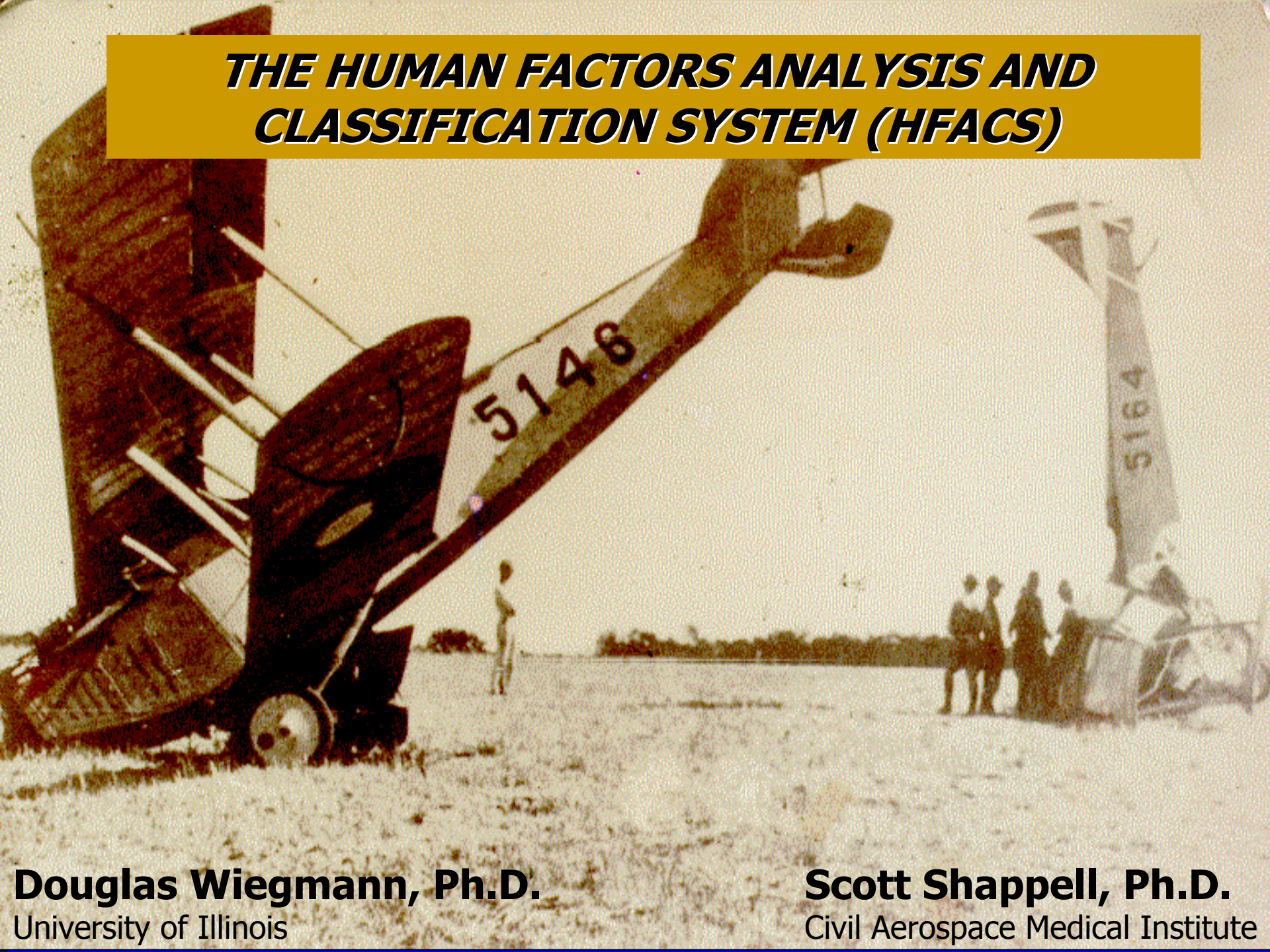
THE HUMAN FACTORS ANALYSIS AND CLASSIFICATION SYSTEM (HFACS)



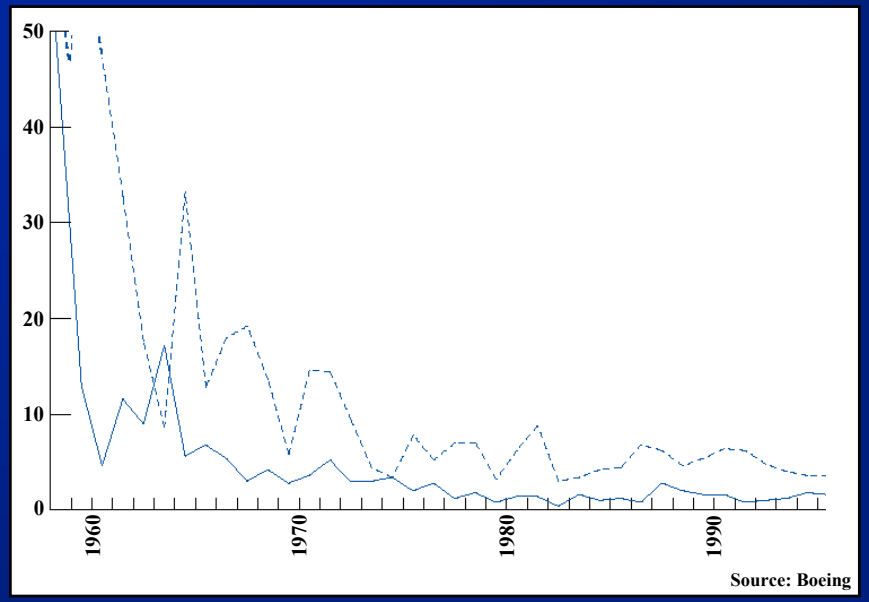
Douglas Wiegmann, Ph.D.
University of Illinois

Scott Shappell, Ph.D.
Civil Aerospace Medical Institute

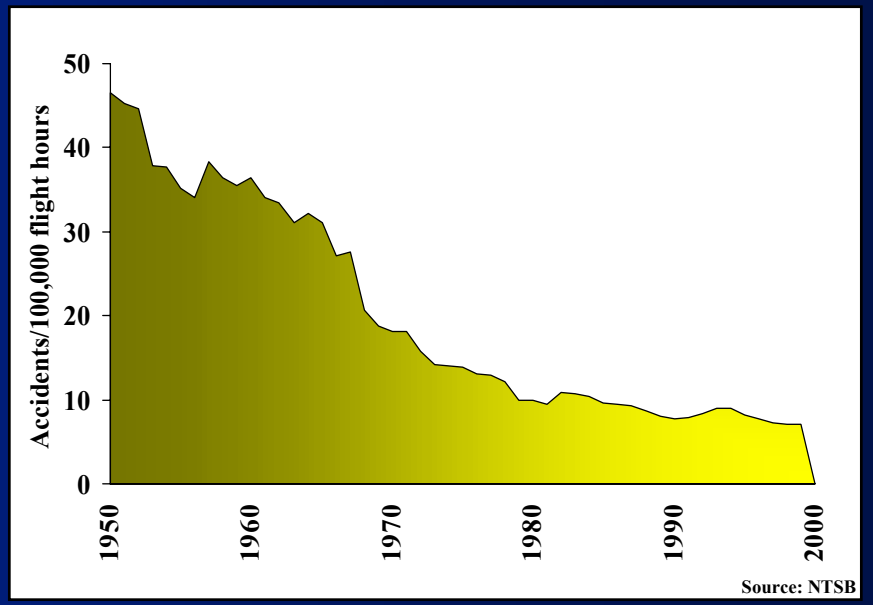
MISTAKES

It Could Be that the Purpose of Your Life Is
Only to Serve as a Warning to Others.

