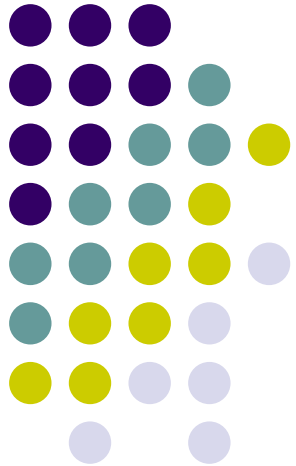
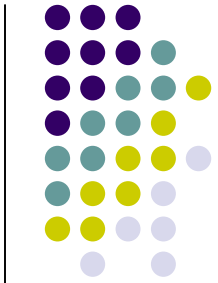
Have FAA-Industry Windshear Investments Been Effective?: Some Observations



David Chin, Federal Aviation Administration
Linda Lau, Cornell University

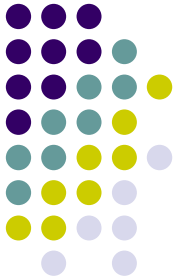
January 2004

Overview



- Study Objectives
- Windshear (W/S) History
  - 1982 – 2001: Total Accidents, Weather and Wind Shear
  - Wind Shear Accident Characteristics
- What Preventative Measures are Out There?
  - FAA and Industry Initiatives
  - Implementation Schedules
- Pre and Post Implementation Accident Rates and Trends
- Concluding Observations
- Background
  - References
  - Sources and Databases

Study Objectives



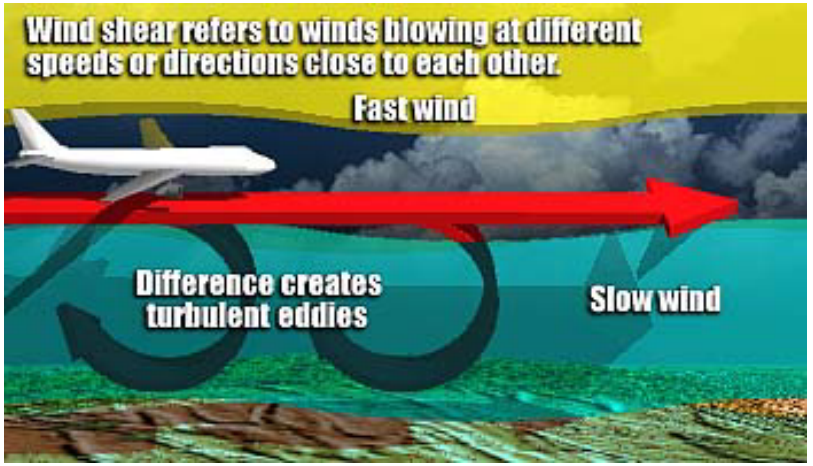
- Evaluate Mix of Ground-based and Airborne Investments
  - Did we make the right investments?
  - What are the post-implementation results?
    - Accident rates
    - By User Class

Windshear History

Accident Data Analysis: 1982 - 2001

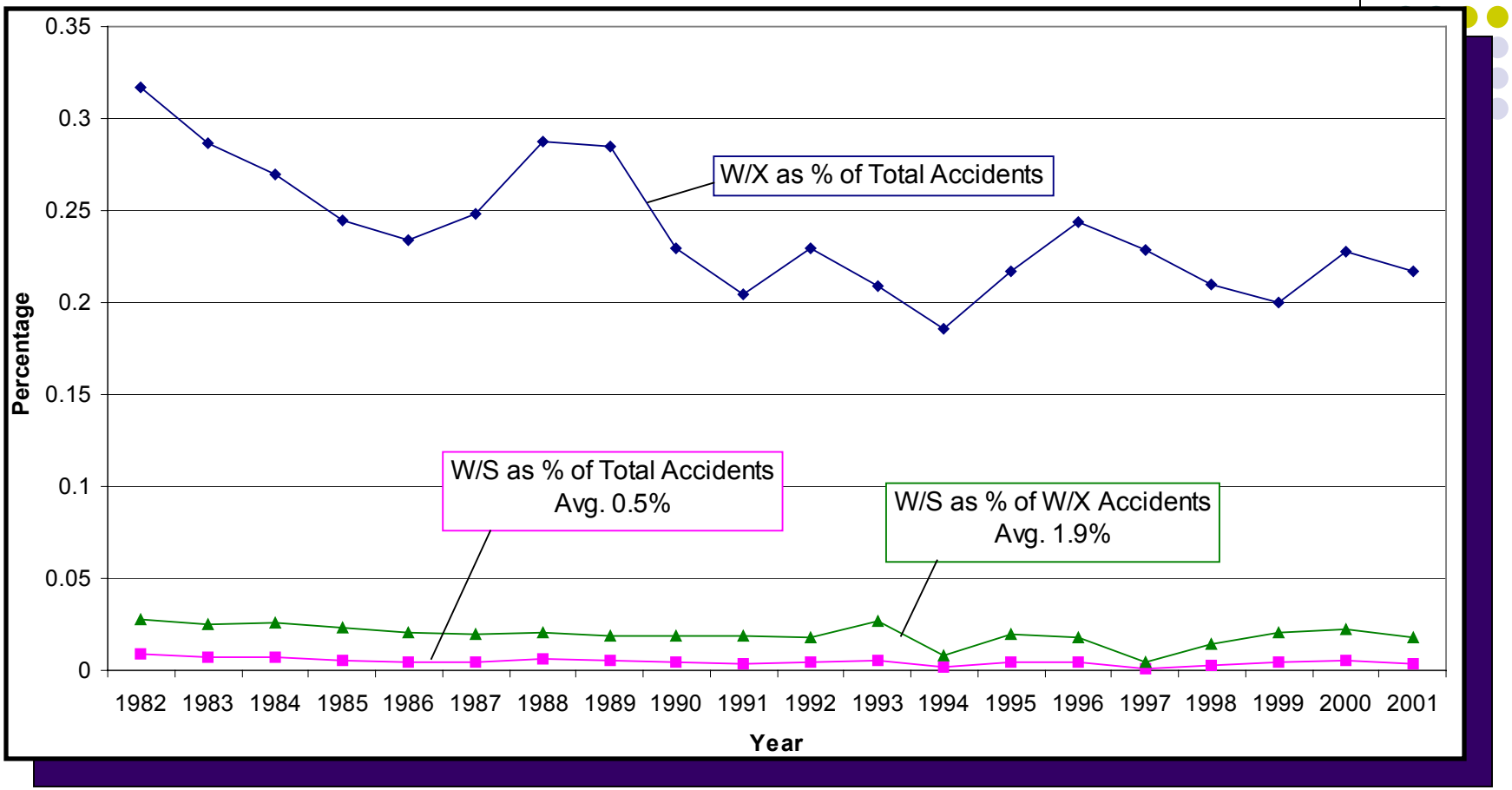
What is Windshear?

