

REAL TARGETS - UNREAL DISPLAYS
THE INADVERTENT SUPPRESSION OF CRITICAL RADAR DATA

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ABSTRACT

In today's Air Route Traffic Control Center (ARTCC) environment, some very important low-altitude radar data is suppressed. This radar data is not suppressed by the controllers themselves. Rather, it is a result of a compromise in the radar data processing software, and the manner in which the software is adapted by automation personnel. This suppressed radar data has led to air traffic controllers being unable to provide accurate and timely advisories about aircraft which pose a collision threat. An existing software technique to correct a portion of this problem has existed for years, but it is optional and is not adapted system-wide. There must be a concerted effort to address this inadvertent suppression of low-altitude radar data, as well as an examination into the human factors aspect of why it is allowed to continue.

BACKGROUND

On August 24, 1984, Wings West Airlines Flight 628 departed the San Luis Obispo, CA airport en route to San Francisco. Twenty two seconds after the controller advised Flight 628 that radar contact was established, the Wings West aircraft collided head-on with a single-engine Rockwell Commander aircraft at an altitude of approximately 3,400 ft. No safety advisory was issued by the controller to the crew of Flight 628. When Flight 628 was advised of radar contact, the Rockwell Commander, flying under Visual Flight Rules (VFR), was a mere 2 1/2 nautical miles (nm) away. Seventeen people lost their lives. The Los Angeles Center controllers testified that the radar return of the VFR aircraft was *not* displayed. The National Transportation Safety Board (1985) concluded that it had to have been displayed.

In early 1985, while I was providing radar service to a commuter flight, a similar tragedy nearly took place. I was paying close attention to the radar scope. During the commuter's climb to cruising altitude, I was surprised when the pilot radioed, "Center, did you SEE THAT AIRCRAFT?!" Just after this unnerving query, a VFR code 1-2-0-0 beacon target appeared directly behind the commuter aircraft's target. I immediately verified that it was indeed the first time this VFR aircraft was displayed within the previous minute.

In 1988, I wrote a paper addressing this compromise of suppressed targets. It was submitted as [Unsatisfactory Condition Report \(UCR\) #330069](#) to Cleveland ARTCC (Lusch, 1989). The UCR was closed in April, 1989. No action was taken.

DISCUSSION

The primary purpose of the air traffic control system is to prevent a collision between aircraft. The controller's highest priority duty is described in the ATC procedures manual 7110.65F, para. 2-2. That duty is to separate Instrument Flight Rules (IFR) aircraft and to issue a safety alert to the pilot if the controller is aware of any aircraft which may be on a collision course. Monan (1989) writes of several near-midair collisions where controllers claimed that aircraft were not displayed on their scopes.

An aircraft, detected by radar, may be suppressed from the controller's display by the software process of *selective rejection*. The ARTCC controller has absolutely no control over this radar data filtering process.

In the following discussions, all references to radar refer strictly to radar data processed by computers at Air Route Traffic Control Centers. Also, all examples are based on Cleveland Center. It should be emphasized that Cleveland Center is likely doing a better job than most other ARTCCs in the processing of low-altitude radar data. Due to the nature of this problem, however, the inadvertent suppression of low-altitude radar data still occurs.

Mosaicing

Mosaicing is the method employed to deal with the enormous amount of radar data from overlapping radar sites. Mosaicing is a method of sorting the data from several radars of an ARTCC into hundreds of small boxes, known as *radar sort boxes (RSBs)*. The dimensions of a radar sort box is 16 nm by 16 nm. Mosaicing makes it possible for the computer to utilize data from one and only one radar site at a time, at any given point in space. Within a sort box, data from overlapping radar sites is prioritized into *preferred* data, and *supplemental* data. Data from a preferred radar site will be utilized first, and if unavailable, the data from the supplemental radar site may be utilized. Where a radar site is neither assigned as preferred nor as supplemental within a sort box, its radar data is completely rejected by the computer within that 256 square nautical mile (sq nm) area.