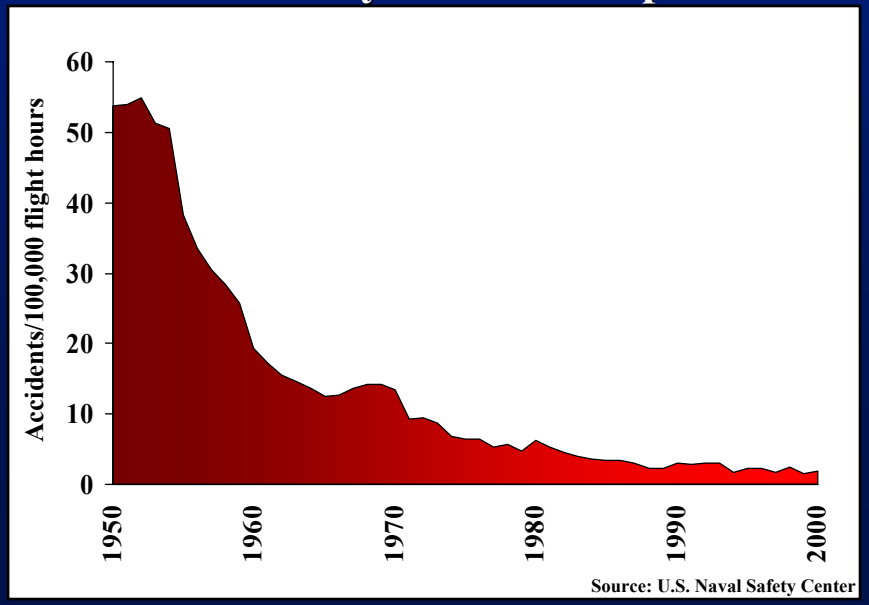
Scheduled Air Carrier



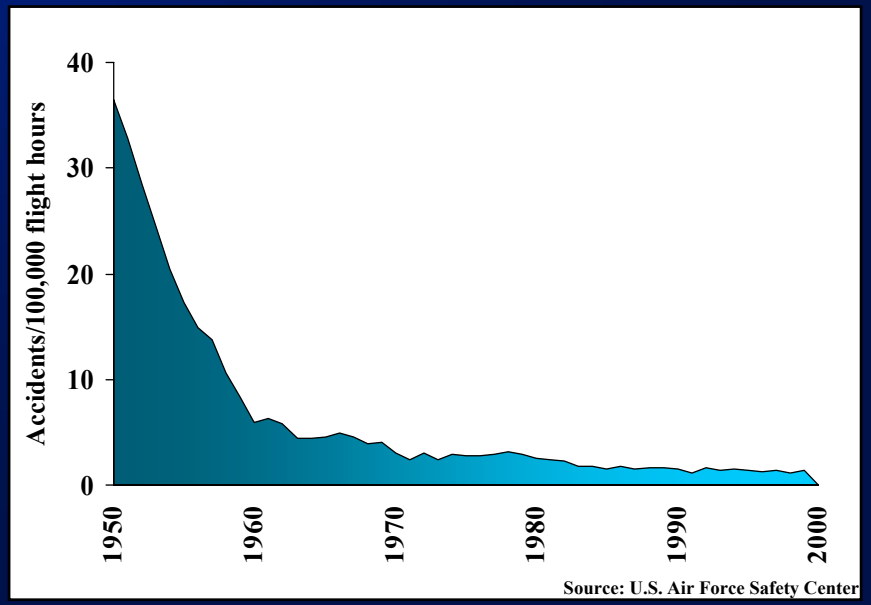
U.S. General Aviation



U.S. Navy/Marine Corps



U.S. Air Force



REASONS FOR CONCERN

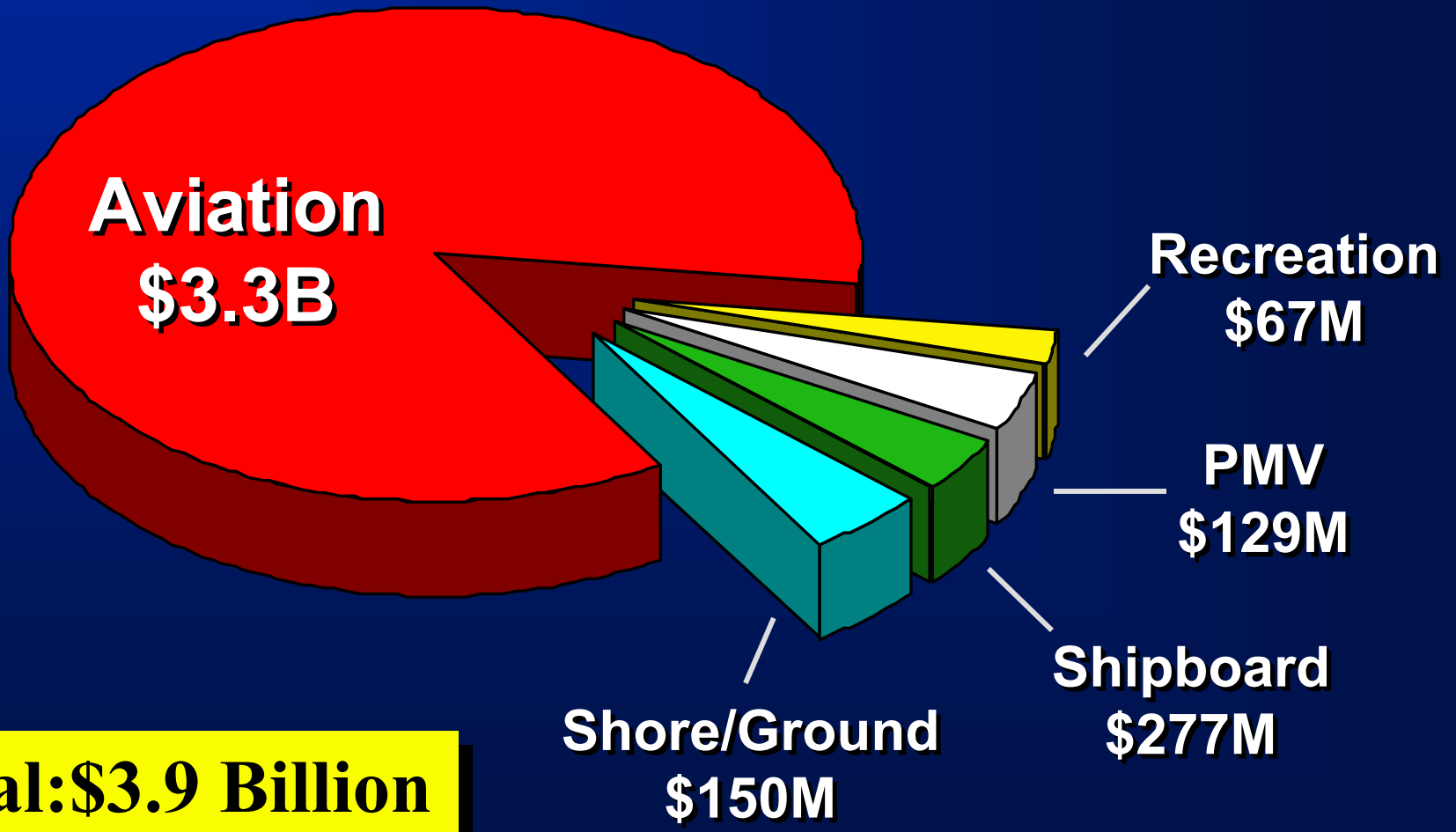
- The rate of improvement has slowed significantly and substantially during the last 25 years.
  - This has led some to conclude that further reductions in accident rates are improbable, if not impossible.

REASONS FOR CONCERN

- The rate of improvement has slowed significantly and substantially during the last 10 years.
  - This has led some to conclude that further reductions in accident rates are improbable, if not impossible.
- **Still, aircraft are becoming increasingly expensive raising the cost of aviation accidents.**