- Windshear refers to a rapid change in wind speed or direction, or both, over a short distance. These changes create eddies, or swirls of air, that cause turbulence.
- Windshear can be both vertical and horizontal.
- Vertical windshear is caused by the winds that blast down from thunderstorms may cause severe damage as aircrafts land.
- Windshear and microbursts are usually related to convective weather.



*The USA TODAY Weather Book *by Jack Williams*

Comparison: Total Accidents, W/X and W/S



From 1982 to 2001

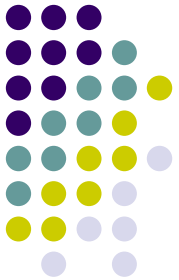
- Out of 47,622 aircraft accidents, weather (W/X) was the contributing factor to 22.4% (11,595 accidents).
  - Windshear (W/S) accounts for only 0.5% of all reported accidents

Wind Shear Accidents 1982-2001

	NAS	W/X	W/S
Part 121 – Air Carriers			
Accidents	676	269	10
Fatalities	3051 *(4.5)*	1745 *(6.5)*	**279** *(28.0)*
Part 135 – Air Taxi/Commuter			
Accidents	2394	1281	**14**
Fatalities	1714 *(0.7)*	1312 *(1.0)*	**15** *(1.1)*
Part 91 – General Aviation			
Accidents	43930	16095	198
Fatalities	16465 *(0.4)*	11202 *(0.7)*	**53** *(0.3)*

(Number in parentheses denotes the average fatalities per accident)

Wind Shear Fatalities/Injuries 1982-2001

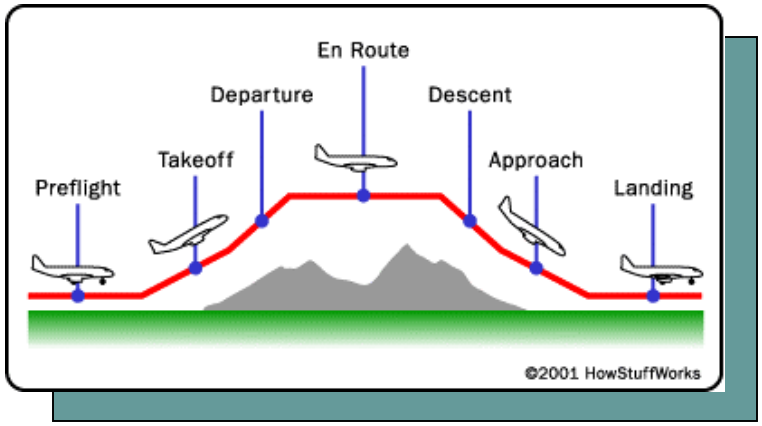


- 347 Fatalities & 89 Serious Injuries
- 1154 Non Fatal Injuries (Serious, Minor or No Injuries)

Part	Fatal	Serious	Minor or None
121	279	23	674
135	15	6	38
91	53	60	353

Phase of Flight

- For Air Carriers, more W/S accidents during Landing to Takeoff phase
- For GA and AT, more accidents during Approach to Landing phase
- Approx. 50% of W/S related accidents occurred on the airport.



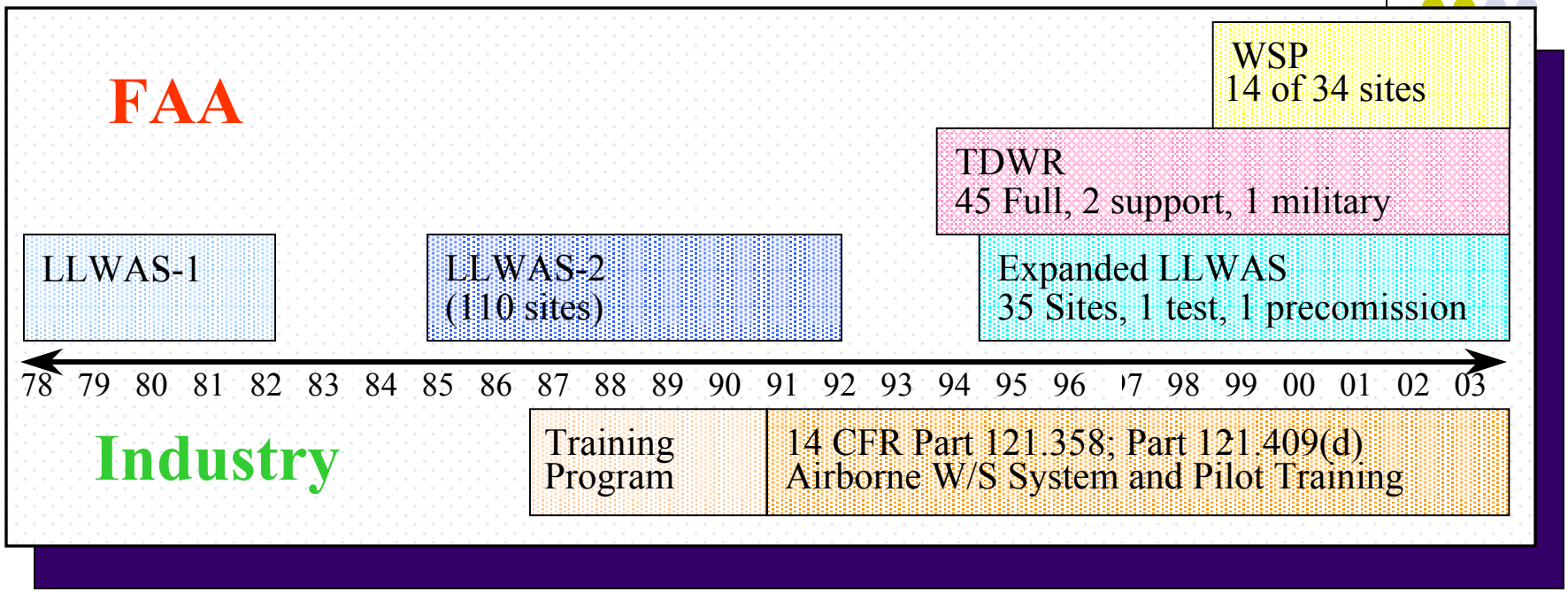
Part	Takeoff	Approach	Landing	Other	Total
121	3	1	4	2	**10**
135	1	5	4	4	**14**
91	26	40	80	52	**198**

