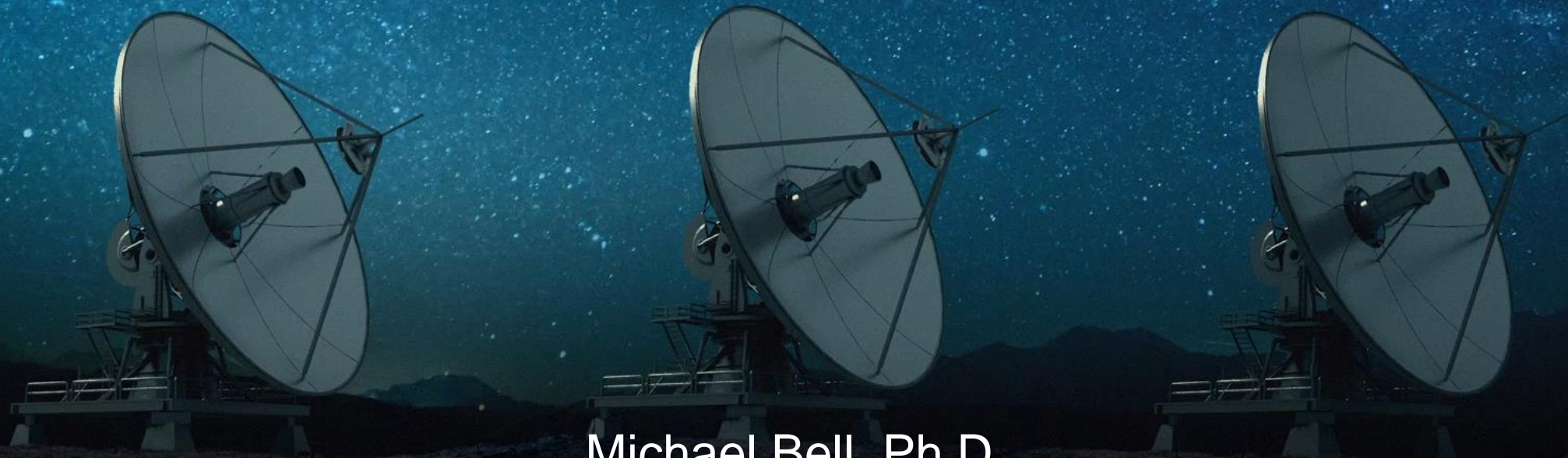


Ideas for Applying Artificial Intelligence to NASA Lessons Learned



Michael Bell, Ph.D.
Chief Knowledge Officer, Kennedy Space Center



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A lesson learned is **knowledge** or understanding gained by experience. The experience may be **positive**, as in a successful test or mission, or negative, as in a mishap or **failure**. Both should be considered excellent sources of lessons learned.

The NASA Lessons Learned Program enables employees to **share and find** knowledge easily and as broadly as possible. The system facilitates self-paced and **collaborative learning**.

Lessons learned are important to **future** programs because they show insights from past projects experiences.



Lessons Learned are:

Knowledge or understanding gained by experience – either a successful mission, project or failure

Lessons Learned Entry: 1534

Lesson Info:

- Lesson Number: 1534
- Lesson Date: 2005-04-29
- Submitting Organization: DFRC
- Submitted by: Trong Bui



Subject:

Excessive Slack in the Retention Line of the Main Rocket Recovery Parachute

Abstract:

The Dryden Aerospire Rocket Test Director's Discretionary Fund (DDF) project conducted flight research of an aerospire rocket nozzle design using high power amateur rockets. The standard nozzles in these rockets were replaced by the aerospire nozzles and the rockets are then flown with aerospire nozzles only. Two aerospire rockets were flown successfully to altitudes of over 26,000 ft and speeds of over Mach 1.5. The flight data acquired during the flight tests were stored onboard and retrieved after the rockets were recovered. The rockets were recovered using a dual-stage parachute system. The smaller drogue chute comes out at rocket apogee to stabilize the rocket. The main chute deploys at approximately 2500 ft above ground level to slow the rocket descend for a soft impact on landing. During the first rocket launch, the main chute deployed inadvertently when the drogue chute activated, and the rocket descended on the main chute from apogee. During the second rocket launch, the main chute bag got outside of the rocket airframe and was entangled with the main chute retention line, preventing main chute deployment and causing the rocket to descend under drogue chute only. Both of these problems were caused by excessive slack in the main parachute retaining line.

