AAL77

On Sep 11, 2001, American Airlines Flight 77 was one of 4 aircraft hijacked. It was subsequently utilized as a weapon of mass destruction as it was flown into the Pentagon. At approximately 8:56 a.m. EDT, while in Indianapolis Center (ZID) airspace, cruising at FL350 (approximately 35,000 feet above sea level), the transponder was simply turned off. Normally, disabling a transponder does not make an aircraft invisible to air traffic controllers, as the high-altitude Center controller need only select the "ALL PRIM" (all primary) filter to view the aircraft's SEARCH radar (i.e. "primary" aka "skin paint") targets. As a matter of fact, Chuck Thomas, the radar controller who was working AAL77, selected the ALL PRIM filter *within one second* of AAL77's datablock displaying "CST" (Coast Mode...which indicates that the aircraft's datablock is no longer being updated with radar data). The disturbing thing is, there was no primary target on AAL77 available for Thomas. AAL77 ultimately flew the entire way back to its impact, some 41 minutes later, unnoticed by Air Traffic Control.

Key 9/11 Commission findings about radar data processing: On page 25 (pdf pg 42) of THE 9/11 COMMISSION REPORT, they write "The reasons are technical, arising from the way the software processed radar information, as well as from poor primary radar coverage where American 77 was flying." Footnote 142 (pg 460...pdf pg 477) states "142. Primary radar contact for Flight 77 was lost because the "preferred" radar in this geographic area had no primary radar system, the "supplemental" radar had poor primary coverage, and the FAA ATC software did not allow the display of primary radar data from the "tertiary" and "quadrary" radars."

Comments on above findings: The above findings by the 9/11 Commission help to shed light on the fact that even though an aircraft may be detected by radar, that aircraft may not necessarily appear on the air traffic controller's display. My emphasis for over the past two decades has been on the low-altitude aspects of this unsatisfactory condition, where even an aircraft with a perfectly working transponder, that is properly replying to interrogations, can be invisible to the air traffic controller (learn more about my criticism of multiple radar data processing here).

I feel that the 9/11 Commission was not able to dig deep enough into the radar picture concerning AAL77, otherwise they wouldn't have stated that there was "...poor primary coverage where American 77 was flying." AAL77 was over southern Ohio at the time the transponder was disabled, and being approximately five-and-a-half miles high, *there was considerable overlapping coverage from surrounding Air Route Surveillance Radar (ARSR) sites that do (or could) feed to Indianapolis ARTCC (ZID)*.

Those long-range radar sites, their distance and direction from AAL77 at the time the transponder was disabled, and a graphic depicting the relationship of AAL77's return flight with respect to those individual ARSR sites, are available below. [A special thank you to Glen H Schulze <contact>, who provided the "picture is worth a thousand words" graphics.]

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London, OH...................QWO...79 nm north-northwest..see AAL77_QWO_ARSR_Schulze.jpg
Lynch, KY....................QRI..105 nm south............see AAL77_QRI_ARSR_Schulze.jpg
Oakdale (Pittsburgh), PA.....PIT..158 nm northeast........see AAL77_PIT_ARSR_Schulze.jpg
Brecksville (Cleveland), OH..QDB..165 nm north-northeast..see AAL77_QDB(CLE)_ARSR_Schulze.jpg
Bedford (Roanoke), VA........QBE..167 nm east-southeast...see AAL77_QBE_ARSR_Schulze.jpg
Indianapolis, IN.............IND..177 nm west-northwest...see AAL77_IND_ARSR_Schulze.jpg
Maiden (Charlotte), NC.......QRM..197 nm south-southeast..see AAL77_QRM_ARSR_Schulze.jpg
```

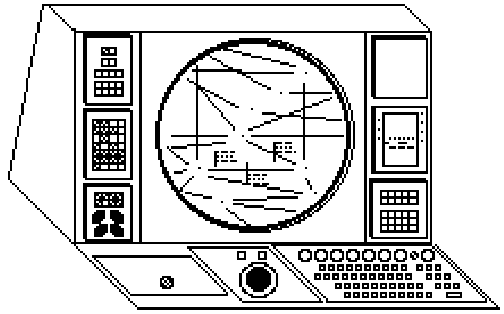
Thomas G. Lusch
June 10, 2010

Dec 2, 2010 update: For the past year I had intentions to write, and submit for publication to the *Journal of Air Traffic Control*, an authoritative paper that called into question the displayed symbols of AAL77. Specifically, this paper would center on the fact that once AAL77's transponder had been turned off, the SEARCH (i.e. primary radar return, aka "skin paint") targets that represented AAL77 showed that *there may be a latent error in the presentation software*. I would call into question the algorithm that determines if the Center controller's target symbol will be displayed as a STRONG radar return versus a WEAK radar return. This is important for a controller in being able to easily *maintain* radar contact (or spot) an aircraft when a transponder is not working properly. Finding the time to write that paper has been difficult. So, as my ATC career is about to be terminated (see my "about" section), I leave you with a copy of an email from me to the creator of (the no longer available) AAL77.COM web site. In my message (see Lusch2FarmerEmailDec2009.pdf), you will see that in my analysis of the NTAP data, I determined that over 2/3's of the time, AAL77 was available on Washington Center displays as a weak primary target on its trip back to the Washington DC area. However, a Boeing 757 should have been displayed as a strong signal most of the time. But at least it was available on the Washington Center displays (unlike how it was invisible on the Indianapolis Center displays for an extended period of time). If you wish to review the data from which I made this determination, you may contact me, or John Farmer, and we'll be happy to share this FOIA data.

Dec 12, 2010 update: When I updated this page last June to include Glen Schulze's graphical representations of AAL77's return flight path in relation to seven long-range radar sites, I inadvertently left out an earlier analysis I had published. (I'm afraid I got preoccupied with dealing with ageism...see my "about" page for more on that.) The point of my earlier analysis was that there is considerable radar data that is available, but most of it goes unused. Of course, that's been the whole point of my earlier papers and the reason why this web site exists. The problem is NOT radar...***the problem is the processing of the radar data***. That is what Will Meilander has been stating for decades (see this).

Here's the file I inadvertently left out... Lusch_review_AAL77_radar_data_20090708.pdf. It exemplifies that there is considerable radar data that was not utilized in the display of AAL77. It also shows that AAL77 was detected as a SEARCH (aka "primary", aka "skin paint") target by, CLE (QDB), and QWO, not just QBE, directly after AAL77's transponder was turned off.

P.S. Miles Kara, professional staff member of the Congressional Joint Inquiry and the 9-11 Commission, served on Team 8. He continues his interest. Learn more here.



Lusch's Midair Collisions Investigations

It was in 1985, after a commuter aircraft *narrowly missed* having a midair collision with an aircraft that assuredly had to be detected by one of our radar sites, yet was NOT displayed on my "radar scope," that I began to question why that could be. That is when I learned about "radar sort boxes" and the software process termed "selective rejection." I learned from firsthand observation that a an overwhelming amount of radar data is NOT utilized in the presentation of aircraft targets for the enroute air traffic controller. That lead to my writing an Unsatisfactory Condition Report in 1988, which I entitled ***Selective Rejection of Low Altitude Radar Data at Air Route Traffic Control Centers: An Unsatisfactory Compromise*** (click SelRej.pdf). The 1989 response to my UCR was "...the methods used to filter and display radar data are sound, including the selective rejection process" (click UCRreply.pdf). I disagreed with that conclusion. I went on to author another paper, entitled, ***Real Targets – Unreal Displays: The inadvertent Suppression of Critical Radar Data*** (click RTUD.pdf). It was later republished in the Journal of Air Traffic Control (click RTUD_JofATC_JanMar92.pdf). "Selective rejection" *exists to this day* (see "Deja vu"). I have given new life to a slide show I created back in February 2000. That was based upon the slide show I created for my RTUD presentation at the Sixth International Symposium on Aviation Psychology (click Lusch_RTUD_twice_revived_slide_show.pdf).

The disappearance of American Airlines Flight 77 from the Indy Center radar displays on 9/11 exemplifies the unsatisfactory compromise that I have been addressing. Learn more here.

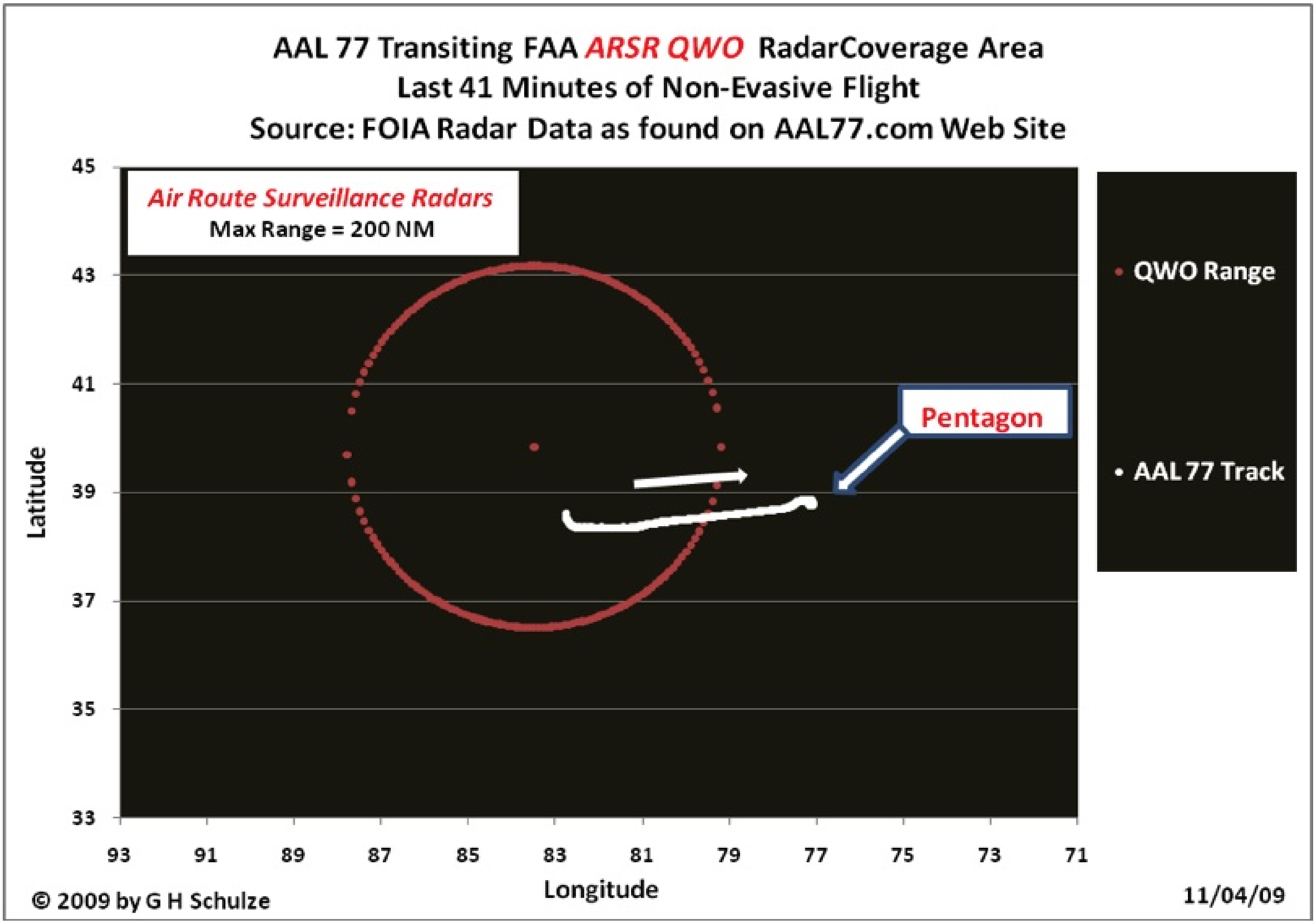
Why can't we process all radar data, from all radars, all the time, so as to be certain that we don't lose an aircraft from our displays? The answer I got in 1992 centered around the fact that the current processing model is based on a uniprocessor, such that "only one function is executed at any one instance." (click RTUDreply.pdf). Some may think of my concerns as outdated, as En Route Automation Modernization (ERAM) is very nearly online. However, when one looks closely, one finds that the term "radar sort box" has been replaced with the term "selective sort cell" (see the old-to-new terminology change of RSB to SSC on page 8 of this document). Thus, it appears that a considerable amount of radar data will still go unused. When it comes to processing radar data from multiple radars, Williard C. Meilander thinks it is time for a paradigm shift. Learn more here.

Thomas G. Lusch (about) (contact)
July 21, 2010

Note: There is more than one way in which an aircraft's properly operating transponder, that is detected by secondary radar, can be invisible to an air traffic controller. For example, see what can occur when airspace assigned to one radar facility is not adequately covered by the radar site the facility utilizes (see this example). And there is yet another problem that is the result of an incompatibility between Mode S interrogators and older ATCRBS transponders. Learn of my personal experience here.

P.S. I also have a keen interest in the midair collision that occurred in 1984 near San Luis Obispo, CA.

Learn about my ***Barefoot For Nourishment*** initiative here.


AAL 77 Transiting FAA ARSR QWO RadarCoverage Area
Last 41 Minutes of Non-Evasive Flight
Source: FOIA Radar Data as found on AAL77.com Web Site
Air Route Surveillance Radars
Max Range = 200 NM
Pentagon
QWO Range
AAL 77 Track
Latitude
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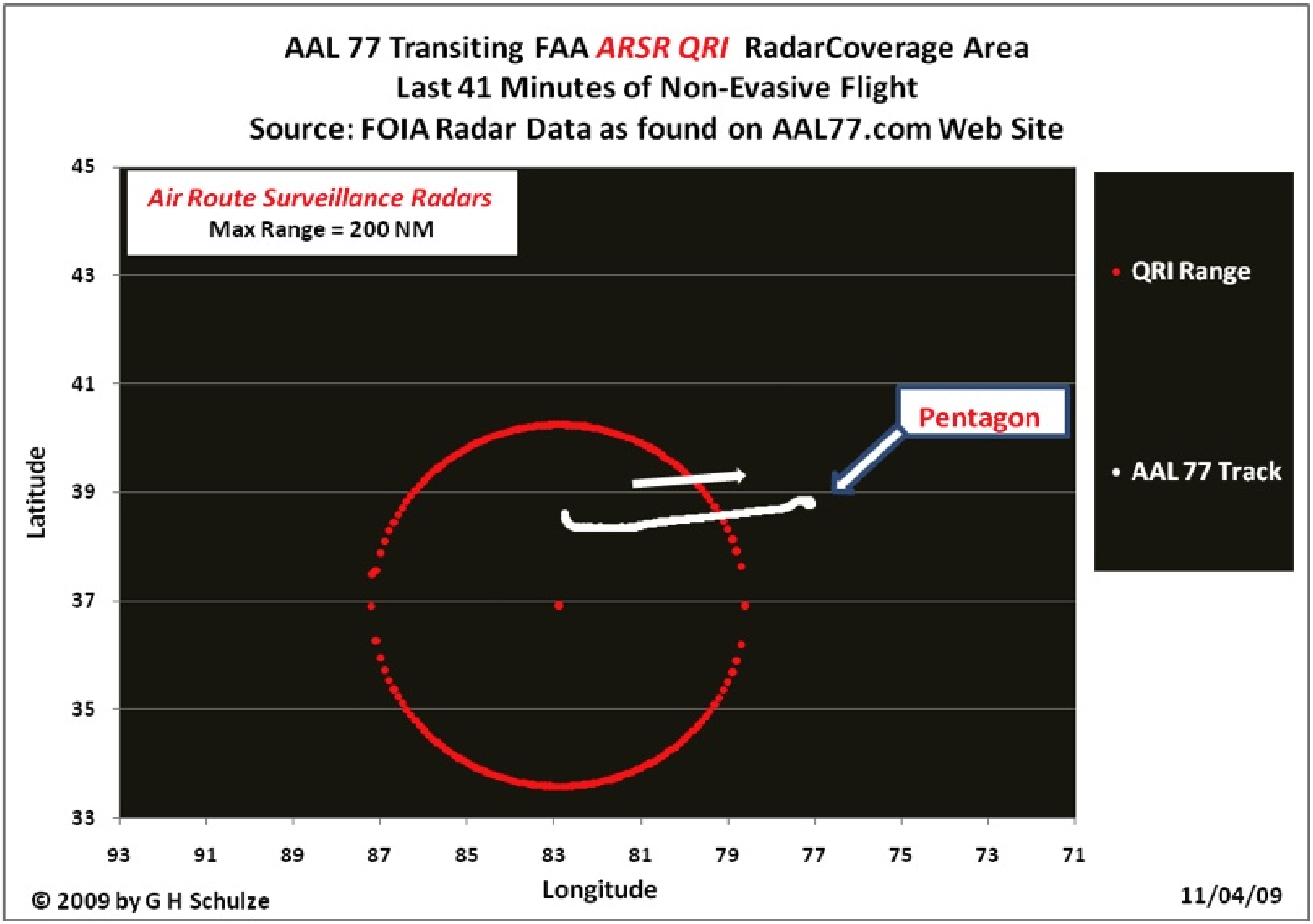
Longitude
© 2009 by G H Schulze
11/04/09


AAL 77 Transiting FAA ARSR QRI RadarCoverage Area
Last 41 Minutes of Non-Evasive Flight
Source: FOIA Radar Data as found on AAL77.com Web Site
Air Route Surveillance Radars
Max Range = 200 NM
Pentagon
QRI Range
AAL 77 Track
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Longitude
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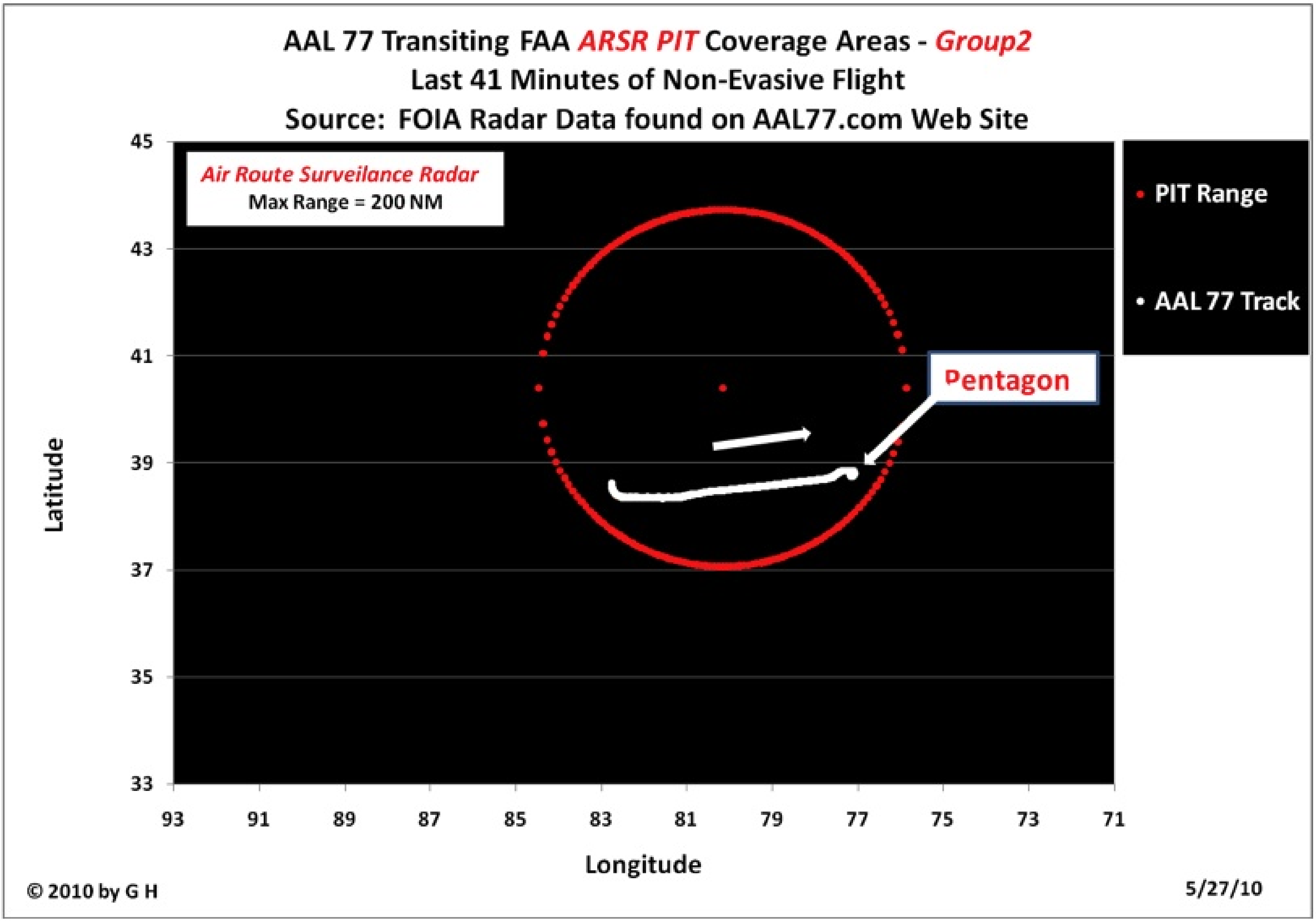

AAL 77 Transiting FAA ARSR PIT Coverage Areas - Group2
Last 41 Minutes of Non-Evasive Flight
Source: FOIA Radar Data found on AAL77.com Web Site
Air Route Surveilance Radar
Max Range = 200 NM
PIT Range
AAL 77 Track
Pentagon
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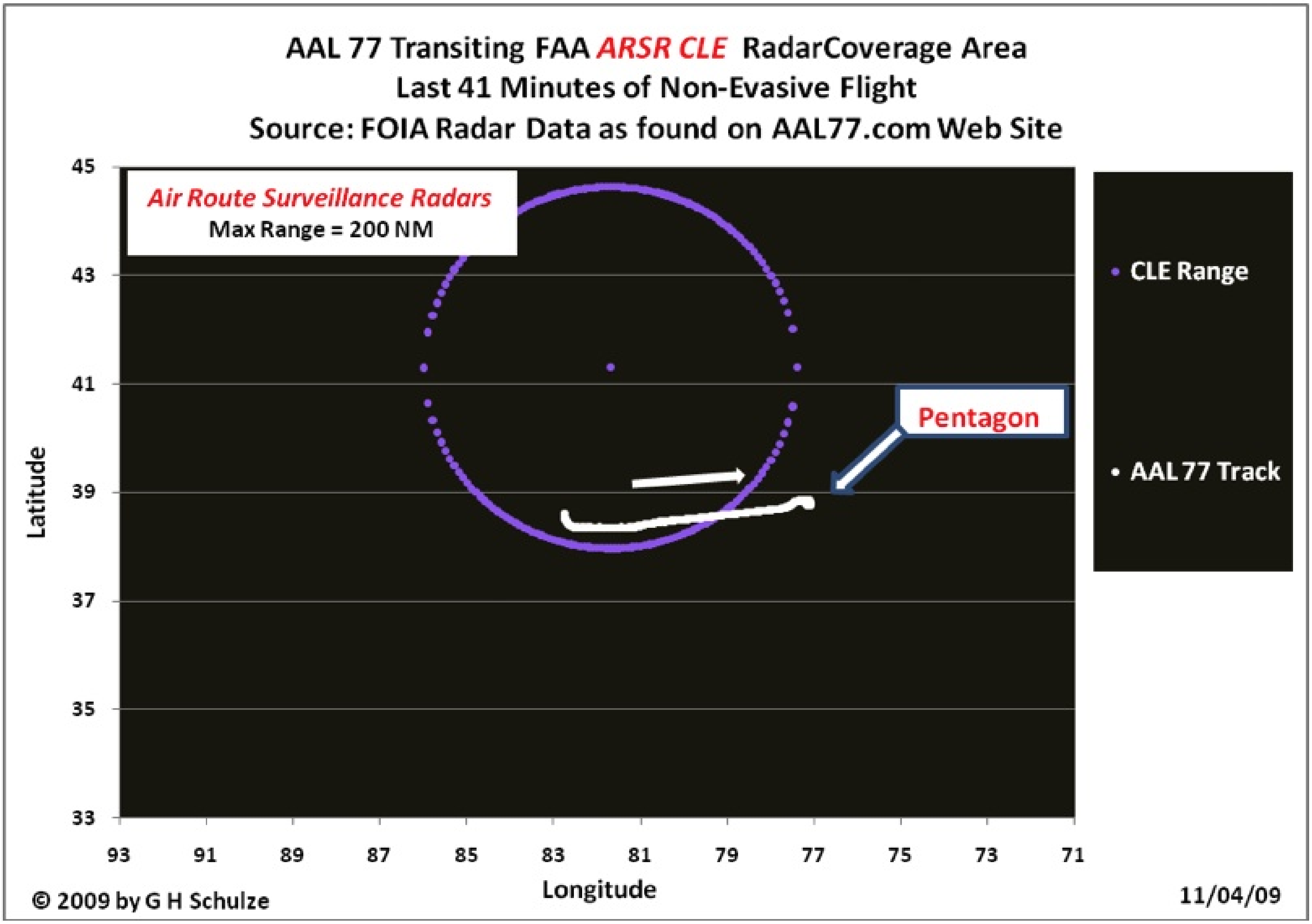
Longitude
© 2010 by G H
5/27/10


AAL 77 Transiting FAA ARSR CLE RadarCoverage Area
Last 41 Minutes of Non-Evasive Flight
Source: FOIA Radar Data as found on AAL77.com Web Site
Air Route Surveillance Radars
Max Range = 200 NM
Pentagon
CLE Range
AAL 77 Track
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Longitude
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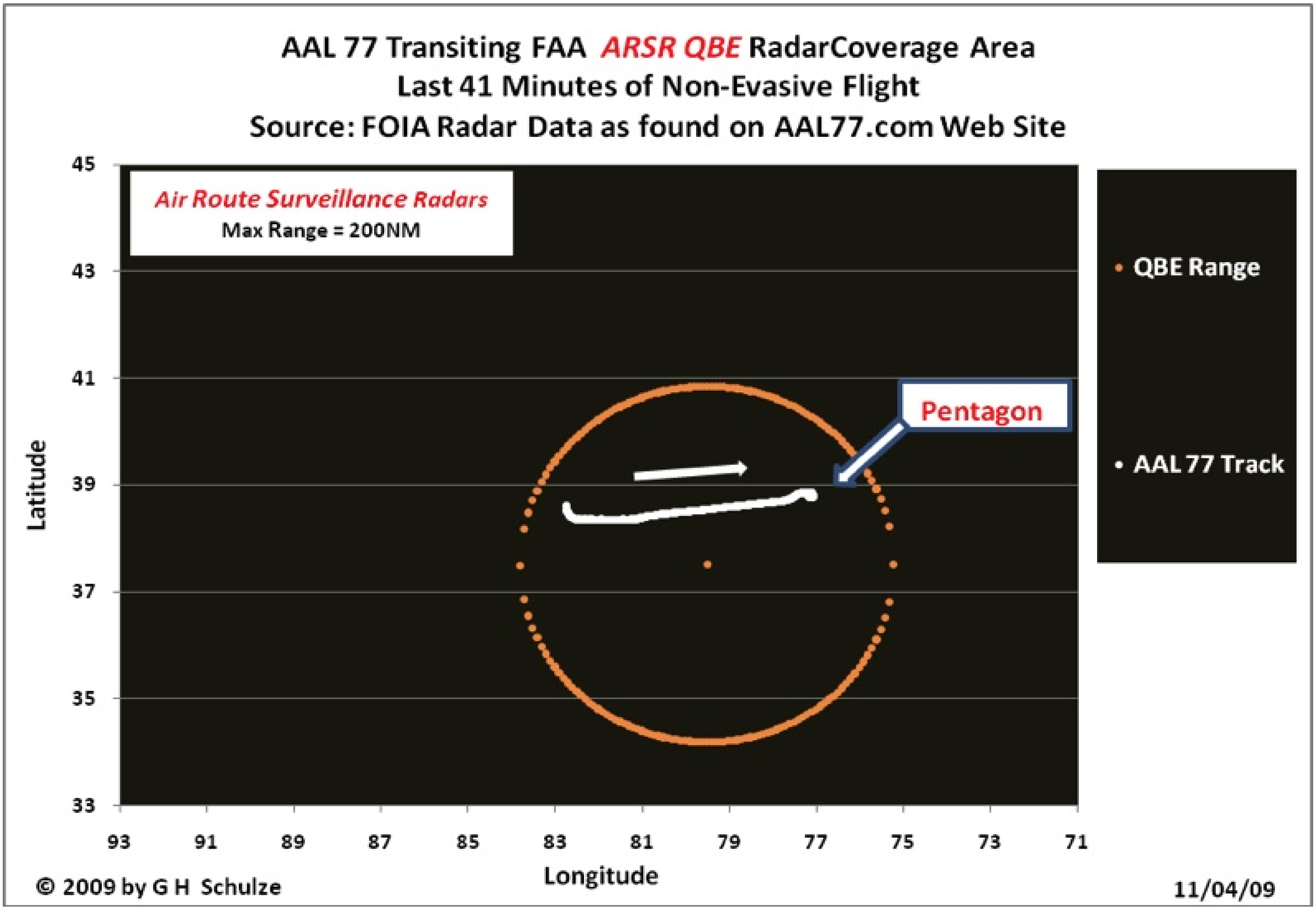
AAL 77 Transiting FAA ARSR QBE RadarCoverage Area
Last 41 Minutes of Non-Evasive Flight
Source: FOIA Radar Data as found on AAL77.com Web Site
Air Route Surveillance Radars
Max Range = 200NM
QBE Range
AAL 77 Track
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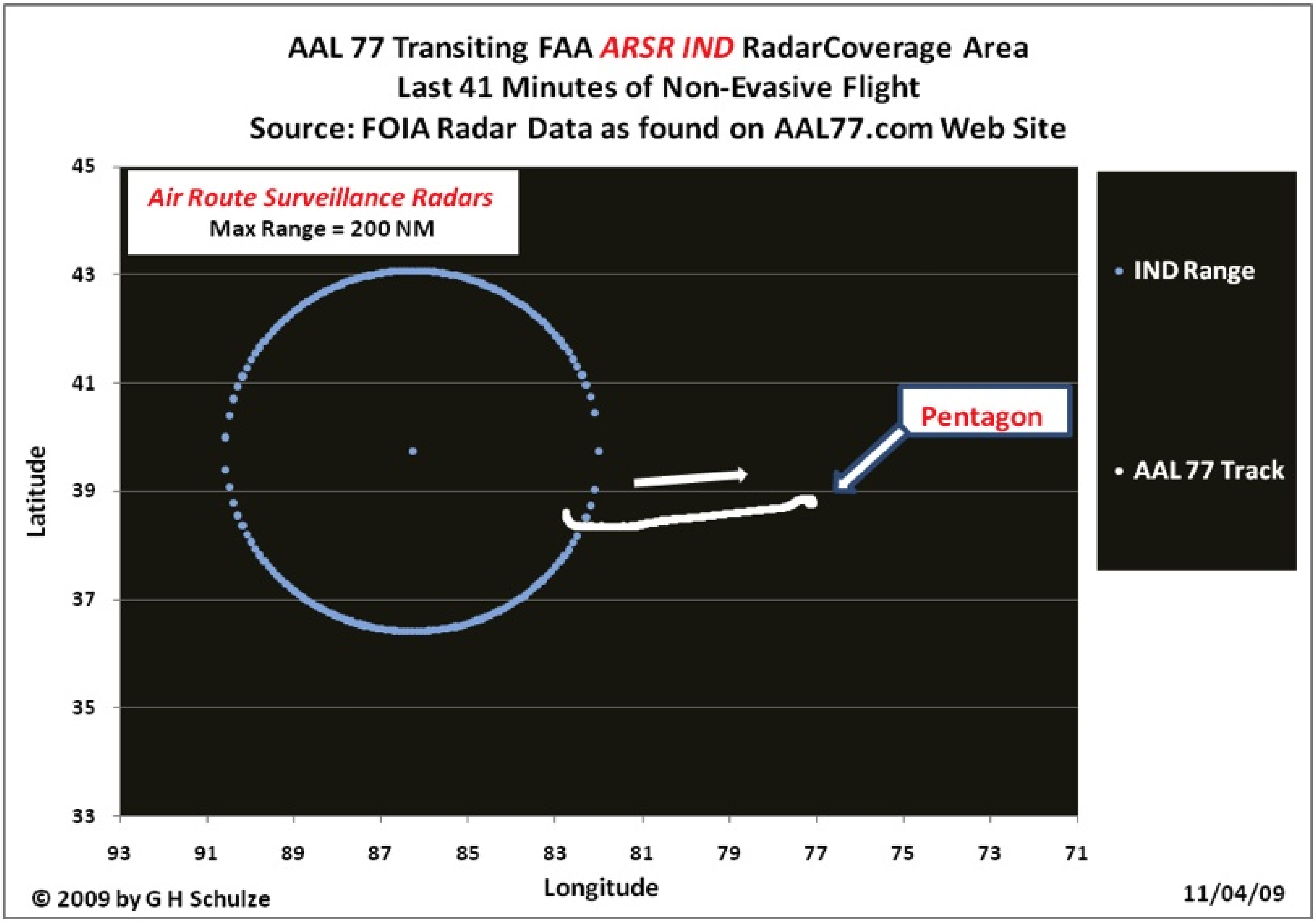
AAL 77 Transiting FAA ARSR IND RadarCoverage Area
Last 41 Minutes of Non-Evasive Flight
Source: FOIA Radar Data as found on AAL77.com Web Site
Air Route Surveillance Radars
Max Range = 200 NM
Pentagon
IND Range
AAL 77 Track
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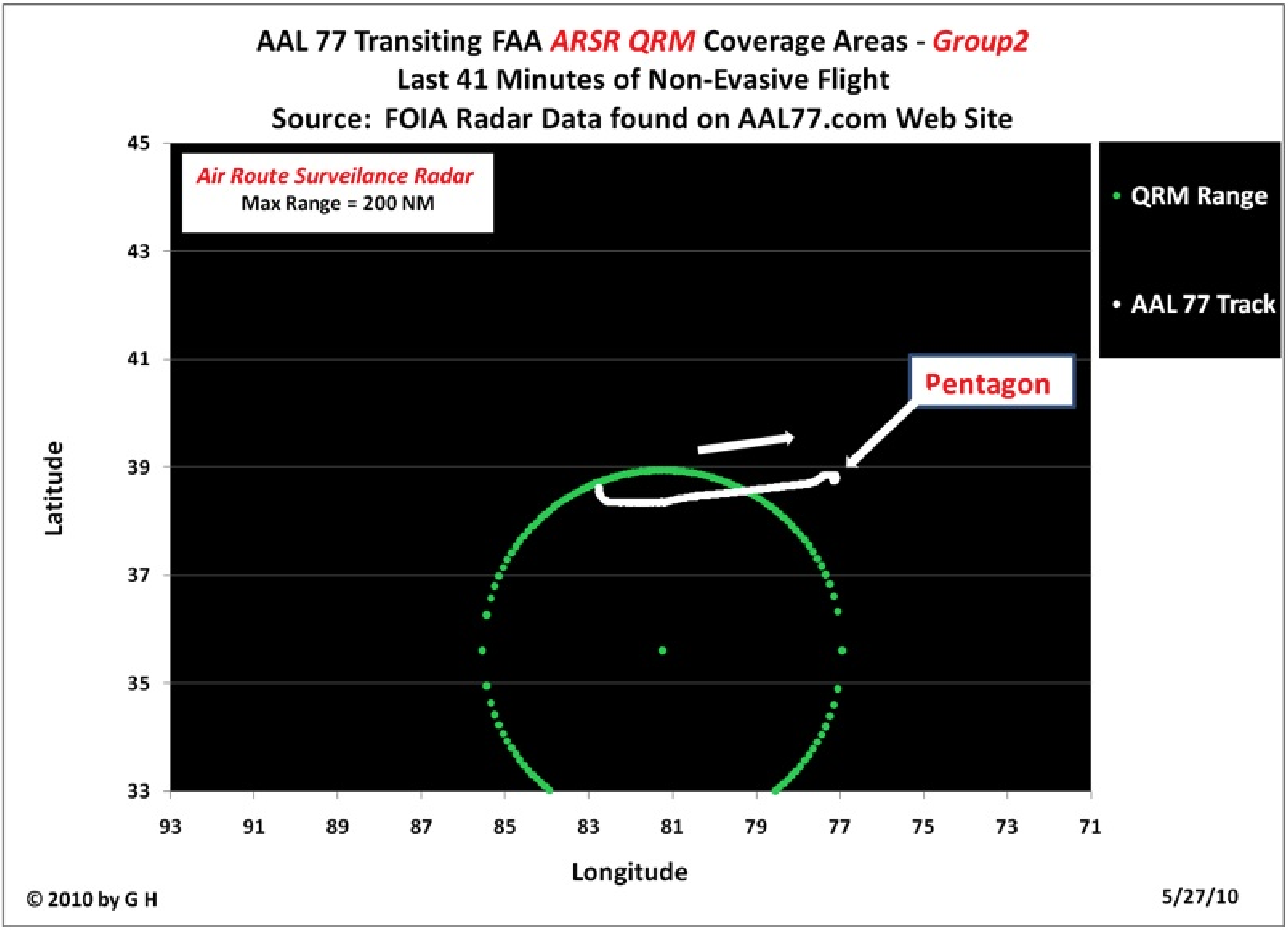
AAL 77 Transiting FAA ARSR QRM Coverage Areas - Group2
Last 41 Minutes of Non-Evasive Flight
Source: FOIA Radar Data found on AAL77.com Web Site
Air Route Surveilance Radar
Max Range = 200 NM
QRM Range
AAL 77 Track
Pentagon
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Longitude
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About Tom Lusch

Welcome to TomLusch.com! I am currently an FAA Certified Professional Controller (Air Traffic Control Specialist) at Port Columbus International Airport (KCMH Tower/Tracon), as well as a certified instrument rated pilot with just under 1200 flight hours logged. I initially had a heck of a time getting hired by the FAA, as they required that I hold a FAA 2nd Class Airman Medical Certificate. As it turned out, the FAA had initially processed my 2nd Class FAA Medical for flying privileges, but not for Air Traffic Control purposes. The FAA essentially stated that I was safe enough to fly commercially, but not safe enough to work for them as an air traffic controller. If you wish to learn more about such a discriminatory hiring practice (based upon myopia), read LuschEEOC1982.pdf.

From 1982 thru 1993 I worked at Cleveland Center (ZOB). The experience of an aircraft that I was handling, nearly being involved in a midair collision, in which the other aircraft was most assuredly detected by radar, yet NOT displayed on my screen, is the primary reason that this web site exists (see main page).

How long will I remain an air traffic controller? Feb 28, 2011 is my anticipated last day on the job. There is a *slim chance* that I may be granted another one-year waiver due to the fact that Dayton Tracon airspace is being taken over by Columbus Tracon (cutover date planned for June 4, 2011). Management may, even at the last moment, determine they need me for staffing. However, unless that comes about, or the law changes *very soon* (extremely slim chance), FORCED RETIREMENT is right around the corner for me.

Incredibly, I recently discovered that if I hadn't done so well as I began my career (i.e. if I had "washed out" at Cleveland Center, been demoted to Flight Service, then worked my way back to controlling traffic), I would not be facing MANDATORY SEPARATION. It was just last July that I learned that several of my colleagues, who hired in around the same time as I, are NOT subject to the "ATCS Age 56 Law." Shortly after I became aware of this incredibly unequal treatment, I had an employment attorney look into this. The attorney informed me that a challenge to the law would be exceedingly costly, and have *a very low probability of success* (see 20101203142252625.pdf). I recently wrote my congressional representative about this situation (see Letter to

Austria and Mica 2010-11-20.pdf).

If you wish to learn more about AGEISM IN AIR TRAFFIC CONTROL, you may find it helpful to read my Sep 17, 2010 paper, In support of the Fair Treatment of Experienced Air Traffic Controllers.pdf, and my earlier July 22, 2010 paper entitled Tom_Lusch_On_Faa_Forced_Controller_Retirement.pdf. Interestingly enough, I have discovered that the FAA is currently in the process of questioning its own policy, and in a year or two may end up recommending that Congress change Public Law 92-297. If you ask me, the expedient and simple thing would be for Congress to change the law so as to maintain the early retirement provision for those air traffic controllers who are “burnt out” (so that they may to exit gracefully), but allow those of us who are not burnt out to continue to serve till age 65 (i.e. make the FAA controller mandatory retirement age equal to the commercial pilot mandatory retirement age).

Thomas G. Lusch
December 9, 2010

Update, January 4. 2011: Yesterday I received the official denial to my 2nd waiver request (see LuschWaiverDenial20101223.pdf).

P.S. In my July 22 paper, I made mention of controller fatigue. Review this ATSAP Alert from September 27, 2010 that discusses this very important safety concern. We are long overdue for a change in controller scheduling. [ATSAP is by far one of the most important programs that the FAA has created.]

P.P.S.S. In Feb 2000 I launched “Lusch’s Midair Collision Investigations” at http://home.columbus.rr.com. Due to situations not under my control, that site went dark on Dec 12, 2008. Shortly thereafter I launched this site.

[Note: If you’re a central Ohio aviator or interested in aviation in Central Ohio, I recommend that you consider subscribing to NOTAM-KCMH, an announcement web site that I created back in 2000.]

Supporting documents for "Is the FAA's mandatory separation law for air traffic controllers rationally related to a legitimate government purpose?"...

TomLuschWaiverRequest.pdf
LuschWaiverApproval20090807.pdf
Lusch2ndWaiverRequest.pdf

From: Tom Lusch <tomlusch@yahoo.com>
Subject: **Re: Sort box schematic**
Date: December 28, 2009 10:29:07 PM EST
To: John Farmer <bcr@bluecollarrepublican.com>
Cc: Glen Schulze <g_schulze@msn.com>

John,

The link to the following document...

http://www.scribd.com/doc/13950396/T8-B3-FAA-GI-Region-Fdr-AA-77-Radar-Info-Emails-Withdrawal-Notice-Memo-and-Questions
...doesn't exactly show us the sort box boundaries, nor does it tell us how each sort box was adapted (all the radar sites that were assigned, and in what order they were assigned), but it is a very rich source of information regarding the radar sort boxes in the area of AAL77's disappearance.

Tom

From: Tom Lusch <tomlusch@yahoo.com>
To: BCR <bcr@bluecollarrepublican.com>
Cc: Schulze Glen <g_schulze@msn.com>
Sent: Wed, December 23, 2009 2:36:26 AM
Subject: Re: Sort box schematic

John,

I had cc'd you (on Sep 14th) with a slightly earlier version of the attached draft. This attachment doesn't have graphics, but I included notations about where the radar sort box boundaries were in relation to AAL77.

One of the things that I feel is ***an extremely important aspect to bring to light*** concerning the NTAPs that you obtained via the FOIA process, is that AAL77 was displayed to ZDC controllers as a "weak" primary along the greater portion of its return to the Pentagon. For instance, concerning ZDC I calculated "Out of 197 possible target symbols displayed from 12:58:44, 59 (30%) were Long Run Length Primary, 129 (65%) were Short Run Length Primary, and 9 (5%) had no symbols (missed hits?)." The fact that 70% of the time AAL77 appeared on the ZDC display like" clutter" or "anomalous propagation" would certainly explain why any ZDC Low-Altitude controller looking at their ZDC display would have not readily noticed a B757 with its transponder turned off, rapidly moving east towards Washington D.C.

I *believe* that abysmal performance is directly related to the what I found when I correlated the Target Run Lengths in the COMDIG with the displayed symbols, which showed Target Run Lengths of 13, 14, & 15 appearing as a strong "+" symbol, whereas Target Run Lengths of 9, 10, 11, 12, *as well as strong values of 16, 17, 18, and 19, displayed as a weak "." symbol*.

It *appears* to me that there *may be* a software error in the ARTCC presentation of primary targets, and that this LATENT ERROR *may* have existed all along! This possible coding error may explain a lot as to why Center controllers rarely have faith in tracking a primary-only targets. I know from the 11 years I worked at ZOB, I was always amazed at the amount of clutter on our screen, yet baffled as to how when an airplane had a transponder that became inoperative, it would not show up as a consistently strong primary return.

I encourage you to dig deeper into these aspects of the presentation of AAL77 as a primary target, confirm my initial findings for yourself, and build upon that for your book. I would certainly be able to guide you along this path.

I would be doing more, but I simply have scant time to pursue this. My latest intent was to take some vacation days in January (while my 3-year old son would be in daycare), as that is the only way I can have a block of time to concentrate without distraction. :)

Tom

On Dec 22, 2009, at 3:10 PM, Tom Lusch wrote:

> John,
>
> The NTAP data shows the position of AAL77 in both X and Y coordinates (as well as Latitude/Longitude coordinates). I pretty sure Glen did some of his plots using the X/Y data, but I'm at work, at don't have my files handy.
>
> With the X/Y data, one can draw lines at every mulitple of 16 and "see" the boundaries of the radar sort boxes.

My desire is to have a plot of these points, but to make each of those points correlate with the "." symbols (weak "short run length" primary target) and "+" symbols (strong "long run length" primary targets), so as to illustrate how AAL77 was so poorly displayed.

Tom

From: BCR <bcr@bluecollarrepublican.com>
To: Tom Lusch <tomlusch@yahoo.com>
Cc: Schulze Glen <g_schulze@msn.com>
Sent: Tue, December 22, 2009 2:16:09 PM
Subject: Sort box schematic

Tom,

Do you have a graphic for the sort box(s) involved in the AAL77 incident? It would be nice to have some specific boundaries for the sort boxes in the HNN area.

John

It is time for a ***Paradigm Shift*** in the processing of ATC surveillance data

Williard C. Meilander <contact> has been writing about the need for a paradigm shift in the processing of radar data *for the past several decades*. He consistently speaks of the need to change to a SINGLE THREAD INSTRUCTION STREAM (STIS) processor. Meilander wishes to refer you to the 1963 Federal Aviation Agency Specification (Central Computer Complex For Engineering Model Of National Airspace System...FAA-ER-606-063), wherein it states (with *my* emphasis added)...

2.3 Automatic Tracking.- Automatic tracking will compute positions and velocities ***for all tracks*** carried by the system. This includes the automatic processing of radar data, both beacon ***and search***, and flight plan data to obtain position and velocity estimates for each track..

Meilander points out that *to this day* SEARCH radar (i.e. primary “skin paint” radar returns) are not automatically tracked, such as when an aircraft's transponder fails or is turned off (i.e. the hijacked aircraft of 9/11, *especially* AAL77, which was lost on Indianapolis Center’s displays and resulted in the fact that no one knew it was headed back east towards Washington, DC...it ultimately was crashed into the Pentagon). Meilander points out that the specification from 1963 calls for much better performance than we currently have reached some *four-and-a-half decades later!*

Meilander states that we don’t have a radar problem...rather, we have a computational problem. With current methods, we do not process the ***excellent*** radar data that is received. Meilander stresses that this is a database management problem. Meilander continues to offer ***a simple, much less expensive alternative***. Meilander advises that the '63 spec acknowledged that the ATC problem is, in fact, a database management problem, in that table structures, including data elements, linking records structure, etc, were defined.

Meilander invites you to read a short (3 page) description of the paradigm shift he recommends. Read “A Quick Look at a Real-Time ATC Solution.pdf.”