What Preventive Measures are Out There?

Investments Initiated by FAA and Industry

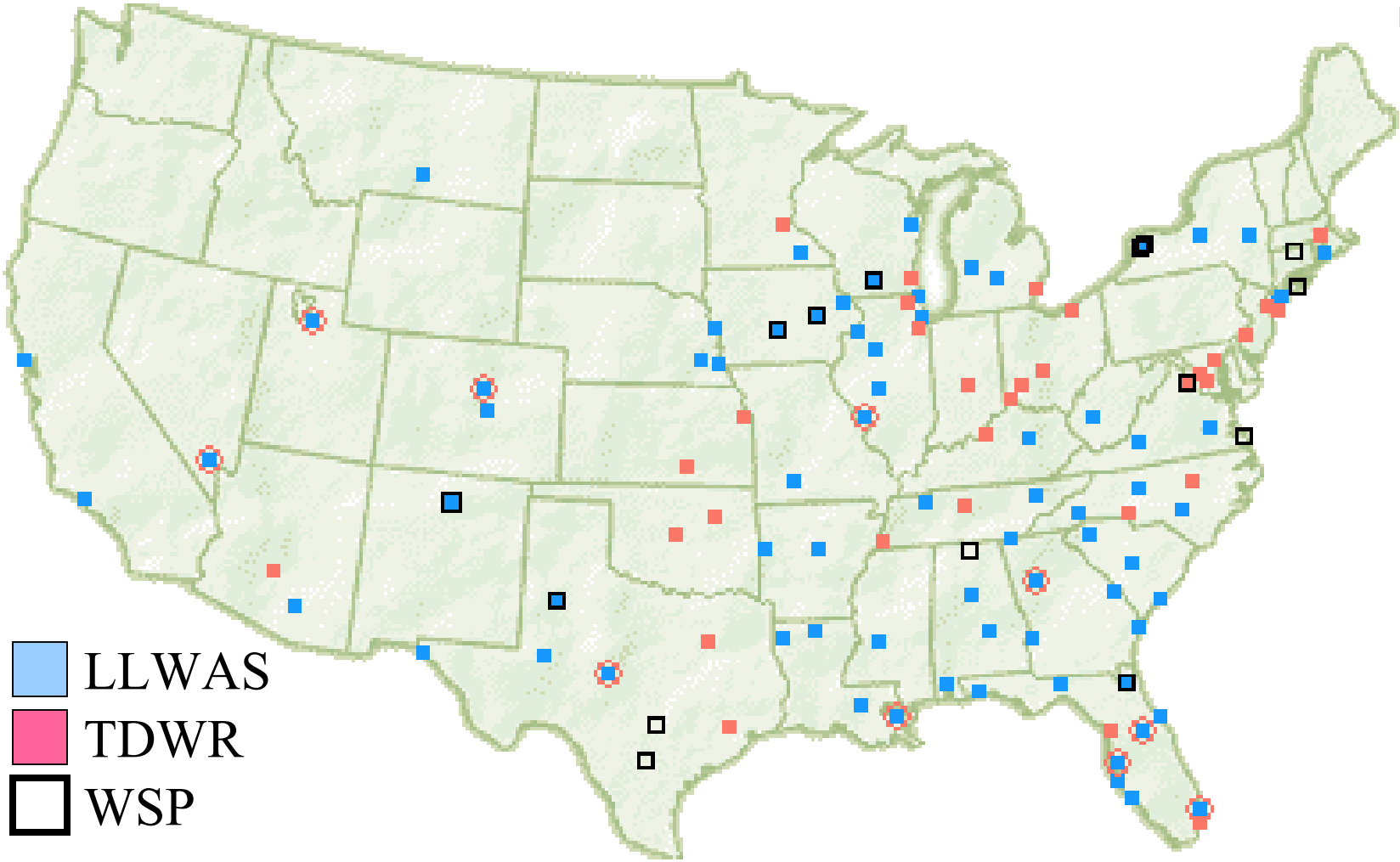
- FAA Ground-Based Systems
  - Low Level Windshear Alert Systems (LLWAS)
  - Terminal Doppler Weather Radar (TDWR)
  - Weather System Processor (WSP)
- Training Programs
  - 1987 - WSTA spearheaded by BOEING and UAL, eventually funded by FAA
- Regulatory Airborne Detection System
  - 1991 – 14 CFR Part 121.358 – Low-Altitude Windshear System Equipment Requirements. (Title 14 Code of Federal Regulations Part 121.358)
  - Affects Part 121 Air Carriers.