COST OF ACCIDENTS

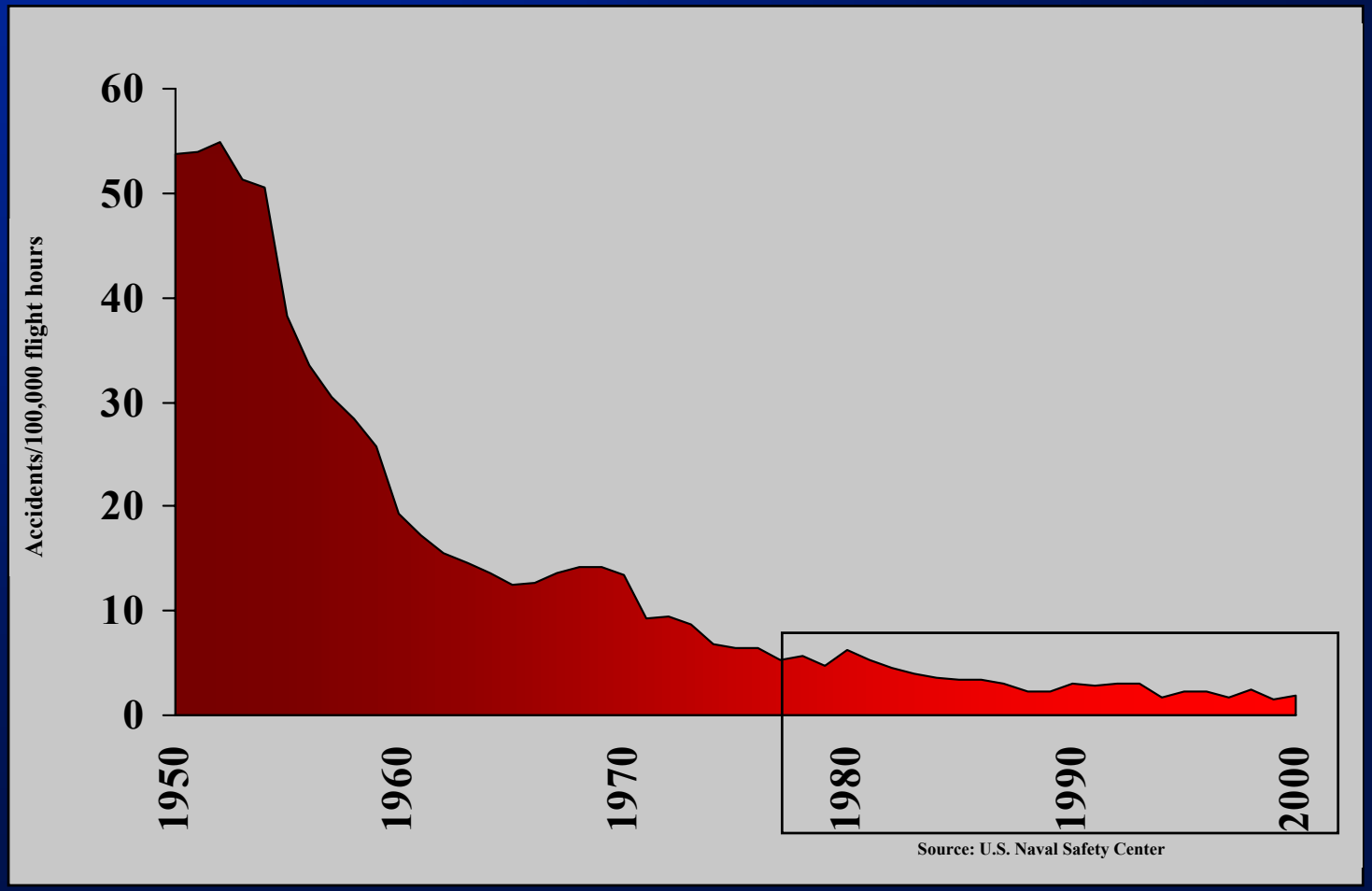
U.S. Navy and Marine Corps
FY96-00



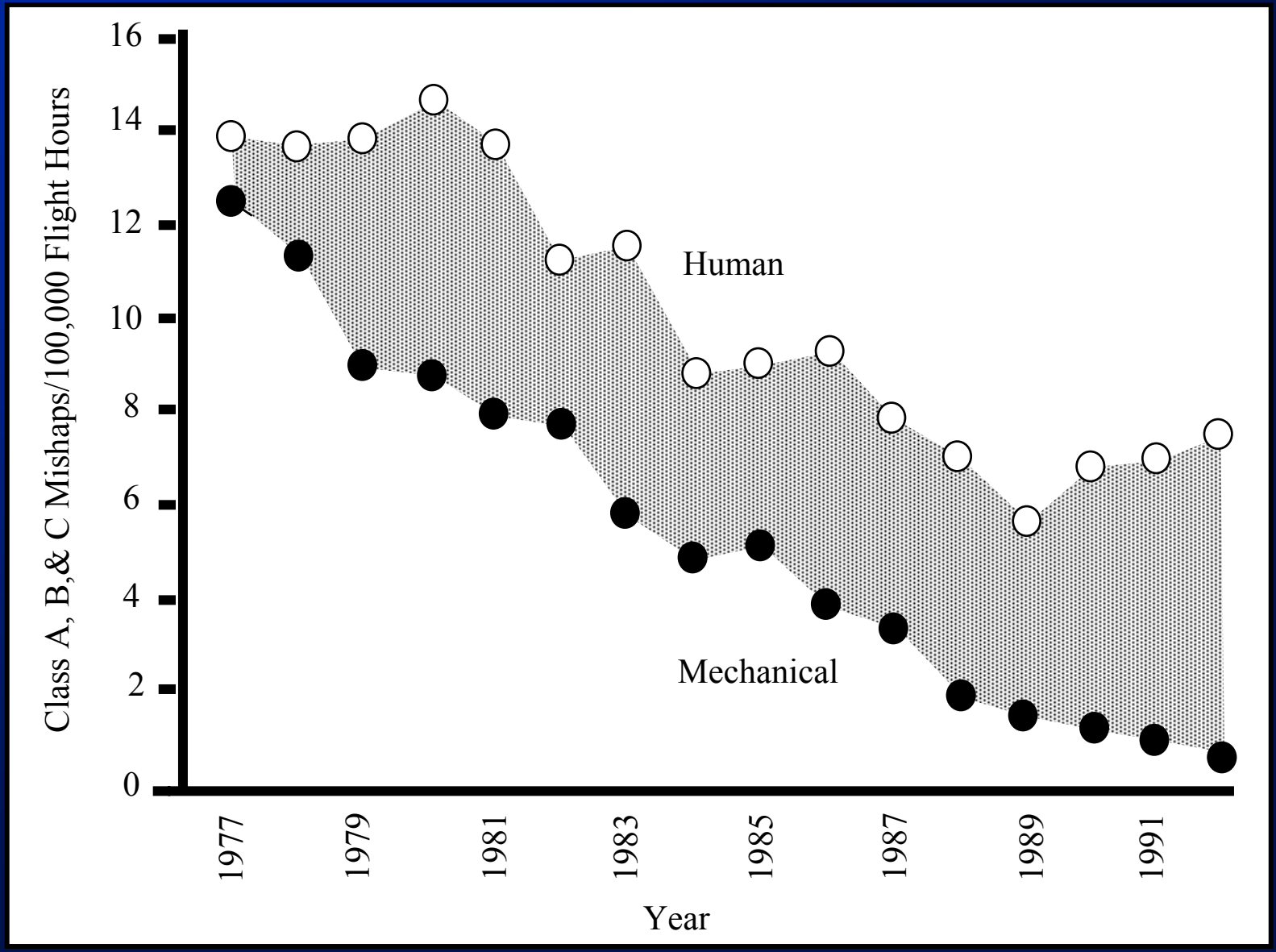
Total:$3.9 Billion

Source: U.S. Naval Safety Center

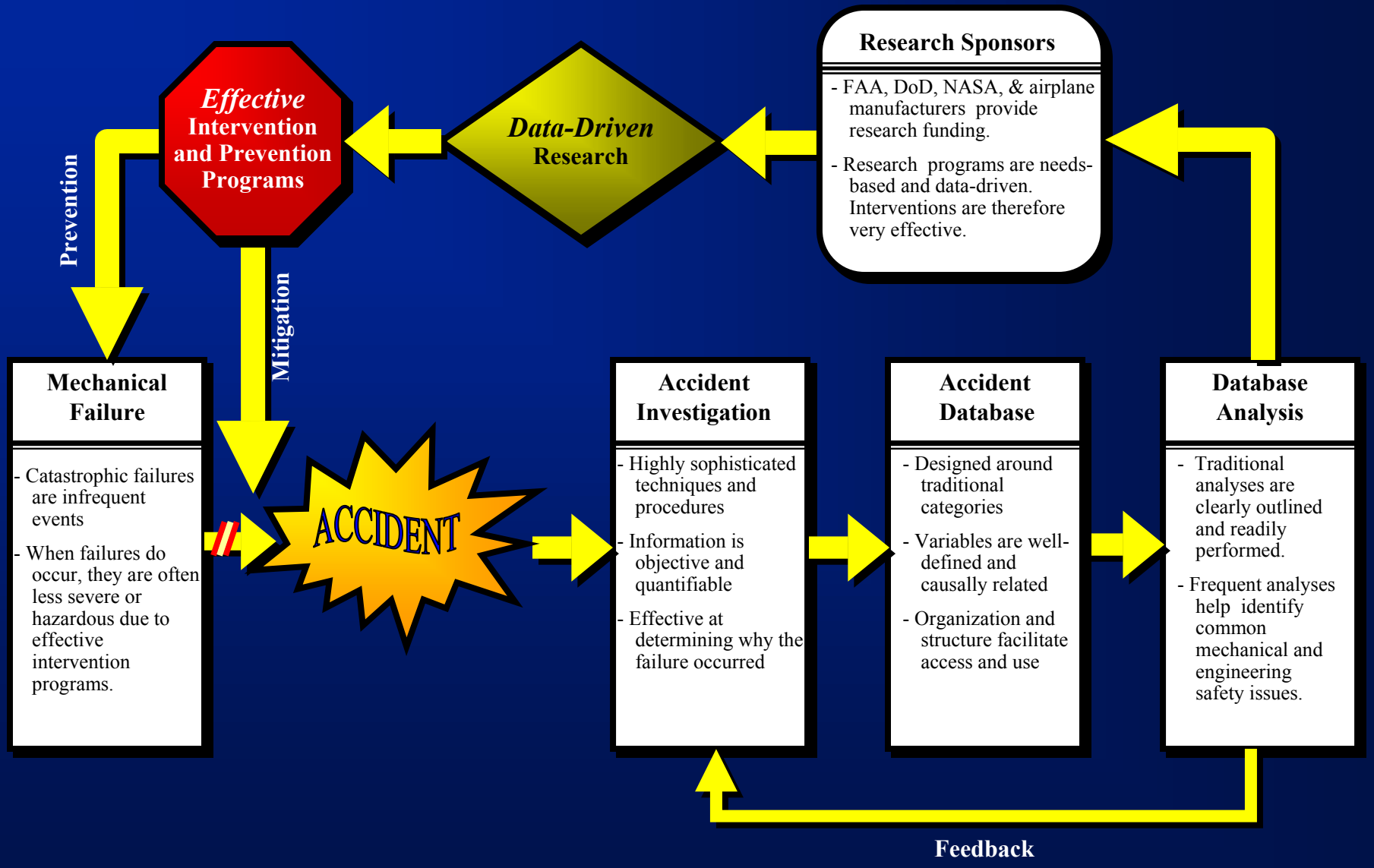
U.S. Navy/Marine Corps (1950-2000)



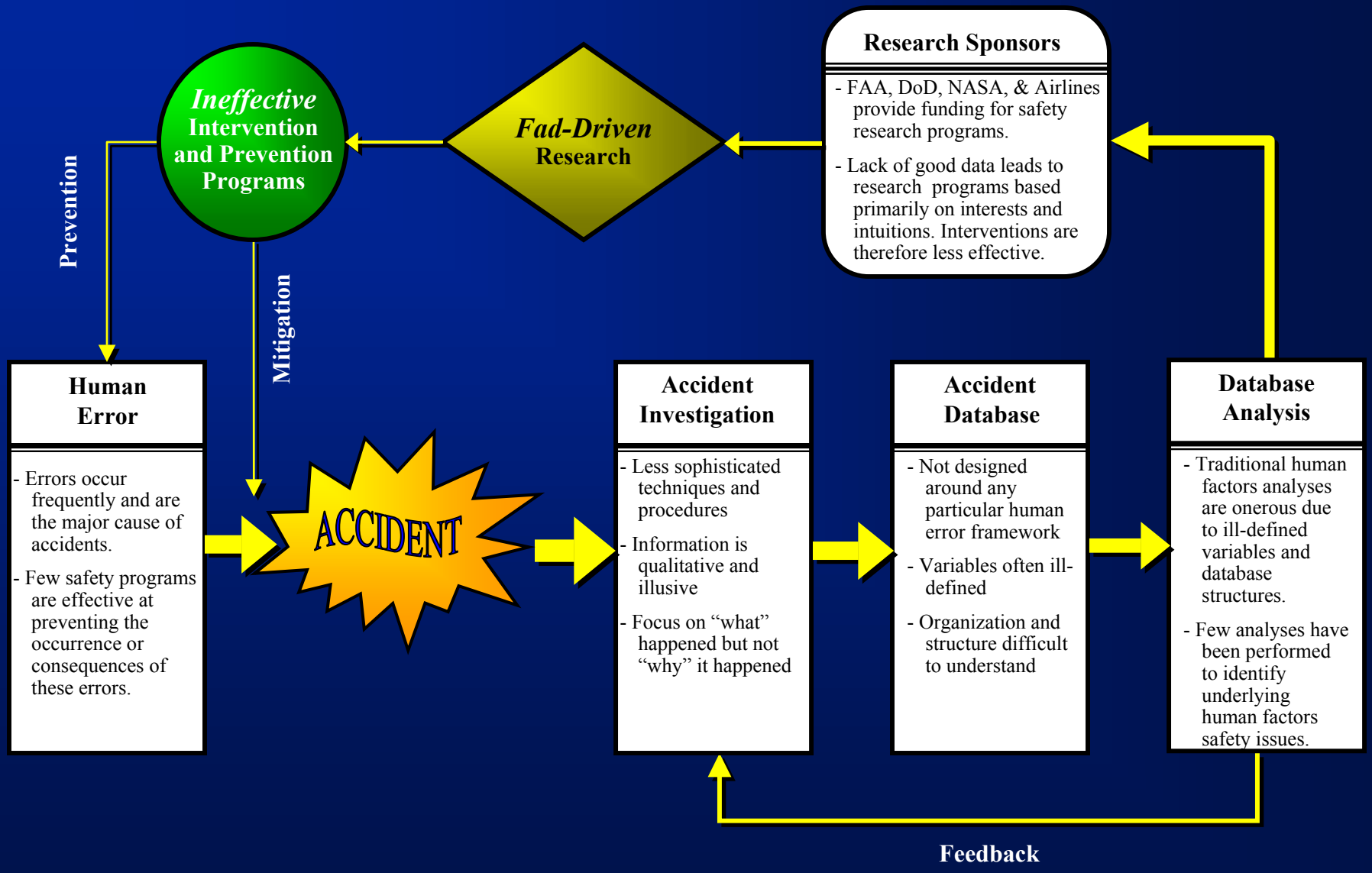
All NAVY/MARINE Class A, B, & C Mishaps



Shappell, S. and Wiegmann, D. (1996). U.S. Naval aviation mishaps 1977-1992: Differences between single and dual-piloted aircraft. *Aviation, Space, and Environmental Medicine*, 67, 65-69.



Wiegmann, D. & Shappell, S. (2001). Human error analysis of commercial aviation accidents: Application of the Human Factors Analysis and Classification System (HFACS). *Aviation, Space, and Environmental Medicine,72, 1006-1016.*



Wiegmann, D. & Shappell, S. (2001). Human error analysis of commercial aviation accidents: Application of the Human Factors Analysis and Classification System (HFACS). *Aviation, Space, and Environmental Medicine,72, 1006-1016.*

ADDRESSING THE PROBLEM

- What was required, therefore, was a general human error framework around which accident investigation and prevention programs can be developed.
- We explored several approaches and "off-the-shelf" frameworks
  - Cognitive
  - Ergonomics
  - Aeromedical
  - Psychosocial
  - Organizational

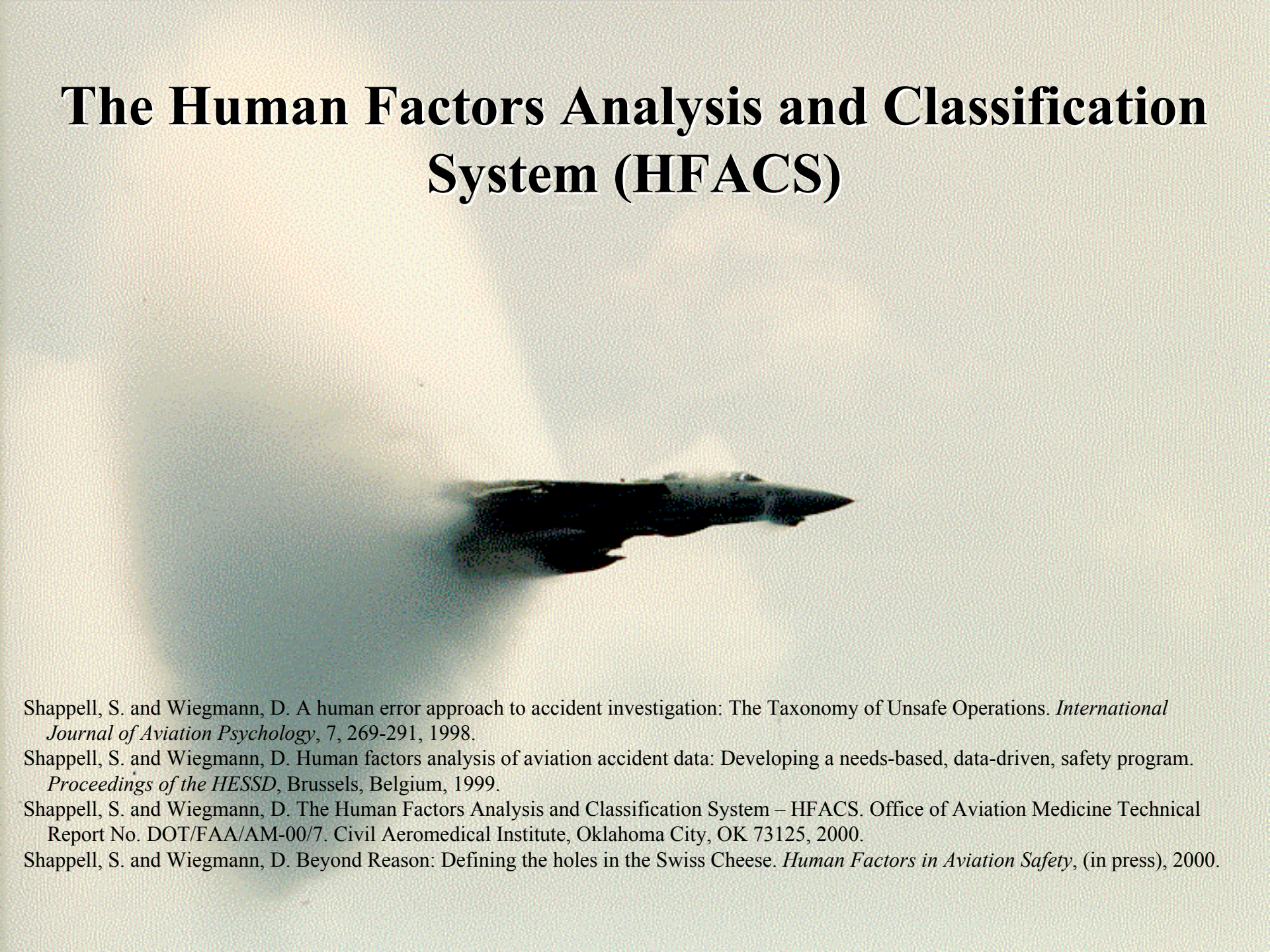
Shappell, S. and Wiegmann, D. Controlled flight into terrain: The utility of an information processing approach to mishap causal factors. *Proceedings of the Eighth Symposium for Aviation Psychology*, Ohio State University, 1300-1306, 1995.

Wiegmann, D and Shappell, S. Human factors in U.S. Naval aviation mishaps: An information processing approach. *Proceedings of the Eighth Symposium for Aviation Psychology*, Ohio State University, 1995.

