19930104/2

Session IV. Airborne Doppler Radar / Industry N93-19601

RDR-4B Doppler Weather Radar With Forward Looking Wind Shear Detection Capability

Steven Grasley, Allied-Signal Aerospace

RDR-4B Doppler Weather Radar With Forward Looking Windshear Detection Capability

Bendix/King ATAD
Status Of Development Activity

Steven S. Grasley
Sr. Radar Product Manager

Allied-Signal Aerospace Company
Bendix/King Air Transport Avionics Division

Allied Signal

Bendix/King ATAD Position

Committed to the development of airborne weather radar with Forward-Looking Windshear Detection/Avoidance capability

Logical Extension For Current Airborne Weather Radar

RDR-4A Technical Baseline

- More Than 4,500 Currently Delivered
- Latest Generation
- Solid State Transmitter
- Fully Coherent
- Doppler Turbulence Detection Capability

Can Be Modified For Windshear Detection Capability

Allied-Signal Aerospace Company
Bendix/King Air Transport Avionics Division

Allied Signal

RTA-4A Characteristics

Transmitter Peak Power	125 Watts (nominal)
Pulse Width	6 and 18 μsecs (alternating)
Pulse Repetition Rate	380 Hz Weather Mode 1600 Hz Doppler Mode
Maximum Range	320 nmiles
Operating Mode	Pulsed Coherent
Frequency	9.345 GHz
Noise Figure	5 dB Minimum
Dynamic Range	50 dB Minimum
Gain Control	60 dB Minimum
Weight	24.5 lbs