Description of Driving Event:

The main chute bag is retained inside the rocket by the main parachute retention line and the main chute's electronically controlled release device. The drogue chute pulls on the main chute pack when the drogue chute is deployed. The excessive length of the main chute retention line causes the main chute to be pulled out of the rocket airframe when the drogue chute is deployed at apogee during the first rocket launch. During the second rocket launch, the main chute retention line was shortened in an attempt to solve this problem. However, it still contained enough slack to cause the main chute bag to exit the rocket airframe and become entangled with the retention line, preventing deployment of the main chute.

Lesson(s) Learned:

Excessive slack in the main chute retention line can cause inadvertent main chute deployment or main chute bag entanglement.

Recommendation(s):

Eliminate the need for a main chute retention line. Use a strap that secures the main bag to the electronically controlled main chute release device.

Evidence of Recurrence Control Effectiveness:

Exploration Flight Test 1 (EFT-1) Nominal End-of-Mission Recovery Operations Lesson #: 14801

ABSTRACT

During the time leading up to the EFT-1 recovery in December 2014, the Ground Systems Development and Operations (GSDO) Program developed nominal end-of-mission recovery procedures and hardware used to recover the Orion Crew Module (CM) into a U.S. Navy well deck ship. After the recovery operation was complete, hardware suitable for the at-sea well deck environment; and 3) need to review methods of integrating trained personnel to accomplish the mission. After EFT-1 was accomplished, GSDO led a Cross Program Integration Team sponsored ad-hoc trade study to apply these lessons and develop an improved nominal end-of-mission recovery concept of operations to meet the Exploration Systems Development (ESD) requirement number R-6.

DRIVING EVENT

During the EFT-1 recovery operation, several events delayed the recovery operation. These include: 1) time required to reconfigure support equipment to prevent equipment failure; 2) time required to accomplish underwater heatshield imagery; and 3) time required to pass tending lines from the recovery ship to small boats. In addition, there was a pre-determined procedural delay to measure thermal soak back (the amount of thermal energy absorbed by the CM). As a result, the time from splashdown to CM secured in the well deck exceeded seven hours.



LESSON(S) LEARNED

- Need to simplify the CM recovery operation. Numerous lessons learned specified that the operation was too complex, required excessive communications, was hampered by competing shipboard operations and requires two separate movements to place the CM into the designated recovery cradle.
- Need to review methods of integrating trained personnel to accomplish the mission. The Recovery Team noted that personnel who were provided mission orientation were pulled away to do other unrelated tasks and replaced with personnel who did not receive familiarization, several ground operations personnel did not participate in pre-mission test activities and were thus unfamiliar with the planned flow of operations, and personnel tasked to accomplish heatshield imagery were unfamiliar with the camera equipment.

RECOMMENDATION(S)

1. Accomplish the Landing and Recovery trade study to evaluate alternate nominal end-of-mission concepts of operation.
2. Publish lessons learned from the development tests and EFT-1 in a single document and make that document easily accessible for quick reference.
3. Apply lessons learned to future training/orientation programs, operations procedures development and support equipment development events.

RELATED POLICIES, STANDARDS, HANDBOOKS, PROCEDURES, OR OTHER DOCUMENTS: SOPI 4003; Ground Systems Development and Operations Program Offline Processing and Infrastructure Integrated Processing Team Results of Orion Crew Module Underway Recovery Development Tests 1-4 and Exploration Flight Test-1