Wish to understand more? Below is a list of *some* of the papers that Meilander has authored and/or co-authored wherein he describes this alternative approach to radar data processing. Where possible, hyperlinks to his papers (or to other official references) are made available...

1. •Real-Time Database Scheduling Simplicity [2009]
2. •Optimal Real-Time DB Management [2008]
3. •A new paradigm for real-time database management [2007]
4. •Overview of Air Traffic Control using an SIMD COTS system [2005]
5. •Importance of SIMD Computation

Reconsidered [2003]

6. •Tractable Real-Time Air Traffic Control Automation [2002]

7. •Predictable Real-Time Scheduling for Air Traffic Control [2002]

8. •The Power of SIMDs vs. MIMDs in Real-Time Scheduling [2002]

9. •Interarchitecture Comparative Analysis [2001]

10. •Predictability for Real-Time Command and Control [2001]

11. •Real-Time Scheduling in Command and Control [1999]

12. •In Air Traffic Control - The Solution is the Problem in Proceedings of the 1st International Workshop on Real-Time Mission-Critical Systems: Grand Challenge Problems , IEEE, Phoenix, AZ (1999)

13. •ATC Architecture Computers – Yesterday, Today, Tomorrow, 43rd Annual Air Traffic Control Association Fall Conference Proceedings, pages 91-95, (1998)

14. •Ground Based Collision

Avoidance—Revisited [1989]
String together the following 8 links *GBCA1, GBCA2, GBCA3, GBCA4, GBCA5, GBCA6, GBCA7, GBCA8*

15. •Array Processor Supercomputers [1989]

16. •Application of an associative processor to aircraft tracking [1975]

17. •Surveillance Netting Study, June 1974, Goodyear Aerospace Crop. Contract F19628-74-C-0400.

18. •Ground Based Collision Avoidance, ATCA 17th Annual Meeting and Technical Program, 9-11, October 1972.

19. •The Coming of Age of the Associative Processor, Electronics 1971

20. •Application of the Associative Memory System to Air Traffic Control, Ger 11160 23 July, 1963 Goodyear Aerospace Corp.

Thomas G. Lusch
August 16, 2010

Five ARSR views of AAL77 from 12:55:06.2Z thru 12:57:56.9Z

This file created July 8, 2009. Data compiled from the following FAA FOIA files as found on http://aal77.com/...

"1 ZID 54 QBE Beacon Data.pdf", "1 ZID 55 QBE2 Primary Targets.pdf", and "1 ZID 42 NTAP.pdf"

QRI showed no primary target on AAL77 during period analyzed.. Squawk was 3743 until Line 43. Mode C of all transponder replies was 35,000 ft.

The point of this analysis is to exemplify that there is considerable radar data that is NOT utilized.

Note: Radar data from 3 other ARSRs within range (PIT, IND, & QRM) has not been found in the aal77.com FOIA data.

Line No.	Time (UTC)	ARSR	Bearing from ARSR	Range from ARSR	Beacon Target?	Radar Reinforced or Primary Target?	Target available on ZID Displays?	Comments
1	12:55:06.2	QHY	275.888	50.625	Y	N	Y	On ZID display at X=362.6875, Y=216.1875
2	12:55:06.4	CLE	195.820	157.000	Y	Y	N	Note: CLE identifier is also known as QDB.
3	12:55:07.4	QRI	6.855	112.875	Y	-N-	N	
4	12:55:09.5	QWO	147.304	76.125	Y	Y	N	
5	12:55:10.0	QBE	298.388	165.125	Y	Y	N	
6	12:55:16.5	CLE	196.083	157.875	Y	Y	N	
7	12:55:17.4	QRI	6.328	112.125	Y	-N-	N	
8	12:55:18.3	QHY	274.833	51.875	Y	N	Y	On ZID display at X=361.3750, Y=215.3750
9	12:55:19.6	QWO	148.183	76.125	Y	Y	N	
10	12:55:21.9	QBE	297.861	165.875	Y	Y	N	
11	12:55:26.6	CLE	196.611	158.875	Y	Y	N	
12	12:55:27.4	QRI	5.800	111.250	Y	-N-	N	
13	12:55:29.7	QWO	149.062	76.250	Y	Y	N	
14	12:55:30.2	QHY	273.779	53.000	Y	N	Y	On ZID display at X=360.1875, Y=214.4375
15	12:55:33.9	QBE	297.509	166.625	Y	Y	N	
16	12:55:36.8	CLE	196.699	160.000	Y	N	N	
17	12:55:37.5	QRI	5.449	110.375	Y	-N-	N	
18	12:55:39.9	QWO	150.380	76.625	Y	Y	N	
19	12:55:42.2	QHY	272.460	54.125	Y	N	Y	On ZID display at X=359.0625, Y=213.2500
20	12:55:45.8	QBE	296.982	167.125	Y	Y	N	
21	12:55:46.9	CLE	197.050	161.250	Y	Y	N	
22	12:55:47.5	QRI	5.009	109.250	Y	-N-	N	
23	12:55:50.0	QWO	151.171	77.000	Y	Y	N	
24	12:55:54.2	QHY	271.142	55.125	Y	N	Y	On ZID display at X=358.0625, Y=212.000
25	12:55:57.0	CLE	197.138	162.500	Y	Y	N	
26	12:55:57.5	QRI	4.570	108.125	Y	-N-	N	
27	12:55:57.7	QBE	296.455	167.500	Y	Y	N	
28	12:56:00.1	QWO	151.962	77.625	Y	Y	N	
29	12:56:06.2	QHY	269.736	56.000	Y	N	Y	On ZID display at X=357.1875, Y=210.6875
30	12:56:07.2	CLE	197.666	163.750	Y	N	N	
31	12:56:07.6	QRI	4.482	106.875	Y	-N-	N	
32	12:56:09.6	QBE	295.927	167.625	Y	Y	N	
33	12:56:10.2	QWO	152.841	78.375	Y	Y	N	
34	12:56:17.2	CLE	197.402	165.125	Y	Y	N	
35	12:56:17.6	QRI	4.042	105.625	Y	-N-	N	
36	12:56:18.2	QHY	268.330	56.625	Y	N	Y	On ZID display at X=356.6250, Y=209.2500 (last)
37	12:56:20.4	QWO	153.632	79.250	Y	Y	N	
38	12:56:21.5	QBE	295.488	167.625	Y	Y	N	
39	12:56:27.4	CLE	197.753	166.375	N	Y*	N	*=S1 (Search Radar)
40	12:56:27.6	QRI	3.867	104.250	Y	-N-	N	
41	12:56:30.2	QHY	266.660	57.250	Y	N	N	This target not on ZID display due to sort box assignments
42	12:56:30.5	QWO	154.335	80.375	Y	Y	N	
43	12:56:33.4	QBE	294.785	167.375	Y*	Y	N	*=Transponder code changed to 6743.
Note: The COMDIG radar data terminates after 3 to 4 radar rotations when it no longer finds the 3743 beacon return.								
44	12:56:37.5	CLE	197.314	167.875	N	Y*	N	*=S1
45	12:56:40.6	QWO	154.951	81.500	N	Y*	N	*=S1
46	12:56:45.4	QBE	294.345	167.000	N	Y*	N	*=S1; Also on "1 ZID 55 QBE Primary Targets.pdf"
47	12:56:47.6	CLE	196.875	169.250	N	Y*	N	*=S1
48	12:56:50.7	QWO	155.566	82.625	N	Y*	N	*=S1
49	12:56:57.4	QBE	293.906	166.375	N	Y*	N	*=S1; Also on "1 ZID 55 QBE Primary Targets.pdf"
50	12:56:57.7	CLE	196.962	170.625	N	Y*	N	*=S1
51	12:57:00.8	QWO	155.830	84.000	N	Y*	N	*=S1
52	12:57:09.3	QBE	293.027	165.625	N	Y*	N	*=S1; Also on "1 ZID 55 QBE Primary Targets.pdf"
Above COMDIG radar data was from "1 ZID 54 QBE Beacon Data.pdf". COMDIG radar data from here on is from "1 ZID 55 QBE2 Primary Targets.pdf"								
53	12:57:21.2	QBE	292.675	164.750	N	Y*	N	*=S1
54	12:57:33.0	QBE	292.324	163.750	N	Y*	N	*=S1
55	12:57:45.2	QBE	291.884	162.500	N	Y*	N	*=S1
56	12:57:56.9	QBE	291.621	161.250	N	Y*	N	*=S1
There are 44 more primary (search radar) targets from QBE shown on "1 ZID 55 QBE2 Primary Targets.pdf"								

Unsatisfactory **C**ondition **R**eport – #330069

Thomas G. Lusch

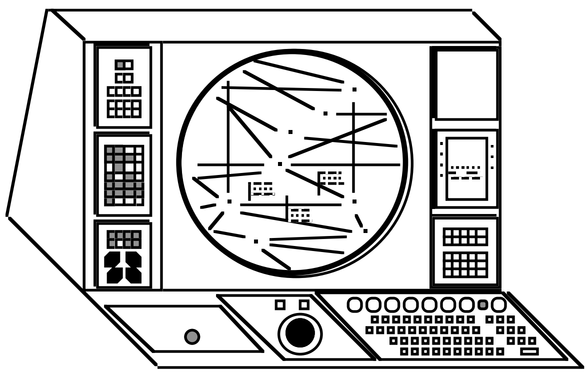
ZOB AREA 5

September 26, 1988

Selective Rejection of Low Altitude Radar Data

at Air Route Traffic Control Centers:

An Unsatisfactory Compromise



By

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Table of Contents

1.0 - Executive Summary

In the National Airspace System (NAS), some important Air Route Surveillance Radar (ARSR) data is not sent to the Air Route Traffic Control Centers (ARTCC's) for processing. In other instances, the radar data which is sent is **not processed for display** since it is **selectively rejected**. The Radar Data Processing (RDP) system is a complex hardware and software package which compels the selective rejection of available and important **low altitude** radar data. There are existing software techniques to deal with some of the compromises in today's system, but these techniques cause clutter on the display, or deal with only a small portion of the problem. A new method of processing low altitude radar data is proposed, to ensure that virtually all of the low altitude aircraft are presented to the air traffic controller.

2.0 - Introduction

The primary purpose of the air traffic control system is to prevent a collision between aircraft. The air traffic controller's first priority[1] is to separate IFR[2] aircraft and to issue a safety alert to the pilot if the controller is aware of another aircraft (IFR or VFR[3]) which may be on a collision course. The tool a controller utilizes in determining conflicts between aircraft is the radar display. If a pilot receives a timely traffic alert, the pilot may spot the threatening aircraft and/or maneuver his aircraft to avoid a collision. It has been demonstrated when two aircraft are on a collision course, the probability of visual acquisition can be improved by a factor of eight if the pilot(s) receive accurate and timely traffic alerts.[4] The display of aircraft in possible conflict is of the utmost importance to the controller, as well as to the flying public.

It is generally believed radar data from the ARSRs[5] is used in an optimal fashion to provide a representation of air traffic to the en route air traffic controller. There is evidence to the contrary. An evaluation of a typical ARTCC shows that some important radar data is not sent to the facility. Also, the current method of processing the radar data which is sent to the facility shows that an aircraft detected by an ARSR may **not be displayed** on the controllers Plan View Display (PVD)[6]. This report outlines significant aspects of the problem of selective rejection that must be solved before there can be confidence the picture presented on the controller's display is the low altitude radar data actually available. Immediate and near term solutions are suggested to deal with the problem of selective rejection.

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[1]Air Traffic Control Handbook, 7110.65E, Chp 2, para. 2-2 (Duty Priority), and para. 2-6 (Safety Alert).

[2]An IFR aircraft is one that is flying under rules that govern the procedures for conducting flight under non-visual (instrument) conditions, such as during flight in clouds where other aircraft cannot be seen. ATC provides instructions to the pilots to keep them safely separated from other IFR aircraft. The pilot of an IFR aircraft must still keep a constant lookout for VFR aircraft and exercise the "see and be seen" concept when not flying in instrument conditions. (IFR = Instrument Flight Rules).

[3]A VFR aircraft is one that is flying under rules that govern the procedures for conducting flight under visual conditions, such as during flight clear of clouds with 3 miles or greater visibility. When a threatening aircraft is seen, a pilot will maneuver his aircraft so as to avoid a midair collision. (VFR = Visual Flight Rules).

[4]"Report of the Interagency Near Midair Collision Working Group", FAA Office of Aviation Safety, December 1987, pg. 4-18.

[5]There are mainly two types of radar used for ATC purposes. The Air Route Surveillance Radar (ARSR) is a long range radar (typically of 200 nautical mile range) which is primarily used to detect an aircraft's position while en route between terminal areas. Airport Surveillance Radar (ASR) has a range of typically 60 nautical miles, and is primarily used to detect an aircraft's position within busy terminal airspace. This paper is not addressing any deficiencies with the radars, rather, this paper specifically deals with the problem of how the data from the ARSRs is processed for display.

[6]An air traffic controller's radar presentation may be termed a "PVD" (Plan View Display), a "radarscope", a "scope", a "screen", or just simply a "display".

2.1 - The Pilot's Role in Being Seen on ATC Radar

In June 1988, the FAA took steps to enhance the radar data transmitted from airborne aircraft by issuing a new ruling which will require that even more aircraft shall be equipped with transponders[7] and altitude reporting equipment[8]. This radar-enhancing beacon equipment will be required in a much greater amount of airspace than was previously required. These new laws will go into effect by the end of 1989. While many aircraft already comply with such equipment requirements, many more pilots will be spending a considerable amount of money in equipping their airplanes with this required transponder equipment. Unfortunately, as will be demonstrated in the following examples, an airplane equipped with such radar-enhancing beacon equipment may not be displayed on the ARTCC controller's screen, even though that aircraft is within ARSR coverage.

3.0 - Discussion

If radar service is provided to one of two aircraft on a collision course, and the other aircraft is detected by radar, but not displayed on the PVD, the controller obviously has no way of issuing a safety advisory or of suggesting an avoidance maneuver. It may be surprising such a scenario is possible. Most people would think it preposterous that such critical data would not be displayed on the radarscope!

It is important to understand, in the discussion that follows, the selective rejection of aircraft targets from the ARTCC display has no bearing whatsoever on how the controller manages the PVD. All examples deal with the ARTCC computer's processing of radar data in the en route environment, over which the controller has no command. It is assumed the controller has the PVD correctly adjusted.[9]

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[7]A transponder is an airborne radar beacon receiver/transmitter which automatically receives radio signals from the ATC radars on the ground, and selectively replies with a specific reply pulse group. This device greatly aides in the identification of aircraft.

[8]ATC radar only shows the azimuth and range of an aircraft---it does not measure the height. Altitude information must be transmitted by use of an altitude encoder which is installed in the aircraft. The altitude data is sent via the transponder. Altitude data greatly improves the quality of service that a controller can provide.

[9]Each PVD has several filter keys which can be adjusted to coincide with the airspace in which the controller is providing radar service. The controller may filter data that is available at the PVD, but if the data is previously filtered, nothing the controller can do will make that data appear.

3.1 - MOSAICING (or the Radar Sort Box COMPROMISE)

Mosaicing is an unfortunate approach to the problem of a computer having to deal with multiple radar reports of one aircraft from several radar sites. Mosaicing has been described as a system in which the "best" radar data available is utilized. Under this definition, "best" radar data is not all radar data, and often it is not the optimum radar data. Most airborne aircraft are detected by several ARSR sites simultaneously.[10]

Mosaicing reduces the large ARSR radar coverage of an ARTCC into hundreds of small boxes, and "optimizes(?)" the coverage for each radar into "preferred," "alternate preferred," and "supplemental[11]" categories. These boxes are referred to as Radar Sort Boxes (RSBs). RSBs are rectangular areas of airspace (16 by 16 nautical miles) which are an aid to the computer in reducing the amount of data it must process.[12] A grid of RSBs cover the entire control area of an ARTCC. 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. Mosaicing creates some very undesirable situations in the low altitude environment by not displaying all of the critical radar data which the controller must have in order to perform his job with confidence.

3.1.1 - Missing Data in the Air Traffic Controller's Picture

Figure 1 gives an approximation of Cleveland ARTCC's (ZOB's[13]) lateral boundaries superimposed on 473 squares (radar sort boxes). The boxes are shaded to show the mosaicing, or coverage utilized, of the eight ARSRs supplying data to ZOB. (An extension beyond the boundary of approximately two RSBs is included since it is customary for a controller to provide radar service to an aircraft for 20-30 miles before it enters ARTCC airspace.) Radar data is

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[10]Most aircraft are also "seen" (detected) by some of the many Airport Surveillance Radar (ASR) sites within an ARTCC's area. For example, there are twenty one (21) ASRs located at busy airport terminals that are within or overlap the Cleveland ARTCC area. Data from the ASR sites is not merged with the data from the ARSR sites.

[11]One RSB may have up to four radar sites assigned, but one and only one radar site is used at any given time, except in a few special cases where double-preferred coverage is utilized. Data from a radar site that is programed to be "supplemental" is utilized in that sort box only if the preferred radar site is out of service.

[12]The data must be reduced, simply because the current processors cannot handle the overwhelming amount of data that is presently available.

[13]ZOB is one of the many 3-letter identifiers used in Air Traffic Control. The letter Z indicates an ARTCC, and the next two letters refer to the facility (i.e. OB = Oberlin. Cleveland ARTCC is located in Oberlin, OH, which is approximately 30 miles from Cleveland, OH).

collected at each radar site, processed, and sent to the "HOST"[14] computer over telephone lines or microwave link. There are three ways by which important radar data is not utilized in building the controller's radar picture. Cleveland ARTCC is used in the following examples. It should be understood that ZOB is processing radar data in similar fashion to other ARTCC's. The problems presented here are symptomatic of the entire ARTCC radar data processing system, not just Cleveland ARTCC.

The following discussion concerning compromises made in the display of aircraft on the controller's display deal with aircraft in the low altitude environment. Over half of all near midair collisions occur below 5,000 ft above ground level (AGL).[15]

[14]The HOST computer is a dual set of IBM3083's, which quite recently replaced the much older IBM9020A & D computers at the 20 conterminous ARTCC's. The term "HOST" was used, since the new computer utilized basically the same programing code as the older computers. The 3083, in effect, "hosted" the existing software.

[15]"Report of the Interagency Near Midair Collision Working Group", FAA Office of Aviation Safety, December 1987, pg. 3-12.

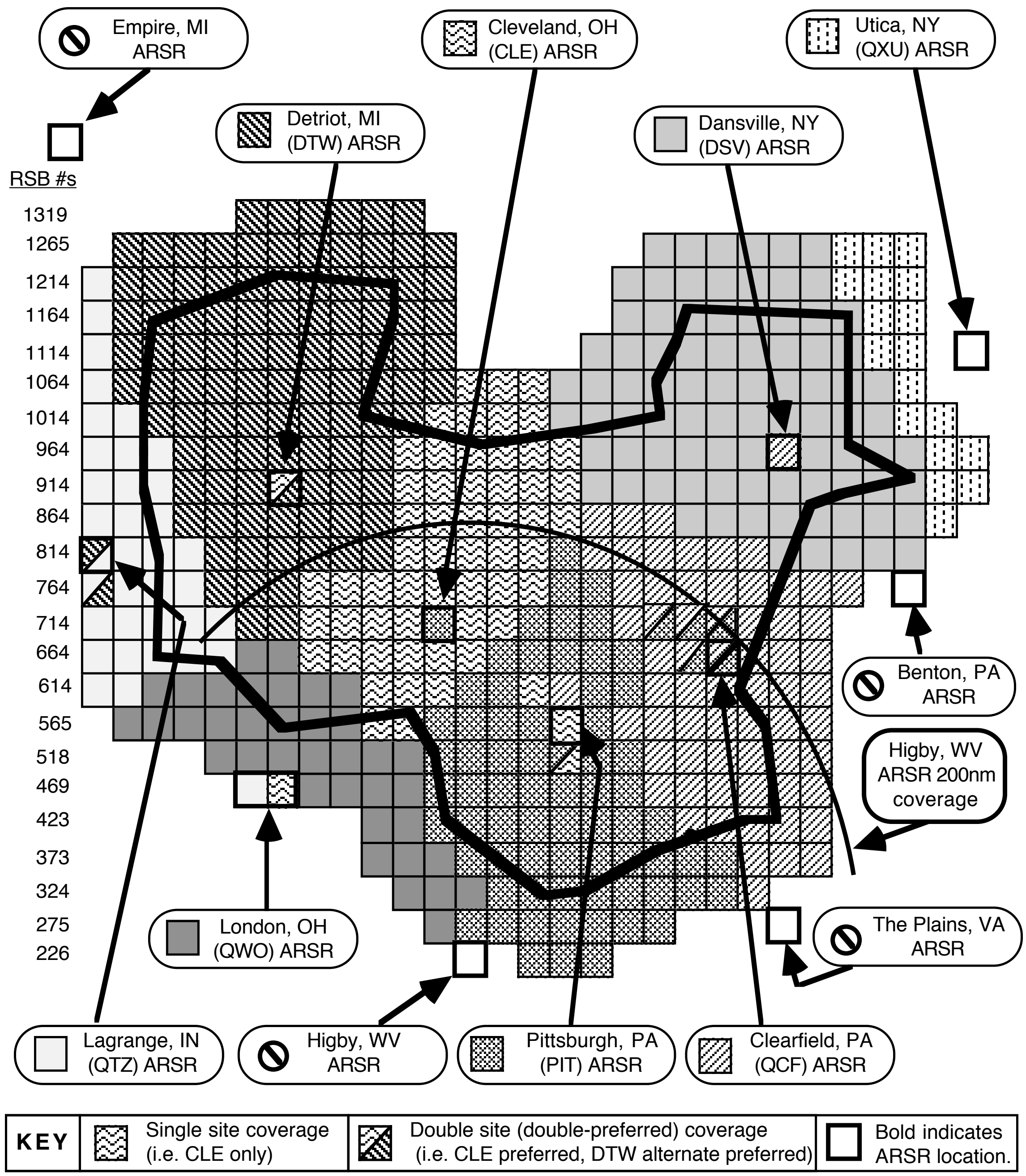

Figure 1 - A representation of ZOB's Radar Sort Box programing[16]

[16]RSB data derived from Cleveland ARTCC's ACES (Adaptation Controlled Environment System) computer listing of 05/05/88.

3.1.1.1 - Compromise #1 (The Data Exists, but is <u>not</u> "On-Line")

Any pilot departing the Cumberland, Maryland airport (CBE) to the southeast will find the airplane's transponder will be replying to interrogations from ATC radar much sooner than the ZOB controller will advise (if ever) of "RADAR CONTACT." Likewise, when an aircraft landing at CBE is handed off from Washington Center to Cleveland Center, the pilot will be told "RADAR SERVICE TERMINATED" or "RADAR CONTACT LOST," yet the pilot can observe that the airplane's transponder will continue to reply to ATC radar interrogations until the aircraft descends through approximately 5,000 ft. MSL[17]. This arriving aircraft may be flying between 5,000 to 6,000 ft. MSL for 25 miles without radar service from ZOB, even though radar coverage exists from an ARSR. Such a dichotomy is probably confusing to the pilot.

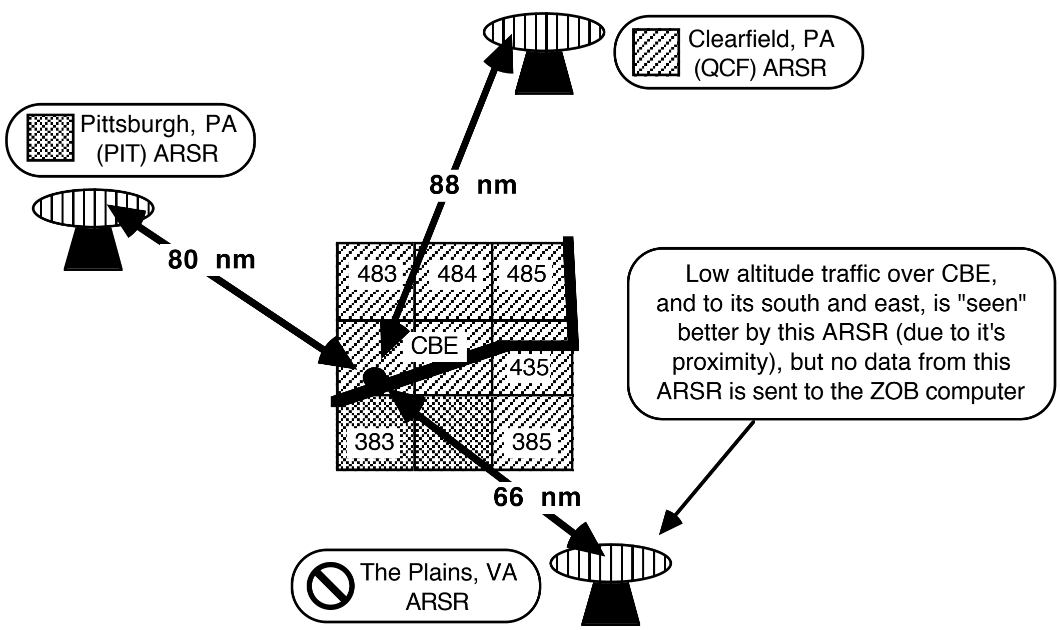

Figure 2. ARSR coverage in the Cumberland, MD area.

Figure 2 shows CBE located within ZOB's RSB #433. This RSB is utilizing the "best" radar site for this airspace, which is the ARSR located at Clearfield, PA (QCF). QCF is located approximately 88 nautical miles (nm) north of the CBE airport. The Pittsburgh, PA (PIT) ARSR (which is utilized for the two sort boxes just to the south and southeast of CBE) is approximately 80 nm northwest of CBE. The ARSR which Washington ARTCC utilizes in this area is located at The Plains, VA, which is only 66 nm to the southeast of CBE. Twenty-two nautical miles can

[17]Altitude expressed in feet measured from mean sea level.

make a great difference to an ARSR when dealing with the detection of low altitude aircraft. Due to the line-of-sight nature of radar, many low altitude aircraft in the vicinity of Cumberland are effectively below the horizon of the QCF and PIT ARSRs. Unfortunately, radar data is not utilized from the more suitable (closer proximity) ARSR which is located at The Plains, VA, simply because it is not "on-line." ZOB receives no data from it whatsoever.

The Cumberland, MD area is not the only area where radar service is provided from a less than optimal ARSR. Figure 3 illustrates this same problem that occurs near the Parkersburg, WV VOR.[18]

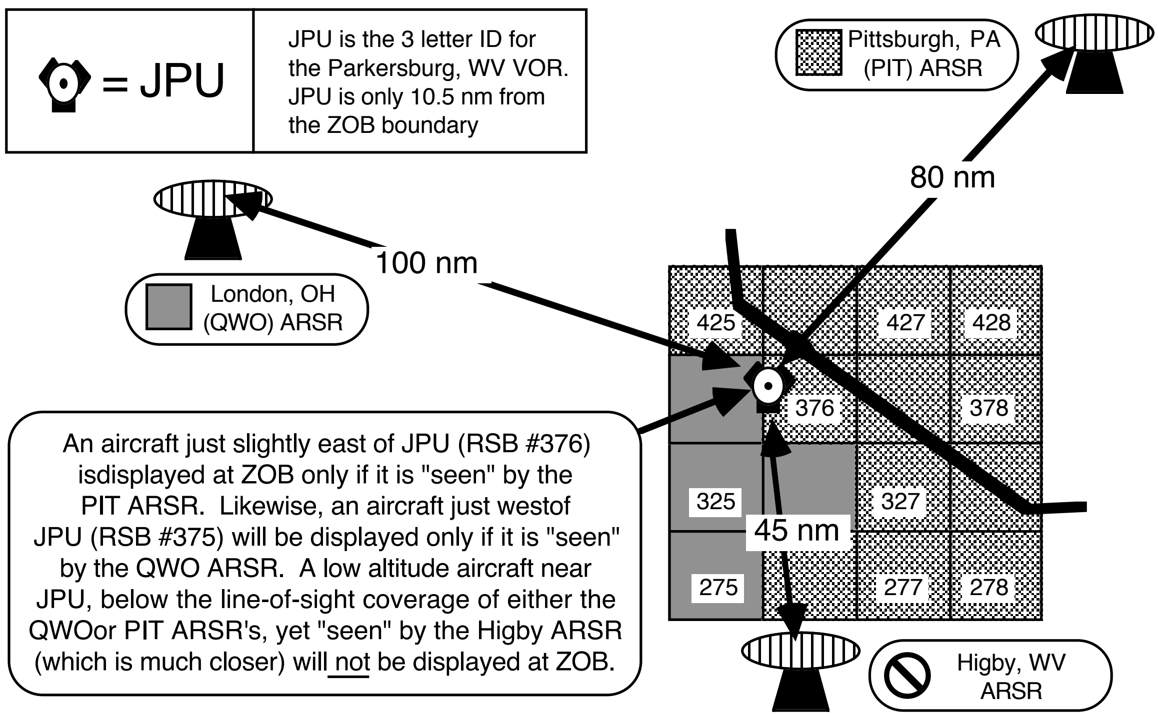

Figure 3. ARSR coverage in the Parkersburg, WV area.

Similar conditions may occur anywhere within the NAS where existing radar data is not "on-line" to a facility.

[18]A VOR is a radio navigational aid that provides azimuth information to aircraft. VOR stands for **V**ery High Frequency **O**mnidirectional **R**ange station.

3.1.1.2 - Compromise #2 (The "Cone of Silence" Excuse)

Figure 4 shows a typical example of how a RSB that lies directly over a radar site may be programed to not display existing radar data. RSB #725 overlays the ARSR located near Cleveland, OH. With all radars working normally, this 256 square miles of airspace is programed to use data received from the PIT ARSR only.

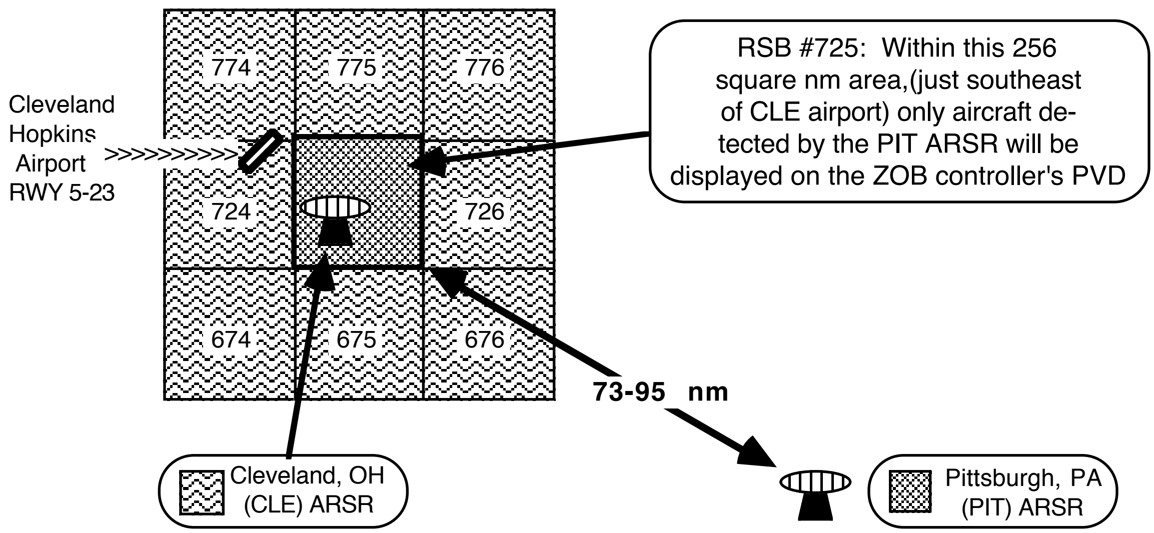

Figure 4. RSB programing near Cleveland, Ohio's main airport.

The airspace contained in RSB #725 lies just to the south and east of Cleveland Hopkins (CLE) airport. Under normal circumstances Cleveland Approach Control[19] has responsibility for aircraft in this airspace below 11,000 ft. MSL, utilizing the Cleveland ASR, which is totally independent of any ARSRs that ZOB utilizes. There have been occasions, however, such as the period of approximately April 15-19, 1988, when Cleveland Approach Control's ASR was out of service. The approach control operated from ZOB, utilizing ZOB's radar display. Low altitude aircraft (below approximately 5,000 ft. MSL) that fly within this 256 square mile area of RSB #725 are **not displayed** for the controller because they are below the line-of-sight coverage of the PIT ARSR, which is located from between 73 to 95 nm to the southeast. Aircraft that depart Cleveland Hopkins airport are immediately displayed on the ZOB controller's PVD as they become airborne, since the airspace directly over CLE airport utilizes radar data from the CLE ARSR, which is located just 9.5 nm to the southeast of the airport. However, the ZOB display loses (selectively rejects) a southeast bound departing aircraft as soon as it enters RSB #725, which occurs

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[19]An approach control (commonly located at the busy airport which it serves) provides service similar to an ARTCC, but typically utilizes only one radar site (an ASR) designed for it's much smaller geographical area. An ARTCC (commonly not located at an airport) handles en route traffic between approach controls.

approximately 4 nm east of the airport. RADAR CONTACT is re-established if/when the aircraft climbs above approximately 5,000 ft. MSL, or exits sort box #725. It is important to understand that most low altitude aircraft within this 256 sq. mi. area are detected by the CLE ARSR, unless they happen to be directly over the top of this ARSR, in its "cone of silence"[20]. The cone of silence at 5,000 ft. above the radar antenna is about four square miles, which is only 1.5% of the 256 square mile sort box! This cone of silence is the reason why this radar sort box is programed to not make use of the CLE ARSR data.[21] Failure to display low altitude aircraft just southeast of Cleveland Hopkins airport is unsafe. This lack of such critical data being displayed is due to the compromise of displaying data from **one and only one radar site** within a given RSB.

3.1.1.3 - Compromise #3 (The Midpoints - a Forced Choice)

Another undesirable situation may occur approximately midway between two ARSRs. Consider the data displayed within RSB #681, as illustrated in Figure 5, which lies approximately midway between the PIT and QCF ARSRs.

[20]ARSRs and ASRs do not 'look up', hence, an aircraft which flies directly over the radar antenna is not able to be detected by that radar. However, if the aircraft is at a high enough altitude, it will be detected by other (distant) ARSRs when it is within this "cone of silence".

[21]RSBs # 469, 470, 579 & 986, as illustrated in Figure 1, are programed similarly.

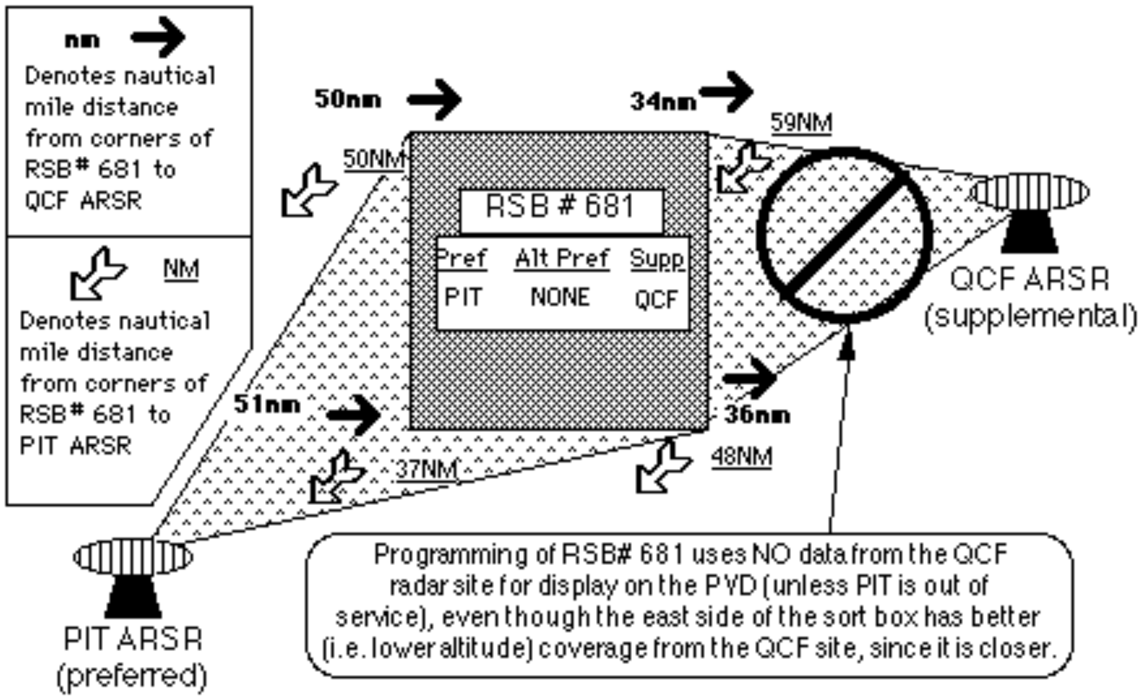

Figure 5. Better coverage changing within a RSB.

Mosaicing forces a choice to be made as to which ARSR will provide the "best" coverage. As figure 5 illustrates, the east half of RSB #681 may be best covered by the QCF ARSR (since it is closer), and the southwest corner best covered by the PIT ARSR. Data from **one and only one radar site** is utilized, and in this case the site chosen was the PIT ARSR. Unfortunately, an eastbound aircraft (Airplane A in Figure 6) in the northeast corner of RSB #681, but just below the line-of-sight coverage of the PIT ARSR (although within QCF ARSR coverage), may be on a collision course with a westbound aircraft (Airplane B). A controller who may be providing radar 'service' to Airplane B, located just to the east of RSB #681, would not have Airplane A on his PVD, even though airplane A would be replying to transponder interrogations (complete with altitude data) from the QCF ARSR.

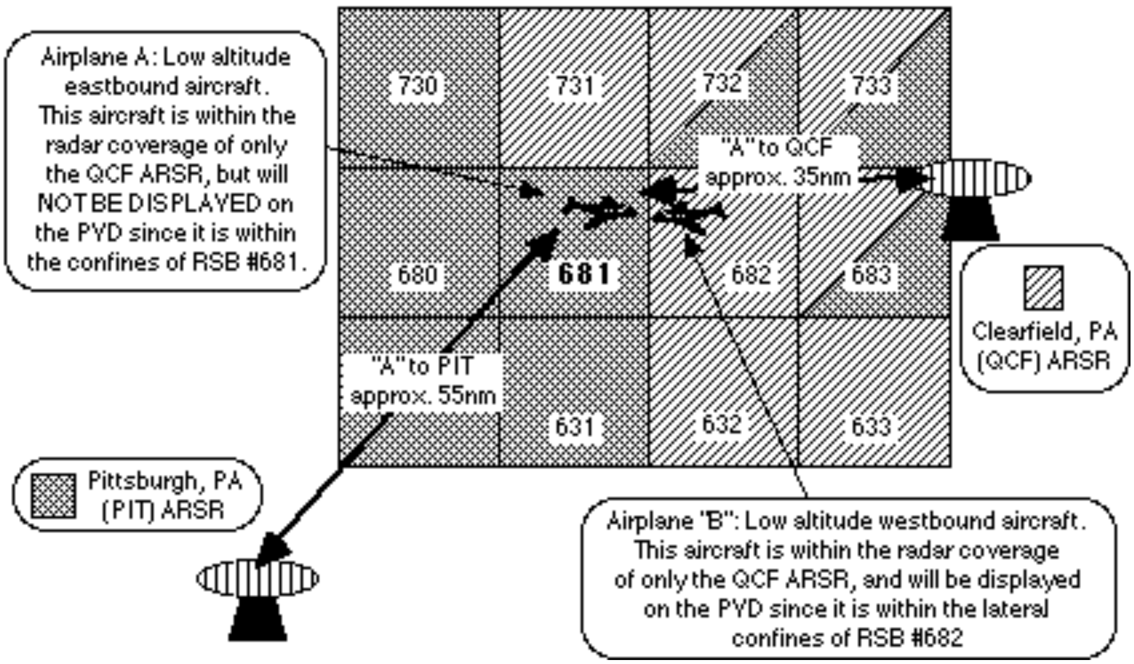

Figure 6. Two aircraft on collision course, both within radar coverage, but only the westbound aircraft is displayed on the controller's PVD.

A review of Figure 1 depicts many sort boxes which lie approximately midway between ARSRs. Is true 'best' coverage really provided by **one and only one radar site** per given sort box? The situation illustrated in Figure 6 could occur at any of these midpoints between ARSRs where the truly **best** coverage may change from one ARSR to another within a sort box. Figure 7 illustrates a similar condition that exists in airspace that is not quite midway between two ARSRs.

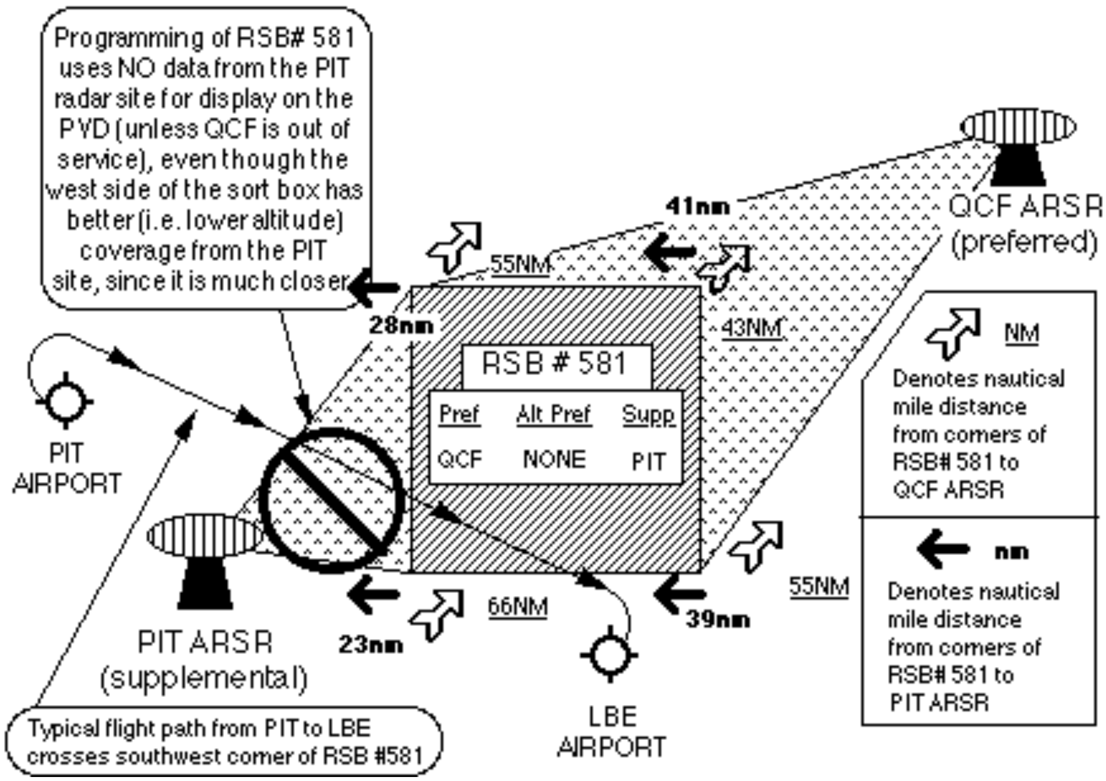

Figure 7. Sort box programing north of Latrobe, PA (LBE) airport.

An aircraft en route from the Greater Pittsburgh, PA (PIT) airport to the Latrobe, PA (LBE) airport will commonly traverse through the very southwestern edge of RSB #581. Typically during the transition through the southwest corner of this sort box, the aircraft will be at a low altitude and beginning a descent for landing at LBE. It is entirely possible that another aircraft, operating VFR, could be on a collision course with the aircraft being provided radar service, yet just below the line-of-sight coverage of the QCF ARSR, which is approximately 65 nm to the northeast. Most likely, this conflicting VFR aircraft is within the coverage of the PIT ARSR, since the aircraft is only approximately 24 miles to the east of this radar. Since the computer will only utilize the QCF ARSR to display traffic within this airspace, the ZOB controller will be unable to issue a safety alert to the aircraft beginning a descent for landing at LBE, simply because the conflicting aircraft is **not displayed**, even though it is detected by the supplemental ARSR. A difference of approximately 40 nm can be very meaningful when one considers the line-of-sight propagation of radar signals, the curvature of the earth, and low altitudes.

Why would an ARSR that is so far away be utilized when there is a much closer ARSR, such as in the case of RSB #581? The answer is not always obvious, but may have to do with poor coverage along a single azimuth of the closer ARSR, which affects a small but important portion of that same RSB. Unfortunately, when a RSB has an anomaly causing a small portion of poor coverage to exist from a seemingly appropriate (close proximity) ARSR, another (more distant) ARSR may be programed as "preferred."[22] When such a compromise is made, it unfortunately affects the entire sort box, or 256 square miles of airspace. As can be seen, utilizing a more distant ARSR for radar coverage in such circumstances can have a significant affect on the radar presentation, especially in the low altitude environment.

4.0 - Dealing with the Compromises - Immediate and Comprehensive Solutions

If a problem exists, there is most likely a solution. Selective rejection of radar data, by use of radar sort boxes, is a solution to the problem of dealing with an overwhelming amount of radar data, which our present computer system cannot adequately handle. Unfortunately, such a solution brings along with it a major compromise in the display of low altitude traffic. A solution to each previously mentioned compromise is offered.

4.1 - Solution #1 - The Data Exists- Let's Bring it "On-Line"

The discussion involving Compromise #1 dealt with two ARSRs (located at The Plains, VA and Higby, WV) which, simply by their proximity to the airspace in the examples, would obviously provide superior low altitude radar coverage. The concentration of VFR traffic in the low altitude environment, coupled with the greater percentage of near midair collisions within this low altitude structure, should be a strong motivation toward utilizing such important radar data from currently available, but unused ARSRs.

4.2 - Solution #2 - The Data Exists - Let's Not Reject It!

The currently utilized solution to overcome the problem of selective rejection of aircraft targets using existing software is rather simple and easily accomplished. This involves adapting a RSB to utilize the data from more than one radar site simultaneously (double-preferred coverage). This solution is less than attractive from a human engineering standpoint because it results in

[22]In addition to RSB #581, notice RSBs # 628 & 629 as illustrated in Figure 1. They are programed in a similar fashion, utilizing an ARSR much further away.

unwanted clutter[23]. This "quick and dirty" solution will easily remedy the problems of compromises # 2 & 3, however, due to the problem of visual clutter on the display, such programing methods are scantily utilized. The documentation for the NAS software specifically cautions against the use of double-preferred coverage.

> "Caution should be used in adapting double-preferred coverage (02 or 03). This coverage will result in the display of *all* radar returns from both radar sites."[24]

Figure 8 illustrates the presentation of this unwanted clutter (the display of double targets of the same aircraft) when double-preferred coverage is utilized, while it also illustrates how a VFR aircraft within radar coverage may be displayed (**or intentionally <u>not</u> displayed**) under four different circumstances.

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[23]Clutter, in this discussion, refers to excessive display of data on the PVD that is not needed (nor wanted) to perform the controller's job.

[24]National Airspace System Configuration Management Document, Model A4e0.1 En Route Stage A, Computer Program Functional Specifications, Adaption Collection Guideline, NAS-MD-326, pg. 7-18 (*emphasis added*).

