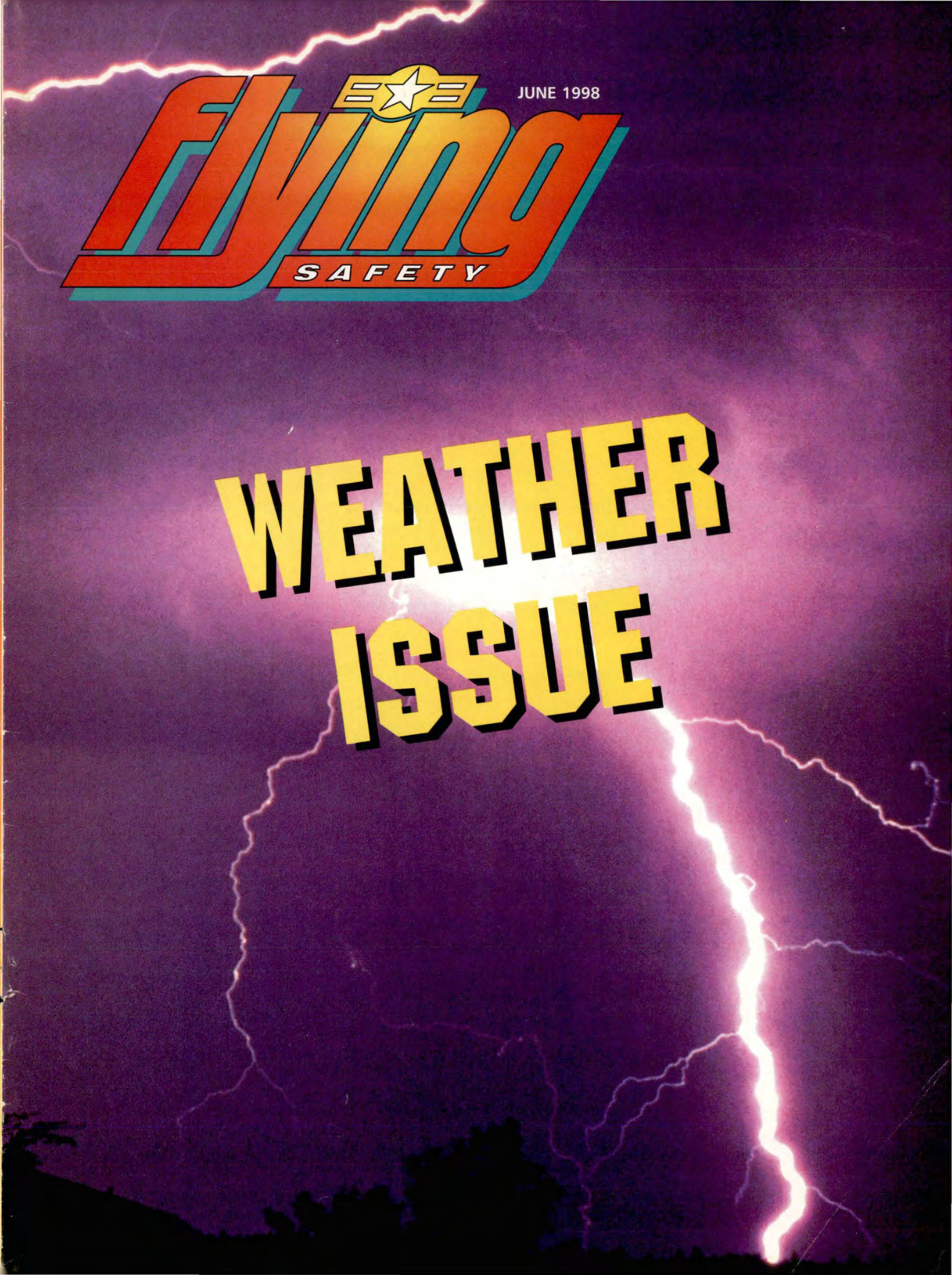
Flying SAFETY
JUNE 1998

WEATHER ISSUE



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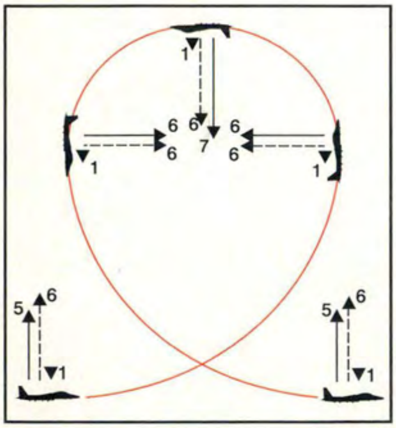
IN THIS ISSUE:

Page 4



Page 13

Page 18

Cover photograph courtesy Lt Col Timothy H. Miner, USAFR

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FSM notams

A Trip Through the MAIS

LT COL BARNEY KNAUSS
Air Force Weather Agency
Offutt AFB, Nebraska

MAIS—Military Aircrew Information Service—you just might like the way it gathers weather and NOTAMs for you. The contact for MAIS is over the NIPRNET at http://www.mais.afwa.af.mil or dial-in with our 1-800 number. However you get to MAIS, push *start*, scroll down the login page, and point and click on *new user* or *1-800-MAIS* if you haven't been here before.

Set your *profile* so the system will remember your name, home plate, and the routes that you would like to save for future use. Tailor your briefing to the map background, class of airfields, navaids, and the types of weather products with *options*.

Get the "big picture" by selecting *national* preview. Here are current satellite and radar images featuring loops for your preview. Current lightning and other charts display hazards to flight, and the forecast weather, watches, warnings, and advisories may help provide some situational awareness. The *local* preview gives you a wide variety of products for home plate or allows you to enter the ICAO of your choice.

Develop a *new* one or revert to an *existing* route or min-time-to-ram plan. *Submit* and presto! You now have the route displayed with an overlay of weather. (See graphic.) If you need something else or have a suggestion, push *feedback*.

We expect worldwide capability in calendar 1998. If you need more information, contact me, Lt Col Barney Knauss, at DSN 271-5520 or knaussb@afwa.af.mil. ✈

Thunderstorms—Up (Too) Close and Personal

LT COL TIMOTHY H. MINER (AFRC)
HQ Air Force Weather Agency

It was only my third mission as an aircraft commander. There I was, at 4 o'clock in the morning, at the briefing for a higher-headquarters-directed air refueling mission. My crew and I were to be No. 2 in the cell to refuel the Habu (SR-71) on a very visible mission. We were good to go (a phrase unheard of in those days) until the weather briefer placed a chart of the VIP level 4 and level 5 (see chart below) thunderstorms all around the air refueling track. We knew something was going to make this a day to remember. It wasn't until 10 minutes later, with the conclusion of the last briefing, that the final slide appeared. "Flying Safety Is Paramount" is all it said.

As we approached the air refueling track some 5 hours later, a large wall of thunderstorms crossed our path. Tops to 50,000 feet were reported. One controller said there were reports of tornadoes on the ground. With the SR-71 already airborne and descending from its "hot run" high on the other side of the thunderstorms, there was little to do in our craft but stay in formation behind the lead as he probed the squall line for a path through these weather giants. It was clearly too late to change tracks.

As the lead headed for a "saddle"—the low portion between large cells—in the squall line of storms, he suddenly turned away just after entering the cloud mass. We turned as soon as we could. Unfortunately, we had already penetrated the clouds, too.

Within a few moments, we encountered just about the worst ride I can say I've ever experienced in an aircraft. It started with a brief bout with heavy precipitation. Next came the pounding of hailstones. Severe turbulence forced us up and down over 400 feet within seconds. Next came the bluish glow on the cockpit windows. Finally a very loud bang accompanied a very bright flash just outside of the cockpit. The AC electrical system quit. We went to battery power until our craft was out of the storm. Once we were clear of the weather, we reset two generators.

Upon landing, we found a 6-inch hole in the radome. We had been hit by lightning, but we were also very fortunate. It could have ended a lot worse. After all, we still have many more good years of aviation left in us.

And so began my passion with the weather and flying…

Introduction to Thunderstorms

At any instant there is, on average, at least one aviator who is looking squarely at a thunderstorm on radar or out the window of the aircraft while flying. Almost once a second, on average, a lightning strike between the ground and a cloud occurs in the United States. Over 100 lightning strikes take place every second above Earth where over 44,000 thunderstorms are occurring right now, which presents a significant hazard to aviation and

FEDERAL AVIATION ADMINISTRATION'S GUIDELINE FOR AIRCRAFT REFLECTIVITY

From FAA Advisory Circular 0045C

VIP Level*	Echo Intensity	Precipitation Intensity	Rain rate (in/hr) in stratiform clouds	Rain rate (in/hr) in convective clouds
1 green	Weak	Light	less than 0.1	less than 0.2
2 yellow	Moderate	Moderate	0.1 - 0.5	0.2 - 1.1
3 red	Strong	Heavy	0.5 - 1.0	1.1 - 2.2
4 red	Very strong	Very heavy	1.0 - 2.0	2.2 - 4.5
5 red	Intense	Intense	2.0 - 5.0	4.5 - 7.1
6 red	Extreme	Extreme	more than 5.0	more than 7.1

*VIP Level refers to the Video Integration Processor which interprets the reflected energy and provides a location and color to the return for display on the monitor.

ground operations. There is a very good chance you'll encounter a thunderstorm within the next month or two. During that encounter, you will face the many and powerful hazards of a thunderstorm, including strong winds and windshears, heavy precipitation, lightning, hail, and tornadoes. Are you ready?

The definition of a thunderstorm is pretty basic, yet misunderstood by many. The weatherman's definition of a thunderstorm is any local storm with lightning and thunder, produced by a cumulonimbus cloud, usually producing gusty winds, heavy rain, and sometimes hail. However, all the weather observer officially uses to identify a thunderstorm is thunder. That's all, just thunder, according to the handbook published for all observers.

Cumulonimbus clouds, or Cbs, are vertical columns of cloud mass, with rain descending from them, which could potentially be thunderstorms. But until the first thunder is heard, there technically is not a thunderstorm.

Actually, a few years ago, weather manuals were changed to allow observers to report thunderstorms when the airport environment's regular noise would hamper the detection of thunder. Weather observers can now use the presence of lightning in the immediate vicinity (5 nm) or hail to identify when a thunderstorm is impacting an airfield.

The weather observation will stop reporting thunderstorms 15 minutes after the last reporting criteria are observed.

This, however, begs one of aviation's biggest questions. How do the new automated weather observing systems found on civilian airports sense thunderstorms? The answer is that unless a human is augmenting the system, it doesn't. By the way, Air Force policy is not to use these systems at airports for this reason.

A Review of Thunderstorm Meteorology

What does it take to make a thunderstorm? While thunder is key to the storm's identification, there are a few basic ingredients to create the phenomenon. We can imagine the whole process as an engine sustained by fuel and activated by a trigger.

An unstable atmosphere is the first ingredient and the "engine" that keeps the process going. Instability occurs when there is air that is warmer than the atmosphere around it. Under those conditions, the warmer air is lighter and will rise, expand, and cool to the same temperature as its environment. As the air cools, it transfers energy to the surrounding air. When the air cools to the dew point temperature, a visible cloud forms. While rising air is the "engine," it needs a source of "fuel."

Moisture in the form of water vapor is the second ingredient in our recipe and the fuel for the process. The more moisture there is, the better the environment is for creating a thunderstorm. With more moisture, the dew point temperature is higher, so clouds will form with less cooling. There will also be more energy to release to the surrounding atmosphere during the cooling process. Warm, moist air is the fuel that keeps the unstable atmosphere creating thunderstorms, but we still need the trigger.

The final ingredient is a mechanical device, the "trigger," that initially lifts the air up so that the atmosphere's instability will keep it rising. There are actually a number of triggering mechanisms: mountainous terrain, fronts, or colliding airflows that force air upward.

All weather fronts (cold, warm, stationary, or occluded) can be sources of uplift for the initial development of thunderstorms. At the frontal boundaries, warmer air rises over cooler air masses to create upward motion. Because cold fronts have a steeper slope, the uplifted air moves faster, which can create more severe thunderstorms. Frontal storms are also hazardous because the thunderstorms can be embedded and unseen within stratiform clouds that also form.

The squall line, associated with rapidly moving cold fronts, is the source of some of the strongest thunderstorms. Here large-scale windflows converge between 50 and 300 miles ahead of the cold front. This strong and rapid movement upward creates a thin band of very unstable air that extends in a long line. The thunderstorms here are very active and potentially quite hazardous.

Another source of uplifting motion comes from the movement of moist air over rising terrain features. The thunderstorm will usually form on the windward side of the terrain if the air is unstable, and the storms are usually embedded within layers of clouds near the peaks.

The collision of moving air, or convergence, plays a role in thunderstorms. Since solar heating of the land occurs unevenly, some areas will be warmer while other areas are cooler. Air rises over the warmer areas and is replaced in low levels by air converging from surrounding cooler areas. These converging airflows collide and force an uplifting motion. Convergence also occurs when cooler air from nearby thunderstorms descends to the ground, spreads out, and pushes under the warmer air, lifting it upward to form a whole new thunderstorm. Sometimes, the descending air from different storms meets and forces warmer air upward.

Once the air is lifted by one of these mechanisms, other processes account for the growth and development of the individual thunderstorm cell.

The Life of a Thunderstorm

There are three major stages of development to the life of a thunderstorm. The whole process lasts from only 20 minutes to several hours. Watching the development of a single cell thunderstorm through all three stages gives us a chance to understand the forces involved in creating this aviation hazard.

The first, or updraft stage, begins with a simple cumulus cloud. During this initial stage, the updraft that carries the moist air aloft can be as rapid as 3,000 feet per minute and extends from the ground to several thousand feet above the cloud. The heat energy released as the air cools expands the bubble of unstable air. As the air moves upward, cloud droplets collide with others and grow in size. The suspended water can be in liquid form well above the altitude that water freezes due to

continued on next page

the energy released in the growing cloud. Towering cumulus clouds (TCU) are now visible.

In the mature stage of the thunderstorm, the liquid droplets grow to a size where they can no longer be suspended aloft by the updrafts within the cloud. Precipitation begins and drags cooler air from the higher altitudes down with it. This creates a **downdraft** within the cloud. This colder air accelerates groundward at up to 2,500 feet per minute. As precipitation descends, drier air mixes into the cloud in a process called "entrainment," causing some of the rain to evaporate. Cooling accompanies the evaporation and accelerates the descent.

When the downdraft strikes Earth's surface, it spreads out to create a **gust front** with strong **windshears** and damaging winds. If the downburst is less than 2.2 nm wide (4 km), it is called a **microburst**; a larger downburst is called a **macroburst**. Updrafts gain intensity to the point that some storm clouds can grow at up to 8,000 to 10,000 feet per minute. With updrafts and downdrafts located close to each other, large droplets that were carried aloft to be frozen in the higher portions of the atmosphere fall and collect more moisture, only to be carried aloft again to eventually form hail. Throughout this stage, movements and collisions of air molecules and water droplets create electrical fields within the cloud producing lightning and, therefore, a thunderstorm. Turbulence is severe within the cloud. At its maximum intensity, a thunderstorm at the top reaches the tropopause, and ice crystals spread out in the faster winds of the higher altitudes to create the familiar anvil formation.

