

Models in Engineering

Project Sample Essay

WEEK 1: WHAT IS A MODEL?

Assignment

Write a ~500 word response on the role that models played during the STS-107 mission and in the post-accident investigation. Word count suggestions are included, but you do not need to feel constrained by them.

In your essay try to answer the following questions:

- A. How would you categorize the model(s) used in the report section assigned with respect to what you have learned about the taxonomy of models (physical, mathematical, etc.)? (100 words)
- B. Based on what you have learned about model credibility and fidelity, where do you think the various models used for the STS-107 should reside in the 2x2 matrix of model confidence and model fidelity? (100 words)
- C. How do you think the models affected the decision to continue flying the Space Shuttle after Columbia? (100 words)
- D. How does this relate to the situation in your firm? In particular, how do models affect the decision-making process in your organization? Be sure to mention a model, its taxonomy, and how the model was used in a decision-making process in your organization. (100 words)
- E. Choose a specific model you have seen within your firm. How does your organization perceive the model in terms of credibility and fidelity? Grade the model on the 2x2. (50 words)

Sample Essay

How would you categorize the model(s) used in the report section assigned with respect to what you have learned about the taxonomy of models (physical, mathematical, etc.)?

Many models have been mentioned in the accident analysis report. Most of the models were mathematical models using some form of simulation to provide estimated output variables. Some of the models used were:

- **Image analysis model (Figure 3.4-3):** Mathematical model using camera imagery for establishing the foam size, velocity, origin, and impact area.
- **Model for establishing the Path of the foam: CART-3D (Figure 3.4-6):** Mathematical simulation model using computational fluid dynamics to determine the path of foam debris from the bipod.
- **Independent analysis of ballistic coefficients (Section 3.4):** Mathematical simulation conducted independently by the board to estimate the ballistic coefficients of the foam.

Based on what you have learned about model credibility and fidelity, where do you think the various models used for the STS-107 should reside in the 2x2 matrix of model confidence and model fidelity?

Image analysis model (Figure 3.4-3) & model for establishing the path of the foam: CART-3D: (Figure 3.4-6): Low fidelity, high credibility: Model results that predicted the damage was not very severe and gave reassurance to the NASA management, even though they could not have done much even if the results predicted otherwise. Therefore, it seems like NASA trusted the model, even though its fidelity was low.

Independent analysis of ballistic coefficients (Section 3.4): Low fidelity, low credibility: The reports talk about the inability to figure out the exact ballistic coefficients of the form, since there could be a lot of variability in its structure depending upon how big it was, how fast it was travelling, its orientation, etc.

NASA employed various models (including the ones mentioned above) for mission assessment, and they were not always in sync with one another and therefore the feeling was that it was harder for management to make decisions based on them, therefore making the overall credibility of all the models low.

How do you think the models affected the decision to continue flying the Space Shuttle after Columbia?

Much of the damage analysis during the mission was done through the image analysis of foam debris from the left bipod and its impact on the shuttle wing. However, the models used to estimate the amount of damage had a high variability; for example, the image analysis revealed that the bipod foam could have hit anywhere between panel 6 and panel 10. Similarity speed of impact was also very variable, ranging from 625 to 840 feet per second.

These wide variations gave very different results when simulated, which prevented NASA from gaining any actionable insights that might have helped them rectify the problem during the mission.

How does this relate to the situation in your firm? In particular, how do models affect the decision-making process in your organization? Be sure to mention a model, its taxonomy, and how the model was used in a decision-making process in your organization.

My company develops financial software. We don't use models that much, but one area where we used models was to predict the likelihood of bugs in our software. We used code analysis tools that helped calculate the complexity of the code based on certain conditions, such as how big the function is, how many branches there are, etc. We used the complexity calculations to assign a likelihood of defect in a given piece of code. The model was a simulation model and relied heavily on actual historic data. We relied on the data from the model in our review process to make decisions about whether to redo parts of code or not.

Early on, when we developed the model, it was difficult to make decisions based off of it since we didn't have data to support that the model would be right. However, with time, we were able to validate the accuracy of the model and started trusting it to make decisions.

Choose a specific model you have seen within your firm. How does your organization perceive the model in terms of credibility and fidelity? Grade the model on the 2x2.

The model had high fidelity. In most of the cases when the code complexity was more than 20, we found that the likelihood of defect to be more than 95%. However, sometimes people still did not trust the model and made decisions based on their instincts, which more often than not were wrong -- therefore, the model is low credibility.