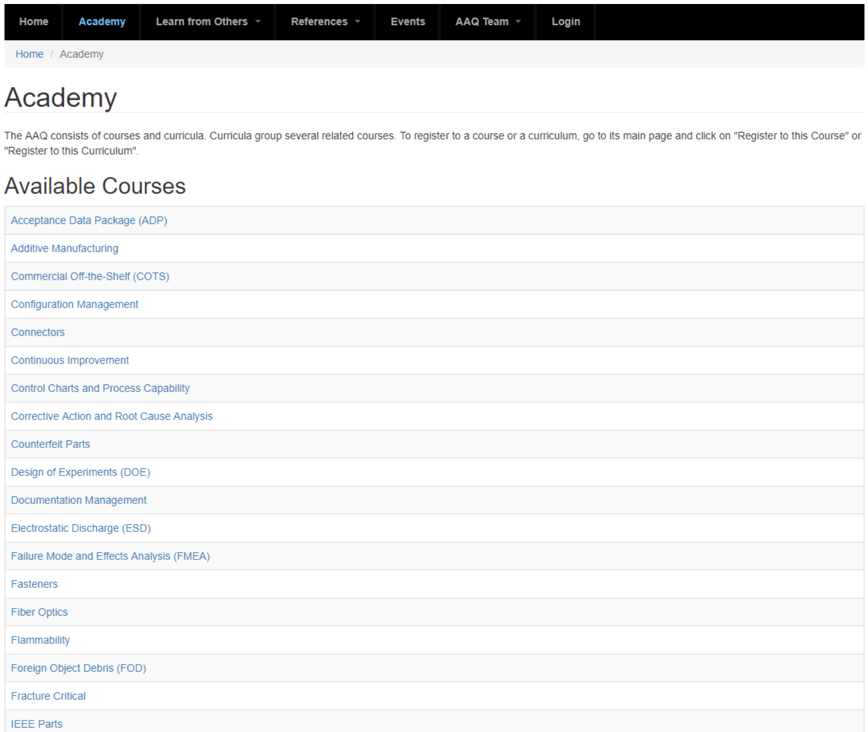

Figure 3: Course and Curricula Listing

An example of a course's main page in shown in Figure 4 (for the Additive Manufacturing course). Each course's main page introduces the course and lists the learning materials (usually tutorials and quizzes) that are available for it. Registered users have the additional option of signing up for the course. Users that have signed up for the course are also shown their current status in the course. Registered users who have completed the course, can access and download their certificate of completion.

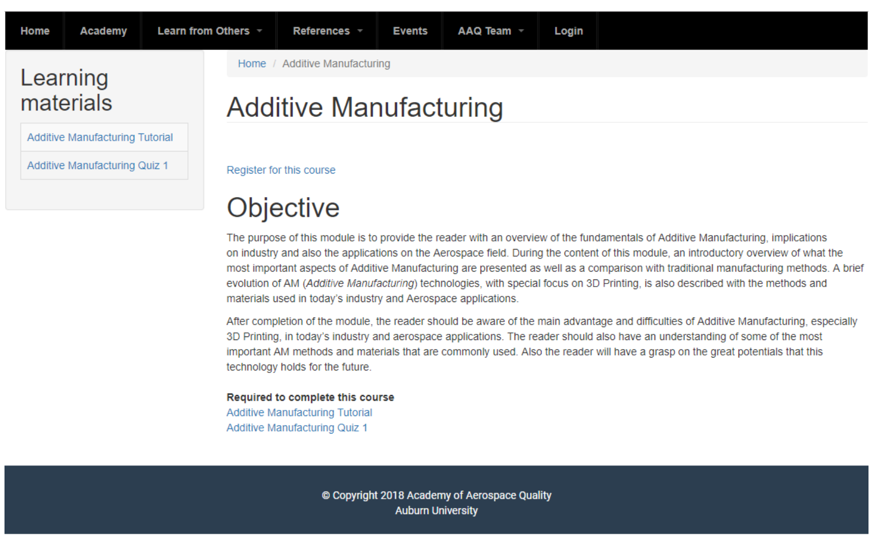

Figure 4: Course Main Page

As mentioned previously, a course consists of a series of learning materials that need to be completed. The learning materials include tutorials and quizzes. Tutorials provide visitors with the required background on the topic and include technical information as well as interactive and multimedia contents. The figures below show screenshots of an NASA AAQ tutorial and an example of the interactive content available in a tutorial.