Finally, in the dissipating stage, downdrafts form throughout the cloud, decreasing the uplifting taking place. The source of energy necessary for sustaining the storm is removed. The intensity then decreases until all that is left is the floating cirrus anvil.

Most individual thunderstorm cells last from 20 minutes to an hour within a system of multi-celled clusters of Cbs. The gust front usually produces additional uplifting action ahead of the thunderstorm creating a new one which will have a life of its own. Where there is a lot of moisture available, the cluster will grow to a large size called a "**mesoscale convective complex,**" or MCC. It's important to understand that new thunderstorms form wherever gust fronts create lifting, but the whole system moves in a direction steered by winds in the middle altitudes.

When there is stronger wind aloft, the mature thunderstorm will tilt. In this situation, the process of growth and maturity is sustained for a long time. This is the "**supercell**," a source of some of the most severe weather produced by thunderstorms.

Thunderstorm Hazards

Supercells exist because of the strong windshears created between lower-level warm, moist air, dry, upper-altitude winds, and the very strong rotation of air moving upward within the cell. The difference in wind speeds and directions also creates a horizontal rotation, much like the formation that creates roll clouds or causes waves to curl on a shoreline. When the horizontal rolling motion is tilted vertically, the portion that is rotating in the same direction as the winds within the cell (usually counterclockwise in the Northern Hemisphere) adds its motion to the storm's spin, and a **tornado** forms. Sustained by large amounts of warm, moist air lifted into the path of the cell by a large gust front up to 15 miles ahead of the cell, the formation can grow to over 60,000 feet in altitude and punch through the tropopause in a formation called an "**overshooting top**." These cells can travel up to 300 miles along the surface of Earth.

In addition to tornadoes and gust fronts, downbursts occurring in a larger-scale thunderstorm system can create very damaging straight-line winds called "**derechoes**." A derecho is a system of downbursts produced by convective weather systems that, because there are so many downbursts so close to each other in time and space, the net effect is a destructive straight-line wind that could reach over 100 knots.

Whether severe or not, all thunderstorms have the vertical motions that create electrical hazards. As liquid and crystal water droplets collide in the violent vertical motions of a towering cumulus cloud growing to maturity, electrical fields are created in the cloud. There is a thin area of negative charge at the top of the cloud. Below it, within the anvil, is an area of positive charge. Around the freezing level, where water exists in all three states, is a strong area of negative charge. Along the cloud bottom is a thin area of positive charge. Finally, underneath the cloud, and traveling with it, is a very strong area of positive charge.

At some point, the differences between the high concentration of negative charge at the freezing level and a nearby positively charged area is so great that nature seeks to neutralize the differences. Most of the time it's a positively charged area within a cloud, whether the same or a different one, that's used. Some of the time it's the positively charged ground that's used.

When this happens, the electrons from the negative area move away from the cloud in a small 20- to 50-foot movement called the "**stepped leader**." Because air is so resistant to the flow of electrons, it takes lots of electrons to flow to find the path of least resistance, making a forked pattern. Additional 15- to 25-foot steps take place from stepped leaders as the path grows towards the positively charged area. When the stepped leader gets close to the target, a path of positive charge is drawn towards the negative charge. If the target is the ground, the positive "**streamer**" ascends through a high point such as a flagpole, lightning rod, tree, or the occasional human.

When contact is made between the negative leaders and a positive streamer, there is a mass migration of positive charge along the entire path created by the leaders. As the positive and negative charges collide, the 1/8- to 6-inch-thick pathway heats up to 10,000 degrees Celsius. (That's hotter than the surface of the sun.) The heat energy creates light and a rapid expansion of the air around it. We see lightning. This whole process has taken less than a second to occur, and with the pathway through the air now less resistant to electrical flow, it can be repeated up to three or more times before a second of time takes place by "**dart leaders**" traveling down the same path as the step leaders. This gives lightning a flickering appearance. We hear thunder "rolling" as the soundwaves from different parts of the flash reach us at different times. We have a thunderstorm on our hands.

If you are out on the ramp and want to know how close lightning is, use the 5-second rule. For every 5 seconds the thunder takes to reach you after the flash, the lightning is 1 mile away.

Avoiding the Thunderstorm in Flight

At the risk of sounding academic, we will point out that "it is intuitively obvious that thunderstorms are laden with a myriad of unacceptable environmental hazards to aviation." In simpler terms, please **avoid thunderstorms while flying your plane.**

But how do you do that?

The first technique is the old "see and avoid" concept. Look out of the cockpit for signs of convective activity. This is but a small list of things to look for that give evidence of convective turbulence, lightning, hail, downbursts, microbursts, and severe windshears.

- anvil cloud form approaching
- darkened color to clouds
- churning vertical clouds
- vertical clouds that are growing

The next step is to use the weather radar (if you have one) available to you while airborne.

Not every weather hazard in a thunderstorm is visible on weather radar. Since the radar is dependent on the return of reflected electromagnetic radiation, the ability of a particular hazard to reflect the beam will have a direct impact on what we can sense.

See the Federal Aviation Administration's guideline for aircraft reflectivity on page 4.

The radar will not sense the following:

- small cloud droplets
- fog
- ice crystals
- small dry hail or graupel (granular snow pellets)

This list is significant because if you are using your weather radar to scan your flightpath for weather out of visual range (150 to 200 nm), you may paint a group of individual cells and conclude you could visually circumnavigate them. In reality, you may be facing a wall of clouds with imbedded thunderstorms. The low reflectivity of the surrounding clouds may not show up on the radar, especially at greater distances. Aviators will also not be able to paint the anvil portion of a thunderstorm since it's primarily ice crystals.

Since radar is our primary method of sensing thunderstorms, it's important to know how each type of precipitation affects what the radar shows. A chart of reflectivity from least-reflective precipitation to the most-reflective precipitation shows us that "bigger and wetter" is more reflective than "smaller and drier:"

Turbulence in a thunderstorm broke off this C-141 tail in flight.

Least: ice crystals
dry snow
dry hail
wet snow
rain
heavy rain
Most: wet hail

Depending on the precipitation type and its movement, recognizable thunderstorm patterns will show where the hazards are. It's important to know what to avoid on our radar screens (see next page).

Avoid any target with a dry intrusion (dryer air being sucked into the thunderstorm) giving it a V or U shape. There are several reasons for this. Severe thunderstorms have dry air mixing in the middle altitudes which can create an intrusion. Hail rising and descending in a thunderstorm would also appear as a missing area cutout from the storm.

Avoid any target with a hook or bow shape. Hook shapes are indicative of rotations taking place within severe thunderstorms. This is a strong clue to ground weather observers that hail and tornadoes are possible.

Avoid any target with protruding "fingers." Like a hook, a finger shows strong possibilities for tornadoes and hail.

Avoid any target with asymmetric coloring and shapes. Remember, severe storms created by windshears aloft will tilt to one side. This gives shapes and colorings that are not even or concentric.

Avoid any target with an "arrow shape." Again, this is indicative of a storm with tilt and the possibility of severe hazardous weather.

Avoid any target with scalloped edges. Scalloped

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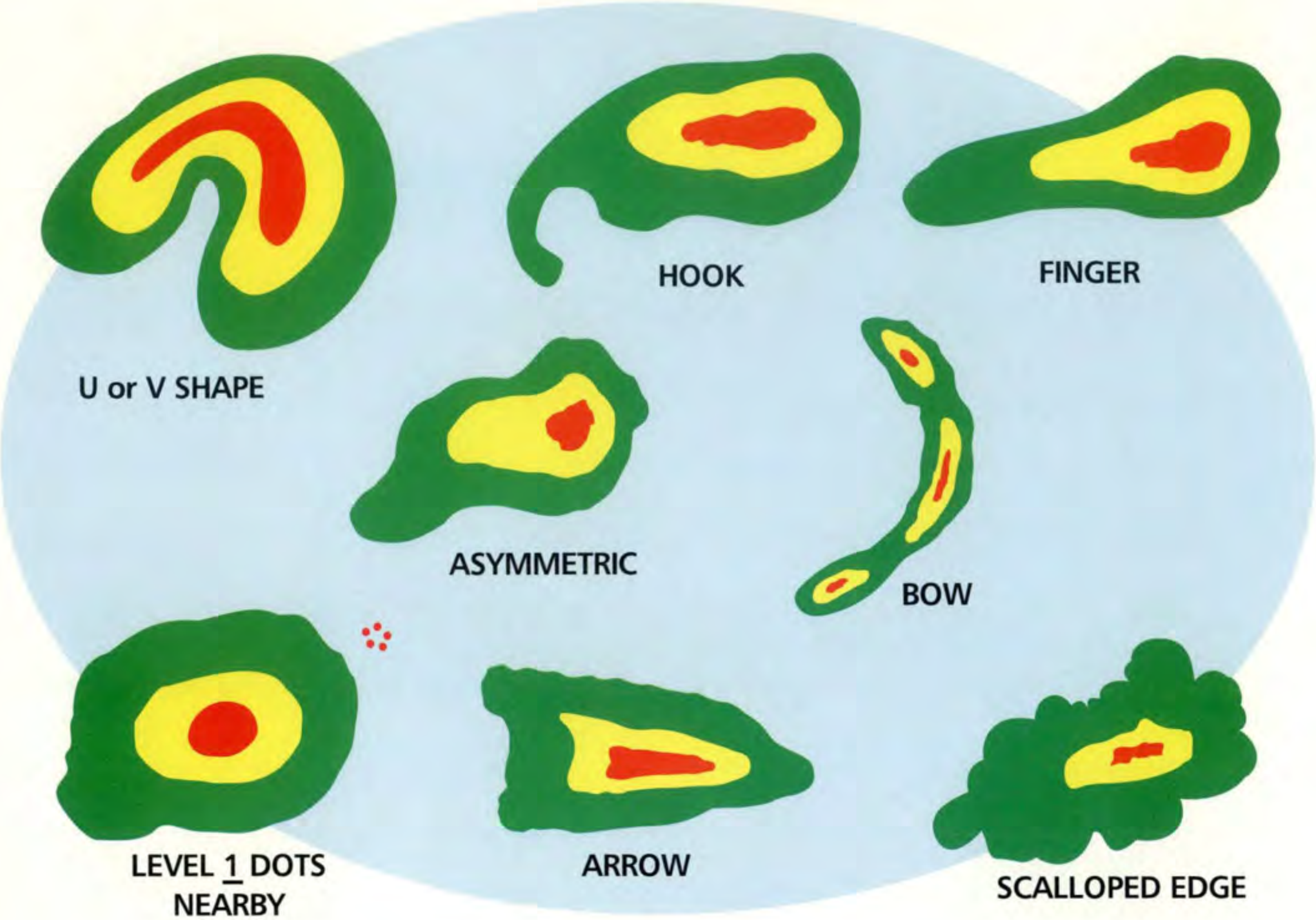

edges show turbulent motions taking place within the cloud. There is a good chance for hail here also.

Avoid any target with changing shapes. Rapidly growing shapes show rapid motions taking place within the cloud. Turbulence will almost always take place under these conditions.

Avoid any target storm with a few VIP Level 1 dots showing nearby. Hail falls many times outside of the thunderstorm. Checking the winds at altitude and correlating it to the side of the storm that hail will fall should help identify that potential hazard.

Flying Techniques to Remember

Publications from the FAA and USAF give us aviators numerous tips and techniques to help with that occasional encounter with a thunderstorm. Some of them are important enough to repeat again.

- Don't try to fly over thunderstorms. They can grow rapidly through your altitude, producing severe turbulence.
- Don't fly under the anvil where hail damage and lightning can occur.
- Don't fly into virga where turbulence is likely.
- Avoid all thunderstorms by 20 nm or more since lightning and hail have been known to extend that far from the clouds.
- Weather warnings are for thunderstorms defined as "severe." These storms produce 3/4-inch hail, tornadoes, or 50-knot wind gusts. There's a lot of damage that can occur in thunderstorms that are *not* flagged by warnings or a SIGMET (significant meteorological report).
- If you have to penetrate:

  Go straight. Don't turn around.

  Avoid the altitudes with temperatures of plus/minus 8 degrees Celsius.

  Don't chase altitude. Hold your attitude and watch airspeed.

  Use all anti-icing equipment.

  Turn all lights in the cockpit on full and lock shoulder harnesses.

Conclusions

Thunderstorms are one of aviation's most hazardous phenomenons. There are many different ways they can impact aviation from windshears, lightning, heavy precipitation, tornadoes, and severe turbulence to hail. Knowing how to recognize and avoid thunderstorms and their hazards is one of the most important lessons of aviation weather training.

Don't let your wake-up call be a bolt from above like mine was.

Fly safe. ✈

Air Force Weather:
Reengineering for the Aircrews

BRIG GEN FRED P. LEWIS
Director of Weather
HQ USAF

Today, thousands of professional aviators will prepare to fly. The methods these aircrew members will use to get their weather information are as different as the paint on their aircraft. Recognizing a need to improve the weather information process, the United States Air Force is reengineering the way it creates and provides services to its aircrew members. Our Air Force took the opportunity to analyze the strengths and weaknesses of a variety of weather information processes, so we could learn and adapt solutions from each in order to set the highest standard for aviation weather into the next century.

Let's look at two scenarios that are in use today to deliver weather information to professional aviators.

Today, over 2,000 professional aircrew members for organization X are located in 15-plus countries around the world. In this first scenario, the aircrew's weather information comes from a team of dedicated and experienced aviation weather forecasters all located in one place. At this location, teams, working nearly around the clock, attempt to provide accurate weather information on a global scale to meet the needs of the aircrews and their flying operations.

From the central facility, the weather team has access to a number of different weather data sets, weather models, and graphic displays of current and forecasted weather all over the world. These meteorologists have no direct contact with the crewmembers and are free to concentrate on the time-consuming analysis necessary to make the best possible weather forecasts.