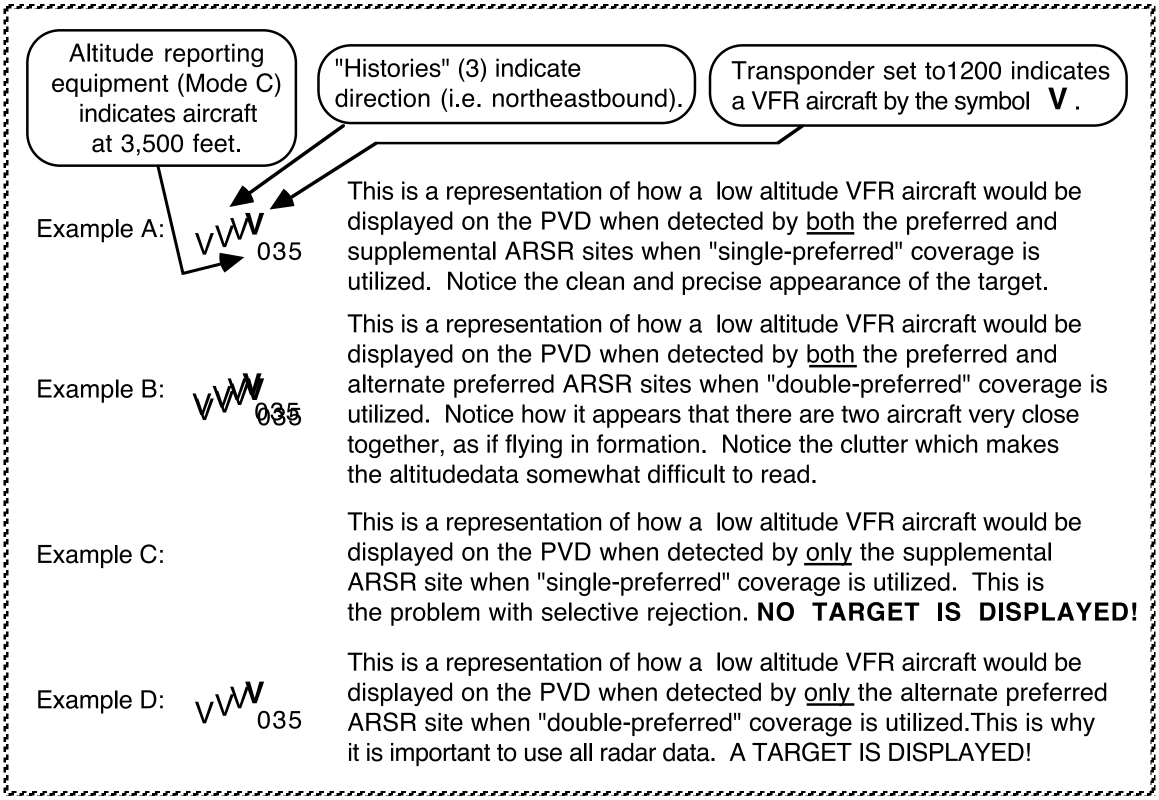

Figure 8. The display of targets utilizing double-preferred coverage versus the display of targets utilizing single preferred coverage.

When using "double-preferred" coverage, an aircraft's radar return that is detected by both the designated preferred and alternate preferred ARSRs of a given sort box will show as two targets. These two displayed targets will likely be in slightly different locations, due to the slight misalignment of the ARSRs, inherent radar errors, and the fact that the ARSRs detect the targets at slightly different times.[25] Nevertheless, such "double-preferred" programming occasionally results in important data (i.e. beacon code and/or altitude data of a single aircraft) becoming difficult to read on the PVD because of overlap, as illustrated in Figure 8(B). Double-preferred coverage, while providing the controller with superior low altitude radar data, is currently kept to an absolute minimum. Figure 1 shows only 9 of 473 RSBs utilizing data from two ARSRs simultaneously.[26] The elimination of this visual clutter by not utilizing double-preferred coverage

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[25]If the preferred ARSR detected the aircraft a few seconds before (or after) it was detected by the alternate preferred ARSR, it would rightly be in a different location, as an airborne aircraft is constantly moving.

[26]Double-preferred coverage is utilized in RSB # 529, 683, 684, 732, 733, 734, 764, 814, & 920, as illustrated in Figure 1.

may often mean the elimination of some important low altitude aircraft from the controller's display, as illustrated in Figure 8(C).

The other currently used solution for dealing with selective rejection is somewhat more sophisticated, in that it reduces double targets, but it involves a much greater programming effort. This solution is in the form of a software patch[27] which stratifies the RSB so that the lower altitude coverage will be handled by one radar site, and the higher altitude coverage will be handled by a distant site[28]. This patch is designed to handle the "cone of silence" problem that was illustrated in Figure 4 (Compromise #2), where the RSB overlying an ARSR is programed to utilize data from another ARSR much further away. However, this type of stratification would not improve the situations depicted in Figures 5,6, and 7 (Compromise #3). This software patch is optional, and in the case of ZOB, not utilized.

Double targets and their associated clutter are certainly annoying. The lack of a safety advisory from ATC, due to selective rejection, is obviously more annoying, as a lack of radar service can result in the complete failure of ATC's primary mission. The need to eliminate the poor display of targets, often accompanied by double-preferred coverage, is important. We should not, however, be content with the elimination of a target from the display when it happens to be at such an altitude that it is not detected by the preferred ARSR, yet is detected by the supplemental ARSR. The controller must be presented with all the necessary data.

4.3 - A Comprehensive Solution - Selective Enhancement, not Rejection

The importance of issuing a safety advisory cannot be overstated. To accomplish the main mission of ATC, the controller needs all aircraft, which are detected by radar, to be displayed. The optimum solution would be to utilize all data, from all radars (ASRs & ARSRs), to track and display all aircraft. Unfortunately, today's processors do not handle the immense amount of radar data that is currently available. It is hoped that when the Advanced Automation System is available[29], all data will be utilized for both tracking and display. In the meantime there must be a remedy utilizing today's equipment and software.

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[27]A software "patch" is a program that is added to a main program. A patch, as the name implies, is designed to fix a problem with the main program, and often adds some additional feature or enables the program to do something that it could not do without the patch.

[28]The patch described is designated by the number IT 200-CPF-008.

[29]The Advanced Automation System is due to be available at ZOB around 1995.

One solution to the problem of selective rejection of aircraft within the low altitude environment would be to display all aircraft detected by all ARSRs. Of course, such a presentation would be totally objectionable, because many high altitude aircraft would be detected by several ARSRs simultaneously. The problem of such unnecessary clutter in the higher altitudes, however, could be alleviated by simply STRATIFYING ALL RSBs. Below a predetermined altitude, all data, from all assigned ARSRs should be processed for display. Above the predetermined altitude, selective rejection would still exist. While such programing would add further clutter to the controller's PVD, this clutter would be associated only with low altitude aircraft that are detected by two (or more) ARSRs simultaneously. As an aircraft (with altitude reporting equipment) climbs above this predetermined stratified altitude[30], double targets would be eliminated, as the selective rejection process of a RSB would then only display one target per aircraft as is currently done. As this same aircraft descends down through this stratified altitude, it would again be displayed as two (or more) targets, in slightly different locations, until it reached an altitude where it is detected by only one of the assigned ARSR sites. The controller's display would then have all aircraft that are detected by ARSRs displayed, especially those important low altitude aircraft where most near midair collisions occur.

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[30] A single predetermined stratified altitude may cover the entire control area, or such an altitude may be sort box specific. Regardless of the the method, a complete analysis would have to be accomplished to determine the most safe choice of altitude at which to stratify a RSB, so that the important low altitude radar data would not be selectively rejected.

5.0 - Conclusion

Anywhere within the NAS system that existing radar data is not utilized to develop a representation of air traffic, the controller will not be able to achieve his number one priority of issuing safety alerts. The occupants of an aircraft may pay the ultimate price for the compromises that should never have been accepted.

Today's ARTCC radar tracking and display system cannot adequately handle the large amounts of excellent radar data that is currently available. Radar data in today's system is selectively rejected before presentation to the air traffic controller, resulting in the **lack of display** of some low altitude aircraft which are actually detected by the ARTCC's radar network. Current radar data processing techniques need to be altered. Ultimately, a system which utilizes all radar data, from all ATC radars (ASRs & ARSRs) simultaneously, needs to be developed. In the meantime, FAA needs to reconsider it's primary mission in ATC. Instead of selectively rejecting radar data in the low altitude structure, ATC needs to **selectively enhance** the radar data of aircraft at these important low altitudes, and display all aircraft which are detected by the existing ARSR network.

6.0 - Recommendations

Until better display and tracking methods can be realized, ultimately utilizing all data from all radars simultaneously , what can be done? The following recommendations are given:

1. Conduct a complete and comprehensive examination of the RSB programming in all 20 ARTCC's. Identify all Radar Sort Boxes where the possibility exists that low altitude aircraft will not be displayed for the controller, even though these aircraft are detected by at least one ARSR.

a.) Identify all RSBs which have superior radar coverage from an existing ARSR that is currently not on-line with the facility (Compromise #1 example), and promptly bring the data on-line.

b.) Identify all RSBs which enclose an ARSR, but do not utilize that ARSR (Compromise #2 - the "cone of silence" example). Program these RSBs to utilize both sites simultaneously (i.e. double-preferred coverage), or utilize software patch "IT200-CPF-008" to ease the problem with clutter (double targets) while providing all radar targets to the controller's PVD. Make the use of this software patch mandatory at all ARTCC's , rather than optional.

c.) Identify all RSBs that lie at a point between two radar sites (Compromise #3 example), where the better coverage changes from one radar site to another radar site within the RSB. Program these RSBs to utilize double-preferred coverage. While this will result in a great many more RSBs that will display double targets, it is preferable to not displaying an aircraft that is a threat.

d.) Promptly develop a new and enhanced software patch to make possible the stratification of all radar sort boxes, so that **all low altitude traffic detected by ARSRs will be displayed** instead of selectively rejected. While this will result in some low altitude aircraft being displayed as multiple targets, this approach should be preferred over not displaying an aircraft that is actually detected by an ARSR. Such a patch would eliminate the need for double-preferred coverage at high altitudes, and would actually result in less visual clutter at these higher altitudes where double-preferred coverage is currently utilized, but not really needed.

7.0 - About the Author

Thomas G. Lusch is a full performance level air traffic controller at Cleveland ARTCC, beginning his ATC career there in January 1982, and has been a member of the Air Traffic Control Association since 1984. Mr. Lusch holds a commercial pilot certificate, glider rating, and is an active instrument pilot. His strong interest in the processing of radar data began in 1985 when a commuter pilot en route from Dubois, PA to Pittsburgh, PA (for whom he was providing radar service), experienced a near midair collision with an aircraft that was not displayed on his PVD until shortly after the near collision.

U.S. Department
of Transportation

**Federal Aviation
Administration**

Memorandum

CLEVELAND ARTC Center
326 East Lorain Street
Oberlin, Ohio 44074

Subject: INFORMATION: Unsatisfactory Condition Report (UCR) 330069

Date: April 4, 1989

From: Assistant Manager, Quality Assurance

Reply to Attn. of: KETTERMAN: Ext. 146

To: Thomas Lusch, ATCS
THRU: Robert H. Purdy, Area Supervisor, #55

Enclosed is the green copy of the subject UCR along with the Facility's Evaluation. Based upon the evaluations and the actions taken, we consider this UCR closed.

Thank you for your participation in the UCR Program and we solicit your continued support.

Richard V. Ketterman

Richard V. Ketterman

Attachment

UCR-330069

ITEM 11b.

This UCR clearly indicates that extensive research was conducted by the submitter. We do not, however, agree with Mr. Lusch's conclusion that what he describes is an unsatisfactory condition or compromise.

This UCR raises two primary issues: 1) The process of Selective Rejection that is used to determine the radar data that is presented on a display from existing radar sites and 2) The fact that additional sites are not integrated into our display system.

We believe that the methods used to filter and display radar data are sound, including the selective rejection process. Radar sort box adaptation is established as the result of evolution through use and modification of the data base, i.e. the radar site adapted to a given sort box is the one that provides the best coverage. If a defienciency is identified that can be corrected by assigning a different site, it is done.

We have looked into alternatives including"double preferred" adaptation and patch IT-200-CPF-008. Both of these methods have significant disadvantages or problems such as the possibility of extensive clutter or loss of adequate display production depending on atmosphere conditions. In short, the limitations do not out weigh the potential advantages, and implementation would not provide an overall improvement.

We do have plans to add several additional radar sites to our system when the capability to expand becomes available with the PAM replacement installation. Additional sites, particularly in the south eastern portion of our control area will expand coverage approximately 2,000 feet lower than existing, but coverage will still be well above ground level. The main advantages of more radar sites will be the redundancy provided by overlapping coverage.

The orginator has described some limitations of our system but not unsatisfactory conditions. Non radar procedures are satisfactorily applied in certain portions of our area to accommodate IFR users. Because we can and do respond to site coverage concerns through adaptation changes, we provide the best overall radar data display available; we've been able to either provide coverage or clearly identify areas where radar is not available and prescribe alternate procedures.

Although we consider this UCR closed, we would recommend that Mr. Lusch's proposal and research be forwarded to the FAA's Technical Development Personnel for analysis and use, with full credit and recognition of his efforts.

UNSATISFACTORY CONDITION REPORT

Reports Identification Symbol OA 1800-1

1. NAME OF ~~ORIGINATOR~~ (last, first, middle initial)
Lusch, Thomas G.

DOCUMENT NUMBER
UCR— 330069

2. OFFICE ADDRESS OF ORIGINATOR
326 East Lorain St Oberlin, OH 44074

ROUTING SYMBOL
ZOB AREA 5

3. DATE CONDITION OBSERVED
1985

4. CONDITION REPORTED
[ ] PROCEDURE [x] EQUIPMENT [ ] WORKING ENVIRONMENT [ ] SERVICES [ ] PUBLICATIONS [ ] OTHER (Specify in item 7)

5. (Check if applicable)
[x] PROPOSED SOLUTION ATTACHED (see item 4 on reverse)

6. ORIGINAL FORWARDED TO WASHINGTON OFFICE OR SERVICE → ROUTING SYMBOL: AAT-1 DATE: 9/26/88

7. DESCRIPTION OF UNSATISFACTORY CONDITION (Refer to item 2 of instructions for conditions to be reported.)

Some low altitude aircraft, even though they are detected by the Air Route Surveillance Radars (ARSRs), are NOT DISPLAYED on the controller's Plan View Display (PVD). This is a process termed "selective rejection". This unsatisfactory condition is a result of a compromise made in the processing of radar data Likewise, other important ARSR data is not sent to the ARTCC that may need it. The attached paper, entitled "Selective Rejection of Low Altitude Radar Data at Air Route Traffic Contoll Centers: An Unsatisfactory Compromise", fully explains this unsatisfactory condition.

8. SIGNATURE OF ORIGINATOR
Thomas G. Lusch

9. DATE SUBMITTED BY ORIGINATOR
September 26, 1988

10. EVALUATIONS AND REVIEWS (continue on attached sheets as needed—show UCR No., office, name, and date)

10a. IMMEDIATE SUPERVISOR
I have after observing some target loss in the area of the QCF radar changed the RSB's from PIT (pref) and QCF (alt. pref) to QCF (pref) and PIT (alt. pref) with good coverage both in NAS and in DARC. Their is a need to adapt some more sites with alt. preffered radars to give better coverage. I would recommend if the patch IT200-CPF-008 is available as stated that we use it, and make available all radar data possible to be used by the HOST.

SIGNATURE (Print or type and sign)
Robert H Purdy

ROUTING SYMBOL: AS-55 DATE: 9/29/88

10b. XXXXXXXXX

SIGNATURE (Print or type and sign)

ROUTING SYMBOL DATE

10c. REGION OR CENTER
We agree this UCR should be closed at the regional level. However, we are sending a copy to the FAA technical Center for their comments.

SIGNATURE (Print or type and sign)
Teddy W. Burcham, Manager, Air Traffic Division

ROUTING SYMBOL: AGL-500 DATE: 4/10/89

11. OFFICE TAKING FINAL ACTION

11a. RESULTS OF EVALUATION (check appropriate block and describe) [ ] CONDITION CORRECTED [ ] ACTION NOT POSSIBLE [X] OTHER (Specify)

11b. REMARKS

See attached

SIGNATURE (Print or type and sign)
J Hevelone
James L. Hevelone, Assistant Air Traffic Manager

ROUTING SYMBOL: ZOB-2 DATE: 3/24/89

FAA Form 1800-1 (4-68) SUPERSEDES PREVIOUS EDITION

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

Thomas G. Lusch
FAA Air Traffic Control Specialist
Oberlin, Ohio

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.

<u>Compromise #1</u>. 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.

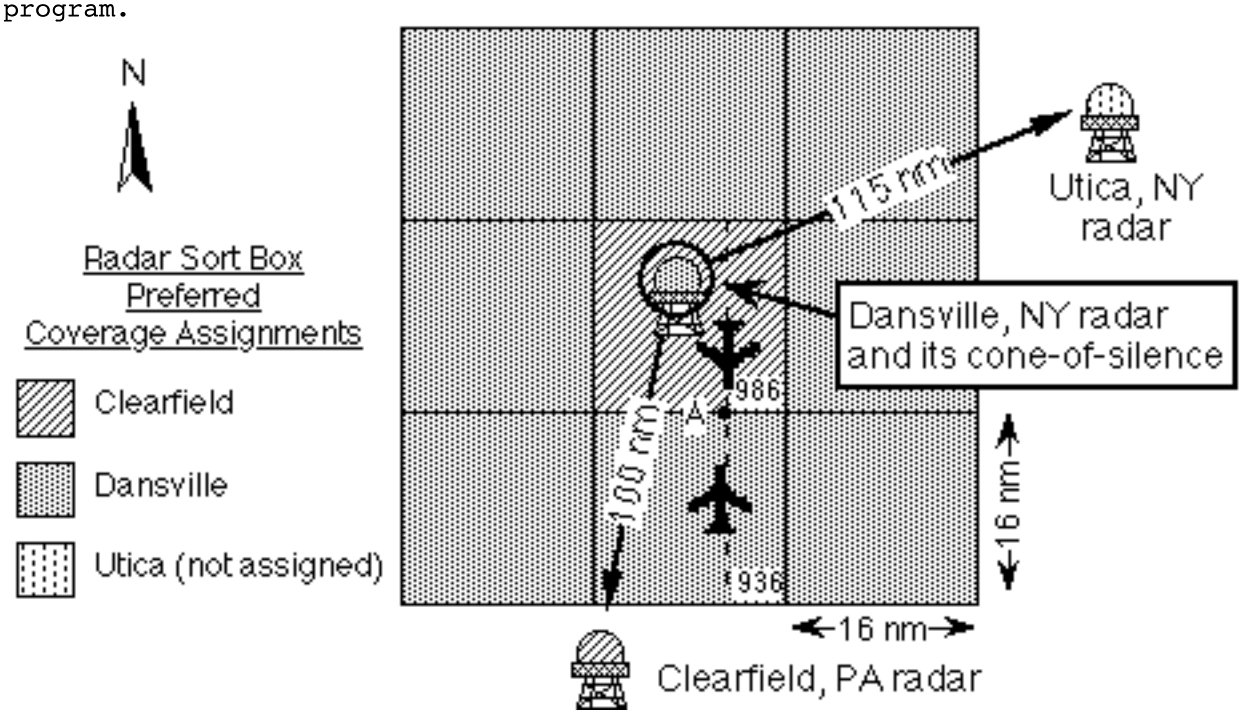

Figure 1. Two aircraft detected by only the Dansville radar. The southbound aircraft is *not* displayed since Dansville radar data is suppressed within RSB#986. (Distances are in nautical miles [nm].)

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.

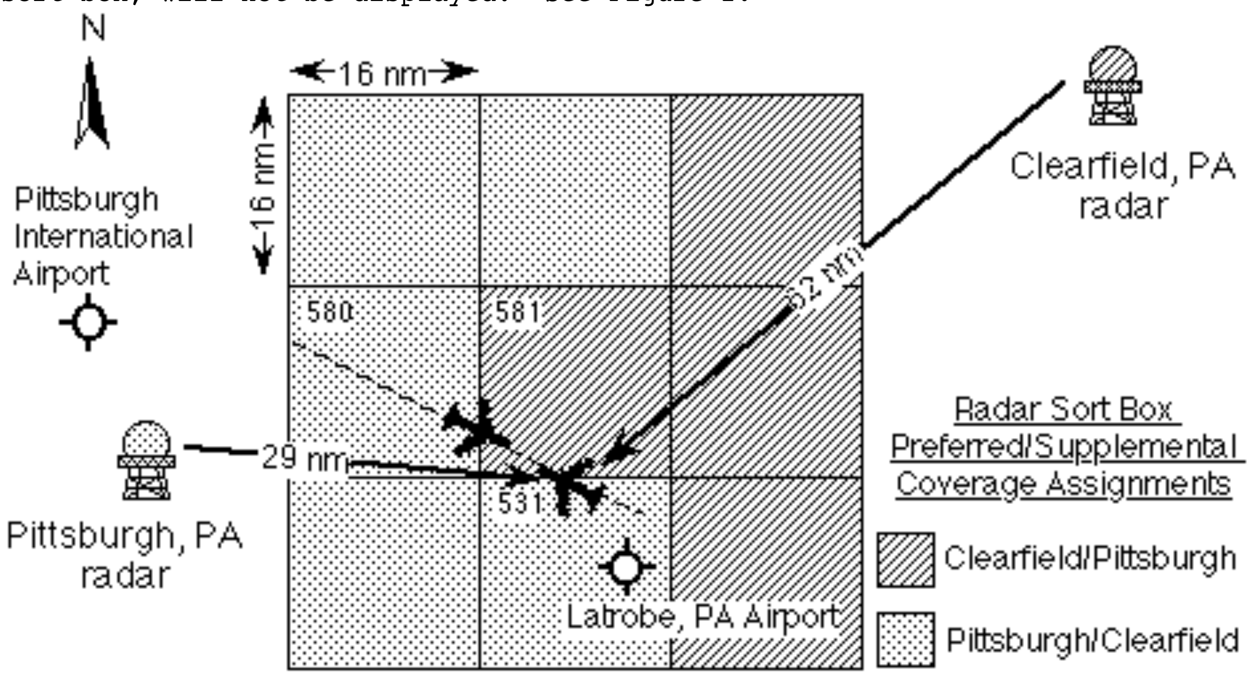

Figure 2. Two aircraft detected by only the Pittsburgh radar. The southeast-bound aircraft is tracked and displayed within RSB#581. The northwest-bound aircraft is untracked, and therefore is *not* displayed within RSB#581. (Distances are in nautical miles [nm].)

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 HOST[1] 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.

REFERENCES

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Real Targets—Unreal Displays

The inadvertent suppression of critical radar data

by Thomas G. Lusch
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Reprinted from the Proceedings of the Sixth Symposium on Aviation Psychology (Ohio State University)

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 2½ 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.

Dansville 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 Dansville radar data on this southbound aircraft is discarded by the program.

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

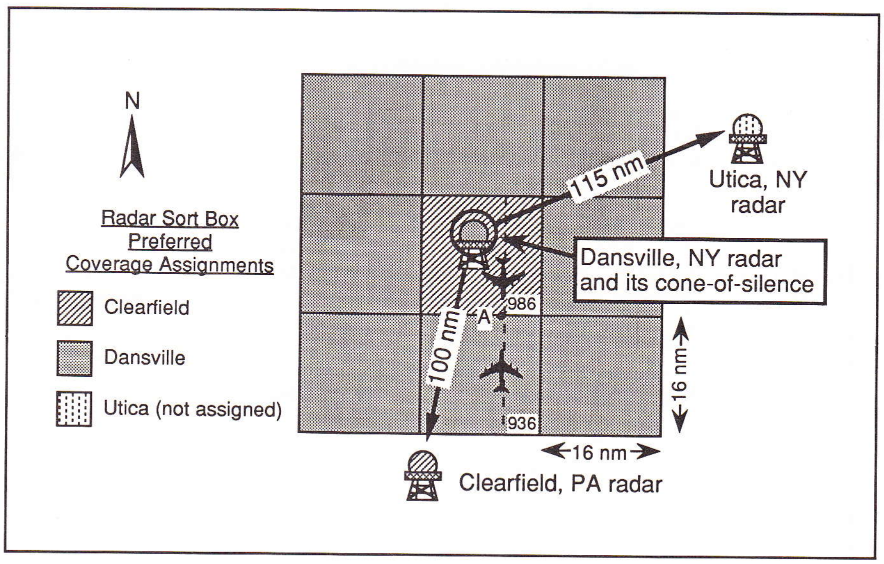

Figure 1. Two aircraft detected by only the Dansville radar. The southbound aircraft is not displayed since Dansville radar data is suppressed within RSB#986. (Distances are in nautical miles [nm].)

radar data is processed results in 236 sq nm of low-altitude radar data not being displayed.

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.

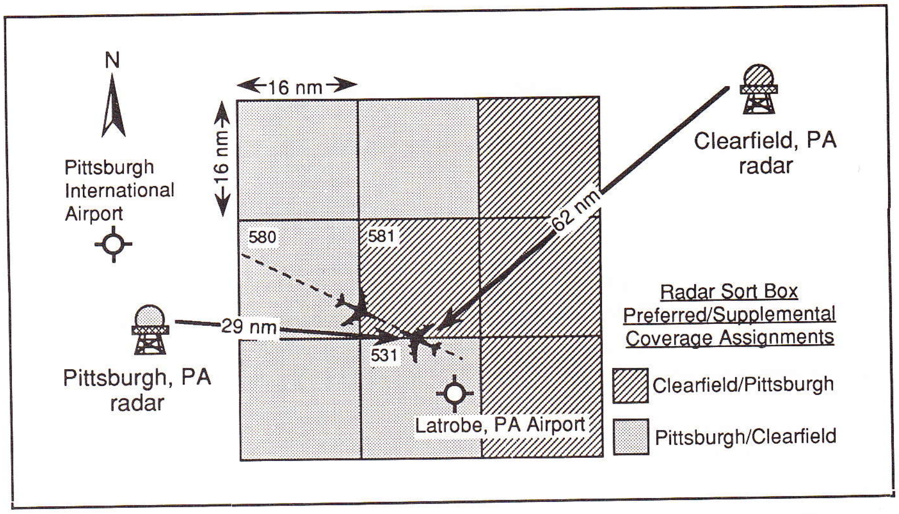

Figure 2. Two aircraft detected by only the Pittsburgh radar. The southeast-bound aircraft is tracked and displayed within RSB#581. The northwest-bound aircraft is untracked, and therefore is not displayed within RSB#581. (Distances are in nautical miles [nm].)

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.

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 291.215, 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 ½ inch (1.27 cm) away on the screen. Could the VFR aircraft have 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 years later, and over three years after the replacement of the ARTCC mainframe computers with the upgraded HOST[1] computer, the suppression of low-altitude radar data still exists. 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

[1]The 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.

collision occur tomorrow, and it was found that no safety advisory is 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.

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Deja vu

The following is a narrative from a NASA Aviation Safety Reporting System report, Number ACN 707567. It is from August 2006 (alternatively, one may view the report's text below with a decoder, by clicking here)...

THIS IS NOT AN ANOMALY OR AN ISOLATED OCCURRENCE. THE FAA ACKNOWLEDGES THAT FACT. THE FAA DOES NOT, HOWEVER, VIEW THIS AS SIGNIFICANT. I DO. OUR PRIMARY RADAR SYS, OR HOST, DOES NOT DISPLAY ALL XPONDER-EQUIPPED (DISCRETE OR NON-DISCRETE CODES) ACFT IN THE AREA OF JBR (JONESBORO, AR), EVEN THOUGH THESE ACFT ARE IN AREAS OF KNOWN RADAR COVERAGE. I WAS WORKING AN IFR ACFT IN THE JBR AREA AT 4000 FT (DISPLAYED ON RADAR), AND THERE WERE VFR ACFT IN THE AREA THAT I WAS NOT DEPICTING ON RADAR. 1 ACFT 3 MI SW OF JBR AT 2500 FT, 1 ACFT 12 MI SW OF JBR AT 4500 FT, AND ANOTHER ACFT 5 MI N OF JBR AT 3500 FT. NONE OF THESE ACFT WERE DEPICTED ON HOST RADAR. HOWEVER, OUR BACKUP SYS, DARC/EBUS, WAS DISPLAYING THESE ACFT ON RADAR, WHICH IS THE ONLY REASON I KNEW THEY WERE THERE. THIS IS A COMMON OCCURRENCE, EVERY DAY, ALL DAY. I'VE EVEN HAD AN ACFT AS HIGH AS 11000 FT THAT WAS NOT DEPICTED ON MY RADAR SCOPE. THIS IS A SAFETY ISSUE. I CANNOT, CONTRARY TO THE STATEMENT BY MGMNT, CONTINUE TO RELY ON THE INTEGRITY OF THE RADAR DISPLAY.

Occasionally one gets a glimpse, from a different perspective, of the way things really are. When that occurs, it can really be eye opening.

I caught such a glimpse back in the mid 80's. It was sometime after a Crown Airways commuter pilot, on his way from Dubois, PA to Pittsburgh, PA, exclaimed on my frequency "Center, DID YOU *SEE THAT AIRCRAFT???!!!*" The pilot had narrowly missed having a midair collision with a VFR aircraft *that was NOT displayed on my scope*. (The VFR aircraft, squawking 1200, appeared shortly thereafter, at the commuter's six o'clock position.)

It made no sense that the other aircraft would've been invisible until just after nearly colliding with the Twin Otter I was working.

It was sometime after that incident that we got the capability to individually select our backup computer display at our workstations. That gave me the ability to compare the presentation of my main display, with the display of my backup system called "DARC" (Direct Access Radar Channel). At that time, DARC allowed one to select one and only one radar site at a time, as it simply wasn't sophisticated enough to process radar data from multiple radar sites. Its inability to process radar data from multiple sites in a concurrent fashion, turned out to be very helpful in understanding what was taking place.

I vividly recall how, when I selected QCF (the Clearfield, PA Air Route Surveillance Radar site) on DARC, *I was amazed to observe multiple VFR aircraft, squawking 1200 (with altitude information), flying around the Clarion VOR in western Pennsylvania*. Yet when I switched back to the display we utilized day in and day out, those low-altitude VFR aircraft were not present for me to see.

That is what lead me to ask a bunch of questions, and dig deep into the maintenance manuals, in an effort to understand what was taking place. That lead me to write my 1988 & 1991 papers. That may seem like ages ago, however....I recently came across the above NASA ASRS report, that shows how the situation really hasn't changed. The air traffic controller who authored that report apparently took the time to compare the backup DARC display, to the main display, *and noticed the same type of situation I observed around Clarion VOR around two decades ago*.

If you wish to view the entire NASA report, I recommend that you go to the NASA ASRS web site, select “ASRS Database Online”, and do a search on ACN #707567. Notice how under "Resolutory Action:" it states "None Taken : Anomaly Accepted."

We need to truly process ALL radar data (secondary returns AND "skin paint" primary returns), from ALL radar sites, ALL the time, and not toss valuable radar data into the electronic "bit bucket." Is it possible to accomplish this? Learn more about one man’s vision and work towards such a paradigm shift here.

Sincerely,

Thomas G Lusch
June 6, 2009

Real Targets - Unreal Displays
The *twice revived* Slide Show

When I come across a NASA Aviation Safety Reporting System report from 2006, which describe the *same* resident pathogen I had observed two decades prior (see Dejavu), I know that my concerns are still valid.

This is a PDF adaptation of the slide show I had revived back in 2000. That slide show was based upon the *original* slide show I had created in 1991, specifically for my presentation at the Sixth International Symposium on Aviation Psychology.

Blue text is original text from that slide show that was on my (no longer available) http://home.columbus.rr.com/lusch web site.

The complete lack of display of primary radar targets that represented American Airlines Flight 77 (AAL77) on September 11, 2001, after its transponder was turned off, is very much related to the fact that we have voluminous amounts of overlapping radar data, but that much of that surveillance data goes unused. Learn more here.

Thomas G. Lusch <contact>
Aug 6, 2009

Lusch's "RTUD Slide Show"

Welcome to my "slide show" presentation of "Real Targets - Unreal Displays," as adapted for the web from the lecture I gave at the Sixth International Symposium on Aviation Psychology back in April '91. This presentation is a lot less formal than the papers I have written and posted here on my web site, but I think you will find it easy to follow and quite compelling. I might lose you a couple times if you don't have any aviation background because of the jargon. Nevertheless, stick with me...I believe my points will come through loud and clear, and you'll understand a lot more about what's taking place in the ARTCC radar data processing computers, and then you'll understand why this issue is so important to me, *and why it should be so important to everyone else who is involved in the ATC system*. So, sit back, and use your mouse to forward through the slides and follow my story.

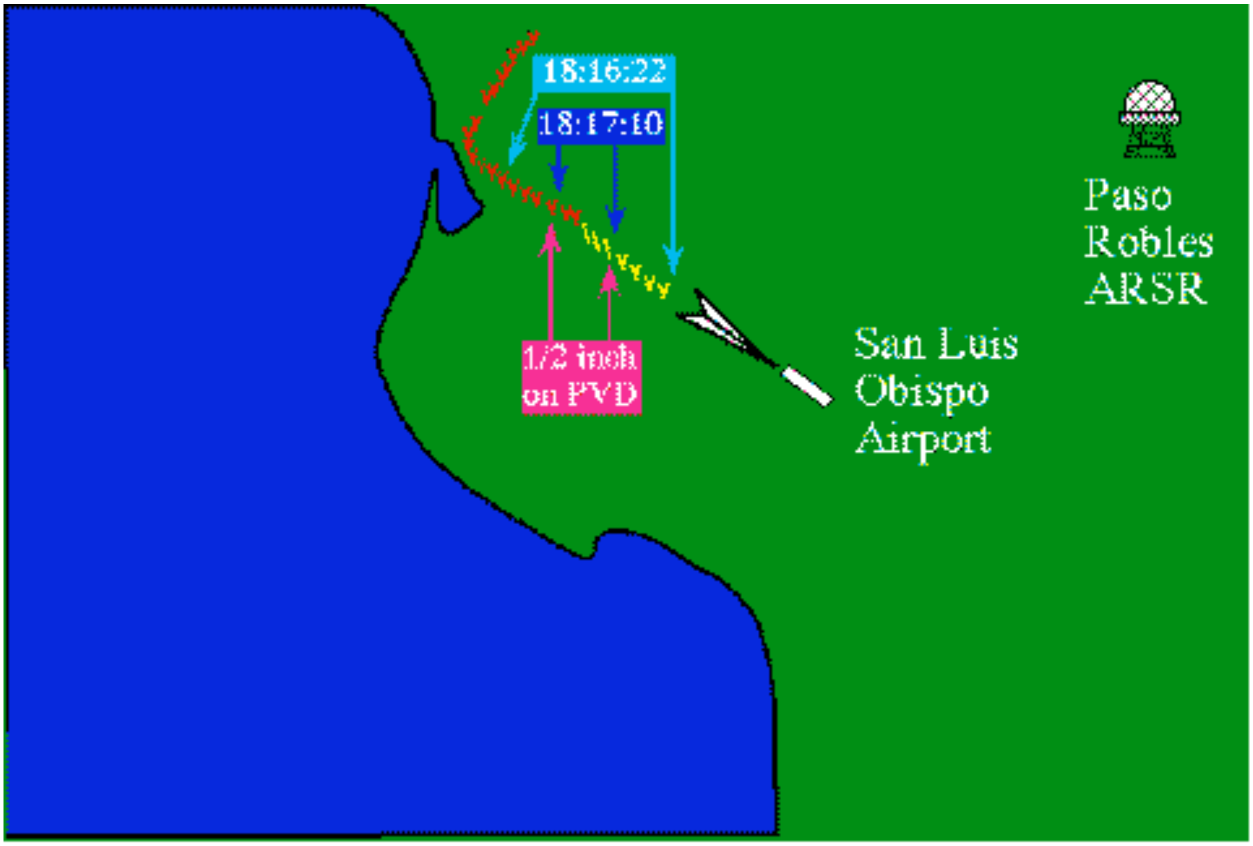
This "slide show" consists of 41 "slides" and will probably take an hour to an hour-and-a-half to review. If you don't have time to do it all in one sitting, just make a note of where you stopped, and when you have time, just come back to this page to be able to easily skip forward to where you left off.

This slide show was first adapted for my web site on Feb 6, 2000, and a week later I upgraded it to a version with "frames." Since then I've tweaked it up for display on different browsers and for different resolutions. If your browser supports "frames," *that is the version of the slide show you should try first*, as in the original more simple version the picture moves up out of view as one reads the text. If, when trying out the framed version, you click on the Slide number on the left side of the screen, and an entirely *different* window opens up (that happens to me with my current version of Netscape Navigator), it'd probably be best to view the slide show version *without* frames.

I welcome your feedback and discussion.

Remember, *the main intent and first mission of this web site is to stimulate positive change within the FAA as to how radar data is processed*. Why is that? Well, on with the story...

Tom Lusch
tomlusch@columbus.rr.com
February 16, 2000

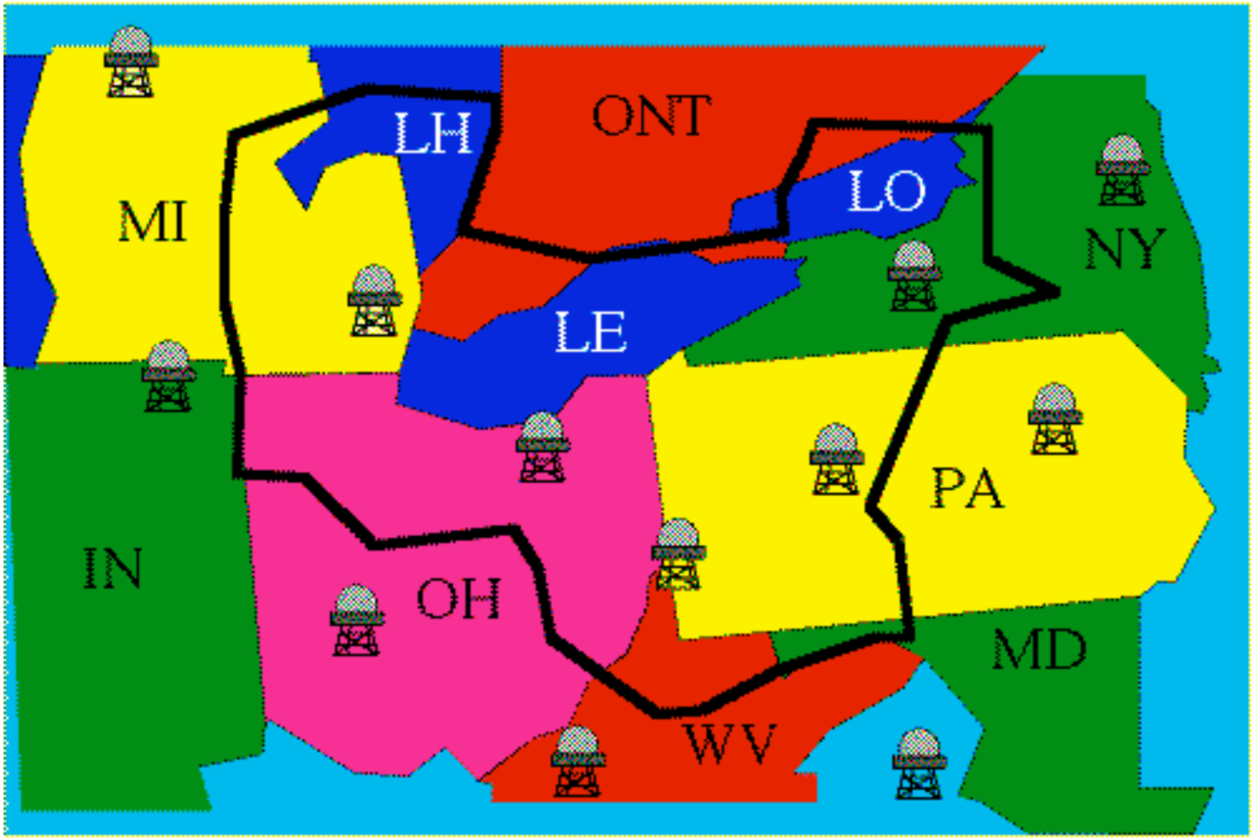


Slide 1 of 41: San Luis Obispo

We'll begin back on August 24, 1984. At that time I was learning how to be a radar controller at Cleveland Center. I was nearly checked out on all the radar sectors in Area C2. Area C2 (later to be known as Area 5) covers much of the Allegheny Mountains to the east of Pittsburgh, from as far south as Cumberland, MD to just south of Bradford, PA.

The news of a midair collision on the west coast got the attention of everyone on the control room floor. We heard that our counterparts in Los Angeles Center were working a commuter aircraft that had just departed an airport, and had just gotten it on radar moments before the collision occurred. In fact, the buzz was that the controllers claimed the other aircraft wasn't on their scope. My first thought was the controller must not have been paying very close attention to have not seen the other aircraft on radar, or maybe the controller wasn't telling the truth, because if you see one aircraft on radar, most certainly the other aircraft that is about to occupy the same chunk of airspace would show up too. *It didn't make sense that the other aircraft wouldn't have been on the radar screen*.

Move on to about a half year later. It was the Spring of '85. I've been a fully certified controller now for just under a half year. I'm working the Clarion sector, which primarily provides sequencing and separation of arrivals into Pittsburgh from the east and northeast, over the GRACE intersection. It wasn't a busy period...I was working maybe 7 aircraft at the time. A Crown Airways Twin Otter departed Dubois, PA and called me for radar traffic advisories. It was such a beautiful day that he didn't need (nor require) ATC separation services, but he did wish to have another set of eyes watching out for him. I radar identified the aircraft, thereby including this commuter's target in my scan, happy to provide such an important service for this pilot and his passengers. Shortly after establishing radar contact with the Twin Otter, this Crown Airways pilot suddenly, and *very emphatically* said, **"Center, DID YOU SEE THAT AIRCRAFT!!!???"** Just after that unnerving transmission did the target symbol of the other aircraft appear...just behind the Twin Otter. I had NOT seen that aircraft in time to warn the Crown Airways pilot, BECAUSE IT WASN'T ON MY RADAR SCOPE till too late. I verified that it wasn't on my radar scope before then by immediately turning my "history" control for a full presentation of the last 5 radar hits (roughly one minute's worth of radar data). It was at that point that I was absolutely positive the other aircraft hadn't been displayed till that very moment. I immediately reported this near midair collision, along with the fact that the other aircraft wasn't on my radar scope, to the supervisor, who then asked if this involved aircraft that were IFR. Since they were both VFR, that was the end of that. Technically, in that airspace, we aren't required to provide separation services to either aircraft. It didn't seem to faze the supervisor that the other aircraft wasn't displayed. I went about my work, but I had this very bad feeling about what just took place...



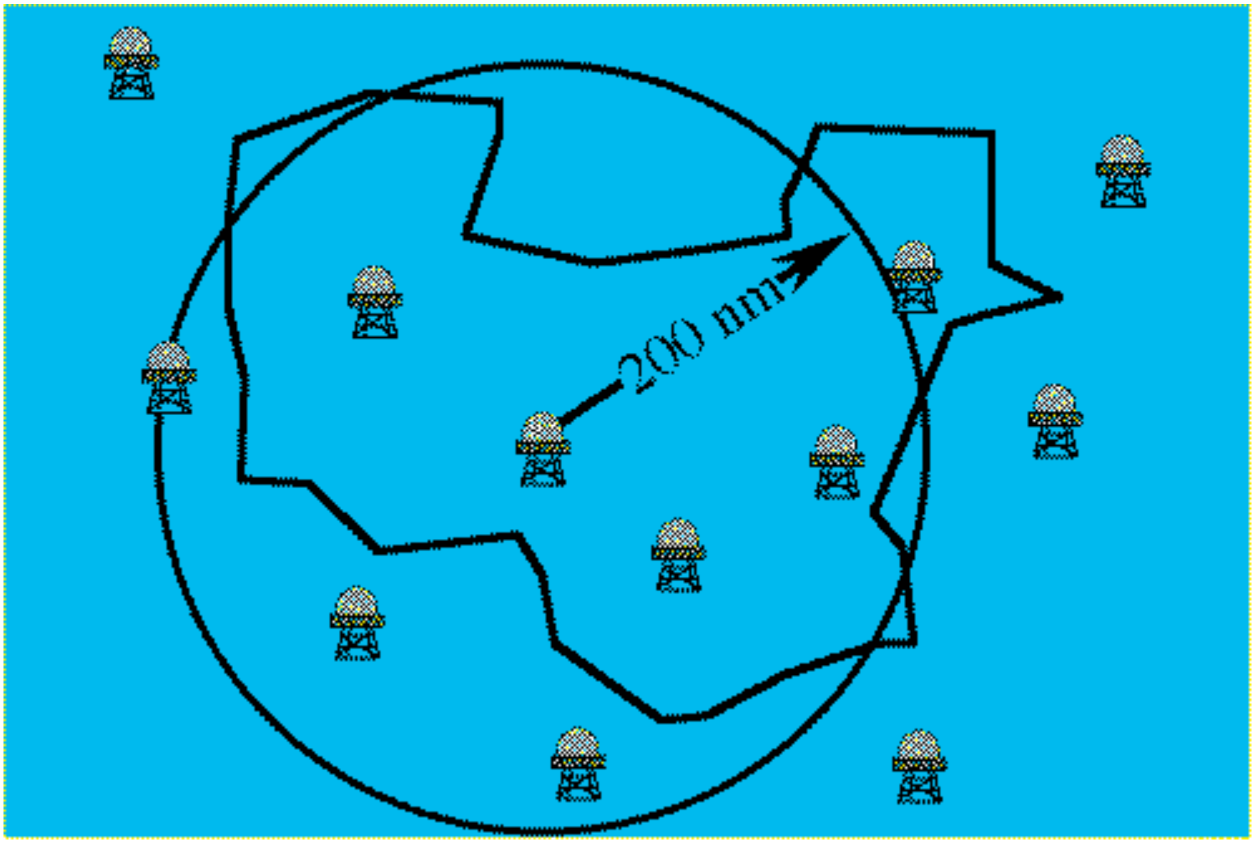
Slide 2 of 41: The long-range radar network

First of all, let me tell you that we have a great network of radar sites in this country. The FAA has done excellent in this aspect, as it is difficult to fly anywhere, especially east of the Mississippi, without being detected by radar. Climb off an airport, and even at low altitudes you're being detected by one or more radar sites. Notice that I used the word "detected." That is a key point in this discussion. As you'll learn, detected by radar, and displayed on a controller's scope, are two different things.

Above is a depiction of the airspace boundary of Cleveland Center. Cleveland Center encompasses approximately 69,000 square miles of airspace. That is small in relation to many other Centers, yet Cleveland Center is the busiest of 'em all. An ARTCC like Cleveland Center utilizes several long-range radar sites (technically termed Air Route Surveillance Radar, or ARSR). These sites are strategically placed to provide the best overall radar coverage. Depicted in this slide are the long-range radar sites located in Empire, MI, LaGrange, IN, Detroit, MI, London, OH, Cleveland, OH, Higby, WV, Pittsburgh, PA, Clearfield, PA, Dansville, NY, Utica, NY, Benton, PA, and The Plains, VA. Missing in this depiction is the ARSR in Coopersville, MI, which lies approximately 120 miles west of the long-range radar in Detroit, or just over 100 miles south of Empire.

