



SYSTEM FAILURE CASE STUDIES

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Strayed Spears

During a 36-hour period on August 29-30, 2007, six nuclear warheads were flown in U.S. airspace without proper authorization. The warheads, mistaken for inert warheads, were loaded onto a B-52 bomber and transported from Minot Air Force Base, North Dakota to Barksdale Air Force Base, Louisiana. Nine hours after the Minot B-52's arrival, Barksdale crews identified the warheads and officers alerted the National Military Command Center at the Pentagon. In the aftermath, a Defense Science Board study publicly examined what Air Force officials considered to be an unprecedented breach in nuclear weapons "surety," or the positive control of nuclear weapons.

BACKGROUND

Tactical Ferry Mission

Minot Air Force Base, stationed in the windswept plains of North Dakota, has housed an arsenal of nuclear and conventional weapons since the 1960's. Minot AFB is also home to a contingent of B-52H Stratofortress Bombers - mammoth aircraft with many missions, including delivery of nuclear-tipped, air-launched cruise missiles (Figure 1). In 2007, the U.S. Air Force used B-52's to transfer stored AGM-129 Advanced Cruise Missiles from Minot Air Force Base to Barksdale Air Force Base near Shreveport, Louisiana, for decommissioning.

The missile transfer procedure at the time (known as a tactical ferry) called for airmen to remove nuclear warheads from the cruise missiles and replace them with inert warheads. Groups of six missiles, attached to pylons for under-wing mounting to the ferry aircraft, were stored in bunkers. A database tracked the missiles according to pylon number, and could display the status of every missile in Minot's custody. One pylon of six missiles could be mounted beneath each wing of the B-52H aircraft, allowing it to ferry 12 missiles per flight (Figure 2).

Transport Procedures

When removing weapons from storage, airmen were required to follow the same USAF weapons-transport procedures for



Figure 1: A B-52H Stratofortress Bomber served as the primary delivery platform for air-launch cruise missiles and nuclear weapons.

inert weapons as for live weapons. These safeguards were particularly important at Minot because nuclear weapons, nuclear training, and nuclear test devices all shared the same storage bunker. Since inert and actual warheads were nearly identical in appearance, regulations specified that nuclear-inert missiles should have placards placed on the pylons indicating their inert status. Each missile also contained a stamp-sized, clear window to identify nuclear and inert payloads by the color within the window. Finally, a serial number printed on the warhead's exterior provided handling crews with an additional identifying reference.

U.S. Air Force Inadvertently Transports 6 Nuclear Warheads Across Country

Proximate Cause:

- Handling crews did not follow established weapons-transport procedures to verify the payload was inert

Underlying Issues:

- Decreasing focus on the nuclear enterprise since the end of the Cold War
- No authority figure over special weapons transfer at Minot Air Force Base
- Poorly defined regulations



Figure 2: A pylon of AGM-129's is attached to a B-52

To begin the transport routine, a Breakout Crew would verify the status of all weapons in the facility. During this 45-minute procedure, the workers were required to check the payload of each missile in the bunker and verify its status to confirm which missiles were prepared and scheduled for breakout. No other activities could occur inside the storage bunker during this verification process. Once the Breakout Crew accomplished its assignment, a Convoy Crew was tasked with loading the pylons onto the munitions trailer and then towing the trailer to the aircraft. Before towing the munitions trailer, they were required to verify the missiles were carrying the correct payloads. Once the Convoy Crew was en route to the aircraft, the driver would call the Munitions Control Center to access the database and relay confirmation that the correct weapons were being transferred.

Upon weapon arrival at the aircraft, a waiting Loading Crew would take weapons custody and mount the pylons beneath the wings (after verifying the payload a fourth time). The final check rested with the Aircrew, who would again verify the payload within each missile and fly the aircraft to its assigned destination (Figure 3).

WHAT HAPPENED?

Procedural Breakdowns

Two pylons were scheduled for transfer to Barksdale AFB on a Barksdale B-52 on August 30, 2007. Some time before this date, the Minot Munitions Maintenance Squadron determined that one of those two pylons would remain behind. A pylon carrying missiles with components closer to their expiration dates would be sent to Barksdale in its place. The change was entered in the electronic tracking database but not on internal documents used for weapons coordination in the bunker. Using the internal paper form, the Breakout Crew remained unaware that one of the originally scheduled pylons had been replaced and a new pylon had been prepared for tactical ferry in its stead.