Systems Commissioned



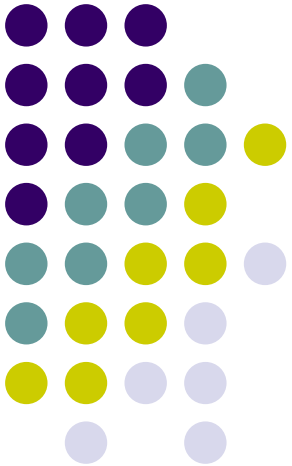
LLWAS-1: 1-6 Wind Sensors
LLWAS-2: Std. 6 Sensor Network w/ enhanced algorithm for less false alarms
Expanded LLWAS: 11-32 Sensor Network w/ improved detection capabilities
TDWR: Terminal Doppler Weather Radar
WSP: Enhanced Weather capabilities for ASR-9 Radar
Training Program: Avoidance and Recovery techniques; 4 volumes
Part 121.358: Mandatory Airborne W/S alert/detect systems for part 121

Site Location of W/S Systems



Accident Rates and Trends

Empirical Observations of W/S Effectiveness 1982-2001



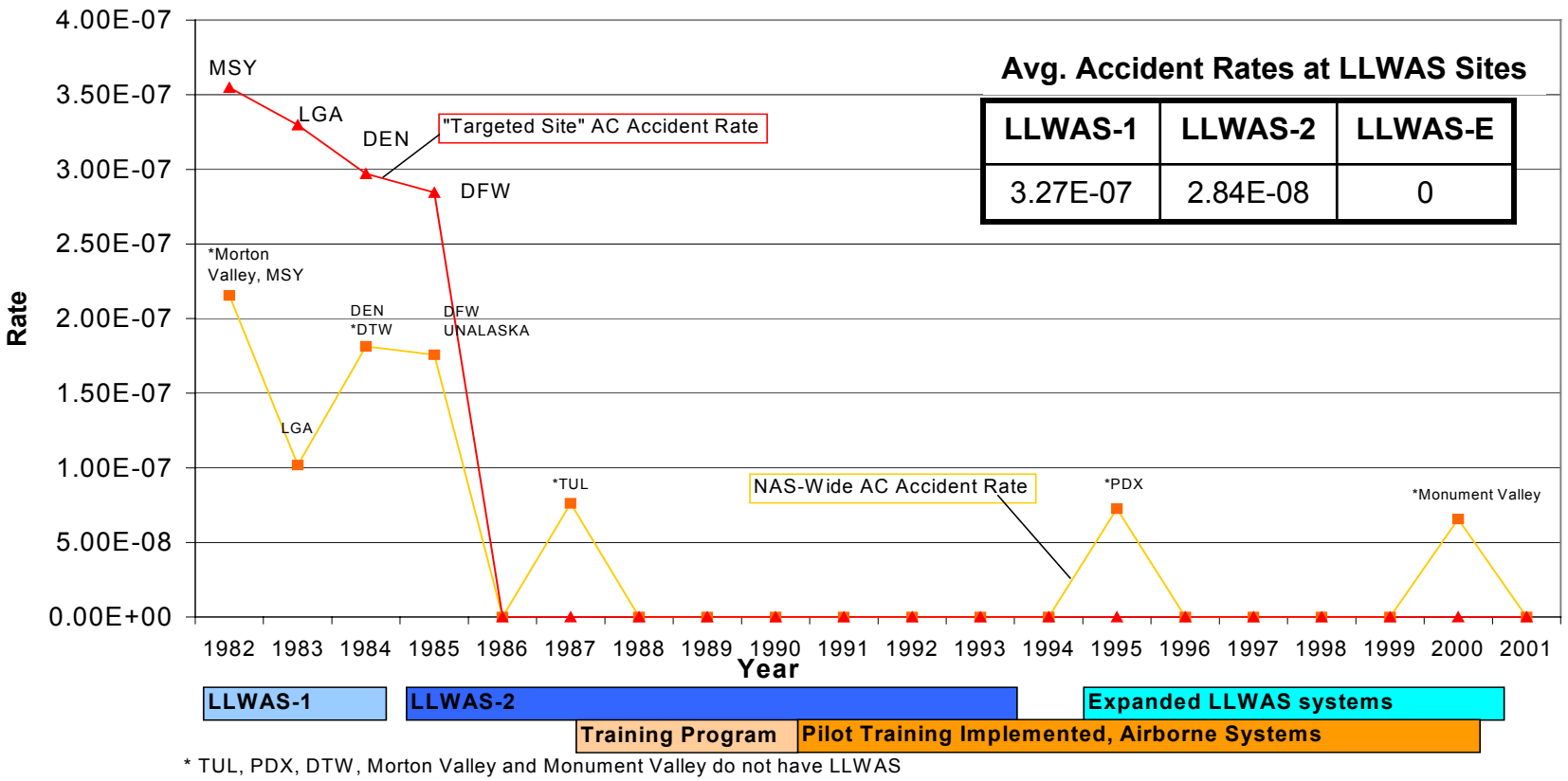
Before and After – Accident Rates

Before After Positive Trend

W/S Initiative	Part 121	Part 135	Part 91	NAS Wide	Years
LLWAS-2	2.84E-08 / 3.27E-07	6.78E-08 / 0	3.74E-07 / 3.19E-07	1.59E-07 / 2.71E-07	1985-1994 / 1982-1984
LLWAS-E	0 / 2.84E-08	0 / 6.78E-08	1.72E-07 / 3.74E-07	5.03E-08 / 1.59E-07	1995-2001 / 1985-1994
TDWR	0 / 6.14E-08	0 / 3.24E-8	0 / 7.91E-08	7.38E-09 / 5.82E-08	1994-2001 / 1982-1993
WSP	0 / 0	0 / 1.20E-7	0 / 2.09E-07	0 / 9.10E-08	1999-2001 / 1982-1998
Training Program	0 / 2.48E-07	2.75E-07 / 5.76E-07	7.60E-08 / 1.65E-07	3.85E-07 / 7.62E-07	1987-1990 / 1982-1986
14 CFR Part 121.358	3.77E-08 / 0	2.33E-08 / 2.75E-07	5.79E-08 / 7.60E-08	2.41E-07 / 3.85E-07	1991-2001 / 1987-1990