With their time devoted to forecasting, their products are consistently better than other weather providers who must cater their product to a wide variety of customers. While the product is good, the delivery has been criticized. Aviators retrieve their weather information from computer files attached to their flight plans about 1 hour prior to flight. Almost all of the weather information is textual—abbreviated descriptions of the area weather;

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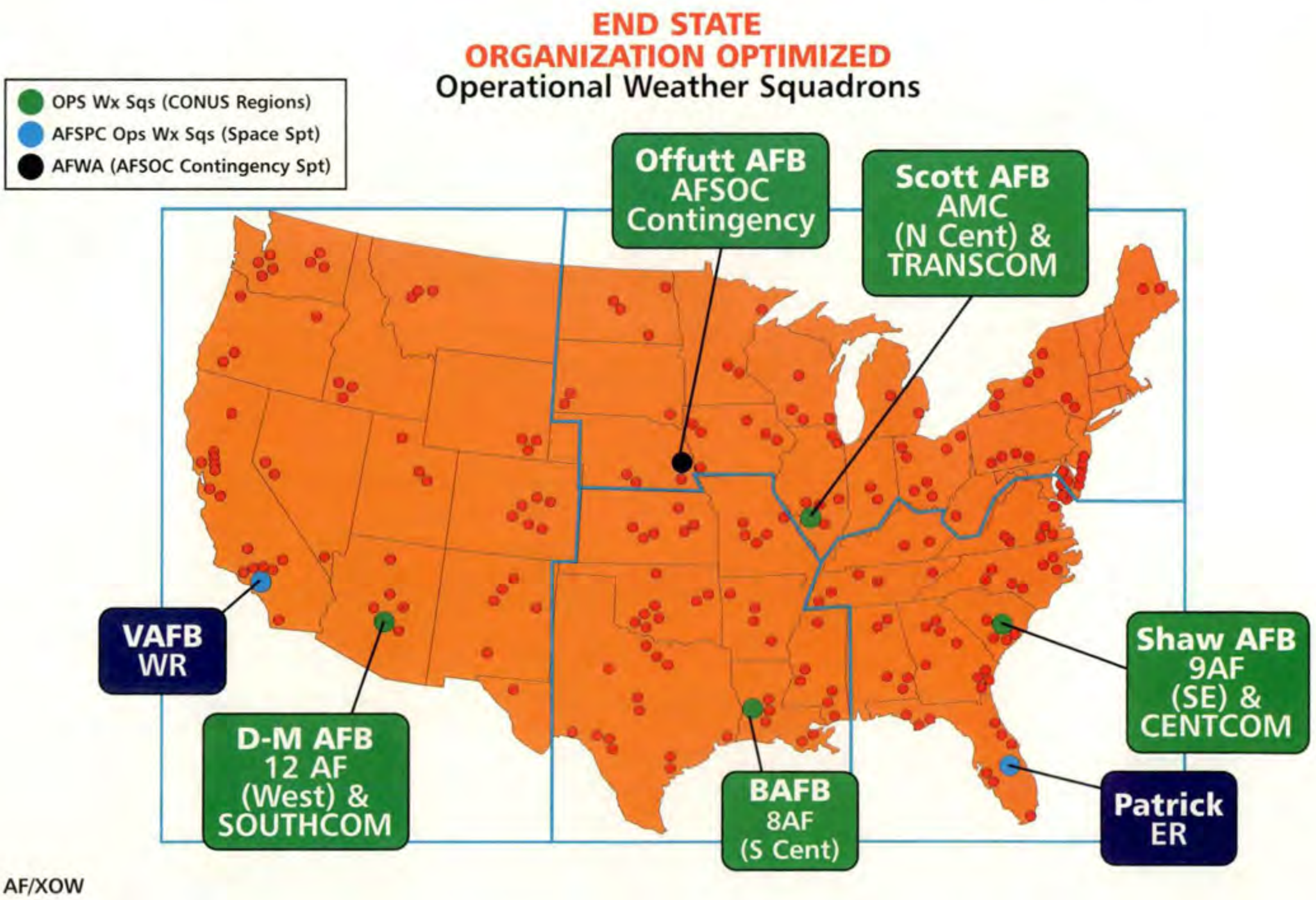

AF/XOW

TAFs and METARs of the takeoff, destination, and alternate airports; and weather warnings.

If the crew has questions, they can contact the "mission planners" who have a lot more weather information at their disposal, including direct contact with the forecasters. The phone is the crew's only means to get questions answered, and there is no method available to deliver graphics. Unless they are at one of a dozen hubs with color computer weather graphics or planning for an international flight, the primary graphic in the United States used by crewmembers is the back page of the newspaper.

In our second scenario, several thousand aviators from organization Y will also prepare to fly. From 1 to 2 hours prior to flight, they will gather for a face-to-face (or telephone) briefing with a trained forecaster who will have a number of graphics available to answer any questions from the aircrew. However, budget limitations are stretching the capabilities of the weather personnel to deliver this product at every airport. The experience level of such forecasters has decreased at a steady rate. As the number of forecasters available continues to decrease, the ability of the weather facility at every single location is taxed to do all the extensive analysis necessary in the forecasting process.

Both of these scenarios are very real and happening today. Perhaps you recognize one. Either scenario has its own strengths and limitations.

Scenario one has a core team of forecasters located in a centralized facility. The team is devoted to the delivery of high quality forecasts of specific terminal areas and broad geographic areas of operations. Because all forecasting takes place at a single center, there is a synergy of talent. Operations managers are given a consistent system-wide forecast delivered from a process that is owned by the organization. Because the process is owned by the organization, the weather products are tailored to the needs of the organization and flexible to change as the situation warrants.

The process can consistently deliver a good product using fewer forecasters. But this scenario also has removed the forecaster from the customer, the aviator, to the extent that many times the crews are unable to have access to the weather information they want and need. The organization has a good weather product but a relatively poor delivery capability to the individual crewmember.

Scenario two has an excellent ability to deliver the weather product to the aviator. It is worldwide and flexible. The delivery capability is distributed in nearly every airport where the organization flies, with a wide variety of graphic and textual products available to meet the needs of the aviator. But the quality of the time-intensive process of weather forecasting, now distributed over every airport, is suffering due to personnel cutbacks. This organization has an excellent delivery capability but a weather product whose quality may spiral downward in the future as further pressures to reduce personnel occur.

It's obvious the first scenario is one that shows how weather information is delivered at almost every flagship airline in the United States. In the face of tough fiscal pressures, major airlines maintain their own meteorology departments to work with flight dispatchers and airfield managers. Many airlines have kept control of the weather information their aircrews use to plan and fly. These companies are certified by the Federal Aviation Administration to produce their own weather products including TAFs and METARs. The companies justify the expense by being able to maintain operations after generic weather support would have limited airlines' activities with too conservative, less mission-focused forecasts.

For example, when a nor'easter was coming up the East Coast several years ago, one of these airlines would have had to cease operations into and out of Hartford airport almost 2 hours sooner than it did if it had not been for its own staff of meteorologists, knowledgeable to the forecasts. By maintaining its own staff of meteorologists, knowledgeable to the needs of the company operations, an airline can show mission success and fiscal profit. Maintaining their own weather staff at a central facility allows an airline to develop their own focused, high-quality weather products with a focused staff of experienced forecasters. However, the central facility structure also limits direct contact with aircrews and the weather information availability to the aircrews.

Scenario two is the current way the United States Air Force manages weather information. In fact, the safety committees of the major professional pilot unions have consistently used our example as "the standard" in weather information presentation to aviators. Face-to-face briefings and available graphics are strengths of our process. But I must confess the drawdown in resources, and particularly experienced people, has the potential to erode quality in our weather service. The average experience of our forecasters has decreased significantly over the past few years. To meet the needs of the Air Force and the Department of Defense in the future, Air Force Weather must evolve in a way that maximizes our ability to effectively forecast diverse weather situations around the world given the reality of having fewer people. Yet we feel committed to doing this in a way that still maintains our superior support to you, the military aviator. So how can we do this?

The Winds of Change

In August 1996, the revolution in our weather service began. We formed reengineering teams and began a wall-to-wall, Total Force self-examination. We got with our Air Force and Army customers and asked the hard questions of how to better integrate our weather information into their decision cycles. The Air Force senior leaders approved our planning, and in October 1997, we began to implement changes.

The old Air Weather Service, headquartered at Scott AFB, changed its name to the Air Force Weather Agency and relocated to the deactivated Air Force Global Weather Center facilities at Offutt AFB. Our goal by combining the people of these two organizations is to get more of our "experts" into the production of fine-scale, highly accurate global weather information. This is a start of much more than cosmetic change. Our goal is to achieve improved forecasting capability by using a modified version of the airline model of centralized facilities. We also intend to maintain our direct involvement in unit operations through face-to-face delivery of products tailored to your missions. The result will be the best of both scenarios. Let me explain further.

Beginning this year, we will begin standing up operational weather squadrons (OWS) to serve as the forecasting centers for theater and regional operations. These squadrons serve the same function as the airline's forecasting hubs and will provide the synergy of experience to deliver high-quality weather products. The OWSs will also serve as our training facilities to develop and maintain the continuity of our personnel.

Unlike the airline model, we will not isolate our weather facilities from operational control. These forecasters will be owned and operated by Air Combat Command numbered air forces at Shaw AFB, Barksdale AFB, and Davis-Monthan AFB. Air Mobility Command's Tanker Airlift Control Center at Scott AFB will also have a weather squadron. Air Force Space Command will have squadrons at Patrick and Vandenberg AFBs. There will be more squadrons located in Germany, South Korea, Japan, Alaska, and Hawaii working for key theater operators.

While many of our weather professionals will gather at these regional facilities, we will still maintain and actually improve our ability to deliver tailored products directly to you. The old Weather Flights will evolve into combat (unit) weather teams (still working for the local operators as a "new and improved" Weather Flight) to intimately know your mission and tailor the forecast products of the OWS to your needs. They will serve as the direct link from Air Force Weather products to your unit.

Our weather experts operating these combat weather teams will also be more highly skilled than the people we have in our weather flights today. Our people in these future units will all be weather technicians that can both forecast and observe the weather—that's right, no more separate forecasters and observers—just weather technicians who can do both jobs. These weather technicians will also be ready to more directly integrate specific technical knowledge into your mission success since everyone in the unit will have a minimum of 3 years'

continued on next page

forecasting experience.

Four Strategic Centers will provide the highly accurate technical support to make the regional OWSs and combat weather teams (new Weather Flights) work. The centers include the operational capabilities of the Air Force Weather Agency, which will run fine-scale, highly accurate numerical weather models and contain a unique ability to provide reach-back, worldwide "target weather" forecasts. The Air Force Combat Climatology Center will analyze worldwide historical records and past weather patterns to provide the OWSs and combat weather teams the most accurate climatology information for anywhere in the world where we might deploy forces.

The 55th Space Weather Squadron will provide space weather information that will help determine GPS navigation accuracy and areas where ionospheric interference will impact UHF satellite and High Frequency communications so the OWSs and combat weather teams can advise military operators. Finally the Joint Typhoon Warning Center, that is moving from Guam to Hawaii, will advise the OWSs and combat weather teams in the Pacific concerning the typhoon threat so they can inform their operators.

Air Force Weather reengineering is an ongoing process. Within just a few years, the result will be a leaner, more mission-centric weather organization devoted to the best fine-scale, mission-specific weather information in the world—providing the operators they serve with the key weather knowledge needed to conduct and sustain military operations anywhere in the world.

This whole effort is designed with you—the warfighter, the operator, and the trainer—in mind. We will provide you the best weather products from our Strategic Centers and the focused central forecasting facilities at the Operational Weather Squadrons. Our combat (unit) weather teams within our Weather Flights will deliver the products you want and need in the manner you expect and in a process that you, the operator, will own from beginning to end. Your ownership guarantees a responsive and flexible environment to obtain the kind of weather products you want, when you want them, with an unprecedented accuracy. All of us in Air Force Weather are looking forward to building this new capability to better serve you, our CUSTOMERS. ✈

Cross Feed

THE GOOD OLD CALIBRATED ELBOW

AMH I (AW) A. J. KALOZ
Courtesy *Mech*, Jan-Mar 98

How many times have you installed a part in a flight-control system that used self-retaining bolts? Probably at least a hundred times if you work like me. When we install one, we do it by the book each and every time, don't we?

When you look at by-the-book procedures, some interesting questions arise. How do you get that great big torque wrench into that tiny little access hole to gain a specified torque value? If adjustments have to be made in the course of the op-check, how do you get the torque wrench through all that linkage to tighten everything that might have been left loose? A new airman or division officer trying to learn from his troops might ask these questions.

Any airframer worth his salt always has at least one or two guys around who own a "calibrated elbow." This asset comes in real handy when there isn't enough room to use a standard combination wrench, let alone a giant torque wrench. Some of these processes aren't done exactly by the book, probably because someone doesn't know where to find the formula for torquing with an extension. Or maybe no one has taken a walk to the tool room lately and blown the dust off the bin of special tools you've had forever but forgot existed. Did you, a CDI (Collateral Duty Inspector), a QAR (Quality Assurance Representative), or whoever is specified in your MIMs watch someone torque those self-retaining bolts? Or did the mech use the "I'll snug them down and align the cotter-pin hole because they're pit-pin bolts and they won't come out" system?

The formula for torquing with an extension can be found in the NAO1-1A-8 (Structural Hardware Manual), Chapter 2. *(Section 7 in T.O. 32B14-3-1-101, "Operation and Service Instructions for Torque Indicating Devices," for Air Force personnel.—Ed.). This information is designed to be used in those installations where the available space is too small for inserting the head of a torque wrench and socket, much less turning the wrench. The Dash-8 manual is often set aside because most of the time all the information and torque values are contained in your specific aircraft's MIMs.

"Snugging" isn't in the book. If you want to continue your career able to proudly say that you've never been responsible for an aircraft mishap, go by the book 100 percent of the time. Before you sign off the next MAF, ask yourself, "Was it done by the book?" You may not like the answer. ✈

(Petty Officer Kaloz is assigned to VAW-139.)

The Problem of the Pullout

MAJ EDWARD B. "MEL" TOMME
USAF Academy, Colorado

You stare at a windscreen full of rapidly approaching ground. As the altimeter quickly unwinds and the airspeed builds, the sound of wind rushing by outside the cockpit gets louder by the second. With the onset of ground rush and only seconds to react, you must make the correct decision now. No second chances. No time to analyze the situation. You've got to rely on your training. How good was it?

Far fetched? Not to anyone who's ever flown in the fighter or trainer community. Student pilots specialize in putting their instructors into just such situations, while fighter pilots routinely do it to themselves for tactical advantage. **In a nose-low situation, there are two basic approaches to recovery. Common sense tells us that we need to pull as hard as the airframe and aerodynamics will allow. At issue is "where to put the throttle."**

Here's the bottom line up front: The seemingly mad act of pushing up the power in a nose-low, altitude-critical situation is the correct move. By pushing up the power, you minimize the parameter of primary importance in this situation—altitude lost during the dive pullout.

This solution is not intuitive and requires a discussion of basic turn performance and turn performance in the vertical plane. I'll then tie the two concepts together to show how the effect of the earth's gravity on turn performance is the key to understanding how to minimize altitude loss in a nose-low recovery.

Turn Rate and Radius: The Critical Parameters

To understand how to minimize the altitude lost during a dive, we must first delve into how an airplane turns. To make the discussion more relevant, I'll use numbers from the F-4G and the T-3A.

Figure 1 shows a fictitious but reasonable flight strength envelope for the T-3. The actual flight strength envelope isn't included in the Dash 1, so I extrapolated the envelope from other Dash 1 parameters. This "unofficial" diagram is about as simple as they come—parabolic aerodynamic limit curves ($n \propto v^2$), constant redline speeds and constant structural limits.

A flight strength envelope plotted like figure 1 is also known as a V-n diagram, as the horizontal axis is the aircraft's airspeed (V) while the vertical axis is the load factor (n), or (*very* loosely) the number of Gs being pulled. The horizontal lines at +6 and -3 Gs are the structural limits. The vertical line at 195 knots is the redline airspeed. The two curved lines that start at the origin and arc up to the structural limit lines are the aerodynamic stall limits. An attempt to fly with a combination of airspeed and G-loading above and to the left of the positive-G stall line will result in a stall. In general, an aircraft may be safely operated anywhere inside of its flight envelope without fear of breaking or stalling the plane.

