
Chapter 9

# The Air Traffic Control System

## Introduction

This chapter covers the communication equipment, communication procedures, and air traffic control (ATC) facilities and services available for a flight under instrument flight rules (IFR) in the National Airspace System (NAS).

## Communication Equipment

### Navigation/Communication (NAV/COM) Equipment

Civilian pilots communicate with ATC on frequencies in the very high frequency (VHF) range between 118.000 and 136.975 MHz. To derive full benefit from the ATC system, radios capable of 25 kHz spacing are required (e.g., 134.500, 134.575, 134.600). If ATC assigns a frequency that cannot be selected, ask for an alternative frequency.

*Figure 9-1* illustrates a typical radio panel installation, consisting of a communications transceiver on the left and a navigational receiver on the right. Many radios allow the pilot to have one or more frequencies stored in memory and one frequency active for transmitting and receiving (called simplex operation). It is possible to communicate with some automated flight service stations (AFSS) by transmitting on 122.1 MHz (selected on the communication radio) and receiving on a VHF omnidirectional range (VOR) frequency (selected on the navigation radio). This is called duplex operation.

An audio panel allows a pilot to adjust the volume of the selected receiver(s) and to select the desired transmitter. *[Figure 9-2]* The audio panel has two positions for receiver selection, cabin speaker, and headphone (some units might have a center "off" position). Use of a hand-held microphone and the cabin speaker introduces the distraction of reaching for and hanging up the microphone. A headset with a boom microphone is recommended for clear communications. The microphone should be positioned close to the lips to reduce


**Figure 9-1.** *Typical NAV/COM Installation.*


**Figure 9-2.** *Audio Panel.*

**Figure 9-3.** *Boom Microphone, Headset, and Push-To-Talk Switch.*

the possibility of ambient flight deck noise interfering with transmissions to the controller. Headphones deliver the received signal directly to the ears; therefore, ambient noise does not interfere with the pilot's ability to understand the transmission. *[Figure 9-3]*

Switching the transmitter selector between COM1 and COM2 changes both transmitter and receiver frequencies. It is necessary only when a pilot wants to monitor one frequency while transmitting on another. One example is listening to automatic terminal information service (ATIS) on one receiver while communicating with ATC on the other. Monitoring a navigation receiver to check for proper identification is another reason to use the switch panel.

Most audio switch panels also include a marker beacon receiver. All marker beacons transmit on 75 MHz, so there is no frequency selector.

*Figure 9-4* illustrates an increasingly popular form of NAV/COM radio; it contains a global positioning system (GPS) receiver and a communications transceiver. Using its navigational capability, this unit can determine when a flight crosses an airspace boundary or fix and can automatically select the appropriate communications frequency for that location in the communications radio.


**Figure 9-4.** *Combination GPS-Com Unit.*

### Radar and Transponders

ATC radars have a limited ability to display primary returns, which is energy reflected from an aircraft's metallic structure. Their ability to display secondary returns (transponder replies to ground interrogation signals) makes possible the many advantages of automation.

A transponder is a radar beacon transmitter/receiver installed in the instrument panel. ATC beacon transmitters send out interrogation signals continuously as the radar antenna rotates. When an interrogation is received by a transponder, a coded reply is sent to the ground station where it is displayed on the controller's scope. A reply light on the transponder panel flickers every time it receives and replies to a radar interrogation. Transponder codes are assigned by ATC.

When a controller asks a pilot to "ident" and the ident button is pushed, the return on the controller's scope is intensified for precise identification of a flight. When requested, briefly push the ident button to activate this feature. It is good practice for pilots to verbally confirm that they have changed codes or pushed the ident button.

#### *Mode C (Altitude Reporting)*

Primary radar returns indicate only range and bearing from the radar antenna to the target; secondary radar returns can display altitude, Mode C, on the control scope if the aircraft is equipped with an encoding altimeter or blind encoder. In either case, when the transponder's function switch is in the ALT position the aircraft's pressure altitude is sent to the controller. Adjusting the altimeter's Kollsman window has no effect on the altitude read by the controller.

Transponders, when installed, must be ON at all times when operating in controlled airspace; altitude reporting is required by regulation in Class B and Class C airspace and inside a 30-mile circle surrounding the primary airport in Class B airspace. Altitude reporting should also be ON at all times.

## Communication Procedures

Clarity in communication is essential for a safe instrument flight. This requires pilots and controllers to use terms that are understood by both—the Pilot/Controller Glossary in the Aeronautical Information Manual (AIM) is the best source of terms and definitions. The AIM is revised twice a year and new definitions are added, so the glossary should be reviewed frequently. Because clearances and instructions are comprised largely of letters and numbers, a phonetic pronunciation guide has been developed for both. *[Figure 9-5]*

ATCs must follow the guidance of the Air Traffic Control Manual when communicating with pilots. The manual presents the controller with different situations and prescribes precise terminology that must be used. This is advantageous for pilots because once they have recognized a pattern or format they can expect future controller transmissions to follow that format. Controllers are faced with a wide variety of communication styles based on pilot experience, proficiency, and professionalism.

Pilots should study the examples in the AIM, listen to other pilots communicate, and apply the lessons learned to their own communications with ATC. Pilots should ask for clarification of a clearance or instruction. If necessary, use plain English to ensure understanding, and expect the controller to reply in the same way. A safe instrument flight is the result of cooperation between controller and pilot.

## Communication Facilities

The controller's primary responsibility is separation of aircraft operating under IFR. This is accomplished with ATC facilities which include the AFSS, airport traffic control tower (ATCT), terminal radar approach control (TRACON), and air route traffic control center (ARTCC).

### Automated Flight Service Stations (AFSS)

A pilot's first contact with ATC is usually through AFSS, either by radio or telephone. AFSSs provide pilot briefings, receive and process flight plans, relay ATC clearances, originate Notices to Airmen (NOTAMs), and broadcast aviation weather. Some facilities provide En Route Flight Advisory Service (EFAS), take weather observations, and advise United States Customs and Immigration of international flights.