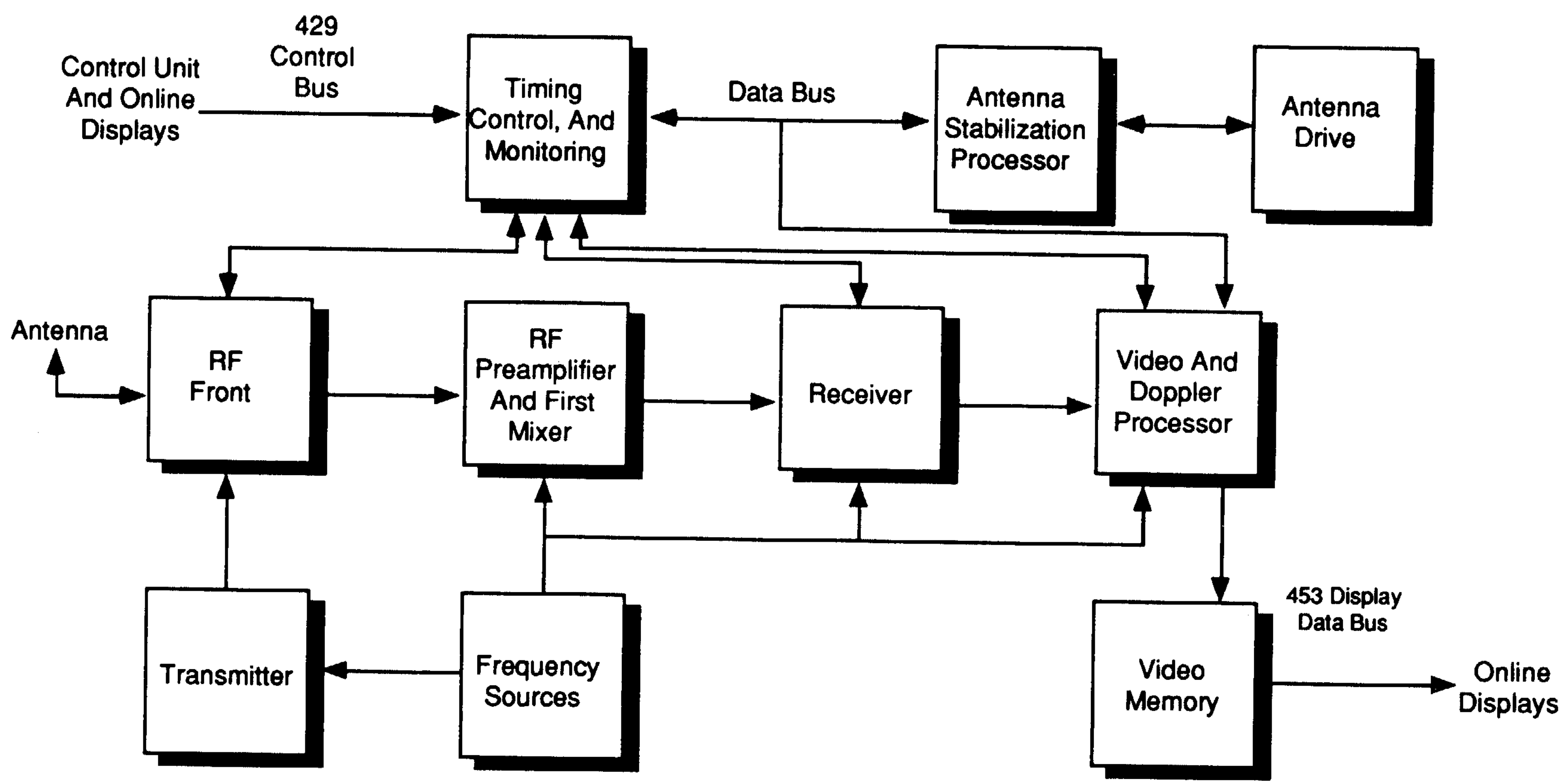
RDR-4 Antenna Characteristics

Radiator	**30" Flat Plate (REA-4B)** **24" Flat Plate (REA-4A)**	
Gain	**35 dB with REA-4B** **33 dB with REA-4A**	
Beam Width	**3.3° REA-4B** **3.8° REA-4A**	
Frequency	**9.345 GHz ± 30 MHz**	
Stabilization Type	**Line-Of-Sight**	
Stabilization Limits	**DAA-4A**	**DAA-4B**
Tilt	± 15°	± 15°
Pitch	± 25°	± 15°
Combined Tilt/Pitch/Roll	±45°	±35°
Azimuth Scan	**180°**	**160°**
Stabilization Accuracy	**± 0.25° Static / ± 0.5° Dynamic**	
Weight	**DAA-4A/REA-4A:**	**28.5 lbs**
	DAA-4A/REA-4B:	**26.7 lbs**
	DAA-4B/REA-4A:	**12.7 lbs**

Modifications of RDR-4A to RDR-4B

- **Receiver/Transmitter**
  - Add Windshear Detection Hardware and Software
  - Add Windshear Mode Control Software
  - Add Windshear Data To The Output Buses
- **Indicator**
  - Add Windshear Data Display Capability
  - Add Windshear Mode Selection (May Also Apply To Control Panel)
- **Antenna**
  - No Modifications Required
- **Aircraft**
  - No Mechanical Modifications
  - Some Wiring Changes Might Be Required For Interfaces
  - No Radome Changes Required

