## Session XI. Regulation, Certification and System Standards



Systems Issues in Airborne Doppler Radar/LIDAR Certification

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# SYSTEMS ISSUES IN AIRBORNE DOPPLER RADAR/LIDAR CERTIFICATION

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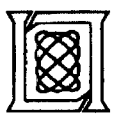
# OUTLINE

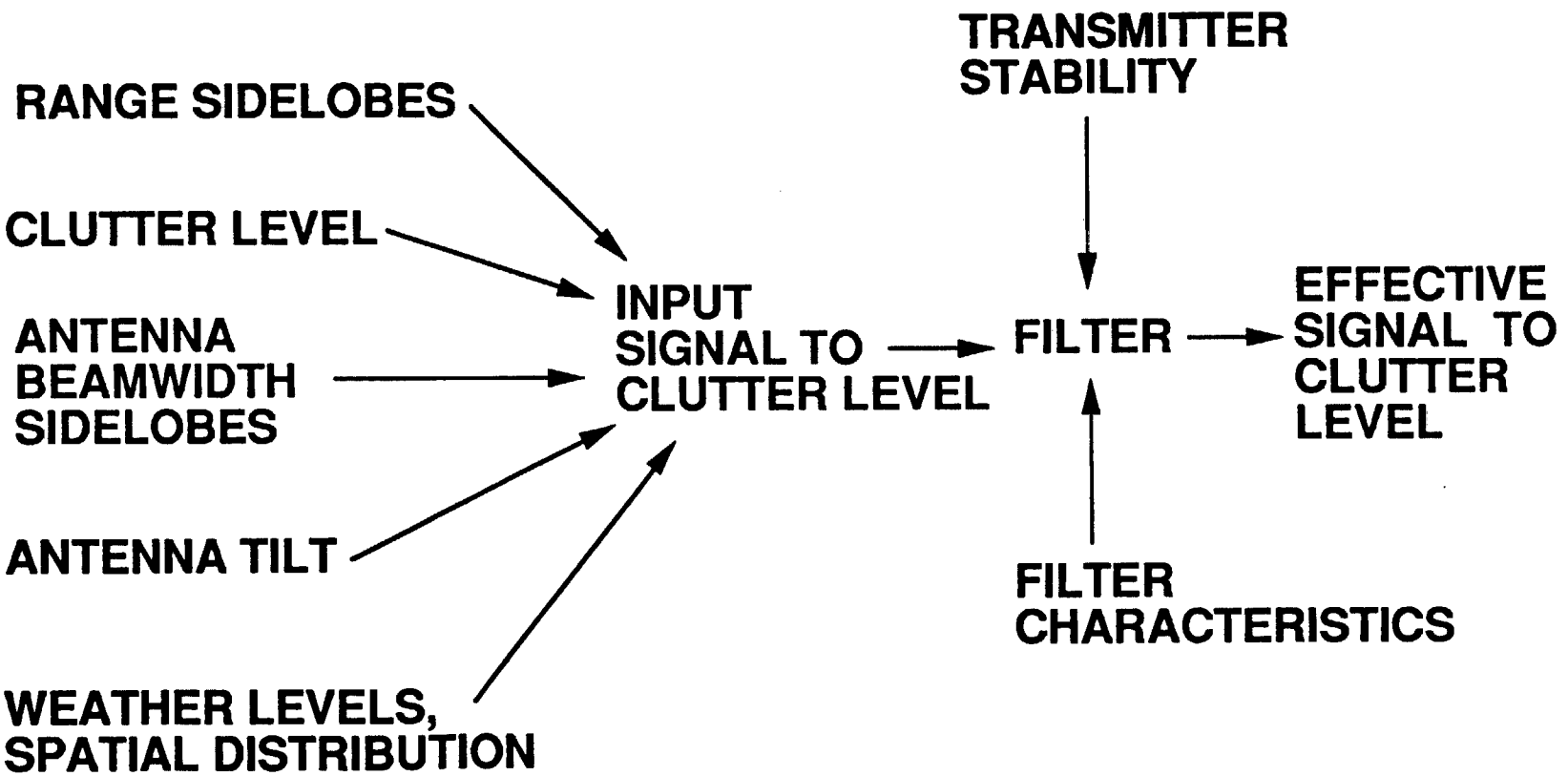
- THESIS
- GROUND CLUTTER CHALLENGE
  - ANTENNA POINTING / MICROBURST OUTLFOW HEIGHTS
  - CLUTTER FILTERING / TRANSMITTER STABILITY
  - RANGE SIDELOBES
- MOVING SCATTERERS (BIRDS, BUGS)
- RANGE AMBIGUITIES
  - WEATHER CLUTTER
  - GROUND CLUTTER
- RAIN ATTENUATION
- SUMMARY