Telephone contact with Flight Service can be obtained by dialing 1-800-WX-BRIEF. This number can be used anywhere in the United States and connects to the nearest AFSS based on the area code from which the call originates. There are a variety of methods of making radio contact: direct transmission, remote communication outlets (RCOs), ground communication outlets (GCOs), and by using duplex transmissions through navigational aids (NAVAIDs). The best source of information on frequency usage is the Airport/Facility Directory (A/FD) and the legend panel on sectional charts also contains contact information.

| Character | Morse Code | Telephony | Phonic (Pronunciation) |
|---|---|---|---|
| A | •— | Alfa | (AL-FAH) |
| B | —••• | Bravo | (BRAH-VOH) |
| C | —•—• | Charlie | (CHAR-LEE) or (SHAR-LEE) |
| D | —•• | Delta | (DELL-TAH) |
| E | • | Echo | (ECK-OH) |
| F | ••—• | Foxtrot | (FOKS-TROT) |
| G | ——• | Golf | (GOLF) |
| H | •••• | Hotel | (HOH-TEL) |
| I | •• | India | (IN-DEE-AH) |
| J | •——— | Juliett | (JEW-LEE-ETT) |
| K | —•— | Kilo | (KEY-LOH) |
| L | •—•• | Lima | (LEE-MAH) |
| M | —— | Mike | (MIKE) |
| N | —• | November | (NO-VEM-BER) |
| O | ——— | Oscar | (OSS-CAH) |
| P | •——• | Papa | (PAH-PAH) |
| Q | ——•— | Quebec | (KEH-BECK) |
| R | •—• | Romeo | (ROW-ME-OH) |
| S | ••• | Sierra | (SEE-AIR-RAH) |
| T | — | Tango | (TANG-GO) |
| U | ••— | Uniform | (YOU-NEE-FORM) or (OO-NEE-FORM) |
| V | •••— | Victor | (VIK-TAH) |
| W | •—— | Whiskey | (WISS-KEY) |
| X | —••— | Xray | (ECKS-RAY) |
| Y | —•—— | Yankee | (YANG-KEY) |
| Z | ——•• | Zulu | (ZOO-LOO) |
| 1 | •———— | One | (WUN) |
| 2 | ••——— | Two | (TOO) |
| 3 | •••—— | Three | (TREE) |
| 4 | ••••— | Four | (FOW-ER) |
| 5 | ••••• | Five | (FIFE) |
| 6 | —•••• | Six | (SIX) |
| 7 | ——••• | Seven | (SEV-EN) |
| 8 | ———•• | Eight | (AIT) |
| 9 | ————• | Nine | (NI-NER) |
| 0 | ————— | Zero | (ZEE-RO) |

**Figure 9-5.** *Phonetic Pronunciation Guide.*

The briefer sends a flight plan to the host computer at the ARTCC (Center). After processing the flight plan, the computer will send flight strips to the tower, to the radar facility that will handle the departure route, and to the Center controller whose sector the flight first enters. *Figure 9-6* shows a typical strip. These strips are delivered approximately 30 minutes prior to the proposed departure time. Strips are delivered to en route facilities 30 minutes before the flight is expected to enter their airspace. If a flight plan is not opened, it will "time out" 2 hours after the proposed departure time.

When departing an airport in Class G airspace, a pilot receives an IFR clearance from the AFSS by radio or telephone. It contains either a clearance void time, in which case an aircraft must be airborne prior to that time, or a release time. Pilots should not take-off prior to the release time. Pilots can help the controller by stating how soon they expect to be airborne. If the void time is, for example, 10 minutes past the hour and an aircraft is airborne at exactly 10 minutes past the hour, the clearance is void—a pilot must take off prior to the void time. A specific void time may be requested when filing a flight plan.

## ATC Towers

Several controllers in the tower cab are involved in handling an instrument flight. Where there is a dedicated clearance delivery position, that frequency is found in the A/FD and on the instrument approach chart for the departure airport. Where there is no clearance delivery position, the ground controller performs this function. At the busiest airports, pre-taxi clearance is required; the frequency for pre-taxi clearance can be found in the A/FD. Taxi clearance should be requested not more than 10 minutes before proposed taxi time.

It is recommended that pilots read their IFR clearance back to the clearance delivery controller. Instrument clearances can be overwhelming when attempting to copy them verbatim, but they follow a format that allows a pilot to be prepared when responding "Ready to copy." The format is: clearance limit (usually the destination airport); route, including any departure procedure; initial altitude; frequency (for departure control); and transponder code. With the exception of the transponder code, a pilot knows most of these items before engine start. One technique for clearance copying is writing C-R-A-F-T.

Assume an IFR flight plan has been filed from Seattle, Washington to Sacramento, California via V-23 at 7,000 feet. Traffic is taking off to the north from Seattle-Tacoma (Sea-Tac) airport and, by monitoring the clearance delivery frequency, a pilot can determine the departure procedure being assigned to southbound flights. The clearance limit is the destination airport, so write "SAC" after the letter C. Write "SEATTLE TWO – V23" after R for Route, because departure control issued this departure to other flights. Write "7" after the A, the departure control frequency printed on the approach charts for Sea-Tac after F, and leave the space after the letter T blank—the transponder code is generated by computer and can seldom be determined in advance. Then, call clearance delivery and report "Ready to copy."

As the controller reads the clearance, check it against what is already written down; if there is a change, draw a line through that item and write in the changed item. Chances are the changes are minimal, and most of the clearance is copied before keying the microphone. Still, it is worthwhile to develop clearance shorthand to decrease the verbiage that must be copied (see Appendix 1).

Pilots are required to have either the text of a departure procedure (DP) or a graphic representation (if one is available), and should review it before accepting a clearance. This is another reason to find out ahead of time which DP is in use. If the DP includes an altitude or a departure control frequency, those items are not included in the clearance.

The last clearance received supersedes all previous clearances. For example, if the DP says "Climb and maintain 2,000 feet, expect higher in 6 miles," but upon contacting the departure controller a new clearance is received: "Climb and maintain 8,000 feet," the 2,000 feet restriction has been canceled. This rule applies in both terminal and Center airspace.

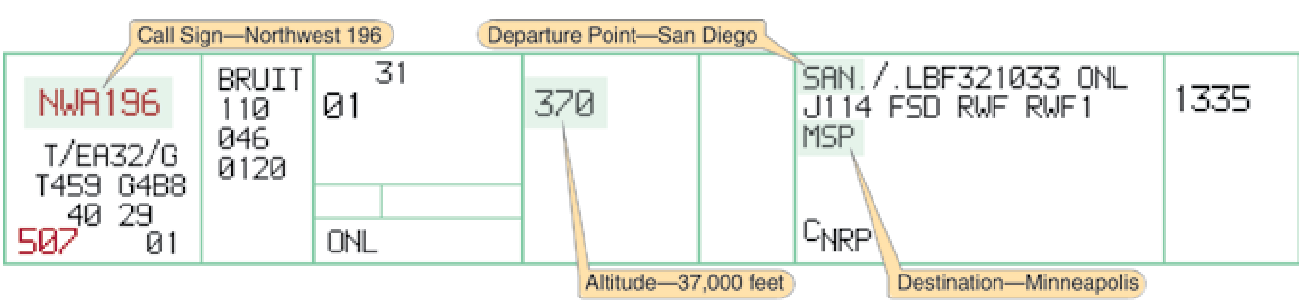



**Figure 9-6.** *Flight Strip.*

When reporting ready to copy an IFR clearance before the strip has been received from the Center computer, pilots are advised "clearance on request." The controller initiates contact when it has been received. This time can be used for taxi and pre-takeoff checks.

