National Aeronautics and Space Administration

Teaching Notes for NASA Case Study SCSC-T-0213

STS-114: Engine Cut-Off Sensors Are a No-Go

Overview

This case study format is intended to simulate the experience of facing the same difficult challenges and making the same critical decisions as managers, engineers, and scientists in the Space Shuttle Program. It has been designed for use in the classroom setting to help students develop skills related to decision-making. Students will read about the engine cut-off sensor anomaly which created challenges during the STS-114 mission and have the opportunity to make decisions as lead NASA engineers and Mission Management Team members. Included within this document are three case study presentation options - class discussion, group activity, and open-ended research. Please read the full case prior to in-class presentation to allow ample time for students' analysis and reflection, as well as to prepare additional questions, activities or exercises, material selection, etc. Depending upon the setting of your presentation and the number of participants, please choose at least one presentation format beforehand and plan accordingly. You may expect the following learning objectives by using the proposed formats.

Learning Objectives:

- To enable students to experience the responsibilities of NASA management, engineers, and analysts
- To discover possible procedures for investigating system anomalies
- To become familiar with the liquid hydrogen low level engine cut-off sensor, including its function, connecting components, and location within the Space Shuttle
- To encourage critical analysis and stimulating discussion of Space Shuttle mission challenges

Class Discussion

For the presentation of this case study as a class discussion format, you should first determine whether or not participants should be separated into groups for some portion of the discussion. Depending upon the time allotted, you may choose to separate participants into small groups after everyone has read the background information and challenges sections. You may also choose to allow participants to develop

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their own reasoning before displaying NASA's final decision and post mission information. Once participants are aware of NASA's official decision, ask them to compare how their decision is different or similar. The small groups should then reconvene as a large group and share their conclusions.

During the discussion, encourage students to imagine themselves in the position of the Mission Management Team that is responsible for determining whether Shuttle Discovery should be launched. Remind them of the critical issues including the pressure to return to flight after the Columbia tragedy, additional backup engine cut-off systems, and the need to move forward with an already delayed launch schedule. Students should think critically about methods to investigate system anomalies and additional possible solutions. Emphasize the relationship between scheduling and budget. Encourage students to debate the benefits of space exploration and research versus the risks to human life. Also consider encouraging them to develop and rank a list of contributing factors for their final decisions. Students should draw analogies to their own experiences and develop as many interpretations as possible. Help them to understand the different viewpoints and motivations of management as well as the importance of team work and group dynamics.

Suggested Discussion Questions:

- As a NASA engineer, how would you and your team choose to begin the investigation into the sensor anomaly?
- As part of the Mission Management Team, how much time would you allot for the investigation? How would you explain this decision to upper management?
- If you were a part of the Mission Management Team and your investigation did not lead to a specific cause of the anomaly, would you give Shuttle Discovery the "go" for launch? Why or why not?
- If Shuttle Discovery was not able to launch within a reasonable timeframe, what solutions would your team develop to help make sure the International Space Station received necessary supplies as soon as possible?
- How does your decision compare with NASA's official decision to proceed with launch?
- How does your group's decision compare with other groups?

Group Activity

For the presentation of this case study as a group activity format, you should first determine the age and grade level of possible participants. Knowing more about your audience can help you cater the activity to their skill level. Are your students in high school or second-year college students? What courses have they already taken or what material have they already received to prepare them for the related activity? Will additional skills and information need to be introduced with the presentation of this case study? Consider these questions and issues during the development of your activity. Plan the best location and required time to complete your activity accordingly. Also, depending upon the time allotted, the difficulty level of the activity, or the number of materials available, you may choose to separate participants into small groups to develop their own unique ideas. The small groups should then reconvene as a large group and share their conclusions.

Suggested Activities:

- Require students to build circuits from schematic drawings. Emphasize the importance of proper connections and wiring. Consider including various components such as resistors, lamps, diodes, and switches to increase the difficulty level.

- Allow students to troubleshoot a faulty circuit. Provide them with multimeters to find shorted and open circuits in wiring. Assist students in determining which areas of the circuit should be analyzed first and recording each step taken during their investigation. Consider providing multiple groups of students with the same faulty circuit. Who can troubleshoot the circuit the fastest?

- Challenge students to design and build their own sensor. Encourage them to consider what their circuit will detect and how their design can be completed with the least number of components. Will their sensors detect changes in temperature, light, or fluid level like the ECO sensors in Shuttle Discovery?

Open-Ended Research

This case-study may also be offered as a possible topic for open-ended research. Once students are done reading the report, encourage them to think of areas they would like to learn more about. You may suggest that they consider how the liquid hydrogen section of the tank is integrated with the liquid oxygen section. They may choose to conduct further research into what happened after STS-114 and how the sensory anomaly investigation progressed. Students may also consider conducting research to develop their own designs, for example, for the sensor. For this format, it is important to consider the requirements of students' research. Will it include only a literature review or should new concepts be explored and designed? Depending upon the age and skill level of your students, research topics as well as the depth of the study could vary greatly.