Wiegmann, D. and Shappell, S. Human factors analyses of post-accident data: Applying theoretical taxonomies of human error. *International Journal of Aviation Psychology*, 7, 67-81, 1997.

Wiegmann, D. and Shappell, S. Human error perspectives in aviation. *International Journal of Aviation Psychology*, 11, 341-357, 2001.

The Human Factors Analysis and Classification System (HFACS)



Shappell, S. and Wiegmann, D. A human error approach to accident investigation: The Taxonomy of Unsafe Operations. *International Journal of Aviation Psychology*, 7, 269-291, 1998.

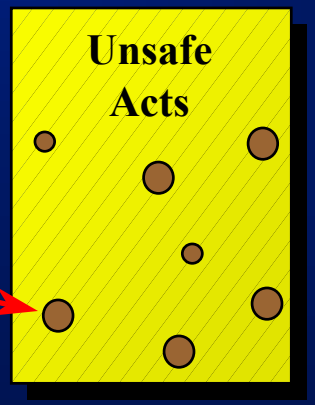
Shappell, S. and Wiegmann, D. Human factors analysis of aviation accident data: Developing a needs-based, data-driven, safety program. *Proceedings of the HESSD*, Brussels, Belgium, 1999.

Shappell, S. and Wiegmann, D. The Human Factors Analysis and Classification System – HFACS. Office of Aviation Medicine Technical Report No. DOT/FAA/AM-00/7. Civil Aeromedical Institute, Oklahoma City, OK 73125, 2000.

Shappell, S. and Wiegmann, D. Beyond Reason: Defining the holes in the Swiss Cheese. *Human Factors in Aviation Safety*, (in press), 2000.

Breakdown of a Productive System

Failed or
Absent Defenses

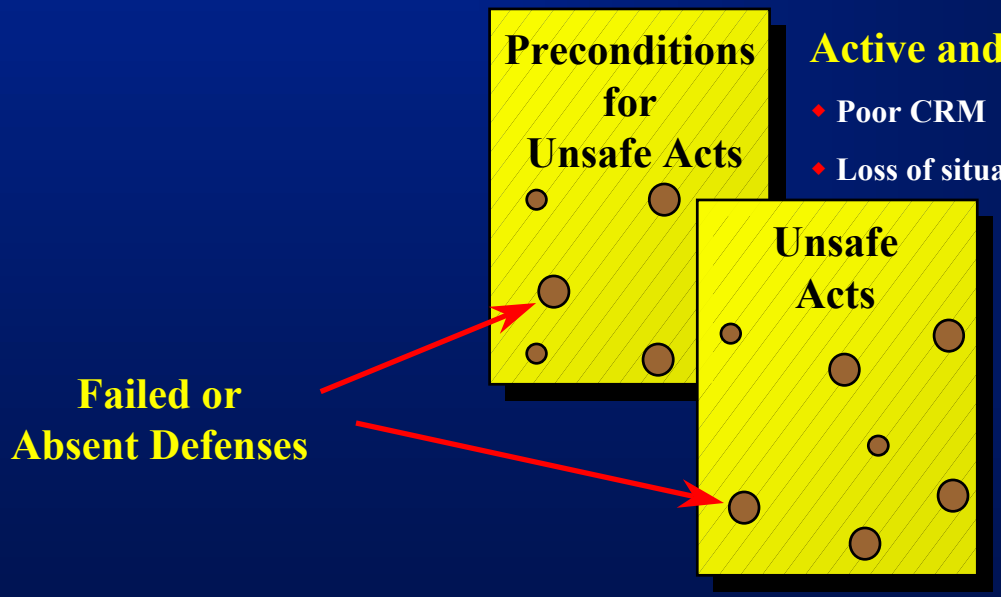


Active Conditions

- Failed to scan instruments
- Penetrated IMC when VFR only

Adapted from Reason (1990)

Breakdown of a Productive System



Active and Latent Conditions

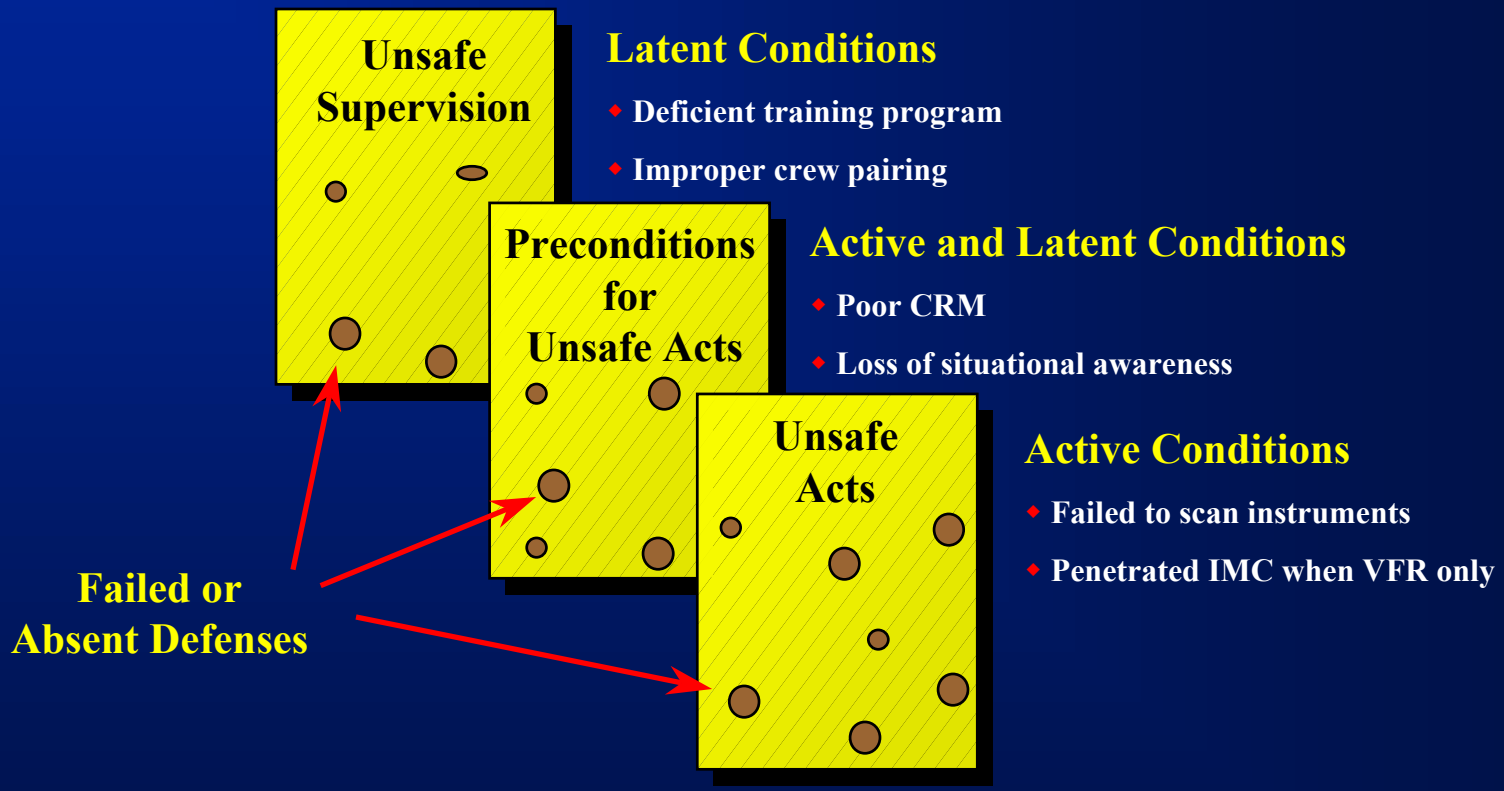
- Poor CRM
- Loss of situational awareness

Active Conditions

- Failed to scan instruments
- Penetrated IMC when VFR only

Adapted from Reason (1990)

Breakdown of a Productive System



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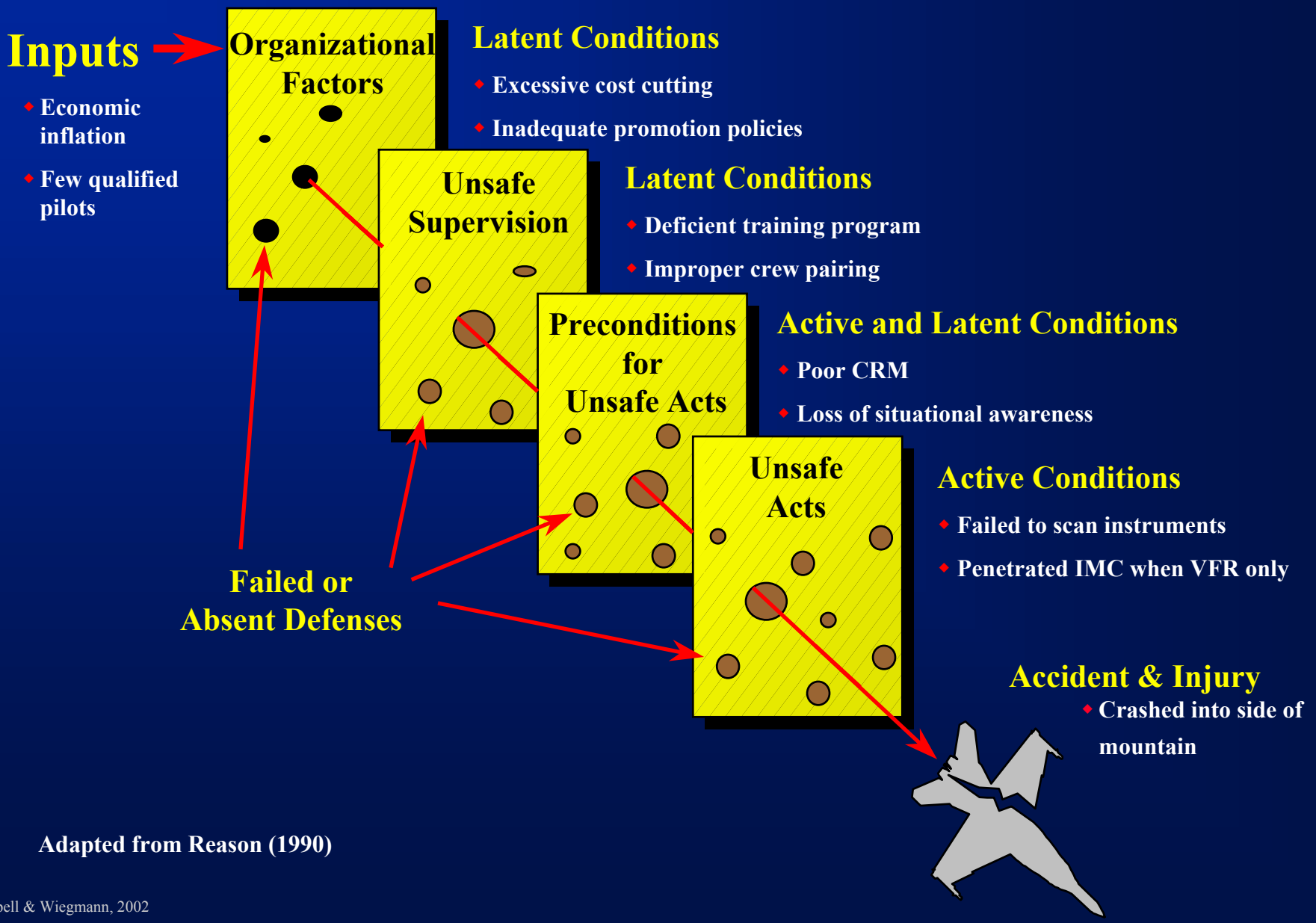
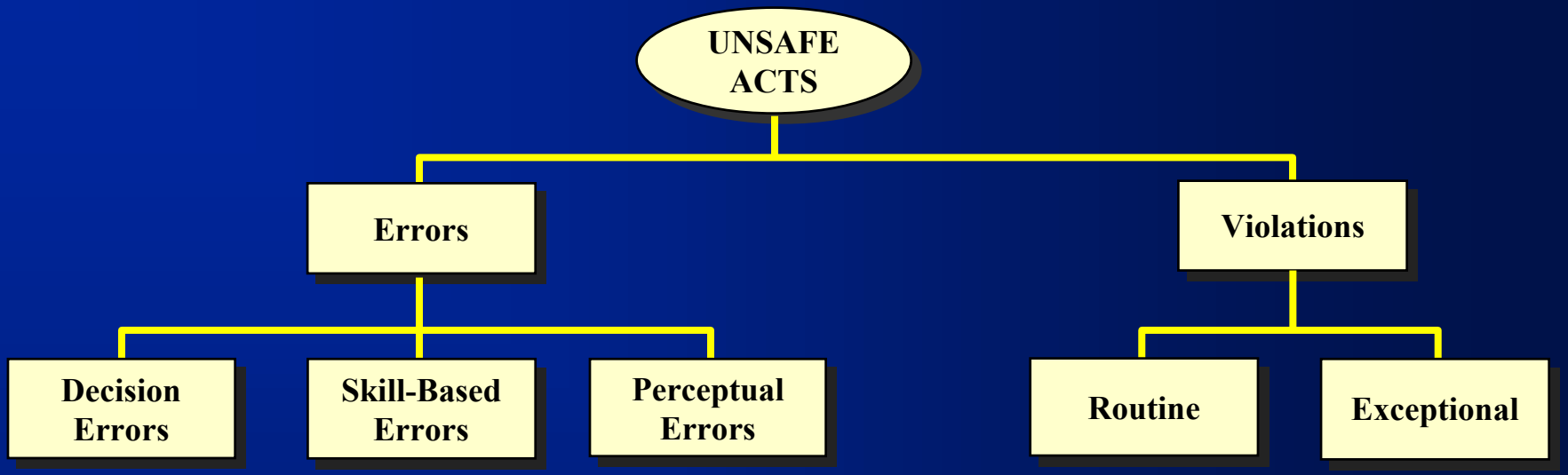
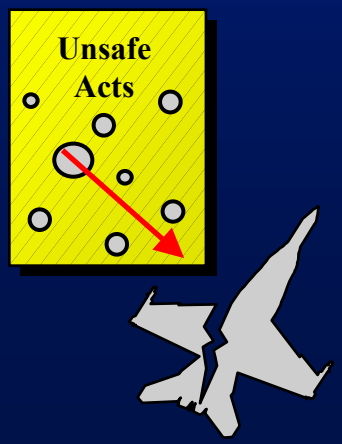
Breakdown of a Productive System