# THESIS

- DESIGN OF COST/EFFECTIVE DOPPLER RADAR/LIDAR SENSOR REQUIRES TRADEOFFS BETWEEN:
  - ENVIRONMENTAL RESILIENCE
  - HARDWARE COST/COMPLEXITY
- ASSUMPTIONS ABOUT ENVIRONMENT ARE UNCLEAR AND, MAY DIFFER AMONGST SYSTEMS
- EXPERIMENTAL TESTING SHOULD BE CONSISTENT WITH VERIFYING ENVIRONMENTAL RESILIENCE
- DETAILED SYSTEM ANALYSIS SHOULD BE A PART OF CERTIFICATION PACKAGE



# GROUND CLUTTER CHALLENGE

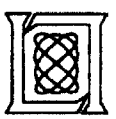


# GROUND CLUTTER CHALLENGE

| NOMINAL WARNING TIME (SEC) | RANGE (km) | URBAN CLUTTER ($\sigma_o$ = -40 dB) EXPRESSED AS dBZ | 3° BEAMWIDTH HEIGHT (m) |
|---|---|---|---|
| 7.5 | 0.5 | 42 | 25 |
| 15 | 1 | 39 | 50 |
| 30 | 2 | 36 | 100 |
| 60 | 4 | 33 | 200 |

**CONCLUSION:**

SOME COMBINATION OF ANTENNA TILTING AND GROUND CLUTTER SUPPRESSION WILL BE REQUIRED



# MOVING CLUTTER CHALLENGE

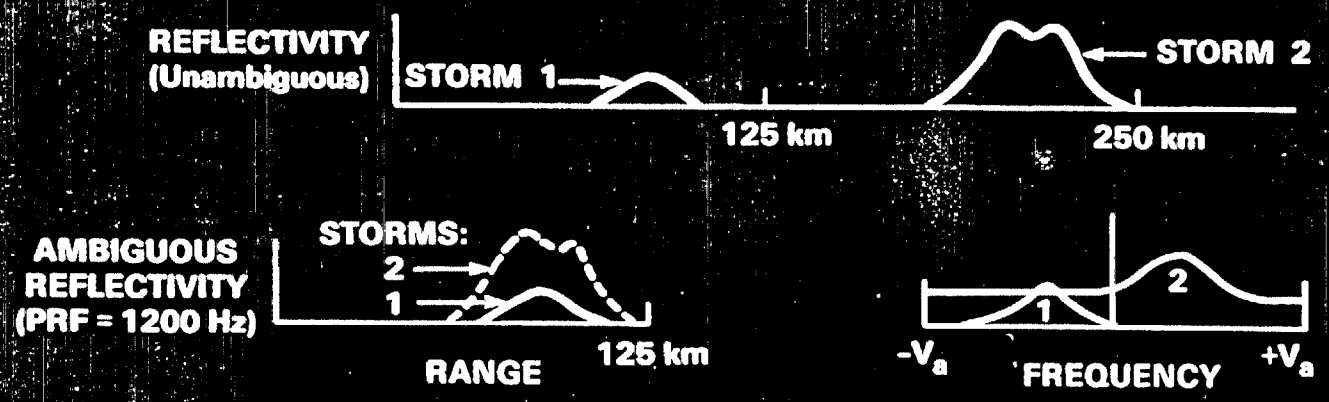
| NOMINAL WARNING TIME (SEC) | RANGE (km) | SEAGULL ( $\sigma = 10^{-2}$ $m^2$ ) IN dBZ | HOUSEFLY ( $\sigma = 10^{-5}$ $m^2$ ) IN dBZ |
|---|---|---|---|
| 7.5 | 0.5 | 50 | 20 |
| 15 | 1.0 | 44 | 14 |
| 30 | 2.0 | 38 | 8 |
| 60 | 4.0 | 32 | 2 |

