

# Infusing Training into the Documentation and Culture of Ares I Upper Stage Design and Manufacturing

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*Abstract*—In roughly two years’ time, Marshall Space Flight Center’s (MSFC) Mission Operations Laboratory (MOL) has incubated a personnel training and certification program for about 1000 learners and multiple phases of the Ares I Upper Stage (US) project. Previous MOL-developed training programs focused on about 100 learners with a focus on operations, and had enough full-time training staff to develop courseware and provide training administration. This paper discusses 1) how creation of a broad, structured training program unfolded as feedback from more narrowly defined tasks, 2) how training philosophy, development methods, and administration are being simplified and tailored so that many Upper Stage organizations can “grow their own” training yet maintain consistency, accountability, and traceability across the project, and 3) possibilities for interfacing with the production contractor’s training system and staff.<sup>12</sup>

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## INTRODUCTION

For the International Space Station (ISS) program, MOL was and is tasked with managing NASA payload operations and related training. This includes providing payload training for flight crew at Johnson Space Center (JSC), basic console operations training for NASA payload developer teams distributed throughout the world, and basic and detailed console ops training for civil service and contractor personnel working at the Payload Operations Integration Center (POIC) at Marshall. We’ve established some resident payload training staff at JSC, primarily for astronaut training, and worked with several outside organizations, including European, Japanese, and Russian

space agencies.

Due to both tradition and the intrinsic nature of operations, training was and is readily accepted and expected as part of the operations culture, and was included in program budgets and plans early on. Budget and redesign issues pushed ISS launch back several years, providing more time to develop the ops training program. Also, experience gained from Spacelab training in the 1980s and 1990s was brought to bear, and many of the learners for ISS had Spacelab ops experience.

In contrast, the MOL was asked to help with training for the Ares I Upper Stage Project (US) development team after the development effort had begun. While the Spacelab and ISS ops populations and organizations were homogeneous and relatively small, about 100 learners at first, the US organization is diverse and large, approximately 1000 learners. To maintain good checks and balances, most sub-teams or disciplines within the US team have a project lead from the Upper Stage Manager’s Office (USMO) in MSFC’s Project Office and an engineering lead from a discipline-related branch or division in MSFC’S Engineering Directorate. The engineering lead serves as chairperson for the associated Integrated Product Team (IPT), and IPT members come from a plethora of organizations within NASA. At this writing, corresponding leads from the Production Contractor (PC) are being designated and added to the org chart. Generally speaking, NASA is not responsible for training PC personnel and vice versa, though there may be some overlaps, and it would be wise to make certain there are no underlaps.

Note – For this paper, “NASA” refers to civil servants and support contractor personnel working directly for NASA to design the US. “Production Contractor” refers to Boeing and its subcontractors working directly to build and deliver the US.

## OVERVIEW OF ARES I AND THE UPPER STAGE

The Ares I vehicle is an in-line, two-stage rocket topped by the Orion crew vehicle and its launch abort system. Its initial mission will be carrying 4 to 6 astronauts to ISS beginning in 2015. At launch, the first-stage solid booster propels the vehicle. In mid-flight, the reusable booster separates and the liquid-fueled upper stage’s J-2X engine

<sup>1</sup> U.S. Government work not protected by U.S. copyright

<sup>2</sup> IEEEAC paper#1550, Version 4, Updated 2008:11:02

ignites to finish putting the vehicle into low Earth orbit. Figure 1 provides an overview of the Ares I and shows the major components of the Upper Stage.