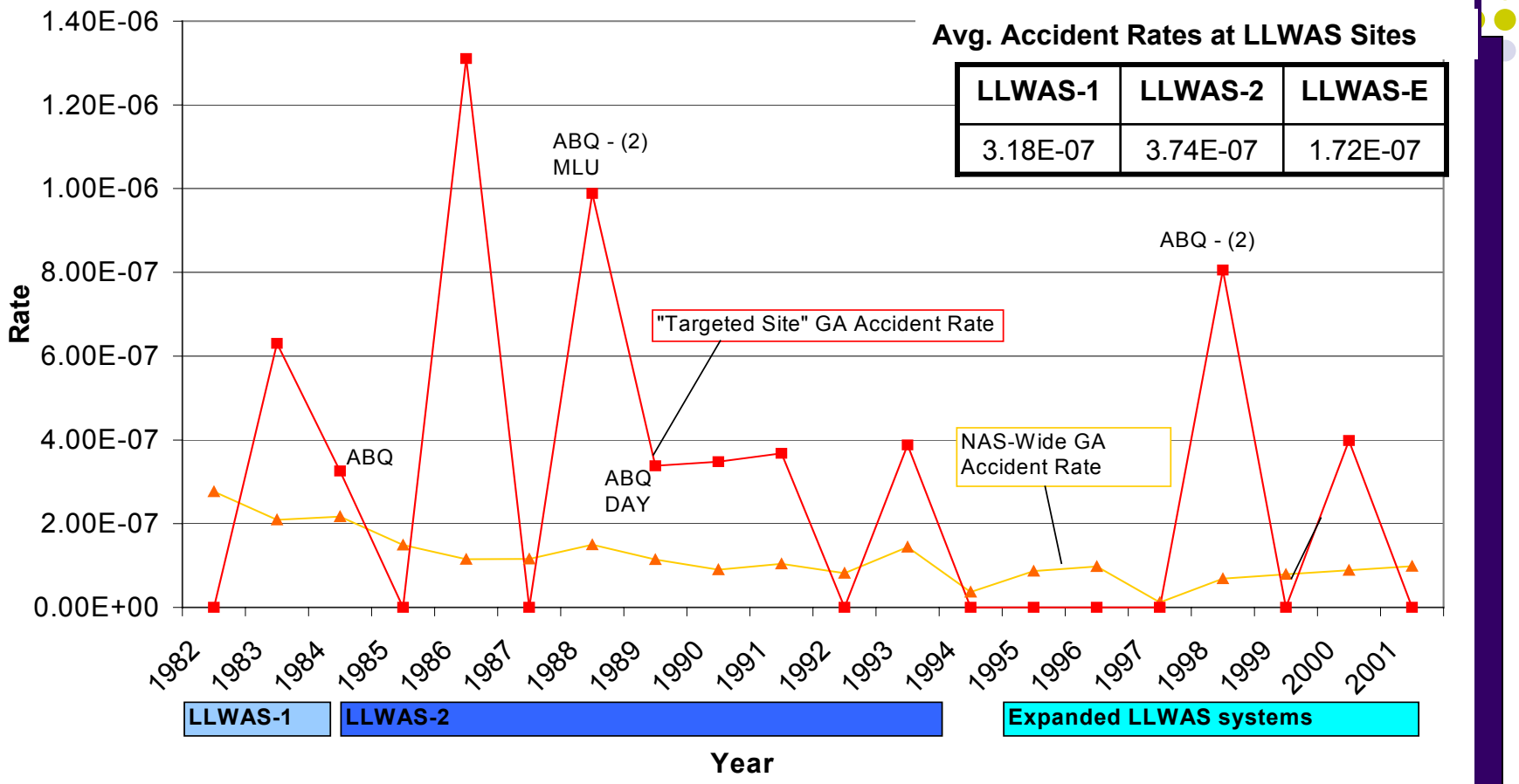
By FAA and Industry Initiatives

LLWAS Locations – Air Carrier Accident Rates



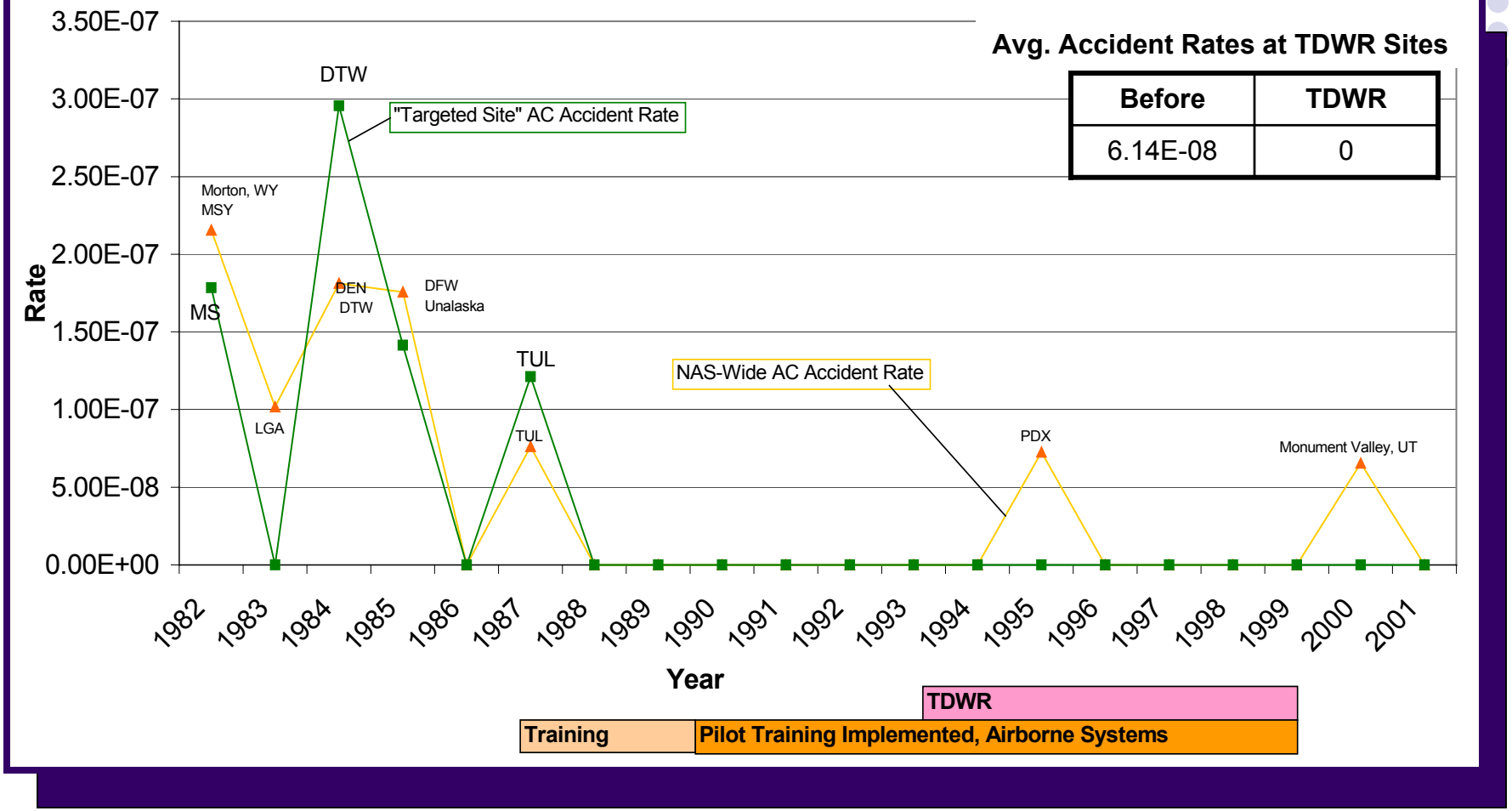
- LLWAS implemented at high risk sites
- Since LLWAS deployment (1985+), there have been no accidents at LLWAS sites