RDR-4A Functional Block Diagram

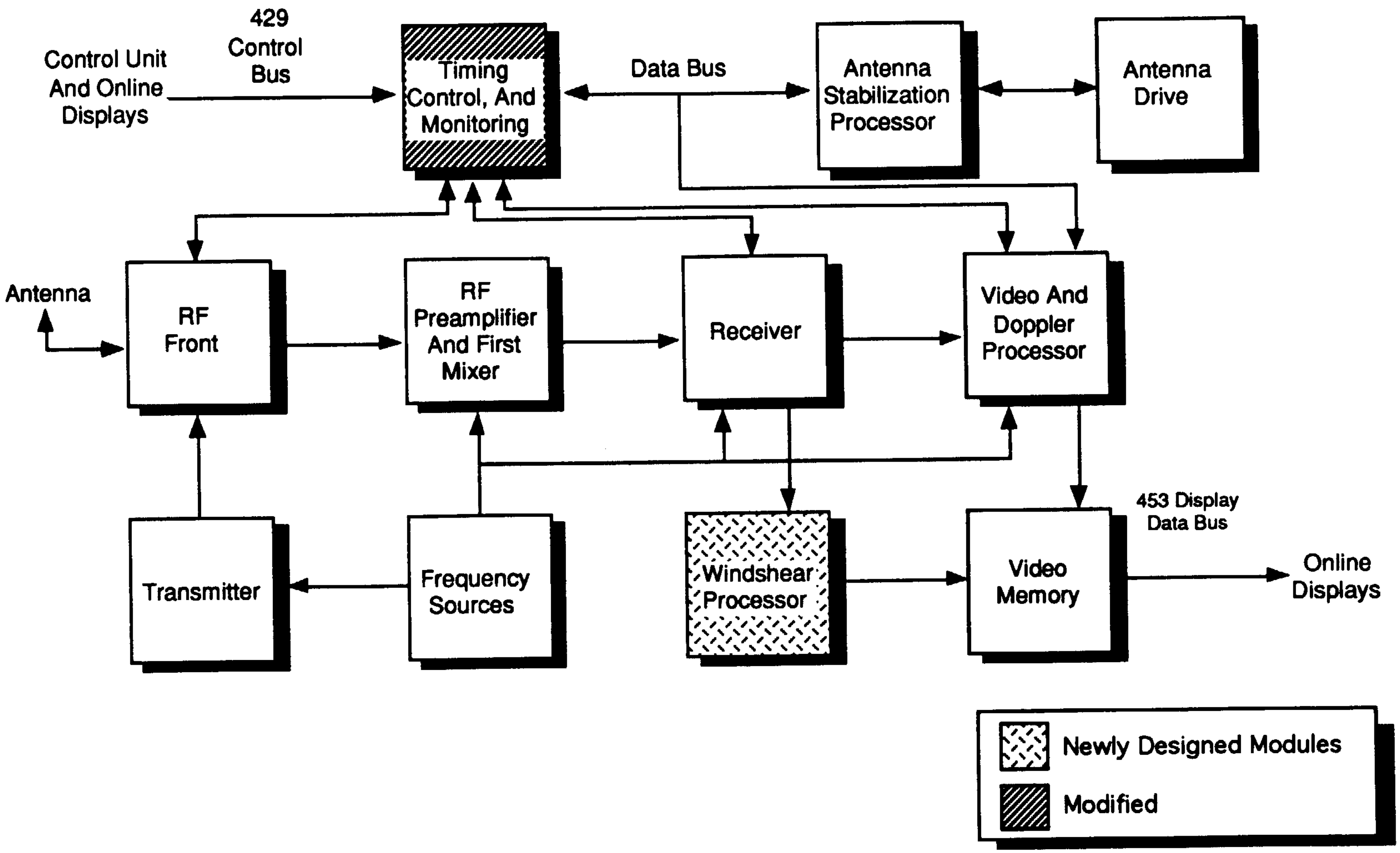


Allied-Signal Aerospace Company

Bendix/King Air Transport Avionics Division

AlliedSignal

RDR-4B Functional Block Diagram



Allied-Signal Aerospace Company

Bendix/King Air Transport Avionics Division

AlliedSignal

RDR-4B Characteristics

	WEATHER AND MAP MODE	TURBULENCE DETECTION	WINDSHEAR DETECTION
TRANSMITTER PEAK POWER	125 Watts (Nominal)		
PULSE WIDTH	6 and 18 μsec Alternating	6 μsec	2 μsec
PRF	380 Hz	1600 Hz	6000 Hz
MAXIMUM RANGE	320 nmi	40 nmi	10 nmi
OPERATING MODE	Pulsed Coherent		
FREQUENCY	9345 ± 2 MHz		
SYSTEM NOISE FIGURE	5 dB		
ANTENNA SCAN	180°		±40°
ANTENNA GAIN	35 dB		
ANTENNA BEAMWIDTH	3.3° Elevation 3.4° Azimuth		
TILT CONTROL	±15° Manual		Automatic

