Session XI. Regulation, Certification and System Standards

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Advanced Technology Wind Shear Prediction System Evaluation
Capt. Greg Gering, American Airlines

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AMERICAN AIRLINES

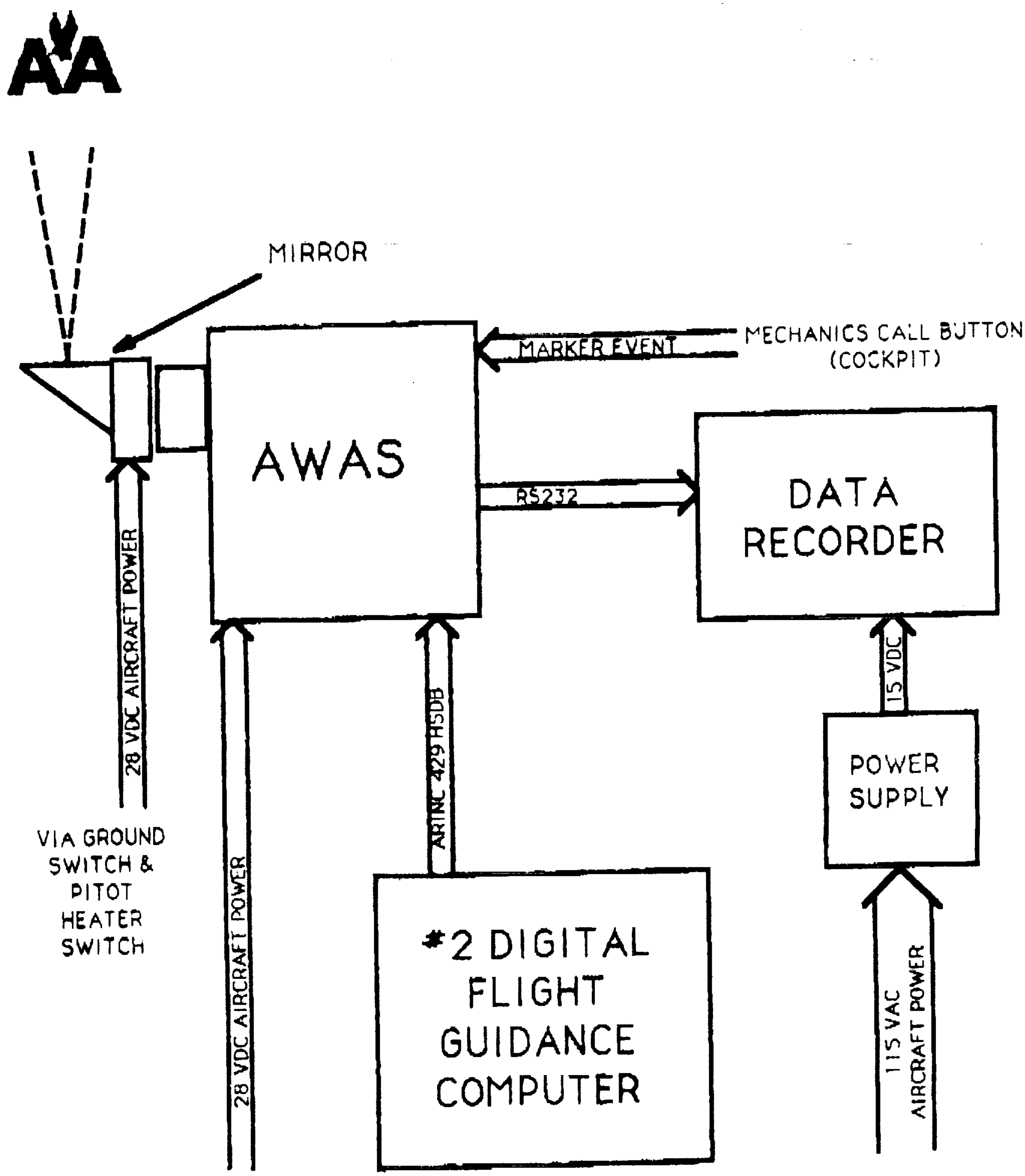
ADVANCED TECHNOLOGY WINDSHEAR PREDICTION SYSTEM EVALUATION

(GMG 1 4/16/92)

PROGRAM OVERVIEW

- AA/Turbulence Prediction Systems have installed Forward Looking Infrared Predictive Windshear System on 3 MD-80 aircraft.
- AA/TPS AWAS III evaluation is a joint effort.
- The AWAS III is installed in the NLG area and a data recorder is installed in the E/E compartment.

(GMG 2 4/16/92)



AA/TPS AWAS INSTALLATION BLOCK DIAGRAM

SYSTEM RELIABILITY

- The AWAS has not been removed due to a hardware failure since the debugging cycle ended.
- When required for S/W update, removal time is approximately 10 minutes.
- Mirrors have been durable. No replacement during the testing.
- Windows cleaned monthly. One window replaced in December by one with a protective epoxy coating.

(GMG 4 4/16/92)

SYSTEM EVALUATION

- O 3700 cycles of data have been collected.
- O All aircraft are flying with the latest S/W (ver 2.1.1.4).
- O S/W has new data labels that match the NASA algorithm.
- O S/W frozen in October 1992. 1000 cycles with latest S/W.