Adapted from Reason (1990)



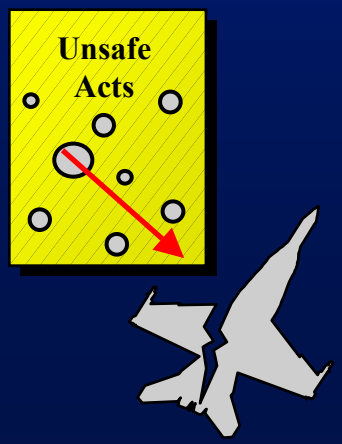


UNSAFE ACTS

- Errors
  - Decision Errors
  - Skill-Based Errors
  - Perceptual Errors
- Violations
  - Routine
  - Exceptional

DECISION ERRORS

- Rule-based Decisions
  - If X, then do Y
  - Highly Procedural
- Choice Decisions
  - Knowledge-based
- Ill-Structured Decisions
  - Problem solving



UNSAFE ACTS

Errors

Violations

Decision Errors

Skill-Based Errors

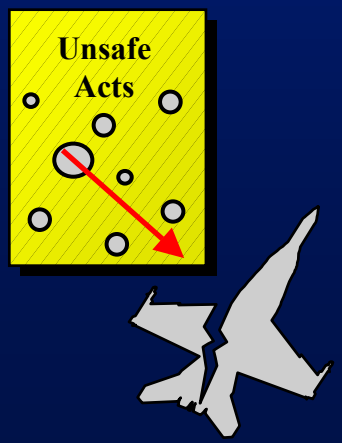
Perceptual Errors

Routine

Exceptional

SKILL-BASED ERRORS

- Attention Failures
  - Breakdown in visual scan
  - Inadvertent operation of control
- Memory Failure
  - Omitted item in checklist
  - Omitted step in procedure
- Stick-and-Rudder Skills



UNSAFE ACTS

- Errors
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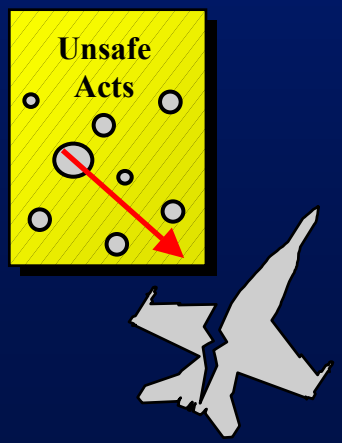
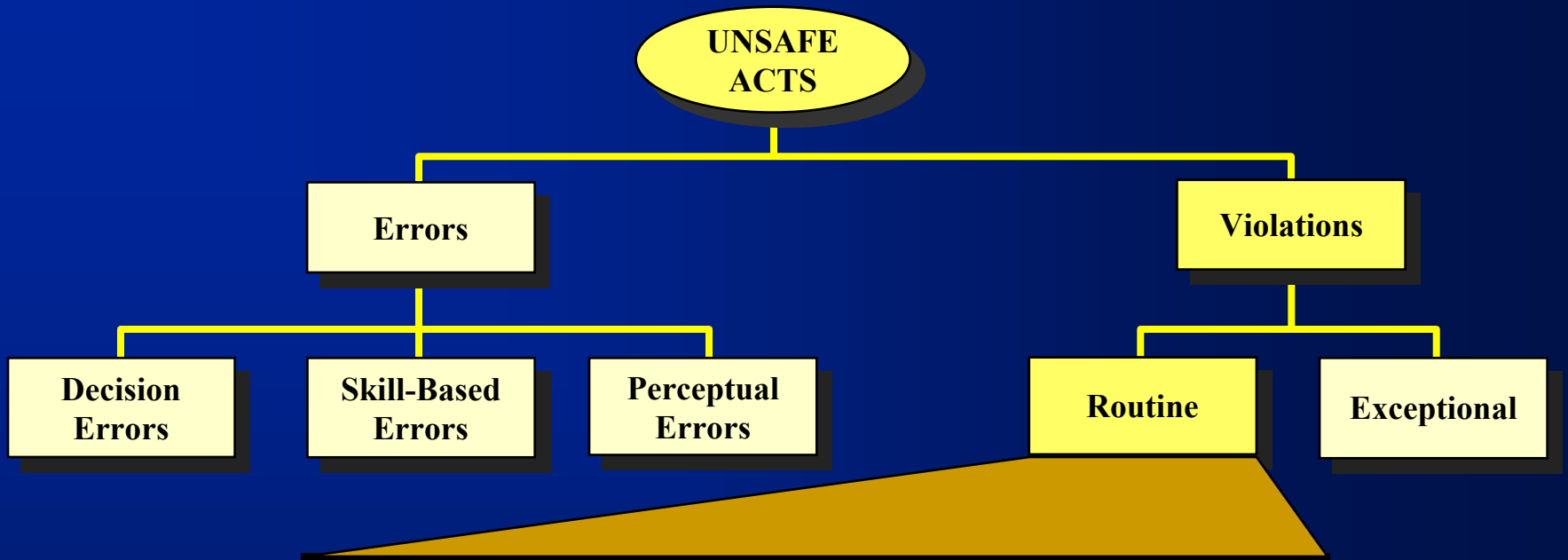
  - Exceptional

PERCEPTUAL ERRORS
(due to)

- Misjudge Distance, Altitude, Airspeed
- Spatial Disorientation
- Visual Illusions

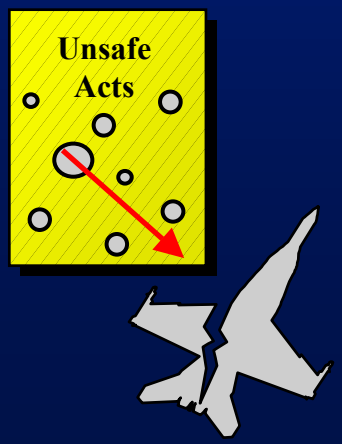


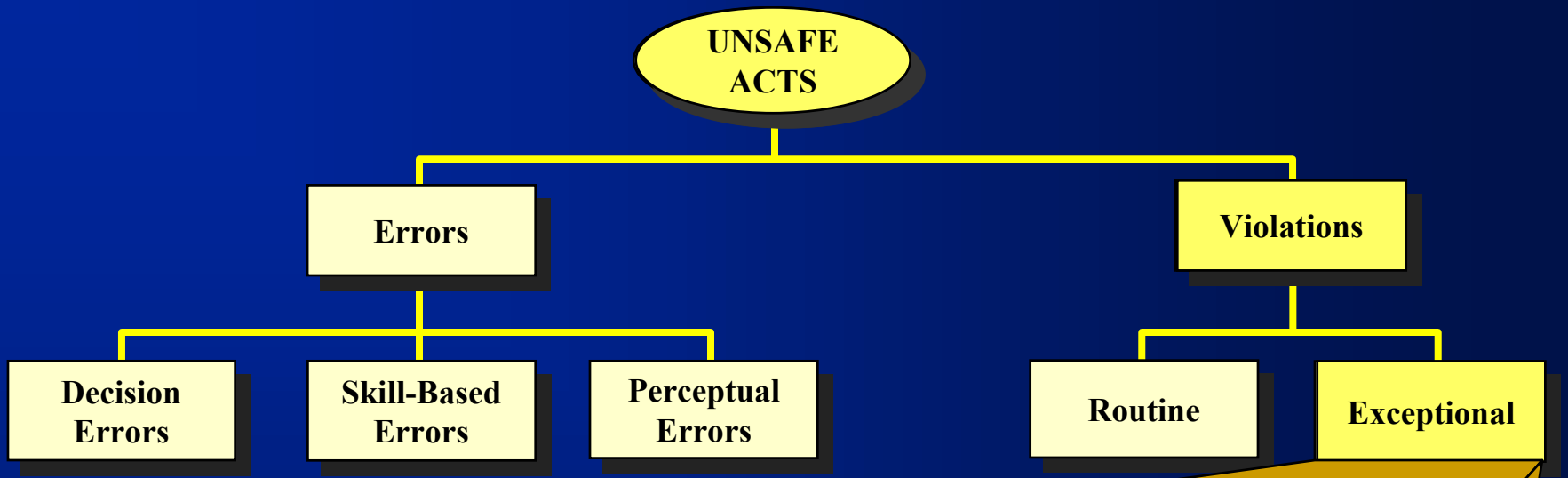


ROUTINE (INFRACTIONS)

(Habitual departures from rules condoned by management)

- VFR Flight into IMC
- Elected to File VFR in Marginal Weather Conditions
- Failed to Use Radar Advisories from ATC
- Inadequate Brief and Limits on Mission
- IFR Procedure Not Followed
- Weight and Balance Exceeded
- Procedure/Directives Not Followed
- Operating With Known Deficiencies
- Min. Descent Altitude not Complied with

