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NEW ARCTIC AIR CRASH AFTERMATH ROLE-PLAY SIMULATION™: ORCHESTRATING A FUNDAMENTAL SURPRISE

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We describe an aviation scenario-based role-play simulation used to teach healthcare practitioners about barriers to learning from accidents. Participants searched for the causes of the crash in a scenario that encouraged a "garden path" explanation that the root cause was a risky decision to take off despite visible ice on the wings. During a debriefing session, the actual structure of how the system failed is revealed, including over 100 active and latent contributors to the failure with a multitude of potential lessons to improve safety. The dissonance between lessons learned during the role-play and the potential lessons creates a "fundamental surprise" situation that allows oversimplified assumptions of how complex systems fail to be challenged.

INTRODUCTION

Scenario-based role-play simulations have a long tradition in human factors and elsewhere. In military settings (Shattuck and Woods, 1997), aviation (Salas et al., 1999), space shuttle mission control, emergency management (Smith et al., 1999), and anesthesiology (Gaba et al., 2001), they have been used to train and evaluate practitioners' technical and teamwork skills. We describe an aviation scenario-based role-play simulation used to teach healthcare practitioners about barriers to learning from accidents.

HOW COMPLEX SYSTEMS FAIL

The pedagogical goal was to introduce the set of patient safety concepts commonly referred to as the NEW LOOK. In particular, participants were taught the "Swiss Cheese" model of how complex systems fail as a result of multiple active and latent contributors breaching systemic defenses against failure (Reason, 1990) and obtained personal experience with the role that hindsight bias (Fischhoff, 1975) plays in encouraging narrowly focused causal attribution during incident investigations.

SIMULATION ROLES

The role-play was conducted on three occasions, interspersed throughout the first day of a 1.5-day workshop on patient safety. 110 participants included vertical and horizontal representation of Veteran's Administration practitioners from 6 facilities, including 22 physicians, 17 pharmacists and pharmacy technicians, 30 nurses and nurse managers, 18 administrators, and others.

Each participant received information about their assigned role several weeks prior to the workshop (Table 1). Distributed among the employees of a small commuter airline, New Arctic Air (NAA), was detailed knowledge of the events leading up to the crash. Employers of Big National Air were provided with historical information about their relationship with NAA, but no detailed information about events immediately prior to the accident. The victims were told how they were personally impacted by the accident. The government officials and representatives of various groups were told about potential political repercussions of the accident, such as impacts to laws regarding airline deregulation. The reporters and attorneys were informed of the nature of the organizations for which they worked and how that might constrain their interactions. Finally, several were provided with eyewitness data.

Participants were discouraged in several ways from dropping out of their roles during the simulation. First, an aviation scenario was selected for healthcare participants to discourage associations with their professional roles. Second, participants were deliberately assigned roles that inverted hierarchical relationships. For instance, hospital administrators were not assigned leadership roles in the airline. Third, workshop nametags included only the participant's first name and the organization affiliated with their role. Fourth, the participants were told that they must stay in role throughout the first day of the workshop, including during breaks, and facilitators, with identifying nametags, enforced this rule. Finally, the role-play simulation activity was video-taped.

Table 1. Simulation roles

New Arctic Air	Big National Air	Victims	Government	Reporters	Attorneys	Other
Vice President	President	Survivor #1	Asst Minister Transport	Congresstown News	Plaintiff's Attorney #1	Restaurant Waiter
Financial Manager	Insurer Rep	Survivor #2	Chief Investigator M. Transport	Congresstown TV	Plaintiff's Attorney #2	Aircraft Safety Rep
Marketing Manager		Deceased victim's family member	Member of Parliament	Congresstown Radio	Plaintiff's Attorney #3	Fire rescue Crew Chief Bearclaw Lake
Operations Manager		Surviving victim's family member	Provincial Crown Counsel	Respected National News	Attorney representing NAA	Airport Manager, Bearclaw
Fight Attendant			Pilot's Union Rep	National Public Newspaper	Attorney representing BNA	
Pilot				Smutty Tabloid		
Alta City Mechanic				Weekly Magazine		
Insurer Rep				Infotainment Weekly TV		
				Foreign National News		

ROLE-PLAY

The simulation director introduced the simulation rules and pointed out labeled physical locations that were relevant to certain roles. For example, the airport manager was likely to begin the role-play at Bearclaw airport. The director played a short video clip of a press story about the accident, including an interview with an ambulance driver and preliminary speculation that the accident was due to human error, at which point the role-play started.

The setting was the day after an airplane crash, based on a 1989 accident in Dryden, Ontario. In the scenario, the pilot took off with wings contaminated by ice after an unscheduled refueling stop at an intermediate airport. The plane stalled during takeoff and crashed less than a mile from the end of the runway, where it broke apart and burned. All the flight crew, except for one flight attendant who sustained minor injuries, were killed on impact or died in the subsequent fire. Approximately half of the occupants survived the crash and fire.