(GMG 5 4/16/92)

TECHNICAL ISSUES

- The lens with the diamond like coating is still not available.
- The NASA algorithm and appropriate flight data, for double checking the AWAS system was only recently implemented.

(GMG 6 4/16/92)

Results of American In-service Evaluations
Questions and Answers

Roland Bowles (NASA Langley) - I feel I have to defend your comment about the In Situ algorithm. As you know there was a formal request that we required for that. It went out to four manufacturers. You saw the results from Collins, they used it. I don't know to what degree Westinghouse has used it, but never the less that information was clearly in your vendors hands. We saw no reasonable attempt to use that algorithm at all. In fact I think it was fairly confusing for people to use because of the distribution of accelerometers located around the airplane. You have got some in the tail, some in the nose, but nothing near the CG. I think it have been in your vendors hands, but there have been no will to work with it.

Greg Gering (American Airlines) - I really was not trying to put blame in any one spot. We started our flight testing before you did your summer flight tests. Some of the decisions that we made were made before the things were available. It was just one of those things where we were trying to meet the time line for a 1995 installation. We ended up going into the flight test before we had all the data and we are trying to back in stuff later. I am not saying that you did not provide it on time or anything else. We were collecting data before we had it and we tried to back it in later.

Q: Roland Bowles (NASA Langley) - What has prevented backing it in? Is it that American has lost interest in the whole program, or is it that your vendor can't work with it?

A: Greg Gering (American Airlines) - We are collecting the data and we have 1,000 cycles since last October of data that we can use for it.

Q: Russel Targ (Lockheed) - As a technologist I am a little puzzled about what seems to be a systems evaluation in which nothing happens. We have three airlines very pleased that they have mounted a brick in the cargo bay. There have been no false alarms, no nuisance alerts, no alerts of any kind, and they all conclude that it looks good to them. I am puzzled as to how this amounts to an enthusiastic systems evaluation of a system that hasn't apparently done anything. Certainly in the NASA flights where your going through microbursts, you have some successes and some failures, but above all there is data. That is of course what anybody would want to evaluate the system. So, I am puzzled as to the criteria that the airlines are applying for these enthusiastic reports that we have heard?

A: Greg Gering (American Airlines) - I won't say that we are enthusiastic about how the system has been totaling working. Our part of the evaluation was not to find a microburst or a wind shear. The basic part that all three airlines went into flight testing for was to provide the high number of cycles and high number of hours in normal operation, and look for some of the base line noise.

Unknown - I was going to add a little bit to that. I have flown for twenty years in all types of environments and in over 12,000 hours I have never flown through a microburst. I think you will find that most pilots, military or air carrier don't. Especially today with the amount of education we have had in the area. If you see one or you think you are about to encounter the conditions where you might find an event like that you tend to avoid them. A test program on an air transport category aircraft is certainly not going to take any precedence over normal procedures.

Sam Shirck (Continental Airlines) - We have collected a tremendous amount of data that we are not processing ourselves. We do not build systems, we do not build radars, we just use them and break them and buy more of them. They keep us out of the mud and the trees and things like that. We are not to interested in the data. We are interested in what is going to be developed. My gut reaction as a pilot to what I am hearing from Bendix, Collins and Westinghouse is that they are damn close, and we are really happy with that. We think by the middle of next year we will possibly have a certified system, at least by the end of 1993. I sit in the back of the airplane once in a while and I am happy that we have got something that is going to keep it from wallowing around like triple seven did, where you don't have a chance on take off. That accident happened on an 82 degree day on a balanced field. The airplane definitely loves the ground at Denver. There is not enough oxygen up there. The type of system we are looking for will prevent this type of an accident, or of it even coming close to happening. So I think we are very optimistic, from all three vendors. We are disappointed that the IR is not showing the results that we had hoped. We are proud of what NASA is doing. We are proud of the support that the FAA has given us and the opportunity that Tony gave us for the two year extension. So we are elated. We are a lot better off than we were before.

GENERAL QUESTIONS AND ANSWERS

Q: Unknown - When you discuss gust rejection, I understand the physics of ignoring short time scale things along the flight path in the horizontal dimension. However, during the real crashes, aren't there some substantial controllability issues. Why is that is never discussed? Is it just because it is to hard to model and measure, or is it really not an issue?

A: Dave Hinton (NASA Langley) - Well, I am not going to say it is not an issue. Obviously in the Dallas/Fort Worth crash there were a few significant control problems associated with coming out the back side of that microburst. However, I do not know of any other cases where that has been true. That turbulence or upset was not a problem to the airplane until a very significant amount of energy had been taken out of the aircraft by the wind shear it had just flown through. By far the predominant effect from a microburst or a wind shear is the performance impact on the airplane. There are control problems. As a matter of fact there was an incident in Japan concerning an L-1011 I believe that made a very severe landing and it popped rivets out of the wings because of turbulence close to the ground. Terrain induced turbulence; that is a problem. But it is not the problem we are studying. You can cite Dallas/Fort Worth, but generally that is not the problem that caused the loss of life in microburst wind shear accidents.