On the morning of August 29, 2007, the Breakout Crew entered the weapons bunker and began verifying each weapon contained therein. However, in a locally developed process to simplify work (and a breach of required procedure), the Convoy Crew entered simultaneously. The Convoy Crew began transferring the scheduled pylons to the munitions trailer and hooking the trailer to the towing vehicle. Later investigation discovered confusion over the meaning of “verification”. Given use of the local form and misunderstanding of the verification task, the Breakout Crew overlooked several pylons, including the ones the Convoy Crew had already begun to tow away.

Established processes mandated written verification of the payload and weapon status each time the weapons changed hands, but crews appeared to misinterpret this regulation at each stage in transit from bunker to bomber. The Minot Munitions Control Center could have discovered the errors by checking the database as per regulations, but they did not do so; hence the loading crew unwittingly mounted nuclear weapons to the aircraft, leaving them there for a 15-hour overnight period without special security. Though the bomber remained within a secure perimeter and the warheads never left U.S. Air Force control, the missiles did not receive appropriate security because the airmen did not realize the payload consisted of real nuclear warheads as opposed to inert substitutes.

The Aircrew was scheduled to fly the bomber 1,100 miles south to Barksdale Air Force Base on August 30, 2007. Procedures directed the Air Crew to conduct a final payload verification before takeoff, but the navigator checked only the pylon mounted to the right wing. For reasons unknown, he did not examine the pylon beneath the left wing – the one that contained the nuclear warheads. When the bomber arrived at Barksdale, it remained on the tarmac for a period of 9 hours, protected only by the security fence and guarded only by roving patrols. That evening, when Barksdale airmen unloaded the missiles and discovered the warheads, the gravity of what had just transpired was revealed. They immediately established appropriate security and alerted the National Military Command Center at the Pentagon of a ‘Bent Spear’ nuclear



Figure 3: The aircrew was required to verify the payload of each missile before navigating to the assigned destination.

incident (a military term used for violations or breaches of nuclear weapon handling and security regulations). To date, the USAF has yet to officially classify the incident.

PROXIMATE CAUSE

The pylon carrying six nuclear warheads was inadvertently transported across the country due to local process changes that compromised established procedure. Remarkably, the warheads slipped through 5 safety nets and were exposed to risks of theft or damage for a combined time period of 36 hours.

UNDERLYING ISSUES

Nuclear Enterprise Focus Lost

A Defense Science Board investigation released in February 2008 remains the primary factual source available to the public of this incident. It places the event in context of a national “nuclear enterprise” (or nuclear mission) which includes the people who develop and conduct nuclear operations, nuclear support systems and delivery platforms, organizations that research nuclear technology, and the nuclear weapons themselves. The operational zenith of the nuclear enterprise to date occurred during the Cold War, when USAF bomber and ICBM squadron personnel often lived and worked under elevated real-world alert conditions. To prevent nuclear attack, the U.S. relied on a strategy of Nuclear Deterrence (or MAD – Mutually Assured Destruction): successful deterrence hinged upon the credible ability and round-the-clock readiness to deliver nuclear weapons. With national security on the line, unsurpassed attention was given to demonstrating 100% positive control of nuclear weapons, translating into zero-defect procedural excellence in every aspect of handling and delivery.

Fears of nuclear attack dissipated at the end of the Cold War in 1991. As national security priorities shifted, some USAF resources dedicated to the nuclear mission were dispersed to address a growing list of conventional warfare missions. Policy changes called for a significant reduction in nuclear arms, and downsizing within nuclear sectors diminished the availability of nuclear expertise. While warhead inventory numbers declined, the portfolio of nuclear-capable weapons systems that fewer people of lesser authority had to manage actually became more complex. A 1992 restructuring of the Air Force dispersed nuclear mission-dedicated assets among three different operational commands and eliminated a single command chain (headed by a three-star Strategic Air Command general) focus on the nuclear mission. Yet, basic handling and delivery procedures remained in place, along with thousands of personnel possessing years of Cold War expertise.

A generation later, Cold-War-experienced personnel were largely gone, replaced by an officer and enlisted complement

with far less nuclear mission training and only exercise-level experience to rely upon. ICBM crews retained a dedicated mission, but bomber and support crew training shifted to a multi-mission skill set. The Defense Science Board (DSB), upon investigating the unauthorized weapons transfer, found no nuclear mission-specific flight training existed for new B-52 crews. Unit-level inspections intended to catch procedural slips had missed all the precursors for the unauthorized transfer event. A B-52 aircraft commander told DSB, “The nuclear mission is all about procedures; the conventional mission is about operational results.” Senior DoD officials, in interviews with DSB, stated “The decline in focus has been more pronounced than realized and too extreme to be acceptable.”