It's obvious that, in our altitude-lost-during-a-dive problem, turn radius is a critical parameter. It's not as obvious that turn rate is just as important. Both of these parameters have extraordinary effects on the decision to use idle or full power. Take me at my word when I tell you that turn radius is proportional to the square of the airspeed and inversely proportional to the number of Gs pulled [$R \propto V^2/n$]. When the airspeed goes up, the turn radius increases very quickly if we hold Gs constant. Hold the airspeed constant and the turn radius decreases when the load factor goes up. Contrast this to the relationships for turn rate. Turn rate (ω) is inversely proportional to airspeed [$\omega \propto n/V$] and proportional to Gs. As you go faster, turn rate decreases. Conversely, the turn rate increases as you pull more on the pole.

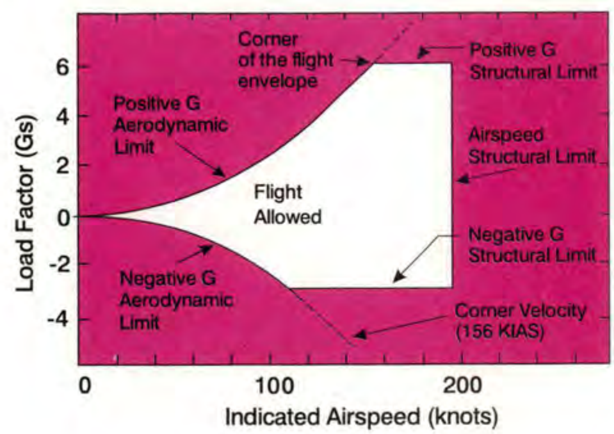

Figure 1

To maximize turn performance, we need to *minimize our turn radius and maximize our turn rate.* Doing both of these things will also minimize the altitude loss. Optimal turn performance will occur when we pull lots of Gs at a slow airspeed. Let's look at the V-n diagram again. Ignoring gravity for now, the turn radius stays pretty fairly constant along the stall line since we increase available G much faster than we increase airspeed. In other words, turn radius is proportional to the square of the airspeed and inversely proportional to the G pulled. G available is also just about proportional to the square of the airspeed, so the airspeed increase cancels out and turn radius stays relatively constant as long as you're pulling to the aerodynamic limit. Once we reach the +6 G structural limit, the turn radius begins to rapidly increase since we're holding allowable G constant while continuing to increase the airspeed. It would seem, then, that our minimum turn radius could be obtained by flying *anywhere* along the stall line. Figure 2 is

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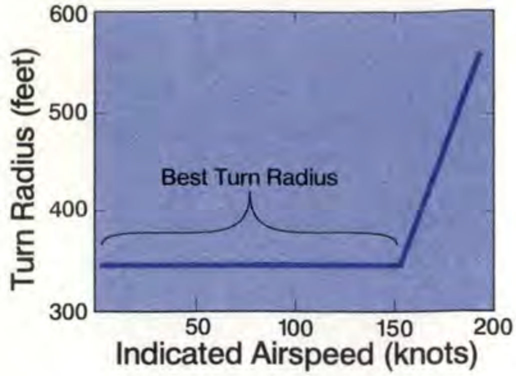

Figure 2

a plot of turn radius vs. airspeed, given that the G for the airspeed is the maximum allowed by aerodynamics or structure. Once the T-3's 6-G structural limit is reached at 156 knots, the radius begins to increase.

Is there some preferred airspeed to fly along the stall line so that turn rate is maximized? Look at the relationship for turn rate and the allowable combinations of airspeed and load factor from the flight strength diagram. As we decrease airspeed from redline to 156 knots, the maximum G we can pull remains constant. This implies that the turn rate increases quickly as we slow down. However, once we start to become limited by the stall line, the rate begins to rapidly decrease again. Figure 3 graphically shows this.

Therefore, it would seem that the only place where both rate and radius are optimized occurs when the aircraft is pulling 6 Gs at 156 knots. This result is by no means unique to the T-3. **TURN PERFORMANCE IS OPTIMIZED WHEN ANY AIRCRAFT IS FLOWN AT THE SLOWEST AIRSPEED WHERE IT CAN FIRST PULL ITS STRUCTURAL LIMIT WITHOUT STALLING.** Fighter pilots know this as the "corner velocity" since it occurs at the corner of the flight envelope.

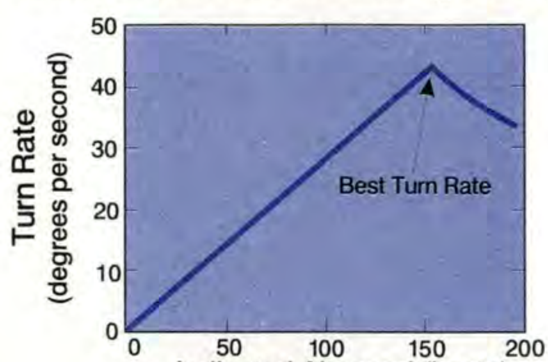

Figure 3

Radial G and the Energy Egg

The final piece of the basic turn performance puzzle is called radial G. The easiest way to explain this concept is to examine an airplane performing a constant airspeed, constant G loop. It highlights the two variables in the turn performance relationships and allows us to examine the other major player in a nose-low recovery—gravity.

Up until now, we've only discussed turn performance in terms of G, which you probably assumed was exactly what you read on your G meter. When you're airborne, the G meter really measures only the effects of the lift force on the aircraft. The force that turns the aircraft is a combination of both lift and gravity. We'll call the *vector* sum of the lift force and the gravitational force "radial G." In the discussion of turn rate and radius, we now need to replace the term n with G_r, radial G. Thus, our relationships become $R \approx V^2/G_r$ and $\omega \approx G_r/V$. To fly a constant airspeed, constant G loop, you pull on the stick to maintain a constant reading on the G meter and modulate the throttle to maintain a constant airspeed. As you first consider this maneuver, you may be convinced that this will turn out to be a perfectly circular loop. After all, turn radius is related only to G and V, so if both are constant, then the radius must be constant, right?

A glance at figure 4, commonly called the "energy egg," will convince you that the loop will not be circular due to the effect of gravity. At the bottom of the loop, we're holding 6 Gs on the G meter, but the earth's gravity is acting in the opposite direction from our lift. This means that radial G, the vector sum of G due to lift and g due to the earth will be only 5 Gs. Turn performance is less than maximum as the earth's gravity works against us.

A bit later in the loop, we're pointed straight up. We still have 6 Gs on our meter due to lift acting horizontally, but the earth's gravity acts down at right angles to lift. Gravity doesn't add to the G due to lift, so radial G equals the G on our G meter. Turn performance here is better than it was at the bottom of the loop since gravity isn't working against lift.

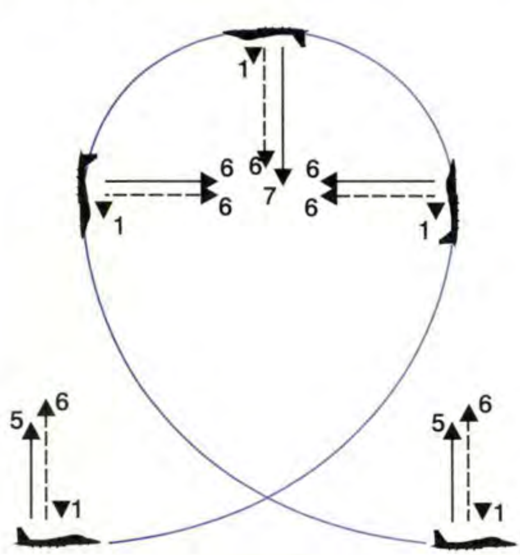

Figure 4

Upside down in our constant G, constant airspeed loop, both forces turning our plane are acting in the same direction, so gravity helps us turn the aircraft here. Radial G becomes 7 Gs, and turn performance is maximized. As we continue around the loop, we come to the point where we're pointing straight down. Similar to when we were on our back, gravity neither helps nor hurts, so our radial G is again 6 Gs.

This explains why our "circular" loop looks more like an egg. We have less effective force turning our plane at the bottom of the loop, so our radius is large and our rate is low. Further toward the top of the loop, the higher the radial G, so our radius continually decreases and our rate continually increases. Down the back side of the loop, turn performance parameters worsen again until they hit their worst values at the bottom of the loop. Our best turn performance occurs when our lift vector points below the horizon, since gravity is assisting our turn.

Combining this energy egg knowledge with figures 2 and 3 will show that they actually apply only when the aircraft is pointed straight up or straight down, the only two times that gravity has no influence on radial G. If we were to look at a more general case of a maximum performance level turn, these two plots would be a little more complicated, but they would still indicate that the combination of minimum turn radius and maximum turn rate occur only at the corner velocity. Figures 5 and 6 show the maximum performance turn radius and rate for a level turn in the T-3.

So what does the energy egg have to do with maximizing turn performance? How will it help us decide what to do with throttle: idle or full power? Don't both solutions have to turn the same angle to get us out of our nose-low situation? Won't both turns be affected by gravity the same?

Tying It All Together

So, how to optimize our turn? In simplistic terms, fly near corner velocity and pull just short of bending the plane. In fact, to optimize our turn *radius,* all we really have to do is fly below corner velocity while pulling to the aerodynamic limit. The closer we get toward a level pull, our desired end-state, the more gravity hurts our ability to turn.

What if radial G didn't care whether gravity was working or not? What if radial G was only a function of the G on the G meter? Let's look at two cases of nose-low turns at two different constant airspeeds that both turn from 90 degrees nose-low back to level flight. If we assume that both airspeeds remain below corner velocity and that we pull to the aerodynamic limit in both turns, then both turn radii should be the same because of our no-gravity situation.

How much time does it take to perform the pullout from the dive? Figure 7 shows the paths taken by our two aircraft, with small aircraft spaced along the arcs at regular distances related to their respective airspeeds. From this figure, it's obvious that it takes less time for the faster aircraft to pull out of the dive (three vs. nine time units). This aircraft has a higher *turn rate* (less time to turn the same angle). This is the crux of the answer to our problem. Let's now add gravity back in. Gravity's effect on turn performance during this nose-low portion of a vertical turn is to subtract a progressively greater and greater amount from the radial G that is turning the plane. This means that the longer it takes to pull out of the dive, the longer gravity has to act against the Gs the aircraft has available due to aerodynamics. In effect, the slower plane has to endure the turn-hindering effect of gravity for a longer time, so it ends up with a much larger average turn radius and ends up losing much more altitude. With all else being equal, *the aircraft that can sustain the highest turn rate loses the least altitude.*

The bottom line is that the faster you can go while staying below corner velocity, the less altitude you'll lose in the dive recovery. From this, it sounds like the correct solution to the scenario stated at the beginning is to immediately begin to pull to the aerodynamic limit and then quickly advance the throttle to full power so you can get your airspeed to build just as rapidly as you can. I need to emphasize that I am not advocating delaying the pull to get your airspeed to build. Again, the solution seems to be to *immediately* begin the pull and *only then* worry about putting in the power.

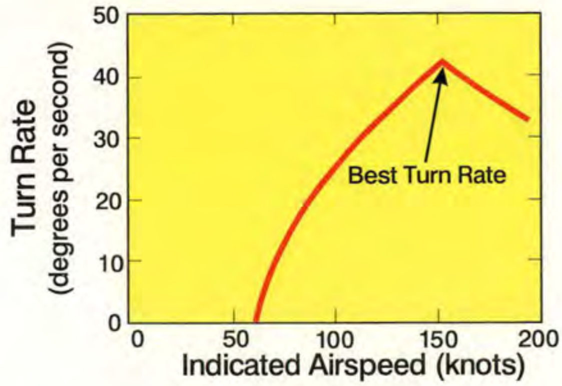

Figure 6

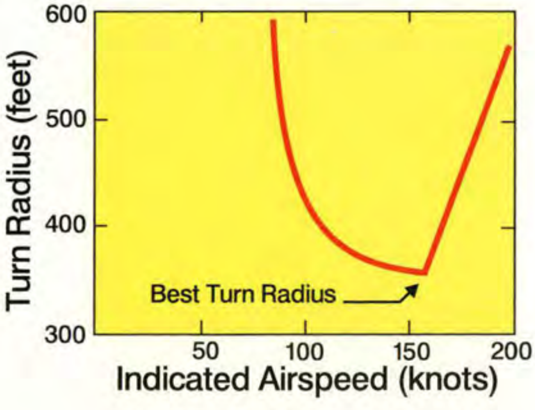

Figure 5

Figure 7

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Solutions of a Dynamic Nature: Comparing the Idle and Full Power Techniques for Jets

While the above gives a reasonably good explanation of which plane will lose less altitude during the dive, it's much too simplistic for us to use to get any numbers (or even a good qualitative feel) for our altitude loss comparison. What we really need to know is *how much* better is it for us to make the pullout at a faster airspeed, and what is the optimum airspeed for the pullout. A complete description of the model is beyond the scope of this article.

To do this, we'll have to resort to a computer model. WARNING: Simplifying assumptions run rampant throughout this model. While the shapes of the curves are essentially correct, the actual numbers quoted are only approximate.

What are the results for this simulation? Figure 8 shows the altitudes lost by an F-4 pulling out of dives from 90 degrees nose-low back to horizontal for a variety of airspeeds. The red curve shows recoveries using 50% thrust (18,500 pounds) and a pull to aircraft limits (aerodynamic and structural, as driven by airspeed). The green curve shows recoveries using maximum afterburner (37,000 pounds thrust) and a pull to the aircraft limits. In both cases, once the lightweight F-4's 8-G corner velocity of 420 knots was exceeded, the throttle was immediately reduced to idle, and the load factor was limited to structural limits. If the jet's airspeed again fell below corner velocity, the throttle was readvanced to maximum afterburner or 50% power, and the pull was readjusted to aerodynamic limits. Notice that the absolute minimum altitude lost during the dive occurred when the dive was entered at corner velocity and the throttle was modulated between idle and full as required to maintain that airspeed. Eventually, both curves match up, as the turn is started above corner velocity and both recoveries must use identical idle power methods to attempt to prevent an overspeed/over-G.

The important thing to compare in this figure is the difference in altitude lost for a given entry airspeed. For example, a dive entered at 300 knots will lose 2,400 feet using the 50% power recovery method (the red curve), while losing only 2,200 feet in maximum afterburner (the green curve). Moving your left hand fully forward can save you a full 200 feet in this case.

It's obvious which method will yield the best results as the green curve is in every case lower than the red curve. Figure 9 shows a plot of the flight paths of two F-4s recovering from identical 90-degree dives entered at 200 knots. As above, the two plots are based upon 50% thrust and maximum afterburner recoveries, again pulling to aircraft limits. The dots along the curve indicate where the respective aircraft are at 1-second intervals. Notice how much faster the maximum afterburner aircraft (the green curve) accelerates (the dots get farther apart) as it quickly completes its turn. You can see that the full power recovery not only loses less altitude, but it takes less horizontal distance and a lot less time to complete. For this case, the altitude savings are even greater than the previous example: 300 feet less altitude loss completed in 7 seconds less time.