Dan Vicroy (NASA Langley) - Just as a side note, I did a study about three years ago that looked at the handling the qualities effect rather than the performance effect. What is the effect on the handling qualities when you fly through a microburst? I looked at pitching and rolling moments and some of the asymmetrical aerodynamic loading, and so on. There is an effect there, but again it is a second order effect when compared to performance degradation that the airplane sees.

Q: Jim Evans (MIT) - I have a question I guess for the FAA. What is the FAA's decision process going to be apropos this rule making for reactive versus forward looking systems. It would appear from the results that Joe Gibson supplied that there is some concern about preventing accidents with reactive systems. Now it can be claimed that they have prevented a lot of accidents, but I will also note that only 15% of the air fleet was equipped, and they are not having accidents either. So it doesn't follow that reactive systems have prevented accidents. If we come to a point two or three years down the line and the look ahead system, which certainly have a desirable factor of being able to do avoidance, aren't yet certified, will the FAA require people to install the reactive systems or instead would it take the attitude that the potential advantages are great enough that people would be able to defer installing the reactive systems to see the look ahead can be brought to a suitable level of maturity?

A: Frank Rock (FAA) - It is a regulation; you have it, it is on the books; it has been mandated and you have a compliance date. I believe this one was mandated by Congress as well, which means you are going to have to get special dispensation to get around that. The regulation in the situation that we had with the predictive systems was one in which the petitioners petitioned the administrator for an extension and they were given two years for an extension. Those people who have not done that will have to comply with the rule. Now when we get to that point of course, other things may happen. There may be petitions by a large group of people such as the ATA or someone like that, who petition the rule to be extended. This is all possible, but right now there is nothing in the works that would indicate that it would go beyond the 1993 date. That is the date that the TCAS as well as the reactive system requirement ends.

Q: Myron Clark (FAA) - There has been extensive discussion on calculating F-factors. I do not believe I have heard any discussion of the error ranges in the calculations.

A: Roland Bowles (NASA Langley) - We have done those, and here is a simple way to look at it. For remote sensors, the way we calculate it is basically the scalar groundspeed divided by acceleration of gravity times a measured estimate of the gradient. That whole term is actually much more complicated, but at the risk of being run out of here I am not going to show you what it is. It actually is a rank two tensor taken with a suitable inner product. It depends on all nine elements of the wind field gradient; three winds shearing in three dimensions. For purposes of this calculation the simple form is O.K. From this we subtract the vertical wind divided by the airspeed. One way to look at this is to let there be a nominal value of the things that can have errors. Groundspeed measurement can have error, that is coming right off of the airplane or an estimate from the ground radar. The gradient estimate, the partial of horizontal wind with distance, can have errors. The vertical wind estimate can have error and airspeed can have an error, because that is a measurement off the airplane state variables. But, the airspeed errors are very small and trivial so we won't bother it. So, the change in F depends upon taking the appropriate derivatives of the things that have errors. You evaluate it around a nominal value. Take the RMS and throw in reasonable errors in groundspeed measurement, gradient measurement and vertical wind measurements, and you find that the error is on the order of 10% of the threshold value. In fact, that was one of our instrument requirements that we try to hold the error to 10% of the threshold value. I did not bring the curve with me, Myron, but the problem is under control.

Myron Clark (FAA) - A little follow up on that, if I may Roland. I know that test pilots want to know the F-factor because they are out there flying in it. But, what I am concerned about and I don't think there is anybody in my organization that is to enthralled with, is the idea of letting pilots know what the F-factor is and what the aircraft performance is so they can play one against the other. So, as long as we are not thinking along those lines.

Roland Bowles (NASA Langley) - No, this is the variable by which one thresholds to enunciate through excepted caution warning protocol in the flight deck, a level 3 alert. No, we don't say it is .09, tell me whether you got that performance at your configuration and weight and if is O.K. No, absolutely not. No sensible person would propose that.

Q: Gerry Aubrey (United Airlines) - We have heard a lot the past couple of days about forward looking wind shear on the glide slope. How about on the takeoff?

A: Brac Bracalente (NASA Langley) - From NASA's standpoint, we are using it during takeoff. We usually tilt it up at about three degrees on takeoff. I did show one event where we landed with a small microburst at the departure end of the runway. We were in an auto-tilt mode, and as we came down the antenna was tilted up. After landing it was at about plus one and a half degrees and as we taxied down the runway we were still detecting it at the other end. We feel the radar can be very useful for takeoff and work there as well as it does in the landing case. In fact, we think the landing case is more difficult than takeoff. So, we feel that if we can solve that, then we can probably handle the takeoff.

Bruce Mathews (Westinghouse) - We have collected data on the Continental from weight on wheels to 2500 feet, landing or takeoff. When we were in Orlando we did see wind shear during one of our takeoffs and we could show you a tape of that if you are interested. We operate the mode the same way whether it is landing or takeoff. We point the beam as a function of altitude, so it does not matter. The prediction is made a little different on takeoff because you are trying to project where the takeoff path is going to be. That would be the only difference, the expected path of the aircraft.