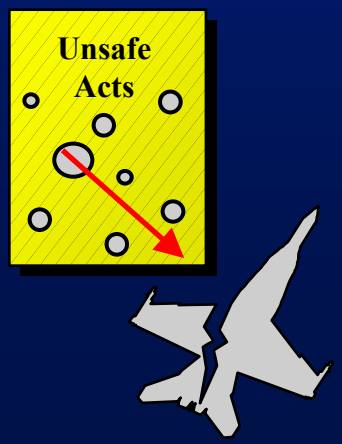


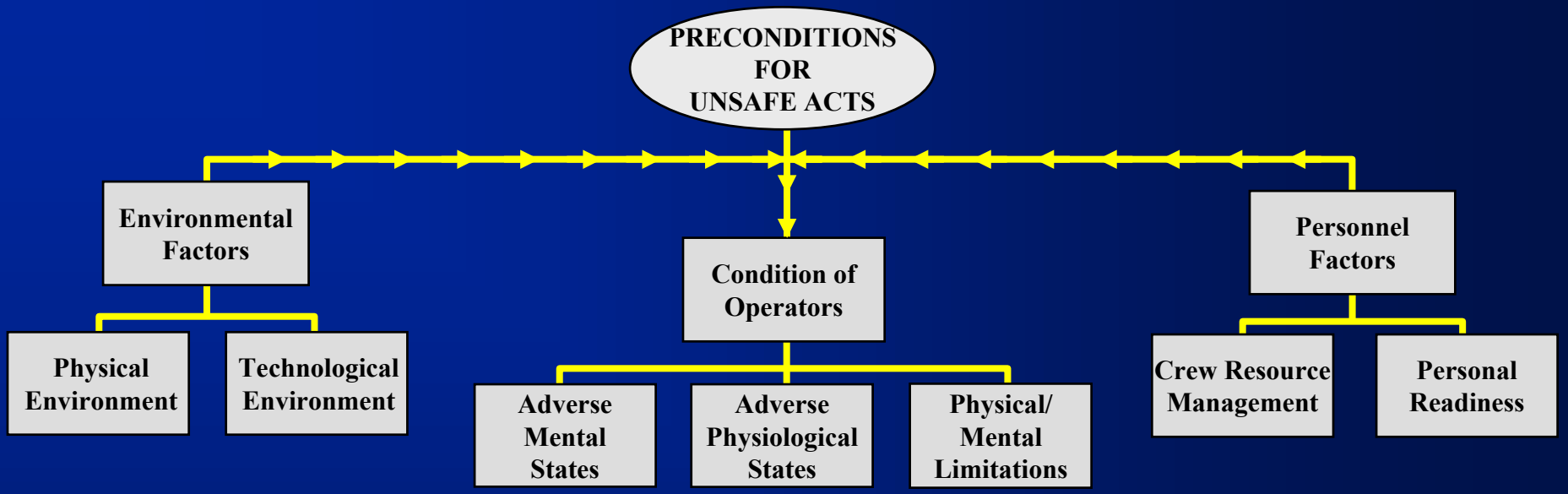


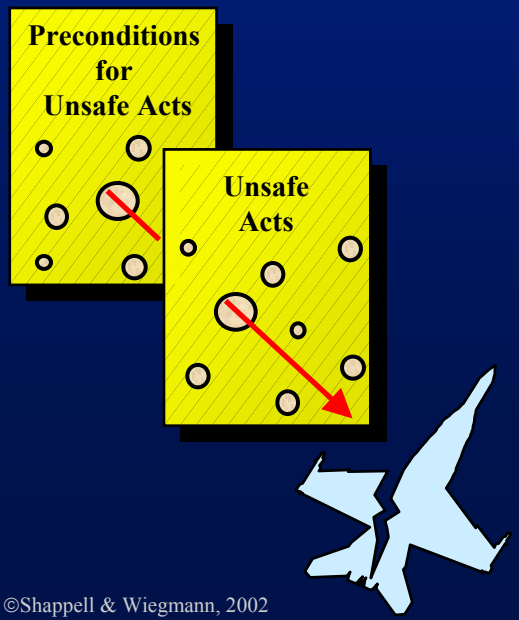
EXCEPTIONAL

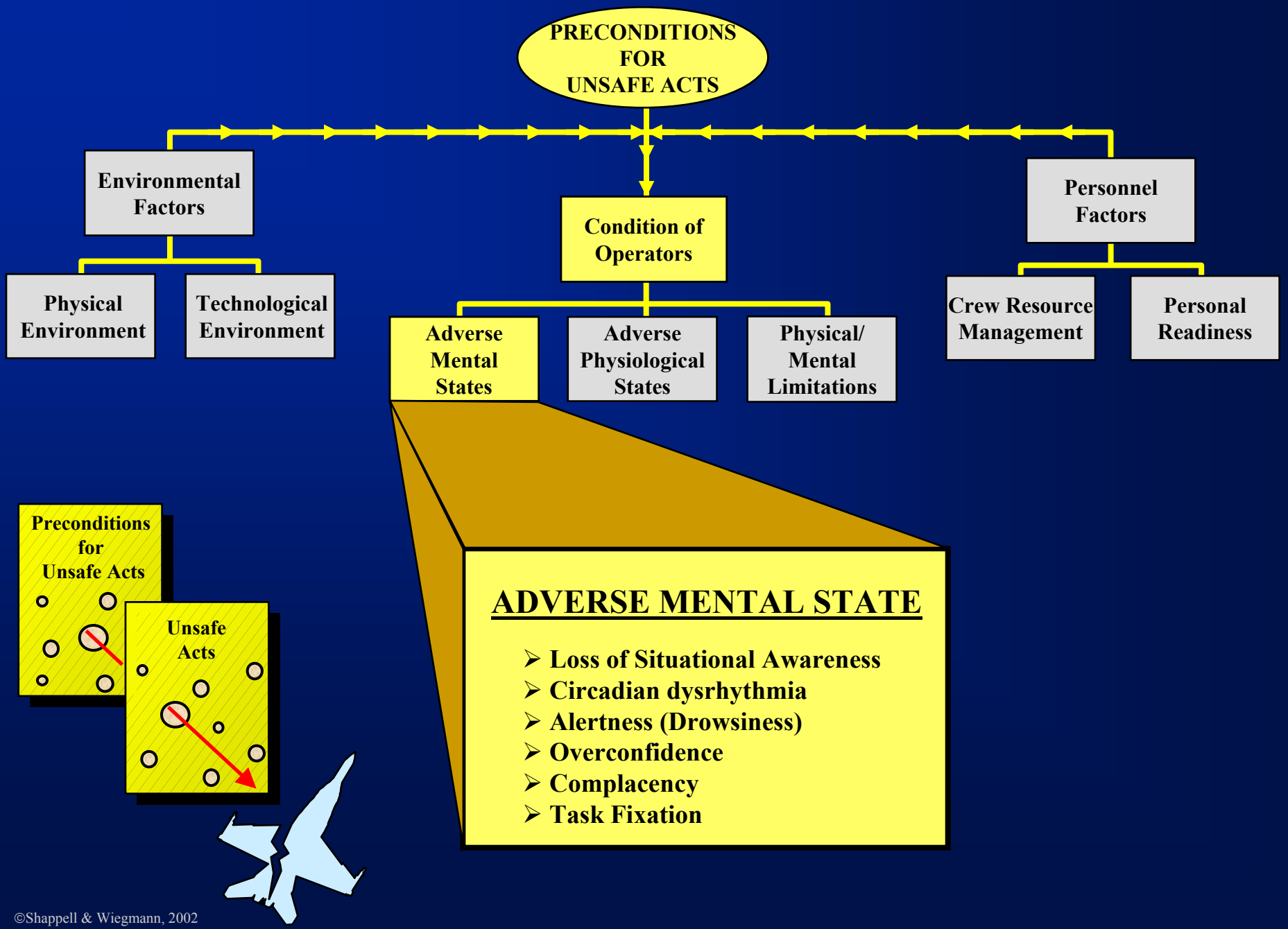
(Isolated departures from the rules not condoned by management)

- **Violated NATOPS/Regulations/SOP**
  - **Performed Unauthorized Acrobatic Maneuver**
  - **Canyon Running**
  - **Failed to Complete Performance Computations for Flight**
  - **Failed to Obtain Valid Weather Brief**
- **Accepted Unnecessary Hazard**
- **Not Current/Qualified for Mission**
- **Exceeded Limits of Aircraft**



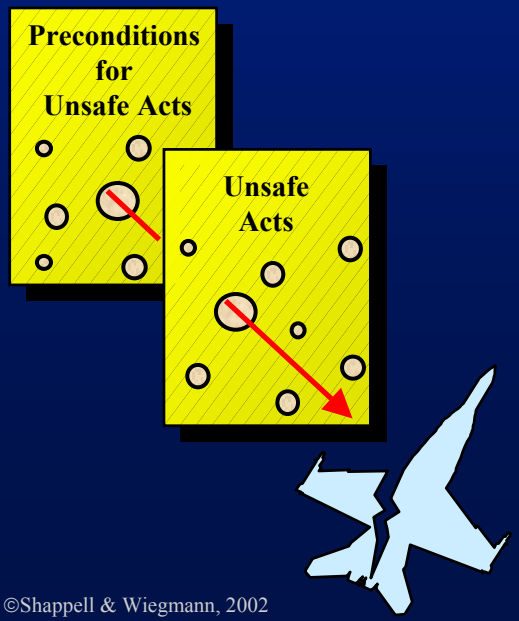






PRECONDITIONS FOR UNSAFE ACTS

- Environmental Factors
  - Physical Environment
  - Technological Environment
- Condition of Operators
  - Adverse Mental States
  - Adverse Physiological States
  - Physical/ Mental Limitations
- Personnel Factors
  - Crew Resource Management
  - Personal Readiness



ADVERSE PHYSIOLOGICAL STATES

- Spatial Disorientation
- Visual Illusions
- G-induced Loss of Consciousness
- Hypoxia
- Medical Illness

