Thunderstorms and ATC

Of all the threats that weather can pose to light aircraft, few are more dangerous than thunderstorms.

Every year, a number of unfortunate aviators get an up-close-and-personal tour of the inside of a thunderstorm, and many pay for the experience with their lives. In 2004, nearly 25 percent of all fatal weather-related accidents involved encounters with thunderstorms. Amazingly, in all those accidents, the pilots flew into extreme conditions *despite being in contact with Air Traffic Control (ATC).*

ATC weather radar can be an invaluable resource for pilots seeking to avoid convective activity. But in order to take advantage of ATC thunderstorm avoidance services, pilots need to have a solid understanding of not only what information is available, but also the limitations of that information and the circumstances under which it's provided. In this Safety Advisor, we'll take a closer look at ATC weather radar services, as well as strategies for dealing with some of nature's most violent storms.

The Threat

Thunderstorms are dangerous for several reasons. For one thing, as compared to other violent weather phenomena, they're quite common: The National Weather Service estimates that 100,000 occur in the United States each year. They can also develop quickly, as anyone who's

Thunderstorms aren't always easy to spot. They can hide in haze or large cloud banks.

watched a puffy, benign-looking cloud blossom into a towering cumulonimbus can attest.

Moreover, despite their often dramatic visual characteristics, thunderstorms can be difficult to see from the cockpit. Thick summer haze can make them hard to spot, and powerful convective activity can hide inside banks of normal, innocent-looking clouds.

That said, it's what's inside (and around) thunderstorms that really makes them dangerous. In addition to extremely heavy rain, they can contain violent up- and downdrafts, strong wind shear, large hail, and severe turbulence, each of which can damage or destroy your aircraft.

Belly of the Beast

A light aircraft caught in a severe thunderstorm is truly "along for the ride." Pilots who've lived to tell the tale describe being out of control—climbing or descending at thousands of feet per minute, pelted with hail, slammed violently against seatbelts, and generally holding on for dear life. Airplanes have emerged from thunderstorms with doors blown off, leading edges smashed in, windshields broken out and airframes distorted beyond repair… and those were the lucky ones. Many more have been torn apart in mid-air, or hurled to the ground out of control.

Clearly, it's best to avoid such encounters. Unfortunately, climbing above convective activity usually isn't an option. Even in a turbine-powered aircraft, you probably won't be able to out-climb a rapidly developing storm. Deviating around build-ups may be a possibility, but it's no guarantee. Holes between developing thunderstorms can close quickly, and staying clear of the clouds doesn't necessarily ensure safety. If it's impossible to maintain a 20 nautical mile buffer between the airplane and the storms, don't try to pick your way through.

For most general aviation pilots, the safest (and best) option when confronted with widespread convective activity is to look for a place to land. In many cases, that means turning around and finding a nearby airport. The nearest runway, however, may not be the best choice: Thunderstorms can move quickly, and it's unwise to "race" one to an airport in harm's way. Pick a field that will allow plenty of time to land and secure the aircraft before the storm hits. At a minimum, consider an airport 20 to 30 miles away. Strong winds can extend miles ahead of a powerful thunderstorm, which may itself be traveling at groundspeeds in excess of 40 knots.

But what if the worst happens and you find yourself in the belly of the beast? You can increase your chances of surviving a thunderstorm encounter by taking a few,

THUNDERSTORM ENCOUNTER

The Beech Bonanza pilot received a preflight briefing that included thunderstorm advisories for his route. He also received convective SIGMET information during the flight. Once aloft, ATC asked the pilot if he had weather detection equipment onboard, to which he replied, "I have a storm scope." The controller then advised the pilot that there were solid cells ahead, 20 miles wide with very heavy rain. In response to the pilot's request for a suggested heading, the controller advised that there were no openings. Finally, the pilot asked his distance from the cells: The controller replied "Five miles" and added, "If you wanted to go eastbound that's the clearest route, due east about 45 miles then northbound, that's the clearest route." The pilot replied, "We'll try that." Radar contact was lost and there were no further radio transmissions from the pilot. Accident investigators concluded that the aircraft broke up in flight. To view other accident reports, visit the ASF accident database: www.asf.org/database

When faced with a line of convective activity, landing is usually the best option—just be sure to pick an airport at least 20 miles from the storm.

simple steps. First, throttle back and slow down *before* getting into severe turbulence. Aiming for maneuvering speed (V_a) can help protect the airframe from being overstressed by the violent air currents of a thunderstorm, but don't try to "chase" a particular airspeed. As the airspeed needle swings wildly, you'll be doing well to hold the average of the swings somewhere near the published V_a.