Allied-Signal Aerospace Company
Bendix/King Air Transport Avionics Division

Development/Test Plan

■ Prototype Completed	1991
■ Proof-of-Concept Flight Test	1992
■ Certification Testing	1992-1993
■ Production	1993

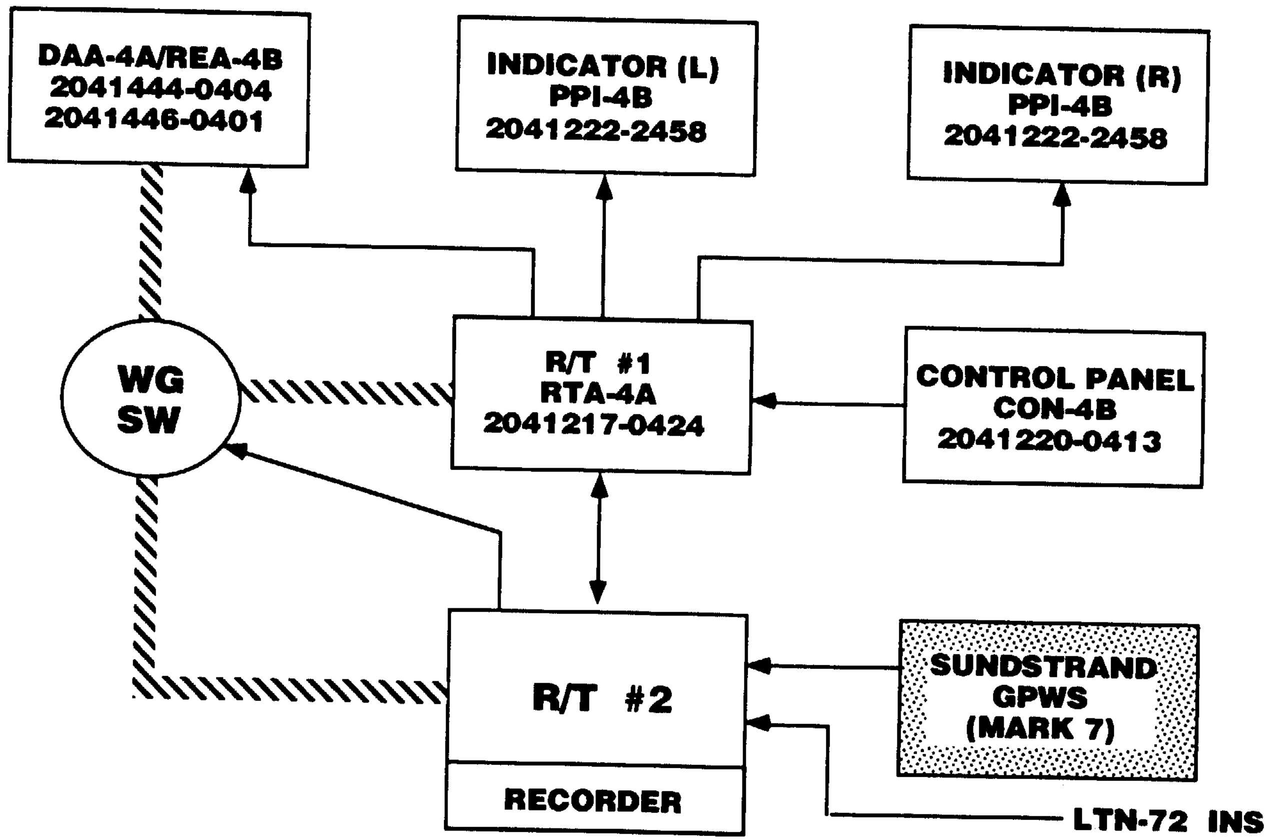
CV-580 Testing Capability

- RDR-4B Prototype Installed
- Real-time, Reconfigurable Computer Displays
- High Speed Data Recording
- TDWR Data Link To Correlate With TDWR and NASA Testing (Planned)