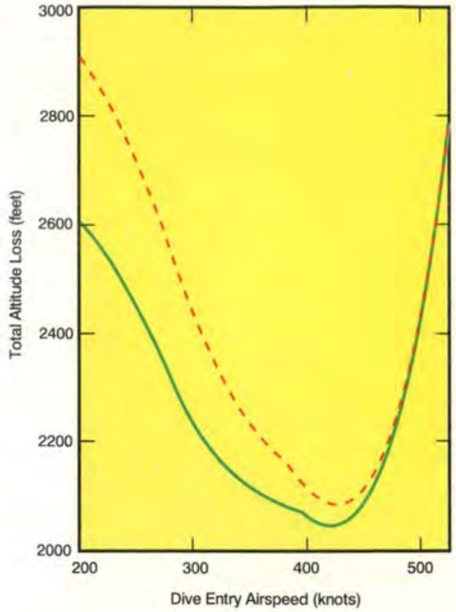

Figure 8

Even More Impressive Results for High-Performance Props

As impressive as the numbers were for the Weasel, they're even better for a prop. With the JPATS aircraft coming on line, the results for prop aircraft would seem to take on an even greater significance. In a jet, the thrust exits the aircraft aft of the wing. In most props, the thrust comes out ahead of the wing and significantly affects the airflow over the wing. Unfortunately, I do not know of any wind tunnel data which would allow me to quantify the difference between idle and full power nose-low recovery methods. You'll have to accept a touchy-feely explanation of why a full-power recovery is enhanced in prop aircraft.

In idle power, all of the negative consequences for jets discussed above occur. In full power, all of the jet benefits are felt as well as the benefit of having your thrust blown across your wings. As soon as you advance the power to full, the airflow across your wings immediately accelerates. Since, below corner velocity, available G is directly related to the square of the airspeed *across the*

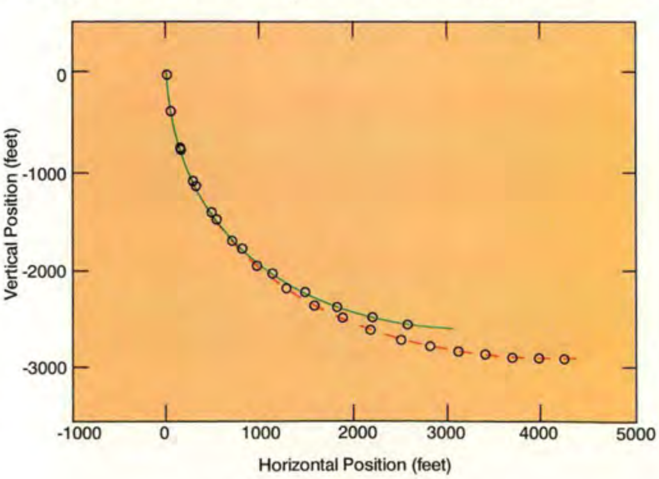

Figure 9

wing, this "blown wing" immediately produces more lift and hence allows more Gs to be pulled. Since turn radius and rate are both helped by increasing the available G, turn performance gets an immediate boost without immediately suffering the negative consequence of actually increasing the aircraft's airspeed, which would tend to decrease turn performance.

Figures from a model of the T-3's turn performance in a dive are similar to the plots for the F-4 from above. The assumptions used to model the additional lift due to the blown wing are tenuous at best, so these plots should in no way be used to quote definitive numbers. They do, however, allow me to better compare and contrast three T-3 dive recovery methods. The three methods discussed are the full and idle power methods used above for the F-4 models (without afterburner, of course!), and the recommended method for recovering from a dive following a spin described in the T-3 Dash 1. The Dash 1 method prescribed a 3-G pullout from the dive recovery, period. As increasing the power during a dive recovery is also inexplicably discouraged in AETCM 11-206 (the how-to-fly-the-T-3 instruction), the modeled method consists of using idle power, pulling to the aerodynamic limit until 3 Gs are reached and then pulling 3 Gs for the remainder of the recovery.

Figure 10 shows the altitude lost in the T-3 during 90-degree dives entered at various airspeeds. The black curve shows the altitude lost by using the Dash 1 procedure. The red line shows an idle-power, maximum-performance pull recovery. (By maximum performance pull recovery I mean that you pull to either the aerodynamic or structural limit, whichever is less.) The blue line shows a full-power recovery not including blown wing effects, and the green curve shows the altitude lost when full power is used and the blown wing is taken into account.

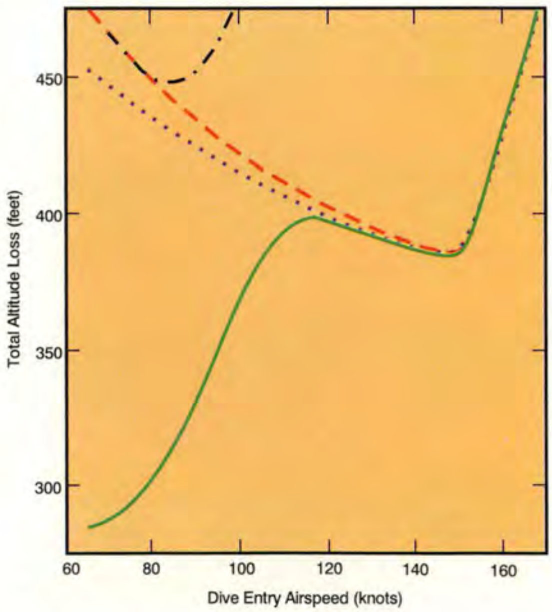

Figure 10

Several notable things are seen in this figure. First, the T-3 Dash 1's method obviously doesn't take advantage of the increased performance due to increased airspeed or the blown wing. Second, the effect of a blown wing is extremely significant at lower airspeeds. Just look at the difference between the blown (green curve) and the non-blown (blue curve) full power methods at 70 to 90 knots, the very airspeeds at which one normally exits a spin in the T-3. The altitude saving due to the blown wing is by far the predominant effect. Figure 11 shows the flight path of just such a recovery. In this case, the dots on the curves are spaced at 1/4-second intervals. Just as for the F-4, these figures show that the proper recovery method for the T-3 should be to get on the pull and then add full power just as soon as possible.

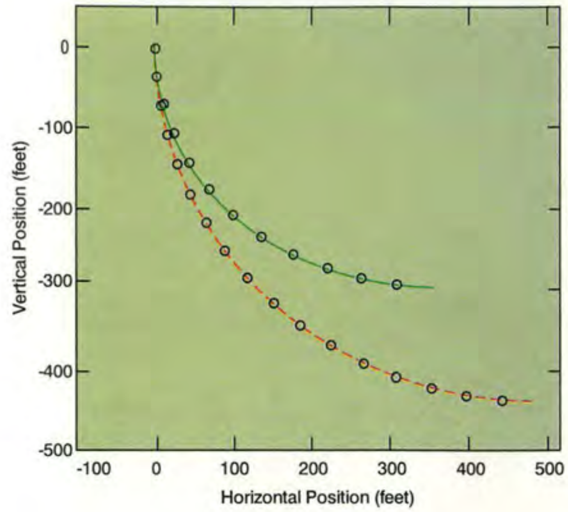

Figure 11

Train Like You Fight and You'll Fight Like You Train: Summary and Conclusions

If you're still not convinced, there's one final thought. Let's say you're flying at very low altitude and an airspeed below corner velocity headed for a very tall cliff. How do you avoid a collision? Full power and a level pull! Now, imagine you're in a nose-low overshooting final turn. How many of you would suggest an idle power pull to correct back to the runway? Probably no one would suggest any other course than a full-power pull. So where's the cutoff? If in a level turn you pull with full power and in a slightly nose-low, overshooting final turn you pull with full power, where does idle power start to be the correct solution? My answer to this question is simple. Once you see that you're going to exceed corner velocity, it's time to yank back on the throttle—*but not before.*

In summary, we've seen that the problem of the pullout is a complicated, dynamic problem that needs a computer model to fully analyze the solution. **THE KEY TO THE SOLUTION IS TO KNOW WHAT THE CORNER VELOCITY FOR YOUR AIRCRAFT IS AND TO USE IT. IN AN ALTITUDE-CRITICAL SITUATION AND BELOW CORNER, PULL TO THE BUFFET AND USE FULL POWER. ABOVE CORNER VELOCITY, PULL TO THE BUFFET AND USE IDLE POWER. AGAIN, DO NOT DELAY THE PULL WAITING FOR A PARTICULAR AIRSPEED—GET THE PLANE TURNING FIRST!** ✈

Contract Bird Control Units

MR. TIM WEST
Bird Control Unit Manager
RAF Mildenhall, UK

Since the crash of an E-3 AWACS aircraft at Elmendorf AFB, Alaska, in September 1995, there has been much interest expressed in setting up contract Bird Control Units (BCU) in the United States, particularly those using falcons. To date in the US, only Scott AFB, Illinois, and Fairchild AFB, Washington, have attempted any form of bird control using falcons. Royal Air Force (RAF) Mildenhall and nearby RAF Lakenheath in the United Kingdom have been conducting contract bird-control programs for USAFE using birds of prey since 1985. This article intends to highlight the advantages and potential problems associated with such programs.

Before I begin, I strongly recommend you take note of the following: An active control program that relies on a single control method, whether it be birds of prey, pyrotechnics, or any other method, will eventually fail due to habituation or associated problems. A balanced approach to the overall situation is required, and this is the basic concept behind the program implemented at RAF Mildenhall. The active control measures employed by the BCU form only half of an effective bird-control program. Active control measures are in no way a substitute for a habitat management program, and reliance on either one or the other will eventually result in an ineffective program.

Habitat management is intended to discourage birds from the airfield, leaving smaller numbers to be dispersed by active control measures. For example, if long grass dies due to drought and you don't have an effective, active control program, then all your BASH (Bird/Wildlife Aircraft Strike Hazard) reduction measures failed at once. Areas of the airfield may flood or become infested with attractive insect food for birds. Active control measures are required to control such sudden and dynamic hazard situations.

History

RAF Mildenhall operated a contract BCU using birds of prey from 1972 to mid 1978, although with no habitat management program. The BCU was disbanded in 1978 due to budget constraints, and personnel from Base Operations then took over bird-control duties. The contract bird-control program was revived on 1 March 1985 due to two crashes in Europe caused by birds and continues to this day. This allows some comparison between the contract and Air Force program.

Falconry

Much emphasis has been placed on the use of falconry to control hazardous bird species. This is where the first confusion may arise. Falconry is defined as a sport where birds of prey are trained to catch wild quarry. The term "falconry program" is, in fact, a misnomer as the intent is not to catch and kill birds. Although RAF Mildenhall employs birds of prey, the training is very different to traditional falconry methods as are the techniques used when flying the birds. Specialized training is essential when operating in an airfield environment if the falcons themselves are not to become a hazard.

In this contractor's experience, birds of prey can be a very effective dispersal method. One excellent advantage is the rapidity of dispersal. It's well known that species such as seagulls can take many minutes to disperse, especially if using standard distress calls. Experience has shown dispersal is almost always immediate when falcons are deployed. Birds that have been removed by falcons are likely to remain away from the airfield for longer time periods, provided there are other suitable foraging areas nearby. Falcons can also be used to remove birds from areas outside the perimeter of the airfield which would not respond to more traditional techniques. This can increase safety margins by setting up a buffer zone, making it less likely that birds will move onto the airfield from adjacent fields.

Despite the birds' effectiveness, there are serious limiting factors that must be considered. The use of falcons alone will not work. Different species of birds show different levels of response to the presence of birds of prey, and times between dispersal and return can be fairly short in some instances. The species of falcon being flown may not be compatible with the species of bird being scared. The wrong type of raptor may even draw more birds in to mob it. Birds of prey cannot be used in many situations; for example, at nighttime or in bad weather such as heavy rain or high winds. These are often the times when hazardous birds are likely to appear. If you are limited to birds of prey, there will be times when your only deterrent will not be available. Conversely, good weather in the summer can seriously limit the performance of some species of raptor. Again, there may be long periods in the day when they cannot be flown.

BIRD SCARING TECNIQUES
EMPLOYED AT MILDENHALL-1997

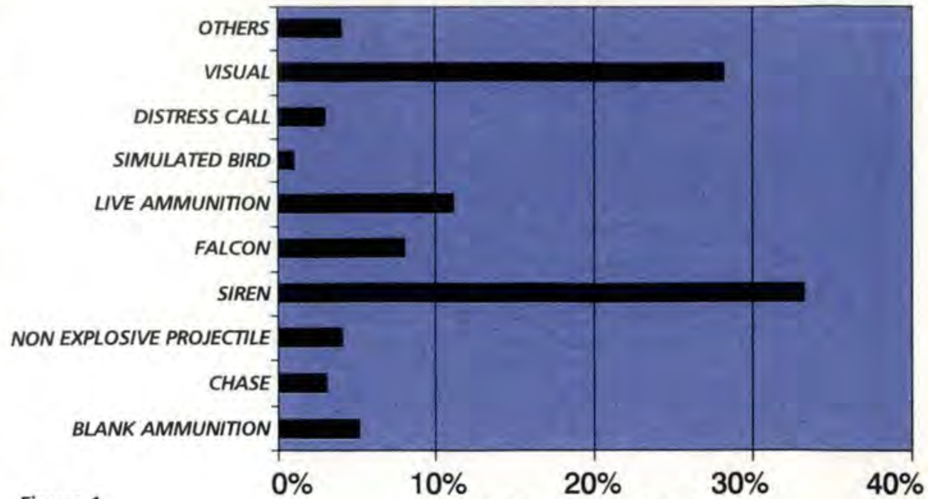

Figure 1

Operating within an airfield environment can be a particularly hazardous pastime. Especially at the busier airfields, a high degree of situational awareness is required. When conducting scaring operations, it's essential to have a sound knowledge of the normal behavior of the species being targeted. If this isn't the case, hazardous situations may arise. It's also necessary for personnel to be well versed in airfield operations and aircraft performance and limitations. An extensive knowledge of operations allows for informed decisions about potential hazards. It's unlikely your local falconer, for example, would have such knowledge. The following are recent examples:

1. On one RAF airfield, three of the contractor's birds were struck by aircraft! The RAF no longer allows birds of prey to be used when flying operations are in progress.

2. At the 1997 Bird Strike Committee (BSC)-USA conference, the manager of a bird-control program using falcons in the United States showed video of what was claimed to be 10,000 migrating blackbirds which were attempting to land in some trees on the airfield. Falcons were shown being flown, keeping these birds from landing in the trees for over an hour. This demonstrates a questionable response to a hazardous situation. The birds were either part of a permanent or a seasonal roost in the trees. In this case, the solution is twofold. Harass the birds away from the site in the evening as they return to roost. Dispersing birds from a roost site is labor-intensive and requires good coordination both before and during the project. Once the birds are dispersed from the site, modifications must be made to the habitat to reduce its attraction as a roost site in the future. This is a clear example of a case where the wrong approach to a situation can potentially cause a more serious hazard to flying operations.