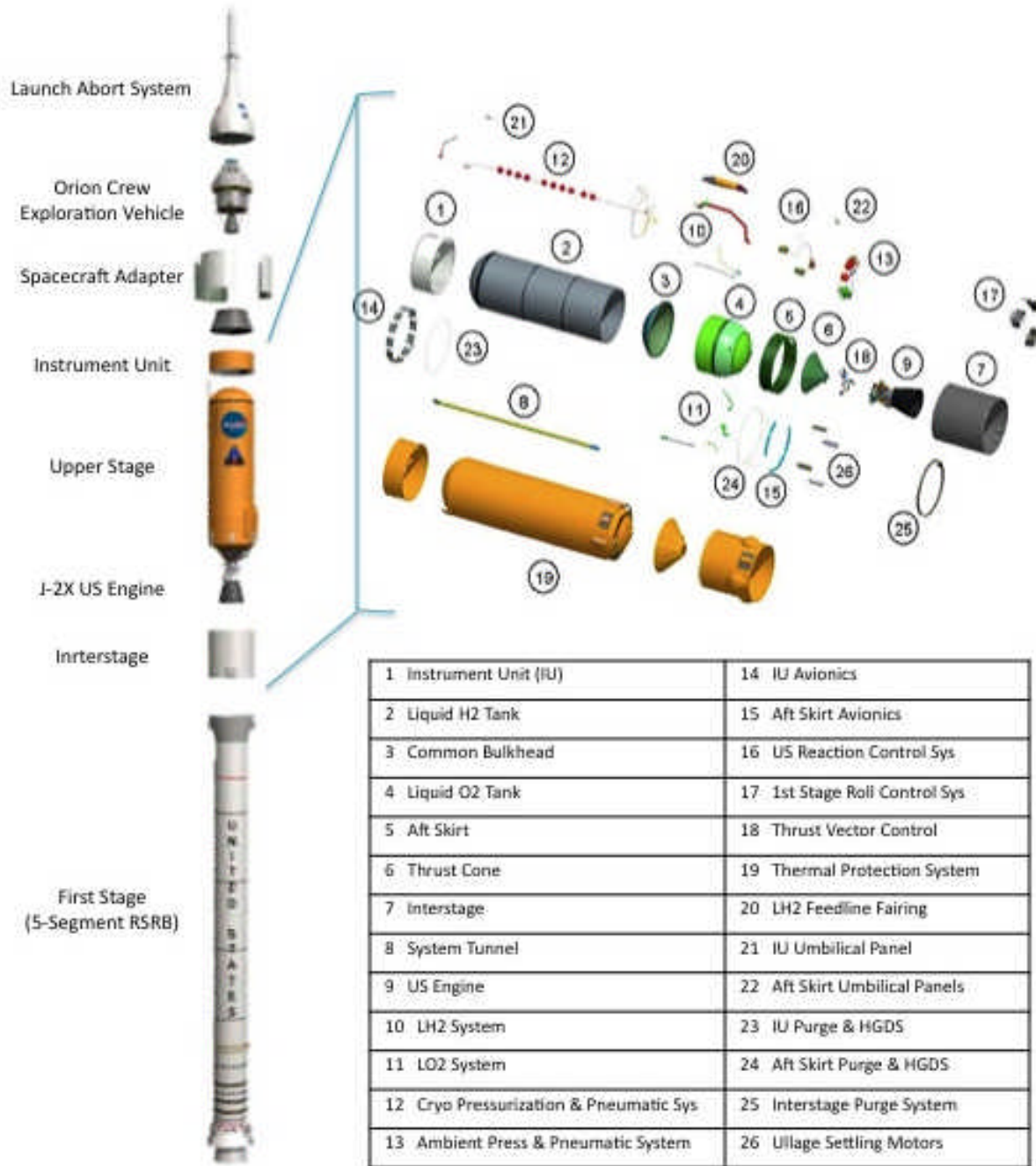


Figure 1 – Ares I Vehicle and Upper Stage Overview

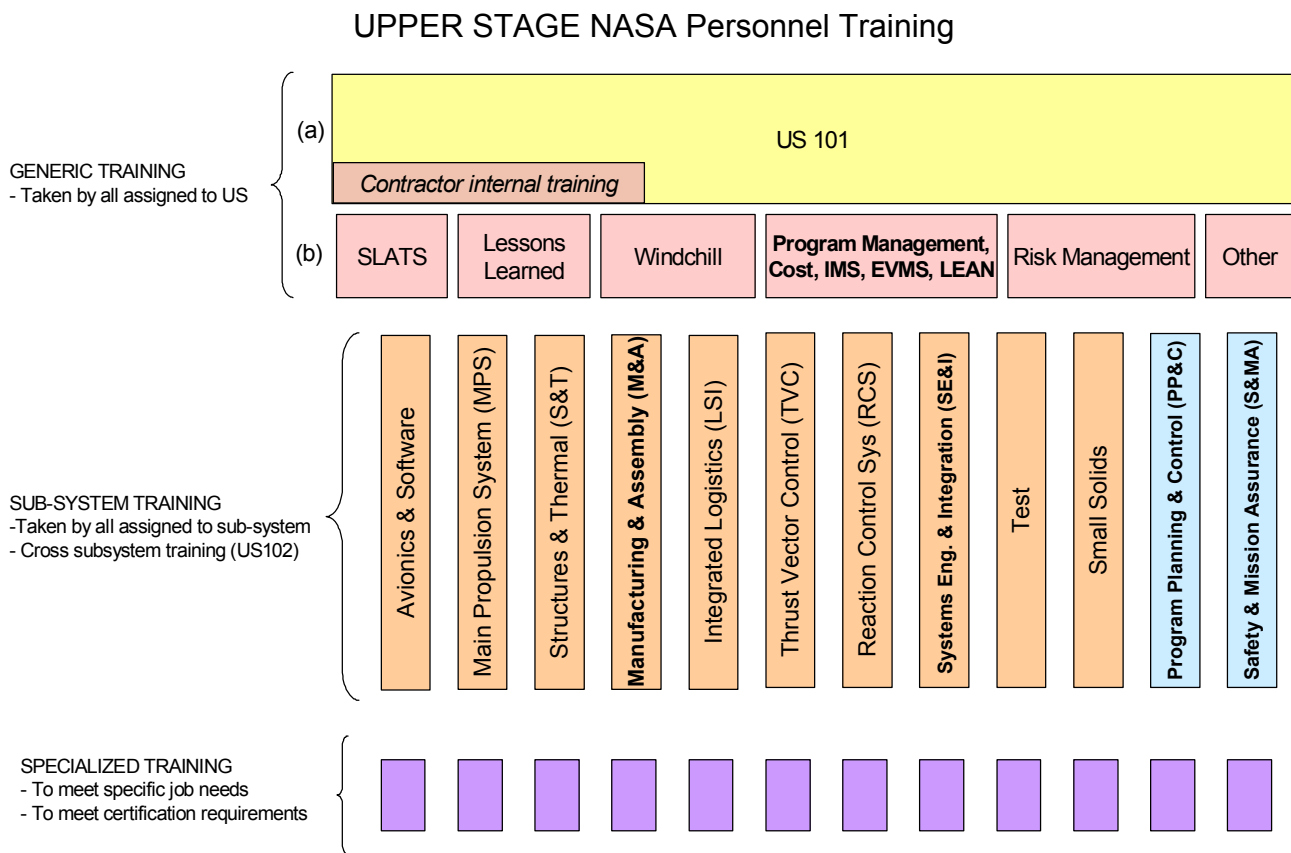
## EVOLUTION OF UPPER STAGE TRAINING

The US Manager’s Office has oversight of training for the US project but does not have formal background in training design or management. MOL’s Training and Crew Support Branch (EO20) is scoped to assist with training as part of the US Integrated Logistics IPT, and has in-house experience in training development and delivery. MSFC’s training office does not perform training development, but supports coordination and delivery of existing courseware, and can provide funding for development on some occasions.

Buildup of personnel for the US design effort had been accomplished by gathering folks from many disciplines, NASA organizations, and other projects. It quickly became apparent that there was little or no common understanding of the basic thrust (pun intended) of fundamental Upper Stage hardware, software, and design philosophy and concepts. Logically enough, the USMO asked EO20 for help in developing and delivering a course to address the situation.

