
# Automatic Altitude Reporting

*Avionics industry official offers case for encoder altimeters, details background, reasoning for plans to make them mandatory in some areas*

*by G. F. QUINBY / AOPA 37841*
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■■ Just about the time we get used to squawking 1200 VFR and squawking codes like 0400 and 0100 as assigned IFR, they start asking us to squawk things like 2413 and 3216. And a few terminal controllers are starting the next campaign—"Are you equipped to squawk altitude?" What's going on? Are we up against more new equipment requirements? Didn't we just lay out pretty good money for a transponder? And didn't that radio shop say it was capable of reporting altitude?

It's easy to get emotional about the demands the Air Traffic Control (ATC) system places upon its users, and whether the system serves the airspace user or vice-versa. And as high density terminal area traffic management gets more complex, noninstrument-rated pilots are getting more closely involved with ATC. So this is a good time to review some of the fundamentals of our ATC system and to put this altitude reporting thing in its proper perspective.

First, it is the pilot's responsibility to navigate his aircraft. The system will provide him with an assortment of aids to navigation and he is expected to be proficient in their use.

Second, it is the controller's responsibility to separate aircraft from each other when they are in the system and under his control. He does this by continuously monitoring the pilot's navigation through the use of radar.

From crude beginnings in World War II, radar has become a very reliable system for air traffic surveillance. It has been developed to the extent that it provides the controller *almost* all the information he needs about the *position* of the aircraft under his control. Of the three coordinates of an aircraft's position, radar gives the controller two. Radar tells him (1) the direction or azimuth and (2) the distance. But radar does not tell him the altitude.

Yes, there are height-finding radars; GCA (ground-controlled approach) includes a form of altitude sensing on its Precision Approach Radar (PAR). And since radar was the backbone of the surveillance system, it was natural that the scientists and engineers tried to develop the altitude dimension-finding component of surveillance with ground-based vertical scan or volume scan radar. A lot of effort was spent by FAA before this approach was abandoned. And in 1961 a committee called the Beacon Committee published a report that tried to lay ground-radar-derived altitude to rest. In its place, they compromised redundancy and recommended that the system use for surveillance altitude the same sensor that the pilot uses for his navigation—the altimeter. So the vertical component of the pilot's navigation process and the vertical component of the controllers' separation process both depend on a little corrugated diaphragm in the aircraft altimeter that travels less than ⅛ inch over the normal operating range of most of our aircraft.

As a result of the adoption of the report of the Beacon Committee, the FAA challenged the computer industry to produce an effective data processing system linking the radar with the controllers' display.

The first production units of these computers are now going in at high-density terminals (see schedule in the accompanying table). The total new system is called ARTS III. [Editor's Note: ARTS is an acronym for Automated Radar Terminal System. The ARTS program is divided into three major categories. ARTS I is the automated radar system established at Atlanta in 1963 and commissioned in 1966 as the initial effort to provide an alphanumeric capability for a single radar system in a medium- to high-density terminal area. Both primary and

INITIAL OPERATING DATES FOR ARTS*

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|---|---|
| Atlanta (ARTS—I) | August 1966 |
| New York City (ARTS—IA) | June 1969 |
| Knoxville Tenn. (ARTS—II) | July 1970 |
| Chicago (ARTS—III) | June 1971 |
| Washington, D.C. (National) | September 1971 |
| Boston | September 1971 |
| Miami | September 1971 |
| Denver | September 1971 |
| Philadelphia | September 1971 |
| Detroit | October 1971 |
| St. Louis | October 1971 |
| Minneapolis | October 1971 |
| Pittsburgh | November 1971 |
| Cleveland | November 1971 |
| Seattle/Tacoma | December 1971 |
| Honolulu, Hawaii | December 1971 |
| Santa Ana, Calif. (El Toro NAS) | January 1972 |
| Houston | January 1972 |
| New Orleans | January 1972 |
| Cincinnati | January 1972 |
| Las Vegas | January 1972 |
| Washington, D.C. (Dulles) | February 1972 |
| Indianapolis, Ind. | February 1972 |
| Columbus, Ohio | February 1972 |
| San Diego (Miramar NAS) | February 1972 |
| Oklahoma City (Tinker AFB) | March 1972 |
| San Juan, P.R. | March 1972 |
| El Paso, Tex. | April 1972 |
| Portland, Ore. | April 1972 |
| Nashville, Tenn. | April 1972 |
| Albany, N.Y. | May 1972 |
| Dayton, Ohio (Wright-Patterson AFB) | May 1972 |
| Norfolk, Va. | May 1972 |
| Salt Lake City | June 1972 |
| Birmingham, Ala. | June 1972 |
| Tampa, Fla. | June 1972 |
| Baltimore | June 1972 |
| Orlando, Fla. | July 1972 |
| Louisville, Ky. | July 1972 |
| Omaha, Neb. | July 1972 |
| Albuquerque | July 1972 |
| Phoenix | August 1972 |
| Charlotte, N.C. | August 1972 |
| Hartford, Conn. | August 1972 |
| Rochester, N.Y. | August 1972 |
| Syracuse, N.Y. | September 1972 |
| Shreveport, La. | September 1972 |
| Jacksonville, Fla. | September 1972 |
| Providence, R.I. (Quonset P.T. NAS) | September 1972 |
| Tucson, Ariz. | October 1972 |
| Burbank, Calif. | October 1972 |
| Memphis | October 1972 |
| Milwaukee | October 1972 |
| Des Moines, Ia. | November 1972 |
| Raleigh/Durham, N.C. | November 1972 |
| Kansas City, Mo. | November 1972 |
| Dallas/Ft. Worth, Tex. | November 1972 |
| Riverside, Calif. | November 1972 |
| Tulsa, Okla. | November 1972 |
| Buffalo, N.Y. | November 1972 |
| San Francisco/Oakland | November 1972 |
| Sacramento, Calif. (McClellan AFB) | December 1972 |
| Los Angeles | December 1972 |
| San Antonio | December 1972 |