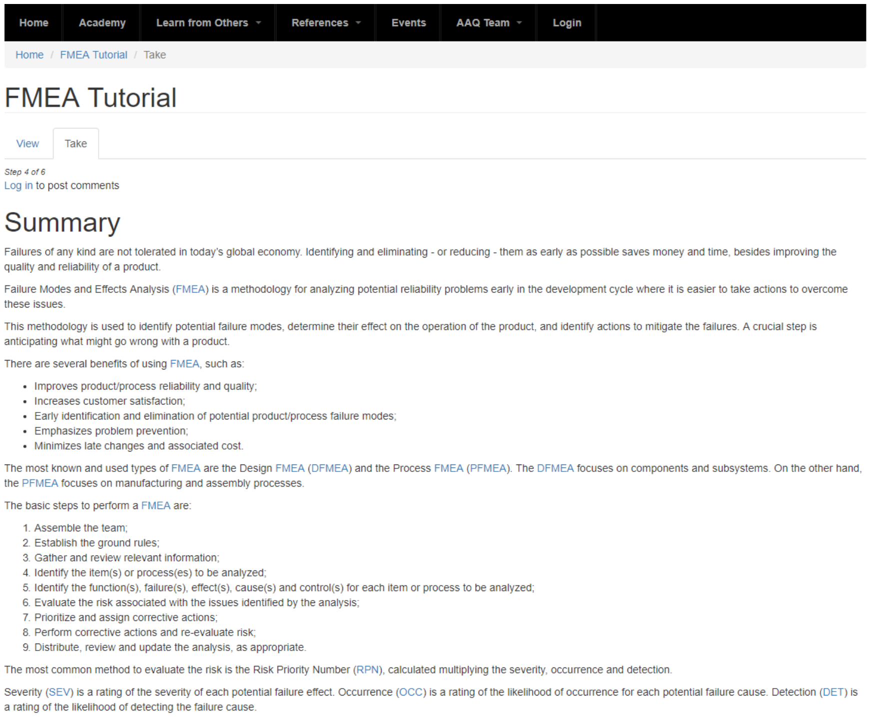

Figure 5: NASA AAQ Tutorial

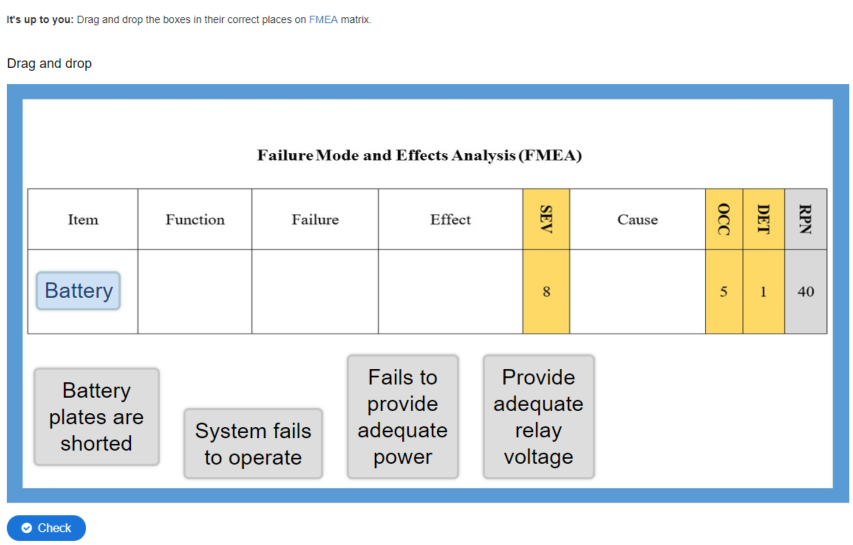

Figure 6: Interactive Content inside a Tutorial

Quizzes allow visitors to test their knowledge of the subject. Passing these is a required step in completing a course. Results from quizzes taken by registered users are stored in the site's database and can be consulted by team leaders. Quiz questions vary in type and include multiple choice, true or false, fill in the blanks, and other familiar types of questions. Figure 7 is a screenshot of a quiz question found on the NASA AAQ website.

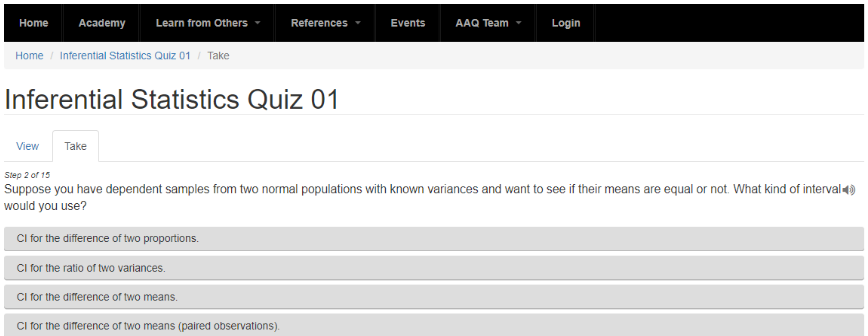

Figure 7: NASA AAQ Quiz

Besides the courses and curricula, the AAQ website also includes other sources of useful information for those involved in small payload projects. Of particular significance is the NASA Standards Search App. This app allows users to search and filter through a list of over 350 NASA standards, and access the documents directly from NASA's websites (see Figure 8). Another valuable tool is the lessons learned database, which contains over 120 lessons learned curated from NASA's databases which have particular relevance to the topics contained in NASA AAQ (see Figure 9).