The second step is to make the airplane as aerodynamically "dirty" as possible ***without lowering the flaps*** (which usually reduces structural strength). In complex aircraft, extend the landing gear. The added drag reduces the potential for rapid acceleration and, in turn, the potential for loss of control, or excessive airframe loads.

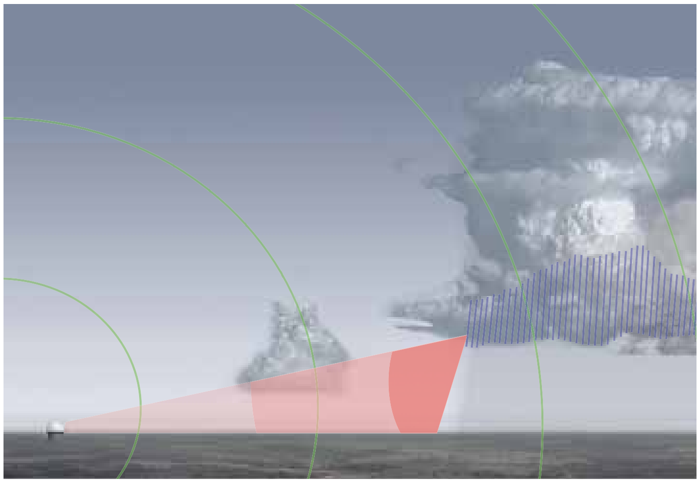
Finally, maintain a very loose straight-and-level flight attitude and forget about holding a particular heading, altitude or airspeed. Trying to exercise precise aircraft control in a thunderstorm is both futile and counterproductive: It's impossible, and it greatly increases the odds of damaging the airframe.

Caution!
Flying through a thunderstorm can be deadly. No matter what precautions are taken, a powerful thunderstorm can overstress the airframe, causing an in-flight break-up or loss of control.

Again, the best idea is to avoid thunderstorms entirely. Thankfully, modern weather radar systems have made it considerably easier for pilots to accomplish that goal.

Radar Basics

Radar works on a very simple principle. A station broadcasts a "pulse" of microwave energy in a particular direction. When that energy collides with an object (a raindrop, for example), a small portion of it bounces back to the station. Radar equipment detects this reflected energy, measures the elapsed time, and uses that information to calculate the distance to the object. The strength of the reflected signal indicates the solidity and size of the object—for our purposes, the strength and dimensions of an area of precipitation. Computers then translate that raw data into the colorful radar graphics we're used to seeing.



Radar signals bounce back when they hit an object, allowing the station to determine its distance and size.

Weather radar is a useful tool for aviators, but it has some inherent limitations. For one thing, it can only detect precipitation. It can't "see" clouds that don't contain precipitation, and thus it can't always warn pilots about instrument meteorological conditions (IMC). Likewise, radar can't detect turbulence, and—because it works through line-of-sight—its coverage at lower altitudes is limited. Line-of-sight can also be problematic in mountainous areas, where terrain often blocks radar signals and high-altitude stations sometimes "overshoot" low-lying precipitation.

Depending on the type of facility, ATC provides radar information to pilots using one of two different systems: ASR (Airport Surveillance Radar) or WARP (Weather and Radar Processor).

ASR (used in Approach Control Facilities)

Airport Surveillance Radar, or ASR, is used exclusively by Approach Control facilities. Several variants of the ASR system are in use around the country, but they all share one characteristic—near real-time display capability. Because ASR data is transmitted directly from the radar station to the controller's scope, there's virtually no time-lag involved, and pilots talking to Approach Control can generally count on up-to-the-minute weather advisories.