The long-range radar near Dubois, which is where the Crown Airways pilot departed, is located high atop a plateau near Clearfield, PA. This radar site served us extremely well. It provided a great depiction of low-altitude aircraft in this area. With it we could even see transponder replies from aircraft *while still on the ground* at Dubois airport, which lies 17 miles west of the radar site! I had a lot of confidence in my radar presentation in this area. It didn't make sense that the Crown Airways aircraft was depicted on my scope, but the VFR that he nearly collided with had not been depicted until too late.

So I began to question how things worked with our radar data processing computer/software. Why would one aircraft show up, and the other not? What follows is an explanation of what I learned...

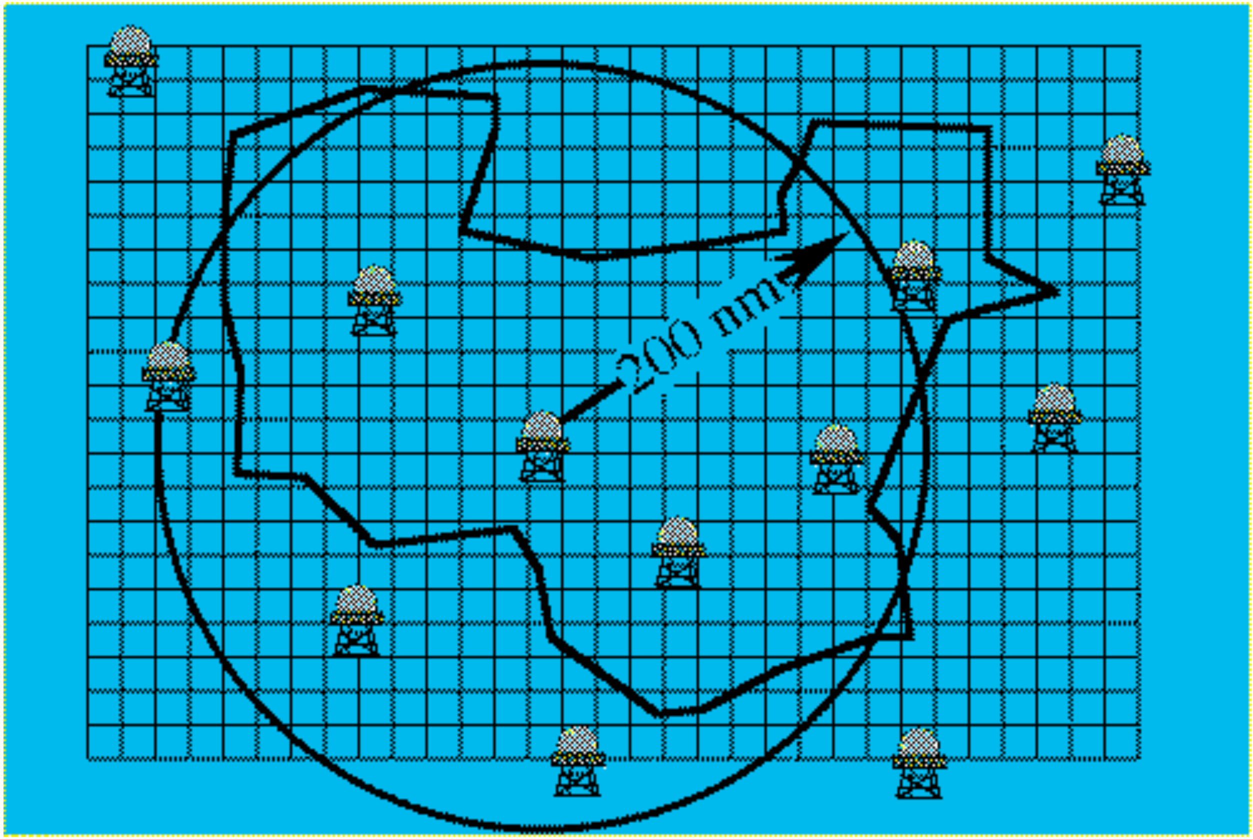


Slide 3 of 41: Overlapping coverage

Did I mention that we have a great amount of overlapping radar coverage out there? A long-range radar can detect aircraft at distances up to approximately 200 nautical miles (if the aircraft is up at a high enough altitude, like 20,000 to 30,000 feet). Notice that 200 miles from the Cleveland (Brecksville) long-range radar overlaps nearly 7 other long-range radar sites. Therefore, an aircraft flying up at Flight Level 310 (roughly 31,000 feet) near Cleveland, Ohio, can be "seen" by probably 8 long-range domestic radar sites at one time. This depiction doesn't show the multitude of Airport Surveillance Radar (ASR) sites located at airports throughout this airspace. Those radar sites have a range of typically 55 miles, and are primary designed for use by controllers serving those airports. None of these smaller terminal radars in the Cleveland Center area are fed to the Cleveland Center computer, and that is typical of other ARTCCs.

There is a lot of radiation out there at the 10 and 23 cm wavelength, along with a lot of interrogation of aircraft transponders taking place on 1030 MHz from these radar sites. Most anywhere east of the Mississippi it is extremely difficult for an airplane to not be detected by one radar site or another.

So, how in the heck does the radar data processing computer handle all that radar data? Just how on earth does it sort it all out?

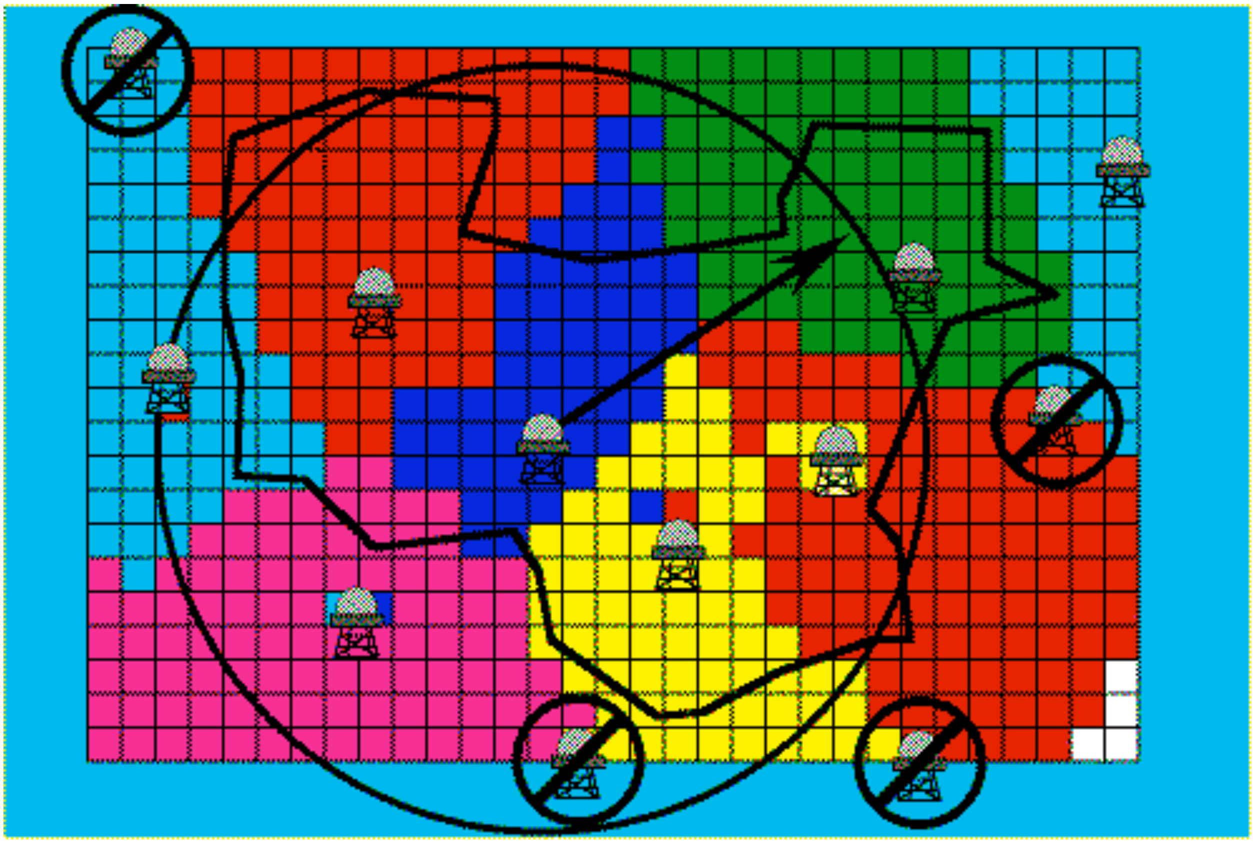


Slide 4 of 41: Bite size chunks

A long time ago a controller would watch a screen that was driven by just one radar site, and it had the typical "sweep." With the advent of computer processing of the radar data, engineers figured out a way to combine all that data from several radar sites, so it could be sent to all plan view displays (another name for radar scopes) in a facility, and the controller didn't necessarily know (or care) which radar site he was using. The displays utilized presumably the "best" data from among the radar sites available.

Apparently crunching all that data was way too much work for the computers, so the engineers had to figure out a way to reduce the data to "bite size chunks." Such was the advent of the "selective rejection" method of handling the data. What the computer program essentially does is divide the airspace into "bite size" boxes. These "bite size" boxes are termed "radar sort boxes." Their size is 16 nautical miles by 16 nautical miles, thereby encompassing 256 square miles each. Each box is assigned up to, but no more than, 4 radar sites. The first radar site is called the preferred radar, the second is the supplemental radar, with the 3rd and 4th radar sites being the backup radar if number 1 or 2 are out of service. If you follow the drift here, you'll be catching on to the fact that ***only one radar site's data is used at any given time and any given location***. That's right, one-and-only-one radar's data is used at a time. All the other radar data goes unused, or is dumped into the "bit bucket" as they say in computer programming jargon. That's right...it is thrown out, discarded, abandoned, chucked, unused.

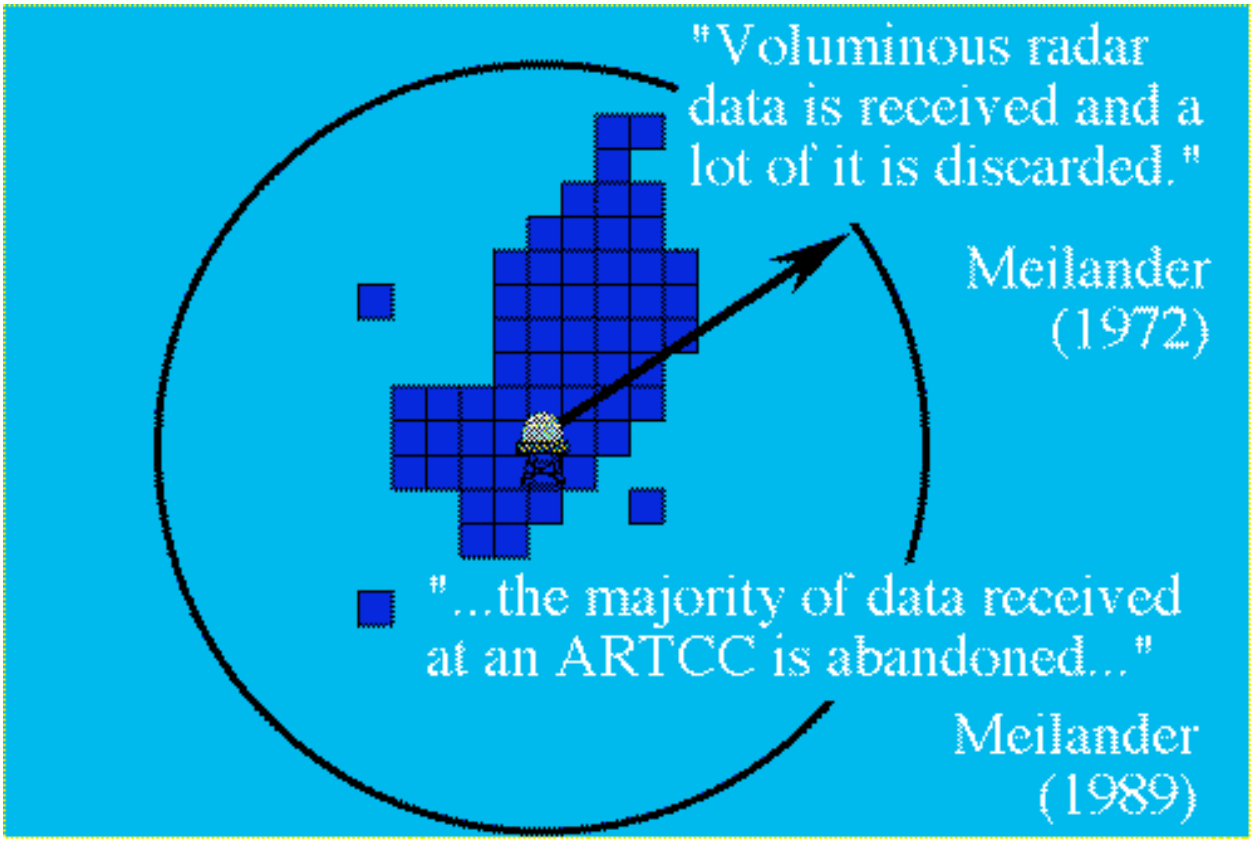
Also, be advised that all of this is taking place inside the bowels of the computer. The air traffic controller has absolutely no control over this internal function. (I know that many people think the air traffic controller can simply "flip a switch" to eliminate VFR radar targets. At the two facilities that I have worked at that is far from the truth...and I never worked beside a colleague who attempted to do such a thing.) By the way, the air traffic controller doesn't see radar sort boxes. These radar sort boxes are strictly an internal thing in the computer program.



Slide 5 of 41: Much radar data goes unused

Take a look at the Cleveland long-range radar site depicted in the middle of this slide (the one with the 200-mile radius drawn), and notice the squares that are filled with the dark blue color. If you count 'em, you should come up with around 60 sort boxes in which the preferred radar site is Cleveland. If you do a little math, 60 times 256, you come up with 15,360 square miles of airspace. Now, do you recall how to determine the area of a circle? Area is equal to Pi times the square of the radius. Therefore, 200 times 200 equals 40,000, times 3.14 equals 125,600 square miles. The percentage of preferred coverage of this one radar, compared to what the long-range radar actually views, is 15,360 divided by 125,600, or around 12%. ***Yes, that's right, only 12% of the Cleveland long-range radar's data is actually utilized!*** In all fairness, the sort boxes that aren't colored dark blue may utilize Cleveland as the second-in-line radar site, known as the supplemental site, wherein that data is used *if and only if* the preferred radar for that box isn't available, or if the tracking program isn't getting a radar return from a tracked aircraft. More on this later. So, as you can see from this little math exercise, much of the radar data collected by each radar site goes unused!

Note: As a secondary consideration, as it appears that typically 80+% of the transponder replies go unused in the ARTCC environment, consider how much this unused data is contributing to the 1090 MHz transponder reply frequency congestion...

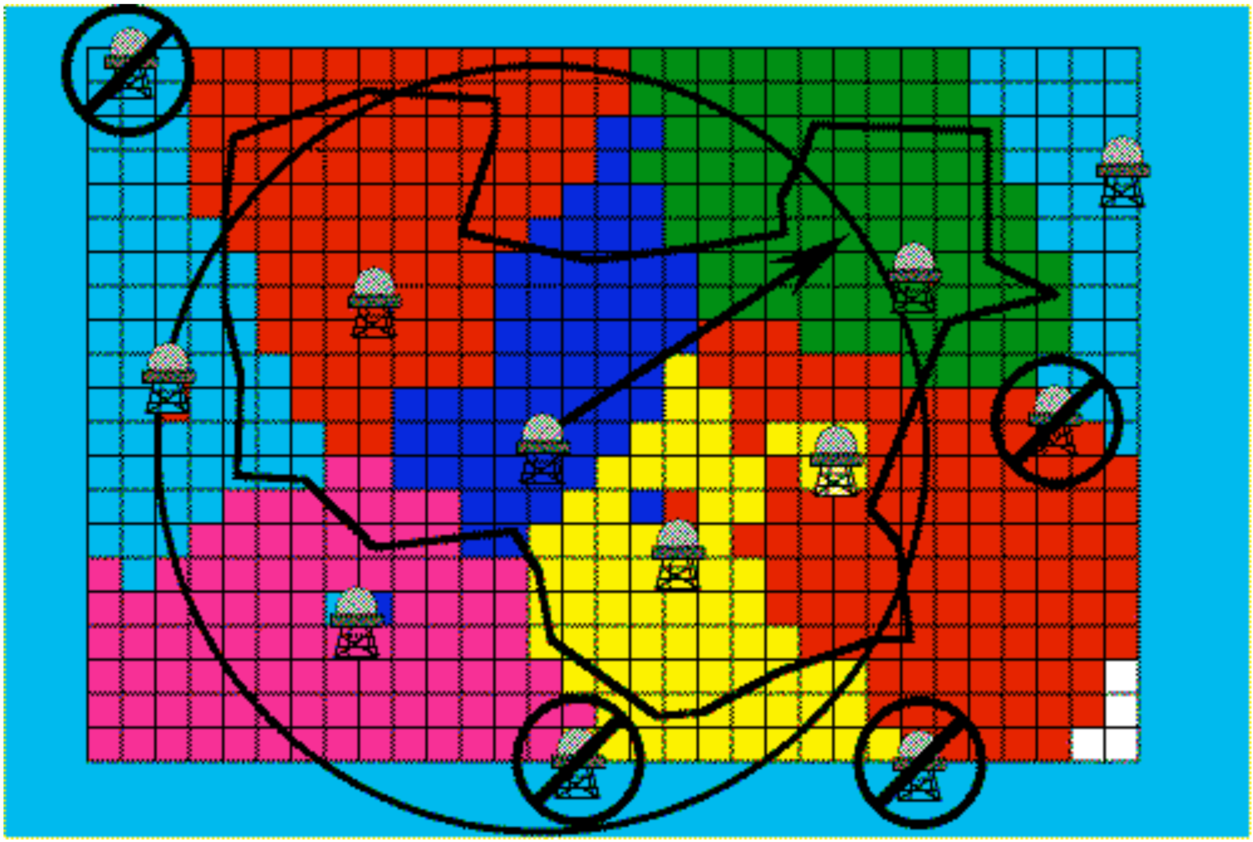


Slide 6 of 41: Willard C. Meilander

The fact that much of the data is thrown out was obvious a long time ago by one of the competitors for the radar data processing contract back in the early 70's. Goodyear Aerospace, one of three companies vying for the contract, had developed a parallel processing computer, termed the Staran. It purportedly utilized all the data, from all the radar sites, all the time, (even the primary radar returns!) and "fused" all the data. Obviously Goodyear Aerospace didn't win the contract, as we utilize serial processors in ATC, not parallel processors. Willard C. Meilander, one of the original designers of the Associative Processor, has written many papers about the importance of utilizing all the data, all the time, from all the radar sites. I made reference to two papers he authored in my "Real Targets - Unreal Displays" paper.

2006-03-23: Read Will Meilander's "Quick Look" note about the state of radar data processing, and his solution.

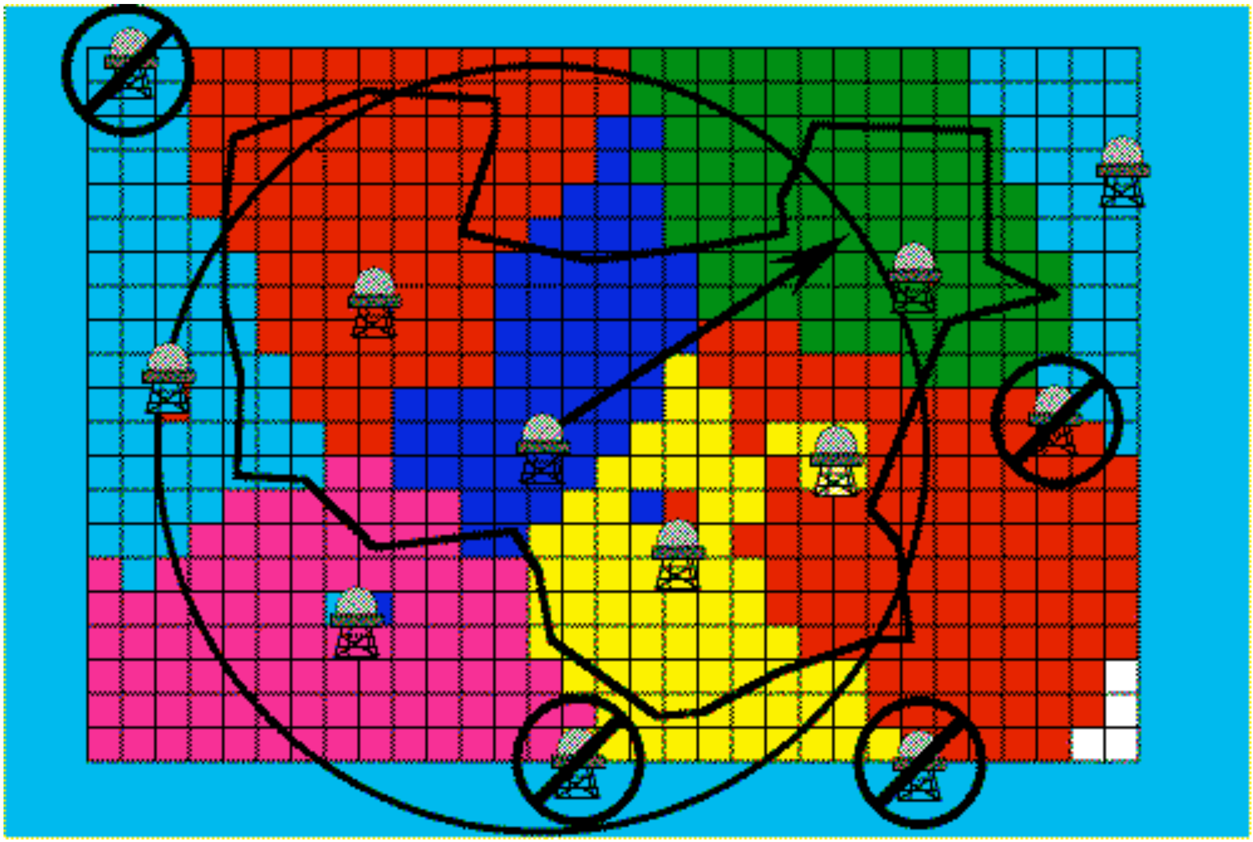
Update to link [2005-07-29]: Professor Meilander is working towards making his papers available via the web. You can view some of them at http://www.cs.kent.edu/~parallel/papers/



Slide 7 of 41: Not on-line

It's a drag to be "not on-line" these days. You miss out on lots of important information if you're not connected to the internet (important information like this presentation!). In our ARTCC network of radar sites, the problem of being "not on-line" exists, as all radar sites that have coverage into and along the edges of ARTCC airspace are not necessarily feeding that facility. Notice the radar sites that surround Cleveland Center that weren't hooked up when this slide was developed for my talk in '91. Take, for instance, the one at the lower center of this slide. That radar site is located in Higby, WV. A low-altitude aircraft on the southern boundary of Cleveland Center airspace near that radar site, being worked by a controller at Cleveland Center, is not afforded any coverage from that site because it is not even hooked up to Cleveland Center. This situation is very similar to my example given at the introduction page of this web site. In that case, the facility that was providing service to that Piper Arrow on its way in to Frederick was not providing *radar* service because the radar data of the site that could see the aircraft wasn't feeding their facility.

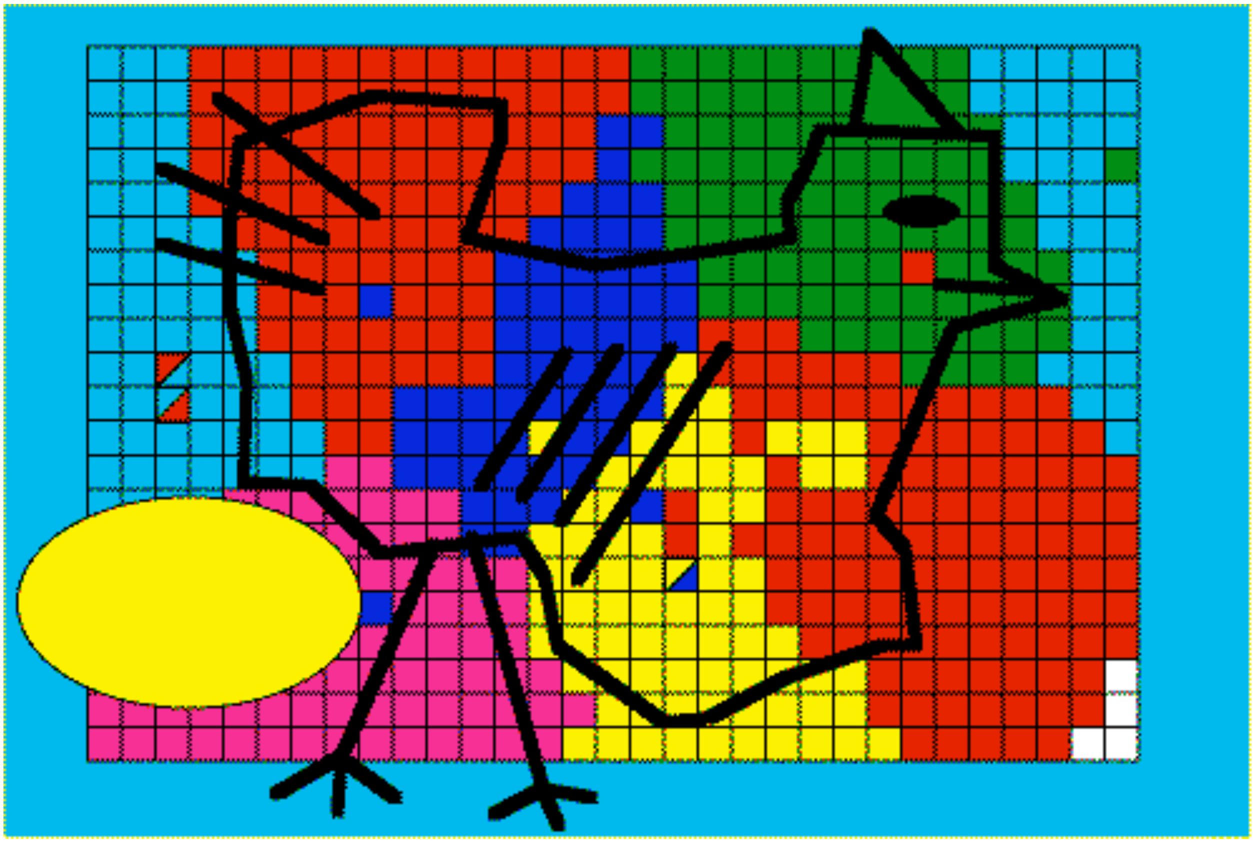
Since I left Cleveland Center in '93, I understand that two more radar sites are now feeding the facility. One of 'em, which I didn't depict, is in Cooperville, MI, and the other is the one in The Plains, VA. Higby ARSR is not yet connected. Nor is the one in Empire, MI. Nor is the one in Benton, PA.



Slide 8 of 41: Rorschach Test

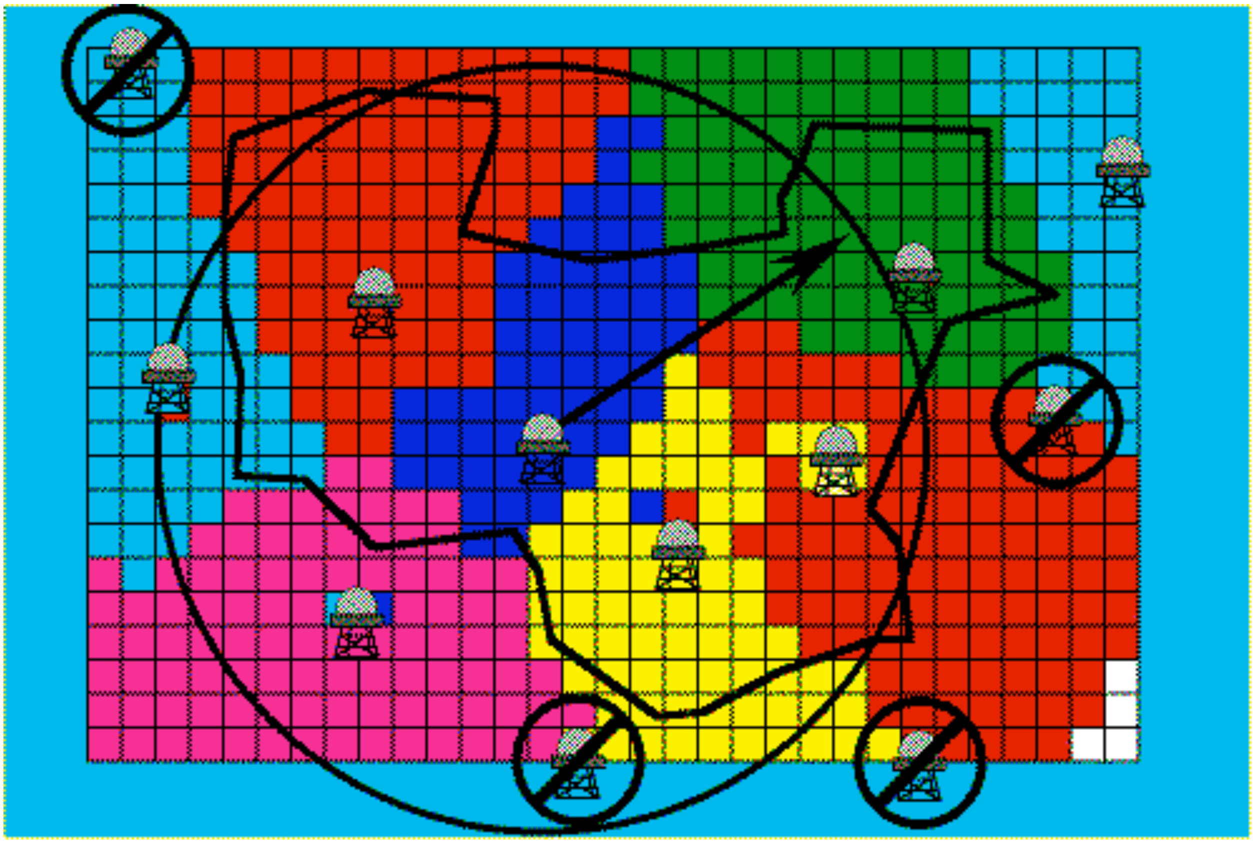
The problems with radar data processing that I discovered and wrote about didn't come up all of the sudden or anything. The near midair collision that occurred in the Spring of '85 was the impetus for my devoting untold hours upon hours upon hours to this topic, in an effort to understand just what was taking place. Then, in April 1988, I observed an operation that made me understand clearly that I wasn't going to get anything addressed by just talking about the problems I saw with radar data processing at Cleveland Center (see section 3.1.1.2 from the paper I reference at the end of this paragraph). I figured I had to learn as much as I could and write something official about it to get things improved. So I started hanging around and talking with the systems maintenance technicians, and asking a lot of questions. Then I dug into their manuals. Mind you, I'm not a computer programmer or electrical engineer, or anything like that. My background had some technical aspects to it. For instance, I got my ham radio license (WA8ZTV) back when I was in 7th or 8th grade, and I built some electronic kits and stuff like that. After high school I went to Ohio Institute of Technology and got an associate degree in Electronics Engineering Technology, then I went out and got a job and worked as an electronic technician. So I have a limited background in electronics and computers, but I'm certainly no whiz at this stuff. However, I stuck with this and learned all I could, then I began to write. What I wrote turned into a paper entitled "Selective Rejection of Low Altitude Radar Data at Air Route Traffic Control Centers: An Unsatisfactory Compromise." I submitted this paper as an Unsatisfactory Condition Report (UCR) on September 26, 1988. The UCR was closed April 4, 1989.

At any rate, one day, out-of-the-blue, I get this letter in the mail. It is a "call for papers" for the Sixth International Symposium on Aviation Psychology (see glossary). I have no idea how I got on this mailing list, but I figure, why not give it a shot, as by that time I had exhausted my avenues in the FAA for addressing this issue. So I submitted an abstract, and much to my surprise I was selected to be one of the speakers! So I then began to formulate another paper, as well as a presentation. The slides you're viewing here originated from that presentation. So, as I'm making up these slides, I'm wondering about what's going to be expected of someone speaking at a symposium on aviation *psychology*. Hmmm...is everyone there going to be psychologists? Let's see, psychologists deal with things like ink blot tests, right? What might be a subject's interpretation of this somewhat abstract graphic design above? What do you see?



Slide 9 of 41: Rorschach Test results

Did you see the chicken??? <grin>

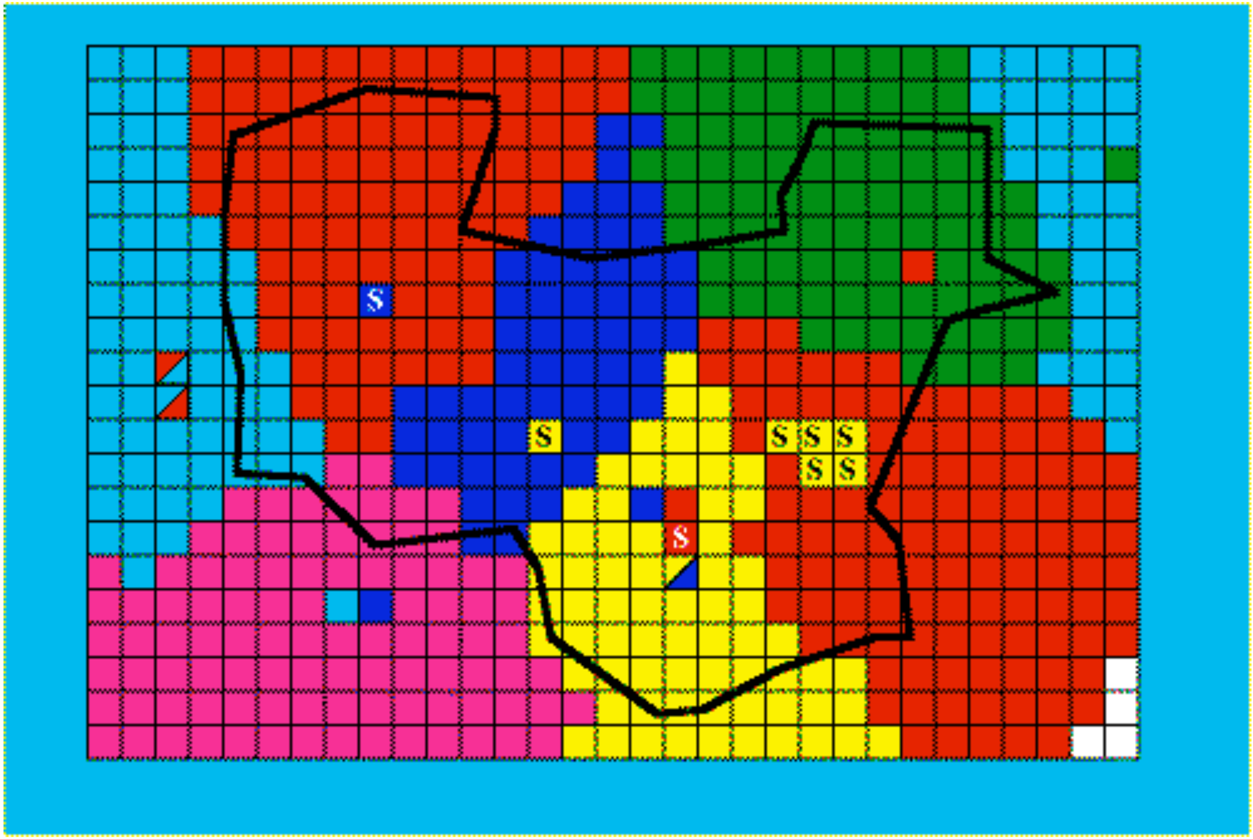


Slide 10 of 41: The "eye of the chicken"

Okay, enough with the questionable humor.

As you recall, one problem I've highlighted thus far is the fact that even though an aircraft may be detected by radar, it may not be on the controller's scope because the data simply isn't fed to the facility. That presents a situation very much like what occurred ~~(and still occurs)~~ at Frederick.

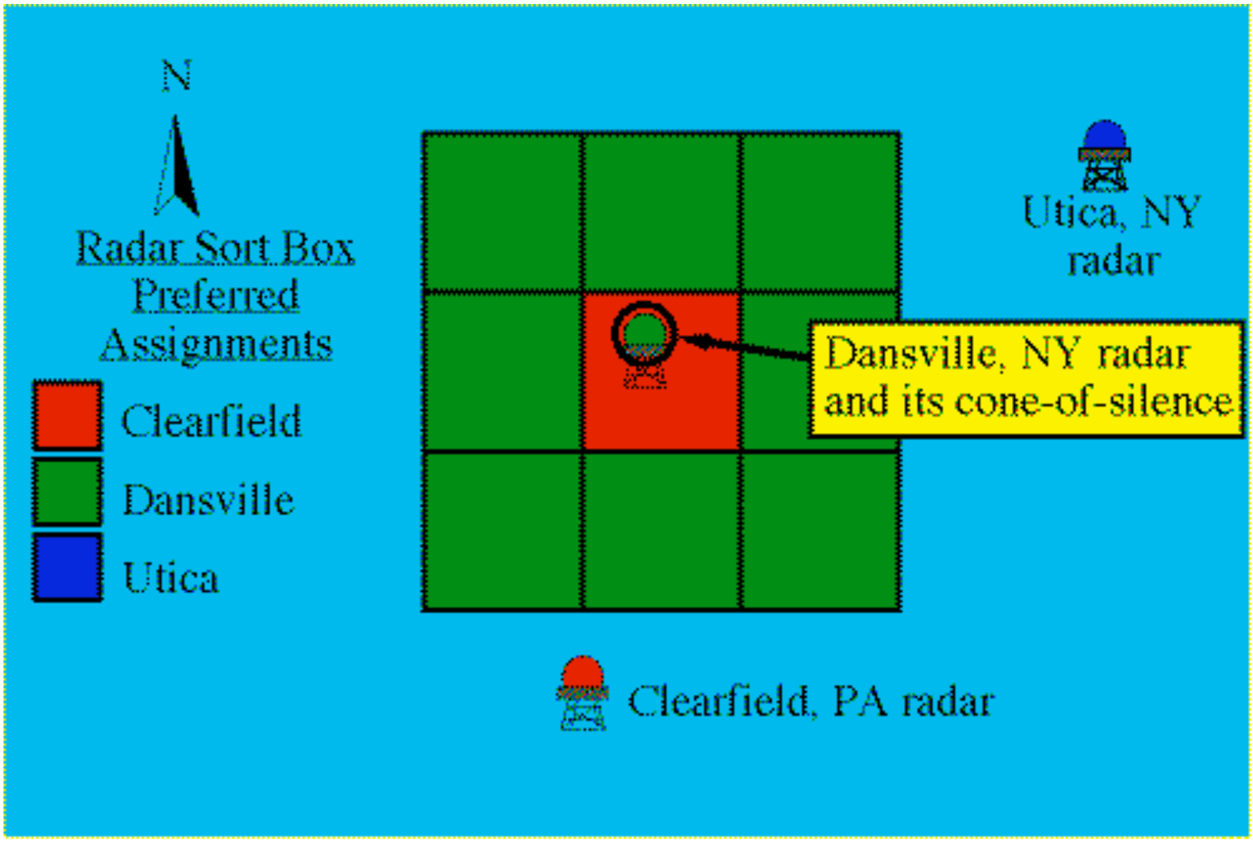
The other problem involves the inability of a radar to see directly overhead. Take a look at the "eye" of our chicken. Now, let's remove the radar icons....



Slide 11 of 41: The "cone-of-silence" issue

There. Do you see the red colored sort box, all by itself, in the upper right. It is about where the "eye of the chicken" is located. That "red eye" is the sort box that lies over the Dansville, NY long-range radar site. Why is it red?

Let's zoom in...



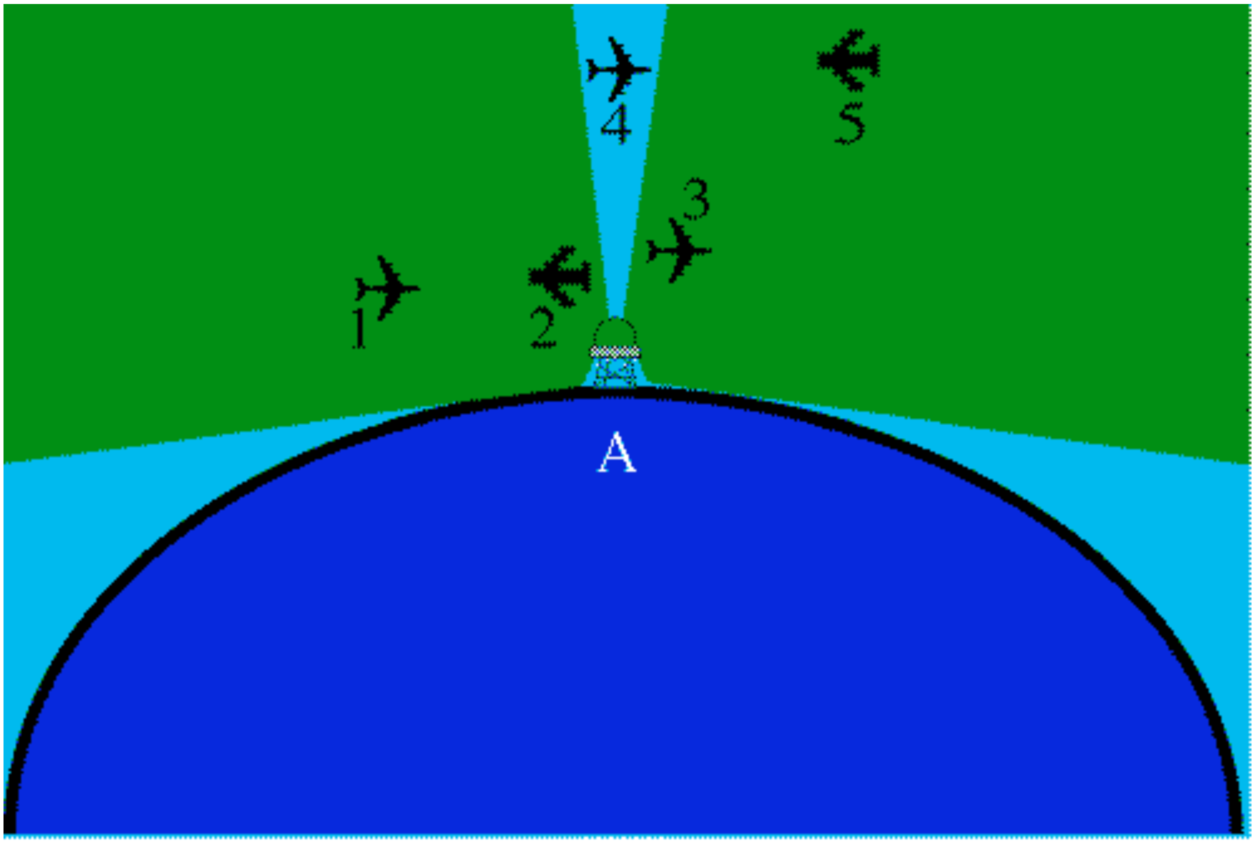
Slide 12 of 41: The "cone-of-silence" adaptation

This slide depicts the programming of preferred assignments in nine sort boxes around the Dansville long-range radar. The Dansville radar itself, which I colored green, is up in the north-northwest part of the middle box. The radar sort boxes which I depicted in green, which match the Dansville radar's icon color, show that the preferred radar for those sort boxes is the "green" Dansville radar. Similarly boxes colored red are utilizing the "red" Clearfield radar as the preferred radar. All boxes colored purple have the "purple" shaded Utica radar as their preferred assignment. Get the idea?

First of all, notice than none of the nine sort boxes are shaded purple. Therefore, even though Utica's coverage extends over this area, it is not used as preferred coverage. The data is tossed into the ole bit bucket. However, the box that overlies the Dansville radar is shaded red, which is the same color I depicted the Clearfield long-range radar. Therefore, any aircraft in this 256 square mile area must been "seen" by Clearfield to be presented for display, because as you recall from our earlier discussion, one-and-only-one radar site is used at any one time. The Clearfield radar site is just over 100 miles south of the Dansville radar site.

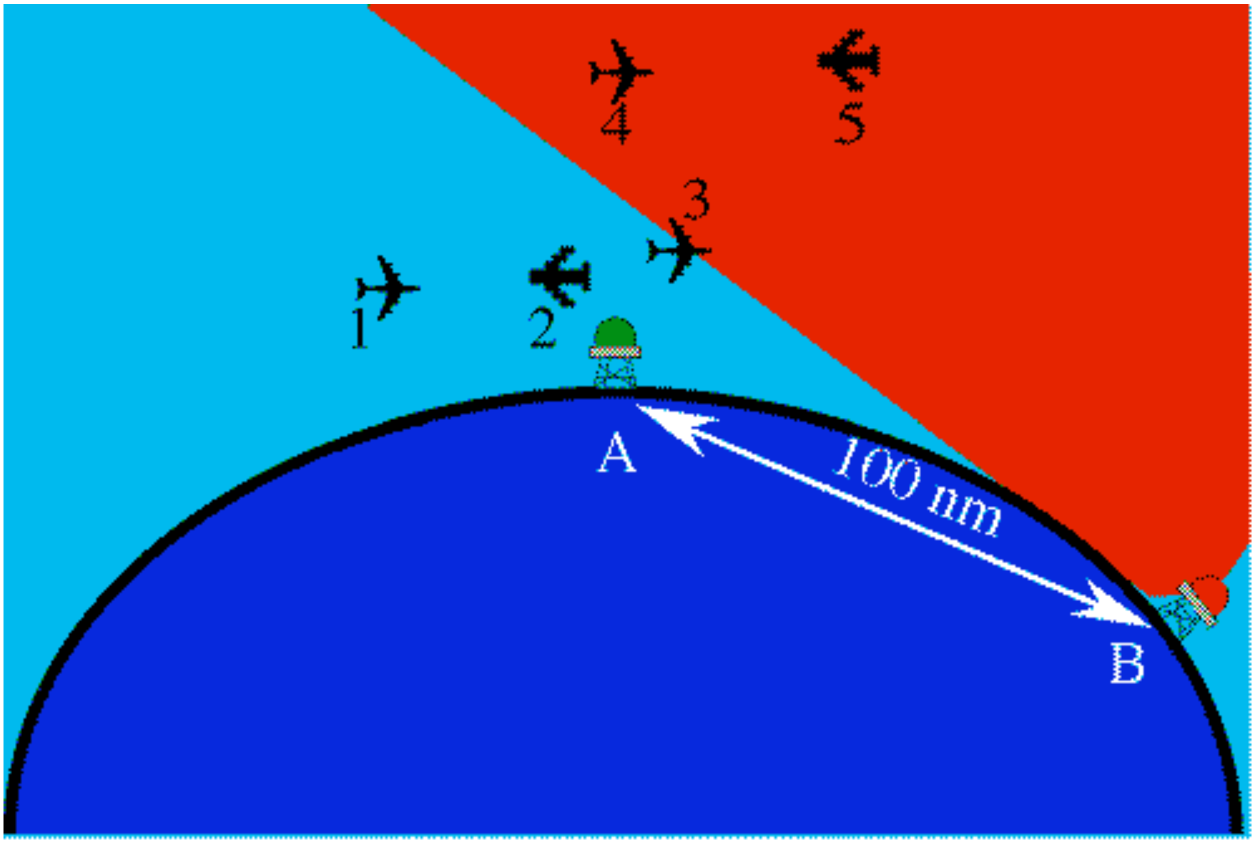
Why is it done this way? This is done to make it so an aircraft that flies directly over a radar site, through it's cone-of-silence, will still be displayed, as the radar can't look directly above itself. That was the adaptation (assignments) back till shortly after my "Real Targets - Unreal Displays" paper was published. In the Center enroute environment, it is typical for a site far away to be assigned as the preferred site, so as to compensate for the cone-of-silence. By the way, before we move on, notice my depiction of the difference in size between a cone-of-silence and the 256 square mile radar sort box. A cone-of-silence increases in size the higher one goes. I used a 5 mile diameter for the cone for comparison with the size of a sort box. So, as you can see, we're correcting for a problem in roughly 20 square miles of airspace, but our fix actually covers 256 square miles.

