

Using Lean Six Sigma To Improve Aircraft Accident Investigations: Ensuring Timeliness and Quality in Accident Reports

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*The views expressed are not those of the Safety Board and are not necessarily endorsed by the Safety Board.

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In 2021, the National Transportation Safety Board (NTSB) investigated more than 1,200 domestic aircraft accidents. Investigating this number of accidents requires that the investigative and report processes at the NTSB be streamlined and efficient. The NTSB's Office of Aviation Safety evaluated the timeliness and quality of its regional investigations using Lean Six Sigma, a method to improve processes by reducing waste and variation. As a result, significant changes were implemented to improve the timeliness and quality of the NTSB's regional accident investigation reports.

Background

Timeliness refers to the amount of time that it takes to complete an investigation. Quality refers to the value of an investigation relative to its purpose. Aircraft accident investigations that are not completed in a timely manner can have a negative impact on aviation safety due to the delay in communicating lessons learned. If those investigations also lack quality, the investigations will likely provide minimal value.

In 2019, we formed a four-person team to analyze the NTSB's regional aviation accident reports and found that the timeliness and quality of the reports varied. To understand

why this situation was occurring, we reviewed accident report timelines and complexity, docket information, travel information, report content, and historical event data to form a framework to build from.

Although we recognized a timely and quality report when we saw it, as we began our work, we realized that our office did not have clear standard definitions for timeliness and quality. We understood the need for such definitions given that some investigations were not completed until 4 years after the accident with no clear reason why and that investigations involving similar defining events did not always contain the same level of factual support and documentation.

From the beginning, we kept in mind the common Lean Six Sigma adage, "it is not a people problem, it is a process problem." It is easy to say that problems result from staff members not doing their work, but, as an organization, we must take responsibility if the work is not meeting timeliness and quality expectations.

Define, Measure, Analyze, Improve, Control (DMAIC)

To focus our methodology and provide tools to work through the process for improving report timeliness and quality, we used the define, measure, analyze, improve, and control (DMAIC) quality strategy [1]. Each letter of DMAIC represents a phase of the process (see figure 1).

Define	Measure	Analyze	Improve	Control
Launch the team	Quantify the problem	Analyze the data	Implement and verify the solutions	Maintain the solution
Define the problem	Collect baseline data	Identify the root causes	Evaluate the solutions	Control the process
	Focus the project			

Figure 1. DMAIC quality strategy.

Define

The first step was to define the problem that we would evaluate. The focus for the team was to improve the quality and timeliness of investigations completed by the NTSB's regional offices. We mapped out the investigative process from the initial notification to the publication of the final report and probable cause.

Measure

With the outline of the investigative process in place, we then created timelines with detailed content for each phase of the investigation. One of our limitations was the lack of information pertaining to quality over time as well as the individual timelines and tasks that comprised each phase of the investigation. Although we had ample data related to overall timelines, more granular data specific to each phase was unavailable.

Analyze

The purpose of the analyze phase of the DMAIC process is to understand the root cause of a problem. As we analyzed the data, we realized that there were many potential underlying issues and solutions. We were uncertain where to focus our efforts to have the greatest impact on our operations.

Improve

When we reached the improve phase, we sought support externally to help us determine the best path forward. We realized that conducting a kaizen would provide the most benefit to our team and help us work through a vast amount of information. Kaizen is a Japanese concept of continuous improvement through work operations and personal actions.

A kaizen is a multiple-day event, usually 3 to 5 days, that aims to create goals to improve a process. Because we did not have the Lean Six Sigma expertise internally at that time, we completed an interagency agreement with the Federal Aviation Administration, and a Lean Six Sigma Master Black Belt facilitated the kaizen event and worked with the team to evaluate our data and complete our analysis.

To conduct the kaizen, we expanded our team to 10 people, including investigators and analysts. We met at an off-site location to help the team focus solely on the task at hand

and completed our core work in 3.5 days. All the data gathering and analysis that we had done before that time supported our kaizen event.

During the kaizen, we used several tools to work our way through the improvement process and determine how to focus our efforts. Some of the primary Lean Six Sigma tools that we used were as follows:[2]

SIPOC (Suppliers, Inputs, Process, Outputs, Customers) Process Map

A SIPOC is a high-level process map that helps to define a business process using a table format. This format allows the team to easily understand the process as work begins.

SWOT (Strengths, Weaknesses, Opportunities, Threats) Analysis

A SWOT is an analysis that allowed the team to understand those areas in which we excelled and those areas in which we did not. When looking at a SWOT analysis, strengths and weaknesses are internal to the organization, and opportunities and threats are typically external. This information then feeds into the process changes.

Stakeholder Analysis

As a US federal government agency, we have many stakeholders that have varying interest in our work. Through a stakeholder analysis, we were better able to understand how to focus our communication.

The stakeholder analysis (see figure 2) is based on a matrix that evaluates stakeholders' power and interests. Depending on where the stakeholders fall on the matrix, they would be managed closely, kept informed, kept satisfied, or monitored.