X - BAND ANTENNA BEAMWIDTH = $3^{o}$

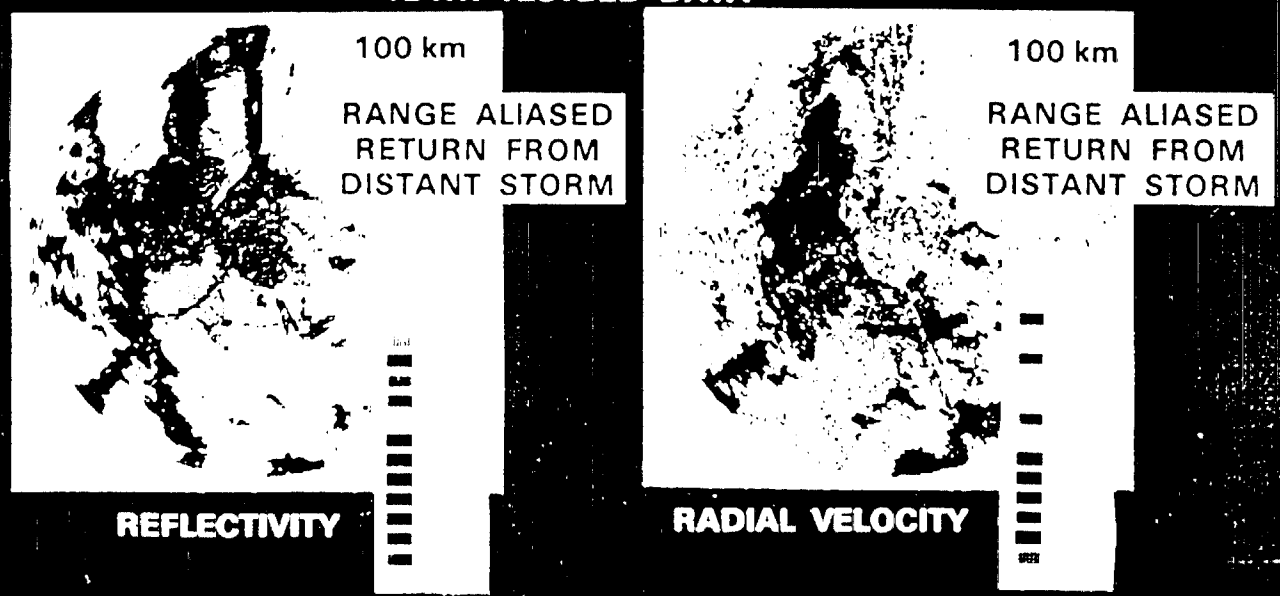
CONCLUSION:

MANY SMALL SCALE PERTURBATIONS WILL BE FOUND IN DOPPLER VELOCITY FIELDS

# OBSCURATION BY DISTANT STORMS




TDWR TESTBED DATA

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# RANGE AMBIGUOUS WEATHER CHALLENGE

| NOMINAL WARNING TIME (SEC) | RANGE (KM) | EFFECTIVE dBZ OF 50 dBZ SECOND TRIP ECHO |
|---|---|---|
| 7.5 | 0.5 | 8 |
| 1.5 | 1 | 14 |
| 30 | 2 | 20 |
| 60 | 4 | 26 |

X BAND PRF = 2000 Hz

CONCLUSION:
RANGE AMBIGUOUS WEATHER ECHOS ARE OF CONCERN FOR LONGER WARNING TIMES

# SUMMARY

- MANY TRADEOFFS EXIST BETWEEN
  - ENVIRONMENTAL RESILIENCE
  - SYSTEM COST / COMPLEXITY
- DEVELOPERS NEED GUIDANCE ON "NOMINAL WORST CASE" ENVIRONMENT FOR SYSTEM DESIGN
- SOME ISSUES (E.G., MOVING SCATTERERS) ARE MOST CONVENIENTLY ADDRESSED EXPERIMENTALLY
- NEED SYSTEM DESIGN ORIENTED APPROACH TO CERTIFICATION DATA PACKAGES

**Bruce Mathews (Westinghouse)** - I would like to state that Westinghouse wishes to distinguish that its antenna beam is in no way pointed in an arbitrary fashion. The hazard factor that we produce and are detecting is for the expected trajectory of the aircraft. We expect that to be accurate, to some degree, no matter what altitude. I think you have raised many valid points. I especially like the point that you made about the limitations of simulation for certifying an airborne radar. Many of the points that you have made about radar cross sections, and the detection of other small targets in the presence of those kinds of radar cross sections are very valid. Thirdly, I would like to say, there are other forms besides this wind shear review meeting where these kinds of systems development issues have been raised including the AIRINC Tag meetings and the RTCA. To some extent I think what NASA has been doing is trying to shape or form a skeleton that we can move along, in sort of a road map fashion, toward certification. In summary though, I think you have made some very good points about certification of airborne radar.

# Session XI. Regulation, Certification and System Standards

FAA Regulatory / System Standards / Certification Status

Frank Rock, Federal Aviation Administration

Presentation not available

**Dave Gollings (FAA)** - I would like to put in a little pitch for the pilots. I think we are in pretty good shape in terms of defining the threat. We are in pretty good shape as far as modeling and what kind of simulation needs to be done to certify. We are way behind the eight ball in terms of defining and standardizing the symbology for the display. I don't think the FAA wants to be in the position of legislating that. We are looking to industry to tell us what kind of symbology they would like, and will work with you on standardizing it.