Due to past computer software and hardware processing limitations, the enormous amount of radar data from multiple radar sites simply had to be reduced. Otherwise the computers were overloaded. Today's software and hardware processing limitations still require mosaicing to reduce computer processor demands, as the majority of radar data received at an ARTCC is still abandoned (Meilander, 1989). Unfortunately, mosaicing contributes to some important low-altitude radar data not being utilized. This results in some aircraft not being displayed on the controller's scope, even though these low-altitude aircraft are, in fact, adequately detected by radar.

Compromise #1. ATC radar is not designed to detect aircraft directly above the radar antenna. This area is known as the *cone-of-silence*. Aircraft flying in a radar's cone-of-silence may, however, be detected by another, or several other radar sites a hundred or so miles away due to their overlapping coverage. Figure 1 depicts a 5 nm diameter cone-of-silence area above the Dansville radar. Aircraft at all altitudes within this cone-of-silence area are not detected by the Dansville radar. If these aircraft are high enough, however, they will be detected by the Clearfield, PA, and Utica, NY, radars, which are between 100 to 115 nm away. To solve a cone-of-silence problem, it is common practice to assign the coverage, within a sort box which overlies the radar, to a distant radar site. As shown in Figure 1, the preferred coverage within RSB#986 is assigned to Clearfield radar. Such

software adaptation easily eliminates the problem of a cone-of-silence. Unfortunately, it also eliminates many low-altitude radar targets near the radar site from being processed for display.

Danville radar data is not utilized within RSB#986. It is neither assigned as preferred nor supplemental. Low-altitude aircraft, below 5,000 to 6,000 ft in this vicinity, will not be detected by either the Clearfield or Utica radars. This is due to the fact that the radar signals are strictly line-of-sight, and are therefore blocked by the earth due to its curvature.

As shown in Figure 1, a northbound aircraft is about to collide with a southbound aircraft. The northbound aircraft is within RSB#936 and is being provided radar service by Cleveland Center. Due to its low altitude, it is detected by only the Dansville radar. The southbound aircraft is within RSB#986 and has a properly functioning transponder set to the VFR code of 1-2-0-0. Since this low-altitude aircraft is not within Dansville radar's cone-of-silence it is detected by Dansville, and its position is sent to the ARTCC computer, along with the position of the northbound aircraft. Like the northbound aircraft, due to its low altitude, this southbound aircraft is not detected by either the Clearfield or Utica radars, which are assigned as preferred and supplemental within RSB#986. Unfortunately, the controller will be unable to issue a warning to the pilot of the northbound aircraft prior to the collision with the southbound aircraft at position A. This is because the Danville radar data on this southbound aircraft is discarded by the program.

