Building Corporate "Black Boxes": A Different Perspective on Organizational Learning

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ABSTRACT: *Most of us are familiar with the role of "black boxes" as they exist in aircraft. We know that they are there to help us learn from mistakes and thereby improve the performance of aircraft and the aviation system as a whole. Imagine what would happen if the aviation system did not learn and adapt to changes quickly and efficiently. Unfortunately, this is the case with most organizations. Nevertheless, a number of corporations have successfully built learning and adaptive systems.*

Keywords: Organizational learning, detection and correction of errors, knowledge-based organizations.

INTRODUCTION

The headline of the *Milwaukee Journal Sentinel*, on Saturday, January 30, 1999, read: "Allis-Chalmers: Nothing Left Now But Memories." The article contained extremely disturbing and grim news. The once-giant industrial corporation, which at one time had employed 30,000 worldwide, had been forced into bankruptcy and was closing for good. Interviewed by the newspaper, William Vatil, the last employee of Allis-Chalmers, said, "I feel sadness in the passing of our company, which at one time was the largest employer—not just in Milwaukee—but in the state." For three generations, Allis-Chalmers provided livings for thousands of workers who then could afford to raise families, send their children to college, and retire in comfort. "Memories have to do principally with the people," Vatil said. "When you wash away all the numbers, including the large losses that the company sustained, it's the people you were working with that you remember the most."

Unfortunately, Allis-Chalmers was not alone in its fate. According to the American Bankruptcy Institute (2000), between 1990 and 1998, business bankruptcy filings averaged over 60,000 per year—even during this period of unprecedented economic growth. Undoubtedly, when a business closes down or downsizes, there are high emotional and social costs for both the affected employees and the communities in which they live. The psychologist James W. Pennebaker, who was called on to help downsized engineers cope with losing their jobs, said the impact was devastating.

> Ashamed and embarrassed, they couldn't talk to their wives about the experience. And they couldn't find new jobs. They were probably the angriest, bitterest bunch of people I have ever seen. Although displaced workers like these engineers are downsizing's most familiar victims, they aren't the only ones. The ones who are left behind also face grave risks to their mental and physical well-being. And even organizations themselves aren't immune to ill effects: New research suggests that downsizing's emphasis on cutting costs actually lowers profits down the road (Clay, 1998).

Surely, a great deal of companies become extinct or downsize at least partially because of mistakes made by their management. Yet safeguarding against even devastating errors is seldom pursued in earnest. Sometimes, when the costs of mistakes are explicit and high in terms of lost lives or health, extensive systems are developed to reduce the risk of errors and improve the quality of responses to crises. Pool (1997) made a similar point: "Some organizations seem to have purged human error, operating highly complex and hazardous technological systems essentially without mistakes." Examples of high-reliability organizations include the U.S. air traffic control, the U.S Navy (aircraft carrier operations), and nuclear power plants.

The purpose of this paper is to show how organizations in the corporate world, too, can employ similar error-reducing systems that will allow them to improve their performance.

U.S. COMMERCIAL AVIATION SYSTEM

Historical data on airline safety show that, in the early days of commercial aviation, airline fatality rates were approximately 1,500 times higher than those of railroads and 900 times higher than those of bus lines. Today it is commonly known that air travel is safer, in terms of passenger miles, than travel by automobile, bus, or railroad. In 1930, there were 28 passenger fatalities for each 100 million passenger miles. Today, the number is less than one (Comptons, 2000). McPherson (1998) wrote the following about the performance of commercial aviation systems:

> Thanks to the high level of professionalism of aircraft manufacturers (through their entire hierarchy), and especially of the airlines' flight crews, plus the vigilance of the Federal Aviation Administration (FAA) and the attention to detail of the National Transportation Board (NTSB), aviation accidents have (and I apologize for this word) plummeted since the advent of big-jet travel in the early 1960s.

Clearly, the commercial aviation industry is doing something right about safety. Indeed, its progress has been impressive. It exemplifies a successful learning and adaptive (L&A) system. In order to understand its accomplishment, it is necessary to understand the principal functions of its system.