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A	B	C	D
			HUMAN FACTORS DESIGN STANDARD HF-STD-001B
			5.2.8.1.5. CLAMPS AND MOUNTING PLATES
	5.2.8.1.5.1	Snug fit.	5.2.8.1.5.1 Snug fit. Clamps and mounting plates shall fit snugly without deforming or crimping the line or cable. [Source: UCRL-15673, 1985]
	5.2.8.1.5.2	Spacing	5.2.8.1.5.2 Spacing. Clamps and mounting plates shall be operable by hand or with common hand tools. [Source: MIL-HDBK-759C, 1995; UCRL-15673, 1985]
	5.2.8.1.5.3	Special clamps	5.2.8.1.5.3 Special clamps. Quick-release clamps (hinged or spring) shall be used if cables are removed frequently. [Source: MIL-HDBK-759C, 1995] Discussion. Hinged preferable for non-overhead mounting, because they support the weight of the line during maintenance, freeing the maintainer's hands for other tasks. Exhibit 5.2.8. these two types of clamps. For overhead mounting, a spring clamp with a hinged, locking latch over the clamp's open side is preferable because it would help prevent [Source: MIL-HDBK-759C, 1995] HF-STD-001B 103 Exhibit 5.2.8.1.5.3 Quick-release clamps, hinged and spring.
	5.2.8.1.5.4	Placement	5.2.8.1.5.4 Placement. Clamps and mounting plates shall be located at both ends of bends where the bending radius is 75 mm (3 in) or less. [Source: UCRL15673, 1985]
	5.2.8.1.5.5	Unsupported cable	5.2.8.1.5.5 Unsupported cable. Lengths of cable or wire longer than 300 mm (12 in) shall be attached to the equipment chassis by means of clamps, unless contained or cable retractors. [Source: MIL-STD-1800A, 1990; MIL-HDBK-759C, 1995]
	5.2.8.1.5.6	Visibility of clamps	5.2.8.1.5.6 Visibility of clamps. All clamps shall be visible when equipment is installed. [Source: MIL-STD-1800A, 1990]
	5.2.8.1.5.7	Mechanically-mou	5.2.8.1.5.7 Mechanically-mounted clamps. If a wire or cable is not routed through a wiring duct or conduit, it shall be attached with mechanicallymounted (not adhes clamps. [Source: MIL-STD-1472G, 2012] Discussion. Mechanically-mounted clamps can ensure the correct routing of electrical cables within and between units of eq can also (a) ensure that cables do not hinder or obstruct equipment maintenance, (b) prevent chafing due to contact with an adjacent surface, and (c) facilitate the m

Lessons Learn...
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1. [NASA's Avionics Steering Committee Technology Roadmap Response](#)
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Avionics is a critical system on all NASA missions providing many key functions including: control, processing, memory/storage...
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4. [Launch Vehicle Design Process: Characterization, Technical Integration, and Lessons Learned](#)
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5. [Avionics F2F October 2012 - Avionics - Document Repository](#)
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6. [Crew Exploration Vehicle \(CEV\) Avionics Integration Laboratory \(CAIL\) Independent Analysis](#)
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Aaron Van Baalen, Avionics and Software T&V Lead, provided a detailed description of the planned CAIL operations...
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7. [Avionics Instrumentation Sub CoP](#)
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Definitions

- active thermal interface with discipline (10)
- life support interface with discipline (10)
- data handling subsystem utilizing onb... (10)
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- National Aeronautics and Space Adm... (223)

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Applications

- Programs/Project (6)
- automation (6)
- robust 1u cubesat architecture (3)
- software development/maintenance lab (3)
- minimal 1u cubesat architecture (3)

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Advantages

- minimization of project cost (0)
- improvement of speed of Space Vehicles (3)
- improvement of usefulness of Aeronaut... (3)
- improvement of performance of Aeron... (3)
- improvement of usefulness of Space V... (3)

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Failures

- easy loss against headline exploit of ... (10)
- easy loss against headline exploit of S... (10)
- easy loss against headline exploit of r... (10)
- easy loss in shadow of NASA's marq... (10)
- easy loss against headline exploit of M... (9)

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Conditions

- first-class institutional capability (1)
- high efficiency of load converters (1)

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Properties

- good bipartisan support in vious civil ser... (1)
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Concepts

- National Aeronautics and Space Ad... (31,750)
- national aeronautics administration (3,140)
- aeronautics research (1,485)
- wireless avionics connection (998)
- avionics @NASA (988)

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Disadvantages

- EDL system risk by reducing control-sys... (3)
- higher Mean Time Between Failure than... (1)