The displays associated with older ASR equipment cannot provide information on precipitation intensity: Controllers using these systems will describe precip as "intensity unknown." Newer systems like ASR-9 and ASR-11, however, have displays that depict the intensity of

ASR returns on a controller's scope

precipitation on a six-level "VIP" scale ranging from "light" (level 1) to "extreme" (level 6). Don't expect to hear controllers talking about "level three cells," though. **Recent procedural changes have resulted in a new reporting system for controllers using ASR: They now describe precipitation to pilots as light, moderate, heavy and extreme** (see Figure 1 below). Approach Control radar displays will soon be updated to reflect the change.

For pilots, the relevant limitations of ASR are the same as those of any ground-based radar system. It detects precipitation—not clouds, or turbulence—and its coverage can be limited at low altitudes, or in mountainous areas. Inherent limitations notwithstanding, however, ASR is a very capable system.

WARP (used in Air Route Traffic Control Centers)

The Weather and Radar Processor, or WARP, takes radar data from one or more NEXRAD (Next-Generation Radar) sites and overlays it on a controller's scope. WARP is used exclusively in Air Route Traffic Control Centers (ARTCCs, or Centers)—the ATC facilities that handle the airspace between Approach Control facilities. It's a relatively new system, and it represents a dramatic improvement over the weather radar displays previously used by Center controllers.

Fig 1: VIP Levels

New Terminology	dBZ	Rain Fall / Hour	VIP Level (no longer used)
Light	18 - 29	.01" to .10"	1
Moderate	30 - 40	.175" to .50"	2
Heavy	40 - 50	.50" to 2.0"	3 and 4
Extreme	50 +	2.0" to 16 +	5 and 6

Still, WARP also has some distinct limitations, some of which can be hazardous if not understood. First, unlike ASR, WARP only displays precipitation in three levels: moderate, heavy and extreme. The system cannot display light precipitation. In practice, this means that Center controllers may not be able to provide warnings about precipitation until it meets the "moderate" threshold… and moderate precipitation can be hazardous for light aircraft or unprepared pilots.

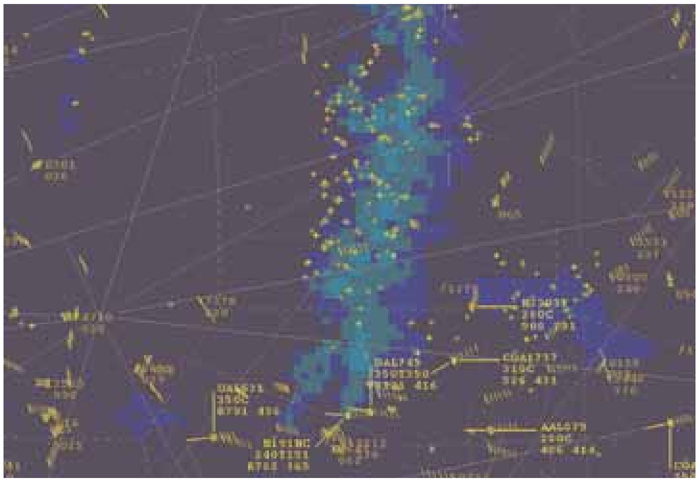
Second, because WARP collects and integrates information from one or more remote NEXRAD sites, the radar data is typically one to six minutes old when it appears on a controller's scope. That's not a problem in most cases, but when convective activity is building rapidly the time lag can render WARP information obsolete before it ever hits the screen. Pilots should keep this in mind when receiving weather updates from Center.

WARP PRECIPITATION LEVELS

Center controllers report precipitation using a three-level system:

• Moderate
• Heavy
• Extreme

Remember that WARP does not display "light" precipitation



WARP radar returns on a controller's scope
(Photo courtesy of Harris Corporation)

Use all the resources at your disposal—ATC, on-board weather detection equipment, pireps, Flight Watch, etc.—to steer clear of thunderstorms.