CV-580 Test Results

- **Flight Testing To Date**
  - Clutter Cancellation Techniques Verified
  - Wind Velocity Calculation Techniques Verified
  - Several Microbursts Recorded - Ft. Lauderdale Area
- **Continuing Testing 1992-93**
  - Further Refinement of Processing Techniques
  - Verification of "Dry" Microburst Detection Capability
  - Correlation of Data With Ground Based Radars At Denver & Orlando
  - Correlation of Data With NASA B737 Activity
  - Certification Proof-of-Concept Flight Tests
  - Performance Verification of Production Configuration

Continental A300 Test Configuration



Allied-Signal Aerospace Company
Bendix/King Air Transport Avionics Division

AlliedSignal

Continental Data Recording Program Operational Considerations

- **Recording Is Fully Automatic**
- **Windshear R/T Is Always Powered**
- **Almost Transparent To Flight Crews**
  - Weather Updates On One Sweep Instead Of The Usual Two
  - No Crew Intervention Required
- **Data Recorder Is Replaced Once A Week**

Continental A300 Test Results

- Data Being Gathered On Take-Off/Landing During Revenue Operation
- Data Analysis On-Going
- No Windshear Events Yet Identified
- Data Gathering To Continue Through 1992

Display Considerations

- **Bendix/King ATAD Proposal:**
  - Hazard Factors In Colors
  - Aural Alert and Visual Alert With Flashing Symbol On PPI Or EFIS
- **FAA / SAE / Airlines Proposal:**
  - Symbolic Display Super Imposed On Weather
  - Alert With Chime And Yellow Light
  - Warning With Audio And Red Light

Key Goals: Simple, Useful, Minimum Mods/Cost

General Development Accomplishments

- System Design Complete
- Prototype Built & Flight Tested
- Production Design In Process
- Certification Concept Defined

Remaining Issues
(From Items Identified At Third Conference)

- **Technical:**
  - Establishment Of Hazard Thresholds
  - Definition Of Display Characteristics
- **Operational:**
  - Means Of Selecting Windshear Mode
  - Displays
  - Aural Alerts
  - Interaction With Reactive Windshear System

RDR-4B Doppler Weather Radar
With Forward Looking Wind Shear Detection Capability
Questions and Answers

Q: Roland Bowles (NASA Langley) - Do you feel that you understand and have a clear path in mind for certification as per the industry government activities on the interim standards document and other certification related questions? Secondly, do you plan in the next six months to move forward with the certification program?

A: Steve Grasley (Allied-Signal) - I think we understand what has been done to date. It certainly is not absolutely clear how certification will ultimately be accomplished. There is still a number of issues that remain open. The MOPS is being firmed up and that is one of the critical things that we are going to need. It is going to take another meeting or two I believe. John Wright is kind of leading up that activity and he shaking his head in agreement. It is going to take a little bit longer before that is done. As far as moving forward within the next six months to do some certification, it is quite dependent on those issues. There is also some of the exempted airlines who are quite interested in moving forward. We'll support them if we are in a position to do that. If they want to move forward and get going with it then we will certainly support whatever they would like in that area.

Q: Kirk Baker (FAA) - You mentioned in your talk that you used some inputs for antenna tilt management, could you elaborate on what those are?