The local controller is responsible for operations in the Class D airspace and on the active runways. At some towers, designated as IFR towers, the local controller has vectoring authority. At visual flight rules (VFR) towers, the local controller accepts inbound IFR flights from the terminal radar facility and cannot provide vectors. The local controller also coordinates flights in the local area with radar controllers. Although Class D airspace normally extends 2,500 feet above field elevation, towers frequently release the top 500 feet to the radar controllers to facilitate overflights. Accordingly, when a flight is vectored over an airport at an altitude that appears to enter the tower controller's airspace, there is no need to contact the tower controller—all coordination is handled by ATC.

The departure radar controller may be in the same building as the control tower, but it is more likely that the departure radar position is remotely located. The tower controller will not issue a takeoff clearance until the departure controller issues a release.

### Terminal Radar Approach Control (TRACON)

TRACONs are considered terminal facilities because they provide the link between the departure airport and the en route structure of the NAS. Terminal airspace normally extends 30 nautical miles (NM) from the facility, with a vertical extent of 10,000 feet; however, dimensions vary widely. Class B and Class C airspace dimensions are provided on aeronautical charts. At terminal radar facilities the airspace is divided into sectors, each with one or more controllers, and each sector is assigned a discrete radio frequency. All terminal facilities are approach controls and should be addressed as "Approach" except when directed to do otherwise (e.g., "Contact departure on 120.4").

Terminal radar antennas are located on or adjacent to the airport. *Figure 9-7* shows a typical configuration. Terminal controllers can assign altitudes lower than published procedural altitudes called minimum vectoring altitudes (MVAs). These altitudes are not published or accessible to pilots, but are displayed at the controller's position, as shown in *Figure 9-8*. However, when pilots are assigned an altitude that seems to be too low, they should query the controller before descending.

When a pilot accepts a clearance and reports ready for takeoff, a controller in the tower contacts the TRACON for a release. An aircraft is not cleared for takeoff until the departure controller can fit the flight into the departure flow. A pilot may have to hold for release. When takeoff clearance is received, the departure controller is aware of the flight and is waiting for a call. All of the information the controller needs is on the departure strip or the computer screen there is no need to repeat any portion of the clearance to that controller. Simply establish contact with the facility when instructed to do so by the tower controller. The terminal facility computer picks up the transponder and initiates tracking as soon as it detects the

**Figure 9-7.** *Combined Radar and Beacon Antenna.*

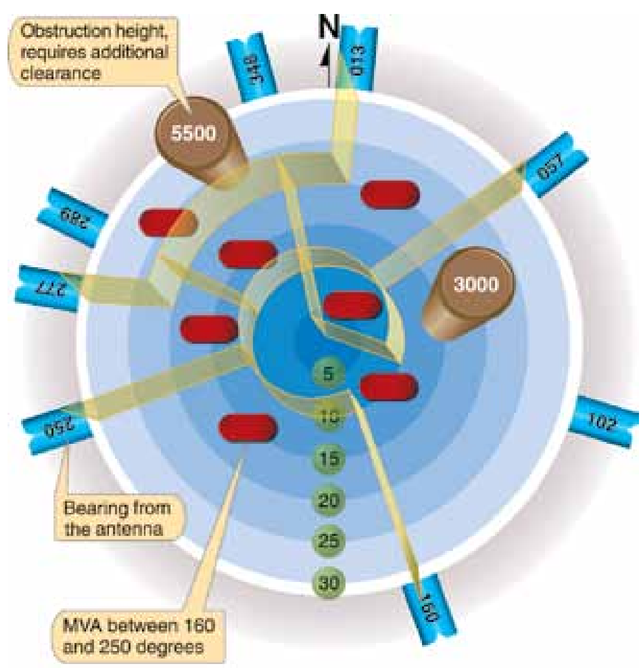



**Figure 9-8.** *Minimum Vectoring Altitude Chart.*

assigned code. For this reason, the transponder should remain on standby until takeoff clearance has been received.

The aircraft appears on the controller's radar display as a target with an associated data block that moves as the aircraft moves through the airspace. The data block includes aircraft identification, aircraft type, altitude, and airspeed.

A TRACON controller uses Airport Surveillance Radar (ASR) to detect primary targets and Automated Radar Terminal Systems (ARTS) to receive transponder signals; the two are combined on the controller's scope. *[Figure 9-9]*

At facilities with ASR-3 equipment, radar returns from precipitation are not displayed as varying levels of intensity, and controllers must rely on pilot reports and experience to provide weather avoidance information. With ASR-9 equipment, the controller can select up to six levels of intensity. Light precipitation does not require avoidance tactics but precipitation levels of moderate, heavy or extreme should cause pilots to plan accordingly. Along with precipitation the pilot must additionally consider the temperature, which if between -20° and +5° C will cause icing even during light precipitation. The returns from higher levels of intensity may obscure aircraft data blocks, and controllers may select the higher levels only on pilot request. When uncertainty exists about the weather ahead, ask the controller if the facility can display intensity levels—pilots of small aircraft should avoid intensity levels 3 or higher.

### Tower En Route Control (TEC)

At many locations, instrument flights can be conducted entirely in terminal airspace. These TEC routes are generally for aircraft operating below 10,000 feet, and they can be found in the A/FD. Pilots desiring to use TEC should include that designation in the remarks section of the flight plan.

Pilots are not limited to the major airports at the city pairs listed in the A/FD. For example, a tower en route flight from an airport in New York (NYC) airspace could terminate at any airport within approximately 30 miles of Bradley International (BDL) airspace, such as Hartford (HFD). *[Figure 9-10]*

A valuable service provided by the automated radar equipment at terminal radar facilities is the Minimum Safe Altitude Warnings (MSAW). This equipment predicts an aircraft's position in 2 minutes based on present path of flight—the controller issues a safety alert if the projected path encounters terrain or an obstruction. An unusually rapid descent rate on a nonprecision approach can trigger such an alert.

### Air Route Traffic Control Center (ARTCC)

ARTCC facilities are responsible for maintaining separation between IFR flights in the en route structure. Center radars (Air Route Surveillance Radar (ARSR)) acquire and track transponder returns using the same basic technology as terminal radars. *[Figure 9-11]*

Earlier Center radars display weather as an area of slashes (light precipitation) and Hs (moderate rainfall), as illustrated in *Figure 9-12*. Because the controller cannot detect higher levels of precipitation, pilots should be wary of areas showing moderate rainfall. Newer radar displays show weather as three levels of blue. Controllers can select the level of weather to be displayed. Weather displays of higher levels of intensity can make it difficult for controllers to see aircraft data blocks, so pilots should not expect ATC to keep weather displayed continuously.