Finally, WARP does not provide specific information on precipitation tops. Controllers can set their scopes to display radar returns from the surface to FL 240, FL 240 to FL 330 and FL 330 to FL 600, but these unwieldy altitude blocks can make it difficult to determine the height of an area of precipitation. To do so, controllers have to look at the big picture: Are pilots deviating around an area where no precipitation is being displayed? Are they asking for altitude changes due to weather or turbulence, or relaying pilot reports that include precipitation? Absent such secondary clues, Center controllers may be unable to provide useful information on precipitation tops.

ATC Weather Advisories

Using WARP or ASR, air traffic controllers can generally provide high-quality weather radar information to pilots. To avoid misunderstandings, though, it's important for aviators to understand the circumstances under which that information will be provided, as well as the "language" that ATC speaks when doing so.

The first (and perhaps most important) thing to understand is that weather reporting is a secondary responsibility for ATC. An air traffic controller's primary duty is to separate IFR traffic—not to provide vectors around thunderstorms. Weather information is provided on a workload-permitting basis… and when the weather goes down, ATC's workload usually goes up. Pilots shouldn't be shy about asking for weather advisories, but they should also understand that a busy controller may deny the request.

On the bright side, though, nothing says that all weather information has to come directly from ATC. A pilot who pays attention to other aircraft on the frequency can often glean some helpful hints. Are nearby aircraft giving pilot reports that include precipitation or turbulence? Are they diverting around cells, or climbing to get above convective activity? Remember that an increasing number of aircraft have either on-board radar or datalink weather information, and can serve (indirectly) as "pathfinders" for the less well-equipped.

When controllers provide radar information, they report three basic pieces of data: 1) the location of radar returns; 2) the strength of those returns; and 3) the size of the precipitation area. For example, ATC might say "Moderate precipitation between twelve o'clock and three o'clock, one five miles. Weather area is two zero miles in diameter." Note that this description does not include the direction of the precipitation's movement—a potentially critical piece of information. Feel free to query ATC for additional information, but remember that it's still your responsibility to ask for a deviation: Don't assume that the controller will automatically provide one.

This raises an important point. Regardless of the weather situation, or the controller's workload, the pilot always retains pilot-in-command (PIC) authority. Although the typical nature of pilot/controller interactions can make it easy to view ATC as the "boss," the fact remains that the pilot—not the controller—has the final say. If you need something, ask for it. And if an ATC clearance (or denial of a request) would put the aircraft in danger, speak up. There's nothing wrong with saying "unable."

Bad Assumptions

As mentioned earlier, thunderstorm encounters are responsible for a large percentage of all fatal weather-related accidents, even though many such accidents are easily preventable. The underlying cause is often a simple misunderstanding, stemming from an unfounded assumption.

Such assumptions are common on both sides of the fence. Pilots, for example, often assume that an ATC clearance to "deviate as necessary" means that the

AVOID CONFUSION

To help avoid thunderstorms, and miscommunications with ATC:

- Ask for deviations early. This will help keep options open as weather develops.
- If you don't have on-board weather detection equipment, let ATC know.
- Confirm the services you're receiving from each controller.
- If you're unsure about any ATC communication, clarify the meaning with the controller.

Don't assume that ATC always knows about the weather at your location.

weather ahead isn't very bad. In truth, such a clearance implies nothing about weather conditions: It simply means that ATC expects the pilot to exercise his or her own judgment in avoiding hazardous weather. Similarly, many pilots interpret a clearance to "proceed on course when able" as an assurance that the weather ahead poses no threat. But again, in such cases ATC is relying on the pilot to determine when it's safe to continue.

Controllers, on the other hand, sometimes assume that a pilot will be able to avoid bad weather visually, when in fact he's operating in IMC and can't see anything beyond the aircraft's windshield (remember that radar can't "see" clouds). Likewise, ATC has been known to mistakenly assume that general aviation aircraft have on-board weather detection equipment.

For both parties, the key to avoiding such dangerous situations is good communication. Pilots should always be on guard for unfounded ATC assumptions about flight conditions or aircraft capabilities. If there's any doubt, ask—or simply tell ATC what they need to know (i.e., "Center, Cherokee 21K, be advised we're IMC").