Let's look at this from a different angle...



Slide 13 of 41: Cone-of-silence (side view)

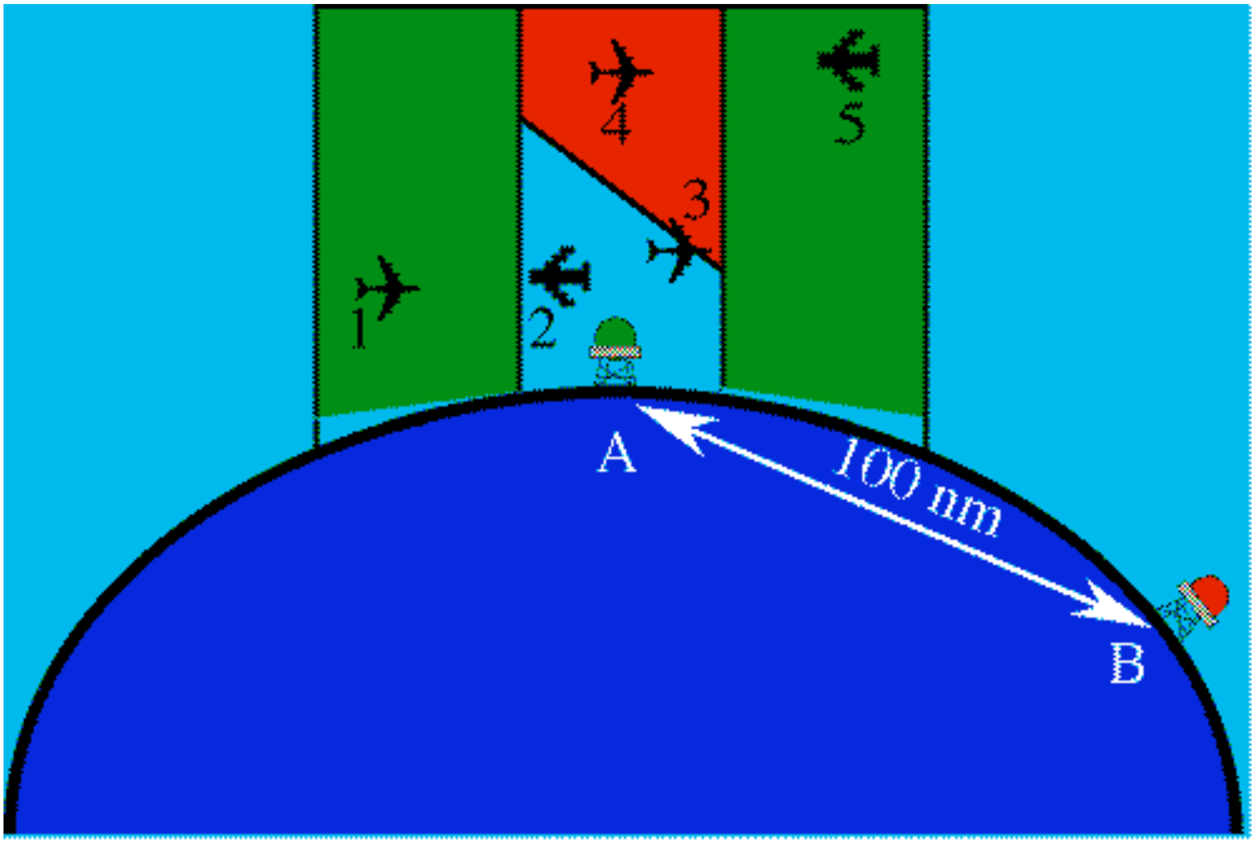
As mentioned, ATC radar cannot see directly above itself. It simply isn't designed to be able to do that. In the above example, all but airplane #4 are detected by radar site A. Aircraft 1 and 2 represent low-altitude aircraft, 3 is a slightly higher aircraft, and 4 & 5 are much higher altitude aircraft. Also, before we move on, notice that the cone-of-silence is very small near the radar, and it gets wider the higher we go. That's why they call it a cone.



Slide 14 of 41: Coverage over the top of the radar

However, radar sites can see above each other quite easily, and therefore not lose an aircraft as it flies through the other site's "cone-of-silence." In this case, airplane 4 is easily seen by radar B, although airplanes 1 & 2 are below the line-of-sight coverage of radar B due to the curvature of the earth, coupled with their lower altitude. Airplane 3 is just barely detected by site B.

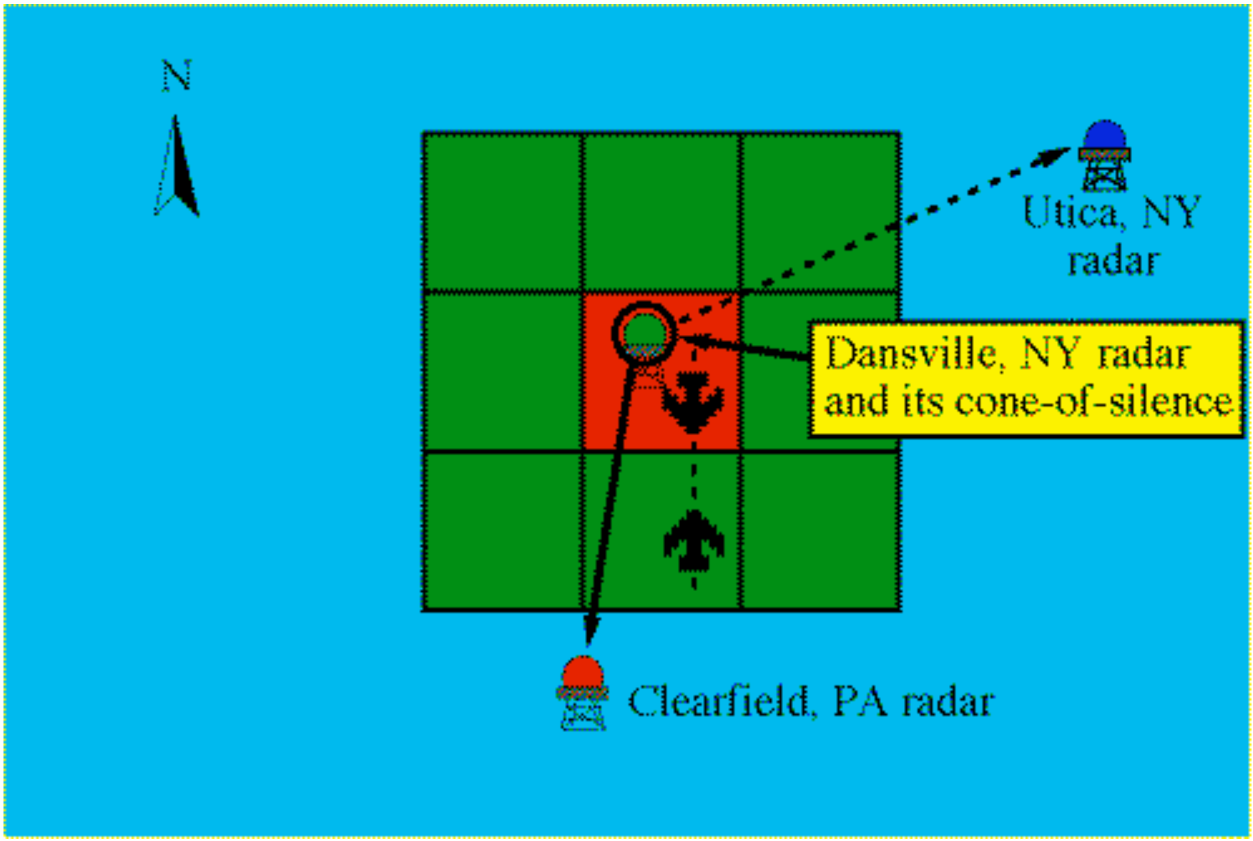
So, remember the "red" chicken's eye? We'll view that from this angle also...



Slide 15 of 41: The "eye of the chicken" (side view)

This is a side view of our red "chicken's eye." The entire 256 square mile area, *from the ground up*, is assigned preferred coverage from radar B (Clearfield in our case), which is nearly 100 miles away. Assigning radar B as preferred over radar A's location takes care of the cone-of-silence problem, as aircraft 4 is detected and processed for display. But look what happens to the low-altitude aircraft. In this example, aircraft 2 & 3 are solidly detected by radar A, but radar A's data is not used. The data made it to the facility, but by the process of selective rejection, this data goes unused, as radar B is assigned preferred. Radar B just barely sees aircraft 3, but it definitely doesn't see aircraft 2.

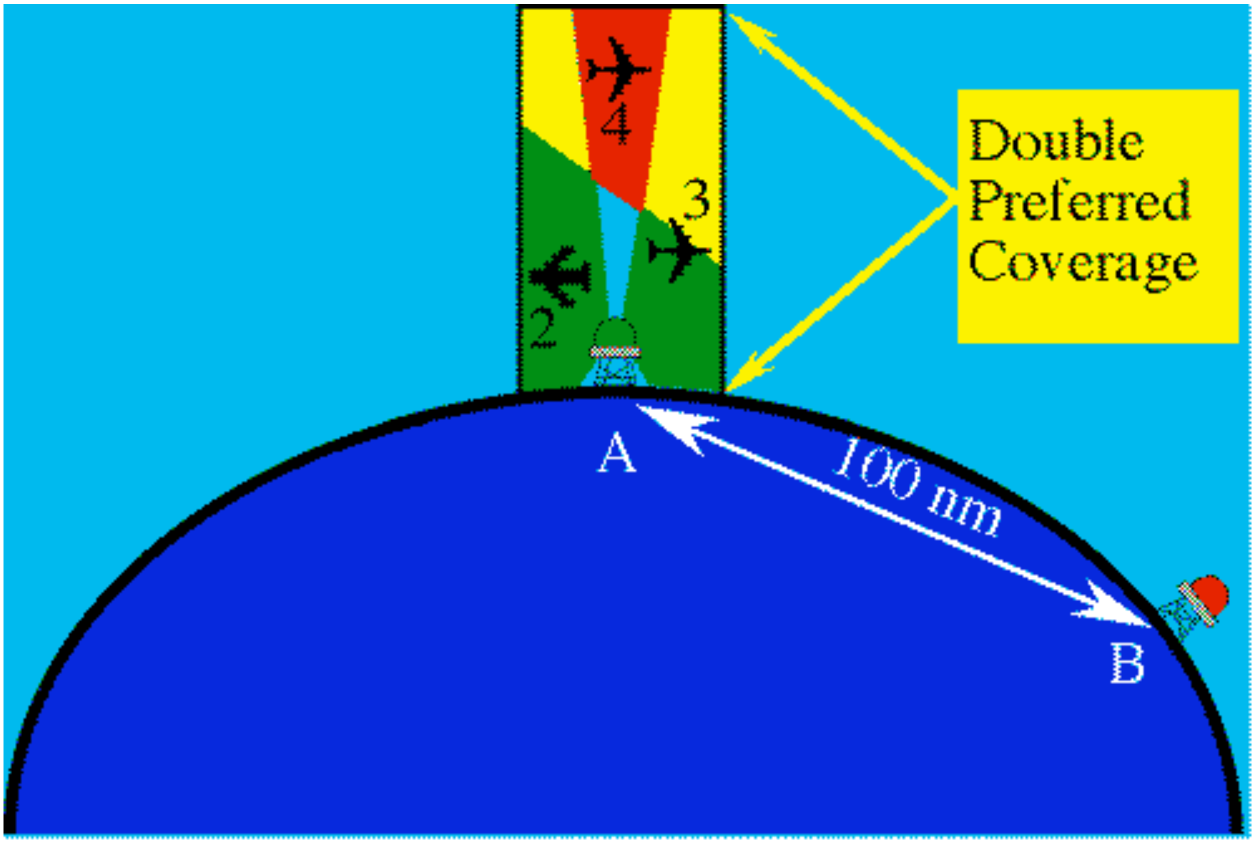
What can happen when sort boxes are adapted in this manner?



Slide 16 of 41: Head-on traffic not displayed

Here we have a case of a low-altitude north bound aircraft receiving radar service from the controller, whereas the south bound aircraft is flying VFR, not talking to Center (or if the pilot wanted to have radar service from Center, the controller wouldn't be able to identify the aircraft, as it wouldn't be displayed). Both aircraft are detected by one-and-only-one radar site (Dansville). The radar data on both aircraft is sent to the computer at Cleveland Center. However, due to the process of selective rejection and the manner in which these sort boxes are adapted in this example, the south bound aircraft is NOT displayed. Hence, the controller can not issue a traffic advisory or safety alert to the north bound aircraft. The fixing of one problem (cone-of-silence) has contributed to another problem (invisible airplane).

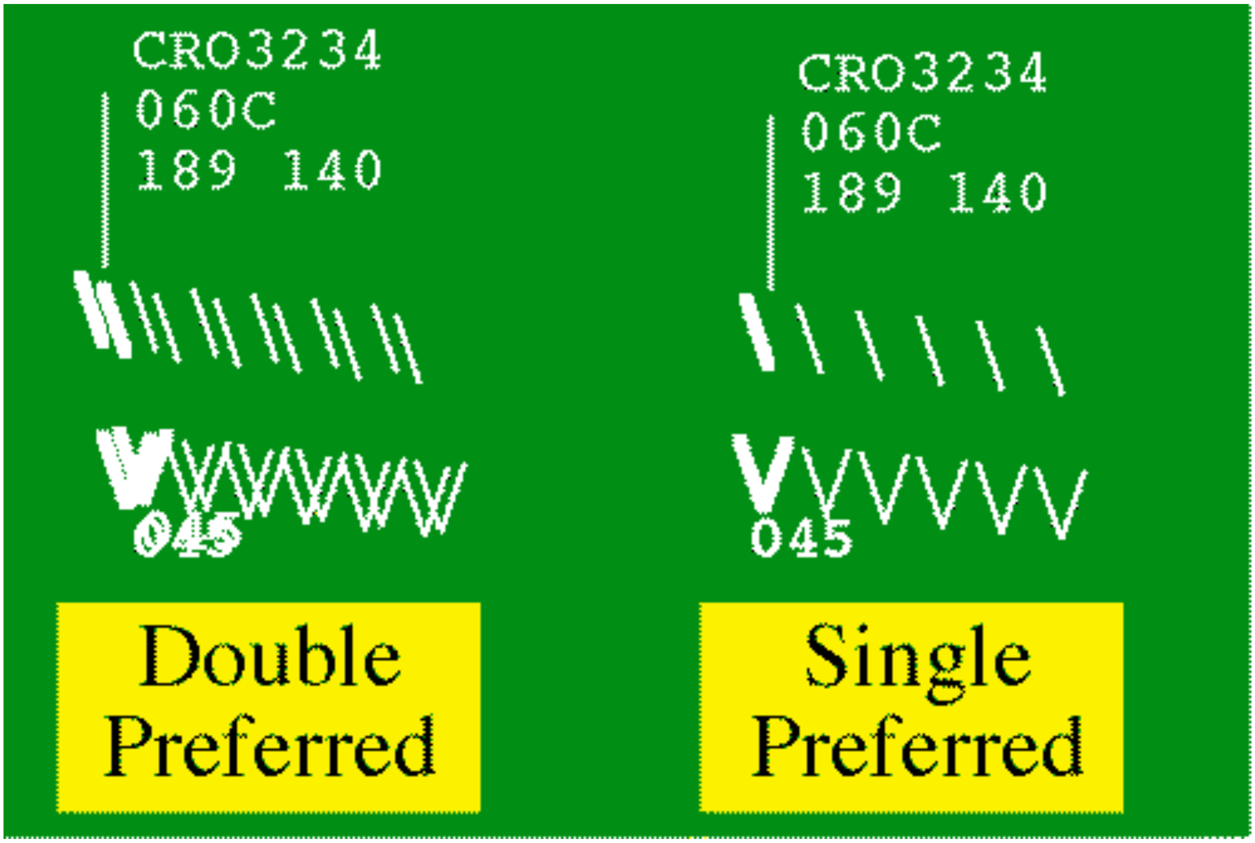
Can this problem be alleviated?



Slide 17 of 41: Double Preferred Coverage

Yes, the problem can be alleviated. Remember how I told you that up to 4 radar sites can be assigned to any one radar sort box? And remember how I told you that the first radar site listed is utilized as preferred, the second as supplemental, and the 3rd and 4th aren't used? Well, this can be adapted somewhat differently in that the second radar site becomes the "alternate preferred." This means that both radar sites in that airspace will be used to display the aircraft. Neither radar site's data will be rejected in a sort box so assigned. This way both aircraft 2 and 4 aren't left out of the picture. However, aircraft 3 is "seen" by both radar sites.

What happens in this case?

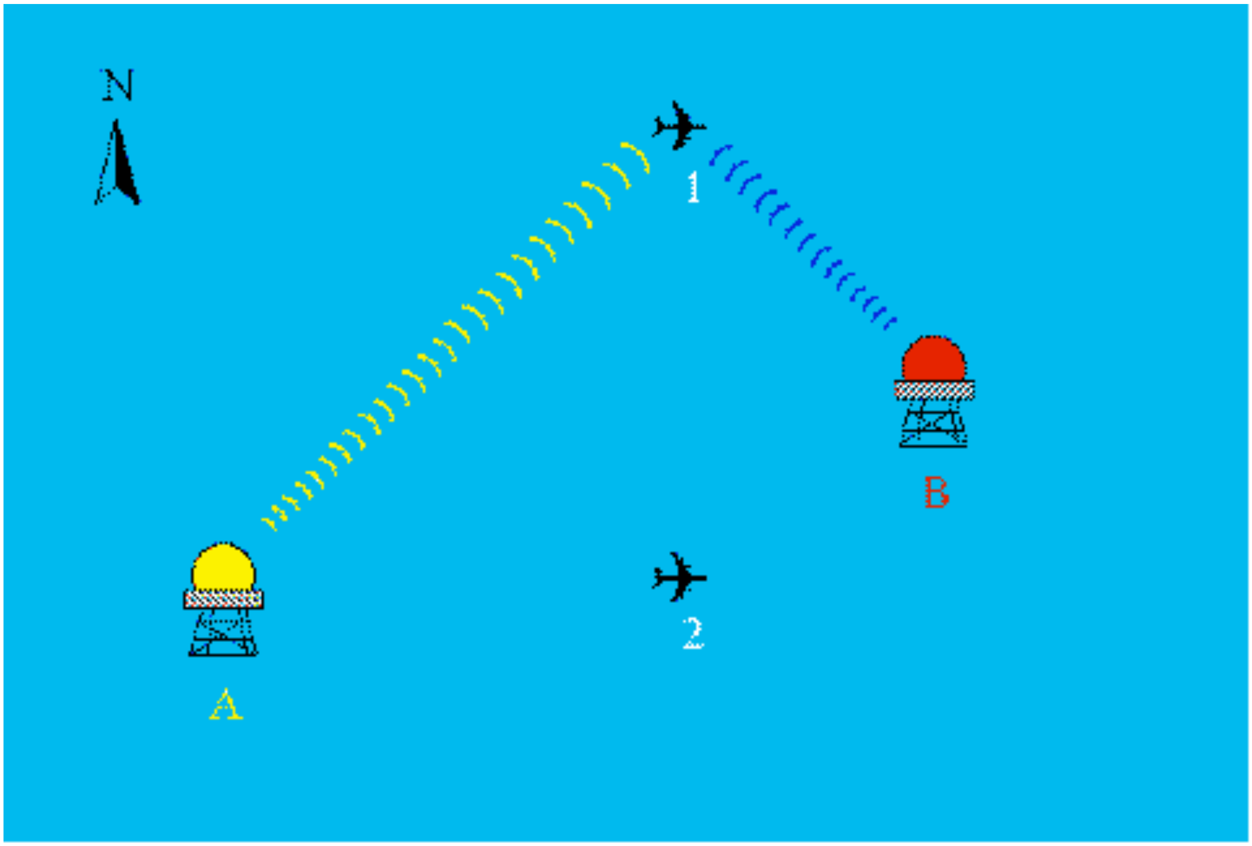


Slide 18 of 41: Display clutter

Here's what occurs on the controller's display when two radar sites are allowed to display the data from the same aircraft at the same time. The slash marks are the targets that represent the airplane. If two radar sites are utilized for display in a given sort box, and the aircraft is detected by both of those sites, two targets will appear, very close to each other. Concentrate on the target symbols (the slash marks and the V symbols). The top left target is what we call a tracked target with a full data block (in this case, the full data block shows that this target is Crown Airways flight 3234). However, with two targets, it looks like two airplanes are in formation flight, westbound. But it is really only that one aircraft, displayed differently by two different radar sites. The bottom target is that of an aircraft flying under VFR, with its transponder set to reply on code 1-2-0-0, and it is reporting an altitude of 4,500 feet. Because the aircraft is detected by both the preferred and the alternate preferred radar sites like the one above it, it also appears that two airplanes are flying in formation, westbound. If the radar sort box only used one radar site for display as is shown on the right side (Single Preferred), the target symbols would appear clean and crisp, showing only one aircraft each (assuming, of course, that the preferred radar actually detected the aircraft). Double Preferred adaptation is specifically kept to an absolute minimum because of this problem of "clutter."

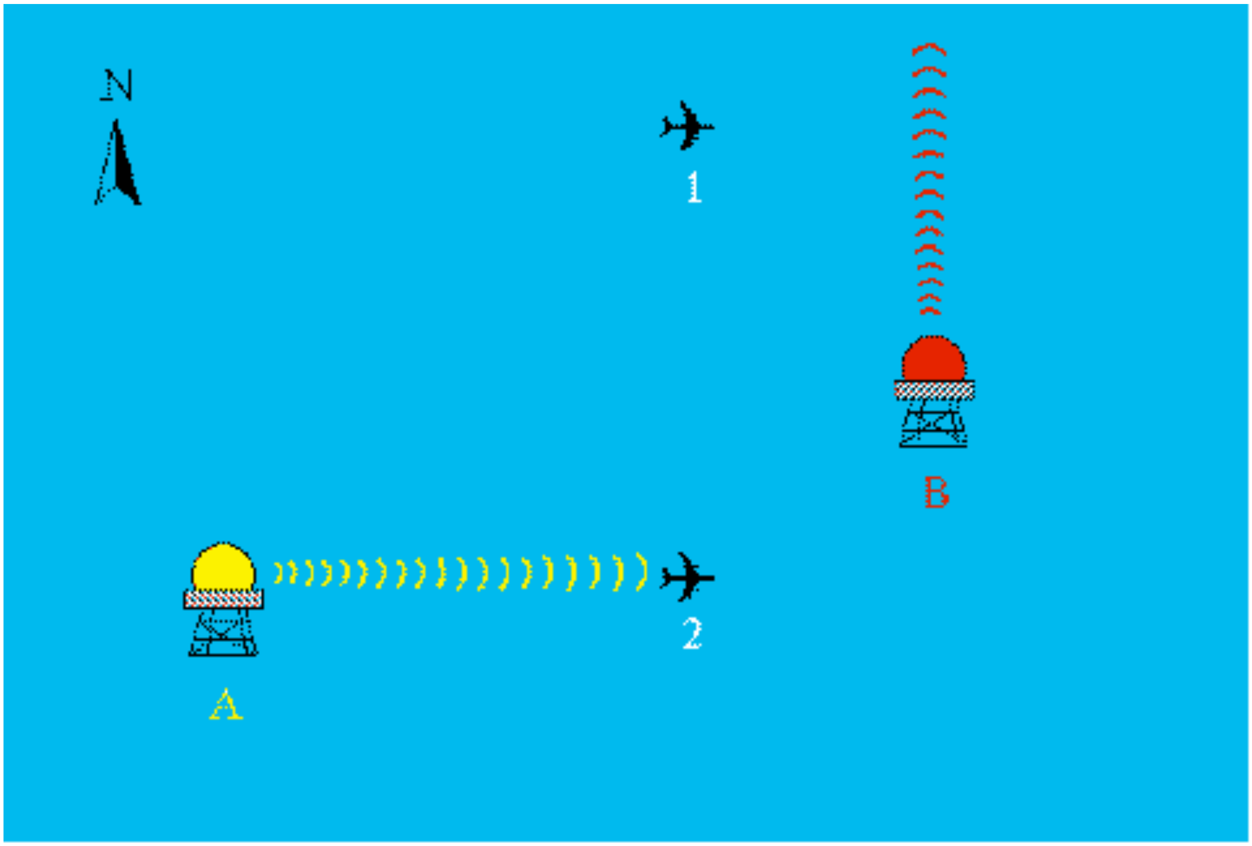
So, why aren't the targets in the exact same location you ask? Are the radar sites that bad at determining an aircraft's point in space, that they don't agree? No, the radar sites are actually pretty darn good, at least from my point of view behind the scope. For example, when I observe an aircraft inbound on an ILS, the center of the target is usually right on the center of the localizer. Also, I can't help but feel that determining an aircraft's position would be much more accurate when two or more radar sites are involved. But it isn't done that way...apparently because the computers can't crunch all that real-time data. Remember, the way it is done to this day, most of the data goes unused...

So, again, why do the targets appear displaced from each other, when in fact they are one in the same airplane?



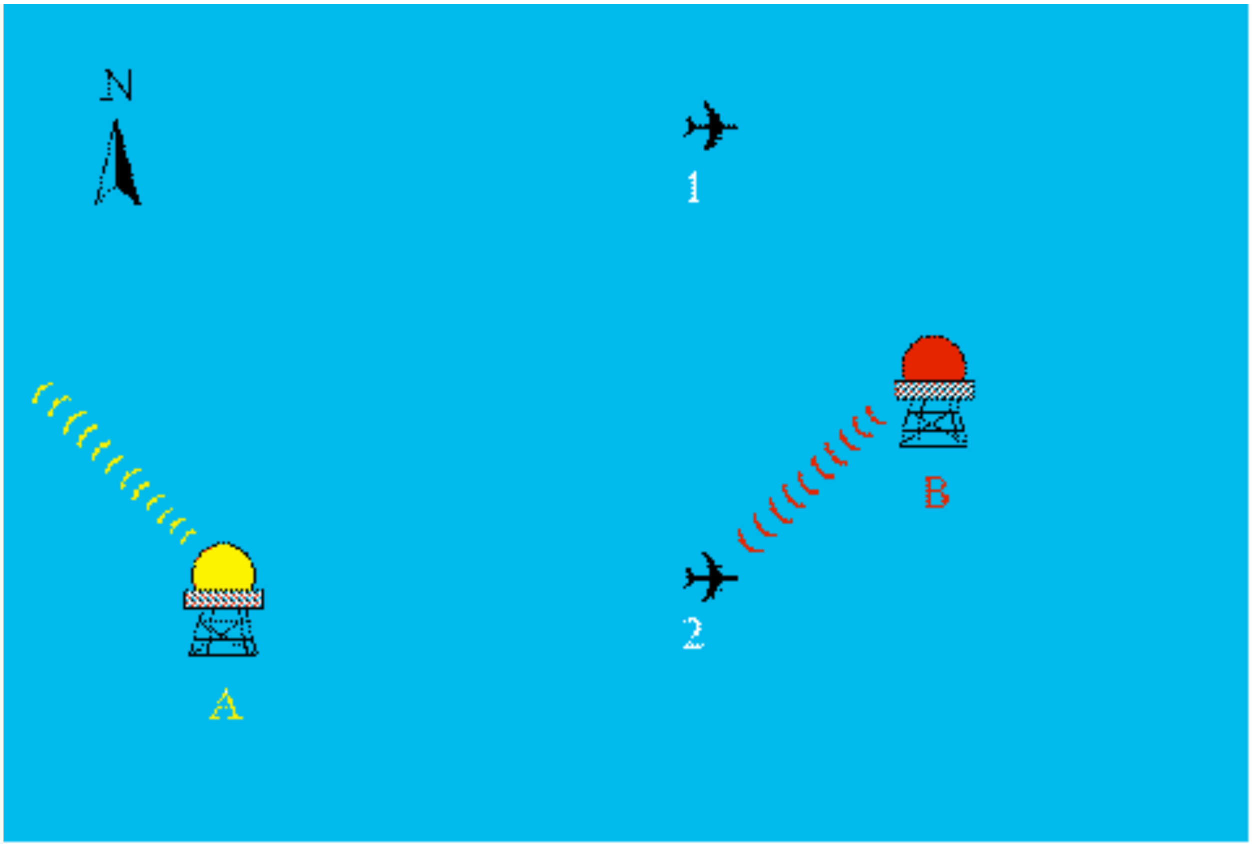
Slide 19 of 41: As the radar turns

In this example, aircraft 1 just happens to be detected by radar sites A & B simultaneously. In this case, the targets would be positioned so close to one another that viewing it at the resolution controllers typically set their scopes to, the two targets would appear virtually as one. However, that was just by chance, and as the radar turns...



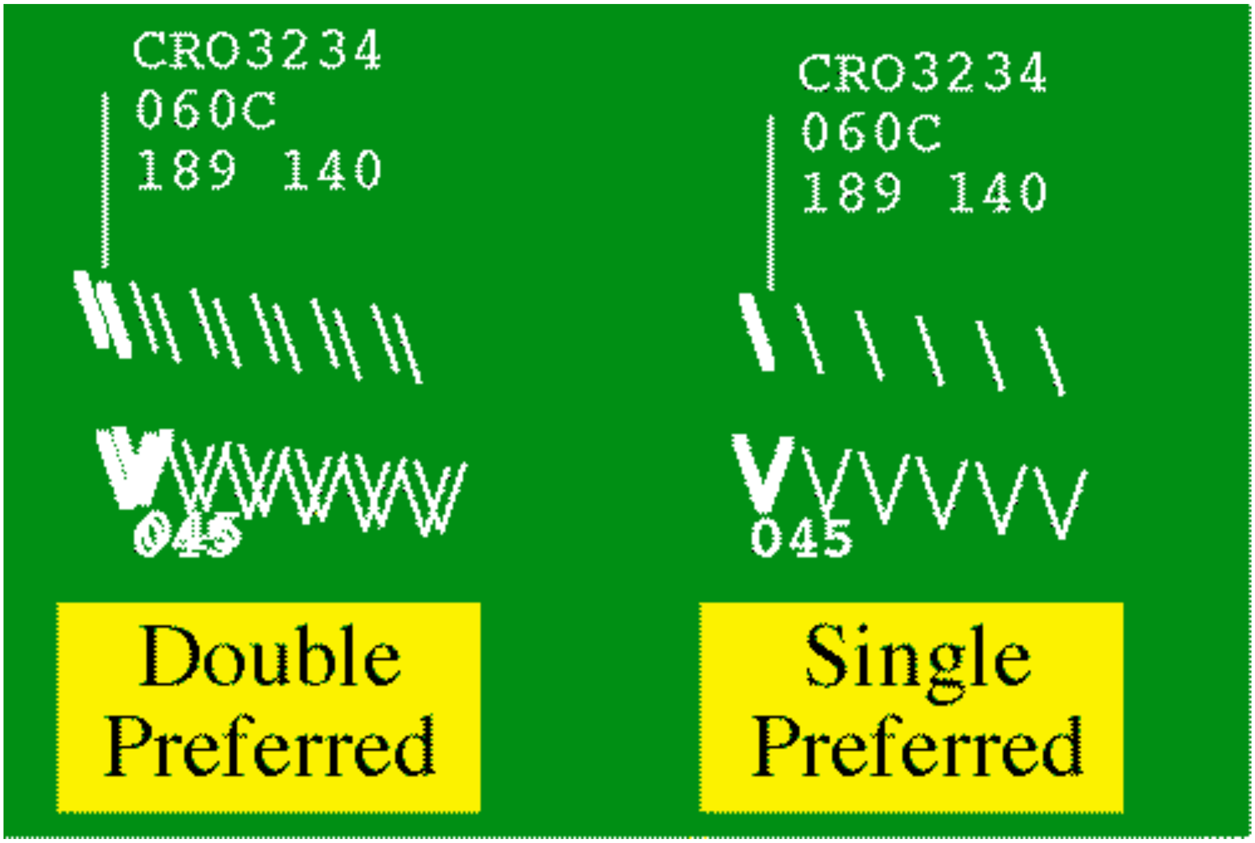
Slide 20 of 41: As the radar keeps turning

Look at airplane 2. When radar A sweeps by airplane 2, radar B is looking up north. Radar B has to sweep 225 degrees before it sees airplane 2.



Slide 21: As the radar continues

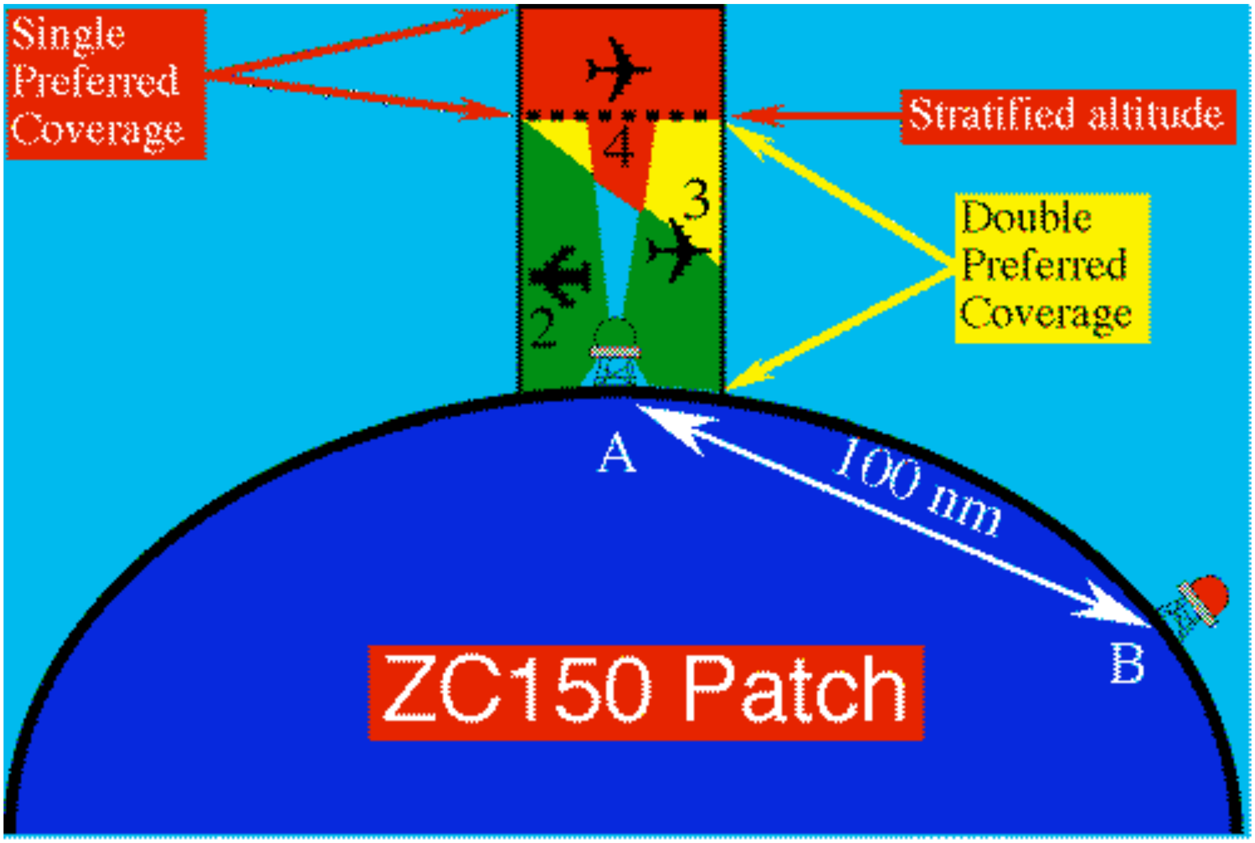
Long-range radar sites turn at a rate of 5 rotations per minute. In other words, it takes 12 seconds to make one complete sweep. So, in our example here, to rotate 225 degrees will have taken 7.5 seconds. If the airplane is traveling at 2 miles per minute (120 miles per hour), in 7.5 seconds it will have traveled 1/4 of a mile from the time radar A saw it, till radar B saw it. That is what makes it look like two aircraft flying in formation on the display if double-preferred adaptation is utilized.



Slide 22 of 41: Double preferred = poor presentation

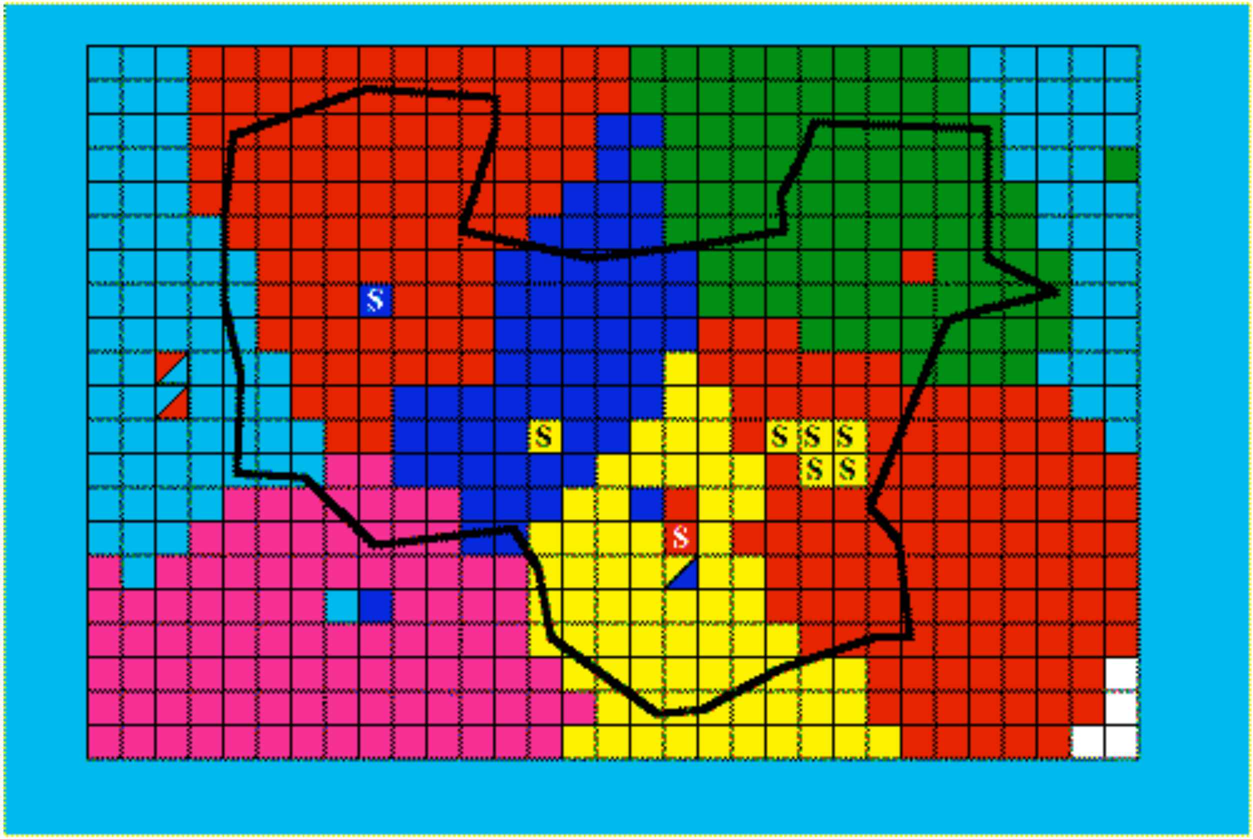
Hence, with a Double Preferred assignment we're likely to get a poor presentation. Single Preferred will always be crisp. Unfortunately, if the target doesn't happen to be detected by the preferred radar, it will be so crisp that it becomes invisible.

Is there a way we can have the best of both worlds?



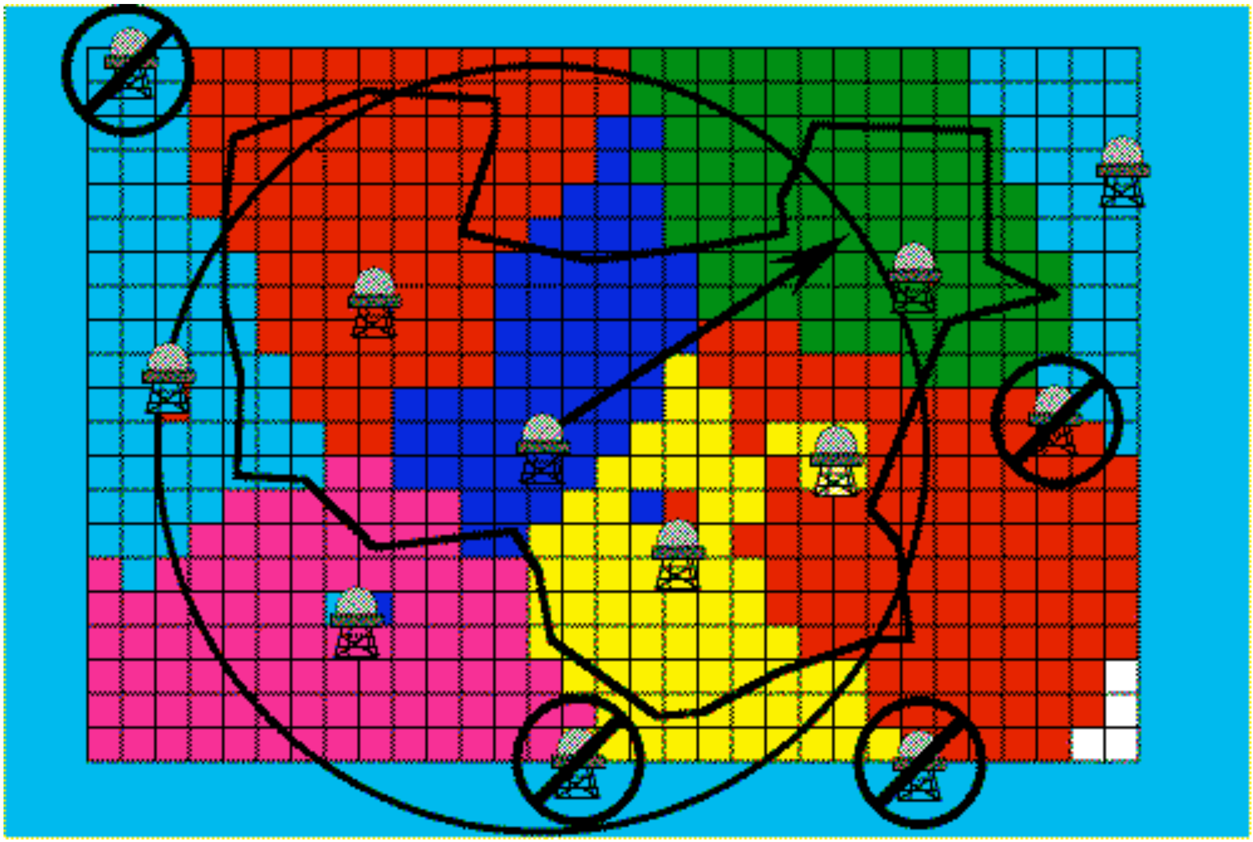
Slide 23 of 41: The best of both worlds

Yes, this problem can be "patched." There had existed for years a software patch, called the "ZC150 patch," that made it so the radar sort boxes could be stratified. With stratification, radar B would be assigned as preferred coverage at a set altitude and above for the sort box encompassing radar A, whereas below that altitude there would exist double-preferred coverage in that same sort box. Therefore, in some cases we may have double targets, but not in the majority of cases as would be with double-preferred adaptation without stratification.



Slide 24 of 41: Stratification finally achieved

My Unsatisfactory Condition Report of Sep '88 addressed this issue and recommended that we implement the use of this software patch. In May '90 this patch was finally implemented for the first time in Cleveland Center. It was used for radar sort boxes over the Detroit, Cleveland, and Pittsburgh long-range radar sites. This was implemented to support CENRAP, wherein center radar data can be supplied to approach controls as an emergency backup should their airport surveillance radar fail. The sort box over Dansville wasn't adapted in this manner until after the Jan-Mar '92 issue of the Journal of Air Traffic Control, which reprinted my paper from the symposium.



Slide 25 of 41: The midpoint problem

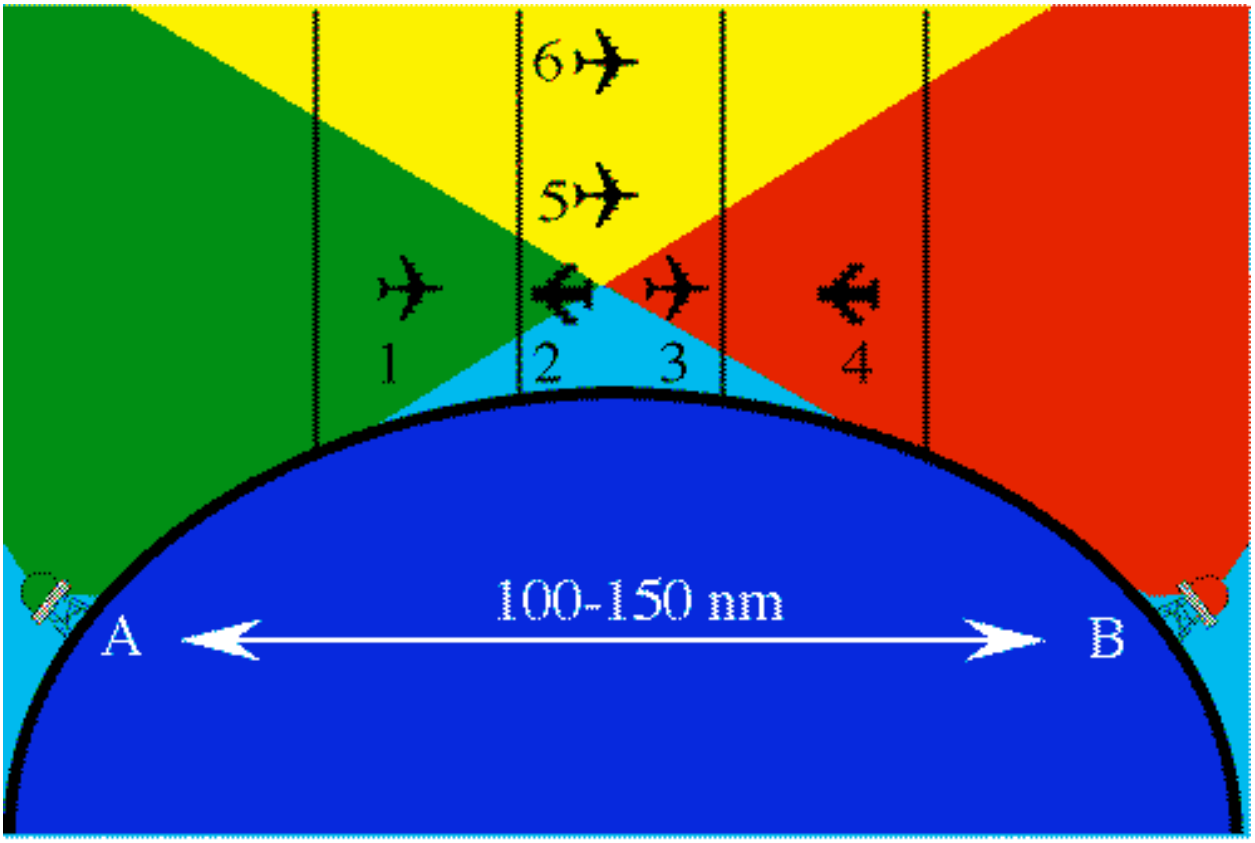
As a review, we have covered two distinct problems in which aircraft, detected by radar, are not displaying on the scope.