LLWAS Locations – GA Accident Rates



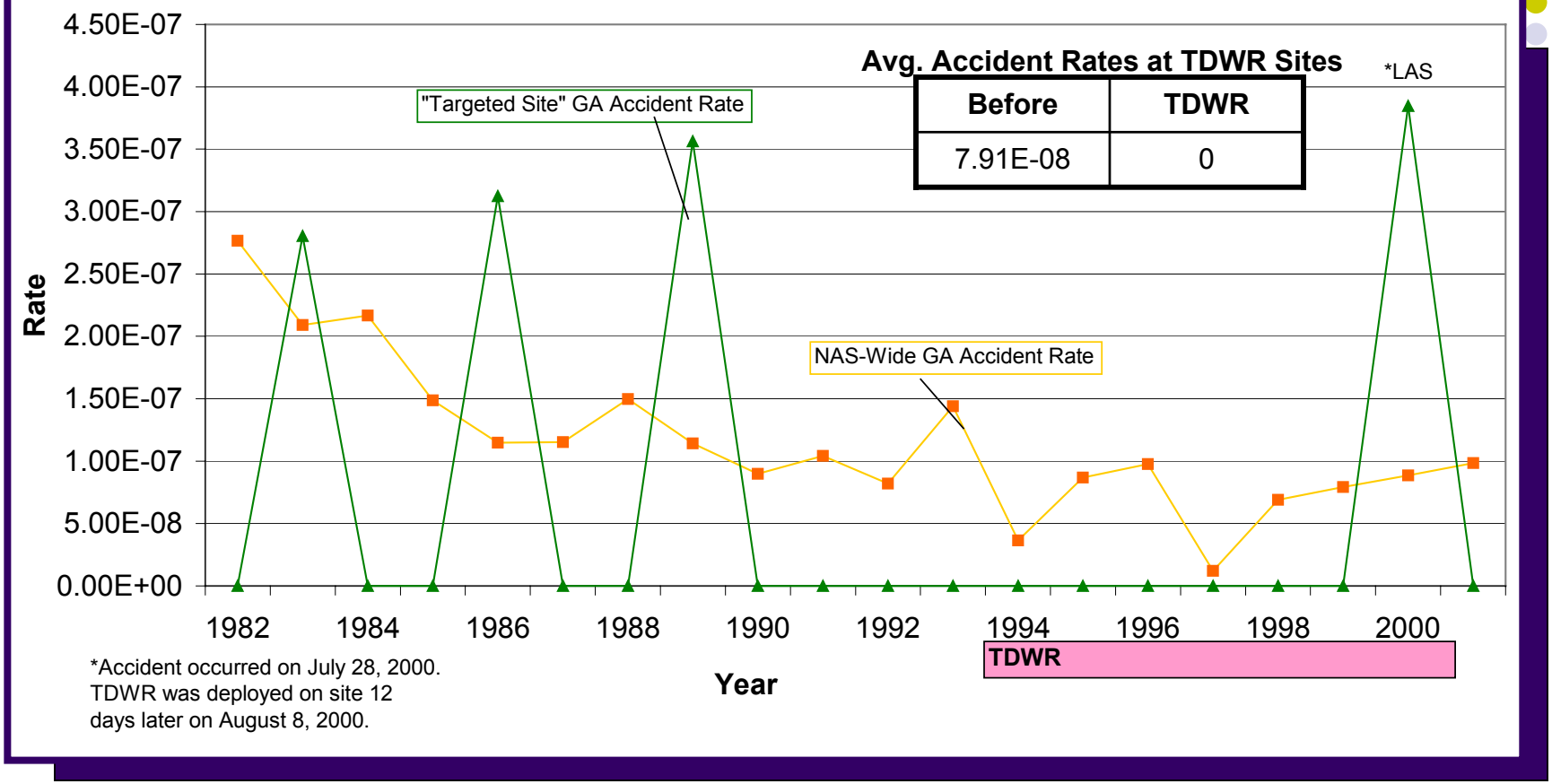
- Slight improvements in accident prevention with LLWAS enhancements
- Many LLWAS systems are now converted to sites with WSP (ie. ABQ)