Each participant was provided information in advance of the workshop about their role, their personal relationship to the accident, and additional information, such as knowledge about events leading up to the accident and concerns about litigation and other risks. Many of the roles included an external stance that differed from internal beliefs about causes of the accident.

Official and unofficial accident investigations by stakeholders, including the airlines, government employees, victims, and reporters, formed the main task of the simulation. Despite high motivation and good intentions, the high-pressure environment and uncertainty that surrounded the accident made it nearly impossible to discover systemic and organizational contributors or to engage in genuine cooperation across organizational boundaries.

Only some of the information internally available to participants was shared as a result of concerns for liability, regulatory, and personal consequences, political posturing, commercial interests and local factors (Figure 2). The NAA employees, encouraged by their lawyers, typically restricted information to the press while they investigated what happened. All members of the press were required to "file stories" by talking to a video camera twice during the role-play. Because the press was not normally granted access to airline employees, they generally interviewed victims (Figure 3), eyewitnesses, and those with a secondary agenda, such as a representative from a pilot's union who wanted to emphasize that the pilot was a non-union pilot. In addition, they reported press statements issued through an airline spokesperson, which never included details, but instead consisted of remorse, assurances that an investigation was underway to determine the causes of the accident, and a request for patience until the investigation was complete. In the absence of sharing the internal information, the external stance of many participants that the (dead) pilot was ultimately responsible for the decision to take off in risky conditions was often the focus of discussions and filed stories.

The role-play encouraged creative improvisation within the context of a character's individual goals and social constraints. As such, each simulation played out in a unique fashion. For example, in one simulation, New Arctic Air's lawyer immediately restricted communication and was successful in presenting a united front through an appointed spokesperson who conducted press conferences. In another simulation, several New Arctic Air employees defected and leaked information to the press in order to repel blame or to victims