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Locations

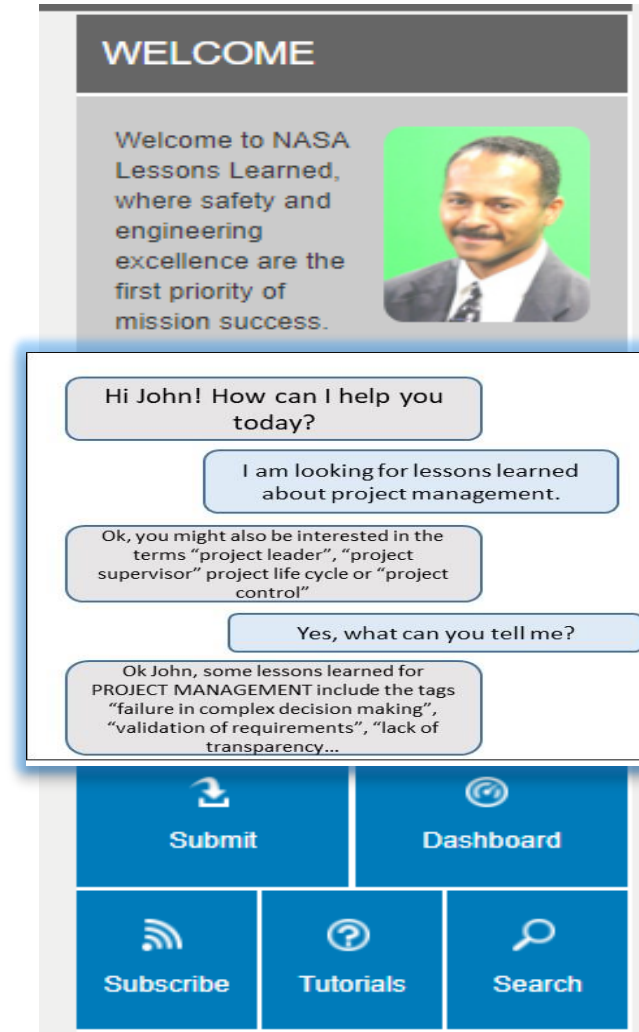
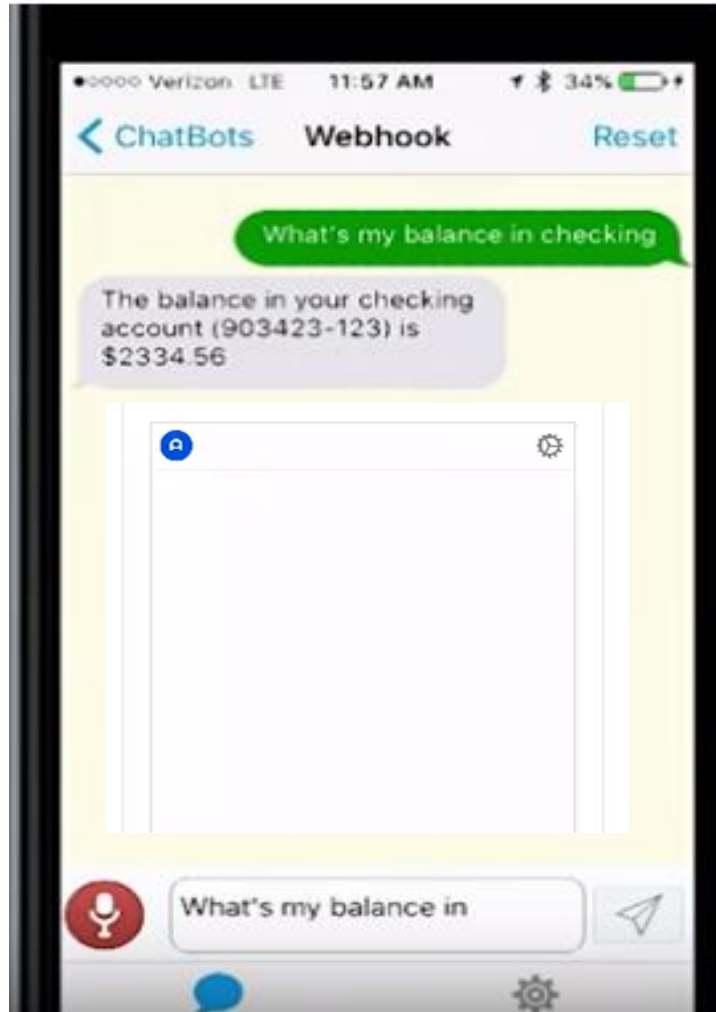
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Story Generation With ChatGPT

Software Traceability Lesson Number 18802

Abstract
 Handling software requirements differently than other project requirements creates unnecessary work. The Stratospheric Aerosol and Gas Experiment III on the International Space Station (SAGE III on ISS) Project met the intent of the NASA Procedural Requirement (NPR) for Software Engineering (NPR 7150.2) requirements by tracking them within the existing Requirements Management processes established by the project's Systems Engineers.