Q: Mike Lewis (NASA Langley) - We have heard throughout the conference fairly open discussion about the IR system and its performance from the other airlines; false alarm rates, nuisance alert rates and things like that. We have not heard the equivalent sort of information about the radar performance on Continental. I think from what you said you aren't looking at the data and that the radar manufacturers are taking it all home, and they say it works great. That is perhaps not the same sort of treatment we have been giving to the IR box. The question is either for Continental or the particular radar vendors who are operating on Continental. Can you provide that same sort of information that we have been hearing about the IR box as to the radar performance on false alarm rate?

A: Steve Grasley (Allied-Signal) - At this point and time the data gathering effort from our perspective at least at Bendix is fairly new. We are analyzing data I don't think we can convincingly say to ourselves that it is performing at X level. We don't know that yet. But you can be assured that we have dialogue with all potential customers about that and we share that data with them rather closely. I would say that there is probably a chance that we can talk about those things more in detail at the next conference or in the future.

Q: Mike Lewis (NASA Langley) - From the data that you have looked at so far have you seen any false or nuisance alarms in the radar results?

A: Steve Grasley (Allied-Signal) - We haven't but we are not processing in that nature yet. We are still looking primarily at raw data and raw calculations as opposed to calculated F-factor and how that may be interpreted. We are not to that stage.

Roland Bowles (NASA Langley) - There was a well defined basis on which airlines were given the exemption option. The real question is has there been sufficient data collected to warrant continuing the exemption process? And if so, where is it? And who has seen it? Fair question, Frank? I don't think we saw any data this morning from the airlines. I think we saw some good stuff from the manufacturers, but we didn't see a hell of a lot of data from the airlines. I guess your point Sam is that you are letting the manufacturers do it for you. Maybe each manufacturer that is in the exemption process could comment on whether he is meeting his plan as approved by the FAA to move forward in the exemption process?

Bruce Mathews (Westinghouse) - In response to Mike's question if I can still remember it. We reached our final configuration about April 3rd. We do not have a lot of data. We have one tape and we were glad we got it. Continental helped us get it by pulling that tape fast for us. We do not have a lot of data to show for what I would say is a final configuration. We will be able to start collecting that though and we will show it to people as we get it. I think our plans are to move into a different phase of development. We are going to get ready to go fly our BAC 111 again with our equipment to gather data on microbursts. It's very difficult to put a qualifying hazardous microburst minimal detectable features into a qualifying urban airport clutter environment and I think that is what we want to do in some sense for certification. I do not know how you can do that with a realistic small number of flights. We have got to get the mountain and Mohammed and super impose them on each other. This is the way we are going to proceed with our development. We are flying for false alarm performance now, and we will fly for microburst but we will have to do these things separately because they don't seem to happen a lot together. To demonstrate a hundred thousand hour false alarm time is going to take a long time. I heard people begging me to turn off that false alarm tape that I was running. If you want to look at it you can look at it. These things are not exciting to look at, and grown men let alone women and children don't want to look at urban clutter as you are landing in it, it is just not neat stuff to look at.

Q: Roland Bowles (NASA Langley) - Where did you get one hundred thousand hour false alarm rate? Where did you get that number from?

A: Bruce Mathews (Westinghouse) - Well, I think that is flight hours, one hundred thousand flight hours of false alarm data.

Roland Bowles (NASA Langley) - It is two hundred and fifty flight hours.

Bruce Mathews (Westinghouse) - Is that what it is? OK, good.

Q: Dan Stack (ALPA) - Regarding in flight detection and prediction of hazards. We have seen presentations that indicate the real risk can exist not only in the immediate vicinity of a microburst but at a considerable distance away. It appears that some testing and evaluation is necessary tangential from the core, prior to the certification process. What plans are in place to insure that these items are adequately addressed? When this area is thoroughly mixed it will probably lose its temperature difference from surrounding air mass

A: Dave Hinton (NASA Langley) - From a performance stand point it is part of our plans when we go into pilot simulations to look into an issue of how close to a microburst icon might you want to come, or how far should you stay away from one of those given various icon shaping algorithms. I see John Hansmen has left, but at MIT they have done some parametric studies looking at the effect of being off center in a microburst and have found the threat drops considerably at very short distances away from the core and it is a very localized event. With respect to other phenomenon that may exist some distance from a microburst such as a gust front, somebody may want to raise the issue. I do not know of anybody looking at gust front detection as generated by microburst that may be some distance away.

Q: Unknown - There were two things that seemed to me to be coming out as somewhat of a standard during the discussion the last few days. One of those was the comparison of different sensors against the In Situ algorithm results. Is there going to be some requirement to make that comparison somewhere? Is that going to be something that we are going to have to consider? Also, we talked a lot in the last couple of days about averaging the F-factor calculation across one kilometer. Is that becoming the standard? You hear a lot of consideration that in some aircraft it is not right, maybe in some others it is? I don't know if there is a real answer at this point and time, but those two things seem to be coming out as kind of a standard. I am not so sure that it is exactly right.