**Frank Rock (FAA)** - That is a very important point that was just made. Standardization of displays and symbology, we have that problem almost every time we get a new product coming on board the airplane. We have gone through it with TCAS and we are looking at it again here for predictive wind shear.

**Randy Avera (FAA)** - I would like to encourage everybody to feel free to give us calls at the FAA when you submit for a supplemental type certificate. A lot of people are intimidated and I would like to remind you that we are not the IRS. We are people who's job is to help you get your project approved, and like has been said here the fewer requirements the better. Some of our applicants will send in a STC application and that is the last you will ever here from them until they call up one day and say "hey where is my STC" and we say "where is your data." Submission of the application, the data, and trips to the ACO's to discuss it face to face has a lot of credit. People working together solve a lot of problems and you understand things clearer. We would like to encourage you at your separate ACO's that you are dealing with, to maintain a good continuous working relationship there. That is going to cut down on the time that it ultimately takes to get the product in the aircraft and approved.

**Frank Rock (FAA)** - That reminds me of the guy that came to the ACO and said, "I want my aircraft certified." And the guy says "where is your data package." He says, "I don't need one I have the airplane outside." And the guy says "well you have got to have the data so that we know that it complies with all the regulations." And he said "I don't see why you need to do that, come on out I will take you for a ride and show you that it does all those nice things."

**Q: Roland Bowles (NASA Langley)** - Is it possible to start a certification procedure without the RTCA having completed its business?

**A: Frank Rock (FAA)** - Tony Broderick reminds us constantly that an applicant has a right to certify his equipment with whatever data he presents. It does not have to be from any recognized group or organization. The RTCA is a committee that has been recognized by us and other agencies as an advisory group, and is made up of all the interested parties in the aviation community. We take their input as being one that at least identifies what needs to be done to equipment onboard the airplane. That is the whole purpose for these men to get together and donate their time, and the manufacturers pay their salaries. We could walk off and do as we please, that could happen. At times I have done it, where I disagreed with the SAE or the RTCA committee. I don't like to do that and I don't think that any of the other FAA types like to do it if at all possible.

**Q: Roland Bowles (NASA Langley)** - But any manufacturer could bring his own technology, his own methodology and means and that could be accepted?

**A: Frank Rock (FAA)** - He has a right to do that yes.

**Roland Bowles (NASA Langley)** - I guess my message is that perhaps somebody ought to be thinking about RTCA's for some of these other technologies. Right now the only one that has made any real headway, and we are supporting it, is the radar.

**Frank Rock (FAA)** - The procedure to generate an RTCA committee is that any interested party could submit a request to what used to be the old executive committee, to consider a technology to be looked at or form a committee to examine and develop the standards for it. That can be done by most industry people. The FAA can do it as well.

**Q: Jim Evans (MIT)** - It was stated that the threat environment specification is largely complete and in good shape. How has the threat specification for the wind shear phenomena and the clutter environment been established and where can one obtain a copy of the specification?

**A: Kirk Baker (FAA)** - The FAA right now is developing a systems requirements document, and part of that document includes wind modeling that we are working with NASA to develop. Those models right now are largely being developed for the wind shear phenomenon itself. One of those includes a gust front, but largely is focused on microburst. Part of what we have seen these last two days obviously is going to effect probably some of the ways that we start to look at those. For example, the flight paths that we have the applicant demonstrate through these different events. The clutter environment is something that we are probably going to look to NASA to help us develop. The vendors themselves have been doing quite a lot of work in clutter mapping and we would expect that they would provide those maps and environments to us and those would be overlaid in the simulations. There is probably going to be some flight testing involved also. I think Roland stated earlier that it is going to be a combined mixture of different types of demonstrations. I encourage the applicants to step forward and make an effort to start putting together their ideas in how they plan to demonstrate the intended functions of their systems. We in the FAA can't provide you with a cookbook answer right now and we do not intend to. We are going to give you some minimum requirements that we think are applicable, and you are going to have to demonstrate those minimum requirements. We are in the process of developing those. This is an on going thing so to say we are in good shape, I think we are. I think we have got some things down in writing and we are continually working to improve those and it will continue through the summer I am sure.

**Q: Unknown** - Will the FAA be willing to certify a non-universal wind shear detector to meet the rule mandate? Should this question be answered prior to the vendors producing their technology?