EO20 organized a 2-day “Upper Stage 101” training session for about 150 learners. Lead personnel and/or experts from each major discipline prepared and delivered overview presentations, with some coaching from EO20 on presentation techniques and maintaining reasonable consistency across ptches. Positive response led to additional sessions for other learners within the US project and from other projects with a vested interest. To date, TBD sessions have been held, serving a total learner population of TBD. The Ares I project office has expressed interest in developing a similar course for the vehicle as a whole.

While collaborating on Upper Stage 101, USMO and EO20 discussed perceived training needs across the US project. While time and manpower didn’t allow for in-depth analysis of job functions/tasks and the learner population, a pictogram characterizing the needs emerged, and is shown in Figure 2. The titles of the vertical bars are the names of the Upper Stage subteams/disciplines.



- Generic Training (b) consists of mostly existing courses on NASA’s way of doing business.
- Specialized Training, e.g., welding, safety compliance courses, are already developed and readily available.

Figure 2 – Ares I Upper Stage – Training Needs Partitioning

As the concept matured and feedback came in from the steady stream of reviews and technical interchanges, it became evident that training needs within each subsystem, (e.g., how does one analyze, design, and build a Type X subsystem?) were minimal – people working within each discipline know and practice their trade well, as most of them have 5 or more years of experience. We found a very real need for more understanding across disciplines, because people are so well versed and entrenched in their specialty (and drenched in the documents and reviews coming their way) that it's difficult for them to pick out another subsystem's key point/issues (relative to their own specialty) from the documents and reviews drenching the other team. The US 102 courses, implemented as hyperlinked reference materials, strive to ease this problem by a) providing easy navigation through the most significant information about a given subsystem, typically drawn from about 50 documents or other sources, and b) highlighting temporal information about current challenges and/or "bonus features" that may not have found their way into formal documents yet.

For the 2007-2008 time frame, USMO had tasked EO20 to help define console ops/training requirements for a Test Control Room (TCR) at the Michoud Assembly Facility (MAF). (Facility schedules called for early design and build commitments.) A small, two-part epiphany erupted while working on a TCR training plan:

NASA will build the TCR, then deliver it to the PC who will operate it. While NASA could deliver training media and/or instruction on systems it built, the PC needs to train/certify its own people on how to run the TCR itself. (This is sort of a mirror image of the manufacturer who supports the aircraft it sold to the military, but the military trains and certifies its own pilots.)

Many other parts of the US Project would need training plans, but there was no project-wide guidance on fundamental training and certification principles and requirements for consistency, accountability, and traceability. Not a good thing, especially when the ultimate product is a man-rated vehicle!

During the US Preliminary Design Review (PDR) in May/June 2008, EO20 worked with USMO and proposed a training architecture via an update to the Integrated Logistics Support Plan (ILSP). The architecture promotes consistency across the US program, aligns US training philosophy with fundamental training industry principles, defines appropriate authority levels and containers for various levels of detail, and even allows for training guidance for future projects.

### **MISSION OPS LAB TRAINING PHILOSOPHY (IN A VERY SMALL NUTSHELL)**

The following principles, which are based on training industry practices and on MOL's Spacelab and ISS

experience, underlie the training architecture that came out of the Upper Stage and Ares I PDRs.

Training is the imparting of knowledge and skills needed to perform a specific job. By definition, someone is qualified to do a job if they have the required knowledge and skills, no matter how they acquired them. Certification is a formal process in which management acknowledges that a job candidate is qualified and authorizes them to do the job. It's possible to certify someone without training (we would not require Mozart to study Composition 101), but training, "qual", and "cert" usually go hand-in hand (most of us are not Mozart).

The more critical a job is and/or the higher the need for accountability, the higher the likelihood that certification is needed. Certifications often require renewal or maintenance due to time passage or configuration changes, just as we renew our driver's license and/or have our license upgraded to let us drive a different kind of vehicle. The closer we get to system production or operations, the more important it is to certify the system, supporting facilities/capabilities, and the people who build and/or operate both the system and the support.

The Instructional Systems Design (ISD) approach for building an effective training program uses systems engineering methods to a) identify training needs (and exclude non-needs), and b) work out reasonable compromises among needs, time, money, and other resources.