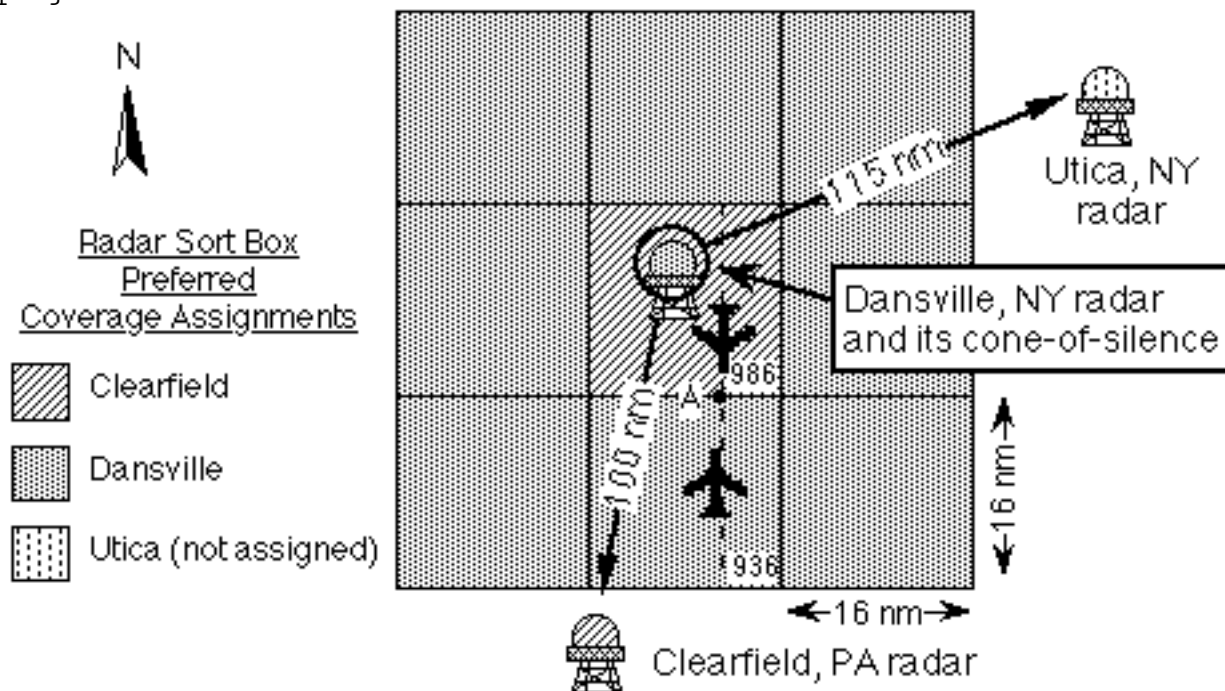


Figure 1. Two aircraft detected by only the Dansville radar. The southbound aircraft is *not* displayed since Dansville radar data is suppressed within RSB#986. (Distances are in nautical miles [nm].)

As one can see, the steps taken to correct the problem of a loss of data in a radar's cone-of-silence leads to the loss of important low-altitude radar data. Note the difference in size between the depicted 20 sq nm cone-of-silence area, as compared to the much greater 256 sq nm area within the sort box. Unfortunately, the manner in which the radar data is processed results in 236 sq nm of low-altitude radar data not being displayed.

Compromise #1 addressed. These inherent shortcomings do not need to be accepted. One method of addressing this problem is to utilize data from more than one radar at the same time. Instead of assigning one and only one radar as the preferred radar, a sort box may be adapted with one radar as preferred and another as *alternate preferred*. When two radars are designated in this manner, a sort box is said to have *double-preferred* coverage. This solution results in a less than pleasing display, as there will be two targets per aircraft when the aircraft are detected by both radars. Software documentation discourages the adaptation of sort boxes as double-preferred.

There is a similar, but much better way to deal with this problem. It is to utilize the *optional* software routine called the *ZC150 patch*. This patch stratifies a sort box. High-altitude aircraft are still depicted by a distant radar site, which solves the cone-of-silence problem, but low-altitude aircraft which are detected by the radar site within the sort box are not suppressed. A sort box with this patch adapted utilizes single-preferred coverage at or above the stratified altitude, whereas double-preferred coverage exists below the stratified altitude. The ZC150 patch has been in use at Cleveland Center since May 23, 1990. It has been adapted for all radar sort boxes overlying radar sites within Cleveland Center, except for RSB#986.

Compromise #2. Another compromise inherent with mosaicing occurs when the adapted preferred coverage changes from one radar to another. This often takes place midway between two radar sites. If the coverage from both radars is equal, suppression of targets may be minimal, but it can still occur. Sometimes the changeover point is much closer to one radar than the other. When sort boxes are adapted in this manner the results can be somewhat mystifying, in that one aircraft will be displayed, but another, within the same sort box, will not be displayed! See Figure 2.