Eroding Adherence to Processes

Although the errors of the handling crews and flight crew played a significant role in this mishap, the DSB investigation found facts that made it possible to misinterpret rules. For instance, some procedures appeared unclear: missiles that were not carrying nuclear warheads were required to have markings on the pylons signifying this fact, but the DSB could not find a specific statement of what the markings should look like. In the past, the pylons carrying inert missiles were surrounded with orange cones and were also covered with multiple placards indicating their status. Over the years, these very clear markings became a single sheet of paper, reducing labeling of nuclear-active versus nuclear-inert devices. Additionally, when the time came for those weapons to be transported, crews expressed uncertainty as to whether or not the instruction: “verify which payload is installed” required a physical inspection or not.

Confusion extended beyond storage regulations and transport processes to scheduling practices. Investigators found that formal scheduling procedures assigning the movements of the pylons, for the most part, were nonexistent. When the munitions squadron changed which pylon would be sent to Barksdale, they did so with such informality that transport teams were never notified. If transport teams had known there was a new plan, that information may have prompted them to adhere more closely to the payload verification directives. Instead, the DSB discovered the Breakout, Convoy, Loading, and Air Crews had, for some time, dispensed with the practice of documenting the payload each time it changed hands; bomber weapons were only moved around as exercises so the formality seemed excessive. Crews did not realize the documentation requirement applied to all missiles, whether loaded with nuclear warheads or not. Inspections missed the simplified local process because the scope of the inspections themselves had narrowed.

No clear understanding was found at Minot of who was explicitly accountable for weapons movement outside the storage area. Without an authority figure to define and enforce guidelines, it was only a matter of time before procedures

broke down: Breakout and Convoy Crews, in a slow evolution of more expedient processes, developed a pattern of working in the storage bunker concurrently. This clear infringement of an unambiguous rule indicates the safety system failed not only because of vague or unclear specifications, but also because clear procedures ensuring accountability had fallen out of use.

AFTERMATH

Although the warheads were never at risk for detonating, top Air Force officials, Congress, and the American people were stunned that mishandling of weapons containing such massive destructive power could have occurred. Congress ordered a top-down review of all nuclear procedures, and the Air Force conducted a service-wide inventory of its nuclear stockpile to check for similar discrepancies. They found none. Barksdale's 2nd Bomb Wing assumed Minot's weapons maintenance duties until its 5th Bomb Wing was recertified in 2008. The USAF issued new policy prohibiting storage of nuclear and non-nuclear weapons in the same facility. Further, non-nuclear weapons must be clearly placarded as such; accountability for weapons movement and custody was specified, and a coordinated visual inspection checklist was required for all units that handle nuclear weapons. In 2009, the USAF published Air Force Doctrine Document 2-12, Nuclear Operations, as its nuclear surety foundation.

FOR FUTURE NASA MISSIONS

The U.S. Air Force established several safety nets meant to prevent accidental weapons movement, but the August 2007 incident shows even processes that survive for decades can fail where training and inspection requirements fall away. When loss or apparent risk seems low, operators can face pressure to streamline procedures that seem cumbersome and time-consuming, leading them to simplify processes and create "efficiencies" that ultimately diminish safety barriers. To avoid this risk, it is important to remind those assigned to follow high-stakes protocols of the reasons those protocols have been established. Similarly, leaders separated from a mission and its resources by time, distance, and other competing priorities must not lose sight of massive potential consequences of mission failure - where causes hide in plain sight, many levels of authority below.

NASA engineers and SMA professionals apply a broad range of procedures and processes to high-energy systems (some older than their operators) every day. It is not enough to comprehend the procedural steps involved; as technical professionals who become managers, we must gain the system knowledge that caused the procedures to exist. This includes software, hardware, environmental and human failure modes and consequences. As years and competing priorities buffet the system and all charged with its operation, that knowledge supports thoroughness in the face of constant demands for efficiency.

Questions for Discussion

- Do your training programs cultivate awareness and respect for safety rationales?
- Have you checked for eroding standards within your organization?
- What have you done to ensure the maintenance of established processes?
- Are there any areas within your organization in which clear authority and accountability is absent?

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