The first problem is where radar data is simply not supplied to a neighboring facility. This is like the Frederick "Radar Service Terminated" example. The aircraft may, in fact, be detected by radar, but not displayed on the controller's scope who has responsibility for the aircraft at that time. This problem can only be remedied if the data is supplied to the facility that needs it (and only then it works if that data isn't thrown out by the program!).

The second problem is the "cone-of-silence" problem, wherein the manner of programming to fix one problem (aircraft can't be seen directly above the radar) results in yet another problem (a whole bunch of low-altitude airspace will not show aircraft targets because the radar data is thrown out).

The third problem, however, is much more sinister. It isn't nearly as distinct or easy to recognize. In fact, it will give the controller the impression that an aircraft has a malfunctioning or intermittent transponder.

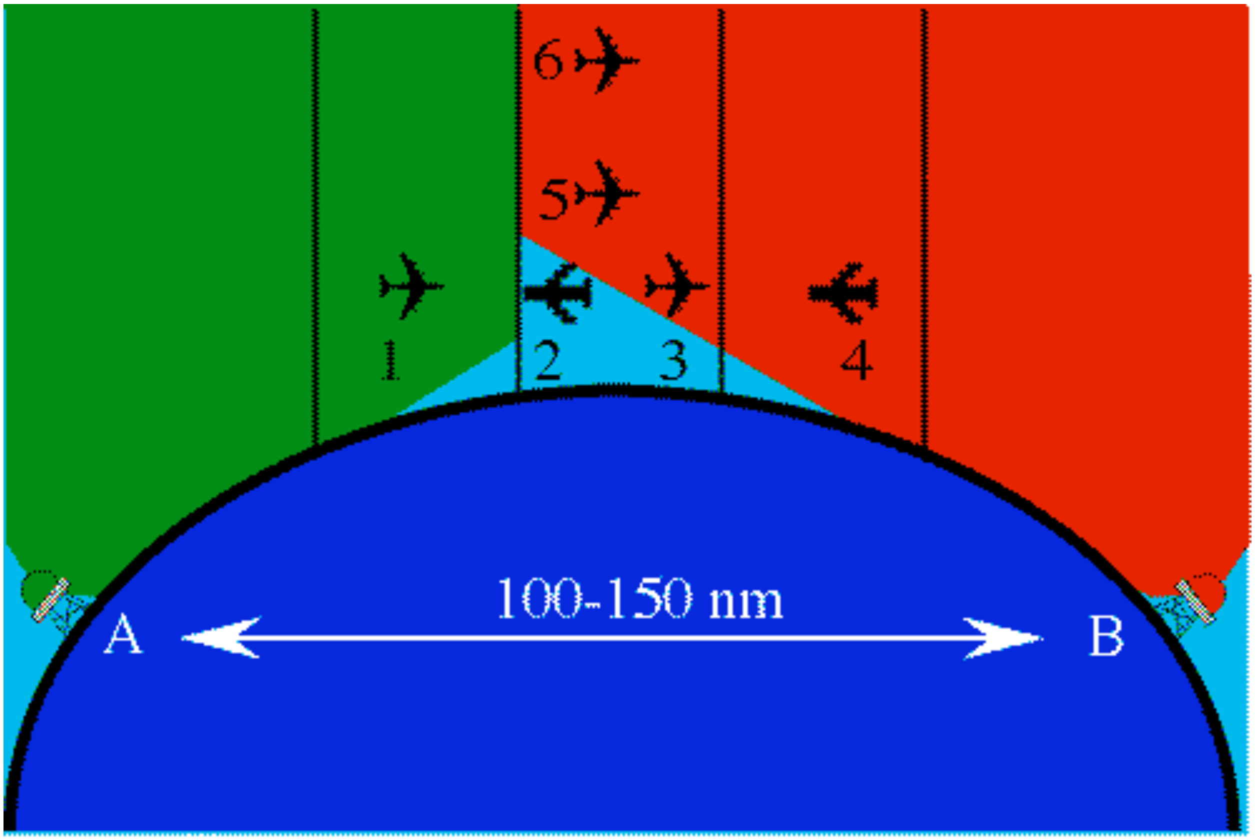
Take a look at any point midway between any two radar sites that are feeding Cleveland Center. At some point, usually near the midpoint between the radar sites, the preferred coverage changes from one radar to the other. There are no if's, and's, or but's. The aircraft is either displayed by the preferred coverage of one radar, or the preferred coverage of the other...but not both.



Slide 26 of 41: Midway coverage

Remember what I said about radar coverage in this country? Overall, it is quite complete, especially east of the Mississippi. In this slide you observe that all six aircraft are detected by either the radar on the left, or the radar on the right.

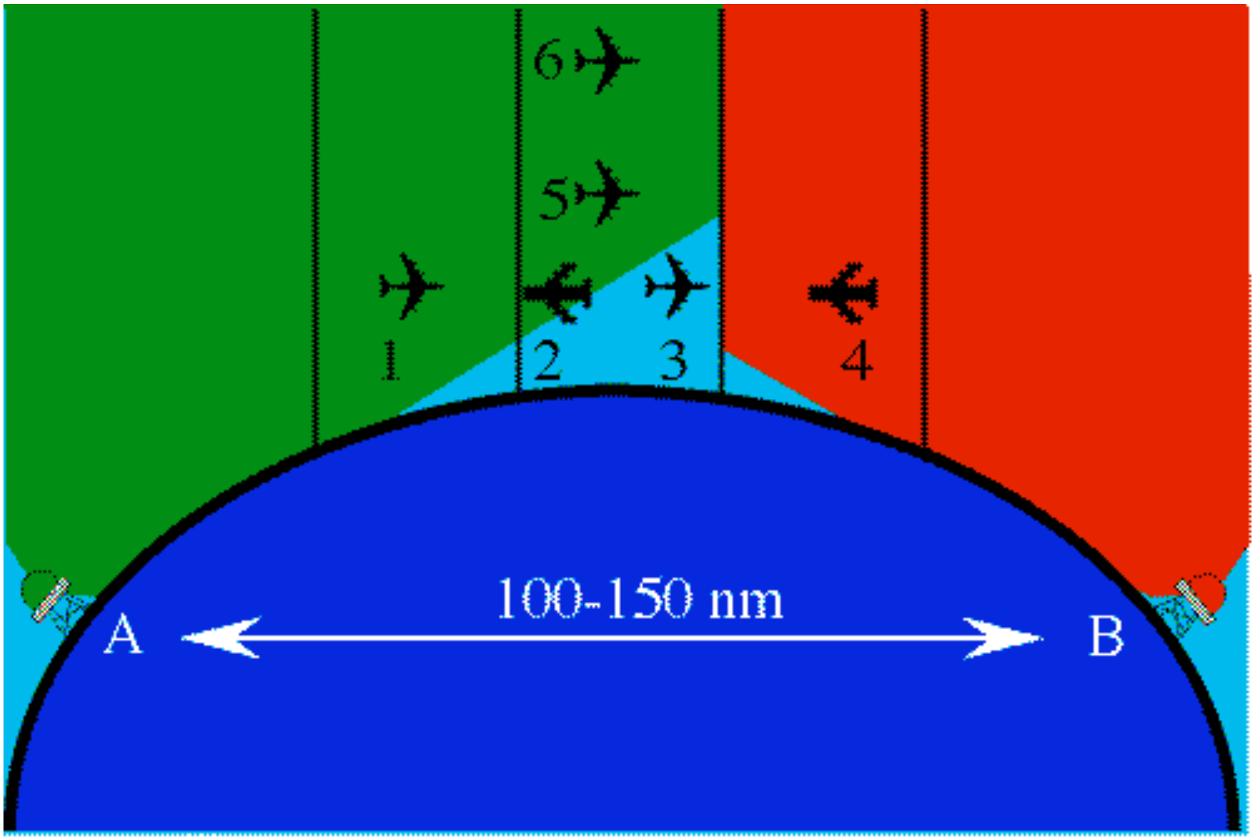
But what happens at some point between the radar sites? Remember, a radar sort box is almost always set to use one-and-only-one radar site's data at any given time or location. So, what if we assign the radar sort box that lies midway between these two radar sites to the radar on the right?



Slide 27 of 41: Midway coverage assigned to one

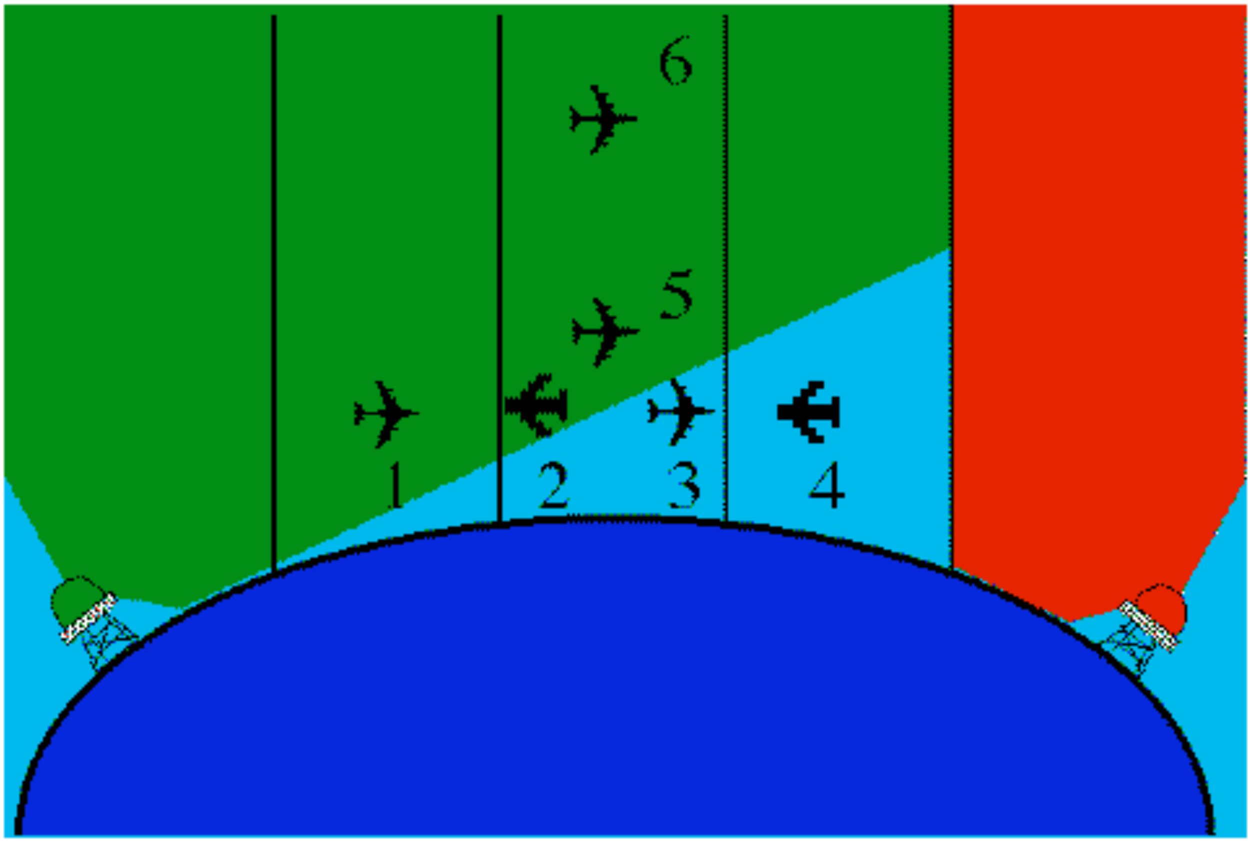
In this example, we see that low-altitude aircraft 2 will not be processed for display. Every other aircraft in this example will be displayed, but not aircraft 2. It is detected, but not displayed. A controller may very likely assume the problem in displaying aircraft 2 has to do with the aircraft's transponder, as every other aircraft appears just fine.

Of course, we can fix the problem in the displaying of aircraft 2...

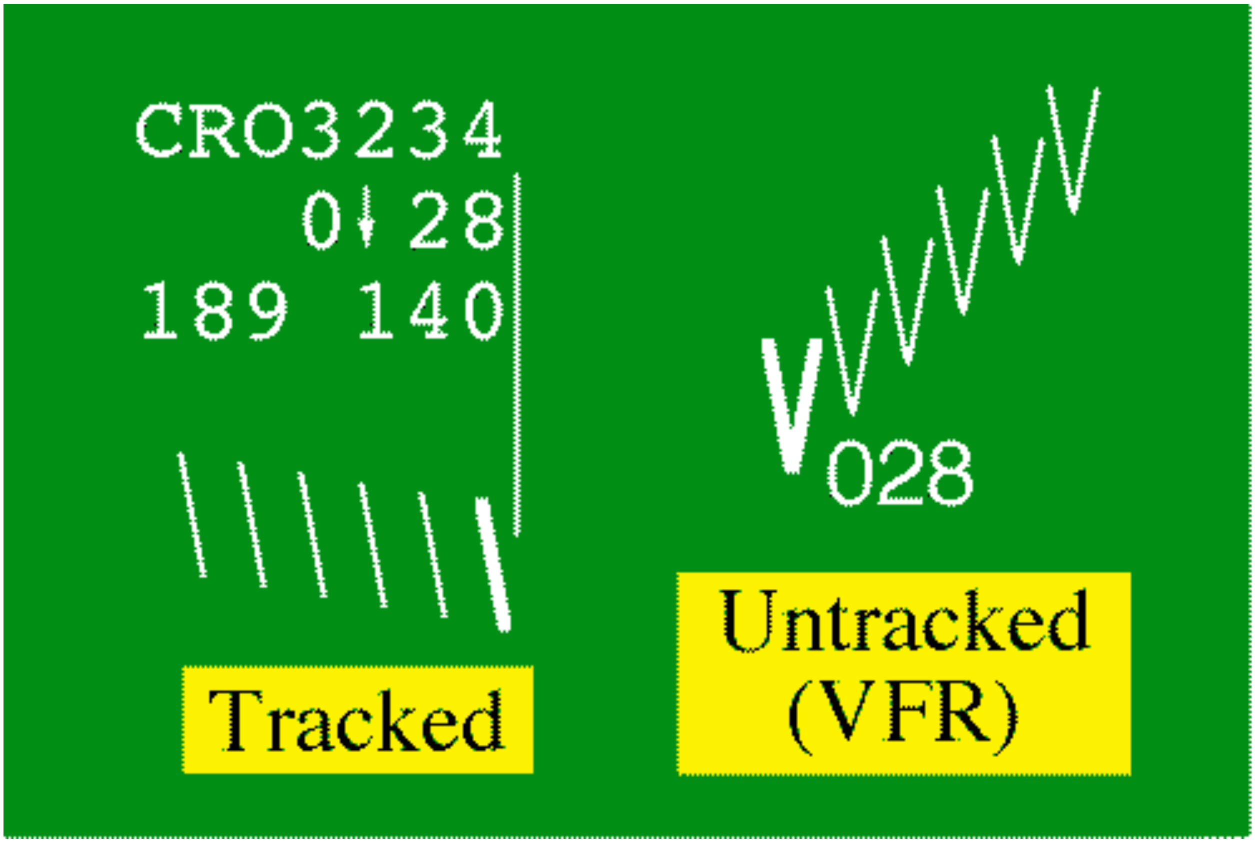


Slide 28 of 41: Midway coverage assigned to the other

But like before, when we fix one problem, another problem can crop up. In this case, the controller will once again likely assume that the problem lies with aircraft, or that the radar coverage is simply marginal in this area, as all other targets "seem" to be displayed without any problems. As you see, we changed the preferred coverage of our midway sort box from the radar on the right, to the radar on the left. Now aircraft 2 is displayed just fine. Aircraft 3 is detected, but it is *not* displayed.



Slide 29 of 41: Sometimes the problem becomes extensive
In some cases, this effect is even more pronounced, increasing the odds that a low-altitude aircraft target won't be processed for display.



Slide 30 of 41: Tracked vs. Untracked

Before we go on to understand how this problem is very sinister and therefore difficult to detect, I'm going to explain the difference between a *tracked* target and an *untracked* target.

A tracked target is associated with an aircraft to whom the controller is providing radar service. In most cases this is an IFR aircraft, but it can also be a VFR aircraft receiving radar traffic advisories. In either case, the tracked target has a Full Data Block.

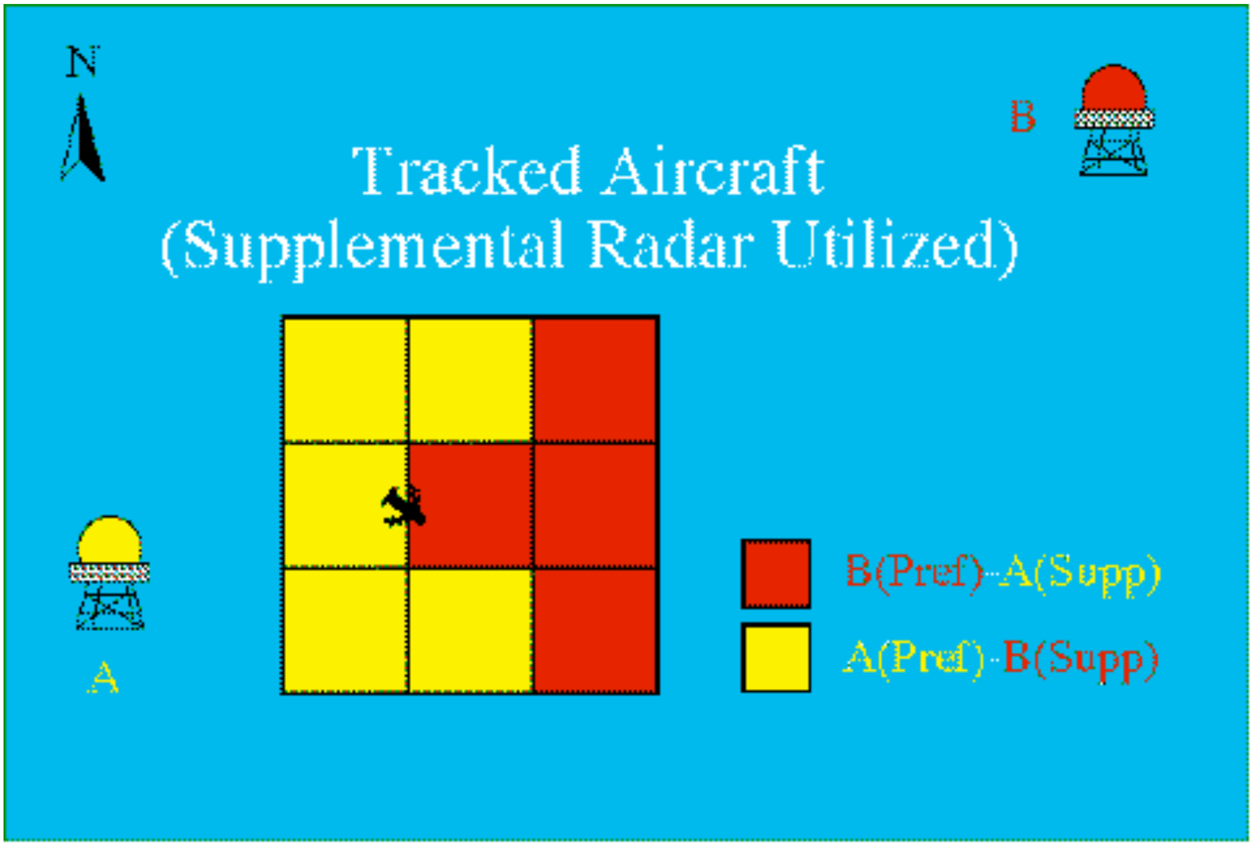
In the above example, the target on the left has a Full Data Block (FDB). This full data block carries along information like identity, altitudes, speed, etc. In the above FDB, the aircraft is Crown Airways flight 3234. In this example the aircraft is assigned an altitude of zero, which is shorthand a lot of us controllers utilized to show that the aircraft was "cleared for the approach." The mode C altitude data, as received via this aircraft's transponder, reports that the aircraft is at an altitude of 2,800 feet. The 189 is simply a computer identification number, and the 140 represents the ground speed as determined by the radar tracking program. This aircraft is traveling eastbound, and there are five "history" target indications that show where the aircraft has been in the last minute.

An untracked target is typically associated with an aircraft that is flying under Visual Flight Rules (VFR), and has its transponder set to reply with a code 1-2-0-0. Its target is represented by the letter V. It has a Limited Data Block (LDB), so the only thing it shows is the altitude as reported by via the aircraft's transponder. It is reporting at an altitude of 2,800 feet. This aircraft is proceeding southwest bound, as can be ascertained by the five history targets. These aircraft are in close proximity, and if the controller is in communication with the pilot of CRO3234, he'd be saying something like this (with *lots* of inflection)...

"Crown thirty two thirty four, TRAFFIC ALERT! Traffic ten o'clock, one mile, southwest bound, altitude indicates two thousand eight hundred. Suggest you climb IMMEDIATELY!!!"

If the pilot of the Crown Airways aircraft didn't already have the traffic in sight and know that he could safely pass by the aircraft visually, he'd probably follow the controller's advice and execute an immediate climb.

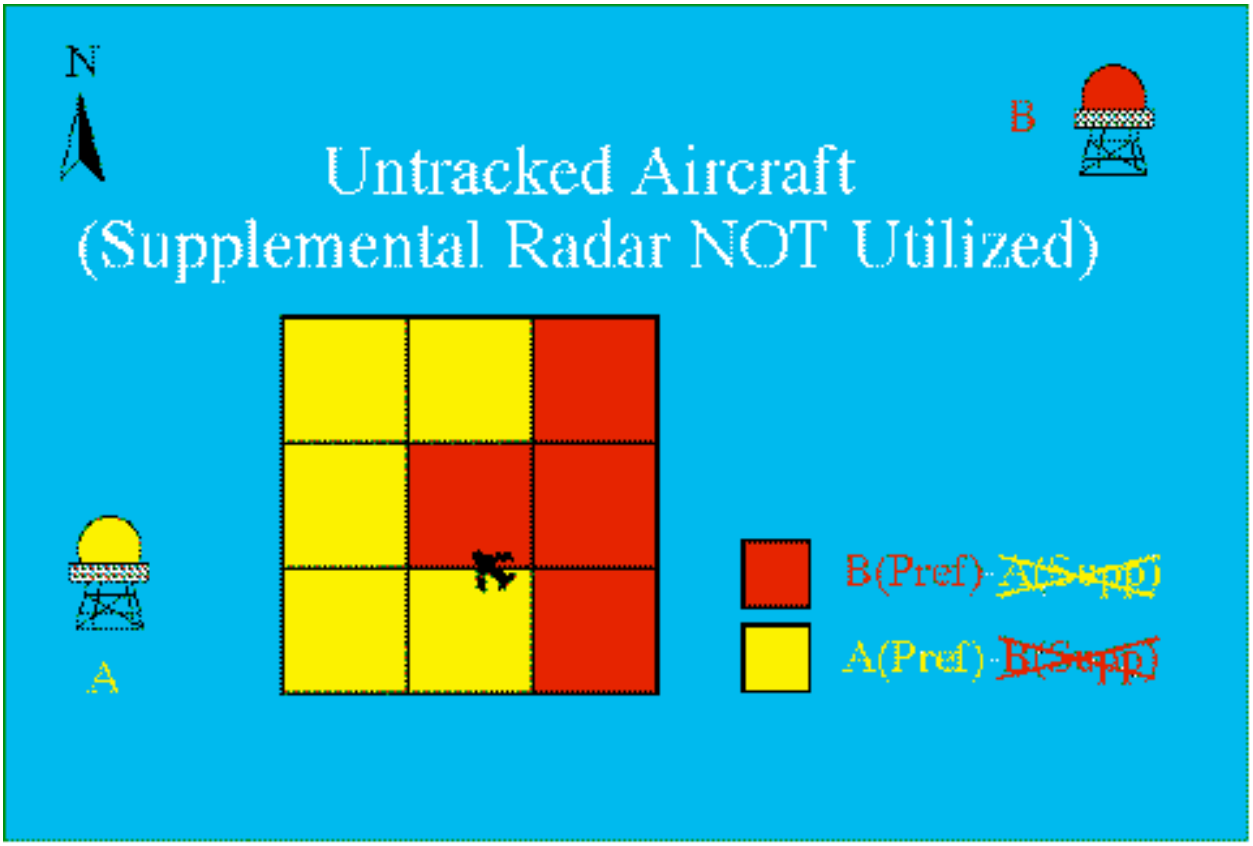
Okay, so other than the full data block versus the limited data block, what's the big deal?



Slide 31 of 41: Tracked uses two radars

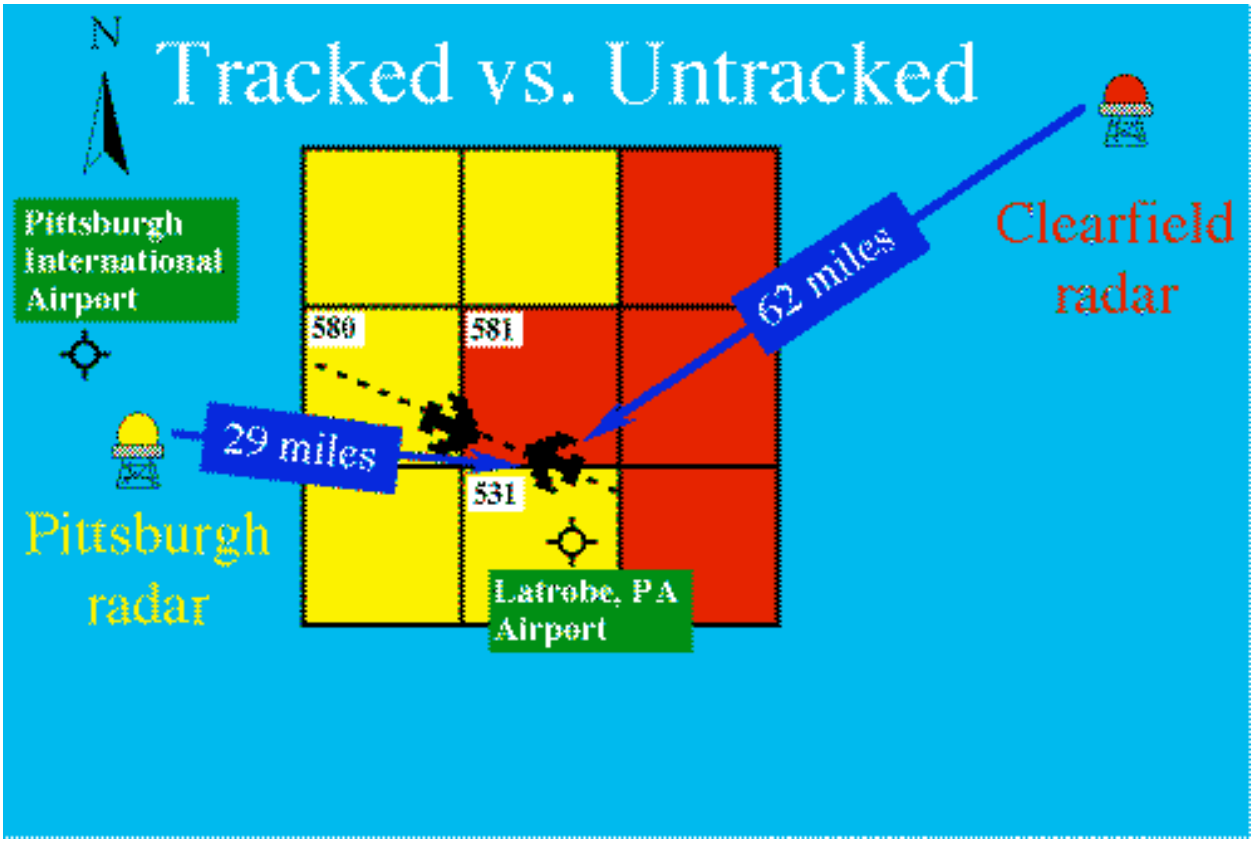
Remember when I told you about 4 radar sites being assigned to one sort box? The first in line was termed "preferred," and the second "supplemental," and the 3rd and 4th were there only to cover for the first two if they were off the air.

Well, a radar site assigned to provide supplemental coverage will basically wait in the background and only show its target symbol if the preferred radar loses the target for some reason. Such a reason could be that the aircraft is below the line-of-sight coverage of the radar that is assigned as preferred in that sort box. In the above example, the southeast bound low-altitude aircraft is crossing into a sort box that has its preferred coverage assigned to radar B (shaded red). However, being as this aircraft is a tracked aircraft (full data block), once it gets too low to be seen by radar B, radar A will automatically fill in for B. That's right. In the red shaded box, the yellow shaded radar will fill in. This technique provides automatic and uninterrupted radar service for this tracked aircraft.



Slide 32 of 41: Untracked uses one radar

Here's where things get interesting. The low-altitude northwest bound aircraft represents an untracked target. As discussed before, untracked means there is no full data block (because no center controller is "working" the aircraft). This would be typical of a VFR aircraft, with its transponder set to 1-2-0-0. This aircraft's relatively close proximity to radar A means it is positively detected by that radar. However, being as it is at a low altitude, and a good deal farther from radar B, it falls just below the line-of-slight coverage of B. That doesn't matter while the aircraft is in the yellow shaded sort box, but as soon as it crosses into the red shaded sort box, that's when problems occur. Remember, radar B can't "see" the aircraft. However, radar B is the preferred radar site for that sort box. Here's the important part. **FOR AN UNTRACKED AIRCRAFT, THE RADAR ASSIGNED AS SUPPLEMENTAL IS _NOT_ UTILIZED.** If that aircraft is not detected by radar B, data from radar A will *not* be utilized to put a target symbol on the display, regardless of the fact that its transponder and mode C altitude is dutifully responding to interrogations to radar A. **The VFR aircraft is now invisible on the Center controller's scope!**

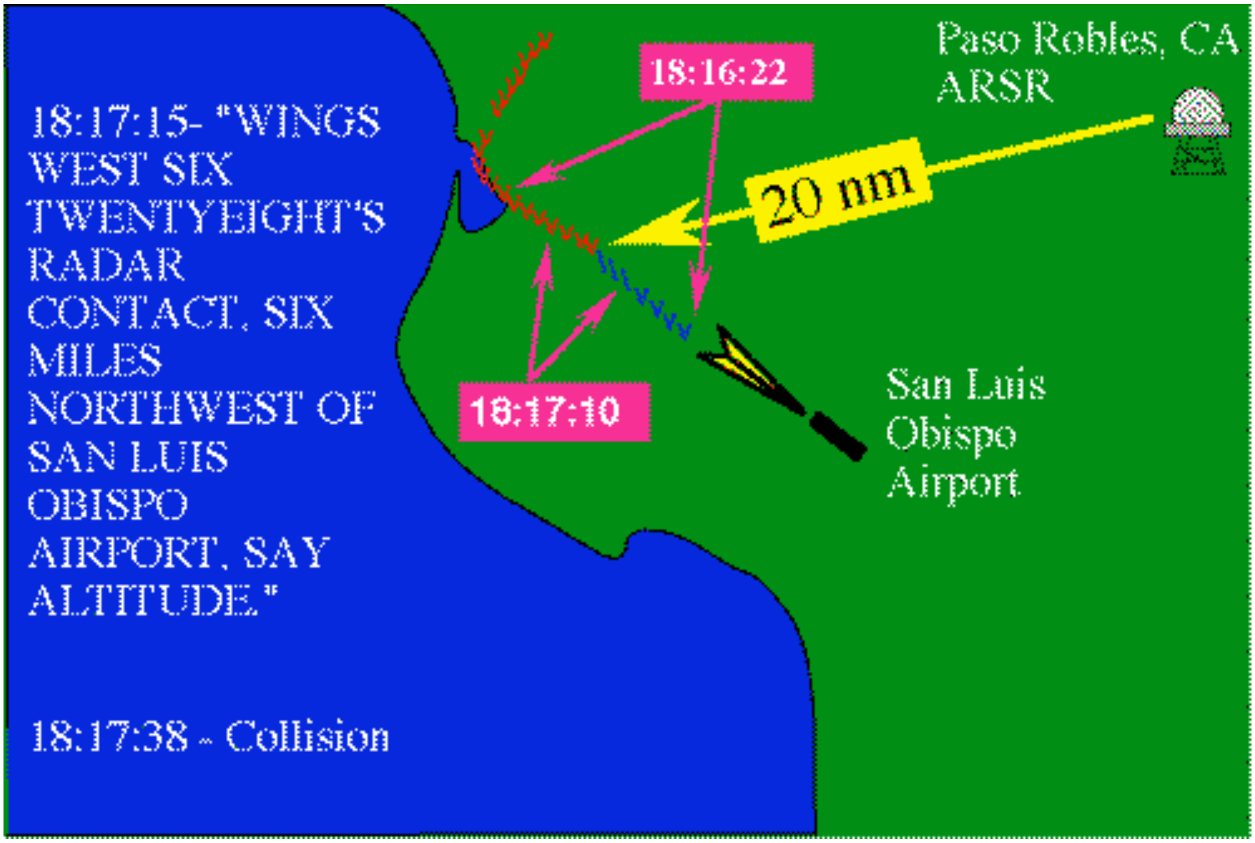


Slide 33 of 41: True life example

This represents a portion of the airspace I worked at Cleveland Center. Sort box 581 had Clearfield as preferred, with Pittsburgh as supplemental. That scenario I just went through on the previous slide was a true life example. On the one hand we (FAA) require aircraft to have a transponder, have it turned on, have it reporting altitude, have it certified every two years, yet on the other hand we take that perfectly good radar data from the transponder and don't necessarily process it for display! (And that assumes the transponder system itself is working reliably. For more on that angle, read my 1999 letter about a transponder stubbornly invisible to just one radar site.)

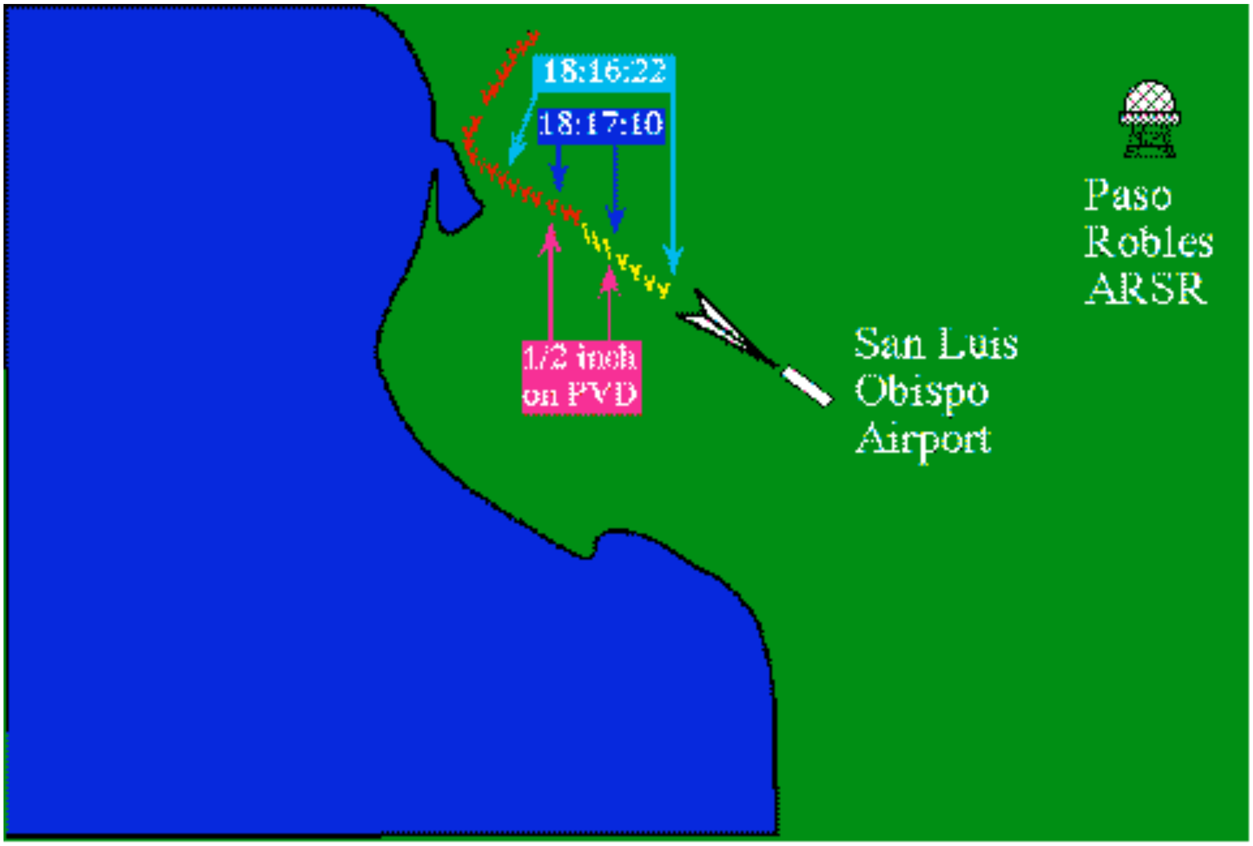
As I recall, after my paper was published in the Journal of ATC, sort box 581 got reprogrammed with Pittsburgh as preferred, and Clearfield as supplemental. However, does that solve our problems? In that particular scenario, sure. But what about all the other locations that lie midway between long-range radar sites? Which radar site has the absolute best coverage? One radar may see better in one portion of the box, whereas another may see better elsewhere in that box. However, for almost every midpoint situation, one-and-only-one radar is assigned as preferred. This can result in a low-altitude aircraft, that is adequately detected by radar, not being on the controller's display.

I recall when our backup radar display computer, which is named DARC (stands for Direct Access Radar Channel), was upgraded. It used to be that when the computer that drove the main computers would fail, one "switch" was thrown (probably a computer entry) so that all control positions would see the backup display. As I say, DARC was upgraded, and one of the improvements was that we now had individual control at each position for when we wished to switch to DARC. We could switch any time we wished. However, DARC was a lot less capable. For instance, it didn't have radar sort boxes at that time. One-and-only-one radar site could be selected at any one time. Changing the radar site was accomplished by an entry at the position. I distinctly recall my surprise one time when I was working the Clarion sector and I switched to DARC, the "less capable" backup computer. Much to my surprise, just west of the Clarion VOR, I saw two VFR targets flying around at low altitudes. Their transponders were working beautifully, and they were showing altitude. I switched back to our main display computer, the one we used all the time, and these two aircraft were invisible. Nada. Nothing. Zero. Zip. Not a trace of these aircraft existed. I switched back to DARC, and there they were. It was one of those enlightening experiences that drove me this far.



Slide 34 of 41: San Luis Obispo revisited

Okay, let's discuss the midair collision near San Luis Obispo. First of all, the Wings West aircraft departed from San Luis Obispo Airport VFR, and immediately called Los Angeles Center for radar services and to obtain their IFR clearance. This is standard operating practice. Every pilot appreciates the extra set of eyes behind the radar screen helping to point out conflicting traffic. The pilot likes to be in contact with the radar controller as soon as possible because of this valuable assistance we can provide. When the pilot made contact with L A Center, the controller advised the pilot to squawk a discreet transponder code. As soon as the controller noticed the code change from the 1-2-0-0 code (represented by the "V") to the one just assigned, the controller advised the flight that it was in "radar contact," and to "say altitude." This is always done to verify that what the pilot sees on the altimeter in the aircraft agrees with what the controller sees on the radar scope. That makes two times the controller had to be *looking directly at the target*. It was 23 seconds after radar contact was established that the airplanes collided head-on. How could the controller possibly not see the VFR target?

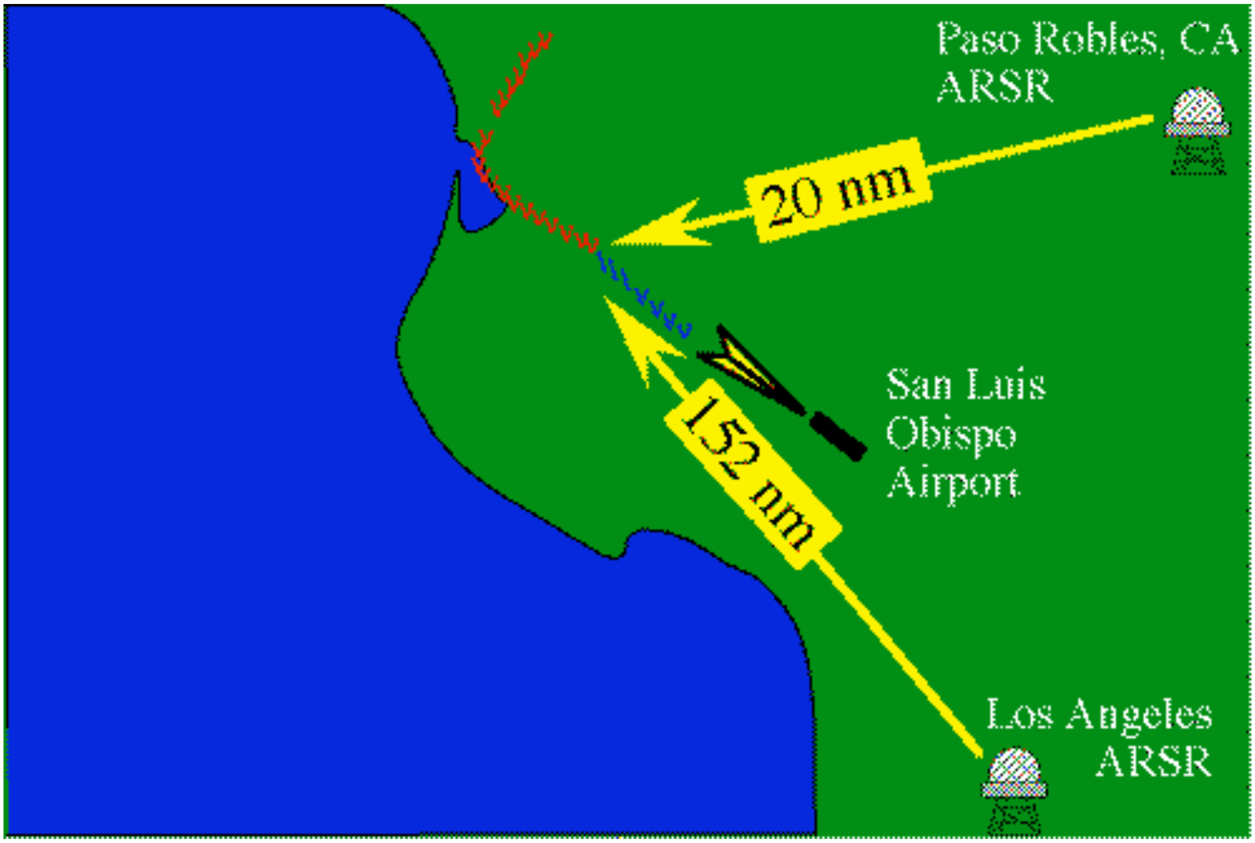


Slide 35 of 41: Only a half of an inch away

When the controller said "radar contact," the conflicting head-on VFR target would only have been 1/2 inch away on the scope. As a controller myself, it is difficult to imagine that a target within that proximity would have been missed. I can understand occasionally neglecting to scan about a target due to one's attention being focused elsewhere on a task, but in this case full attention had to be focused directly on the target of the Wings West aircraft. When a controller says "radar contact," the controller is looking directly at that target symbol. And then when the controller verifies the altitude with the pilot, the controller must once again focus directly at the target. Attention couldn't have been diverted, as the Wings West target was the airplane receiving the full attention of the controller just prior to the collision.

The other item of compelling interest is that this was no ordinary day for the controller working that aircraft. This was a developmental controller who was taking a check ride for sector certification. This is not a time when one slacks off, as one's career progression is on the line. How well one performs during this checkride means everything. And not only was the developmental there, but so was his instructor, right behind him, with full unobstructed view of the scope. And the data position, which is immediately to the right of the scope, was manned by a third experienced controller. And overseeing the certification check ride was a supervisor. None of them noticed any VFR traffic in front of the Wings West aircraft. The two that were ultimately charged with the responsibility of viewing the scope (the developmental and his instructor) testified that the target of the VFR aircraft was NOT displayed.

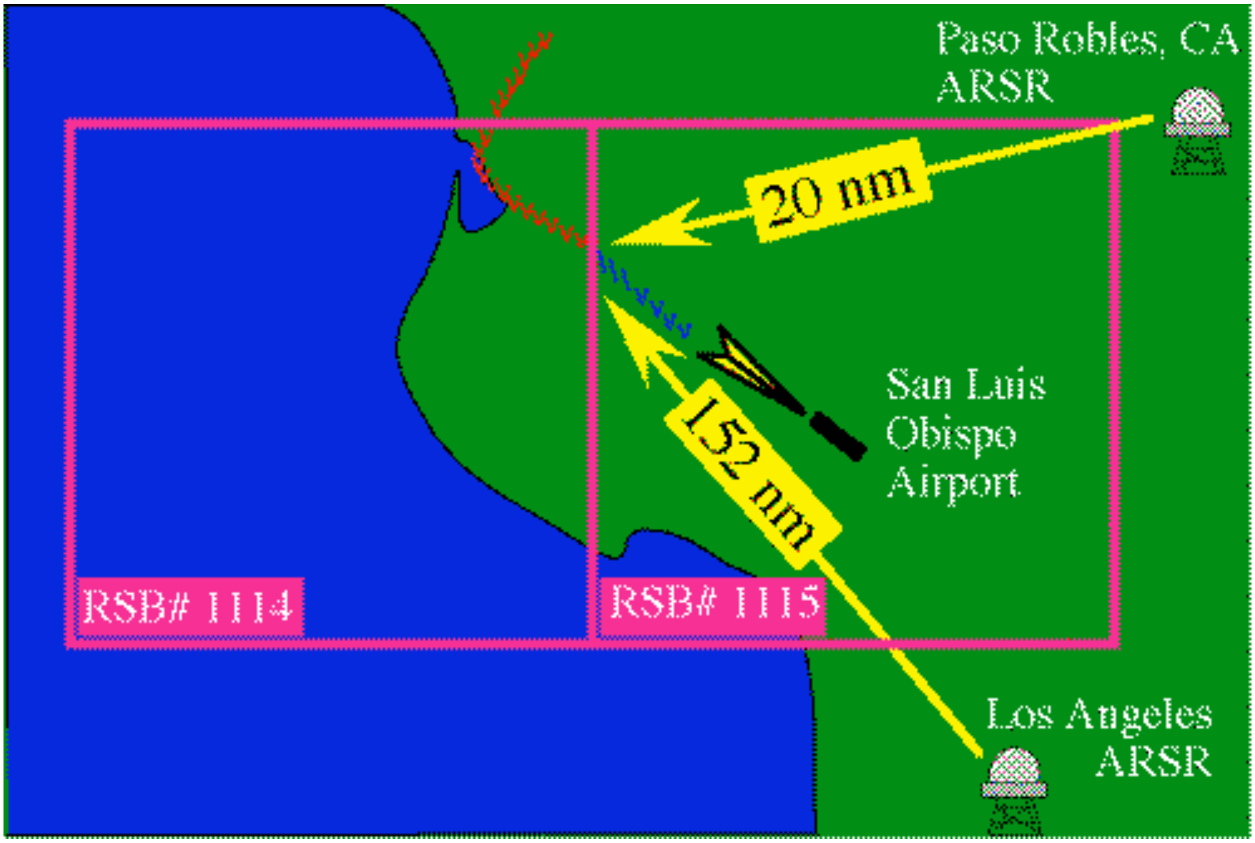
It was frustrating for me to read the transcript of the NTSB investigation. Many questions were asked, but I could find no mention whatsoever of the software radar data processing method of "selective rejection" discussed, or even brought up. Could this have played a part in this midair collision?