PRECONDITIONS FOR UNSAFE ACTS

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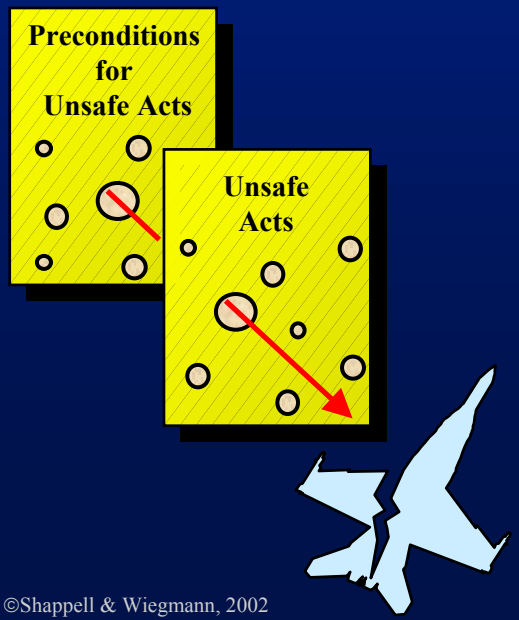
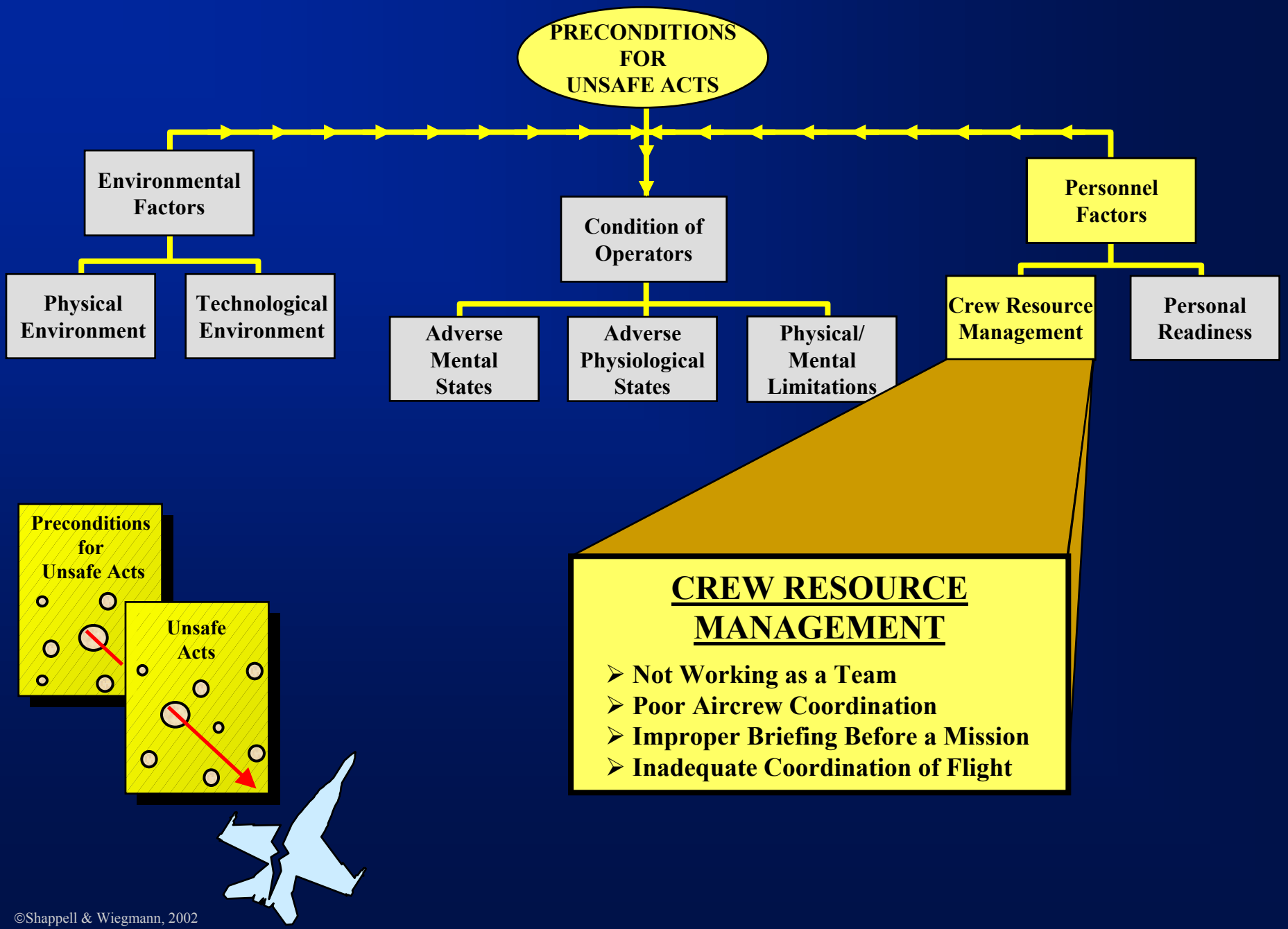
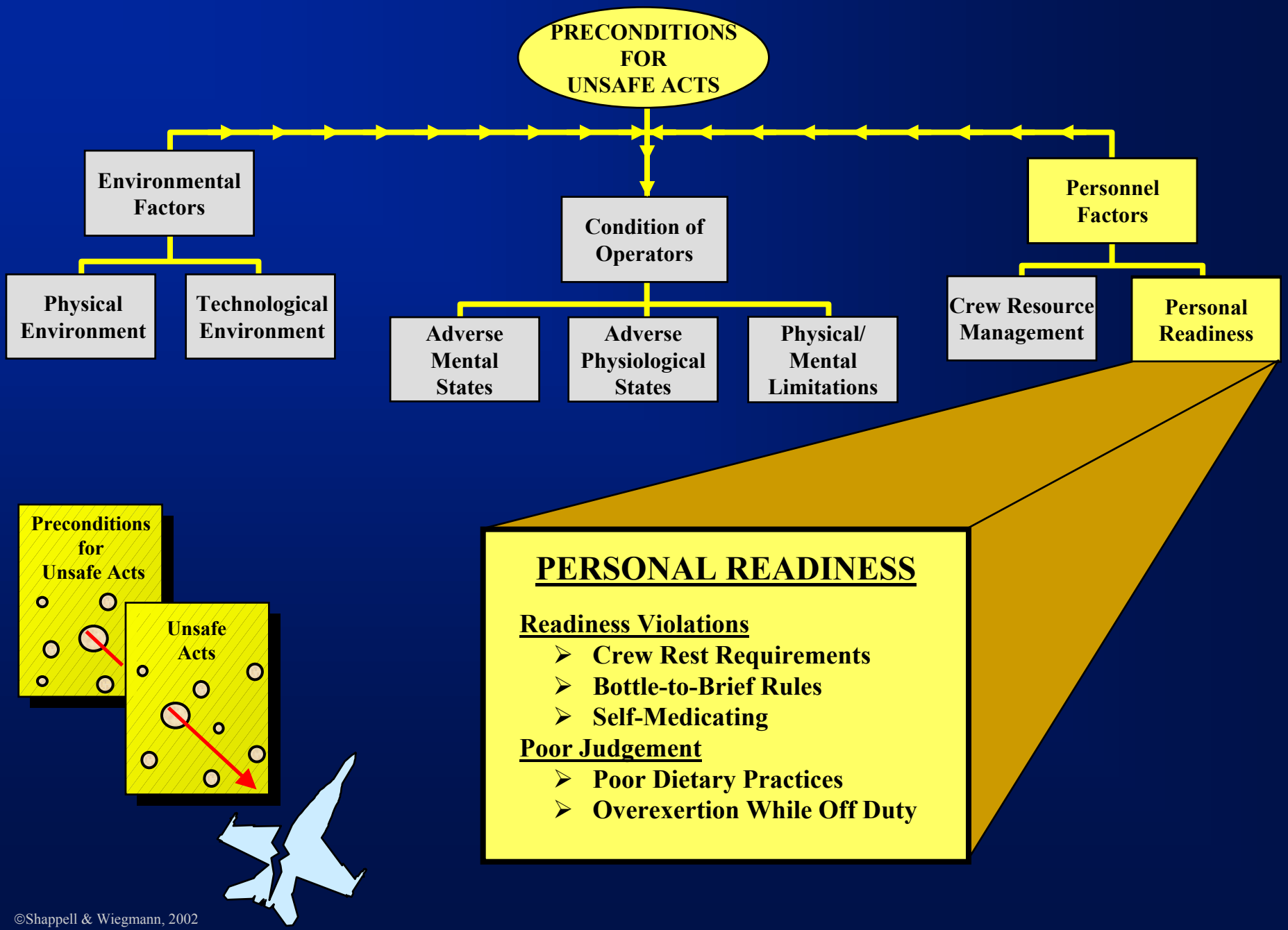
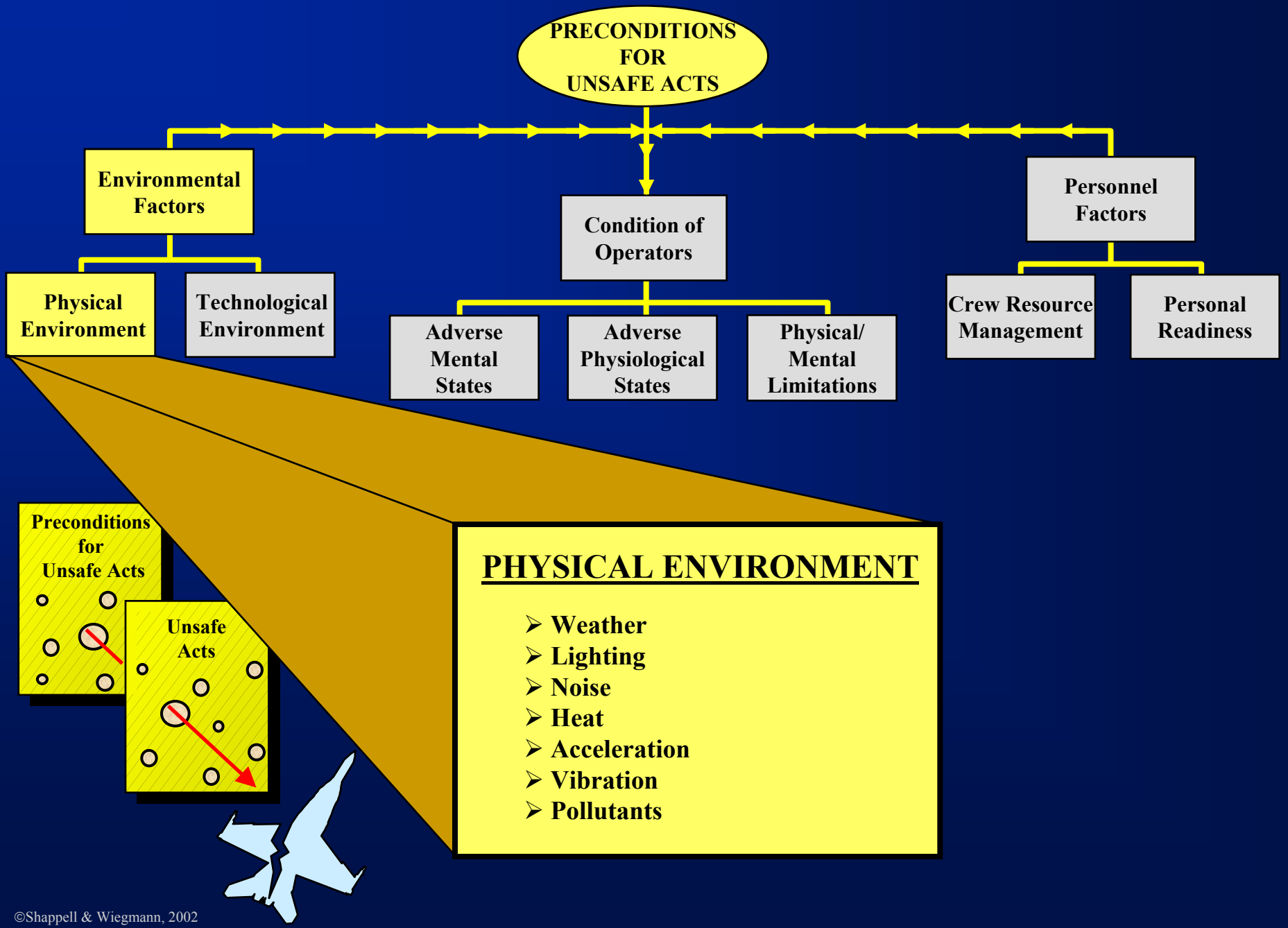