According to Krause (1996), the commercial aviation system, in addition to its operating environment, consists of three major components that continuously interact: (1) software (all the regulations, SOPs, policies, manuals, checklists, maps, performance charts, tables, and graphs); (2) hardware (the aircraft itself and its supporting system); and (3) liveware (pilots and all the people that they deal with on the ground and in the air). "No [function] is totally isolated from the others; if one element is inferior, it will have a negative impact on all the others."

Focus of Learning

Since human errors are believed to contribute to more than 70 percent of aviation accidents, the major focus of learning in the aviation system is on improving decision making by pilots and other key stakeholders. In recent years, study of pilot judgment and aeronautical decision making (ADM) has been a mission of the Federal Aviation Agency (FAA) and the National Aeronautics and Space Administration (NASA).

To reduce errors of judgment and improve decision-making skills, a DECISION-making model has been tailored for the system to fit different flying conditions. It provides a logical decision-making process, even when decisions must be made under pressure. The DECIDE model, according to Krause (1996), stands for:

- D-Detect: The pilot detects the fact that a change has occurred that requires attention.
- E-Estimate: The pilot estimates the significance of the change to the flight.
- C-Choose: The pilot chooses a safe outcome for the flight.
- I-Identify: The pilot identifies plausible actions in response to the change.
- D-Do: The pilot acts on the best options.
- E-Evaluate: The pilot evaluates the effect of the action on the change and on the progress of the flight.

This model is used both prospectively, to train personnel, and retrospectively, to diagnose errors and, in some instances, to prepare case studies of known accidents.

Detecting and Correcting Errors

Although great effort goes into raising the competency level of all those who work within the system, mistakes do occur. In order for the aviation industry to learn and improve, it must and does have a way of identifying errors. A "black box" is aboard every commercial aircraft. It consists of flight data and cockpit voice recorders. Faith (1997) wrote that black boxes are the best single source of information for investigators. As a memory, they provide data on the long series of events that occur during a flight. Crucially, black boxes are completely objective. Because they record events as they occur, they are exempt from interference and influence (an important requirement for any learning system). Analysis of the data in black boxes enables investigators to compare expected happenings with actual happenings and to determine where the difference has occurred.

Determining what caused deviations from expectations is the responsibility of the National Transportation Safety Board (NTSB). Its main function is diagnosis and prescription—to investigate accidents, identify their causes, and recommend improvements. In order to achieve a high standard of excellence, the NTSB is a professional body with its own investigators and methodology. Faith (1997) makes this point:

> Air-accident investigators, or 'tin-kickers,' are a very special breed. In one sense they're detectives operating in a very specialized field, but, at a senior level, they have to be capable of co-coordinating, and thus of comprehending, a far wider range of professional skills than their equivalents in the criminal field.

Despite its responsibilities, the NTSB has no regulatory or enforcement powers. Once the causes of an accident have been determined, its recommendations for action are sent to the Federal Aviation Administration (FAA), which sets and enforces air safety standards. In addition, the FAA plays a major role in assuring system efficiency, regulatory reform, sharing and analysis of safety information, surveillance, inspection, and accident prevention.

System Memory (Knowledge Repository)

In order to provide high-quality input to relevant decision makers, the FAA has created the Aviation Safety Reporting System (ASRS). ASRS captures information about such things as emergency landings, mechanical/maintenance problems, security, health-related fatalities, injuries and illnesses, operational problems, and passenger disturbances. This information is used to identify and remedy deficiencies and discrepancies in the National Aviation System (NAS). The lesson learned from the mistake is documented, organized for easy access, and made available to those who need and are authorized to receive it. In this setting, there is constant support for policy formulation and system improvement. Also, in many instances, expertise is leveraged across the system.

Accidents and Lessons Learned

It is important to understand how these different components of the commercial aviation system function and interact with one another and with the rest of the environment. Such interactions are best illustrated by examples of how major accidents produce "lessons learned" (from *NBC News with Tom Brokaw*, 2000).