**Roland Bowles (NASA Langley)** - As you know, in the airborne side there has been a lot of focus on the convective microburst kinds of environments as hazardous. In fact you can even see in the algorithms, features that depend on some sort of stagnation flow with outflows and estimates of certain mechanical properties in the wind field to help support the alerting structure. The question is, from the certification point of view, are you willing to certify microburst

detectors or are you going to certify wind shear detectors for whatever the atmospheric phenomenon is that gives rise to some level of agreed upon energy change that could be hazardous to the airplane? That is kind of the question.

**A: Kirk Baker (FAA)** - We are going to do wind shear detection that gives rise to hazardous energy changes to airplanes.

**Q: Roland Bowles (NASA Langley)** - How does the industry feel about that? Whose ox does that gore? Nobodies oxen got gored, so it must be all right. I think that has significant ramifications with regard to certification.

**Jim Evans (MIT)** - It seems to me that when you start talking about whether you build physical understanding about the phenomenon that may cause it versus not, you may adopt a slightly different principle. That is, if you have an event that possibly looks marginal, if we can decide what marginal is, that you insist that it have more meteorological characteristics, to rule out the marginal cases. Let me give an example of that. This came up with the LLWAS system. There were a lot of problems with the enhanced LLWAS system creating false alerts in gusty Chinook winds. The problem was, there might be a shear but it was very momentary. In fact, it would not even be there seven seconds later. There was something there, but it wasn't clear it deserved to be called a microburst in the sense that it was a very transient phenomenon. The same issue arises here. You go out and you make a measurement fifteen seconds or thirty seconds in advance and if the thing goes away under some kind of very transient environmental condition then there is a question about creating nuisance alerts. So, when you look at something and it looks like a serious shear, it is a high level shear and it even seems to have some persistence, then maybe I don't demand that it meet a convective storms criteria. If I have something that just popped up and it looks kind of marginal, maybe I insist that it at least look like something that is going to stick around for a while.

**Roland Bowles (NASA Langley)** - A good example of that is a report floating around the country concerning the Cafe Pacific 747-400 that got two wind shear alerts going into Singapore. About 300 miles off shore there was a tropical depression. Reasonable people can look at that data and question, was that just abnormal structure and turbulent flows being produced by that off shore depression, or was that a hazardous wind environment? I suspect you could give to five different competent analyst and get maybe two and a half different answers. The point is that there are many things in the atmosphere that can give rise to energy change, but the ones that we clearly must protect from are the microburst convective downdraft kinds of things. I think the answer that we heard from Kirk was that you must protect against all atmospheric phenomenon that will give rise to hazardous energy change to the airplane. Whatever it's atmospheric source, character or origin. I really thought some of you radar guys out there would say something about this.

**Jim Evans (MIT)** - I think we are beginning to repeal rationality. One thing I always hate about meteorologists is they always talk about extreme events, the most dry, the coldest, the wettest or whatever. If we are going to talk about all possible atmospheric conditions, I don't understand what the test program is going to be to deal with all the possible combinations of atmospheric phenomenon we could ever imagine. You will never test against all that. It is bizarre. In fact it doesn't make practical sense. If you are willing to accept that adequate protection is provided by

a reactive system that doesn't provide any reactive output on takeoff until you have gotten to at least 50 feet in altitude, I would argue that there is a fraction of events that are potentially hazardous that it is not going to protect you against. And, if you are willing to buy that, why do you then want to turn around and require protection against everything when you have already stated it is safe below 50 feet. I think you are repealing rationality. You have to make some value judgments and stick by them.

**Roland Bowles (NASA Langley)** - Don't accuse me of being a meteorologist. I think this is a fairly important question. One of these days somebody is going to walk into an ACO office and say, "Look what I got. This microburst detector is the best thing since sliced bread." and they are going to say, "So what. What about the other nine or ten test cases that you must protect the airplane against." It gets at the heart of the certification procedure. Are we going to do it? Are we going to have the target generator concept that the RTCA is looking at? Are we going to have gust fronts in there, off shore strong sea breezes, Chinook winds, thunder storms and all those embedded. I do not think the industry can afford that target generator to plug your radar into to show a minimum operating performance standard. Are we going to do it in simulation? Who in the country is building the database which will be qualified to subject the various instrumentation capabilities to, for detection performance, rejection of certain characteristics that are not considered hazardous, etc. This is where we are on the airborne side. How do you test the adequacy of a system? By what means do we do this? Who says that these databases are qualified for these uses? Or, do you get some good old boys from the industry together and they write a MOP because they all think they can meet it? I think some of you understand that problem.