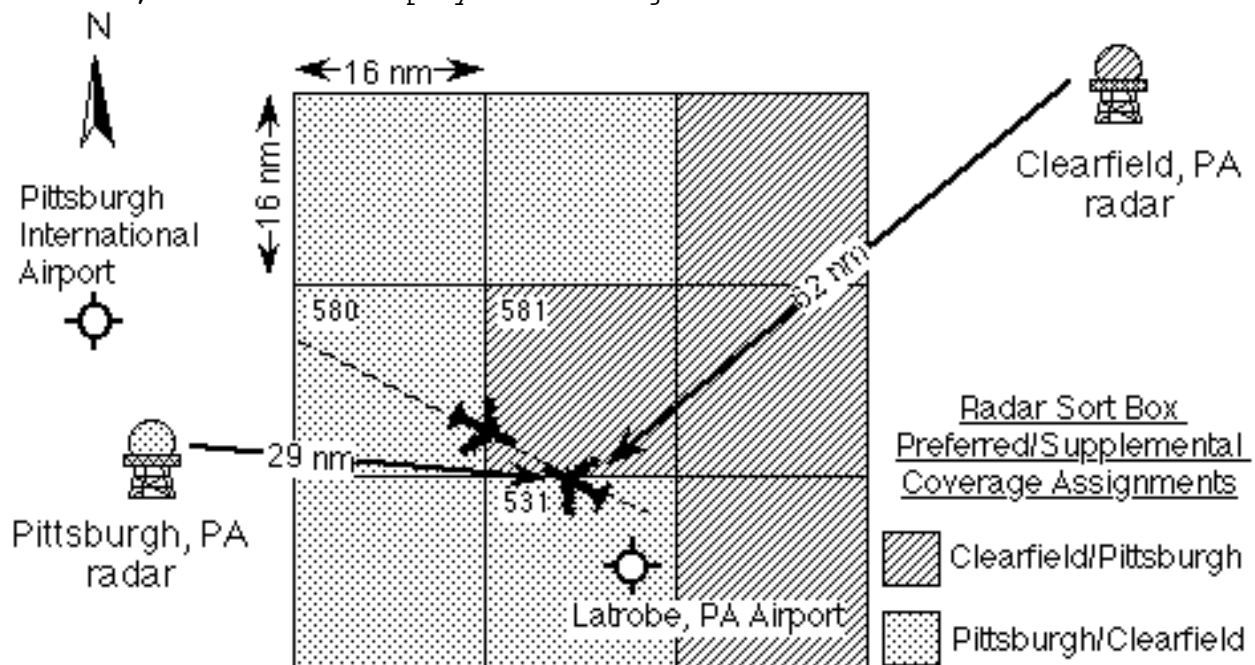


Figure 2. Two aircraft detected by only the Pittsburgh radar. The southeast-bound aircraft is tracked and displayed within RSB#581. The northwest-bound aircraft is untracked, and therefore is *not* displayed within RSB#581. (Distances are in nautical miles [nm].)

One may find it unsettling that two aircraft, both within the same radar sort box, both at the same altitude, both with transponders faithfully responding to radar interrogations from the same radar, and both about to collide, can result in one aircraft being displayed, and the other totally invisible to the controller. The difference that causes this phenomenon is that one aircraft is *tracked*, and the other *untracked*. An aircraft that is tracked by the software is one that is being provided radar service by an ARTCC. Besides having a target symbol, it will include a full datablock, which displays information such as identification, assigned altitude, etc. An untracked target is typically a VFR aircraft, whose pilot is operating under the see-and-be-seen rules, and has the aircraft's transponder set to the VFR code 1-2-0-0. A low-altitude VFR aircraft on the code 1-2-0-0 will be represented by the target symbol **V**, and the only other data that will be associated with it will be its altitude data, assuming the aircraft is equipped with altitude reporting. There is a significant difference between the display of a tracked and an untracked aircraft. This is that a tracked aircraft, when no longer detected by the preferred radar yet still detected by the supplemental radar, will display a target symbol and full datablock. However, an untracked aircraft, when not detected by the preferred radar yet still detected by the supplemental radar, will not display a target symbol nor any other data for that matter. It is invisible to the controller.