Slide 36 of 41: Distances from the radars

If we look at the distances from the long-range radar sites serving this area, it is obvious, to even the most casual observer, that an aircraft flying at a low-altitude near San Luis Obispo would not be detected by the long-range radar located in Los Angeles, just over 150 miles away. There was one and only one long-range radar in this scenario that could have possibly detected the aircraft at this low altitude, and that was the radar at nearby Paso Robles. And, in fact, it most certainly did detect both aircraft. The controllers all testified that they observed the Wings West target change from a VFR code 1-2-0-0 "V" target to the controller assigned code target. It made absolutely no sense why the target of the VFR aircraft would not be displayed, especially since there was 7 minutes and 21 seconds of continuously recorded data for that VFR aircraft's transponder reply.

But in looking through the transcripts of the investigation, I never did find where anyone asked about radar sort boxes, and how they were programmed. That made me wonder. From two independent sources I reconstructed how the radar sort boxes fit into this equation...



Slide 37 of 41: Reasonable doubt

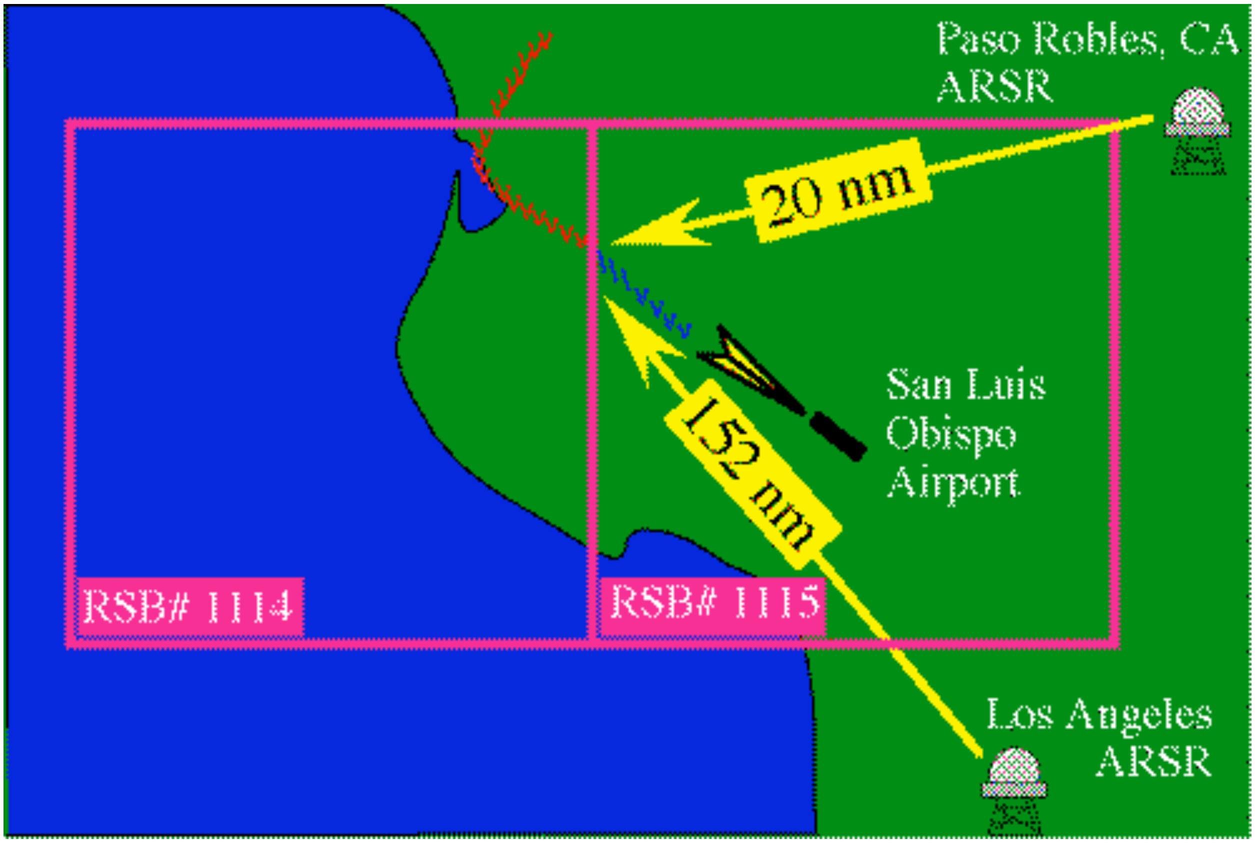
This was an eye opener! The VFR aircraft, during the entire period that it was established on a straight inbound course to San Luis Obispo airport, was entirely within a separate radar sort box, a completely different sort box than the Wings West aircraft! The aircraft collided nearly directly on the edge of these two sort boxes.

If sort box #1114 had been somehow assigned to provide preferred coverage from the Los Angeles long-range radar, with Paso Robles as supplemental, it would be completely obvious that the radar returns of the VFR aircraft would not have been displayed.

However, there is absolutely no good or logical reason why Los Angeles radar would be assigned as preferred in sort box 1114. It would make absolutely no sense whatsoever to have it this way. (It should be, and when checked for me by others, it was the assigned supplemental radar site for this sort box.) However, if somehow it had been assigned as preferred, by some quirk or oddball chain of events, it certainly would account for the controllers not seeing the radar returns of the VFR aircraft.

Also, if such adaptation had been utilized, it could also account for any reports of transponders appearing unreliable in that area. Remember, a tracked aircraft utilizes supplemental coverage, an untracked does not. So, if a low-altitude "tracked" aircraft would fly from sort box 1115 to 1114, the aircraft's target would still be processed for display. Yet, a low-altitude untracked (typically VFR 1-2-0-0 squawk) aircraft, flying the same exact course, would drop off the display the instant it entered sort box 1114.

However, from what I have been told many times, and as best I can understand from reading the manuals, if a target symbol is not displayed, the radar data for that symbol will not be recorded on the data storage tapes. *[Note: Having radar data go unrecorded carries serious implications for the support of search and rescue operations, especially when attempting to determine the LKP (last known position) of an overdue aircraft.]* My tests at Cleveland Center confirmed for me that VFR targets are not stored if they're not displayed. So I am still left with a feeling of puzzlement about San Luis Obispo. Since the VFR radar returns were stored, according to how I know things work now, it must have been displayed. *I certainly wish the issue of selective rejection and radar sort box programing had been discussed and looked into back then*. *(continued next page)*



Slide 37 of 41: Reasonable doubt (continued)

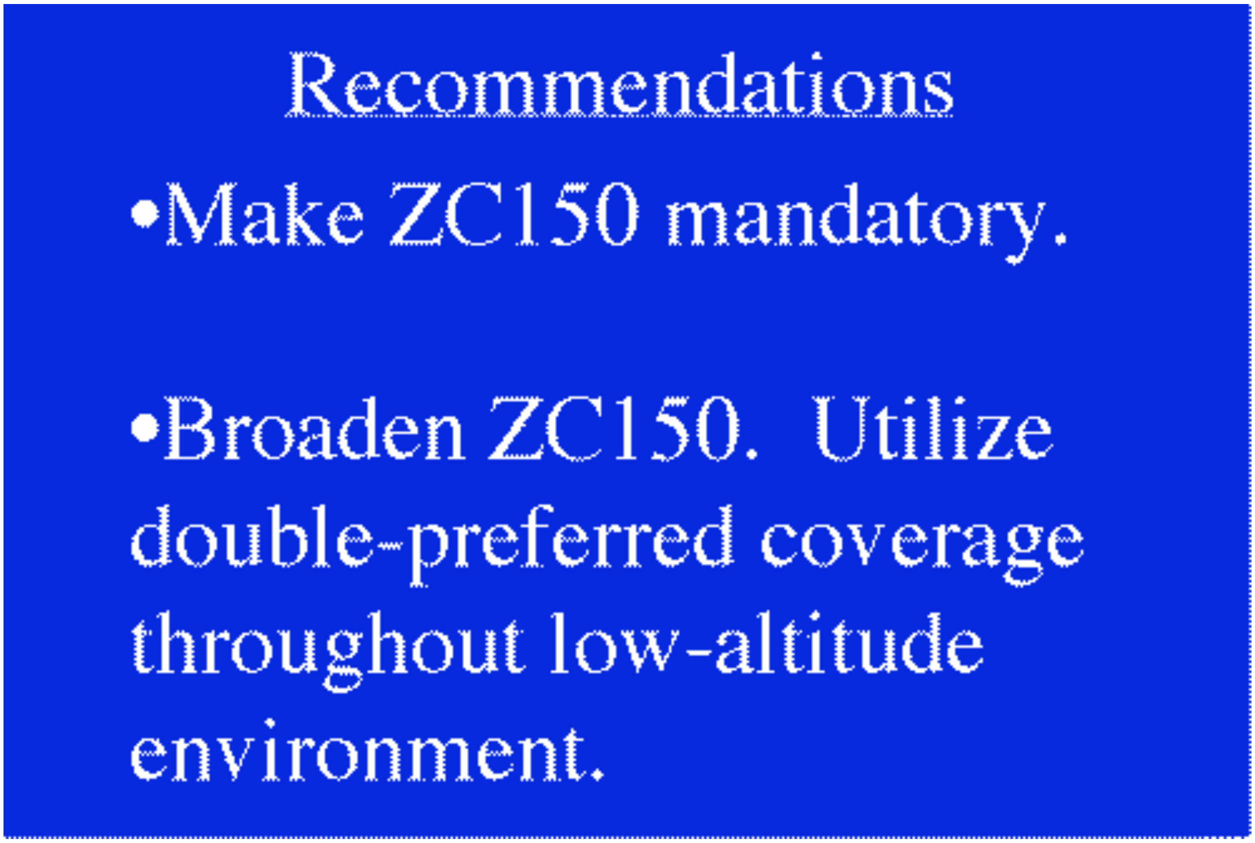
However, *without a doubt*, **as I hope you understand from this review, due to the nature of today's radar data processing, THERE ARE DEFINITELY REASONS WHY AN AIRCRAFT THAT IS DETECTED BY RADAR WILL NOT BE DISPLAYED, EVEN IF THAT RADAR SITE FEEDS THE FACILITY**.

Given the above, I have an extremely difficult time accepting the NTSB's analysis in the San Luis Obispo midair collision report that says...

> Since the manager of the FAA En Route Automation Program had testified that, under these conditions, there was no functional reason why the Rockwell Commander's radar return, or any other VFR transponder return, should not have been displayed on the R-15 radar scope, the Safety Board concludes that the Rockwell radar return had been displayed and that the reason the controllers did not observe it cannot be attributed to any failure or malfunction of the Nas Stage A's computers or associated equipment.

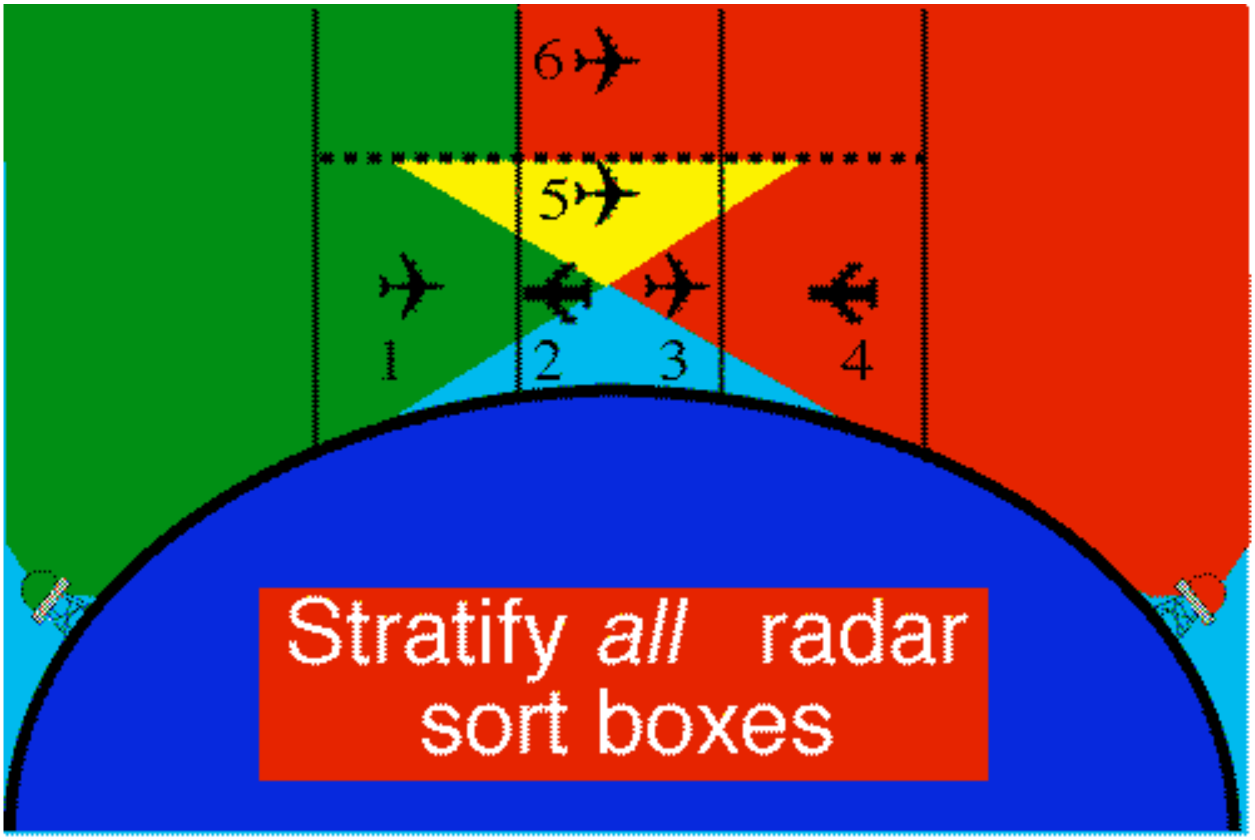
Being as the NTSB report made no mention of the software process of selective rejection, and that there was no mention of radar sort box adaptation for that airspace, I feel that there exists reasonable doubt about that analysis. (For more on this subject, jump to "Reasonable Doubt.")

Regardless of what occurred at San Luis Obispo, the manner in which radar data is processed today must be improved upon. I call upon the industry to correct this problem and improve upon radar data processing methods. As I have suggested in the past, here are my recommendations...



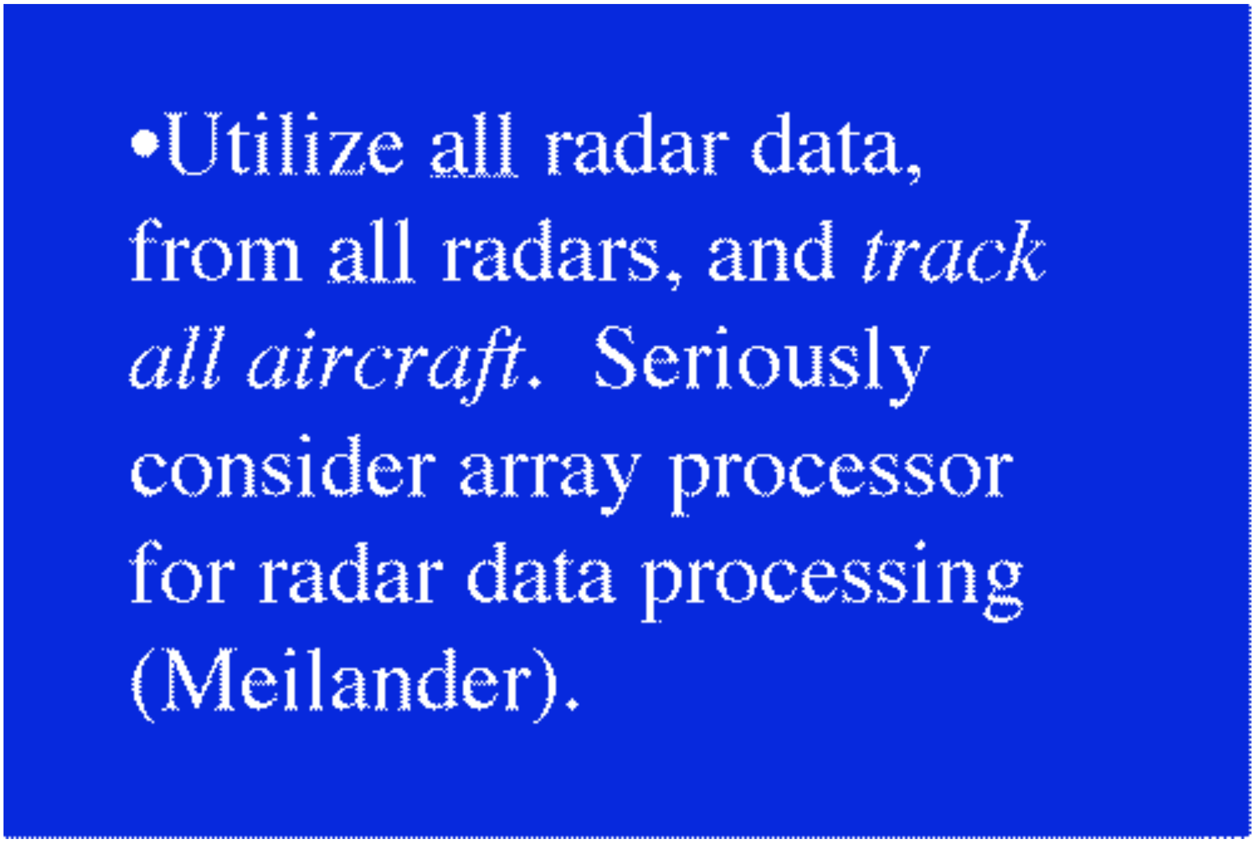
Slide 38 of 41: Recommendations

My Unsatisfactory Condition Report suggested that the software patch that stratifies the sort box over radar sites be *mandatory*, not optional. As mentioned earlier, this patch was implemented at Cleveland Center in 1990 to support CENRAP. However, it wasn't implemented over Dansville at the same time as there is no approach control located near there that required that support. However, shortly after my "Real Targets - Unreal Displays" paper was reprinted in the Jan-Mar '92 issue of the Journal of Air Traffic Control, the sort box over Dansville was stratified. *Remember, use of the patch isn't mandatory.*



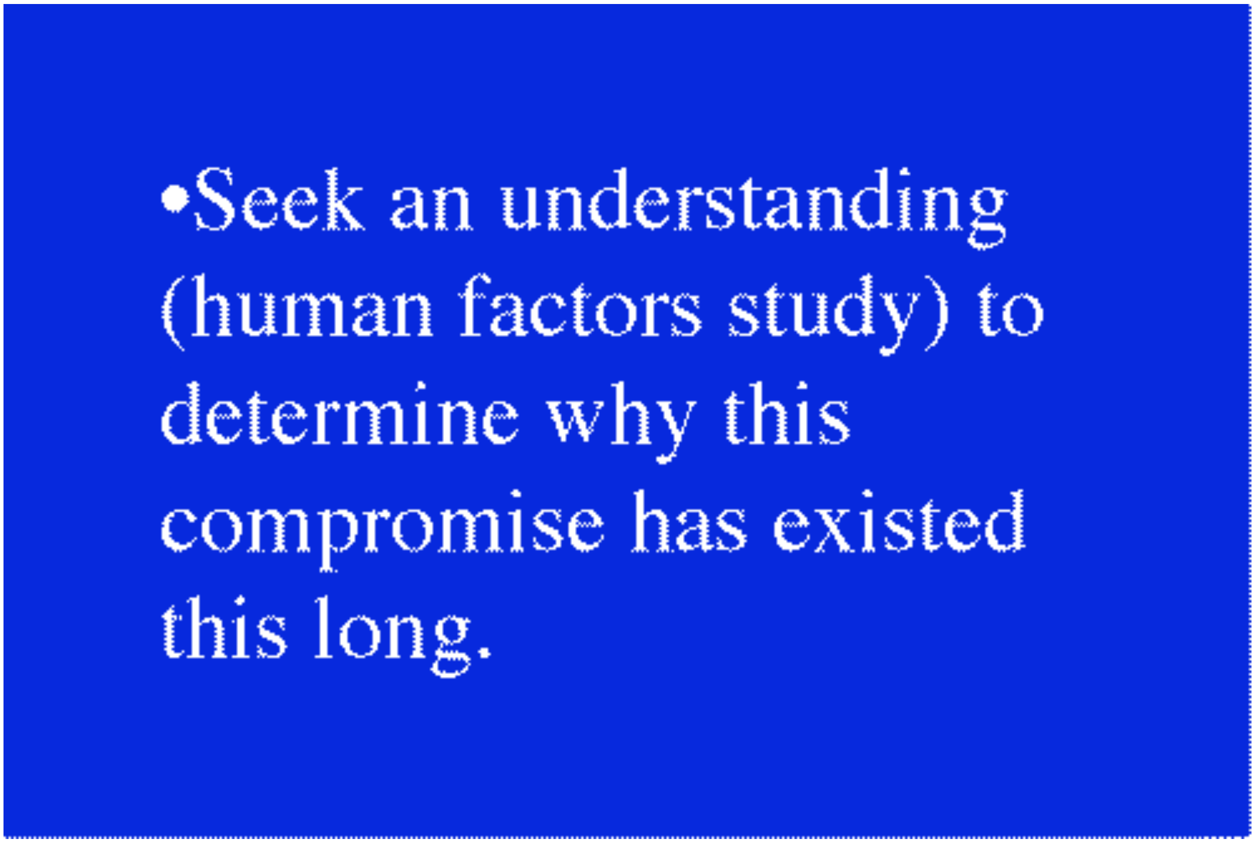
Slide 39 of 41: Stratify many more sort boxes

My second suggestion was then, and still is, that the implementation of this patch be broadened. This would take care of many of those in-between locations where coverage can be unequal. That is, of course, a short term fix, until true fusing of radar data can be accomplished. And it is not a panacea, as there may still be areas where aircraft could be detected but not displayed (where radar site 3 or radar site 4 picks up the target that radar site 1 or radar site 2 missed). It may be objectionable to have the opportunity for double targets to exist, but that sure beats having *invisible* airplanes. And it would only be in the low-altitude strata. I could see it done for virtually all sort boxes in Cleveland Center, say below 10,000 feet as a good safety buffer. This recommendation should apply to every ARTCC.



Slide 40 of 41: Utilize ALL radar data

This was my third suggestion, and still is. Willard Meilander <willcm@mcs.kent.edu> has written many papers over the years, which basically say that current ATC data processing techniques have shown that they cannot satisfy the processing tasks they are called upon to do. He states that "...scheduling complexity theory, an expanding branch of computer technology, shows that dynamically scheduled multiprocessors are not predictable in real-time missions." He says that the FAA has been proving the validity of that statement since the first multiprocessors in 1965. Is anybody listening to this man?



Slide 41 of 41: Why?

I think the aviation psychologists need to work on this one. What is it about an agency that shows such resistance toward fixes for such obvious flaws in our radar data processing? Why has this gone on so long? What is the mind set within the FAA that generates replies to my Unsatisfactory Condition Report in which statements like "...described some limitations of our system but *not unsatisfactory conditions*." Huh? Read Lusch's Petition for Reconsideration concerning the San Luis Obispo midair collision.

Rx'D
02-21-92

U.S. Department
of Transportation

Federal Aviation
Administration

800 Independence Ave., S.W.
Washington, D.C. 20591

FEB 13 1992

Mr. Thomas G. Lusch
Cleveland ARTCC
326 East Lorain Street
Oberlin, Ohio 44074

Dear Mr. Lusch:

This is in response to an inquiry made on your behalf by Congressman Bob McEwen. In our initial reply to Mr. McEwen, we advised him that we would be directing the National Automation Field Support Division, ATR-400, to perform an analysis of your paper, entitled, "Real Targets-Unreal Displays." We further advised him that we would be responding to you directly.

Extensive time has been devoted to the analysis of your paper and recommendations. Our initial review was completed in 1989 when your longer paper on the same subject was forwarded to us from the Great Lakes Region. The En Route Support Branch, ATR-420, a branch of ATR-400, completed a detailed analysis of your recent submission. Additionally, we tasked the Computer Sciences Corporation (CSC) to aid in the evaluation and analysis of the report. The CSC is a company which has been involved with software development for the en route system since 1976 and has developed a level of expertise unmatched in industry.

The results of the efforts of both offices lead us to the following conclusions concerning your recommendations:

1. The recommendation to make the optional software modification (Patch ZC150) mandatory for all operational sites.

We believe that each air route traffic control center (ARTCC) is in the best position to know what operational environmental configuration is most appropriate for their needs in this matter. This patch is available to all sites, and it is at the Centers' discretion to utilize this patch. It is possible that some ARTCC's (including Cleveland Center) may not have the conditions as described by you as the cone-of-silence. Some facilities have determined that the disadvantages, such as excessive clutter on the controller display, outweigh the benefits of the patch. Consequently, we have recommended that this patch continue as a national local patch and remain optional for use by each ARTCC.

2. The recommendation that the scope of patch ZC150 be broadened to provide stratification and double preferred coverage for all radar sort boxes.

Implementation of this recommendation would require an excessive amount of the considerable computer resources available in the Host Computer System (HCS).

The current compute element utilization (CPU) resources in an ARTCC at peak Work load are approximately 35 percent. The CSC analysis of this approach determined that an additional 30 percent of CPU would be needed to process all radar data via this method. We do not know the exact additional CPU requirements for the integration of the upcoming Initial Sector Suite System (ISSS), but are unwilling to compromise the efficiency of the ISSS by bringing the existing computer load to 65 percent, even prior to ISSS implementation.

In addition, since the current processor is a uniprocessor, only one function is executed at any one instance. If the system is required to operate at peak capacity routinely, it is possible that the processing of data or instructions will be delayed to the degree that data will be lost, or controller response times be significantly increased. Any lost data could effect the flight plan and target data bases which could severely impact the reliability of the en route system.

Finally, there is a minor concern about the cost of redesigning and implementing such a change. It has been estimated that this developmental effort would take 30 man years and about 4 million dollars to accomplish. While these costs are significant, our major objection to this recommendation is the estimated computer resources that would be required to accomplish this change.

3. The recommendation to use all radar data and track all aircraft.

We agree with the benefit of this recommendation, and one of the goals for the Advanced Automation System project is to accomplish the same objective. However, it is impossible to accomplish this goal with the current hardware and software configuration.

In summary, you have described situation in the current en route system including areas where radar coverage is not available or displayed. There are software methods to alleviate some of them. We continue to strive towards the ultimate goal of tracking all targets utilizing all data acquisition information and displaying them in an appropriate manner. An interim solution to the issues cited in your document will be the ability to expand the number of radar sites interfaced with the HCS. This capability is planned for incorporation into the software system release scheduled for June 1992.

We thank you for your interest in this matter. A copy of this letter is being sent to Congressman McEwen.

Sincerely,

for Rodney D. ...

Walter H. Mitchell
Director, Air Traffic Plans
and Requirements Service

Barefoot for Nourishment

The Problem: According to UNICEF's statement on poverty...

"Every 3.6 seconds one person dies of starvation. Usually it is a child under the age of 5."

[Do the arithmetic: That's 1,000 *every hour*...24,000 per day, over 8 million a year!]

If we wait for governments to solve this problem...that's exactly what we'll do....................WAIT.

One way to address this is by *this unique solution/product* (watch 10-minute video)

Aug 16, 2010 update: Five years ago I offered that if I could run a half-marathon (13.1 mile race) *without running shoes*, would one purchase a bag of very nutritious food ***and donate it***? Last May I completed my 5th annual running/charitable sales event (one can read about the running aspect of my 5th half-marathon here). Since my first half-marathon in 2005, 64 generous individuals have made purchases that have resulted in 6,960 meals being donated! THANK YOU! (Look here to see the *millions* of meals donated since the inception of the program, to which my *Barefoot For Nourishment* initiative, contributes.)

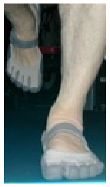
Of course, the need is continual. You don't have to wait for me to ask, or for me to complete another half-marathon to contribute. Contact me via email and I'll be happy to place an order for a bag of very nutritious food for donation in your name. Or order via 1-800-487-1000 (or via the web). Simply tell the operator that you'd like to become a customer of Tom Lusch, and place your order. When they asked who referred you, tell 'em US8182396.

Thank you very much for taking the time to read and consider this!

Tom Lusch
Sponsoring Distributor ID: US8182396
614-370-1437
tomlusch@yahoo.com

Fellow Runners/Walkers: Consider putting your feet to good use and join with me and become a distributor under my initiative!

[Many thanks to Barefoot Ken Bob Saxton, who, back in 2005, opened up my eyes to the healthful benefits of running barefoot. I am not be a "purist" when it comes to running barefoot (I train on a treadmill barefoot...but usually wear some protection when running outside). Nevertheless, I believe I have benefited greatly with this paradigm shift. Here's a picture of me as I neared the end of the half-marathon in 2007 (picture courtesy of TSC Graphics). That was before I discovered footwear that allows me to *emulate* being barefoot (as seen below). One can learn more about that footwear here.]



EDITORIAL: RADAR SERVICE TERMINATED

by Mark R. Twombly

(from AOPA PILOT, July 1991, page 18)

A pilot training for an instrument rating learns to fly a full approach-cross the initial approach fix, fly outbound for a minute or two, execute a procedure turn to get headed the opposite direction, and fly inbound on the final approach course while descending to decision altitude or the missed approach point. A full approach is a staple of instrument flying, yet some pilots rarely, if ever, have to fly one other than during initial or recurrency/proficiency training. That's because a full approach usually is required only when radar service is not available, and radar is available at most larger and busier instrument airports. Pilots come to expect radar vectors to final approach courses and that ATC will keep an electronic eye on them all the way to a successful conclusion of every approach.

Imagine, then, the surprise of the Air Force pilots ferrying then-President Ronald Reagan from Andrews Air Force Base to Frederick, Maryland, on October 21, 1988. At 4,000 feet, they were told by approach controllers at Baltimore-Washington International Airport that the Air Force One Gulfstream III was cleared for the ILS 23 at Frederick, and by the way, radar service was being terminated. Radar service terminated? The presidential pilots, along with Air Force C-12A pilots who preceded them into Frederick, later told National Transportation Safety Board investigators they had expected radar vectors to the final approach course.

In fact, radar coverage is not available at Frederick, at least not from Baltimore Approach, which is the controlling facility. Ironically, Dulles, which is about the same distance from Frederick as Baltimore, has a far better radar view of the Frederick area. Dulles radar controllers handling aircraft inbound to Frederick from the west and south often advise of traffic in the pattern at Frederick before handing pilots off to Baltimore for the approach. The folly of the situation-being assigned to the jurisdiction of an ATC facility that has no radar coverage when another nearby approach control could provide much better service--has had Frederick pilots complaining for years. But the issue took on much greater importance when the President entered the picture.

Except for the no-radar surprise, Air Force One and the C-12A made routine approaches and landing at Frederick that Friday evening. President Reagan debarked and immediately climbed into a car for the 15-mile drive to his weekend retreat at Camp David in the Catoctin hills north of Frederick. He probably was not aware that, about 20 minutes after he landed, a Piper Arrow crashed into a ridge not too far south of Camp David. The pilot of the Arrow had been cleared for the approach into Frederick, but for no discernible reason, the airplane wandered about 7 miles off the approach course and descended.

Baltimore Approach could not monitor the Arrow's flight path because its radar is not reliably effective below about 4,000 feet at Frederick, but Dulles Approach could and did. The pilot was being handled by Dulles before he was handed off to Baltimore. A plot of transponder replies shows that even after the hand-off, the Arrow was tracked by Dulles radar all the way to the point of impact. In 12 minutes of erratic flying, the Arrow triggered 39 minimum safe altitude warning alarms at Dulles Approach, yet Baltimore was never notified nor were any safety alerts radioed to the Arrow pilot.

In its final report on the accident, the NTSB noted that Baltimore's lack of radar coverage at Frederick affects all pilots who use the airport, including pilots of Air Force One. Frederick is designated as a reliever airport for the President when he is unable to helicopter to Camp David because of the kind of weather that was present on October 21, 1988. The safety board recommended that the FAA evaluate which ATC facility could provide the best radar service at Frederick and, if necessary, make a change.

Nearly three years after the accident and more than a year after the NTSB issued its report, the situation has remained exactly the same. Baltimore still controls instrument traffic into and out of Frederick. Baltimore does have a new ASR-9 radar, and the coverage at Frederick has improved, but controllers still are blind below about 3,000 feet. Dulles, which is awaiting an ASR-9 of its own, still has a much better view of Frederick traffic.

The NTSB and many pilots in the area are convinced that Frederick is assigned to Baltimore for political and economic reasons-to boost BWI traffic counts, which help determine controller pay scales. We have been assured that that is not the case, that the explanation is rooted in history. Dulles did not even exist when Baltimore was designated the controlling facility for Frederick.

Regardless, it makes no sense to perpetuate an obvious safety problem. Frederick should be switched to Dulles Approach Control. The issue has implications that go far beyond Frederick. Pilots who operate at airports not well-served by ATC radar should ask hard questions about why the service is not available. They may discover it is.

Invisible Transponders

In yet another aspect of transponders not appearing on the air traffic controller's display (which is *totally unrelated to* "selective rejection"), I was personally affected by the "P4 problem" (aka "The Terra Problem"). That occurred when my aircraft's transponder became invisible to our newly installed Mode S interrogator (see Letter2Talotta.pdf). That problem seemed to go away shortly thereafter, as the FAA installed a "temporary" fix. This archived message may help you to understand the beginning of that issue. In January 2009, I learned that *all* FAA "Mode S" interrogators *still* utilize a software fix (referred to as the "Terra Algorithm") to deal with other transponders that exhibit "Terra like characteristics," and that long-range radars have not even been interrogating in the Mode S format since June 2006. See "Turning off Mode-S: A Maintenance Alert was issued on 6/1/2006 instructing BI-6 sites to stop interrogating Mode-S. Instructions for doing this are included in the alert. Go to TechNet for a copy of the alert."

Thomas G. Lusch
May 27, 2009

Update April 22, 2010: I found it extremely puzzling that Lincoln Labs would have created an interrogation pulse waveform in such a way that ATCRBS transponders could inadvertently become invisible. I did some research and learned that *originally* the technical specifications had the P4 pulse 1.5 microseconds after the P3 pulse. That 1.5 microsecond spacing certainly wouldn't have caused the Side Lobe Suppression (SLS) to inadvertently activate on ATCRBS transponders, resulting in the possibility of them becoming invisible. However, a change from 1.5 to 2.0 microseconds spacing took place to fix an unanticipated problem. One can read in the Thursday, March 6, 1980 Federal Register, on page 14780, where the FAA proposed the change. It reads...

1. *Changes in RF waveforms*. Changes to the RF waveforms have been made in two areas. The P4 pulse used in the ATCRBS/ DABS All-Call interrogation has been lengthened and relocated to prevent false

All-Call decodes
due to multipath
on the
interrogation
link."

Michael C. Stevens, in Chapter 9 "Multipath and Interference" of his book Secondary Surveillance Radar, discusses the early Mode S Trials. As best I understand this technical stuff, due to the effect of multipath (i.e. radio waves arriving at the airborne transponder from more than one path...like when they come directly from the radar *and* bounce off a building and arrive a tiny bit later), a classical ATCRBS interrogation could result in a the Mode S transponder thinking it was seeing a "Mode S All Call" interrogation, which in effect said "do not reply to this classical ATCRBS interrogation...but instead reply as a Mode S transponder." That apparently generated a false response from the Mode S transponder, and formed a false target at an erroneous range.

Thus, it appears that we *may* have observed The Law Of Unintended Consequences, in that it appears that in an effort to fix an unanticipated problem (false All-Call decodes due to multipath), a later unanticipated problem ("The Terra Problem") was created.

San Luis Obispo midair collision

I question the NTSB's finding of "Probable Cause" regarding the midair collision that occurred near San Luis Obispo, CA on August 24, 1984. The controllers claimed that the VFR target symbol of the Rockwell Commander was NOT displayed, yet the NTSB concluded that it had to have been displayed...and that the controllers simply failed to observe it. Having reviewed hundreds upon hundreds of pages of documentation from that accident, I could find no mention whatsoever of "radar sort boxes," nor could I find any mention of "selective rejection." *I have concluded that a plausible explanation exists wherein the Los Angeles Center (ZLA) controllers may NOT have had the VFR target symbol of the Rockwell Commander presented on their display, due to the software process termed "selective rejection."* ***This software process is something that controllers have absolutely no control over.***

To understand more about this, see the slide show I created for my RTUD presentation at the Sixth International Symposium on Aviation Psychology (click Lusch_RTUD_twice_revived_slide_show.pdf).

Thomas G. Lusch
May 27, 2009

EQUAL EMPLOYMENT OPPORTUNITY COMMISSION
WASHINGTON, D.C. 20506

Thomas G. Lusch,
Appellant,

v.

Department of Transportation,
Agency.

Appeal No. 01801135

Decision

Introduction

This is an appeal by an applicant for federal employment, hereinafter appellant, from a final decision of the above-captioned agency, dated August 7, 1979, which rejected appellant's complaint of discrimination on the basis of handicap (myopia) as not within the purview of equal employment opportunity regulations. The appeal was brought under Section 501 of the Rehabilitation Act of 1973, as amended, 29 U.S.C. Section 791. The appeal was accepted for decision by the Commissioners of the Equal Employment Opportunity Commission in accordance with the provisions of EEOC Order No. 960, as amended.

Background

Appellant sought employment with the agency as an Air Traffic Control Specialsit. His application was rejected on the grounds that his uncorrected distant visual acuity (20/400) was below the agency's standard for uncorrected distant visual acuity for candidates for Air Traffic Control Specialist positions (20/200).

Appellant has demonstrated, through the introduction of a substantial body of medical and other documentation, that his visual impairment is not degenerative in nature; that he is fully capable of performing the duties of an Air Traffic Control Specialist if he is accommodated to the extent of being allowed to wear corrective lenses on the job; that the agency allows currently employed Air Traffic Control Specialists to wear corrective lenses on the job; that a hiring standard based upon uncorrected visual acuity is not related to actual job performance requirements; and that the controverted uncorrected visual acuity requirement is not applied by the agency in other situations (e.g., the certification of private pilots) were safety considerations require visual acuity.

The Office of Personnel Management (OPM) submitted an amicus curiae brief regarding the appeal sub judice. In that brief, OPM stated that, on September 24, 1979, it had promulgated a qualification standard for air traffic control positions (FPM Letter 339-15, Attachment 2) which specified that physical conditions or impairments could be disqualifying only if there was a direct relationship between the condition and the nature of the duties of the specific position to be filled. The standard further specified that disqualification was not to take place in situations where an impairment could be compensated through prosthesis, mechanical aids, or reasonable accommodation. OPM took the position that, absent a demonstration that appellant's lack of uncorrected visual acuity would impair his ability to perform the duties of an Air Traffic Control Specialist, the agency's disqualification of appellant constituted a failure to comply with OPM's directive.

The record is devoid of evidence that, with corrective lenses, appellant could not safely perform the duties of an Air Traffic Control Specialist.

Analysis and Findings

The equal employment opportunity regulations concerning federal employees with handicapping conditions have been codified at 29 C.F.R. §1613.701-710 (1979). These regulations define a "handicapped person" as one who has a "physical or mental impairment which substantially limits one or more of such person's major life activities..." 29 C.F.R. §1613.702(a). A physical impairment is defined to include "any physiological disorder or condition...affecting one or more of the following systems...(including)special sense organs..." 29 C.F.R. §1613.702(b). "Major life activities" includes the function of seeing. 29 C.F.R. §1613.702(c). The uncontested evidence in this case reveals that appellant has a medical condition (poor eyesight) affecting his sense organs (eyes) which substantially limits a major life function (seeing). Accordingly, even though appellant's vision can be substantially improved through the use of corrective lenses, this Commission finds, under the standards noted above, that appellant may be regarded as being a "handicapped person." Accordingly, this Commission finds that the complaint sub judice falls within the purview of the equal employment opportunity regulations concerning discrimination on the basis of handicap.

Notwithstanding the existence of a handicapping condition, it must be determined whether appellant also meets the standard of being a "qualified handicapped person." If the appellant meets this standard, then under 29 C.F.R. §1613.704 he was entitled to a "reasonable accommodation" of his handicapping condition unless the agency is able to demonstrate that such accommodation would have imposed an "undue hardship" on the operation of the agency. The term "qualified handicapped person" has been defined at 29 C.F.R. §1613.702(f) to mean a handicapped person who, with or without reasonable accommodation, can perform the "essential functions" of his/her position without endangering his/her own health and safety or the health and safety of others.

Since the evidence here establishes that appellant did not meet the threshold qualifications required for the position, the thrust of his argument goes to the reasonableness of the standards in question. The issue that must be addressed, therefore, is whether appellant could have performed the duties of the position without endangering the health and safety of himself and others in view of his uncorrected visual condition, or, in the alternative, whether he could have safely performed them had the agency offered a reasonable accommodation for his condition.

Appellant has adduced copious medical evidence that his visual impairment is not indicative of a degenerative medical condition; that his corrected visual acuity is no different from that of an individual whose uncorrected visual acuity (i.e. 20/200) satisfies the agency's threshold qualification standard; that his lack of uncorrected visual acuity is fully compensated by the simple accommodation of wearing corrective lenses; and that there is no rational basis for the assumption that his lack of uncorrected visual acuity would impair his ability to safely perform the duties of an Air Traffic Control Specialist. He has also demonstrated that the agency allowed the wearing of corrective lenses by currently employed Air Traffic Control Specialists. Finally, he has shown that his lack of uncorrected visual acuity did not prevent him from demonstrating corrected functional visual acuity sufficient to receive, from the agency, a First Class Medical Certificate in connection with his pilot's license.

The agency has adduced no evidence, beyond its bare assertion, that appellant's visual impairment, if accommodated through the use of corrective lenses, would be an obstacle to his safe performance of the duties of an Air Traffic Control Specialist. Nor has it shown that accommodation would be unduly burdensome.

Accordingly, this Commission finds that appellant has been subjected to discrimination on the basis of handicap. Since the agency has not demonstrated, by clear and convincing evidence, that appellant would not have been hired in the absence of discrimination, relief is ordered in accordance with the provisions of 29 C.F.R. Section 1613.271(a)(1), except that, since appellant was an applicant for employment, no backpay shall be awarded. 29 C.F.R. Section 1613.710.

Conclusion

For the reasons stated herein, the final agency decision is reversed and this matter is remanded to the agency for action consistent with the foregoing.

IMPLEMENTATION OF THE COMMISSION DECISION

Under EEOC regulations, compliance with the Commission's corrective action is mandatory. The agency must report to the Commission, within thirty (30) calendar days of receipt of the decision, that corrective action has been taken. The agency's report should be forwarded to the Compliance Officer, Office of Review and Appeals, Equal Employment Opportunity Commission, 2401 E Street, N.W., Washington, D.C. 20506. A copy of the report should be sent to the appellant.

NOTICE OF RIGHT TO FILE A CIVIL ACTION

Pursuant to 29 C.F.R. §1613.282, the appellant is hereby notified that this decision is final and that he has the right to file a civil action on the Rehabilitation Act claim in the appropriate U.S. District Court within thirty (30) days of the date of receipt of this decision.

APPOINTMENT OF COUNSEL

If the appellant does not have an attorney, or is unable to obtain the services of one, upon his request, the District Court may, in its discretion, appoint counsel to represent him.

ATTORNEY'S FEES

If appellant has been represented by a member of the Bar, appellant shall be awarded attorney's fees under 29 C.F.R. §1613.271(c). The attorney shall submit to the agency, within twenty (20) days of receipt of this decision, the documentation required by 29 C.F.R. §1613.271(c)(2). The agency shall process the claim within the time frames set forth in §1613.271(c)(2).

NOTICE OF RIGHT TO REQUEST REOPENING

The appellant and the agency are hereby notified that the Commissioners may, in their discretion, reopen and reconsider any previous decision when the party requesting reopening submits written argument or evidence which tends to establish that:

1. New and material evidence is available that was not readily available when the previous decision was issued;

2. The previous decision involves an erroneous interpretation of law or regulations or misapplication of established policy; or

3. The previous decision is of precedential nature involving a new or unreviewed policy consideration that may have effects beyond the actual case at hand or is otherwise of such an exceptional nature as to merit the personal attention of the Commissioners.

This notice is in accord with 29 C.F.R. Section 1613.235. The agency's attention is directed to 29 C.F.R. Section 1613.235(b) for time limitations on agency requests to reopen.

FOR THE COMMISSION:

3/3/82
DATE

Executive Officer
Executive Secretariat

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December 3, 2010

VIA EMAIL: tomlusch@yahoo.com
AND REGULAR U.S. MAIL

Thomas G. Lusch
7204 Sweet Meadow Dr.
Canal Winchester, OH 43110

Re: Research of Potential Employment Action

Dear Tom:

I am enclosing for your review a memorandum summarizing our firm's review and research of your employment situation. Based upon that review and research, we have determined that we cannot represent you. Should you have any further questions after reviewing the enclosed memorandum, please do not hesitate to contact me.

Finally, our bookkeeper has adjusted your balance for legal services to zero, so that the only amount you have paid is/was for my initial consultation fee of $220.00.

Very truly yours,

Judith E. Galeano

JEG/ph
Enclosure

RESEARCH MEMORANDUM

Regarding Thomas Lusch

Judy:

I reviewed again the materials regarding Tom Lusch's employment. After further research, I stand by my original statement that there is little likelihood of success in challenging the statute. In fact, I would like to iterate that success is only marginally possible in the event we can appeal the case to the Supreme Court level. Obviously, this would be quite costly to Mr. Lusch and may not result in the outcome he desires.