TDWR Locations – Air Carrier Accident Rates



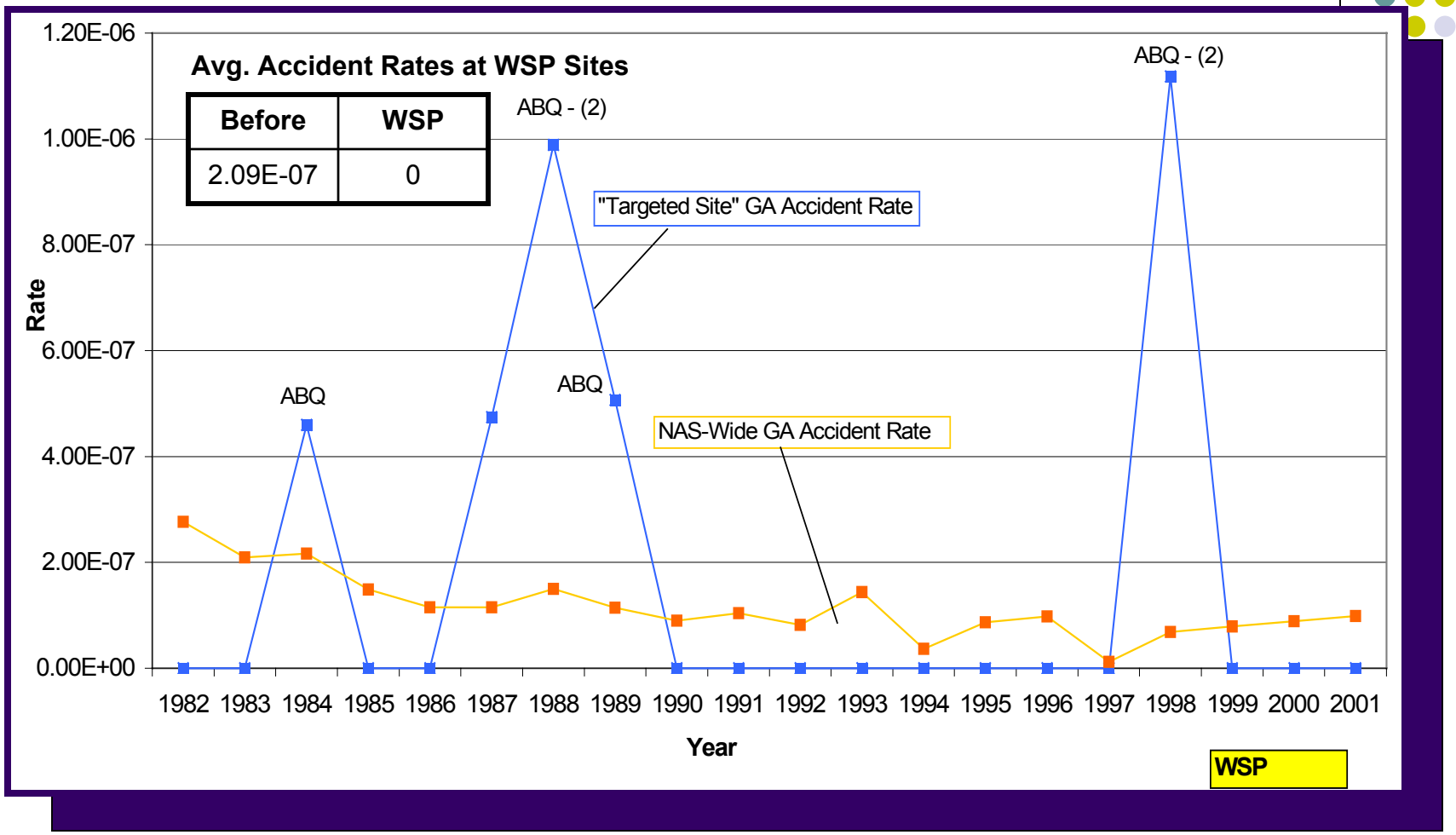
- TDWR implemented at high risk sites
- Since TDWR deployment (1994+), there have been no accidents at TDWR Sites
- Trend may also be affected by Training Program/Airborne Systems

TDWR Locations – GA Accident Rates



- TDWR implemented at high risk sites
- Since TDWR deployment (1994+), there have been no accidents at TDWR sites

WSP Locations – GA Accident Rates



- WSP implemented at high risk sites (ie. ABQ – 6 GA accidents)