Center airspace is divided into sectors in the same manner as terminal airspace; additionally, most Center airspace is divided by altitudes into high and low sectors. Each sector has a dedicated team of controllers and a selection of radio frequencies, because each Center has a network of remote transmitter/receiver sites. All Center frequencies can be found in the back of the A/FD in the format shown in *Figure 9-13;* they are also found on en route charts.

Each ARTCC's area of responsibility covers several states; when flying from the vicinity of one remote communication site toward another, expect to hear the same controller on different frequencies.

### Center Approach/Departure Control

The majority of airports with instrument approaches do not lie within terminal radar airspace, and when operating to or from these airports pilots communicate directly with the Center controller. Departing from a tower-controlled airport, the tower controller provides instructions for contacting the appropriate Center controller. When departing an airport without an operating control tower, the clearance includes instructions such as "Upon entering controlled airspace, contact Houston Center on 126.5." Pilots are responsible for terrain clearance until reaching the controller's MVA. Simply hearing "Radar contact" does not relieve a pilot of this responsibility.

If obstacles in the departure path require a steeper-than-standard climb gradient (200 FPNM), then the controller advises the pilot. However, it is the pilot's responsibility to check the departure airport listing in the A/FD to determine if there are trees or wires in the departure path. When in doubt, ask the controller for the required climb gradient.

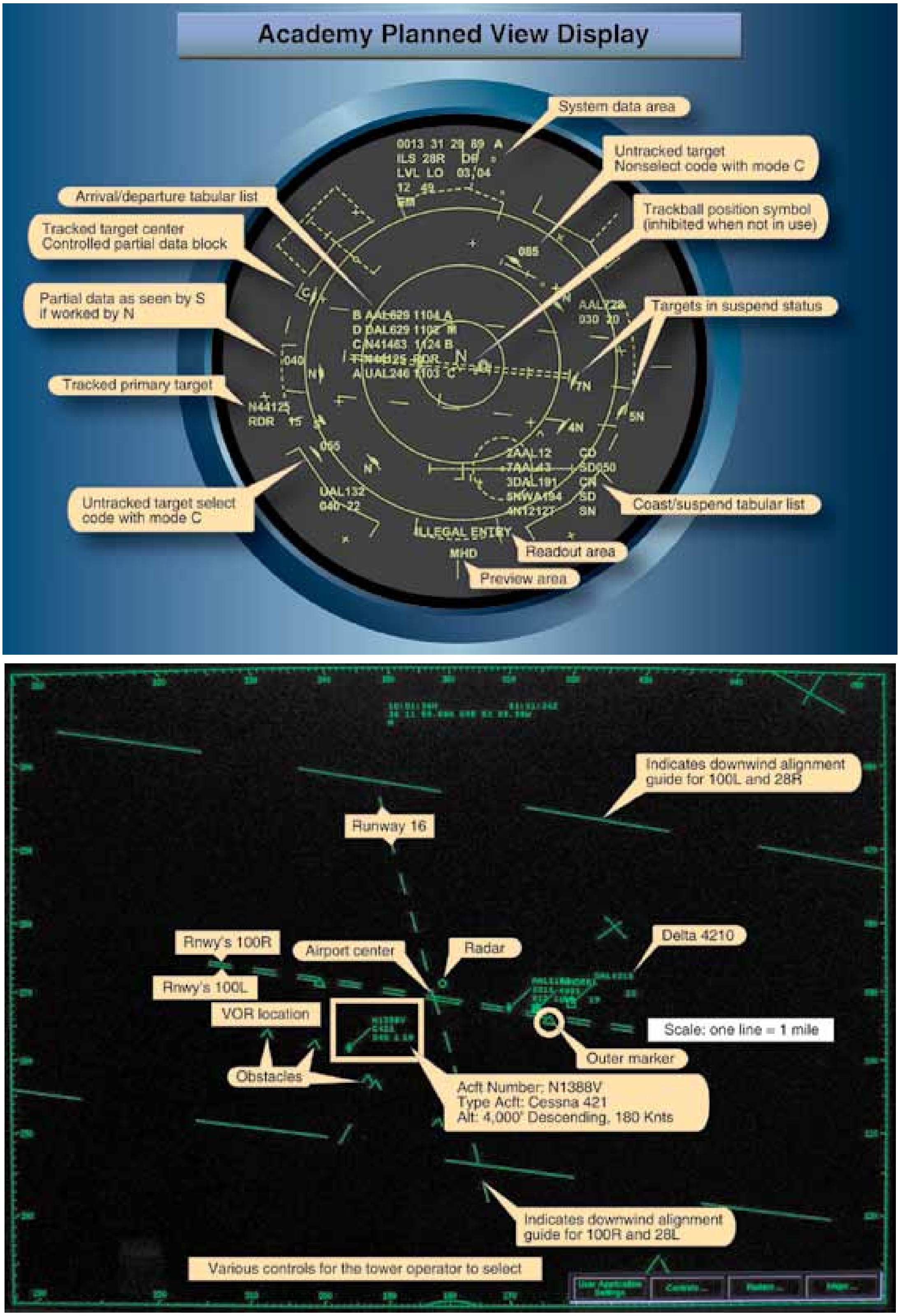
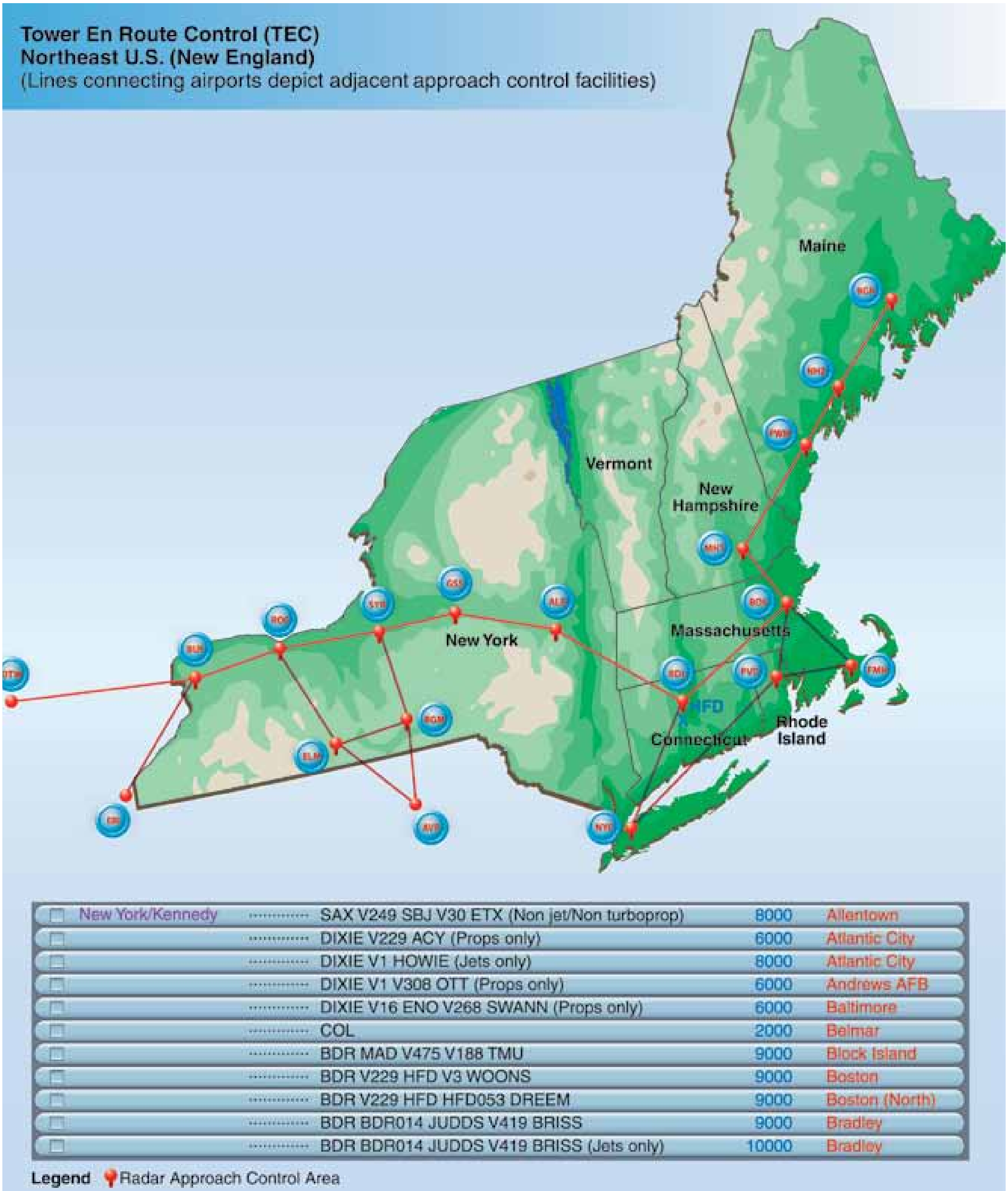