In the past, it has often been falsely claimed that simply flying a falcon will scare all birds over a 1-mile radius. Although this is sometimes the case, on many occasions even nearby birds may not be scared away due to not seeing the falcon or not considering it a threat. Even highly trained, specialized falcons will have days when they are unable to fly either through illness or because they haven't cast pellets from the previous day's meal, to name just two examples. There will also be days when a bird is lost or will refuse to return to its handler. A falconer is very unlikely to fly a bird if another one is missing or is present but refuses to return.

The situations outlined above illustrate areas of vulnerability that must be considered before contracting the services of a falconer. Having said this, there are many situations in which birds of prey can be invaluable. Here are some more positive points. Personnel using falcons tend to be highly motivated individuals. Motivation is very important in a job which can be very boring and may entail long duty hours with little to do. As part of a comprehensive program, falcons can yield great benefits when briefing aircrews about bird hazards. Taking a large bird along is excellent for maintaining audience attention. Additionally, BASH programs using falcons generally have a high profile on the base, and this serves to increase the awareness of the base populace to the overall BASH problem.

Factors Essential to Any Bird Control Program

It is essential to keep a database of all airfield bird-control operations. Collecting data before a contract program is implemented will provide important information on the new program's effectiveness. Figure 1, shown above, was derived from the RAF Mildenhall bird dispersal database. It shows how this contract program is not limited to a single control technique, such as

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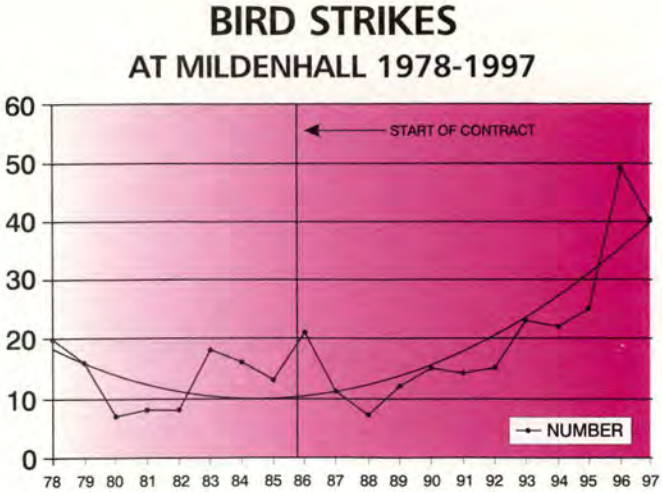

Figure 2

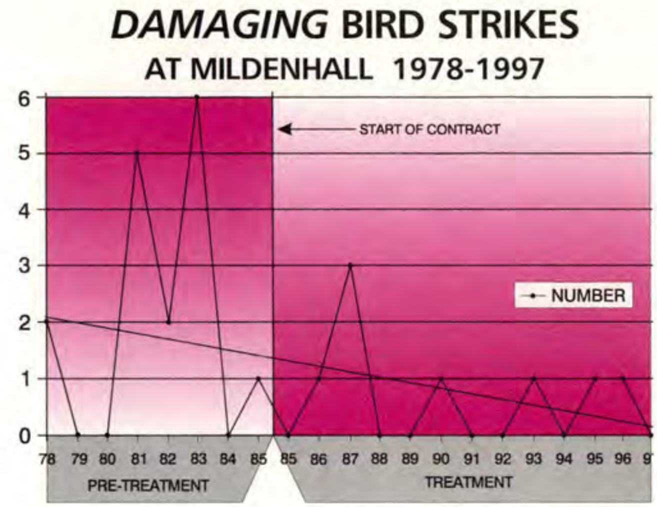

Figure 3

falcons. RAF Mildenhall uses a variety of *bird-scaring* techniques, even though the program is often regarded as a *bird-of-prey* program.

The chart in figure 1 covers all bird-scaring actions conducted during 1997. The data demonstrate that falconry accounts for just 8 percent of the bird dispersals performed. Eleven other methods were also employed. Although 8 percent does not sound like a large proportion of the total, it must be remembered that 5,698 dispersal actions were performed during the year on a total of around 500,000 birds! The number of birds of prey required to provide that number of dispersals would be astronomical and essentially unworkable, especially when you consider that on many days there were few birds for the hawks to chase.

It appears from figure 1 that a heavy reliance is placed on sirens as a means of dispersal. This method is successful due to classical conditioning of the birds to this stimulus. Visual scares are also extensively used, almost always at times when the birds fled before the bird-control unit was in a position to employ any traditional scaring methods. Many of the dispersals with the siren were just added impetus to birds already flying from the approaching bird-control vehicle. We operate on the principle that you don't use a sledge hammer to crack a nut. The big guns, i.e., falcons, although flown every day, are used at times of peak bird activity.

Contractor personnel should be on, or close, to the flightline during all flying operations, actively looking for birds. If they are required to respond only to specific requests to scare birds, their performance will be unsatisfactory, and hazardous situations will arise. If they aren't actively patrolling, then the onus is on other base agencies to detect and report birds. Birds that haven't been detected or that aren't considered by the observing agency to be hazardous due to their numbers or location may prove hazardous due to the dynamic nature of bird activity.

Air Traffic Control (ATC) cannot be relied upon to detect and report birds in the airfield environment. An extreme example is the loss of the E-3 in Alaska. Looking for birds is considered a secondary duty for ATC. There are times when the birds cannot be seen; for example, if they are a similar color to the runway surface, as in the case of a T-38 that crashed at Dallas NAS, Texas.

At RAF Mildenhall, the bird-control vehicle actively patrols the flightline looking for birds and effects immediate removal of any birds found. Perceptions from the ground differ greatly from those experienced by ATC personnel, and their objective view allows bird control personnel to make informed risk assessments. ***Active patrolling of the flightline is the safest method of bird control.***

In 1996, a C-130 crashed in the Netherlands, killing the 34 people on board. The accident report states there was an on-duty bird-control person, but, using binoculars, he had scanned only the airfield from the control tower. He didn't see the flock of 600 starlings and plovers around the runway at the approach end which ultimately caused the aircraft to crash. This dramatically illustrates the need for bird-control personnel to be mobile and in a position suitable to best protect aircraft operations in progress. As is shown in the table of scare methods, local birds will often actively avoid the bird-control vehicle, so its presence alone can be an effective deterrent.

Even with bird control on the airfield, hazards may arise as these examples from RAF Mildenhall show:

1. Bird control performed a runway check and observed no bird activity. The vehicle exited the runway to give way to an aircraft back-taxiing on the runway for takeoff. Three thousand feet from the approach end of the runway, the aircraft passed through a flock of large seagulls. The crew discussed the birds, decided they had flown up, and thus departed the area. The aircraft then turned around and accelerated for takeoff. At 120 knots, 1 knot below S1, they struck the seagulls and rejected the takeoff. They only narrowly avoided overrunning the runway.

2. A Navy C-12 aircraft, departing from midfield, reported a flock of seagulls on the runway in that area. The

Figure 4

control tower passed the information to bird control, who requested permission onto the runway. Permission was denied due to a KC-135 taking the runway for departure. The tower controller reported the birds had flown up and must have left the area. Experienced bird control personnel insisted on checking the runway before the KC-135 took off. Tower relented, and a flock of gulls was found in the center of the runway at the location previously reported by the C-12. Thus, an almost certain bird strike was averted.

These examples clearly demonstrate the benefits derived by having an experienced contractor on the airfield—and a successful program depends on cooperation and awareness by all agencies.

Measuring the Success of a Bird Control Program

In the absence of before-and-after bird activity information, the use of bird-strike data may help judge the success of a program. Bird-strike numbers alone may not give the full picture. Figure 2 shows the total bird-strike numbers for RAF Mildenhall before and after the implementation of the contract program. It clearly shows a general declining trend during the years when the Air Force was conducting bird-control operations. Since the start of contract services, the bird-strike numbers seem to climb consistently from 1988 onwards. This rise in the number of strikes could easily be construed as a decline in performance of the contractor.

If we look at strikes causing damage, a different picture emerges. Figure 3 shows a significant decline in the number of instances of damage. Further analysis shows that for the pre-contract period, there were 12 instances where there was some form of engine damage, a rate of 1.17 annually. Since the start of the contract, there have been only four instances where there has been damage to the engines, a rate of 0.3 annually.

Looking at bird strikes by month (figure 4), we see another significant change over the two periods. The peak in the summer months in both cases is consistent with the arrival of small, uncontrollable swifts and swallows, which migrate from Africa to breed during the summer months. For the noncontract period, there is an increasing number of bird strikes in November, which trails off during the winter months as expected due to winter mortality. The corresponding contract period shows a similar curve, but the dropoff is more dramatic. The increase in bird strikes during the autumn and winter months is generally attributable to larger and thus more hazardous birds, especially seagulls and plovers, which are considered controllable species. The percentage of bird strikes for these winter months is 42 percent (or 5.5 strikes per year) for the pre-contract period, but only 12 percent (or 2.2 strikes per year) for the contract period.

When considering the disparity between the autumn/winter bird-strike rates, it's difficult to make statements about the type of bird being struck due to the large number of birds not identified in the pre-contract period. It must be said that RAF Mildenhall's strike rate on the target species is dramatically lower than for any comparable airfield in the UK. Our identification rate also stands above 96 percent.

Conclusions

When looking at the option of commencing bird-control operations using a contractor, it's essential to use caution when specifying the type of service that's required. In a recent UK example, an inexperienced contractor was employed and told to keep birds off the runway. He did this dutifully, but he completely ignored any birds in the grass immediately adjacent to the runway! Limitations within the specifications of a contract can easily lead to undesirable performance. Experience from contract bird-control services provided in the United Kingdom have shown that when performed correctly, a very high level of service can be provided.

It must be remembered that it will take at least 1 year for a reasonable knowledge of local bird activity to be gained before realistic reductions in target species bird strikes can be expected. It's also likely there will be nuances in local bird activity which haven't been recorded due to sporadic or incomplete data collection. Again, as shown in the figures, the total elimination of all bird strikes cannot be realistically expected. It would, however, seem reasonable to expect a reduction in aircraft collisions with the target species for a particular airfield.

The need for a comprehensive database of bird activity is essential in order to measure the effectiveness of a program. Only then can it be determined if the desired effect is being achieved. Claims of the effectiveness of a program without hard data to back them up are relatively meaningless. Unfortunately, even here at RAF Mildenhall we have limited before-and-after data. There is little hard evidence for the benefits derived from the use of birds of prey as little hard research has been done in this area. Some of the anecdotal evidence given by various people offering "falconry" programs is dubious, and anyone claiming to have the perfect single-method solution to bird problems, whether it be falcons or gas cannons, must be avoided. They are wrong! ✈

Echoes From the Past

AUTHOR UNKNOWN
Courtesy *Mech*, Oct-Dec 97

I know my job, and I certainly know how to do it, so why should I use the book? It slows me down. Besides, most jobs I do aren't really that important anyway. That was my attitude—until I nearly cost a pilot his life.

Ops tempo was high, and pressure to provide "up" aircraft could be felt all the way down the ranks. There were only four men in our shop, but we had the highest system-availability rate. We knew our systems well and were good at our jobs; we didn't mess with anything that slowed us down—like maintenance manuals.

We had an unusually large workload one night. There was no way we could work off all the gripes unless our CDI (Collateral Duty Inspector) worked with us. So that was the plan: Four men, four stacks of gripes, and all our planes would be FMC by first launch. Once again, we would rise to the occasion.

By night's end, all our systems had been repaired; it was time for the paperwork. "Here, sign this MAF (Maintenance Action Form) so I can sign CDI," I was told. It was for removing and reinstalling an indicator—an easy job. Take two screws out, pull out the indicator, slide a new one in, replace the screws. The CDI had replaced a million of them and never made mistakes, *so I signed the MAF without checking the aircraft.* The first launch came and our VIDS (Visual Information Display System) board was clean.

It should have been time to congratulate ourselves on a job well done. Instead, that "easy indicator job" had been rushed, and the retaining screws had been left out. When the aircraft was catapult launched, the 9-pound indicator slid aft and smashed into the control stick and the pilot's chest. With the stick jammed full aft, the aircraft over-rotated and almost stalled right off the cat! Ejection with the indicator out wasn't possible.

The pilot didn't panic; he forced the indicator off the stick and made corrections before the bird could crash. Holding the indicator in one hand, he eventually maneuvered to a safe recovery. We knew that someone had looked out for us that day.

I hadn't done maintenance on that aircraft. What I did was worse. *I signed a MAF without checking the work.* The job was so simple it just wasn't worth checking. Some argued that I shouldn't feel responsible for what someone else didn't do, but my conscience said otherwise: I didn't use the book or follow SOP (standard operating procedure). I am a very competent maintainer, but I became the weak link in a chain that nearly killed a man.

Believe me, you never want to have to ask yourself, "Did I cause a death?" You have to do every job by the book. SOPs are the way they are because someone got hurt after taking a shortcut. So before you sign a MAF, ask yourself, "Would I trust my life with the work just done?" After all, you're asking others to risk their lives on your signature.

***Naval Safety Center Analyst's Note:** Any number of maintainers could have written this piece, and many who work on aircraft today may have been in a similar situation. LCDR Seppla found this story in a stack of papers in the bottom drawer of an old desk.*

We omitted a paragraph that declared this story took place on board a CVA on Yankee Station in the South China Sea during the Vietnam conflict. The story was written when Phantoms, Corsairs, and Skyhawks crowded our flight decks and war was being waged. You can easily envision a story about Tomcats, Hornets, Vikings, and Prowlers or any aircraft found on our flight decks today.

This story proves that the cost of shortcutting procedures is the same today as it was 25 years ago. Mishaps result from maintenance shortcuts, not just pilot error—many involved shipmates who weren't as lucky as the pilot in this story. Aircraft and people change, but the stories and lessons stay the same.

When Weather Goes to Extremes

MARTIN CAIDIN
Aviation Safety, 15 Apr 93

Those who fly know well the value of sharing the priceless ingredient called *the experience of others.* It matters little how many years of logged (or unlogged) hours are in the picture. There is *always* something new, different, surprising, and often frightening to contemplate what others have endured.

So it was when we gathered in an airport lounge on the east coast of Florida one balmy early evening. Our group consisted of young neophytes, old-time fighter jocks, airline captains, barnstormers, crop dusters, aerobatic champions, and carrier pilots.

Newcomers and grizzled veterans alike were hanging on every word of an elderly pilot who had the warm, leathered face of a kindly grandfather—a gentle soul you *know* has run many of the gauntlets of life in the skies. His name was Kurt Streit, a legend among military and civilian pilots in Germany. He had more than 4,500 hours in Ju-52 armed transports alone, most of it combat time in such places as North Africa and Stalingrad. He also was a test pilot, pioneering zero-zero landings.

Yet on this day he wasn't talking about combat or test flying. "I was on a Concorde," he told the group, "and it was one of the really few times in my life I was convinced I was going to die."