Within the training industry, there are approximately 50 delivery methods, such as workbooks, lectures, simulations, internships, etc. Many are variations on a theme. Fortunately, they all fit into one or more of four strategies, each of which has a distinct advantage:

- Job Aid – Learning tool doubles as a work companion
- On-The-Job Training – There's no experience like experience
- Self-Paced Instruction – Easy to schedule!
- Group Instruction – Opportunities for team building and shared experience

If training needs elude functional decomposition, establishing a rich learning environment based on what is known allows content (and sometimes requirements) to surface as discovery.

Adult learners prefer activity over academics and, especially for US, bring a wealth of outside experience into the learning environment. Because of this, a healthy mix for training delivery is 35% presentation, 65% application and feedback. We remember what we do far better than what we merely see, read, or hear.

## UPPER STAGE TRAINING ARCHITECTURE

A key feature of the training scheme for Upper Stage is partitioning of documentation and responsibilities. Let's begin with the former:

- Integrated Logistics Support Plan (ILSP) – Provides an executive view only.
- Upper Stage Personnel Training and Support Plan (Attachment to ILSP) – Explains basic approach to US training; describes documentation, roles, and responsibilities; explains course development and acceptance process
- Subsystem Training Plans – Summarize training needs for personnel within each discipline, identify broad job performance requirements for positions
- Position Training Plans – Explain the details of performance requirements for each position, and suggested/preferred strategies/methods for training them.
- Individual Training Plans (ITP) – Each Upper Stage NASA learner will have a training plan (including certification criteria, if appropriate) tailored to the job(s) they will do and their abilities and needs. These will be based on the Position Training Plans
- MOL Training Systems Guide – Explains MOL training philosophy, strategies, and methods in significant details, and includes examples of what has worked (and not worked) in past programs. Document is internal to MOL, i.e., not under the Ares I / Upper Stage umbrella, so that other programs need not reinvent the wheel.

Basic responsibilities are as follows:

- USMO – Oversight of US training. Provide Generic Training and access to Specialized Training.
- MOL/EO20 – Provide consulting and authoring services, primarily to USMO and subteam management. Build templates (“blank books”) and guidance from which customized training plans can be built by lower level teams.
- Subteam project and engineering management – Define high-level and mid-level training plans.
- Branch management of each NASA participant – Customize, implement, and provide training administration for each participant/ITP.

Figure 3 illustrates the relationships among documents and responsible organizations. [Figure will be included in final paper. ]

## INTERFACE WITH PRODUCTION CONTRACTOR

NASA (including its support contractors) is designing Ares I and the Upper Stage, while the PC will actually build it. For the most part, each group will look after their own when it comes to training, though there will obviously be some crossover. The situation is a little bit like building the transcontinental railroad: two entities are laying track, but

they need to meet in the middle, and the tracks need to line up. During the TCR effort, MOL had some very preliminary discussions with the PC about gaining insight into each other's approaches and implementations of training. Knowing what to expect has tremendous value. We hope to devote more to this effort before the next round of design reviews begins.

## CONCLUSION

Even without a large training staff, and especially in the absence of one, the fundamental principles of ISD can be applied to ensure well-targeted, effective use of whatever resources are available. By using the available training staff as consultant, design organizations can do much if not most of their own training development. The 20-80 principle (20% of the effort needed to do a job completely provides 80% of the benefits) applies here, with the caveat that there should be no gaps in covering critical and/or safety items.

## REFERENCES

- [1] [Will provide in final paper.]

## BIOGRAPHY



**David W. Scott**, alias “Scotty”, has been a Payload Communications Manager for the International Space Station since 1999, and is also involved with training and operations development for NASA's next-generation ARES launch vehicles. He's spearheaded several console technology projects, especially in space-to-ground videoconferencing and audio archiving. He was a payload communicator for the ATLAS-1 Spacelab mission in 1992, and helped design the payload training program for Space Station. He spent 6 years as a U.S. Naval Officer, including flight duty in F-14s, and holds a B.S. in Physics and Mathematics from Principia College.