**Figure 9-9.** *The top image is a display as seen by controllers in an Air Traffic Facility. The one illustrated is an ARTS III (Automated Radar Terminal System). The display shown provides an explanation of the symbols in the graphic. The lower figure is an example of the Digital Bright Radar Indicator Tower Equipment (DBRITE) screen as seen by tower personnel. It provides tower controllers with a visual display of the airport surveillance radar, beacon signals, and data received from ARTS III. The display shown provides an explanation of the symbols in the graphic.*




| | | | |
|---|---|---|---|
| New York/Kennedy | SAX V249 SBJ V30 ETX (Non jet/Non turboprop) | 8000 | Allentown |
| | DIXIE V229 ACY (Props only) | 6000 | Atlantic City |
| | DIXIE V1 HOWIE (Jets only) | 8000 | Atlantic City |
| | DIXIE V1 V308 OTT (Props only) | 6000 | Andrews AFB |
| | DIXIE V16 ENO V268 SWANN (Props only) | 6000 | Baltimore |
| | COL | 2000 | Belmar |
| | BDR MAD V475 V188 TMU | 9000 | Block Island |
| | BDR V229 HFD V3 WOONS | 9000 | Boston |
| | BDR V229 HFD HFD053 DREEM | 9000 | Boston (North) |
| | BDR BDR014 JUDDS V419 BRISS | 9000 | Bradley |
| | BDR BDR014 JUDDS V419 BRISS (Jets only) | 10000 | Bradley |

**Figure 9-10.** *A Portion of the New York Area Tower En Route List. (From the A/FD)*

Figure 9-11. *Center Radar Displays.*

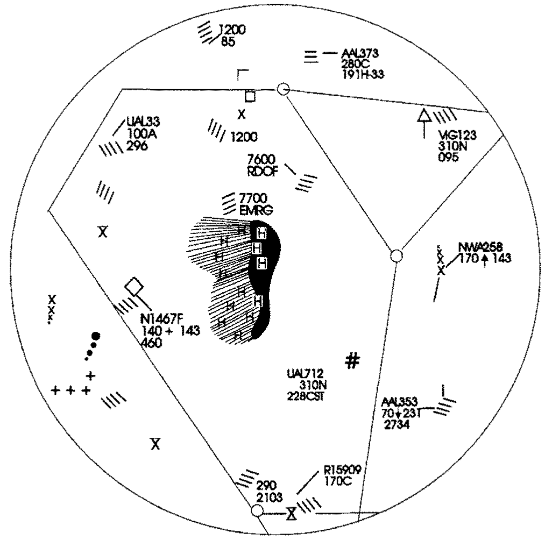



Figure 9-12. *A Center Controller's Scope.*

A common clearance in these situations is "When able, proceed direct to the Astoria VOR…" The words "when able" mean to proceed to the waypoint, intersection, or NAVAID when the pilot is able to navigate directly to that point using onboard available systems providing proper guidance, usable signal, etc. If provided such guidance while flying VFR, the pilot remains responsible for terrain and obstacle clearance. Using the standard climb gradient, an aircraft is 2 miles from the departure end of the runway before it is safe to turn (400 feet above ground level (AGL)). When a Center controller issues a heading, a direct route, or says "direct when able," the controller becomes responsible for terrain and obstruction clearance.

Another common Center clearance is "Leaving (altitude) fly (heading) or proceed direct when able." This keeps the terrain/obstruction clearance responsibility in the flight deck until above the minimum IFR altitude. A controller cannot issue an IFR clearance until an aircraft is above the minimum IFR altitude unless it is able to climb in VFR conditions.