Hangar flying was what we had gathered for, but—*the Concorde?* He saw the questions in the eyes of his audience. "Our flight was from Germany to Africa," he went on. "We were cruising at 62,000 feet. Perfect weather. Absolutely clear and smooth. Then, without any warning, we were hurled about violently. I thought the airplane was out of control or an engine had exploded.

"We *were* out of control. We were thrown about with terrible force. There was nothing wrong with the airplane. *We had encountered clear air turbulence*, the worst I have ever known, and I have flown through terrible blizzards in Russia, sandstorms in Africa, all manner of thunderstorms. Nothing compared to the way we were hurled about. It was so bad, I was convinced the Concorde would break up. The motions in the cabin were so severe—plus and minus accelerations changing like rifle shots—it was almost impossible to *see*, to have focus.

"Then, abruptly, it eased. We were flying smoothly again." He laughed. "What I will never forget, even more than the turbulence, is after more than 50 years of flying, I had encountered flight violence of which I knew nothing, and neither did any other pilot I knew. But, we know *now*."

Holy Rules

Not many pilots can expect to be flying at 62,000 feet or need to concern themselves with turbulence of a nature that's not in the meteorology books.

Or do we? Will you ever run into weather phenomena not predicted by the authorities? Is everything you might encounter described in books and classroom lessons?

Those of us who have been flying for decades, rather than years, remember the "holy rules" of thunderstorms. Those who are relatively new to the field need only look in flight instruction books of the thirties and forties to see thunderstorms always topped at no more than 35,000 feet. That was *it*. Seven miles up was the barrier beyond which the skies were cloudless. The met crowd insisted this was true.

In retrospect, that rule was myopic. We now know really big thunderstorms break 70,000 feet on a regular basis. Just how high can they climb? Try 80,000 and then 90,000 feet, and you're still beneath the tops.

Talk to some pilots who flew U-2, RB-57D, and other extreme-altitude reconnaissance machines and expect to be both surprised and awed. One such pilot is retired Air Force Col Charles Maultsby, who flew with the Thunderbirds demonstration team and enough combat missions to turn anyone's hair white before spending much time aloft in the high-powered late models of the U-2.

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Once, at 70,000 feet, he judged the storm tops at 20,000 feet *above* him. There are other moments he still cannot divulge when he was much higher than 70 grand and weaving around storm tops all about him.

Photographs taken at oblique angles from Mercury, Gemini, and Apollo spacecraft, as well as the old Skylab station, show storm tops at about 95,000 feet.

No use hammering more nails into the coffins of the old rules. There are moments when every rule ever written is smashed like a vase slammed against a concrete floor. From the fragments emerge knowledge.

The Air Force learned a lesson when B-29s began daylight bombing of Japanese cities during World War II. The initial results were lousy. The problem lay in the fact some of the B-29s, flying *with* the wind, were showing ground speeds of between 500 and 600 mph. Other B-29s in formation were virtually standing still in the air, despite high cruise power. They were flying *into* those same winds.

That's when we first learned with proof-positive there was something in the sky called the jet stream. Now it's part and parcel of everyday flying life for many pilots. But in the "old days," it was a shocking discovery.

You don't need to climb that high to run into winds equaling the best of the cyclones. Pilots who made the runs to South America before and during World War II, by flying down the east coast of the land and then turning inland, were stunned to find their ground speed had dropped to a paltry few miles per hour. At other times, trying to fly through mountain passes on a westerly run because the mountains were cloud covered, they found themselves in troughs of air spilling downward and across the ocean with speeds in excess of 100 mph.

Other pilots who flew along the Nullabor Plain along Australia's southwest coast sometimes ran into storms not only of an intensity they termed "savage," but with winds just above or at ground level of better than 200 mph. The lucky pilots were blown above terrain. The unlucky ones were sent tumbling groundward, out of control.

There is a jet stream pattern running both north and south along the eastern quadrant of the United States, from the waters south of Florida on up into Canada. Twenty years ago, forecasts of these winds were available for pilots flying between 4,000 and 10,000 feet. Then, for some unaccountable reason, the "low jet streams" seemed to go out of favor. Now, meteorologists respond with blank looks when questioned about them.

Out of Nowhere

On 2 December 1988, a research group surveying the limestone caves along the Pannikan Plain (Australia) was nearly wiped out by a fierce storm which "appeared out of nowhere." One of the surveyors, Wes Skiles, described the storm as "terrifying in its final approach, evil and menacing." Without warning, it struck with winds exceeding 200 mph.

I once encountered a similar storm, with the fury and turbulence of a hurricane (and this pilot *has* flown hurricane missions searching for downed aircraft), which appeared without warning. It was 31 December 1970, and I was southbound with two other pilots from Zahns Airport in New York to Merritt Island, Florida, in a Piper Apache. We'd scheduled a landing at Myrtle Beach for a pit stop and refueling. For a good part of the way out of New York, we were in and out of snow squalls. After skirting a particularly heavy blow, we turned due east for the run to Myrtle Beach.

If there weren't records of this flight made by the FAA and the weather station at North Myrtle Beach, and eyewitness reports from observers who included a police chief, I wouldn't put this incident on paper. But I commend any pilot flying along the east coast to keep in mind this type of storm can snap into existence without the slightest warning and throw just about anything with wings out of control.

We were talking with a flight service station when it suddenly went off the air. We didn't learn until later they were *blown* off the air (their tower went down among other things) by a storm "that wasn't there."

Within seconds, literally, winds of 15 to 20 mph increased to storm fury exceeding 120 mph. Before us, the sky turned a strange milky gray. We noticed high grass bowing down to the ground before the wind. Just before the winds hit us, we saw it wasn't grass at all, but entire forests laid low.

The turbulence was unexpected and frightening, and it snatched control away from me. We tumbled, shot up and down, and were convinced the airplane would come apart. I opted for a gear-up landing at *any* field we could reach. But this was impossible.

We were being tossed like a toy boat in a maelstrom. It took 45 minutes to cover 20 miles. The police chief of the town over which we traversed (a better description than "flew") reported our airplane "was like a toy being tossed end over end."

We went through rain squalls which blotted out the world and disappeared as quickly as they came. We stared at a picket-fence line of funnel clouds racing in from the ocean.

We made it down in a wild and hairy approach which was the craziest roller-coaster ride I've ever experienced. Five minutes after landing, the winds stopped. *Just like that.* We discovered later we'd been punished by what was described as a *neutercane*.

The weather people, for the most part, have never heard of a neutercane and will dismiss the whole concept as ridiculous. It took 5 years to get official confirmation of what we'd been through. And the official word was this kind of storm is not unknown in what the FAA calls "extreme weather conditions which suddenly occur in places such as the Bermuda Triangle."

These are the words of the FAA, not mine. More specifically, in the October 1975 issue of *FAA World,* there appeared this statement:

"The usually benign weather can change radically. A pilot may fly into a localized storm lurking under an apparently innocent nimbo-cumulus cloud, or into small hurricane-like storms known locally as neutercanes, which may be imbedded in otherwise harmless rainstorms. The pilot flying in restricted visibility has no warning he is headed towards disaster until it is too late. These cyclical storms pack a punch which can rip the wing off a plane and drop the pieces into the ocean where they will never be found."

No Explanation

There are times when being in the wrong place at the *wrong* time is enough to wipe out any airplane ever built. The wind storms are but one such source. There are others for which science has not an iota of understanding or explanation.

On the night of 9 April 1984, a Boeing 747 of Japan Air Lines, with Capt Charles L. McDade in the left seat, was 180 miles on the northeast run out of Tokyo. The time was 2306 local when *it* happened.

McDade and his crew, in bright moonlight, stared aghast at the cloud deck 5 miles below them at what they called "a terrifying sight." The cloud deck bulged and, as the crew stared in disbelief, expanded swiftly. *Something* then lunged upward through the solid cloud deck below. A monstrous mushroom cloud boomed upward into the night sky. It had the size of one of the most powerful hydrogen bombs ever exploded.

The mushroom cloud expanded as it rose until it was more than 200 miles in diameter. In 2 minutes, it had punched its way upward to 60,000 feet. McDade called Anchorage Center. "Japan Air 36. We have a…round ball cloud. Looks like a nuclear explosion, only there was no fireball and there was no lighting. But the cloud was there, very definitely…easy to see it. The moon is behind it, and it expanded very rapidly. I turned off course to get away from it as much as possible. We are on 100 percent oxygen, just as a precaution…"

The cloud climbed and expanded until it was estimated at between 70,000 and 80,000 feet high and covered a distance which would have stretched farther than from Washington to New York. Other airline crews called in with emergency reports. The Japanese sent an F-4J racing through the mushroom stalk in search of radioactivity. *There wasn't any.*

No one has ever come up with an explanation of what caused the cloud—the tremendous energy needed to hurl it 20 miles high. Extensive investigation ruled out a hydrogen bomb explosion, land or underocean volcano, huge shift in the ocean floor. Anything and everything was investigated.

The cloud was impossible. It could not be—except four airline crews saw it and an F-4J flew through the writhing stalk. To this day, there is no scientific explanation.

Forewarned, Forearmed

Sometimes you can avoid being in the wrong place at the wrong time because a bunch of pilots got there before you and enough horror stories made the rounds to forewarn newcomers of the danger zones.

That's why flying downwind of Mt. Washington in New Hampshire is a recognized no-no. Winds have been recorded streaming off the mountain, nearly 6,300 feet high, at better than 100 mph on what is considered a comparatively calm day in that area. When the wind picks up, the air howls around, over, and down this peak at better than 200 mph.

As already mentioned in our exploration of neutercanes and booming mushroom clouds, there are times when there simply isn't any warning. For instance, in the early 1980s, I encountered a sledgehammer in the sky which I'd not only never known before, but had never read about or heard of from any other pilot.

We had just completed 2 days of air show flying at Leesburg, Florida, in a Junkers Ju-52 and were anxious to return northward to Gainesville. Summer thunder bumpers were building rapidly, and just north of the field, the sky was turning that greenish pallor smacking of severe turbulence and hail. We went through a fast startup, took off to the north, and initiated an immediate left turn to head west and stay clear of the visible trouble. As soon as we had some altitude, we called Gainesville. A storm was over the field but was moving out fast. Another 30 minutes would see easy flying home.

So we eased west of north for Ocala, which told us a thunderstorm had just passed by, the sky was blue overhead, and "come on in—the coffee's on." Ocala was clearly visible from 5 miles out, the runways and grass areas glistening in

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the sun from the recent downpour. We'd land there, have coffee and doughnuts with friends, and get Gainesville Tower on the phone. When they said, "Y'all come on in," we'd jump north to home field.

Egg-Shaped Clouds

As we eased into our descent, the sky overhead looked like the bottom of an endless line of egg cartons, with the rounded bottoms parading as far as the western horizon.

We decided to stay well below the stuff and sail on. As we approached Ocala Airport, the visibility to the west was unlimited, sparkling fresh and clear. To the north and northeast, though, it was all bad news. Black and green. Ominous, like *Keep Out!* signs posted in the sky.

Well, okay. Power back slowly, nose down. Smooth as silk. And then, *bang!* The blow which struck the airplane was the single greatest impact I have ever known in 50 years of flying. It was as if our landing gear had slammed into railroad tracks.

The nose pitched up violently. Roger Daigen, my crew chief, had been standing just behind the pilots' seats. He was whisked out of sight and sailed through the air 21 feet back to the aft cabin bulkhead, where he was pinned, spread-eagled, helpless to move. I got the nose down with a hard shove forward on the yoke, coming back on the power. Daigen dropped to the floor and scrambled forward. Fortunately, our passengers were belted in securely.

My wife, Dee Dee, flying right seat, pointed to the VSI and made some remark which was lost in the thunder of the engines. One look told the story. We were climbing, nose down, at better than 2,000 fpm, and the rate was increasing. I put the nose down more steeply. We were going up now at 3,000 fpm toward those egg-shaped clouds. With full power, props full forward, and the nose down at a steep angle, we should have been diving, but we were *going up* at 4,000 fpm.

I had no idea what we were into or how or why this was happening, but I knew I'd better get out of that crazy ascent as fast as I could. What awaited us in those clouds coming closer every second was something I didn't want to meet. Since power back and power full-on made no difference, I wrestled the airplane into a vertical bank. Now I knew we weren't generating any lift to keep us flying. The upward rush eased as 23,000 pounds of airplane became a big spread of angled iron. The VSI needle came around, and we started down.

Then abruptly, another *bang*. Not as wild as the first one, but now we were coming downstairs in a rush. Wings level, power back. We went through a series of slams into these invisible rails, but each time with less force of impact. And then, we were out.

Coming South

I wanted to get on the ground to check the airplane for damage. Brooksville came into view off the right wing. But before I turned toward the field, Daigen tapped me on the shoulder. "Whatever that stuff is that was over us, it's coming south fast."

Good-bye, Brooksville. I went to high-cruise power and made a long, flat descent toward Lakeland. When we landed, the sky was clear blue, without a cloud anywhere. We borrowed chains, ropes, and cables and used them, in addition to the tiedowns we carried aboard the Ju-52, to lash down the big airplane. People watching us figured we were nuts. Ropes first and then cables in the tiedown rings, chains wherever we could wrap them about the gear.

We always carried large plastic garbage bags, and my passengers hied off to an area of soft ground to shovel dirt into them. We placed the bags along the wings to break up any lift. We wanted the airplane tail-heavy, so we loaded up the horizontal stabilizer with its own share of bags.

By now, the blue sky was gone. A gray haze had formed, and small, dirty clouds scudded overhead. We'd already called a friend, Jack Kehoe, to come and pick us up. When he arrived 20 minutes later, the sky was ominously overcast, the wind was whipping up, and we felt the first raindrops.

Later, standing in Kehoe's living room, drinks in hand, we watched a 100-mph storm beat up the countryside. An hour later, it was gone. The setting sun was clearly in view when we drove back to the field to check on the airplane. The tail had swung around about a dozen feet, but otherwise it was in good shape.

Not so for a dozen airplanes which had been torn from their tiedowns and tossed about. The only question we got from local pilots was, "How did you know this was coming? The weather people never said a word about it."

Funnel Trouble

There are days in Florida when you can *feel* you're going to have unwanted company in the air. There's little scientific basis for sensing trouble on the way, but pilots who fly for years in Florida often just seem to know when to be ready for the unexpected.

I have never determined just what conditions prevail to bring on a spate of funnel clouds (which don't touch the surface) and tornadoes (which chew up the surface), but sometimes they really do come in bunches.

We encountered *nine* in one day, and never once were we in precipitation.

We took off from Merritt Island Airport for our usual leisurely run southward off the coastline. It wasn't to be. We turned right to cross over Cocoa Beach and were talking with Patrick AFB when we saw a waterspout roaring in from the ocean toward the Air Force base. It changed to a tornado as it hit the beach. We let Patrick know about it and then turned to get out of its way.

Good move. Another funnel dropped out of those clouds off the coastline and rushed overland without touching down until it hit a river, where it dipped into the water and scared the local citizens.

The remainder of our flight to Miami International to pick up some new equipment for the Ju-52 was uneventful. We took off on Runway 9L, which requires you either go straight out or turn left. I was about to turn left when Nick Silverio in the right seat, Frank Ray in the engineer's seat, and I stared ahead in awe. "Clear me right," I called. Nick confirmed nobody was coming down or taking off from 9R, and we swung into a right turn.