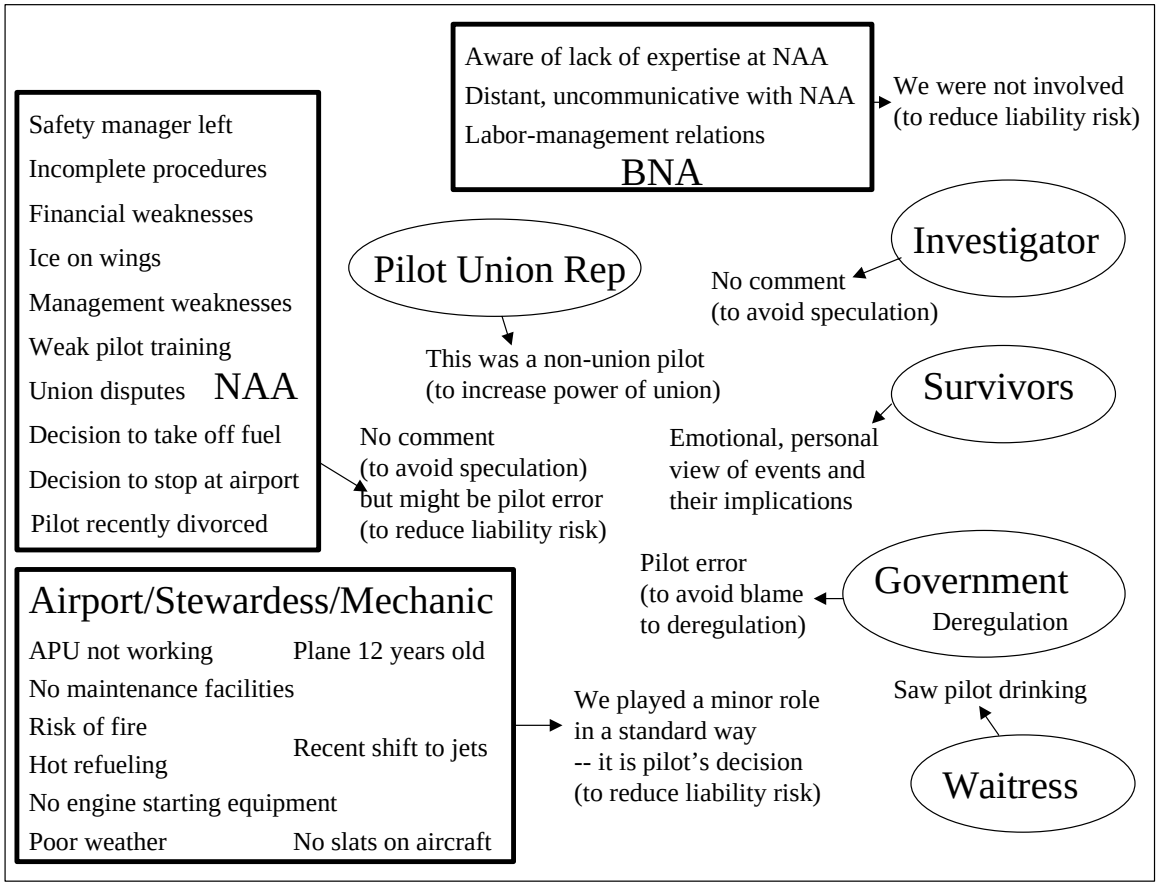

Figure 2. Internal Knowledge and External Stances

because they felt they had a right to know. Surprising events initiated by participants included a coalition of victims to file a class action suit, a member of parliament replacing the airlines' investigation with an external investigation, and the Vice President of New Arctic Air having a heart attack during a press conference.

At the end of the simulation, key participants were required to hold a group press conference and answer questions from the (now-frustrated) reporters and victims. Tensions usually ran high during this conference as potentially "damaging" information was revealed.

DEBRIEF

Immediately following the press conference, the participants were allowed to drop out of their roles. The simulation director revealed the design of the simulation, including bringing out information that was not shared and why. At this point, the director facilitated discussion about issues raised during the simulation. In particular, the participants described the intense conflicts that they experienced between the need to protect themselves and their organizations, the desire to help with the investigation, the temptation to answer questions by stakeholders, and the desire to apologize to victims. In this discussion, the group reflected on their experiences during the role-play and the facilitator reinforced and synthesized lessons learned.

Finally, the participants were polled regarding their assessment of the likely explanation for the accident. They were expected to, and in every case did, follow a "garden path" line of reasoning which led to blaming the individual pilot for a "risky" decision to take off despite visible ice on the wings. In every debriefing, it was also been pointed out that the decision might have been influenced by the pilot consuming alcohol prior to take-off.

The debriefing continued with a revelation of the actual structure of the 1989 Dryden accident on which the simulation was based. An exhaustive investigation of the accident led by a Supreme Court Justice had identified over 100 active and latent contributors to the failure as well as provided numerous recommendations for regulatory, organizational, design, and training changes. The simulation experience highlighted in a personal manner the challenges to discovering these complex patterns in the atmosphere following tragic events. This portion of the debriefing directly confronted the (stunned) participants with how circumstances surrounding a tragedy make it difficult for individuals and organizations to learn.

Figure 3. Reporter's interview with a survivor

The director then reviewed the NEW LOOK safety concepts associated with how complex systems fail, including the "Swiss Cheese" model of accidents, the nature of hindsight bias, and the limitations of attributing "human error" as the "cause" of an accident. The discussion following the lecture was more sophisticated than typically experienced with other audiences that have not been participated in the simulation.

TRANSLATING LESSONS TO HEALTHCARE

In response to feedback from the first simulation, we implemented two activities on the second day of the workshop in order to better link the lessons learned to healthcare. The first was a small group activity to generate a list of similarities and differences between the simulation and their workplace. The groups easily described parallels between the simulation setting and their workplace after 20 minutes of discussion.

In the second activity, the full group observed a role-play of volunteer health care personnel in their typical roles (one Attending physician, resident, pharmacist, nurse, senior administrator, and computer support person) trying to learn lessons from a chemotherapy overdose case. The facilitator halted the role-play at various points to elicit audience critiques about the process. For example, when the participants got sidetracked into defensive posturing or captured by oversimplified views of how the system failed, the audience encouraged the participants to engage in more constructive discussions.

EVALUATION

We evaluated the simulation via (1) responses to the following question turned in at the end of the workshop: "Whom do you expect to talk to, and what will you tell folks back at your institution about the simulation and the lessons learned, if any?" (2) pre-post comparison of survey responses, and (3) semi-structured interviews several months after the experience.

The responses from the open-ended questions indicated that the participants learned the main lessons from the simulation experience. Some representative responses include:

- The simulation was a new and informative way to look at how we look into things that affects patient safety…
- I will relate our finding that ultimately there is no one single person or factor to blame when a failure situation arises. That if we can eliminate blame from the equation that then the study of the real situation can begin and only then can we get to the roots of the issues and effect change.
- Good session…I hope more people will apply these concepts when doing incident/accident investigations. If used, this will create increased "safety" for patients and staff.
- Blame often doesn't work -- address the root problem. An error or accident isn't due to one single cause, but a series of incidents, all happening together, in sequence, that brings about the incident…
- This simulation has provided me different insights into solving these problems…I will advise them to attend this simulation if they are invited…
- Accidents/errors do and will continue to occur. What's more important is our response to them. It's time to look beyond blame and look for ways to prevent as many as can from occurring or at a minimum decrease the severity of the outcome…Do not become apathetic toward errors/incidents resulting in minimal adverse outcomes/consequences but look at this as an opportunity to possibly prevent severe adverse outcomes from occurring…

In addition to the open-ended questions, we found significant differences ($p<0.05$ two-tailed ANOVA) on 7 of 23 questions from a pre-post survey (N=35, scale of 1 = strongly agree to 5 = strongly disagree) (Table 2) conducted during the second of three simulations.