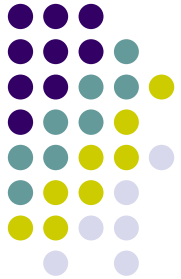
Before and After – Accident Rates

Before After Positive Trend

W/S Initiative	Part 121	Part 135	Part 91	NAS Wide	Years
LLWAS-2	2.84E-08 / 3.27E-07	6.78E-08 / 0	3.74E-07 / 3.19E-07	1.59E-07 / 2.71E-07	1985-1994 / 1982-1984
Training Program	0 / 2.48E-07	2.75E-07 / 5.76E-07	7.60E-08 / 1.65E-07	3.85E-07 / 7.62E-07	1987-1990 / 1982-1986
14 CFR Part 121.358	3.77E-08 / 0	2.33E-08 / 2.75E-07	5.79E-08 / 7.60E-08	2.41E-07 / 3.85E-07	1991-2001 / 1987-1990
TDWR	0 / 6.14E-08	0 / 3.24E-8	0 / 7.91E-08	7.38E-09 / 5.82E-08	1994-2001 / 1982-1993
LLWAS-E	0 / 2.84E-08	0 / 6.78E-08	1.72E-07 / 3.74E-07	5.03E-08 / 1.59E-07	1995-2001 / 1985-1994
WSP	0 / 0	0 / 1.20E-7	0 / 2.09E-07	0 / 9.10E-08	1999-2001 / 1982-1998

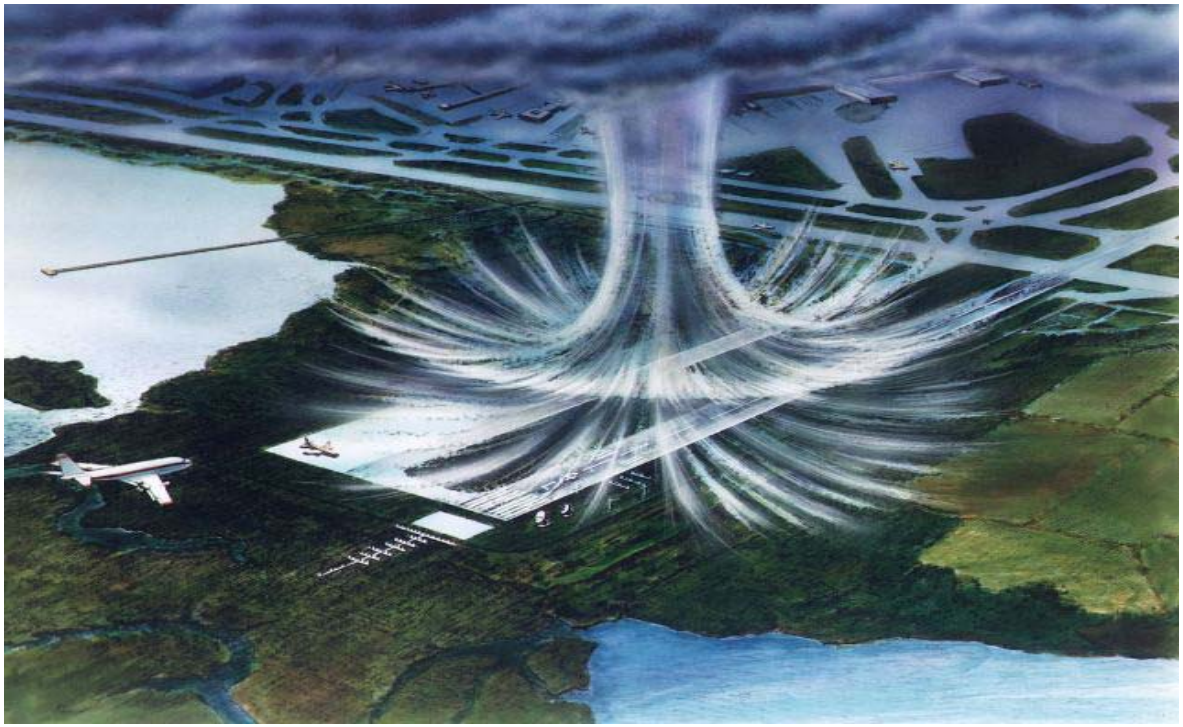
By Phase of Implementation

Summary



Observations	Conclusions
For Windshear Sites	
• Windshear systems are deployed at high risk sites	⇨ Invested in the right sites
• GA accident rate remains relatively unchanged	⇨ GA Users not benefiting from Windshear initiatives compared to AC & AT
• At LLWAS-E, TDWR and WSP sites, no Part 121 and 135 accidents have occurred since deployment.	⇨ Windshear systems have been effective
For NAS-wide	
• General accident trend for Part 121 and Part 135 is decreasing	⇨ Mix of Investment strategies mitigate Windshear risk.
• Accident rate is lower after the Training program and airborne systems were implemented	⇨ Training program and avionics have been effective at non-ground-based Windshear sites

Background



References

- 1999: Low Level Wind Shear Alert System Study (RAP, NCAR, UCAR).
- 1998: NTSB Weather Related Accident Study. (NASDAC)
- 1996: Low Altitude Windshear: A 15-Year Retrospective. (John McCarthy)
- 1996: Performance Metrics for NAS 2.0 Architecture Safety Analysis: Wind Shear Related Accidents & Incidents
- 1992: Integrated Wind Shear Systems Cost-Benefit and Deployment Study. (Martin Marietta Air Traffic Systems)

Sources and Databases

- NTSB - National Transportation Safety Board Accident Database (1982-2002)
  - 47,622 Accident Reports - **239** W/S related
- TAF - Terminal Area Forecasts (1976-2001)
  - Traffic operations for 3508 Airports (for NAS)
  - 447 Airports with Air Carrier Operations
- FSEP - Facility Service and Equipment Profile
  - Commissioning dates for:
    - Low level Windshear Alert System (LLWAS)
    - Terminal Doppler Weather Radar (TDWR)
    - Weather System Processor (WSP)