**NOTE*: Initial operating dates shown do not mean the starting date for continuous operation. Final operational readiness follows initial operating date by three to four months.

secondary radar targets are tracked and the alphanumeric tag displays the aircraft identification, altitude and groundspeed on the radarscope. ARTS 1A is the automated system serving the New York complex (Kennedy, LaGuardia and Newark Airports). It provides automated functions similar to those at Atlanta. ARTS II is the automation system designed for use at small and minor hub airports served by radar-equipped control towers. ARTS II can automatically display the transponder beacon code information readout associated with the radar beacon return of transponder-equipped aircraft. The alphanumeric identity is displayed for aircraft equipped with discrete (4,096) codes. If the aircraft is equipped with an altitude-reporting transponder, the altitude is also displayed.] FAA's ARTS III has two major tricks it can perform [Sept. 1971 PILOT, page 27]. It can print numbers and letters (alphanumerics) on the scope, and it can "track" the targets and follow them across the screen automatically. The number-letter trick is used to generate a tag on each target giving its identity and altitude, as well as other interesting information. The tracking trick makes this tag follow the target wherever it goes, generating a groundspeed print to add to the tag in the process.

Dandy. Now where does this smart machine get the identity and altitude of the target to display to the controller? It could get it in a couple of ways. The controller could ask the pilot and set the answer into the computer. Or the computer could pick it up from the pilot's flight plan. But the best way of all is through the installation in the aircraft of a transponder and an altitude encoder, which enables the aircraft to reply with an identity and altitude signal to the ground radar.

The identity capability is in essentially all transponders. Except for the very early units that have or had only 64 codes, all transponders now have 4,096 possible code combinations. (This strange number, by the way, is simply 8 x 8 x 8 x 8, for the eight positions on each of four code switches.) So each transponder-equipped aircraft under computer control can have its own identity code assigned, and each code will have its own tracking circuit in the computer for as long as that aircraft stays within the control area of that radar. You know when you are being tracked by a computer, because when you are, ATC assigns you a code that does not end in two zeros—"Squawk code 1422," which means automatic tracking is at work. And you might hear the next flight in line assigned 1423.

*Figure 1—When the pilot is asked to "squawk Mode C," or "squawk altitude," his transponder transmits coded altitude information from his encoding altimeter to FAA's ground radar equipment. The altitude information is then decoded and automatically displayed on the controller's scope. Figure 2—this blowup of an Arts III alphanumeric information block shows the type of information that is automatically available to the controller. The aircraft shown is United Air Lines flight 789, squawking 6,900 feet msl, with a computed groundspeed of 170 knots. Univac photos*

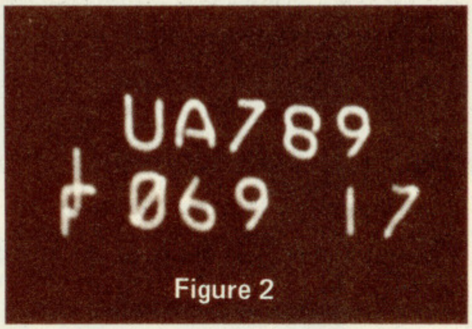

Figure 2


Figure 1

If your aircraft is not equipped with a reporting altimeter, the controller will verify your altitude and punch it into his computer. If you are equipped to "squawk altitude," or "squawk mode C," an altitude code will be transmitted by your transponder in reply to the mode C interrogation from the ground, and your actual altitude will be decoded in the computer and displayed in your tag on the controller's scope, as in Figure 1. This altitude is to the nearest 100 feet and the computer faithfully follows any change in altitude. If you carelessly stray off your assigned IFR altitude by 100 or 200 feet, you may not hear from the controller. Drift 300 feet low or high though and he will politely check your altimeter setting.