The tower gave us hell, but we told them to look to the east, where two huge funnels were smacking down and hurling debris wildly into the air. The tower, in rapid-fire calls, cleared us to continue to the right and told everybody else coming in to break off.

Later, we were just north of Homestead AFB, doing flight-test runs, when we heard the base clear an F-100 to land. A moment later, we advised Homestead to send the 100 around. A funnel cloud was boring down from the sky where the airplane would flare. But there was no need for them to call. The fighter jock had heard us and was already peeling off with full afterburner.

After wrapping up our work at Miami, we headed for Tampa to pick up a passenger. There were lots of broken clouds to work our way around. We came around one cumulus only to execute one of the fastest breakaways I've ever done in the Ju-52. At 4,000 feet, dancing in the sky, was a glowering funnel cloud, spitting lightning. (I wonder how many pilots have bored through seemingly innocuous clouds only to fly into one of those buzz saws.)

Later, we saw three more of them dancing about the waters of Lake Okeechobee, long known to the locals as a spawning ground of funnels. It was quite a day.

Getting Bugged

Logbook entry for 2 August 1980, N52JU from Gainesville to Huntsville: "Strong head winds, thick haze, rotten trip." A quick stop for fuel, and we pushed on to RON at Nashville through "hazy but smooth skies."

Next day, it was Nashville to Champaign, and the log entry said it all. "Severe rain. Zero-zero vis. Punched up to get on top. Major deviations. 4 hrs 40 mins."

Break for fuel, food. Let's go. "It's Oshkosh time! Out of Champaign, it was "zero-zero vis, heavy rain, bad chop, long climb up to 11 grand." We leveled off, luxuriating in the cool air above the fleecy white cloud hills and valleys beneath us. Next stop, the EAA (Experimental Aircraft Association) convention where we'd make an air show arrival.

Then we heard a radio call which always chills the blood. "Mayday! Mayday!" It was the pilot of a Mustang headed the same way, reporting loss of oil pressure, his front windshield smeared with oil. Before we could figure which one of our friends it might be, another Mustang pilot called in with *another* broken oil line.

Then three more mayday calls. A formation of T-28s, all with busted oil lines. The frequency became filled with mayday calls. It was a sudden epidemic of oil line failures, which made no sense at all.

Then it was our turn. In front of me, the windshield became a swirl of greasy, yellow-black oil from the nose engine. Forward visibility went to zero. No problem seeing from the huge greenhouse, but it was Trouble Time. I reached for the quadrant to kill the nose engine in case we had a fire, but my hand met that of my crew chief. "Hold it," he said. He tapped the oil temperature gauge for the No. 2 engine. Right on the money. His finger moved to the oil pressure. Perfect. CAT, EGT, CHT, RPM, MAP—everything was on the money.

"Slow down," he said. I brought back the power, slowed to an indicated 85. He slid back my side window, reached around to the windshield and wiped his finger along the oily smear. He held it out for us to see.

The oil had wings. Every airplane in the area had a *bug-smeared* windshield. We chopped the nose engine to idle and clung to Daigen's legs as he stood on the quadrant to clean the windshield.

What we'd all run into—and what not one of us had ever heard of before—was an annual migration of lake bugs. Trillions of them in great clouds from the ground to 20,000 feet and more (where a few jets got smeared and ran for the nearest field). Bugs, tiny little things, when smeared *en masse* on the windshield look exactly like Shell or Mobil, or whatever you put into your engine.

Expect the unexpected. It'll get you every time. ✈

Martin Caidin has over 10,000 hours of flying time and has written more than 140 books.

Maintenan

Strut Strategy = $ticker $hock

Two aircraft maintainers were dispatched to fix a chaffing NLG shock strut door fairing and shock strut door on a multi-motor aircraft. After removal, repair, and reinstallation of the offending parts, they nose-jacked the aircraft to swing the NLG to check for fit. During retraction, the NLG strut contacted the shock strut door, which, in turn, damaged the shock strut door fairing. Subsequent investigation revealed that the mishap could have been prevented if two crucial tech data steps had been heeded. It also highlights the importance of effective communications between team members, both before and during critical tasks. Cost? More than $16,000 in aircraft damage, several additional hours of NMC time, and a tarnished reputation for two hard-working maintainers.

Accidental Injections

Responding to a "Red Ball" to repair a hydraulic leak, a specialist probed with a wrench inside an F-15's access panel to locate and tighten a suspected loose B nut. Seconds later, he felt a sharp pain and quickly pulled his arm out of the panel.

With the help of a crew chief, the hydraulics troop removed his field jacket, revealing a swollen and discolored arm. Within minutes, he was in the emergency room with a corps of doctors working to save his injured limb.

The cause of his painful and potentially fatal injury was the injection of hydraulic fluid into his arm as a result of a pinhole leak in the aircraft's 3,000-psi hydraulic system. Fortunately, after painful surgery and several weeks' recovery, the specialist returned to duty.

Most maintainers are aware of the hazards of working with high-pressure hydraulic systems. However, many are surprised to learn low-pressure systems, such as paint spray systems and grease guns used in aircraft maintenance, are also capable of injecting foreign substances into an unmindful maintainer's body.

An unwary corrosion control specialist also learned a painful lesson when he was seriously injured attempting to clean the spray orifice of an airless paint gun. The specialist was new on the job and had not been briefed on the safety requirements for using and cleaning airless sprayers.

With his hand over the orifice, he accidentally injected himself with a dose of polyurethane paint. Since aircraft paints contain exotic chemicals such as heavy metals, in addition to causing painful injuries, an injection can also cause deadly systemic poisoning. As a result of this mishap, the untrained painter lost 15 days of work.

A grease gun may seem like a pretty innocuous piece of equipment, yet, it too is capable of causing personal injury.

A maintainer was using a piece of safety wire to unplug a clogged fitting on a manual grease gun. When the wire was removed and the obstruction cleared, grease was injected into his finger, through his hand, and into his wrist. Another maintainer was injured as he was wiping a grease gun fitting with a rag. The grease penetrated the rag and was injected into his palm.

As with any type of equipment, it's important to keep hydraulic systems properly maintained. It's also important for supervisors to ensure personnel are properly trained and follow technical and safety directives when working with them.

ce Matters

Wire Specifications

Murphy sets his first trap at the bench stock board before we even get to the aircraft. Generally, the type of wire to be installed is specified in tech data. However, in many cases, tech data guidance is lacking, and one must choose the type of wire to be installed. Remember: Choosing the correct wire for an aircraft system is not simply a matter of selecting the proper voltage rating or wire size.

Over the years, manufacturers have developed many types of wire designed to operate in a variety of functions and environments. Some are resistant to fluids, such as fuel or hydraulic fluid, while others are designed to operate at extremely high temperatures.

The different qualities of aircraft wire are dictated to us by strict standards known as military specifications or "MIL SPECS," developed by the various branches of the armed forces. To choose the correct wire, when one is not already specified by the T.O., is a simple matter of selecting the MIL SPEC with the desired characteristics.

For example: MIL-W-22759C specifies a wire with a fluoropolymer insulation which is resistant to fluids and suitable for use around fuel and hydraulic systems. MIL-W-25038 has a fire-resistant glass or asbestos insulator and is used in high-temperature environments such as engine bays or near bleed air ducts. It will endure temperatures of up to 400°C (750°F) for periods totaling up to 100 hours.

The Defense Department publishes thousands of MIL SPECs. A complete edition alone could fill several shelves in a publication library. Fortunately, aircraft wiring MIL SPECs are also contained in T.O. 1-1A-14, "Aircraft Electric and Electronic Wiring," which can be found in most T.O. libraries.

Terminal Fire

During a routine phase inspection, a tanker crew chief found a broken wire on the pilot's window heat terminal. An environmental systems specialist was called to replace the terminal lug.

During climbout on the first flight after the inspection, the flightcrew heard a loud pop followed by 2-inch flames and black smoke coming from the pilot's window. The crew immediately turned off the window heat and the flames disappeared. The pilot declared an emergency, dumped fuel, and made an uneventful landing.

A maintenance team had no trouble determining the cause of the fire—a short between the window heat electrical terminal and one of the window bolts. A closer look revealed the terminal lug installed by the environmental specialist was the wrong part number. It was too long and arced against an adjacent window bolt.

To preclude surprises like this, always verify the part number *with the tech order* before installing a part. Don't simply match the old part with the new one. It could be that the old part had failed because it was incorrect to start with. As magic as our computerized supply system is, there is always the human element—Murphy's Law—to consider. Take the time to check the T.O. for the right part every time. ✈

Sneaky Wind Shear

LT JIM DVORAK
Courtesy *Approach*, Feb 98

As I scanned my VSI, it jumped from 1,000 to 4,000 fpm; we all felt our seats fall out from under us.

We were an hour out of NAS Keflavik in a P-3C Orion on a reposition flight. My copilot was a brand-new third pilot fresh from the FRS. Weather was briefed to be less than VFR but nothing to be overly concerned with as we enjoyed the Northern Lights in the clear night sky.

As we prepared for descent and approach, Reykjavik Approach Control reported weather to be 1,000 feet and overcast, 10 miles visibility with snow showers, and the wind nearly down the runway. I felt comfortable with the weather as I knew the ILS approach available would take me well below the 1,000-foot ceiling.

Reykjavik was vectoring us for the approach when I realized that we were still high and would need a higher rate of descent than usual to ensure that we would be able to intercept the ILS at the right altitude. I told my copilot about my plan.

We intercepted the localizer and turned inbound. I brought the rate of descent back to 1,000 fpm, slightly higher than the normal 700 to 800 fpm, and called for the gear. Five miles from the field, descending through 2,000 feet (about 350 feet above glide slope), it hit us. As I scanned my VSI, it jumped form 1,000 to 4,000 fpm; we all felt our seats fall out from under us.

I called for a wave-off, added max power, and requested the gear be retracted as the altimeter scrolled through 1,200 feet and the glide slope indicator showed us well below glide slope. We recovered at 1,000 feet and began climbing when my TACCO reported seeing wind readings indicating the possibility of wind shear.

We were quickly approaching 190 KIAS when I again called for gear retraction, including the flaps, as we had ample airspeed and were climbing. Leveling off at 3,000 feet and still IFR with moderate turbulence and icing, the copilot said we had an unsafe gear-up indication for the port mainmount. He quickly requested vectors for holding so we could all catch our breath and discuss what had just occurred.

Entering holding, we broke out of the clouds and into clear weather. My flight engineer looked in the NATOPS manual to work on getting a safe gear-down indication. It did not take long to achieve this, but there was still some doubt about the integrity of the tires. We weren't sure the main doors hadn't closed on the tires. (They hadn't.) We discussed our options and decided to declare an emergency because of this uncertainty. Approach control vectored us for another ILS approach, and this time we could see the field from 15 miles out on the localizer course. We landed, glad to be on deck.

In the VP community, they say the real learning begins after qualifying as plane commander. I learned a lot about weather that night and will never take it for granted again. In the future, if I find myself in questionable weather, I'll give the local metro station a call for a thorough observation instead of depending on tower to recite a weather line to me that could be an hour old. That night, a lack of good information made the difference between a roller-coaster ride through a microburst and waiting 10 minutes to land in VFR weather. ✈

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THE Well Done AWARD

Presented for outstanding airmanship and professional performance during a hazardous situation and for a significant contribution to the United States Air Force Mishap Prevention Program.




Lt Col Rick Ferguson, Instructor Pilot
Capt Butch Allen, Pilot
Capt Kenny Duck, Instructor Weapon Systems Operator
Capt J. M. Janukatys, Instructor Weapon Systems Operator
7th Bomb Wing, Dyess AFB TX

■ The crew of Hawk 84 was No. 2 in a two-ship formation of B-1Bs in IR-178BG, a high-speed, low-level training route. Each aircraft was scheduled to drop four BDU-50 practice bombs in the Melrose Range for an initial qualification sortie for Capt Allen. The mission proceeded uneventfully until Hawk 84 entered low level. Approximately 10 minutes after entering the route, while flying automatic terrain following at 600 feet AGL, 550 KIAS, the crew experienced a sudden aircraft vibration. After confirming that the vibration was not caused by turbulence, Lt Col Ferguson took control of the aircraft and began an immediate climb to IFR altitude. As he added power for the climb, the aircraft shuddered and experienced significant control problems—the rudder pedals, throttles, and control stick vibrated and intermittently jammed.

As the aircraft was gaining altitude, the Oxygen Caution light illuminated, followed by an immediate loss of oxygen airflow. Once level at 9,000 feet, Lt Col Ferguson began slowing the aircraft to 350 KIAS and sweeping the wings forward. Vibrations in the flight controls continued, despite this reduction in airspeed. The crew made the decision to abort the low-level route and land at the nearest emergency airfield. While heading to Midland International Airport, Lt Col Ferguson noticed a significant degradation in lateral control stick authority, with stick movement limited to 1/2 to 1 inch from center, requiring 60 to 80 pounds of stick force to achieve stick displacement.

After slowing to 300 KIAS and sweeping the wings forward to 25 degrees, the crew initiated fuel dumping procedures to adjust the aircraft gross weight to 250,000 pounds for immediate landing. During this time, numerous caution lights illuminated for environmental overloads due to reduced air availability. Capt Duck and Capt Janukatys began shutting down all nonessential equipment to prevent damage to the offensive and defensive equipment IAW Dash One procedures. As the crew approached the airfield, Lt Col Ferguson experienced complete stick lockup in the lateral axis for 3 to 5 seconds. He directed the crew to prepare for ejection while using the rudders to maintain a wings-level attitude. During repeated attempts to move the control stick, a small amount of lateral stick authority was regained.

Avoiding populated areas, the crew managed an extended straight-in final, and Capt Allen lowered the landing gear. While waiting for the red light in the gear handle to extinguish, a loud thump was heard and felt in the cockpit, and the aircraft immediately pitched up. Lt Col Ferguson lowered the nose to regain level flight. With limited lateral authority, he used rudder inputs to fly a visual straight-in approach. Landing and rollout were uneventful, and the crew performed an emergency egress once the aircraft came to a complete stop.

Post-flight inspection of the aircraft revealed that a 4-foot section of environmental control duct had ruptured near the spine of the aircraft, interrupting normal airflow to numerous components. The extremely high temperature (520°F) and air velocity (70 to 90 psi) from the ruptured duct had caused the flight control cables to vibrate. Duct insulation, melted and blown by the airflow, began to lodge in the right spoiler override bungee which limited the pilot's ability to control the aircraft in the roll axis. The extreme hot airflow heat-soaked the aircraft spinal longeron and caused the dorsal longeron to separate into two pieces. This compromised aircraft structural integrity and was the cause for the abrupt pitchup on final to midland.

The aviation skill, timely actions, crew coordination, and superior systems knowledge demonstrated by the crew of Hawk 84 averted loss of life and saved a $280 million combat asset.

WELL DONE! ✈

Photograph courtesy Lt Col Timothy H. Miner, USAFR

Any attempt to stretch fuel is guaranteed to increase headwinds.