A: Kirk Baker (FAA) - If you are flight testing a radar there is a couple of ways you can validate what you are seeing, and NASA has shown that. One is by TDWR and the other is by an In Situ F measurement. I don't see us deviating from that method of demonstrating the truth of your system. I think that is the technique that is around and I think we will be using it. It is something that we are going to have to negotiate, depending on what you propose to do in your certification plans to demonstrate that your system performs its intended function. Something that we have also asked NASA to help us with is defining the threat. The one kilometer averaged F seems to be something that is coming out as a viable way to probably take care of some of the wind shears that people keep trying to get us to say you don't have to protect against. One kilometer seems to weed those out. It is a sustained F over one kilometer. I think that the real threat to an airplane is a sustained F, so that is a standard that we will probably be starting out with?

Mike Lewis (NASA Langley) - What we have tried to do and was summarized in the curves that I showed a couple of days ago, is to postulate a certain set of assumptions and show what an aircraft can withstand given that set of assumptions. I think it is NASA's feeling that it is the FAA's job to decide whether those are in fact FAA agreed upon assumptions, or whether they want to change those. That may or may not have an effect on whether that simple one kilometer test is adequate. From what we have seen, and I showed in the last curve of my presentation, that simple test seemed to do a very adequate job of protecting against even the close call incidents by a wide margin and certainly against the accident cases.

Mary Jo Hoffman (Honeywell) - I have a comment on this F-factor issue. This is my first wind shear conference. I think I can help you guys see the forest for the trees. I came in here and everyone was talking about F values of 0.15 and it is kind of an assumed thing now that it is a standard. It is the same as this one kilometer sustained F-factor issue. Perhaps we should consider a ranking of the performance of the vehicle as something like a percentage of the thrust minus the drag over the weight, the energy capability of the aircraft. For example, in a 727 I might want my red alert to go off at a F of 0.1 but if I am in a 747-400 I do not want it to go off unless it is a 0.2. It is just an issue that I am throwing out for discussion.

Sam Shirk (Continental Airlines) - I think you are going to find a lot of comments from the airlines on that. A lot of the newer two engine aircraft have tremendous performance capabilities. I know discussions at American, Northwest and we at Continental are hoping that the FAA can see fit to certify a system where aircraft performance will be factored in, I hate to say that because I know they are here to help us and it is the other FAA, but there are some good reasons to have a relaxed F-factor if you will on the airplanes that have great performance. I think it is an issue that we as airlines I know hope that the FAA does address and hopefully in a manner that we would like to see it addressed.

Q: Roland Bowles (NASA Langley) - Why Sam?

A: Sam Shirk (Continental Airlines) - What we are really talking about here is a true performance factor. I think operationally the airlines really need this latitude. I can see it plugging our system up. Our ATC system is overloaded right now. I think there is good reason to be able to depart with a 737-300, a 767 or a 757 series airplane, when a 747-400 or a 727 might sit on the ground because it doesn't have the performance margin. I think it is something that we have to look at, at least from the ATC side of the equation. As to whether that same microburst that we have decided now that we are going to fly through is going to grow, that is a touchy situation. Maybe it will get smaller too. I am not suggesting that on takeoff if we have got a microburst inside of a mile and a half we say "Hey this airplane has got a lot of go to it, that is no problem, I'll press on." I am not saying that at all. I am saying for that stuff that is perhaps outside a three miles, that might be a consideration that we would have. It also might be a consideration on final whether to abort the landing or to continue. I think it is something that we have to look at.

Q: Roland Bowles (NASA Langley) - When you look at the one kilometer criteria, what you are saying is that it is O.K. to go ahead and take something on the order of a three knot per second hit, for something on the order of ten seconds. Or equivalently, almost 2,000 foot per minute induced sink rate. That is what 0.105 will do for you. Now you may have a lot of performance left, but I am not so sure you would necessarily want to use it. You would like not to expose yourself, because it can get worse. Kurt, do you ever envision a situation where you will make thresholding aircraft specific?

A: Kirk Baker (FAA) - Maybe some of you old dinosaurs can help me that were around when the TSO was written. I think this subject was heavily debated, varying the threshold for the performance of the airplane. The situation that you ran into with the reactive system was you could have a 737 on the runway in front of your 747 takeoff and fly right through something that you probably would not want the 747 to fly through. I think that was one of the reasons that we felt that we would stick with just one threshold. For predictive systems, where you have the ability to look ahead, in my opinion you are going to run into the same type of operational concerns. You are going to have guys going through and some guys going around, and they are all going to be wondering why did that guy go through it and I did not have an alert, or why did that guy go around I don't see anything out there. I think it is something we can entertain, but I am not sure much is going to be gained out of it. These events are not that common and they are short lived. I would like to see the thresholds stay at the same standard that we have it now for reactive. If someone can come up with a scheme that seems to make sense both technically and operationally I am sure we would consider it for the forward looking system.