On a Center controller's scope, 1 NM is about 1/28 of an inch. When a Center controller is providing Approach/Departure control services at an airport many miles from the radar antenna, estimating headings and distances is very difficult. Controllers providing vectors to final must set the range on their scopes to not more than 125 NM to provide the greatest possible accuracy for intercept headings. Accordingly, at locations more distant from a Center radar antenna, pilots should expect a minimum of vectoring.

| ®FORT WORTH CENTER | | | | |
|---|---|---|---|---|
| H–2–3–4, L–4–6–13–14–15–17 (KZFW) | | | | 134.4 |
| Abilene | –134.25 | 127.45 | | |
| Ardmore | –132.975 | 128.1 | | |
| Big Spring | –133.7 | | | |
| Blue Ridge | –127.6 | 124.87 | | |
| Brownwood | –127.45 | | | |
| Clinton-Sherman | –132.45 | 128.4 | 126.3 | |
| Cumby | –132.85 | 132.02 | 126.57 | |
| Dublin | –135.375 | 128.32 | 127.15 | |
| El Dorado | –133.875 | 128.2 | | |
| Frankston | –135.25 | 134.025 | | |
| Gainsville | –134.15 | 126.77 | | |
| Hobbs | –133.1 | | | |
| Keller | –135.275 | 134.15 | 133.25 | |
| Lubbock | –133.35 | 127.7 | 126.45 | |
| Marshall | –135.1 | 128.125 | | |
| McAlester | –135.45 | 132.2 | | |
| Midland (Site A) | –133.1 | 132.075 | | |
| Mineral Wells | –135.6 | 127.0 | | |
| Monroe | –135.1 | | | |
| Oklahoma City | –133.9 | 132.45 | | |
| Paducah | –134.55 | 133.5 | 133.35 | 126.45 |
| Paris | –127.6 | | | |
| Plainview | –126.45 | | | |
| San Angelo | –132.075 | 126.15 | | |
| Scurry | –135.75 | 126.725 | | |
| Shreveport | –135.1 | 132.275 | | |
| Texarkana | –134.475 | 133.95 | 126.57 | |
| Tyler | –135.25 | 134.025 | | |
| Waco | –133.3 | | | |
| Wichita Falls | –(Site Nr1) | - 134.55 | 132.925 | |
| Wichita Falls | –(Site Nr2) | - 133.5 | 127.95 | |

Figure 9-13. *Center Symbology.*

## ATC Inflight Weather Avoidance Assistance

### ATC Radar Weather Displays

ATC radar systems are able to display areas of precipitation by sending out a beam of radio energy that is reflected back to the radar antenna when it strikes an object or moisture which may be in the form of rain drops, hail, or snow. The larger the object, or the denser its reflective surface, the stronger the return will be. Radar weather processors indicate the intensity of reflective returns in terms of decibels with respect to the radar reflectively factor (dBZ).

ATC systems cannot detect the presence or absence of clouds. ATC radar systems can often determine the intensity of a precipitation area, but the specific character of that area (snow, rain, hail, VIRGA, etc.) cannot be determined. For this reason, ATC refers to all weather areas displayed on ATC radar scopes as "precipitation."

All ATC facilities using radar weather processors with the ability to determine precipitation intensity describes the intensity to pilots as:

1. "LIGHT" (< 30 dBZ)
2. "MODERATE" (30 to 40 dBZ)
3. "HEAVY" (>40 to 50 dBZ)
4. "EXTREME" (>50 dBZ)

ARTCC controllers do not use the term "LIGHT" because their systems do not display "LIGHT" precipitation intensities. ATC facilities that, due to equipment limitations, cannot display the intensity levels of precipitation, will describe the location of the precipitation area by geographic position, or position relative to the aircraft. Since the intensity level is not available, the controller states, "INTENSITY UNKNOWN."

ARTCC facilities normally use a Weather and Radar Processor (WARP) to display a mosaic of data obtained from multiple NEXRAD sites. The WARP processor is only used in ARTCC facilities.

There is a time delay between actual conditions and those displayed to the controller. For example, the precipitation data on the ARTCC controller's display could be up to 6 minutes old. When the WARP is not available, a secondary system, the narrowband ARSR is utilized. The ARSR system can display two distinct levels of precipitation intensity that is described to pilots as "MODERATE" (30 to 40 dBZ) and "HEAVY to EXTREME" (>40 dBZ).

ATC radar systems cannot detect turbulence. Generally, turbulence can be expected to occur as the rate of rainfall or intensity of precipitation increases. Turbulence associated with greater rates of rainfall/precipitation is normally more severe than any associated with lesser rates of rainfall/precipitation. Turbulence should be expected to occur near convective activity, even in clear air. Thunderstorms are a form of convective activity that implies severe or greater turbulence. Operation within 20 miles of thunderstorms should be approached with great caution, as the severity of turbulence can be markedly greater than the precipitation intensity might indicate.

### Weather Avoidance Assistance

ATC's first duty priority is to separate aircraft and issue safety alerts. ATC provides additional services to the extent possible, contingent upon higher priority duties and other factors including limitations of radar, volume of traffic, frequency congestion, and workload. Subject to the above factors/limitations, controllers issue pertinent information on weather or chaff areas; and if requested, assist pilots, to the extent possible, in avoiding areas of precipitation. Pilots should respond to a weather advisory by acknowledging the advisory and, if desired, requesting an alternate course of action, such as:

1. Request to deviate off course by stating the direction and number of degrees or miles needed to deviate from the original course;
2. Request a change of altitude; or
3. Request routing assistance to avoid the affected area. Because ATC radar systems cannot detect the presence or absence of clouds and turbulence, such assistance conveys no guarantee that the pilot will not encounter hazards associated with convective activity. Pilots wishing to circumnavigate precipitation areas by a specific distance should make their desires clearly known to ATC at the time of the request for services. Pilots must advise ATC when they can resume normal navigation.

IFR pilots shall not deviate from their assigned course or altitude without an ATC clearance. Plan ahead for possible course deviations because hazardous convective conditions can develop quite rapidly. This is important to consider because the precipitation data displayed on ARTCC radar scopes can be up to 6 minutes old and thunderstorms can develop at rates exceeding 6,000 feet per minute (fpm). When encountering weather conditions that threaten the safety of the aircraft, the pilot may exercise emergency authority as stated in 14 CFR part 91, section 91.3 should an immediate deviation from the assigned clearance be necessary and time does not permit approval by ATC.

Generally, when weather disrupts the flow of air traffic, greater workload demands are placed on the controller. Requests for deviations from course and other services should be made as far in advance as possible to better assure the controller's ability to approve these requests promptly. When requesting approval to detour around weather activity, include the following information to facilitate the request:

1. The proposed point where detour commences;
2. The proposed route and extent of detour (direction and distance);
3. The point where original route will be resumed;
4. Flight conditions (IMC or VMC);
5. Whether the aircraft is equipped with functioning airborne radar; and
6. Any further deviation that may become necessary.

To a large degree, the assistance that might be rendered by ATC depends upon the weather information available to controllers. Due to the extremely transitory nature of hazardous weather, the controller's displayed precipitation information may be of limited value.

Obtaining IFR clearance or approval to circumnavigate hazardous weather can often be accommodated more readily in the en route areas away from terminals because there is usually less congestion and, therefore, greater freedom of action. In terminal areas, the problem is more acute because of traffic density, ATC coordination requirements, complex departure and arrival routes, and adjacent airports. As a consequence, controllers are less likely to be able to accommodate all requests for weather detours in a terminal area. Nevertheless, pilots should not hesitate to advise controllers of any observed hazardous weather and should specifically advise controllers if they desire circumnavigation of observed weather.