Courts have not only upheld the law as exempt from the provisions of the ADEA, but they have also addressed the different treatment and status applied to different Air Traffic Controllers based on their employment history and/or date of hire. At least one Circuit Court has upheld the challenge on the basis that Congress had a rational reason for creating different classes of Air Traffic Controllers: ease of administering the federal retirement systems. *See Dungan v. Slater,* 252 F.3d 670, 674 (3d Cir. 2001). I also reviewed his Union Constitution and found that there is no duty imposed on the Union to pursue his claims. There is also no duty under common law, at least that my research revealed. Below is the memo I originally submitted to you.

You asked me to research Tom Lusch's circumstances and determine whether a cause of action exists based on the mandatory retirement age statutorily imposed by 5 USC § 8335. I have done some research and wanted to update you as to my findings. My research has indicated that:

Challenge Under the ADEA

The statute mandates retirement for federal air traffic controllers, firefighters, and certain law enforcement personnel. It was challenged by a class of firefighters in 1985 and the case went up to the Supreme Court. *Johnson v. Mayor and City of Baltimore,* 472 U.S. 353 (1985). In *Johnson,* the Supreme Court specifically addressed the statute's application in light of the 1978 amendment to the ADEA, which extended the Act to include federal employees. *Id.* at 357. The Court stated, "The 1978 Amendments eliminated substantially all federal age limits on employment, but they left untouched several mandatory retirement provisions of the federal civil service statute applicable to specific federal occupations, including firefighters, air traffic controllers, and law enforcement officers." *Id.* Therefore, it is clear that Tom Lusch will not be able to pursue an ADEA claim regarding the mandatory retirement provision of 5 USC § 8335.

Challenge Under the Constitution

Another possible route is to challenge the provision under the Equal Protection Clause of the Fifth Amendment of the Constitution. Because the law classifies people on the basis of age, the law would only be subject to rational basis review. *Mass. Bd. of Ret. v. Murgia,* 427 U.S. 307 (1976). Under this test, the court would determine whether the law is rationally related to a legitimate government interest. *Id.* In *Murgia,* which was decided before the ADEA covered public sector employees, the Supreme Court upheld a mandatory retirement age of 50 for state police officers. *Id.* Clearly, this is a very deferential standard. It would require Tom Lusch to carry the burden of persuasion and refute the conceivable bases on which the act relies. In other words, unless there is some evidence that the law was enacted arbitrarily or on the basis of some prejudice, he is not likely to be successful. In fact, the case he provided us in his notebook, *Dungan v. Slater,* E.D. Penn. No. 99CV-2376 (2000), addresses this issue. The court dismissed Dungan's claim on summary judgment, finding that "Congress has a legitimate interest in ensuring the professional competence and physical reliability of [air traffic controllers] ... to protect 'the safety of the public traveling by air.'" *Dungan* at 18, *citing* S. Rep. No. 92-774 (1972), *reprinted in* 1972 U.S.C.C.A.N. 2287. Although the *Dungan* case focuses on the fact that air traffic controllers who were on strike and subsequently rehired were allowed to work past age 56, a very similar analysis would apply to air traffic controllers who began or were demoted to flight service. *Id.*

Tom Lusch points out that § 8335 is over-inclusive because it mandates retirement regardless of the mental or physical acuity of the individual air traffic controller. He provided us with some studies that show the law does not necessarily promote safety because there is little difference between younger and older air traffic controllers. However, this sort of claim challenges the wisdom of the statute and invariably fails. *See, e.g., Vance v. Bradley,* 440 U.S. 93, 97 ("[A]bsent some reason to infer antipathy, even improvident decisions will eventually be rectified by the democratic process and . . . judicial intervention is generally unwarranted no matter how unwisely we think a political branch has acted."). It is permissible for a law to be over-inclusive or under-inclusive when it regulates neither fundamental rights nor a suspect classification. Moreover, the *Dungan* Court noted that the mandatory retirement requirements are really "'packages of benefits, requirements, and restrictions serving many different purposes. When Congress decided to include groups of employees within one system or the other, it made its judgments in light of those amalgamations of factors.'" *Dungan,* at 19, *citing* Vance, 440 U.S. 93 (1979). Similar rationale will apply when comparing the fairness or wisdom of allowing air traffic controllers who were first in Flight Service and worked their way up to live traffic control, because the Constitutional question is really about Congress's power to act and not the equity of how they acted. *See U.S. RR Ret. Bd. v. Fritz,* 449 U.S. 166 (1980). Congress clearly has the authority to regulate the conditions of employment for federal employees.

Conclusion

My research shows that the likelihood of Tom Lusch's claim succeeding is low. Unless you can think of any other basis on which to challenge the statute, I think we should tell him that we cannot take his case.

Nov 20, 2010

Thomas G. Lusch
7204 Sweet Meadow Dr
Canal Winchester, OH 43110

Representative Steve Austria
1641 Longworth House Office Building
Washington, DC 20515

Re: The Fair Treatment of Experienced Air Traffic Controllers

Dear Representative Austria,

In the April 29, 2005 edition of The Washington Times was written, "**Rep. John L. Mica...said mandatory retirement at 56 years old is an arcane rule**." ("FAA offers waivers to aging controllers" by William Glanz.)

Representative Mica's statement is accurate. Public Law 92-297 (the "ATCS Age 56 Law") was designed to maintain a young and vigorous workforce for those that are called upon to make recurring time-critical safety decision affecting the safety of flight. However, the intent of the law has eroded over time. Due to various amendments, the retention policy has become a prime example of stunning unequal and discriminatory treatment.

Those of us who began our ATC career shortly after the air traffic controller's strike in 1981, knew full well that we would encounter forced retirement upon reaching age 56. I feel fortunate to have been approved to work one year beyond age 56, yet several of my same-aged colleagues have been dismissed this year. What has truly astounded us is the very recent revelation that *several* of our colleagues, <u>who began with us</u>, have no concerns whatsoever about forced retirement. Amazingly, they are permitted to work as an air traffic controller ***indefinitely***! The twisted outcome of this law now even affects FAA employees like Terry L. Patterson, a Flight Service Station Specialist. His work is not like ours, yet he will be forced out of his occupation at age 56, while many of his co-workers work on indefinitely.

My being able to work until the end of next February, those colleagues who are totally exempt from mandatory separation, and FSS employees like Patterson, are *just some* of the examples of the incredibly disparate treatment that has evolved. Public Law 92-297 is not based upon a Bona Fide Occupational Qualification (BFOQ). 56 is merely an arbitrary number, which in no way follows the intent of the Age Discrimination in Employment Act (ADEA).

I urge you to level the playing field, and allow FAA controllers to work until age 65. Take into account that...

- Commercial air carrier pilots may now work until age 65.
- Canadian air traffic controllers are allowed to work until age 65.
- Non-federal ATCs (i.e. like at nearby OSU, Bolton, and Rickenbacker airports) face no mandatory separation.
- Two 2005 FAA studies show no correlation between age and air traffic controller ability.
- A 2009 independent study concluded that older controllers perform as well as young controllers.
- In the UK, similar arbitrary age related hiring practices in ATC have recently been declared unlawful.

References to the above information (and more) may be found in the enclosed paper, entitled ***In Support of the Fair Treatment of Experienced Air Traffic Controllers***. This paper may also be found on the "about" section of TomLusch.com.

Thank you for taking the time to consider this appeal that encourages the fair treatment of your civil servants.

Sincerely,

Thomas G. Lusch

cc: Representative John L. Mica

In Support of the Fair Treatment of Experienced Air Traffic Controllers

by
Thomas G. Lusch
September 17, 2010

In 1982 I was hired as an Air Traffic Control Specialist (ATCS) for the Federal Aviation Administration (FAA). My first SF-50 (Notification of Personnel Action) clearly stated...

"POSITION COVERED UNDER PL 92-297. IF 1ST ATC APPT IS AFTER 5/15/72, YOU CANT CONTINUE IN A COVERED POSITION AFTER 56 YRS OF AGE."

There was no if's, and's, or but's about it. I and my colleagues knew fully well that we would no longer be allowed to work traffic once we reached age 56.

Yet, around the end of July 2010, I was quite surprised to learn that approximately 25% of my colleagues, specifically those that I work with at Port Columbus International Airport (KCMH) Tower & Tracon, *who were hired right around the same time as I*, **were NOT subject to this age discrimination**! Much to everyone's astonishment (even to the astonishment of those 5 controllers), we learned that *they could work as an ATCS for as long as they wished!* They were not subject to any age discrimination whatsoever. I opined about that initial revelation here.

I am certain that these colleagues had received the same exact notice that I had received on their first SF-50. What was the difference between these five controllers and the rest of us? Oddly enough, the determining factor was that those 5 *had been assigned to a Flight Service Station (FSS) prior to January 1, 1987*. Even more baffling is that 4 of those 5 had failed at their initial ATC appointment, and were offered a position at Flight Service. The “first appointment” wording on our original SF-50s obviously didn’t apply to at least four of those five. Regardless, the exemption makes no rational sense. **This policy results in *stunning* unequal and discriminatory treatment**.

After becoming aware of this, I began to research Public Law 92-297. I've learned many interesting things along the way. Here is *some* of what I’ve learned...

Public Law 92-297 background: In the early 70’s, way before I was hired by the FAA, the U.S. Congress heard testimony as to how the job of an air traffic controller was so mentally and physically challenging, that FAA ATCS employees, by the time they reached their mid 50's, would be on the verge of "burn out." In the interest of aviation safety, Congress created Public Law 92-297, which is also known as the "ATCS Age 56 Law." This law allowed the FAA to discriminate on the basis of age in their hiring and retaining of employees assigned ATCS positions. Congress decided that controlling air traffic was a young person’s occupation, and for safety’s sake, they wanted to keep it that way. From May 16, 1972 and onward, the FAA would not hire anyone as an ATCS if they had reached their 31st birthday. Plus, they'd boot 'em out of the position (mandatory separation, aka forced retirement) once they reached their 56th birthday. **At least, that was their *intent* with this law.** (They did build a *little* wiggle room into this law regarding retention…see “Waivers to the age 56 law” further down).

Public Law 92-297 exemptions: Of course, as with most any rule, it isn’t deemed fair to change the rules of the game after one has already been hired. Thus...

•The first employees exempt from mandatory separation were the FAA controllers who had been hired prior to May 16, 1972.

•Some years later another exemption was created for those FAA controllers who were first appointed by the Department of Defense before September 12, 1980.

•Then, the exemption that I and my colleagues were not aware existed, was created for FSS specialists who were appointed before Jan 1, 1987.

Waivers to the age 56 law: Special Federal Aviation Regulation No. 103 dictates the waiver process. Waivers are based upon whether a controller wishes to continue to work, and whether or not the controller is considered to have "exceptional skills and experience." In an April 29, 2005 article in The Washington Times (*FAA offers waivers to aging controllers*) it was written that "Up to 40 percent of retirement-age controllers are expected to request waivers, but no more than 15 percent will receive them." (Look at the bottom of this link and you may see a copy of that article.)

More about the FSS exemption to the age 56 law: You'll note that SFAR No. 103 also covers FAA *Flight Service Station* ATCSs. (I'll term these as FAA FSS ATCSs, and those like myself as FAA ATC ATCSs.) These FSS folks, even though they perform important work that is critical to aviation safety, they do not *control* air traffic like those of us in the Terminal or En Route options. Nonetheless, they had been, for as long as I've known, designated as "air traffic controllers," and are in the same 2152 position classification.

In the 1979 testimony of Charles E. Weithoner, you'll see where he explains (beginning on page 11) that Public Law 92-297 was *intended for air traffic controllers who separate traffic*, not for FSS specialists. However, at some point, FAA FSS ATCSs appear to have been afforded the same "covered position" (early retirement) benefits of FAA ATC ATCSs. I *believe* that change came about with the government retirement program changing from the Civil Service Retirement System (CSRS) to the Federal Employees Retirement System (FERS) back in 1987 (this GAO letter from 1984 shows that FSS folks hadn't gotten "covered position" benefits as of the date of that letter). When FAA FSS ATCSs received those early retirement benefit provisions, they must've also gotten the mandatory separation at age 56 provision as well. Thus must've been born the "grandfather clause" which applies to FAA FSS ATCSs under the older CSRS system. This exemption is what has been afforded to my 5 colleagues at CMH. They are equally qualified air traffic controllers in every respect to the rest of us, except that they are afforded stunning unequal treatment, merely because they had all been appointed to a FSS prior to January 1, 1987.

Note: Interestingly enough, the exemption to the mandatory separation at age 56 is also resulting in unequal treatment for FAA FSS ATCSs in Alaska, as you can see from Terry L. Patterson's statement here. (Unfortunately, for many FSS folks, they got early retirement much earlier than they desired, as the FAA privatized FSS back in 2005 and turned FSS over to Lockheed Martin...except for FSSs in Alaska.)

Multiple exemptions erode the intent of Public Law 92-297: The General Accounting Office, in a 2002 report entitled "AIR TRAFFIC CONTROL: FAA Needs to Better Prepare for Impending Wave of Controller Attrition," discussed the ***multiple*** **exemptions** from the ATCS Age 56 Law. Back in 2002 their analysis showed that "…approximately 700 of those controllers currently engaged in separation and control of traffic are exempt from the requirement and have already turned age 56, and another 1,200 will reach 56 by December 31,2006, if they do not leave FAA before then." [see "Exemptions to the Age 56 Separation Provision Raise Safety and Equity Concerns" beginning on page 40 (pdf page 43)]. **Obviously, the intent of Public Law 92-297 has become eroded over the years, and unequal treatment is the norm, more so than the exception.** Interestingly enough, while GAO described the various exempted controllers, they were mum about this other "special class" of air traffic controller that I just recently discovered. As best I can surmise, they didn't even realize this special class of "appointed to FSS prior to 1987" controller would add to the "Equity Concerns."

Prior challenge to Public Law 92-297: Back in 1999, Air Traffic Control Specialist Dean Dungan challenged his mandatory separation at age 56. He had stayed on the job through the strike in 1981. In 1993 President Clinton decided to allow those controllers who had went on strike to be re-hired. Those that were re-hired are allowed to work beyond age 56 so as to reach their 20 years "good time" ("good time" is time spent actually controlling traffic, and is needed to qualify for a full early retirement ATC pension). Understandably, Dungan, who had stayed faithful to the FAA and worked thru the strike, felt quite discriminated against. Read more about Dungan's case here and here. You'll see that the court determined that the Age Discrimination in Employment Act (ADEA) was considered to not apply in Dungan's situation, and essentially that it is okay for the federal government to treat older air traffic controllers in unequal manners.

Can controllers work safety beyond age 56?: When one considers all the exemptions and exceptions, I'd say that the FAA has demonstrated that working beyond age 56 is safe. In the GAO article cited above, on page 43 (pdf page 47), besides the hundreds of exceptions they found, they also found one controller still working at age 69. In fact, until just a couple years ago, I worked with a colleague who had hired on in 1967. He worked traffic until he was 68 years of age. And like Dean Dungan, I also have a colleague at CMH that is ex-PATCO. He is allowed to work traffic two-and-a-half years beyond his turning age 56. I had another colleague who was ex-PATCO and has since retired, but he also worked well past age 56 (till he got his "good time" and was then forced out). Also, the FAA obviously has no qualms about five of my immediate colleagues not being subject to mandatory separation whatsoever. How many others are there?

Also consider that there are many controllers who have applied for and received a waiver to work beyond age 56. I have no idea what the national numbers are, but at CMH I am aware of 3 controllers who have worked on 4 separate one-year waivers. One worked one year, the other two years. They have both since retired. At the moment, I am the only controller working at CMH on a waiver. It expires at the end of February 2011 (or *anytime* with 60 days notice). I have applied for another waiver. (You can view my waiver requests and current waiver approval by accessing links near the end of this document.) A colleague who turns 56 this December has also applied for a waiver, but with just a little over 3 months remaining for him, as of this date he has not received a thumbs up nor a thumbs down on his request. As it turns out, with the current recession and our less traffic counts, our staffing numbers have recently been decreased. However, with our facility acquiring Dayton airspace within less than a year (but not necessarily a full complement of Dayton controllers), and with the accompanying training that will be required to get everyone "checked out" across the facility, my colleague, and/or myself, *may* be granted a waiver. It all depends on staffing needs.

Public Law 92-297 & SFAR No. 103...a powerful combination: If a facility is well staffed, it doesn't really matter if one is considered to have "exceptional skills and experience." Dean Dungan learned that, as he was reaching age 56 well before the current wave of retirements, and waivers simply weren't being processed back then. Also, this Checklist for Making Recommendations for Granting a Waiver to Mandatory Separation at Age 56, with its "Facility Staffing Numbers" and "Projected Retirements" drives the point home that if the FAA doesn't figure they'll need you, you'll be shown the door. And as it states in the SFAR, "The denial or termination of a waiver of mandatory separation request is neither appealable nor grievable (sic)." Thus, Public Law 92-297, combined with SFAR No. 103, are an extremely powerful combination that allows the FAA to remove us older (read "higher paid") air traffic controllers with little concern for repercussions relating to age discrimination and/or unequal treatment. Two other of my colleagues at CMH were shown the door this past June and July.

My union's position on age 56: On September 15, 2004, AVWEB wrote "NATCA Opposes Lifting Controller Age-56 Limit." As I looked into that, I discovered the testimony of Eugene R. Freedman, NATCA policy counsel, before Congress. Among other things, he made the following statements...

> "...cognitive abilities among air traffic controllers peaked between 38 and 45 and then decline begins. The decline becomes most severe after the age of 50."
>
> "...study revealed that performance also, not just cognitive ability, but performance declines after age 45, and very severely after age 50."

One can read Freedman's testimony in "A FRESH LOOK AT MANDATORY RETIREMENTS: DO THEY STILL MAKE SENSE?" (a text-only version is also available here). In stark contrast to his testimony, *within that same hearing,* one can read considerable support for the mandatory retirement age of pilots being raised. Congress followed through on that, and the commercial air carrier pilot's mandatory retirement age was raised from age 60 to age 65 in 2007. See the "Fair Treatment for Experienced Pilots Act."

At CMH, approximately 70% of us Certified Professional Controllers are over the age where my union testifies that "performance...not just cognitive ability...declines" (age 45), and approximately 40% of us are over the age where my union testifies that "performance...not just cognitive ability...declines...very severely" (age 50).

Recent FAA studies on older controllers: In 2004 Congress directed the FAA to issue regulations so that the FAA could grant waivers to allow controllers to work beyond age 56. Receiving those directions from Congress, the FAA conducted studies to assess the relationship of age to controller performance.

> •In an April 2005 report, entitled "Review of the Scientific Basis for the Mandatory Separation of an Air Traffic Control Specialist at Age 56," the FAA conducted a review of literature relevant as to how the "ATCS Age 56 Law" came into being. They looked at the studies that were referred to in Congressional testimony that convinced Congress to create Public Law 92-297. One of their conclusions was that the scientific evidence available back then provided *only weak support for the basis of the "ATCS Age 56 Law*."
>
> •In a December 2005 report entitled "Relationship of Air Traffic Control Specialist Age to En Route Operational Errors," the FAA examined Operational Errors (OEs) in relationship to controller age. OEs are mistakes where two airplanes got closer than the minimum amount of altitude or lateral separation required. In controller parlance, we call that "a deal." After reviewing over 3,000 OEs over a six year period, they were unable to correlate a controller's age with having "deals."

A recent independent study on older controllers:

> In 2009 there was a study that basically stated that us older air traffic controllers perform as well as young controllers *on job-related tasks*. The title of that paper is *"Experience-based mitigation of age-related performance declines: Evidence from air traffic control."* See a news link about it here. **In that study, I learned that Canadian air traffic controllers can work up to age 65**. You *may* be able to see the actual paper here.

Age discrimination in Air Traffic Controller hiring determined unlawful: In early 2009 we find that the National Air Traffic Services (NATS...the provider of air traffic control services in the United Kingdom) maximum entry age of 35 was declared unlawful. See this newspaper article from Feb 27, 2009

ADEA, BFOQ, and Congress postponing decisions: Recently, a colleague, who will be shown the door at the end of this month, pointed me to where a judge, in Johnson v. Mayor of Baltimore (non-federal firefighters fighting age discrimination), **delved into the history behind the federal mandatory separation provisions.**

As best I can summarize, in a case of what I call "presumed and circular reasoning," the City of Baltimore defended their mandatory separation at age 55 for their firefighters *based upon federal law*, essentially stating that if age 55 is good enough for the feds, then it was good enough for their city. The city argued that the feds, by the fact that they had such a law, automatically made age 55 a "bona fide occupational qualification" (BFOQ).

But the judge wrote as to how the feds never actually determined that age 55 was in any way related to a BFOQ, but essentially that **congress, in not wishing to delay Age Discrimination in Employment Act (ADEA) from becoming law, decided to maintain the status quo,** ***pending further study*****.**

Here are a couple passages from the link provided above...

> Instead of delaying passage of the ADEA while those Committees studied the mandatory retirement provisions in light of the proposed ADEA, Congress decided to preserve the status quo with respect to the retirement program, **pending further study**. This express purpose definitively rules out any conclusion that Congress approved the retirement programs in light of the ADEA.
>
> In sum, almost four decades of legislative history establish that Congress at no time has indicated that the federal retirement age for federal firefighters is based on a determination that age 55 is a BFOQ within the meaning of the ADEA. Congress adopted what might well have been an arbitrarily designated retirement age in an era not concerned with the pervasive discrimination against the elderly that eventually gave rise to the ADEA. Thereafter, although Congress retained mandatory limitations in 1978, while questioning whether they continued to make good policy sense, **it did so for the sake of expediency alone**.

Legitimate government purpose? Would the unequal treatment that I and my colleagues are experiencing live up to the Rational Basis Test? Am I afforded Equal Protection? Are my five colleagues, who are not subject to mandatory separation whatsoever, be considered a Suspect Classification? It will take much legal wrangling to figure these things out...and it'll be quite costly. I am supportive of a legal challenge to such a discriminatory law that results in such gross inequity. If you are also supportive of a challenge to an outdated law that is fraught with unequal treatment, contact me.

Call to action: Unlike most other occupations, it takes considerable time and effort to train our new crop of air traffic controllers. The FAA faces *considerable challenges* in meeting this need, while simultaneously dealing with the tremendous loss of experienced air traffic controllers that has been created by Public Law 92-297. That loss of expertise and experience could be reduced *immediately*, ***by an Act of Congress***...**an act that could simply set the mandatory retirement age of FAA controllers equal to the mandatory retirement age of commercial air carrier pilots (age 65).**

Is the FAA's mandatory separation law for air traffic controllers rationally related to a legitimate government purpose?

by

Thomas G. Lusch

July 22, 2010

Why must a FAA air traffic controller be forced to retire at age 56? Is this truly a safety issue, or is this simply sanctioned discrimination?

That is a very good question, and one that Dean Dungan unsuccessfully argued in a civil action back in 2000, when he found that colleagues (rehired PATCO controllers) were allowed to work beyond the age of 56, yet he was not afforded such an opportunity. He felt that he was not receiving fair treatment.

At the present time, I, and many other colleagues in my workplace, are disturbed about a similar form of sanctioned discrimination of which we have just begun to become aware. We didn't see this coming. All of us "old" controllers were fully expecting to be forced out as we reached age 56, unless we could obtain a waiver that extended our career for up to one year at a time, for up to a total of 4 years. However, all of us have not been able to take advantage of this program, and we are having retirement/goodbye parties for many experienced colleagues.

Recently, we learned that there was one controller amongst us, who, as he was preparing to retire, quite unexpectedly learned that he could work beyond age 56. He would not be forced out! He could remain working traffic for as long as he wished (assuming of course, that he passed the yearly FAA physical).

Even more recently we learned that there are now four other colleagues at our facility, who will also <u>not</u> face mandatory separation! That means that of the controllers that are eligible to retire at CMH, over 25% are not subject to mandatory separation! Why is that? What's going on?

How can it be that two controllers, both having been hired on exactly the same date, both having attended the same initial training in Oklahoma City, both having successfully graduated from the academy together, can end up being treated so inexplicably different as they reach age 56?

Believe it or not, the difference is that one of the controllers "washed out" at their initial facility. Yet, this controller eventually managed to re-apply to an air traffic control tower, worked their way back up the ladder to become a very capable and competent air traffic controller, yet is treated inexplicably differently upon reaching age 56. Is that fair? Should not this controller be treated the same as the colleague that managed to make it to full performance level status sooner in their career? What's the difference between these two classes of controllers anyway?

The difference is that the controllers who overcame adversity, the ones that picked their selves back up and recycled through ATC training, had been placed at a Flight Service Station *at some point prior to 1987*. Because they worked as pilot weather briefers, they are treated differently, in that they are ***not*** forced to retire. Yes, you heard me correctly...they are <u>not</u> subject to the mandatory separation. Is this not baffling?

I have learned that it is this way because of a unique provision in the law which exempts these particular air traffic controllers, solely because they had worked at a Flight Service Station prior to Jan 1, 1987 (see NOTE 2 at this link).

Is this discrimination rationally related to a legitimate government purpose?

Thus far this year we have lost 3 of 5 very experienced air traffic controllers at my workplace. These five have all reached (are reaching) the mandatory separation age of 56 during this calendar year. While CMH has been a facility that has been well staffed throughout its existence, I began to see the affect of this drain of experienced controllers just before leaving work yesterday. This came in the form of a supervisor who was looking for a controller to voluntarily work this Thursday evening/Friday morning midnight shift which didn't meet the minimum staffing (3 controllers total, to staff the radar room and the tower cab). I declined this offer of earning overtime pay, and apparently so did all of my other colleagues. This puts management into the position of having to involuntarily assign an overtime midnight shift to a controller that may not really wish to adversely affect their biorhythms.

My personal reason for declining the offer of overtime pay centers around just that...preparing my body for adequate rest before a "graveyard" shift in a safety critical profession. Over the past decade I have used my seniority to select schedules that avoided, to the greatest degree possible, the dreaded 2-2-1 shift (two evening shifts, followed by two day shifts, followed by a midnight shift). Controller fatigue is a very real concern, especially considering our "quick turn-around" schedules that have us manning the facility 24/7/365 (imagine yourself arriving for work at 8:00 a.m., getting off work at 3:00 p.m. then having to return a mere 8-hours later at 11:00 p.m. for a job that requires sharp focus and steady concentration). The FAA, at the behest of the NTSB, is finally beginning to address controller fatigue, as can be seen in this 2009 study.

One way to mitigate controller fatigue is by creating shifts that allow at least 10 hours between shifts. Of course, that would would likely require more controllers to adequately staff facilities based upon such a schedule.

The General Accounting Office cautioned about the ensuing rapid drain of experienced controllers (see GAO 02-591), as well as the adverse affect of staffing numbers dropping. I term that "getting behind the power curve."

I recommend that the law regarding mandatory separation for air traffic controllers be promptly addressed, and changed so as to allow FAA air traffic controllers to work till age 65, such has been recently changed for commercial pilots. Such action would end the peculiar form of sanctioned discrimination that I, and many of my colleagues, are just now learning about. Such action would help to stem the rapid drain of experienced controllers that the FAA is dealing with. Changing the law would help the FAA to mitigate the affects of this difficult transition period while we train our young and eager replacements.

What about me? I am one of those controllers that is subject to mandatory separation. I applied for a waiver in 2009 (see TomLuschWaiverRequest.pdf), and I am currently enjoying being able to work traffic (see LuschWaiverApproval20090807.pdf). I have recently applied for another waiver (see Lusch2ndWaiverRequest.pdf).

Federal Aviation Administration

Memorandum

DEC 23 2010

Date:	DEC 23 2010
From:	fo Debra Larson Matthew P. Amato, Director, Human Resource Management Office, AGL-10
To:	Thomas G. Lusch, Air Traffic Control Specialist, Columbus, OH ATCT
Prepared by:	Diane Cain, Human Resource Specialist, AGL-14B
Subject:	Denial for a Waiver to the Mandatory Separation Age of 56

Your request for a mandatory separation waiver was denied by the Administrator on December 20, 2010. Your mandatory separation date remains as February 28, 2011. Mandatory separation is not considered an adverse action; consequently, your separation is not appealable to any forum.

While this separation is mandated by law, this does not preclude you from applying for a non-covered Air Traffic Control Specialist position in the FAA, or for any other non-covered position for which you qualify either within the FAA or elsewhere in the Federal government. If you would like to pursue this option, and need assistance, you may call Gabriela Weimann at (847) 294-7750 to obtain information about applying for other positions, as well as for guidance in completing the required application forms.

Because you will be eligible for an immediate annuity, you will not be eligible for severance pay. Even if you elect not to retire or resign, you will be separated on February 28, 2011.

If you have been enrolled in the Federal Employee Health Benefits (FEHB) program for five years immediately prior to your separation date, you will be eligible to continue your health benefits into retirement. Likewise, if you have been covered by the Federal Employees Group Life Insurance (FEGLI) program for five years prior to your separation date, you will be eligible to continue your insurance coverage into retirement.

For further information regarding retirement benefits please contact Diane Cain, Human Resource Specialist, Human Resource Management Office, Great Lakes Region, at (847) 294-7748.

Nothing in this action should be construed as reflecting negatively on your performance or conduct. Please accept my sincere appreciation for your many years of dedicated service to the Federal Aviation Administration and particularly the Air Traffic Organization. I wish you the very best in all your future endeavors.

CC: Air Traffic Manager
ATO Central Service Area
Official Personnel Folder

April 21, 2009

Mr. Chris Lenfest
Air Traffic Manager, CMH ATCT
4277 International Gateway
Port Columbus International Airport
Columbus, OH 43219

Dear Mr. Lenfest,

Under policy bulletin #35, I respectfully request to be considered for a waiver to the mandatory separation at age 56. I am currently a Full Performance Level, Air Traffic Control Specialist, certified on all operational positions in the tower cab and the tracon, as well as Controller-In-Charge and On the Job Training Instructor here at Port Columbus International Airport, Columbus, Ohio (KCMH).

I began employment in the FAA on January 31, 1982, and worked at Cleveland ARTCC (upon reclassification it was considered as a Level 12 facility). I transferred to our Level 9 Port Columbus ATCT on April 18, 1993. I achieved facility certification at CMH in 658 hours. I currently work a three evening, two day schedule (Sat thru Wed). I have not been involved in an operation error, deviation, nor runway incursion, within the last 5 years.

During my tenure at Cleveland Center I received five (5) Exceptional and three (3) Outstanding annual performance ratings. Over the past three years I have received three Group Awards. Over the span of my career I have been recognized for one (1) Special Act Award (saved pilot from gear up landing), three (3) Flight Assists, received seven (7) Letters of Commendation, fourteen (14) Time Off Awards, and numerous Letters of Appreciation. I served as an AirVenture/Oshkosh Air Traffic Control Specialist in 1999 & 2000.

I have pilot experience, as I began flying in 1977. I hold a commercial pilot rating in gliders, with private privileges for Airplane Single Engine Land, along with an instrument rating. I have logged 1,199.6 hours of flight time. During 1990 I wrote instructional articles that appeared in Aviation Safety Magazine and IFR Magazine. I was honored to have a paper I wrote, concerning radar data processing, republished in the Jan-Mar 1992 issue of the *Journal of Air Traffic Control*.

Thank you for this opportunity to be considered for an extension.

Respectfully,

Thomas G. Lusch

Federal Aviation Administration

Memorandum

Date: AUG 7 2009

From: for Debra Larson Johnnie Terry-Flemming, Acting Director of Human Resource Management Office, AGL-10

To: Thomas G. Lusch, Air Traffic Control Specialist, Columbus, Ohio Air Traffic Control Tower

Prepared by: Diane Cain, Human Resource Specialist, AGL-14B

Subject: Approval for a Waiver to the Mandatory Separation Age of 56

Your request for a waiver to mandatory separation at age 56 is granted. This waiver expires on February 28, 2011. You will receive an official personnel action (Standard Form-50) stating that you have been "Continued NTE February 28, 2011."

During the period that you are continued in your position, your appointment, pay and benefits remain unchanged.

Although you are continued in your covered position until February 28, 2011, you can be terminated at any time based on the needs of the Federal Aviation Administration, or if you are identified as a primary contributor to an operational error/deviation or runway incursion.

If the decision is made to terminate your waiver, you will be notified 60 days in advance of the termination date and then be separated according to the procedures used for employees who have reached the mandatory separation age of 56. The decision to terminate the waiver is not appealable or grievable.

If you wish to have your waiver extended beyond February 28, 2011, you must submit another request in writing to your facility manager no later than six months prior to the waiver's termination date. Your request will be reviewed by your chain of command and forwarded to the Administrator for final approval or disapproval. The Administrator's final decision is not appealable or grievable.

If you have any questions about this process, you may contact Diane Cain at 847-294-7748.

Cc: Electronic Official Personnel Folder
Manager, CMH Tower
ATO, Central Service Center

June 8, 2010

Mr. Chris Lenfest
Air Traffic Manager, CMH ATCT
4277 International Gateway
Port Columbus International Airport
Columbus, OH 43219

Dear Mr. Lenfest,

Under policy bulletin #35, I respectfully request to be considered for a waiver to the mandatory separation at age 56. I am currently working under a waiver that expires Feb 28, 2011. I am a Certified Professional Controller, certified on all operational positions in the Tower Cab and the Tracon, as well as Controller-In-Charge and On the Job Training Instructor here at Columbus ATCT.

I began employment in the FAA on January 31, 1982, and worked at Cleveland ARTCC (upon reclassification it was considered as a Level 12 facility). I transferred to our Level 9 Port Columbus ATCT on April 18, 1993. I achieved facility certification at CMH in 658 hours. I currently work a two evening, three day schedule (Sat thru Wed). I have not been involved in an operation error, deviation, nor runway incursion, within the last 5 years.

During my tenure at Cleveland Center I received five (5) Exceptional and three (3) Outstanding annual performance ratings. Over the past four years I have received three Group Awards. Over the span of my career I have been recognized for one (1) Special Act Award (saved pilot from gear up landing), three (3) Flight Assists, received seven (7) Letters of Commendation, fourteen (14) Time Off Awards, and numerous Letters of Appreciation. I served as an AirVenture/Oshkosh Air Traffic Control Specialist in 1999 & 2000.

I have pilot experience, as I began flying in 1977. I hold a commercial pilot rating in gliders, with private privileges for Airplane Single Engine Land, along with an instrument rating. I have logged 1,199.6 hours of flight time. During 1990 I wrote instructional articles that appeared in Aviation Safety Magazine and IFR Magazine. I was honored to have a paper I authored, concerning radar data processing, republished in the Jan-Mar 1992 issue of the Journal of Air Traffic Control.

With the very near-term challenge of adding Dayton Tracon airspace into our operation, I feel that my experience, background, as well as dedication, can be an asset to your mission.

Thank you for this opportunity to be considered for an extension.

Respectfully,

Thomas G. Lusch

A Quick Look at a Real-Time ATC Solution

This write-up is about Air Traffic control automation. The ATC environment is dependent on a real-time database. That database should contain the relevant data of the system updated to the latest second. Where is every aircraft (cooperative and **non-cooperative**), where is it going and at what speed? What flight plans exist, what are the current weather conditions, what is the minimum terrain, what flights are scheduled for arrival and departure at each terminal? Inconsistent data – like ***separate Flight Plan processing*** - must never be permitted. Trying to make separate parts of the real-time database converge into a whole has never been and never will be successful. The ATC database must be **completely coherent** at its start, and **performance must be completely predictable**.

With this predictable database such needs as route optimization, minimization of delays and cockpit display can be realized. Air to air conflicts and controlled flight into terrain can be detected and advisories issued to both IFR controllers and VFR traffic to correct problems as they are found. **NEXGEN** can become a reality - soon.

But – these capabilities are dependent on a simpler much more efficient computer capability than the multiprocessor in use today (or tomorrow). The multiprocessor has repeatedly, since 1963, been proven inadequate for the real-time ATC problem. Theorists declare ATC problems intractable when using the multiprocessor. Let's look at some examples of a ***different – simpler -*** technology that **is capable of managing our real-time ATM database problems today and tomorrow.** Especially ***note the instruction count.***

Example 1

ON TOP

By Richard Collins

"BACK TO THE FUTURE"

In "Flying" Magazine Dec. 1995 pg 16

"In November 1971, I flew to Knoxville, Tennessee, for a demonstration of a revolutionary new use of air traffic control computers. It was the first system to offer conflict alert plus the promise of low altitude alert. There was a potential additional benefit from the new equipment: automated VFR traffic advisories. You were given a transponder code that was identified with your aircraft. Then, in a computer-generated voice (not as good as they are today) the computer would automatically call traffic at five, three and one mile ranges. A VHF frequency was dedicated to this experimental service in the area. The information was based primarily on the Mode A transponder. Mode C (altitude reporting) was in its infancy at the time, but if both airplanes were so equipped the automated system would also give the altitude of the other aircraft. Once the threat had passed, the voice would let you know that the traffic was no longer a factor."

The system also provided direction to traffic "***traffic 3miles at ten o'clock***". Terrain avoidance was implemented in December 1971. It worked as specified. An aircraft was automatically advised: ***"terrain 2 miles at flight level 31***."

In addition to the functions mentioned in Collins' note, the AP was **automatically** initiating and tracking all primary and secondary radar targets, and was providing display data for all traffic. The AP was programmed with about three man-years of effort, and had less than 2,800 instructions. It was a predictable **single thread instruction stream** (**STIS**) machine.

I was project engineer on the Knoxville experiment, and I can state, unequivocally, that **what was done in Knoxville in 1971 cannot be done in any ATC system in our country today.**

Example 2

Based on the Knoxville experiment, Goodyear Aerospace, designed, fabricated and programmed an improved version of the Knoxville computer. This new machine, called the STARAN associative processor (**AP**), had much more capability and was programmed to function as a complete ATC system. It could **automatically** track 500 primary radar targets. Secondary radar was used for identification and altitude reporting. It contained all the functions of the Knoxville system plus flight plan and display processing.

Programming STARAN was started on Jan. 4, 1972 and six programmers wrote about 7,600 instructions before the hardware was delivered to Dulles Field on May 15th for the 1972 International Air Show. It used Suitland radar data for the demonstration. It performed all its design functions in less than 8% of available time, and contained simulation routines that demonstrated the very high-speed performance capabilities of the technology.

The real-time database management system at Knoxville and in STARAN used a **single thread instruction stream** architecture to achieve the performance demonstrated. The key is the simultaneity achieved. **One instruction--hundreds of simultaneous operations.**

Example 3:

Based on the success of the AP in '71 through '73, the U. S. Navy, in 1977, started a development program to design an AP for their airborne early warning command and control system in the E2C aircraft. Their goal was to be able to automatically track 2,000 aircraft based on 4,000 primary radar reports. The problem was predicted to require about 173.3 milliseconds in the AP. Grumman engineers programmed the correlation and tracking solution to "assure" equivalent performance. The measured time was 113.8 milliseconds. The AP (called ASPRO by the Navy) became the repository for much of the E2C real-time database.

Janes.com reported about the E2C

"The early 1980s saw the introduction of the Group 0 standard with the AN/APS-138 radar …………entered US Navy service in 1988 as part of the E-2C Group I package. Other enhancements **included ASPRO adjunct processors to improve track management and display processing functionality,…"**

And Janes.com described **ASPRO**:

" Enhanced High Speed Processor - To handle the increased radar track file and required expansion of display symbol capacity, a high-speed parallel processor is incorporated into the mission computer which expands the active track file by 400% over Group 0. The enhanced high-speed processor equipped L-304 computer allows the E-2C the capability to process more than 2000 tracks."

These references were removed from Janes.com when ASPRO was replaced by an "off the shelf" system. As in FAA ATC, the tracking requirements for the E2C had to be changed. They were reduced by 333%, from 2,000 to 600 tracks.

ASPRO occupied a space of about 0.42 cu ft (including power supply and battery backup). More than 150 units were delivered to the Navy starting in 1983.

ASPRO could have easily satisfied the AAS requirements, thus eliminating the need for multiple ATC development programs. **Billions** of dollars would have been saved while achieving full functionality.

The aircraft tracking performance shown in ASPRO, using hardware designed in 1978 **cannot be realized in any ATC system in the Nation today!**

AP performance in the ATC problem is **predictable**. Multiprocessor performance for ATC **is not predictable**. All theoretical studies declare the multiprocessor solution intractable.

The capability of the AP is difficult to understand because it is so simple.
(*We all know computers are supposed to be complex.)*

The AP can predictably manage the real-time database in NEXTGEN. There is not a predictable multiprocessor ATC database management system available in the world at this time. Theorists state that such a system is unlikely.

The AP has been demonstrated repeatedly!

The AP can improve ATC performance starting very soon!

I'd like to discuss it with you. I can be reached by phone at 678-450-4413, by email: willcm@charter.net or by postal service: Will Meilander, APT 1110, 3801 Village View Dr. Gainesville, GA 30605.

(This article republished on TomLusch.com, on Aug 16, 2010, with permission of the author,)


BAREFOOT
FOR
LaSalle Bank
1742

September 11, 1999

Thomas G. Lusch
2185 Olde Sawmill Bl
Dublin, OH 43016-8221
Tel 614-889-9809 (Voice & Fax)
Email:tomlusch@columbus.rr.com

Nicholas J. Talotta
Technical Program Manager DOT/FAA
FAA Technical Center
Atlantic City Airport, NJ 08405

RE: Transponders becoming invisible

Dear Mr. Talotta,

I had a chance to speak with you briefly on the flight line at this year's EAA Airventure convention (I was the one proudly wearing my pink Oshkosh Tower ATC controller's shirt). I had a great time being part of FAA's ATC Team that helps to make AirVenture a safe operation.

Because of your interest in transponder operations, I promised that I would forward to you a report I wrote several years ago concerning aircraft not appearing on ARTCC controller scopes. As I was preparing to send that to you, I came across the report you wrote entitled "A Field Study of Transponder Performance in General Aviation Aircraft," dated Dec 5, 1997. I found your report extremely interesting, especially your key finding (page vii) that nearly 1 in 5 transponders "...would create functionally significant problems when interacting with ground Secondary Surveillance Radar (SSR) processors, TCAS, or both." You elucidate that behavior when you describe the "Terra Problem" wherein "...a design characteristic of certain Terra transponders prevent them from responding consistently to...interrogations." During your study you were surprised to learn that some Narco AT150 transponders exhibited similar problems. You stated "Prior to this study, no reports have been published to suggest that the 'Terra like characteristic' had been observed in other transponder models."

THE PURPOSE OF THIS LETTER IS TO REPORT TO YOU THAT YET ANOTHER MAKE OF TRANSPONDER EXHIBITED THAT "TERRA LIKE CHARACTERISTIC." I documented this anomaly when I posted the following message on CompuServe's AViation Special Interest Group (AVSIG) forum...

Message: #852440, S/3 Air Traffic Control
Date: Sat, Jul 15, 1995 1:11:18
Subject: Xpdr problem @ 1 tracon
From: Thomas Lusch/CMH 76545,2004
To: ALL

Here's a baffling radar problem...

Around two or so weeks ago one of our club aircraft began to get bad transponder reports from ATC. Columbus Ohio (CMH) approach control would assign us a squawk, but they wouldn't "see" our transponder reply. Members began "squawking" <g> about the problem.

On Wednesday I took the "bad" transponder (a King KT-76) to Capital Aircraft Electronics at Port Columbus Airport. They let it run for several hours, running it hot and running it cold, and it "bench checked" with flying colors. They stated that the problem might be in the aircraft system. On Thursday I flew the aircraft over. Their test equipment showed it working just fine in the aircraft. They released it to me saying it was performing as per specifications.

Shortly thereafter I departed CMH and flew west for 25 or so miles. The transponder's reply light indicated it was replying to interrogations. However, not even once did any of my transponder replies show on CMH's radar! I was a primary target the _entire_ way.

>>>> Here's where it really gets interesting.... <<<<

Directly after terminating radar, I called Dayton (DAY) approach, asking for a transponder check. They assigned a code and my transponder replies showed up on their radar just fine. I immediately switched back to CMH to see if they were seeing my DAY assigned code, but I still only showed as a primary target!

After a fuel stop, I departed and flew midway between CMH & DAY. DAY saw my transponder replies just fine. CMH didn't. I then checked with Indianapolis Center, and they saw my CMH assigned squawk just fine! CMH didn't see my transponder replies at all that Thursday.

This is particularly hard for me to understand, as I happen to be a controller at CMH. Nearly three weeks ago our new ASR-9 was commissioned. From my vantage point behind the scope I am very impressed with how much _better_ the ASR-9 is compared to the ASR-8 that we had been running. Our new radar has a much cleaner presentation. We see primary targets much more reliably, and the same goes for transponder targets. We can see aircraft much more reliably, at a greater distance, and at lower altitudes. (And the precip display is a quantum leap beyond the old ASR-8!)

As you may have ascertained, our club aircraft's transponder problem appears to be coincident with about the time CMH's ASR-9 was commissioned.

I took the aircraft over to CMH again on Friday. I spoke to the FAA radar techs about our problem, and they find it very strange. They hadn't received any other such problem reports. Capital Electronics ran their tests again, and everything appeared just fine. With a spare transponder in hand, myself and a Capital Electronics technician decided to fly it, and see if the problem was still there. We were prepared to swap out the transponder while in flight. As you might suspect, our "bad" transponder performed flawlessly.

We're all really baffled by this anomaly. If anybody out there might be able provide some guidance with this problem, we're all ears...

Tom

The only replies to the question I posed back in 1995 dealt with similar anecdotal problems...but no explanations. The radar technicians never did provide a plausible theory to this mystery. The FAA certified avionics shop was baffled too, especially since the transponder passed their repeated tests with flying colors. Then, some time later, the problem mysteriously went away. All indications pointed toward the newly running ASR-9 radar...but then something changed. It was sort of like the transponder magically got better. It didn't make sense. I now understand, having read your report, that modifications have been made to the Mode S ground radar interrogations (as described on page 18) to fix the "Terra problem." That is the most plausible explanation as to why these anomalies occurred.

I feel it is important to bring this to your (and the industry's) attention because it attests to the possibility of a more widespread problem in the fleet of GA transponders than may be realized or reported. This concerns me a great deal, as proper operation of transponders is the backbone of the ATC radar beacon & TCAS systems. It is disconcerting to realize that possibly 1 in 5 transponders, those that exhibit this "Terra like characteristic," are likely to be invisible to TCAS equipped aircraft!!!

The pieces of this puzzle all point to Mode S interrogations.

On an unrelated, yet extremely similar topic, I have enclosed a copy of my paper, "Real Targets - Unreal Displays..," as reprinted from the March '92 issue of the Journal of Air Traffic Control. That paper has nothing to do with transponders, or radar, or Mode S. It is purely a radar data processing problem...a result of ARTCC software not being able to handle the voluminous amount of excellent radar data available. However, it results in a similar condition...aircraft becoming invisible to the controller. Having visited Cleveland Center just last June, I observed that the problem still exists.

Sincerely,

Thomas G. Lusch

cc: FAA Administrator Jane Garvey, AOPA, ATCA, EAA, NASA-ASRS, NATCA, and others...