Jim Evans (MIT) - I would like to make some comments on what we have learned from TDWR experience. TDWR and LLWAS have both gone through a mode which for example there are a distinction between microburst alerts and wind shear alerts with loss. The guidance by the airlines has been by and large when they get a microburst alert the people should not operate and when they get wind shear alert with loss they in fact have a pilot decision that takes into account how loaded the plane is, the density altitude, a bunch of things can be worked in. When we look at our statistics we see far greater numbers, by factors of four or five, of the wind shear alerts with loss than microburst alerts. I can certainly say that in places like Orlando, based on some of our experiences between 1990-1991, it made a big difference whether we were calling some alerts a microburst alert versus a wind shear alert with loss. I think that at least in Orlando where you get a lot of minutes a year of alerts it does make a difference. Now you can say it doesn't make a difference so much to one pilot, but I can tell you that the air traffic down there was getting pretty annoyed after a while in 1990 when we were very conservative. I think that right now in the ground based systems there is some reason for latitude. One of the other elements about some of the look ahead systems is if I have gone over an F of some number for one kilometer, I would also ask what about the next kilometer, and the next kilometer beyond that. If I have a thing that sticks up like a thumb nail and it is one kilometer I may feel differently than if it is a little longer than that. That is another thing that you would know from the look ahead system, presumably in some cases at least, it would know how big it is. John Hansmen showed some examples of a pilot presentation that in a sense had some form of gradation that allowed a pilot to take into consideration these other factors that get lost when you go to a fixed red-green threshold.

Q: Roland Bowles (NASA Langley) - In effect we are doing some of that today. It is my understanding that in some of the certified reactive systems today we will gain schedule before the threshold test as a function of altitude. For example, we might be computing the energy loss parameter, but down gaining it to 80% value before testing threshold. Then, let the gain go through one, as you go through 750 feet, therefore increasing the sensitivity of the system. So in effect, depending on what airplane that is on, we may be doing some aircraft specific stuff right now. I believe there are systems out there that gain schedule with altitude. Kurt, do you know of any such systems?

A: Kirk Baker (FAA) - Sundstrand does do some gain scheduling. I am not that familiar with their systems so I don't really feel I can get into the technical side of it. It is usually not the varying of the threshold, it is the timing of the gain itself.

Roland Bowles (NASA Langley) - I do not know how many airplanes we have out there, but a reasonably significant number were equipped prior to the TSO locking up 0.105 as the threshold. So, I know we have some planes out there that the thresholds are set at 0.12 right now. There is a 20% variation right there between some early variance and what the threshold calls for right now.

Dave Hinton (NASA Langley) - I guess I also would like to add one thing to that. Think about what we are trying to do with these systems. We are trying to prevent the airplane from being exposed to a hazardous situation, perhaps very close to the ground. If you park one of these microbursts at the middle marker and you throw 767 with a lot of performance into that, but you throw in a little pilot recognition delay, you may be digging up approach lights before you get all that thrust turned around and going the other direction. It is possible. Also, we have an existing training package out in the fleet that has played a major role in preventing any accidents since 1985. It gives the pilot certain guidelines as to when the atmosphere is doing something very unnatural and you shouldn't be there and you should go around. Now if we start talking about bumping thresholds up to perhaps 0.15 when you are back at the outer marker, and there is a 0.13 microburst sitting inside, you are going to deny that pilot an alert yet expose the airplane to a situation where the wind shear training is going to kick in, and the crew is going to say I shouldn't be here. So you are going to go around anyway, but you have exposed the airplane to the threat at low altitude. That is something that has to be considered I think if you want to start bumping up thresholds as a function of airplane performance.

Mike Lewis (NASA Langley) - I would agree, and the same case holds on rotation. You can postulate the special case of the microburst right at rotation for which all the extra power in the world isn't doing you much good. At that point all the air planes are essentially equal as far as there margins and so forth.

Terry Zweifel (Honeywell) - If you vary these things with altitude, in essence what you are doing is sucking the guy in to go lower. The lower he goes the worse it gets, and you just delay and lose valuable time. Those who have been in simulators with reactive systems and flown out of a wind shear know that one, two or three seconds can make a big difference on whether you survive the accident. That is why I personally do not like the idea of scheduling. In our system we don't actually use 0.105. We use an energy loss threshold which is kind of the equivalent of what Roland has been talking about. 0.105 is really an energy rate of the airplane. So if you take it over 1,000 meters, in essence you are integrating that rate. Whenever you establish the distance you are saying that is how much energy I will let the airplane lose before I turn on the light. We do the same thing except it is a time based type of thing.

Roland Bowles (NASA Langley) - It seems to me that any kind of tinkering with that kind of mechanics inside the boxes is no substitute for good design. A lot of the reasons for raising thresholds is to get rid of other undesirable features. There may be better ways to design those features out, and maintain the integrity of the protection system.

Terry Zweifel (Honeywell) - Obviously if you could do it somehow you would like to set the threshold much lower than that. The reason for raising it is to get some gust rejection out of it. There is always a compromise over where that level is going to be. I think that is going to be true of some of these predictive systems as well as the reactive systems. I think the 0.105 establishes a base line for commercial airplanes and is probably valid for the whole fleet that we see out there now. I think Roland has probably looked into that and in fact proven that to himself.