Pilot reports (PIREPs) of flight conditions help define the nature and extent of weather conditions in a particular area. These reports are disseminated by radio and electronic means to other pilots. Provide PIREP information to ATC regarding pertinent flight conditions, such as:

1. Turbulence;
2. Visibility;
3. Cloud tops and bases; and
4. The presence of hazards such as ice, hail, and lightning.

## Approach Control Facility

An approach control facility is a terminal ATC facility that provides approach control service in the terminal area. Services are provided for arriving and departing VFR and IFR aircraft and, on occasion, en route aircraft. In addition, for airports with parallel runways with ILS or LDA approaches, the approach control facility provides monitoring of the approaches.

## Approach Control Advances

### Precision Runway Monitor (PRM)

Over the past few years, a new technology has been installed at airports that permits a decreased separation distance between parallel runways. The system is called a Precision Runway Monitor (PRM) and is comprised of high-update radar, high-resolution ATC displays, and PRM-certified controllers. *[Figure 9-14]*

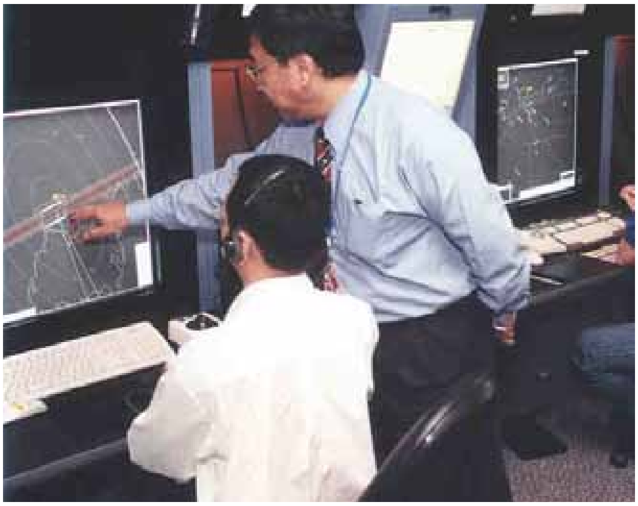


**Figure 9-14.** *High Resolution ATC Displays Used in PRM.*

#### *Precision Runway Monitor (PRM) Radar*

The PRM uses a Monopulse Secondary Surveillance Radar (MSSR) that employs electronically scanned antennas. Because the PRM has no scan rate restrictions, it is capable of providing a faster update rate (up to 0.5 second) over conventional systems, thereby providing better target presentation in terms of accuracy, resolution, and track prediction. The system is designed to search, track, process, and display SSR-equipped aircraft within airspace of over 30 miles in range and over 15,000 feet in elevation. Visual and audible alerts are generated to warn controllers to take corrective actions.

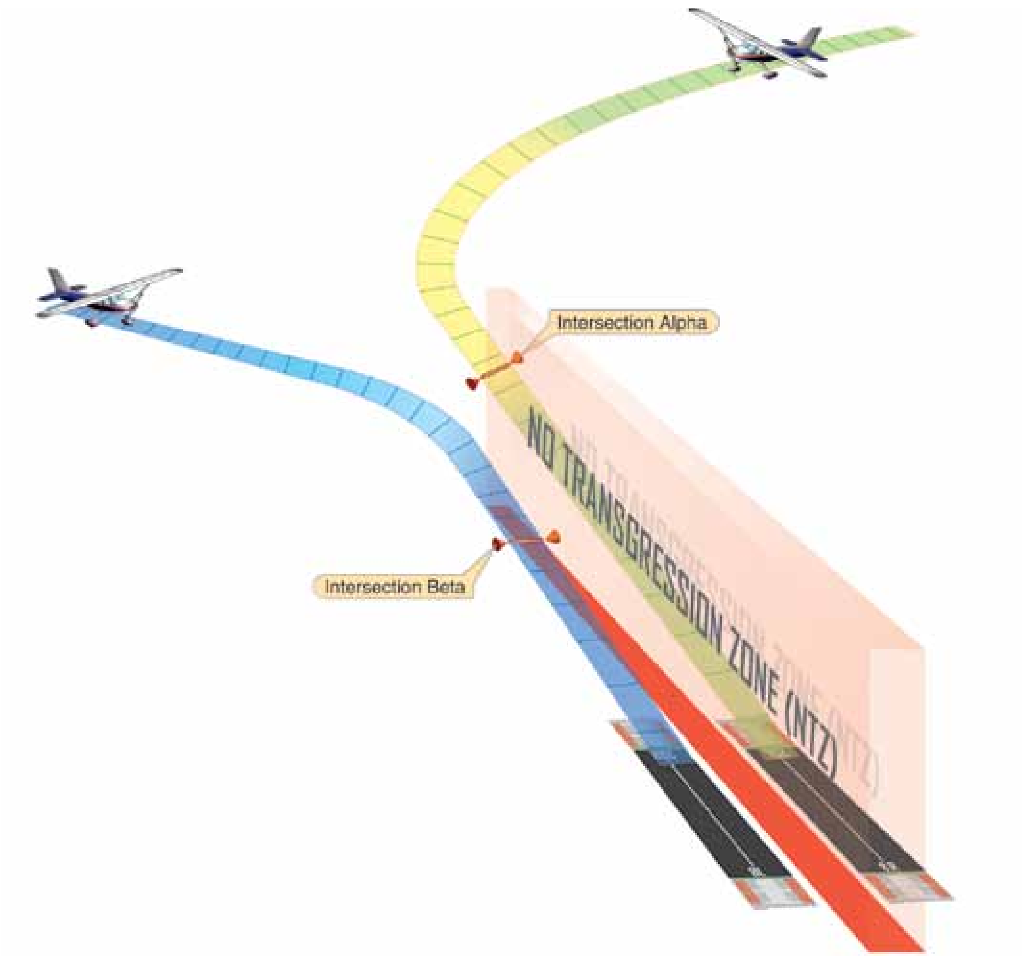



**Figure 9-15.** *Aircraft Management Using PRM. (Note the no transgression zone (NTZ) and how the aircraft are separated.)*

### *PRM Benefits*

Typically, PRM is used with dual approaches with centerlines separated less than 4,300 feet but not less than 3,000 feet (under most conditions). *[Figure 9-15]* Separating the two final approach courses is a No Transgression Zone (NTZ) with surveillance of that zone provided by two controllers, one for each active approach. The system tracking software provides PRM monitor controllers with aircraft identification, position, speed, projected position, as well as visual and aural alerts.