Figure 2 shows the path of a typical commuter flight from Pittsburgh International Airport to the Latrobe, PA Airport. Cleveland Center provides radar service to an aircraft on this route of flight from approximately 15 nm east of Pittsburgh until the aircraft is instructed to contact the Latrobe air traffic control tower. As the commuter aircraft enters RSB#581 the preferred radar coverage changes from Pittsburgh to Clearfield. As this aircraft descends through 2,900 ft, the Clearfield radar will no longer detect it. The computer software will then automatically utilize the supplemental radar data from the much nearer Pittsburgh radar to continue to display this tracked aircraft within RSB#581. Simultaneously, a northwest-bound VFR aircraft which is 62 nm away from the Clearfield radar yet only 29 nm away from Pittsburgh radar, is on a collision course with the commuter. This VFR aircraft will soon be within 30 nm of Pittsburgh International Airport, and as required by Federal Aviation Regulation 91.125, it is equipped with an operable transponder with automatic altitude reporting. This VFR aircraft's altitude is steady at 2,800 ft. As this untracked VFR aircraft enters RSB#581 it disappears from the controller's display. This is due to the fact that it is detected by only the Pittsburgh radar, and it is not tracked by the computer software. While this VFR aircraft was in RSB#531, it was displayed because Pittsburgh radar is designated as preferred within that sort box. As the aircraft enters RSB#581, where Pittsburgh radar is no longer assigned as preferred, yet it is the only radar that detects this VFR aircraft, the target vanishes from the controller's display. The pilot of the commuter aircraft will not be warned about this VFR aircraft. The Pittsburgh radar detects both aircraft and sends this data to the ARTCC computer, but only the tracked aircraft receiving radar service by Cleveland Center is displayed. The VFR aircraft is detected by radar but not displayed!

CONCLUSION

Did the controllers at Los Angeles Center simply not see the VFR aircraft as it was about to collide with the Wings West commuter aircraft? When the controller established radar contact on the commuter aircraft, the VFR aircraft would have been a mere 1/2 inch (1.27 cm) away on the screen. Could the VFR aircraft had been inadvertently suppressed from their display due to selective rejection? Upon my review of the radar data from that accident, I

could not help but notice that both aircraft were in separate radar sort boxes until the collision took place. Regardless of whether the controller just didn't see the VFR aircraft, or whether selective rejection made that VFR aircraft invisible to the controller, it is important to realize that in *today's* ARTCC environment, the ongoing inadvertent suppression of low-altitude radar data could result in a similar tragic scenario being replayed.

Shortly after I became a full performance level radar controller, that near-midair collision occurred in which I was unable to issue a safety advisory because a VFR aircraft was not displayed. I then began to question our radar data processing methods. Nearly everywhere I turned, I was assured that the new computer hardware and software would most certainly enhance the display of traffic, and that this new equipment was "coming soon." That was 1985. Six year later, and over three years after the replacement of the ARTCC mainframe computers with the upgraded HOST¹ computer, the suppression of low-altitude radar data still exist. New hardware and software are "coming soon," but can we be *assured* that the display of low-altitude aircraft will be enhanced? When a partial remedy has existed for years, such as the ZC150 patch, it is difficult to understand why it has not been fully implemented. It is truly a shame to have excellent radar coverage, yet not have done our utmost to be certain that the radar data of low-altitude aircraft are displayed for the controller. This problem begs for immediate attention. Should a midair collision occur tomorrow, and it was found that no safety advisory was issued because of target suppression due to selective rejection, this problem would certainly be addressed and corrected nearly immediately. This subject should be addressed as if tomorrow's midair has already occurred.

RECOMMENDATIONS

To correct the problems as related in Compromise #1, the first step should be to make the ZC150 patch *mandatory* instead of optional. Such immediate action costs little, as the software and hardware already exists. The only thing necessary is a directive that it be accomplished. The second step should be to correct the suppression of low-altitude aircraft targets as described in Compromise #2. There is no software patch currently designed to address this specific problem. Resources should be directed to remedy this situation. Possibly the most expeditious way to handle this task is to *stratify all sort boxes* and utilize double-preferred coverage throughout the low-altitude environment. The methods in the ZC150 patch could likely be broadened to include all sort boxes to achieve this goal. The third step, which is a long range goal, should be to seriously consider the advantages of simultaneously utilizing *all* data from *all* radars, in an effort to *track all aircraft*. Potter and Meilander (1989) discuss the advantages of utilizing an array processor supercomputer to achieve the performance requirements necessary to process the great amount of radar data that goes unused today.

It would also be wise to initiate a human factors study to determine why, when a problem of such importance is brought to the attention of the Federal Aviation Administration (Lusch, 1989), that no action is taken.

¹The HOST computer systems, installed in all 20 ARTCCs, replaced the 20 year old IBM 9020 computers. Cleveland's HOST was inaugurated on Jan 29, 1988.

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