Frank Rock (FAA) - I wasn't getting up to say anything, I was getting up to leave, but let me just throw a little bit into there. After forty years of working in this business, I haven's seen a system that hasn't been improved for some reason or other over a period of time. I have never seen a system go out on the market and stay static. It always improves, so we can always expect that there is somebody coming behind us that is smarter than we are and do it better.

Q: Terry Zweifel (Honeywell) - I do not want this to appear as a biased comment coming from someone who works on reactive shears, but over the past three days we saw the Doppler radar, the infrared and the LIDAR results, and while I can't say that it is true, it looks like there is a possibility there may be shears that they won't detect. It was stated that maybe the Doppler radar would have to go down to minus 15 dBZ. I am not a radar guy, I don't even know if that is feasible, but it doesn't sound real good. My question is, would the FAA certify a system for which there were known cases where it would not detect a shear?

A: Kirk Baker (FAA) - One of the things that you have heard talked about, is what is the real intent behind a system like a wind shear detection system? Is it to detect a wind shear, or to prevent an accident as a result of a wind shear? That question has come up, it is not the first time we have been asked, and it is going to keep coming up. It is part of establishing a probability of a missed event. In our requirements document we have something called a missed event and that is what you just described. How are we going to decide what is an acceptable rating? I am not sure yet. TDWR has a 90% probability miss, and we have heard discussions on what that really means. When you put something on an airplane and it is classified as an essential system, it has to have a probability of missing of 10^{-5}. Now there is also a lot of conjecture about whether a radar system can meet a requirement like that Somewhere along the line we are going to have to sit down and grind through some safety tradeoffs. If we can only detect 98% with a forward looking system, we have to make sure that for the 2% that we miss we can justify why we accepted that. I have a feeling it is going to be based on some great improvement on safety. That is the only way I can see it. From what I have seen right now I don't think the radars can meet 10^{-5}, maybe they can. That is going to come out in the certification work that we do. We are going to see what the extremes are, and we are going to test the extremes. The models that we create are going to be in high clutter, embedded rain, dry microburst on the other side scenarios. We are going to have to test the bounds to see if we can come up with what is the probability of a missed event for a system like this. I think it is kind of early to say that we won't certify a system that can't detect that 2%. We are going to have to look at it. We want to be careful not to stifle some real promising technology.

Roland Bowles (NASA Langley) - This is one that I really get sort of excited about because if I look at the TSO there is no such specification in there for reactive manufacturers. They state a probability of nuisance alert. All these alerts are carefully defined as per the SAE document, very carefully defined. I think that is one of rigorous things that has come up on the airborne side. When we talk about alerts for ground base systems is not a rigorously defined alert. Some people would argue that is advisory information. I don't think there is a missed alert specification in the TSO. What you do is you take 7 or 8 or 10 accident reconstructions and show that you could have detected those. Now we are coming in with other industries and we are going to generate a new number and hold them accountable for some ten to the minus whatever. I don't see that it is necessary. The point is that you can be so rigorous here that you lock out some growth in marketplace and competitive issues involving this nation's avionics and civil transport. You could do that real easy.

Q: Terry Zweifel (Honeywell) - Does that mean that the LIDAR would have its own value and the Doppler radar would have a different percentage that you allow it to miss and the infrared another, or how would you do that?

A: Roland Bowles (NASA Langley) - No, I would hope not. I would hope that a careful analysis from an aviation safety perspective would be done. Someday there will be a hole in the ground resulting from an airplane crash involving a reactive box. If we could have prevented that with a forward look system that had a detection probability of 0.7 it may have been worth it. We don't want to rule out the technology based on an arbitrary set of numbers unless it is based on really careful analysis. I think the issue on the analog airplane is a good one, I was in the room when that one was set up and I know where it came from?

Terry Zweifel (Honeywell) - Well, obviously one of the things you could do is something like TPS did. You can incorporate a backup In Situ algorithm, that is a possibility. That makes the system cost more because now it has to have accelerometers and air data inputs that perhaps weren't needed in the first place. I was just curious to know what the thinking of the FAA was on all of this.

Jim Evans (MIT) - You really haven't responded in a fair way to the challenge that was put forth by Joe Gibson. What we are trying to do is to prevent accidents. Now we have already heard about the Continental Flight, there was also an Air Cubana flight which crashed in Havana, and there was a takeoff accident. You wouldn't even argue that they would have been prevented by and In Situ system. It seems to me that if we are going to run around arguing about accidents and which accidents would or would not have been prevented, you would lump those two incidents in and you would be down to an 80% system. The challenge that was put forth by Gibson was, as you go to more and more severe sheared events you come to events for which a reactive system does not react fast enough, and what is the probability of that? I don't know how you could prove that it was 10^{-5} of all microburst events. I don't think you could hold that for one minute. It seems to me that what you are talking about is the probability of preventing accidents. I think Joe Gibson put forth a structured approach for dealing with the analysis. I have never seen the details of the simulations that proved on all the accidents which occurred that you surely could have prevented them and I don't think we would know that. The reason we don't know that is all we know is what the winds were like on the path that the plane flew. We have no way of knowing what the winds were had the plane been responding and tried to fly a slightly different path. I think there is a lot of elements to it that we just don't know. I would argue that you want to go back and start worrying about probabilities of preventing accidents and we will start talking about where the accidents would occur and why they might occur.