Driving Event
 NPR 7150.2 requires four process requirements related to bidirectional traceability. These requirements consist of tracking software requirements at six multiple levels from the top-down and bottom-up. This includes between the software requirements and higher-level requirements, software requirements and software architecture, software architecture and software design, software requirements and software design, software design and software code, and software requirements and software test procedures. SAGE III on ISS met the intent of these requirements by tracking them within the existing Requirements Management processes established by the project's Systems Engineers. This process established a structured method of handling requirements definition, management, and verification using CORETM as their primary tool. This process provided for systematic identification of the flight software requirements and automated the traceability of the software requirements to the higher and lower level requirements along with the verification artifacts. The verification process included the normal software test processes that ensured the requirements and software works in the intended operational environment. This confidence is gained by running the software at various levels against test scenarios designed to detect failures or defects while accomplishing the intended functions (requirements). The software product's technical excellence was assured through the normal project and Branch-level Peer Reviews and project technical reviews which involved the project management, engineering, assurance, and Branch-level Technical Authorities.

Lesson(s) Learned
 Software requirements can be successfully managed within a project's existing project-level requirements management and verification processes.

Recommendation(s)
 Manage flight software requirements within existing project-level requirements management and verification processes as successfully demonstrated by the SAGE III on ISS Project.

Program Relation
 SAGE III on ISS

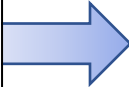
Program/Project Phase
 Formulation » Phase A

Mission Directorate(s)

- Aeronautics Research
- Human Exploration and Operations
- Science
- Space Technology

Topic(s)

- Software
- Software Engineering



Software Traceability Lesson Number 18802

Once upon a time in the vast cosmos, aboard the International Space Station, a diligent team of engineers embarked on a mission with the Stratospheric Aerosol and Gas Experiment III (SAGE III). Their quest was to master the art of software traceability, a challenge set forth by the NASA Procedural Requirement (NPR) 7150.2.

The NPR demanded a rigorous tracking of software requirements across multiple levels, ensuring a seamless harmony between the software's architecture, design, code, and test procedures. The engineers, with their wisdom, decided to integrate these software requirements into the project's existing Systems Engineering processes, utilizing CORE™ as their guiding tool.

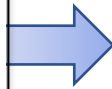
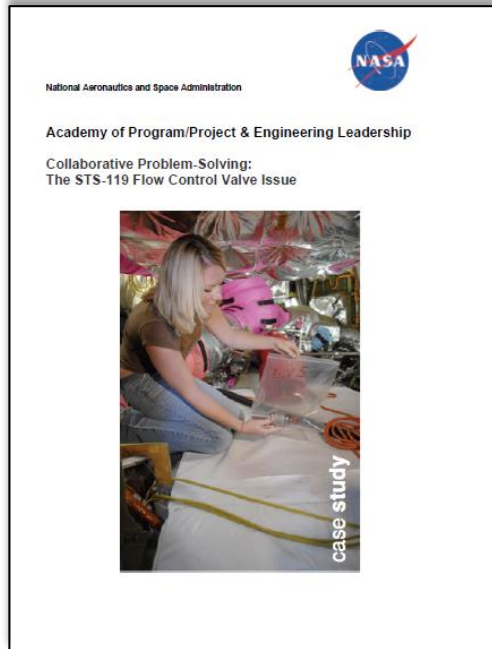
[Through this structured approach, they achieved a symphony of requirements definition, management, and verification¹.](#) The software was tested against various scenarios, revealing its resilience and confirming its readiness for the intended operational environment. [The project's technical excellence was further validated through peer reviews and technical assessments involving the project's management and technical authorities².](#) [In the end, the SAGE III on ISS Project stood as a testament to the possibility of managing flight software requirements within the established project-level requirements management and verification processes³.](#)

The moral of the story: **Embrace the established wisdom and tools at hand to navigate complex challenges, for they can lead to successful outcomes and new frontiers in the cosmic odyssey of exploration.**