During follow-up interviews, we discovered a wide variation in how much of the detailed material was retained and applied to the individual's workplace setting. For example, one participant described that she applies what she learned every time she conducts a root cause analysis of an incident. The simulation experience serves as a reminder to focus on the process not the outcome, and to look for multiple contributors rather than a single root cause. On the other hand, another participant could not remember lessons from the simulation and did not think that it had changed his behavior in the workplace. Therefore, we are developing a set of follow-on educational activities to reinforce the lessons learned and further encourage behavioral change.

Table 2. Pre-Post Survey Responses

Pre	Post	P value	Survey Statement
2.60	1.86	0.001	Health care workers create layers of defenses against predictable erroneous actions. When accidents occur, it is almost always because gaps in the layers of defense line up, not because of individual mistakes.
2.11	1.68	0.008	Failure of complex systems is the result of the combination of multiple latent failures, each necessary but only jointly sufficient to create a path to failure.
2.97	2.57	0.05	Policies and procedures designed to produce another layer of defense against failure are a powerful tool for shaping human practitioner behavior to prevent these individuals from creating accidents.
3.19	2.75	0.04	Policies and procedures designed to produce another layer of defense against failure have little impact on overall system rates.
3.47	4.08	0.003	Hindsight bias is an easily overcome prejudice against practitioners.
2.47	3.41	0.0001	Human error is the cause of most adverse events.
3.36	3.00	0.05	Most medical errors are due to problems with processes that are out of a clinician's control.

DISCUSSION

"Fundamental surprises" (Lanir, 1986) such as the Three Mile Island nuclear accident, provide tremendous learning opportunities because they call into question underlying assumptions. The revelation during the debriefing about the complex processes involved in the accident are fundamentally surprising to participants who concluded that the primary cause was a risky decision to take off despite ice on the wings. In reaction to the dissonance that this surprise triggers, basic assumptions about how complex systems fail can be challenged because explanations are demanded that require new concepts (Woods et al., 1994).

The simulation of a non-healthcare accident allows participants to explore how safety is created without provoking defensive reactions. It allows deeper processing (cf., Sitkin, 1996; Evensen et al., 2000) and experiential, transformative learning that continues past the workshop experience. In addition, by involving members throughout horizontal and vertical matrices of the same organization in the shared experience, it is hoped that there will be a step change in the ability to productively recognize, debate, and learn from complex system failures and "near misses" in the work setting.

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REFERENCES

Evensen, D. & Hmelo, C. E. (2000). *Problem-based learning: Research perspectives on learning interactions*. Mahwah NJ. Erlbaum.

Fischhoff, B. (1975). Hindsight does not equal foresight: The effect of outcome knowledge on judgment under uncertainty. *Journal of Experimental Psychology: Human Perception and Performance*, 1, 288-299.

Gaba, D.M., Howard, S.K., Fish, K.J., Smith, B.E., Sowb, Y.A. (2001). Simulation-based training in anesthesia crisis resource management (ACRM): A decade of experience. *Simulation & Gaming*, 32(2), 175-193.

Lanir, Z. (1986). *Fundamental Surprise*. Eugene, Oregon: Decision Research.

Perrow, C (1984). *Normal Accidents: Living with High-Risk Technologies*, Basic Books.

Reason, J. (1990). *Human Error*. Cambridge, MA: Cambridge University Press.

Salas, E., Fowlkes, J.E., Stout, R.J., Milanovich, D.M. & Prince, C. (1999). Does CRM training improve teamwork in the cockpit?: Two evaluation studies. *Human Factors 41*, 326-343.

Shattuck, L. & Woods, D.D. (1997). Communication Of Intent In Distributed Supervisory Control Systems. In *Proceedings of the 41st Annual Meeting of the Human Factors and Ergonomics Society*, 259-263.

Sitkin, S.B. (1996). Learning through failure: the strategy of small losses. In Cohen, M.D. & Sproull, L.S. (eds.), *Organizational Learning*. CA: Sage, 541-577.

Smith, W., Dowell, J., & Ortega-Lafuente, M.A. (1999). Designing for paper disasters: An authoring environment for developing training exercises in integrated emergency management. Cognition, Technology, and Work 1: 119-131.
Woods, D. D., Johannesen, L. J., Cook, R. I., & Sarter, N. B. (1994). *Behind Human Error: Cognitive Systems, Computers, and Hindsight*. Dayton, OH: CSERIAC.