## Control Sequence

The IFR system is flexible and accommodating if pilots do their homework, have as many frequencies as possible written down before they are needed, and have an alternate in mind if the flight cannot be completed as planned. Pilots should familiarize themselves with all the facilities and services available along the planned route of flight. *[Figure 9-16]* Always know where the nearest VFR conditions can be found, and be prepared to head in that direction if the situation deteriorates.

A typical IFR flight, with departure and arrival at airports with control towers, would use the ATC facilities and services in the following sequence:

1. AFSS: Obtain a weather briefing for a departure, destination and alternate airports, and en route conditions, and then file a flight plan by calling 1-800-WX-BRIEF.
2. ATIS: Preflight complete, listen for present conditions and the approach in use.
3. Clearance Delivery: Prior to taxiing, obtain a departure clearance.
4. Ground Control: Noting that the flight is IFR, receive taxi instructions.
5. Tower: Pre-takeoff checks complete, receive clearance to takeoff.
6. Departure Control: Once the transponder "tags up" with the ARTS, the tower controller instructs the pilot to contact Departure to establish radar contact.

7. ARTCC: After departing the departure controller's airspace, aircraft is handed off to Center, who coordinates the flight while en route. Pilots may be in contact with multiple ARTCC facilities; they coordinate the hand-offs.
8. EFAS/HIWAS: Coordinate with ATC before leaving their frequency to obtain inflight weather information.
9. ATIS: Coordinate with ATC before leaving their frequency to obtain ATIS information.
10. Approach Control: Center hands off to approach control where pilots receive additional information and clearances.
11. Tower: Once cleared for the approach, pilots are instructed to contact tower control; the flight plan is canceled by the tower controller upon landing.

A typical IFR flight, with departure and arrival at airports without operating control towers, would use the ATC facilities and services in the following sequence:

1. AFSS: Obtain a weather briefing for departure, destination, and alternate airports, and en route conditions, and then file a flight plan by calling 1-800-WX-BRIEF. Provide the latitude/longitude description for small airports to ensure that Center is able to locate departure and arrival locations.
2. AFSS or UNICOM: ATC clearances can be filed and received on the UNICOM frequency if the licensee has made arrangements with the controlling ARTCC; otherwise, file with AFSS via telephone. Be sure all preflight preparations are complete before filing. The clearance includes a clearance void time. Pilots must be airborne prior to the void time.
3. ARTCC: After takeoff, establish contact with Center. During the flight, pilots may be in contact with multiple ARTCC facilities; ATC coordinates the hand-offs.
4. EFAS/HIWAS: Coordinate with ATC before leaving their frequency to obtain in-flight weather information.
5. Approach Control: Center hands off to approach control where pilots receive additional information and clearances. If a landing under visual meteorological conditions (VMC) is possible, pilots may cancel their IFR clearance before landing.

### Letters of Agreement (LOA)

The ATC system is indeed a system, and very little happens by chance. As a flight progresses, controllers in adjoining sectors or adjoining Centers coordinate its handling by telephone or by computer. Where there is a boundary between the airspace controlled by different facilities, the location and altitude for hand-off is determined by Letters of Agreement (LOA) negotiated between the two facility managers. This information is not available to pilots in any Federal Aviation Administration (FAA) publication. For this reason, it is good practice to note on the en route chart the points at which hand-offs occur. Each time a flight is handed-off to a different facility, the controller knows the altitude and location—this was part of the hand-off procedure.

| Communications Facility | Description | Frequency |
|---|---|---|
| Airport Advisory Area<br>"[AFSS name] RADIO" | AFSS personnel provide traffic advisories to pilots operating within 10 miles of the airport. | 123.6 MHz. |
| UNICOM<br>"[airport name] UNICOM" | Airport advisories from an airport without an operating control tower or AFSS. | Listed in A/FD under the city name; also on sectional charts in airport data block. |
| Air Route Traffic Control Center (ARTCC)<br>"CENTER" | En route radar facilities that maintain separation between IFR flights, and between IFR flights and known VFR flights. Centers provide VFR traffic advisories on a workload permitting basis. | Listed in A/FD and on instrument enroute charts. |
| Approach/Departure Control<br>"[airport name] APPROACH"<br>(unless otherwise advised) | Positions at a terminal radar facility responsible for handling of IFR flights to and from the primary airport (where Class B airspace exists). | Listed in A/FD; also on sectional charts in the communications panel and on terminal area charts. |
| Automatic Terminal Information Service (ATIS) | Continuous broadcast of audio tape prepared by ATC controller containing wind direction and velocity, temperature, altimeter setting, runway and approach in use, and other information of interest to pilots. | Listed in A/FD under the city name; also on sectional charts in airport data block and in the communications panel, and on terminal area charts. |
| Clearance Delivery<br>"[airport name] CLEARANCE" | Control tower position responsible for transmitting departure clearances to IFR flights. | Listed on instrument approach procedure charts. |
| Common Traffic Advisory Frequency (CTAF) | CTAF provides a single frequency for pilots in the area to use for contacting the facility and/or broadcasting their position and intentions to other pilots. | Listed in A/FD; also on sectional charts in the airport data block (followed by a white C on a blue or magenta background). At airports with no tower, CTAF is 122.9, the "MULTICOM" frequency. |
| Automated Flight Service Station (AFSS)<br>"[facility name] RADIO" | Provides information and services to pilots, using remote communications outlets (RCOs) and ground communications outlets (GCOs). | Listed in A/FD and sectional charts, both under city name and in a separate listing of AFSS frequencies. On sectional charts, listed above the VOR boxes, or in separate boxes when remote. |
| Ground Control<br>"[airport name] GROUND" | At tower-controlled airports, a position in the tower responsible for controlling aircraft taxiing to and from the runways. | Listed in A/FD under city name. |
| Hazardous Inflight Weather Advisory Service (HIWAS) | Continuous broadcast of forecast hazardous weather conditions on selected NAVAIDs. No communication capability. | Black circle with white "H" in VOR frequency box; notation in A/FD airport listing under "Radio Aids to Navigation." |
| MULTICOM<br>"[airport name] TRAFFIC" | Intended for use by pilots at airports with no radio facilities. Pilots should use self-announce procedures given in the AIM. | 122.9 MHz.<br>A/FD shows 122.9 as CTAF; also on sectional charts 122.9 is followed by a white C on a dark background, indicating CTAF. |
| Tower<br>"[airport name] TOWER" | "Local" controller responsible for operations on the runways and in Class B, C, or D airspace surrounding the airport. | Listed in A/FD under city name; also on sectional and terminal control area charts in the airport data block and communications panel. |
| En Route Flight Advisory Service (EFAS)<br>"FLIGHT WATCH" | For inflight weather information. | 122.0 MHz<br>(0600-2200 local time) |

**Figure 9-16.** *ATC Facilities, Services, and Radio Call Signs.*