"Okay," you say. "But how does this thing know my altimeter setting?" Good question. Your altitude encoder, or reporting altimeter, has a barometer set knob and a window just like any altimeter, as can be seen in the photo at the beginning of this article. But regardless of how you change this to correct your indicated altitude, the reporting device tells the ground the standard altitude you're at—that altitude your altimeter would indicate if you set it to "29.92." Then the computer on the ground applies the local barometric pressure to your sector and you and the controller are back in the same language. You are, that is, if you have set your altimeter "to the current reported altimeter setting of a station along the route and within 100 nm of the aircraft" [FAR 91.81 (a) (1) (i)].

The wonders that this reporting altimeter can perform don't stop at the ARTS III controller's scope. There's a very interesting prototype system in experimental service on an ARTS II system in Knoxville, Tenn., which takes this reported altitude, direction and distance of each aircraft in its area, projects its track 15 seconds to a minute into the future, detects "conflicts," and automatically "advises" conflict avoidance maneuvers.

And there are serious proposals for super-beacon and other collision avoidance data exchange systems that use the altitude reported to today's mode C ground interrogation. Not that these super-systems couldn't benefit from better altitude data; they realistically resign themselves to the conviction that this is the best they are likely to get.

And it's not easy to get even that. With the exception of one line manufactured in Clearwater, Fla., reporting altimeters today cost from $1,495 to over $4,000. (They must meet very demanding performance specifications and, unlike your present inexpensive ($150?) *non*reporting altimeter, their reading is being checked continuously.) Against what? Another good question. Your reported altitude is checked against your indicated altitude to make

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# Altitude

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sure they correspond within specified limits. But what ensures that they are *right*? Nothing but the periodic check required by FAR 91.170. How many of us insist that our instrument shop keep our altimeter setting and our airport elevation in exact agreement? Or do we make a mental note at runup that we have to add or subtract a few points of setting to make the altimeter read field elevation? How many of us fly with two independent altimeters in the airplane? If we did, how closely would they agree? We know that measurement of our vertical position in reasonably common terms among a community of aircraft is a problem. So does FAA.

The March 1972 PILOT contained an article entitled "$4 Altitude Reporting Unit." I flew the described device and in view of a close relationship with its "inventor," A. R. Applegarth (AOPA 55393), undertook to solicit FAA approval of such an approach. In view of the foregoing, we were not optimistic about FAA approval, but we did have some embellishments which would correct the ambiguity between local barometric pressure and standard barometric pressure, and we even had a "semi-fail-safe" scheme that would tend to prevent the reporting of incorrect cruise altitudes. We received two replies from FAA. The first was from the Air Traffic Control Systems Programs Division. It said, in part, "We have given careful consideration to your proposal for the manual altitude encoder device and believe that it would derogate the Air Traffic Control (ATC) system with or without a vertical direction indicator." (The vertical direction indicator was one of our embellishments.) "The amount of funds already expended on automation added to our future plans," continued FAA, "make it appear that any new device not compatible with automatic altitude reporting would be shortchanging both the ATC system and the users."

Somewhat later, and shortly after the subject was discussed at the Fourth Annual National Aviation Systems Planning Review Conference [Jan. PILOT, page 82], a letter went out from FAA to a list of potential altitude reporting manufacturers. It said, in part, "All FAA actions in the past, on the subject of altitude reporting, have assumed, and have been built around, continuous and automatic reporting. Air traffic control must (in the future system) receive altitude information continuously, whether the aircraft is cruising, climbing, or descending, and the altitude reporting system must not add more than a very minimum amount of workload for the crew."

In spite of considerable pecuniary temptation to the contrary, the author agrees completely with both of the preceding FAA statements. The measurement and surveillance of the vertical dimension of our navigation and of our air traffic *separation system* deserve at least as good as our technology has produced to date. Hopefully, technology will now recognize the urgency of the problem and find more cost-effective solutions. □

## Narco's Reporting Altimeter

■■ An AOPA staff member has had a Narco AR-800 encoder altimeter in his plane for about five months. The accompanying photograph shows it just below the airspeed indicator and to the immediate right of the transponder. It has operated effectively whenever the aircraft has been in flight.

In actual use, all the pilot needs to do is flip on the altitude switch on the transponder (in this case on the left edge of the face panel); the rest is automatic. That switch is left on all the time, and controllers can see 100-foot changes in altitude whenever the plane is within range of an ARTS III radar.

*AR-800 encoder altimeter, installed and operating.* *PILOT staff photo*

From the pilot's point of view, and assuming ARTS III coverage is available, he no longer needs to report altitudes to the terminal controller when he has an encoder altimeter. Also, the controller can tell the pilot with this equipment what his actual groundspeed is at any given time.

In this particular installation, an adapter box had to be added to the older-type transponder; current models usually are equipped internally to take altitude encoders. As shown in the photograph, the plane is cruising at 8,560 feet at a true airspeed of 184 mph, squawking 1217 on the transponder. Eventually, all FAA Air Route Traffic Control Centers (ARTCC) will be equipped with automatic altitude receiving capability, enabling them to follow aircraft throughout the country on individually assigned codes, read precise altitudes, and give continuous groundspeeds on the ground radar.

This AR-800 encoder altimeter, with its adapter box, lists for about $1,500.
—M.K.