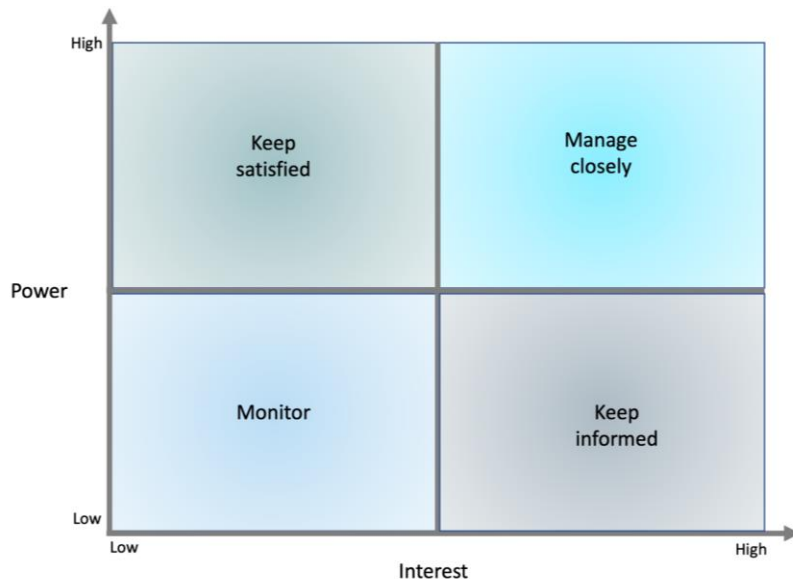


Figure 2. Stakeholder analysis.

Process Map

The SIPOC provided a high-level diagram of our process; from there, we created a process map (also referred to as a workflow diagram) that showed each of the steps in the process and the workflow for each. For those sections of the process for which we had data available, we also included average overall timelines for step completion.

Fishbone Diagram

A fishbone diagram (also referred to as a cause-and-effect diagram) allows the problem to be identified and the potential causes to be brainstormed within the group. Each of the problems is categorized using topics such as methods, technology, and personnel, although any category can be used. Under the categories, the causes are identified.

The team outlined the investigative phases, which included the initial notification, launch and return, preliminary report, fact-gathering, report writing, analysis, and report publication. Due to the range of investigations and their associated timelines, for the kaizen we used timelines for regional investigations for which one or more of our regional investigators traveled to the accident site, and then we developed the average times for each phase using that information.

The most extensive time period was from the completion of the preliminary stage (notification, launch and return, and publication of the preliminary report) to the completion and submission of the draft accident report. Rather than focus on improving the entire process at once, we decided to keep our efforts focused on building quality early in the process.

By working methodically through the process, we were able to determine several areas of improvement that focused on the early investigative phases. These areas included the following:

- creating standard work plans for common defining events,
- updating case types and adding classifications,
- requiring a work plan and progress meetings for investigations, and
- developing guidance.

With these key improvement efforts identified, we prepared an A3 report and briefed the office directors. The A3 process is a way to use systematic problem-solving to define the problem, identify the root causes, and implement the solutions. The A3 report includes background, current conditions, objectives, analysis, proposed countermeasures, the implementation plan, and any required follow up (see figure 3). The implementation plan can be updated as the team works through the process.

Background
Understanding the importance of the issue
Current conditions
Defining the problem statement and scale of the problem
Objectives
Defining the desired target(s) and goal(s)
Analysis
Identifying the root causes of the problem
Countermeasures
Describing how the countermeasures will solve the problem
Implementation plan
Defining actions, outcomes, timelines, and responsibilities
Follow-up actions
Identifying additional issues that may arise and controlling the process

Figure 3. A3 report.

After the A3 report was approved by the directors, we began to communicate the upcoming changes to staff through in-person meetings, providing time to answer questions and address concerns. Throughout the process, we continuously communicated with staff about the current status of the project and the path ahead. During this time, we also created the standard operating procedures and standard work plans that would form the foundation of the upcoming process changes.

In early March 2020, we held in-person training for all investigative staff to review the standard operating procedures, work plans, and other guidance. We worked through many case study examples together before having staff use the guidance to work through other case study scenarios during the training.

On March 15, 2020, the process changes were implemented. These process changes required the following:

- creating a work plan, in consultation with the regional chief, for all investigations within 15 business days of an accident;
- using standard work plans, as applicable, based on the defining event of an accident;
- publishing a preliminary report, when required, within 15 business days of the accident;
- scheduling progress meetings to review and evaluate the work plan with the regional chief during the investigation;
- using three primary accident types—MA, FA, and LA—based on the type of launch (NTSB Board Member launch, team launch, and no team launch, respectively);
- categorizing accidents, using classes 1 through 4 (most complex to least complex, respectively), based on the scope of the accident; and
- submitting class 4 investigations for final review within 90 days after the determination that an accident occurred.

Control

As we implemented these changes, all chiefs in the Office of Aviation Safety met biweekly to review the metrics and discuss and resolve any issues. Through these initial meetings, we were able to identify procedural inconsistencies early on and receive feedback on the overall process.

Additionally, all Office of Aviation Safety staff initially met quarterly to discuss these same metrics as well as to review scenarios and receive further training on the new

process. Staff provided feedback on the process changes and let us know what additional guidance would be helpful to clarify their understanding of the process. As these changes became part of our standard process, the length between meetings was increased from quarterly to three times per year. We also created an electronic form so that staff could submit feedback at any time.

In addition to increased communication, we periodically sample investigation reports to identify whether the timeliness and quality requirements are being met. As quality issues are identified, they are discussed with the chiefs, and training is provided as needed.

Conclusion

Building quality into the beginning of a process has helped us streamline how we conduct our investigations as well as reduce the number of early errors or omissions that need to be corrected downstream during the report review process. The timeliness of our reports has also improved: there are no longer any open cases more than 4 years old, and the number of open cases that are more than 2 years old continues to decrease.

Standard work defines how a process, including an investigation, is carried out. When there are no standard work requirements for investigations, each investigator will develop their own way of completing an investigation, and inconsistencies in both quality and time can result. Standard work does not restrict an investigator on the paths that they might pursue during an investigation. Instead, standard work ensures that the investigation is appropriately scaled based on the accident circumstances and that the tasks required for the investigation are clearly defined with a plan for their timely completion.

References

1. Pyzdek, T. (2014), *The Six Sigma Handbook 3rd Edition*. McGraw Hill.
2. Tague, N. (2013). *The Quality Toolbox 2nd Edition*. ASQ Quality Press.