> Accident: On a clear night on September 8, 1994, a USAir Boeing 737 fell from the sky nose first and slammed into a wooded area near a small shopping center in Hopewell Township, Pennsylvania. The aircraft shattered on impact and all 137 people aboard Flight 427 were killed.
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> Lesson Learned: Both this and a 1991 Colorado Springs plane crash give the NTSB and Boeing the opportunity to focus on the 737's rudder control system. NTSB investigators discovered that the Boeing 737's rudders can jam on rare occasions, and when pilots try to correct the problem, it could steer the plane in the opposite direction. In August 1996, the FAA prepared to make recommendations for changes in the flight-control systems of the Boeing 737. In 1997, the FAA indicated that it would issue four Airworthiness Directives requiring all 737 operators to implement improvements, proposed by Boeing, to the rudder system within a two-year period.

On April 16, 2000, A U.S. Federal Aviation Administration scientific panel recommended long-term design changes to the rudder of the Boeing 737.

> Accident: At twilight on February 1, 1991, in Los Angeles, 12 people in a Skywest Fairchild Metroliner commuter plane were waiting for takeoff at a runway intersection when a USAir Boeing 737 landed on the same runway. All 12 people on the commuter plane and 22 people on the 737 were killed. One air traffic controller sent the commuter plane to the runway to await takeoff, and later told the Boeing 737 to land on the same runway.

> Lesson Learned: In response to the Los Angeles collision, the FAA issued a rule limiting takeoffs from the middle of long runways. Specifically, the rule prohibits planes from entering runways at taxiway intersections and holding there for further clearance. The rule is in effect from sundown to sunrise, and around the clock at intersections that are not visible from control tower windows.

In both cases, the NTSB was called in to find out what went wrong, what lessons could be learned from the crash, and what could be done to avoid similar accidents. Its initial step in both cases was to find the black boxes for analysis. In the first case, examination of the black boxes exonerated the flight crew. For awhile, the focus of the study was on the flight environment (being too close to another plane). Finally, the most extensive study in the history of aviation accidents culminated in a recommendation to redesign the rudder mechanism in 737s. In the case of the second accident, the investigation also found no wrongdoing by the pilots. In fact, they had complied with the instructions given to them by the air traffic controller at Los Angeles airport without being aware that another flight had been cleared to land on the same runway. The accident investigation concluded with a recommendation to change the FAA's policy and rule for commuter aircraft takeoffs. The FAA is currently enforcing the new procedure.

Once an investigation is complete and recommendations for change are made, all the reports are saved in the NTSB Aviation Accident/Incident database. This database and other electronic repositories (e.g., Air Crash Rescue News and Aviation Safety Institute database) form a distributed memory for the whole aviation system. The lessons learned from past airline accidents are applied to prevent future accidents.

The learning and adaptation support system created by the commercial aviation industry has significantly and effectively increased air travel safety. *But any organization can employ the features of such a system to improve performance.*

ORGANIZATIONAL LEARNING AND ADAPTATION MODEL (L&A)

In 1997, while flying in a corporate jet, an executive of a Fortune 25 company was reading a corporate report and noticed a very poor performance compared to expectations (sales volumes, penetrations, unit profitability, unit cost) for two of the company's products. He wrote the following memo: "How come these products are performing so poorly vs. our expectations when the products were conceived? What went wrong?" This questioning had coincided with the company's decision to develop a system to facilitate organizational learning and adaptation based on the conceptual framework developed by Russell L. Ackoff (1999). In this approach, the focus of learning is on improvement of decision making. The model is based on experiential learning and assumes that learning occurs as a result of detection and correction of errors.

The following steps represent the logical flow of experiential learning in the L&A model:

- *Decide* – Choose a course of action and make a record of the decision (as described below).
- *Act* – Take action or instruct others to do so.
- *Monitor* – Track the implementation, expected outcomes, and the validity of the assumptions on which the expectations are based.
- *Detect* – Identify any significant differences between the performance observed and expected outcomes and assumptions.
- *Diagnose* – Determine the causes of mistaken expectations and assumptions.
- *Prescribe* – Initiate changes in the system or its environment based on the diagnoses and prepare a decision record on such action.
- *Evaluate* – Assess the impact of the prescribed changes.
- *Retain* – Collect lessons and make them easily accessible to all those authorized.