Other Resources

One of the great strengths of our air traffic system is the fact that it provides pilots with multiple sources of information. ATC may be too busy to provide weather advisories during a stormy day in the Northeast corridor, but that doesn't mean that pilots have to press on "in the dark."

Automated Flight Service Stations (AFSSs) are some of the best resources for in-flight weather updates. Although an AFSS can't provide the kind of turn-by-turn tactical weather information you might receive from Approach Control or Center, it can probably give you

Issue	Suggested Language	Points to Remember
I want to confirm weather avoidance services with a new controller.	Cherokee 8121K, 5,000 feet, heading 180 assigned. Confirm we're still getting vectors around the precip?	You should confirm weather avoidance services with every new controller.
I can't accept ATC's instructions.	21K, unable. Can we turn 15 degrees to the right instead?	As the PIC, if you're uncomfortable with an instruction or clearance from ATC, let the controller know.
ATC did not tell me the intensity of precipitation along my route of flight.	Center, 21K. What intensity precipitation are you showing along my route?	When describing precipitation, ATC should include its intensity: There's a big difference between "light" and "extreme." If ATC omits the intensity, query them.
I need a deviation for weather.	Approach, 21K. I need to turn 10 degrees left to avoid the weather.	If you need a deviation for weather, ask ATC as soon as practical. Waiting until the last minute gives both you and the controller fewer options.

an excellent “big picture” report. Likewise, Enroute Flight Advisory Service (EFAS)—commonly known as Flight Watch—is dedicated to providing in-flight weather information. Simply ask ATC for a momentary frequency change and call Flight Watch on 122.0.

Of course, no AIRMET, METAR or TAF can substitute for a report from a pilot who’s already been where you’re headed. Pilot reports are *the* way to find out what other aviators have observed. AFSS, Flight Watch and (in some cases) ATC can provide them. Keep in mind, though, that not all pilot reports have to be official. It can be just as useful to speak directly to other pilots—either on the ground or in the air—about the weather conditions they’ve encountered. Whatever the source, though, pay close attention to the time a weather report was issued. Around thunderstorms, a flyable route can become impassable in just a few minutes.

Finally, as mentioned earlier, weather detection equipment is finding its way into an increasing number of aircraft. If radar coverage is limited at your location, consider asking ATC to check with an airliner, or corporate jet, to find out what their onboard radar is showing. If you make frequent flights around weather, it may be wise to consider purchasing a datalink system. Satellite technology can beam weather graphics and data right into the cockpit, at prices increasingly affordable for most general aviation pilots.

Conclusion

ATC weather radar can be an invaluable resource for pilots seeking to avoid dangerous convective activity. As with so much else in flying, though, radar advisories are only as useful as a pilot’s understanding of them—and that understanding hinges on a basic knowledge of the systems being used. Some points to remember:

OTHER RESOURCES

If ATC can’t provide the information you need, consult alternate sources:

- Other aircraft on the frequency
- Automated Flight Service Stations
- Flight Watch (EFAS)
- Datalink equipment (if installed)
- Pilot reports

- Thunderstorms are extremely dangerous: They can literally tear an airplane to pieces.
- If thunderstorms are wide spread, avoid the entire area. Don’t try to pick your way through.
- Approach controllers use ASR, which is a near real-time radar display.
- Center controllers use WARP, which has a time lag and does not display light precipitation.
- Weather advisories are not ATC’s number one priority. Verify the services you’re receiving, and use other resources if necessary.
- You’re the PIC: Ask for what you need, and don’t be afraid to negotiate with ATC.

Pilots who treat thunderstorms with respect, and use all the resources at their disposal to avoid them, are much less likely to end up casualties of convective activity.

For more information, check out our online course Weather Wise: Thunderstorms and ATC. www.asf.org/wxwise_thunder

“Hmmm. . . increased dihedral, a hail modification and a fuselage twist. You should have taken the AOPA Air Safety Foundation’s online course, Weather Wise: Thunderstorms and ATC, rather than doing all that research yourself! www.asf.org (courtesy of Gary Steiner)

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