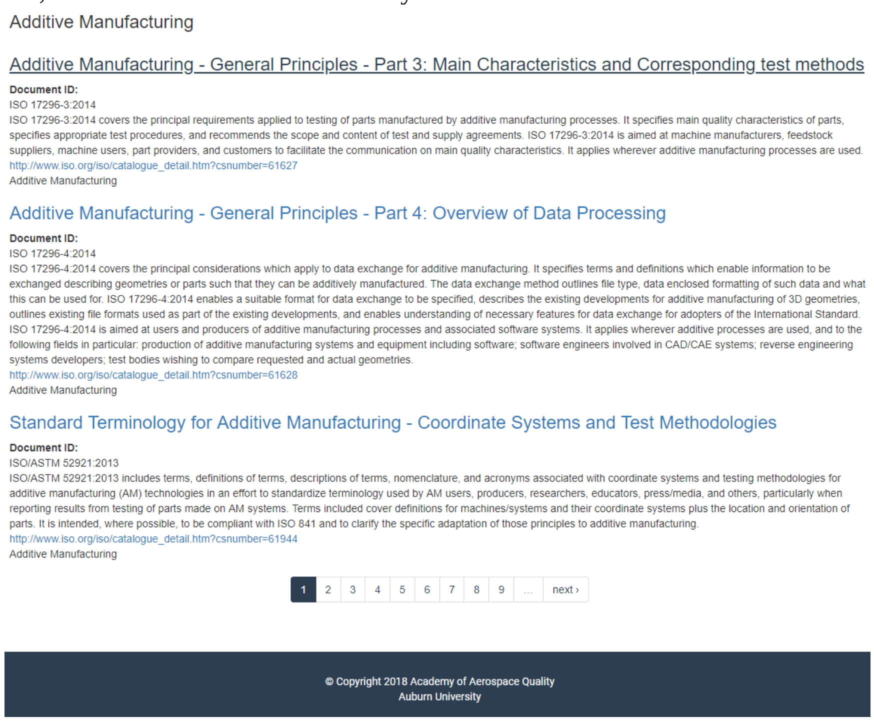

Figure 8: NASA Standards Search App

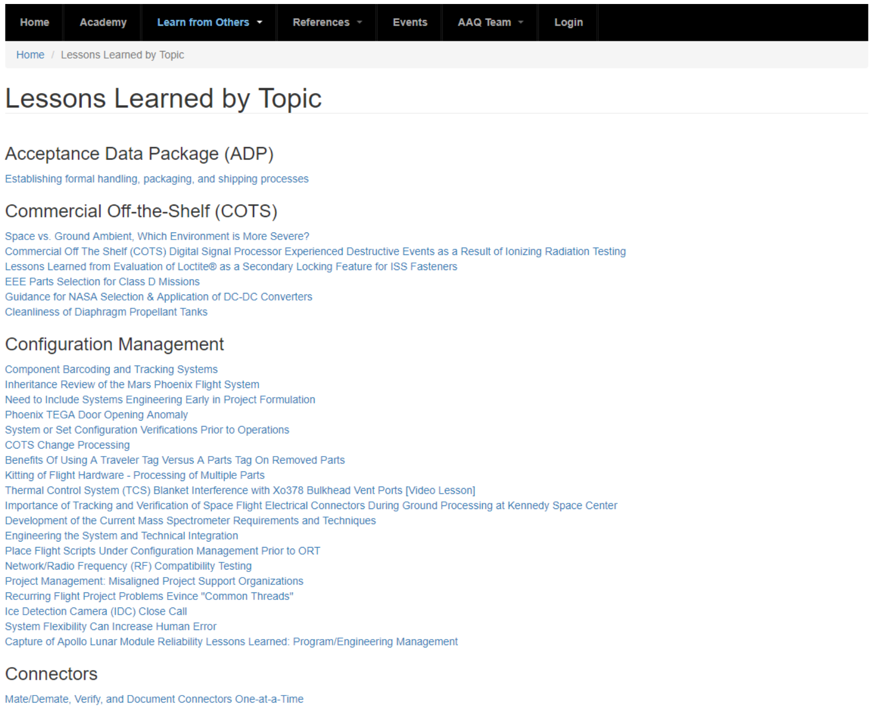

Figure 9: Lessons Learned Database

The NASA AAQ holds an annual (subject to available funding) workshop where those involved with academic space payload projects can meet and exchange experiences and best-practices. The oral and poster presentations from these workshops as wells as photos are available on the “Events” page of the NASA AAQ site.

CONCLUSIONS

The NASA AAQ represents a valuable resource for all those involved in the development of academic space load projects. It can be used either as a simple tool for learning about some specific quality assurance topic, or as a comprehensive training platform where team members can complete certain required training curricula and team leaders can keep track of their student’s progress. In addition, NASA AAQ’s annual workshops offer a forum where those involved in these types of projects can meet and learn from others. This is an ongoing project so not all of the courses are fully developed but the NASA AAQ grows in content and functionality every year.

Acknowledgments

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