For the company mentioned above, the L&A model was used to reconstruct the decisions that led to creating the under-performing products. Using a "decision record" template as a starting place, the company retrieved the data from its own "black box"—identifying and recording the decision makers, the strategic context for the decisions, arguments pro and con, expected outcomes, assumptions on which the expected outcomes were based, the individuals responsible for the implementation, key information used, and the decision-making process employed.

For every decision, two sets of variables should be made explicit and monitored. First, in the case described above, expected-outcome variables such as design cost, capital investment, volume, market share, profit, quality, warranty, and so on were identified and tracked. Second, assumption variables on which the expectations were based were identified through studying the program development charters and business plans and interviewing the decision makers. The variables identified and tracked included market segment growth, product life cycle, program potential, pricing, and customer preferences. By retrospectively collecting these data and plotting "behavior over time" charts, it became apparent that the product programs were off course right from the time of launch.

Next, the challenge for the investigative team was to understand why this happened and why the attempts to correct these errors did not bear results for the product management teams. The first significant finding was that the assumptions were never made explicit and hence were never monitored by the product managers in the early stages of development. If these assumptions had been identified and tracked, changes that were taking place in the market segment that were negatively impacting segment growth potential would have been detected and could have provided an early warning of poor product performance. If these errors had been recognized at the early stages of product development, particularly before the launch, it would have led the management team to reframe its expectations and perhaps change the outcomes.

It was important to demonstrate how the different variables were interacting to create a system of problems for the product programs. Through the creation of an "influence diagram," it became apparent that isolating problem areas and applying local remedies (e.g., increasing the advertising budget) did not help the overall performances of the programs. As a result of these findings, the investigative team recommended the total redesign of these programs and a change in the company's prevailing product development paradigm (e.g., a change in long development cycle times).

Today, the company uses an organizational system based on the L&A model to accelerate its ability to learn and adapt and thereby improve strategic decisions. An organizational unit has been created to help with training and incorporation of learning functions into the "common processes" (e.g., product development process). A standard format for capturing decisions in "real time" and committing them to the organization's "memory" has been developed. Tracking assistance and comparing of relevant expected outcomes with associated assumption variables are provided in order to determine any significant deviations. After diagnosis of the cause(s) of errors, assistance in prescribing corrective actions is made (cf., NTSB).

An additional function in the L&A model provides decision makers with the ability to anticipate threats and opportunities. This function performs scanning and surveillance of the internal and external environments for significant trends or changes. Statistical procedures are used to identify such trends or changes in critical indicators before organizational performance is affected.

Finally, the decision-support function supplies decision makers with data: information, knowledge, and understanding derived either from inquiry or from lessons previously learned. This function allows learning from the past to be brought to bear on present strategic decisions.

CONCLUSION

The ability to gain understanding from experience requires the willingness to examine both successes and, particularly, failures. Yet, many organizational systems conceal mistakes and thereby reduce, if not preclude, experiential learning. Unable to learn from their mistakes, they may fail to adapt to customer needs and to improve their processes to meet increasing competition. Many eventually lose market share and drop out of the corporate sky.

Like pilots on the flight deck, executives and managers are continuously making decisions. But unlike the pilots, they are rarely supported by systems that help them navigate the "permanent white water" in today's environment.

Of great importance is the ability to examine the cause(s) of errors and to correct them. In this regard, a number of the NTSB's critical attributes are worth noting. The NTSB is, for all practical purposes, an independent organization. Moreover, it is a knowledge-based organization that derives its power from its reputation for impartiality and thoroughness. Because of its standing and despite having no regulatory or enforcement powers, more than 80 percent of its recommendations are adopted. This result is in stark contrast with the detection and correction work that goes on in the corporate world under the banner of "lessons learned." Unfortunately, the scientific rigor required for creating high-quality learning is usually absent in corporate diagnosis processes.

In the Ackoff framework (1999), once the recommendations for change have been made and implemented, the changes themselves are tracked. This process enables what learning theorists call "learning to learn." It accelerates and improves the learning process itself.

Although this paper has focused on the elements necessary to create a learning and adaptive system, the author is mindful of the roles culture, technology, structure, communication, and environment play in high-reliability systems relevant to corporations. As it relates to the commercial aviation system, the distribution of power among different functions in the commercial aviation system is certainly an important factor contributing to learning.

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