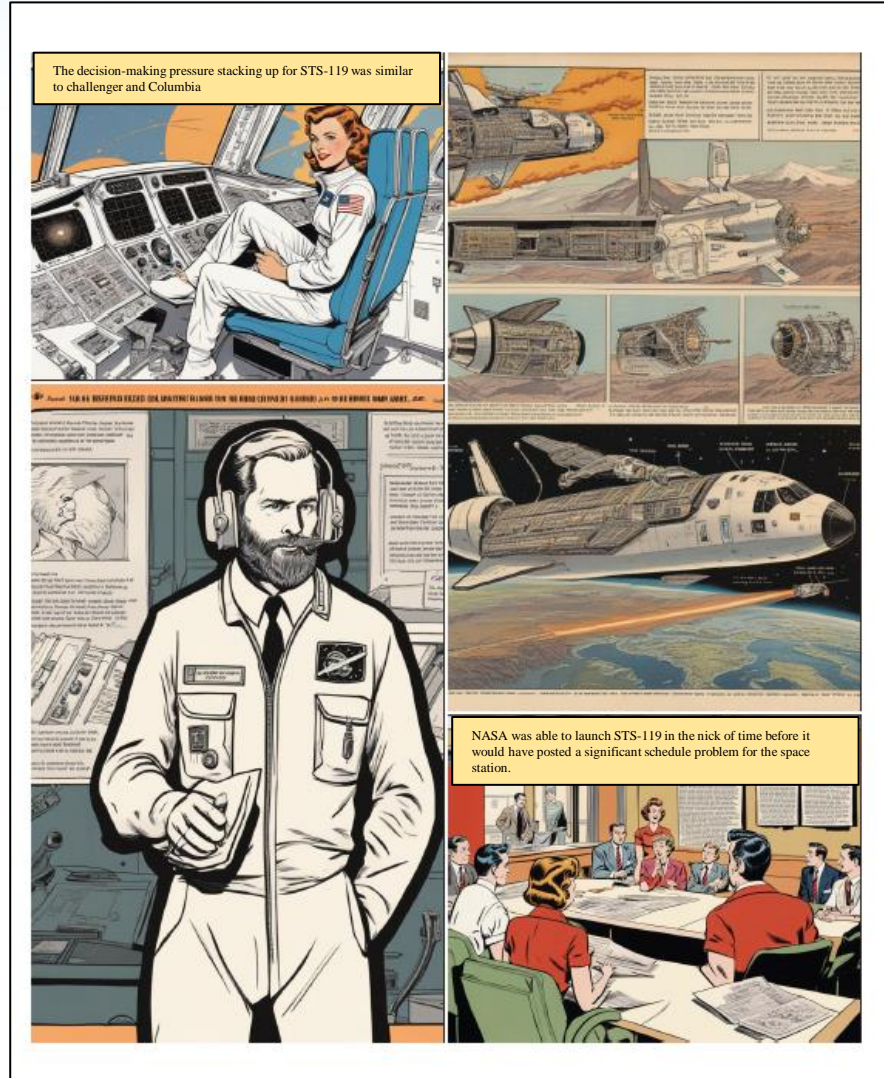
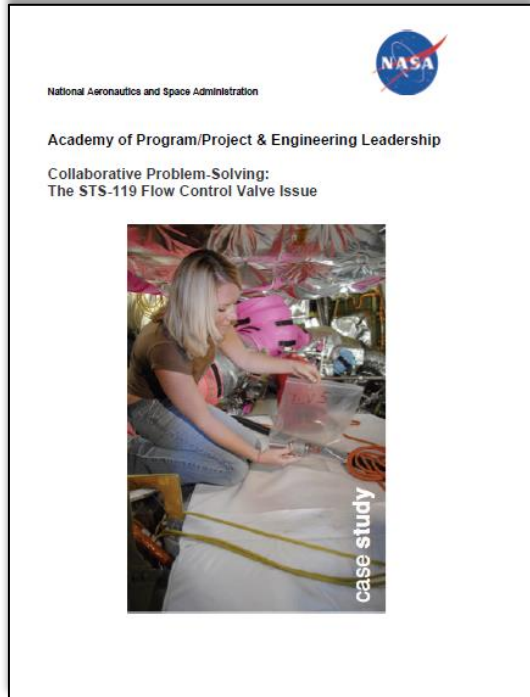


Artificial Intelligence Video Generation



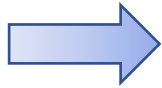


Artificial Intelligence Comic Generation





Co Pilot Search and Summarization





Questions?