A: Steve Grasley (Allied-Signal) - The key issue is to steer the antenna beam in the outflow areas so we can get the measurements that we need and limit the amount of ground clutter that we get through the main beam. The inputs are defined by the new and evolving 708-A interface specification, radio altimeter is really the key one. We know how high we are above the ground and approximately where we want to be looking, in terms of tilt angle, so we can steer the beam into that region. As I mentioned, one scan did weather and one scan would do wind shear processing. You are looking at two different types of phenomenon in that case. You want to see the weather in front of you as well as the wind shears. The idea being that we could steer the beam during weather based upon what the pilot has selected and the weather of interest to the pilot, but then to get back down and do the scan in the wind shear mode right where we want it, through the region of interest in the microburst event. The radio altimeter data is primarily used to know our height above the ground, so we can steer the beam properly.

Q: Bruce Steakley (Lockheed) - What is the residual sensitivity of your system after your clutter cancellation techniques?

A: Steve Grasley (Allied-Signal) - I do not know the numbers right off the top of my head. We can certainly give you a little more background on that a little bit later. Certainly, we are not seeing things drastically different from what was seen in the NASA flight test in terms of sensitivity. It is very similar. It was encouraging.

Q: Ernie Baxa (Clemson University) - Can you say anything about the clutter rejection algorithms for the wind shear detection mode?

A: Steve Grasley (Allied-Signal) - We have verified that the way that we are doing it is working. I am probably not at liberty in this particular forum to talk about specifics of that, we might be able to do that in another way. So far we are satisfied with the way our clutter rejection processing is working and we have good evidence to show that it does a good job. We can see the wind shears and get rid of the clutter data. I am sure that is not really the answer you were looking for, but it will have to do for today.

Q: Bob McMillan (GTRI) - You mentioned earlier in your talk that the Bendix radar can detect turbulence. Given the tenuous nature of back scatter from clear air atmospheric inhomogenities, what is the reliability of detecting turbulence at useful ranges?

A: Steve Grasley (Allied-Signal) - We certainly make no claim to be able to detect clear air turbulence. You need something to see and something to bounce energy off of. Our objective in turbulence detection is to detect it in weather conditions. We are not attacking the clear air turbulence problem at this time, not from a radar perspective anyway.

Q: Pete Saraceni (FAA) - How well do the you predict the 4B radar will see a dry microburst?

A: Steve Grasley (Allied-Signal) - I think we pretty much agree with what the NASA folks have said about the capability of detecting a dry microburst, as well as what the Collins and Westinghouse folks have said. You are basically into physics and the technology available today Somewhere in the zero, down in the fairly low dBZ range we can get useful detection at reasonable detection ranges. What exactly can we see and how far away can we see it? That is to be determined this year. That is going to be a major objective of our activity and testing this summer, this storm season. We can see something that is currently classified as dry, but exactly how much? That is what we will find out.

Q: Dave Hinton (NASA Langley) - You suggested that pilots wanted to have the option of manually selecting the wind shear mode above 2500 feet. Do you believe that there is any operation requirement for wind shear avoidance above 2500 feet? Is there any safety hazard from wind shear at those altitudes?

A: Steve Grasley (Allied-Signal) - No, we don't think there is any issue of hazard at those kind of altitudes. When you start getting into shear type conditions above those things people tend to say that is turbulence of some sort more than wind shear. I did suggest that pilots wanted the option of manually selecting it. You get a wide range of inputs and desires on capabilities when you start talking to pilots. They want all kinds of neat stuff. Are we going to end up providing that option to be able to select wind shear above 2500 feet? No, that is not the intention at this point and time. We have just gotten inputs that said it would be kind of neat to look.

Q: Dave Hinton (NASA Langley) - Do you believe that Doppler technology can support wind shear detection at those altitudes given that downdraft estimation may be unreliable above 2500 feet and there may be little or no microburst outflow for the Doppler system to detect.

A: Steve Grasley (Allied-Signal) - That is true. We don't necessarily believe the radar Doppler technology can really provide you any benefit at that altitude. As I mentioned earlier, we do not believe there is really a wind shear hazard at those kind of altitudes.