Terry Zweifel (Honeywell) - But then you run into the same problem. How can you prove the infrared would have prevented an accident? That is the difficulty that you can get into when you try that tack. How do you prove any of them would have prevented it?

Jim Evans (MIT) - My only point would be that if you are willing to acknowledge that the reactive systems don't really provide effective protection from a microburst on the runway when you are about to takeoff. It seems that we can argue from there.

Terry Zweifel (Honeywell) - Actually what you are saying isn't quite true, some of the systems do detect wind shears on takeoff.

Q: Sam Shirk (Continental Airlines) - Do they detect them effectively?

A: Terry Zweifel (Honeywell) - Well, define effectively?

Q: Sam Shirk (Continental Airlines) - Do they work?

A: Terry Zweifel (Honeywell) - Yes, they are certified to do it. I hope that the FAA would not certify a system that flat out did not work. I mean I think we can give them a lot more credit than that. We have run it on simulations of the accidents, including the one you had the picture of, and it did detect it.

Roland Bowles (NASA Langley) - I don't how many valid alerts we have got out there right now in the reactive system. But I know one thing, NASA 515 got more real confirmed microburst penetrations than you have probably got in the civil fleet right now. We know how our reactive box works. I have not seen any evidence of how the boxes that are already out there work.

Q: Terry Zweifel (Honeywell) - It sounds like you think I am pushing a cause here. I wasn't trying to say take your radars and go home, the reactive has solved the problem. That is not what I am trying to do. I am trying to say, suppose you get to the point where these technologies simply can not do it, you simply can not design, for example, a Doppler radar that can go down to minus 15 dBZ and detect a shear. What do you do then? You say well lets stop and go look at some other technology or how do you define where this is?

A: Roland Bowles (NASA Langley) - Well, I think there is very adequate precedence in the air worthiness flight standard side of FAA. We know there is a gust load that will not keep a wing on an airplane and we design to some maximum gust load, but there is one out there that is going to tear it apart.

Q: Terry Zweifel (Honeywell) - But the probability there is a lot higher than 10^{-5}. Either that or I am going to take the bus back to Phoenix. Obviously airplanes are not totally bullet proof. I was just bringing up the point of what do you do. I would hate to see everybody go down these different technology roads and it very well could be that no one of these technologies can detect all of these shears - dry microbursts, wet microburst all of that stuff. Then where are you and how do you define what is acceptable?

A: Roland Bowles (NASA Langley) - It is going to be settled in policy I think, with some degree of analysis to support that. As Jim pointed out there is no doubt some out there that will bite anybody regardless of how good your reactive system is. If you could save one accident per ten years would that be justifiable for forward look, even though its detection probability may be 0.8?

Terry Zweifel (Honeywell) - But then we can take that to the extreme. Lets assume it can only detect 0.05 and it saves one airplane. Where is the line?

Roland Bowles (NASA Langley) - I think the engineering integrity has to be good enough to prevent something like that getting through.

Terry Zweifel (Honeywell) - That is the point, the whole area seems to be fuzzy to me. I was just wondering how the FAA and the industry were addressing that or if any real thought had been given to it. You have got some pretty gung-ho programs going here and 1995 isn't that far away. It seems like some of these things have got to be settled fairly soon.

Kirk Baker (FAA) - I don't think we can answer that question right now. I haven't seen the vendors step up and say this is as good as my system can do. I don't know how the FAA can make a judgment until we know exactly what you can do. Right now the position that I have taken is to go to the regulations. It says in AC1309 an essential system to performance intended function must meet 10^{-5}. That is where I am at right now. I have not seen any of the vendors step up and say, well, I can only see a 2 dBZ dry microburst in a certain clutter environment. We are going to take the hard line.

Q: Unknown - You made the statement earlier on that the criteria was one of preventing accidents and things bumping into the ground. That is not necessarily the same as detecting a dry microburst because there are category dry microburst that may not be detected, but they also may not be hazardous? We as manufacturers and designers do have a set of design criteria. We depend upon Roland Bowles and his team to define a target. I think it is Byron and Lee that provided statistics on probabilities of various microbursts occurring. We look at designing air system to detect those. What is missing from those statistics is how many of those remaining are hazardous. We do need that information from the scientific community if we are going to answer the 10^{-5} question. Depending upon how you chose to define that. Is it the detection of the microburst that is important or is it prevention of the accident that is important?

A: Kirk Baker (FAA) - That is the obvious question. That is why I stated earlier that I think we need to sit down and come up with a logical and scientifically validated, as well as it can be, description of what "intended function" really means. That is what you are trying to describe. Is it to detect any microburst or wind shear phenomenon or is it to prevent accidents? We are going to have to sit down and develop that, and I am not going to give you the answer right now because I do not know what it is.

Roland Bowles (NASA Langley) - I would like to challenge the other side of the industry, Joe and Boeing and all of you guys, lets build a reactive system for 10^{-5} that we can slip into some of this technology, and all march forward. Lets hybridize! That gets a lot of people off the hook doesn't it.

Kirk Baker (FAA) - Sure does and it makes my job easier.