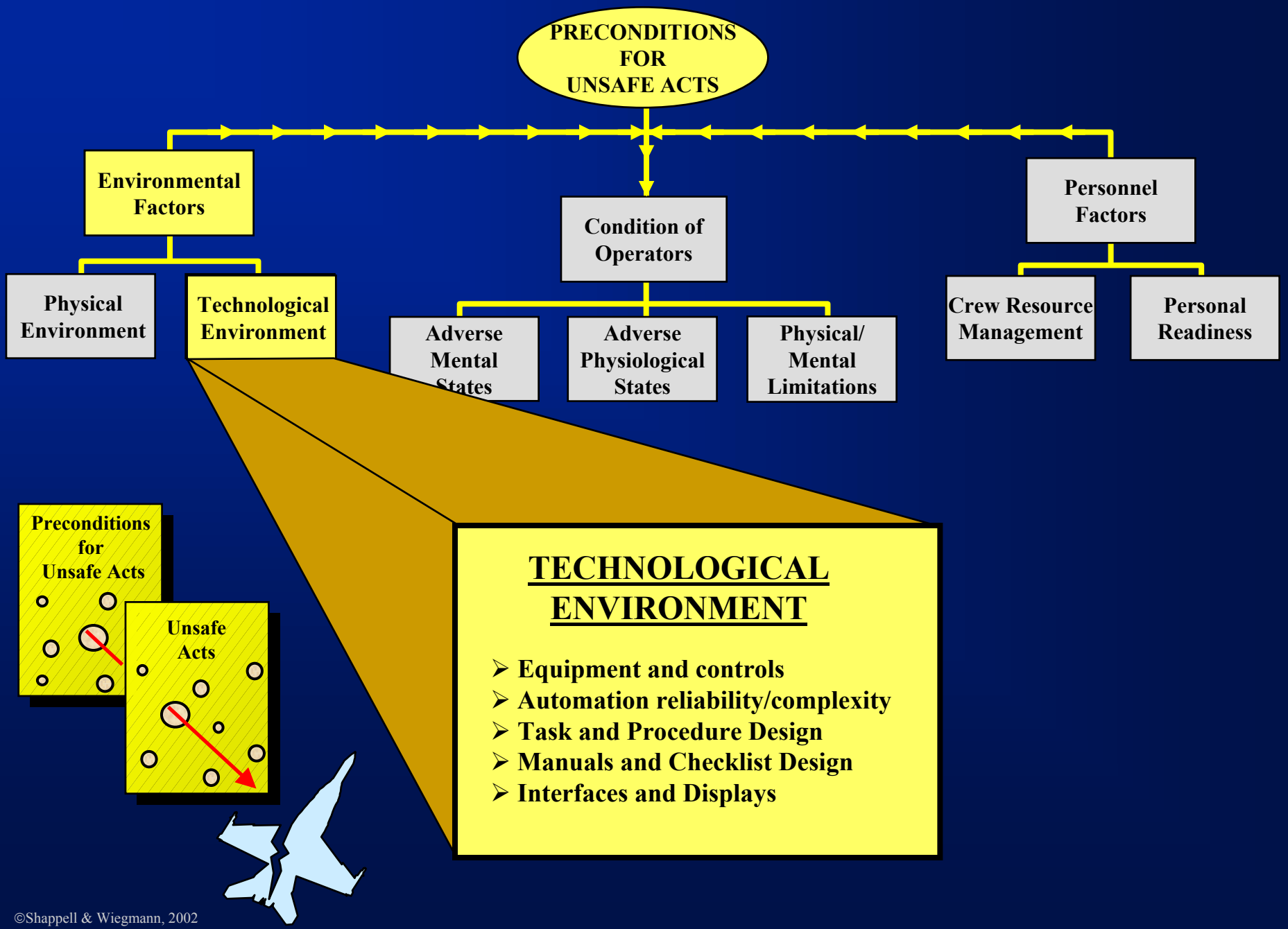
PHYSICAL/MENTAL LIMITATIONS

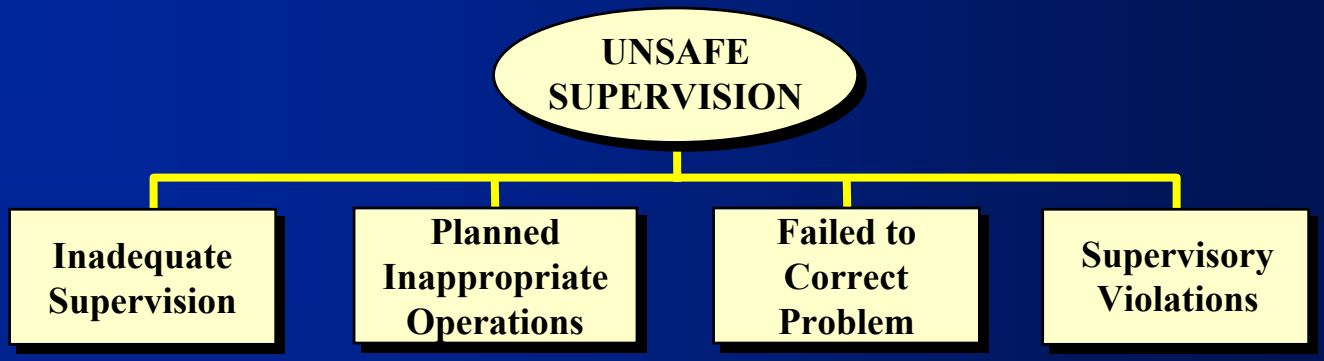
- Lack of Sensory Input
- Limited Reaction Time
- Incompatible Physical Capabilities
- Incompatible Intelligence/Aptitude

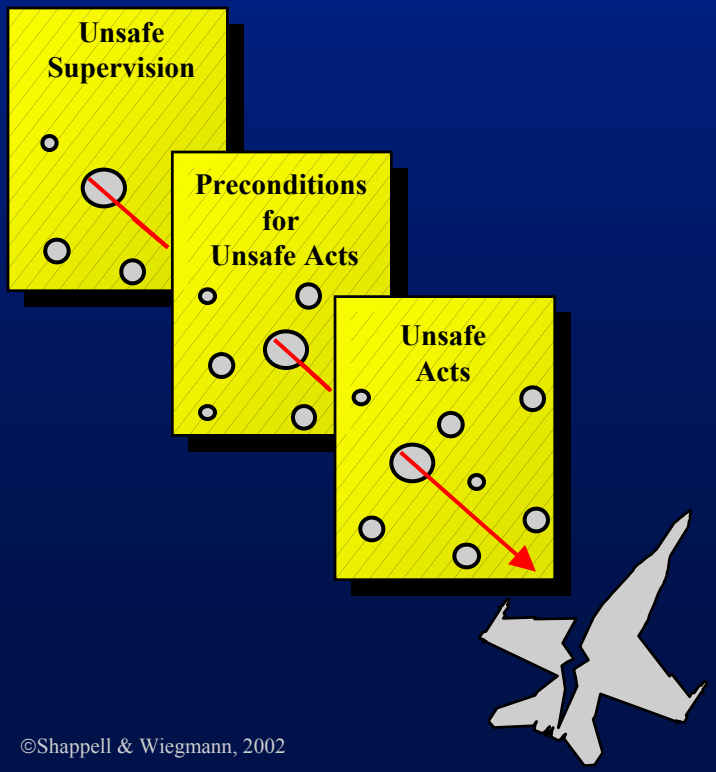


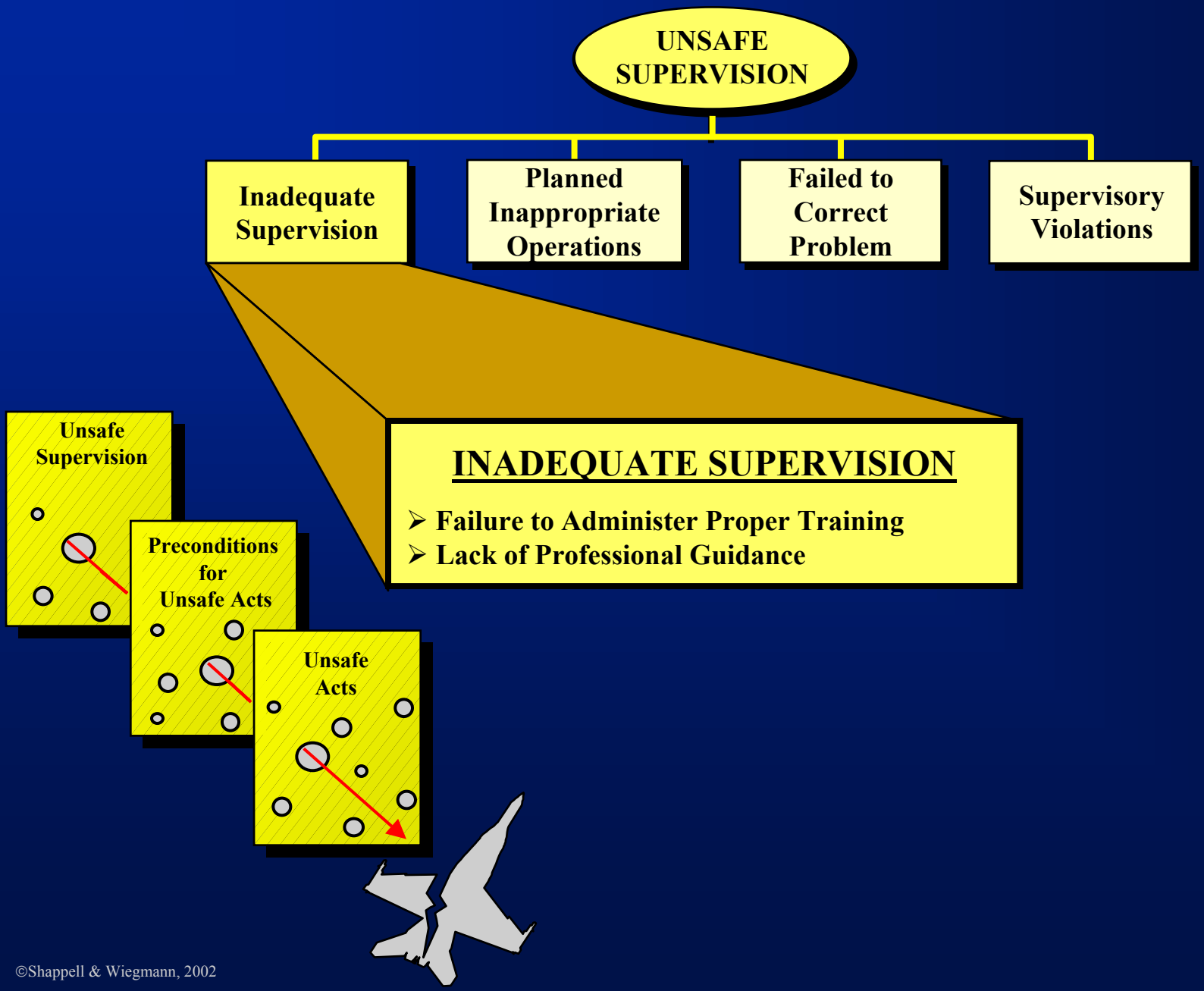


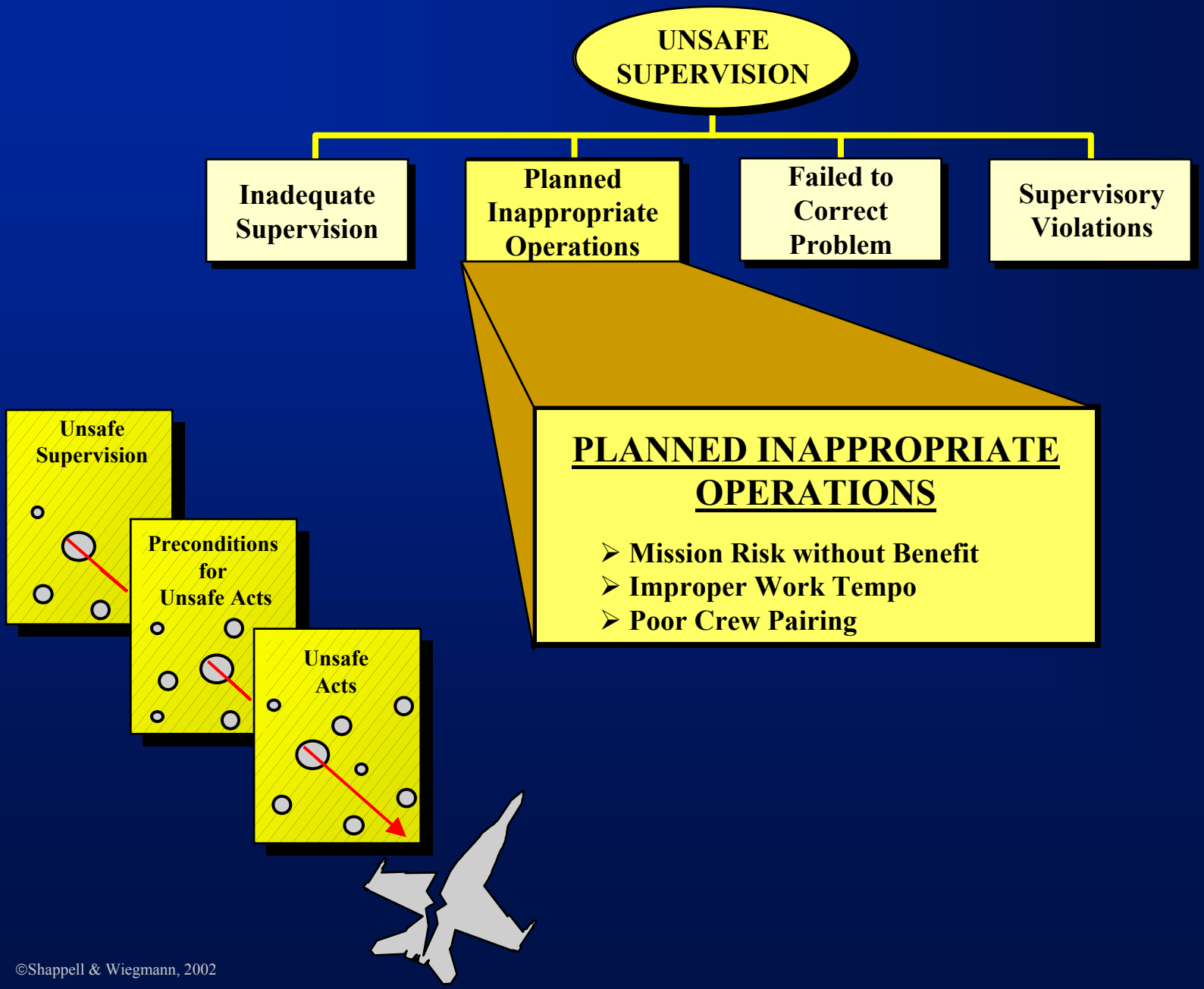










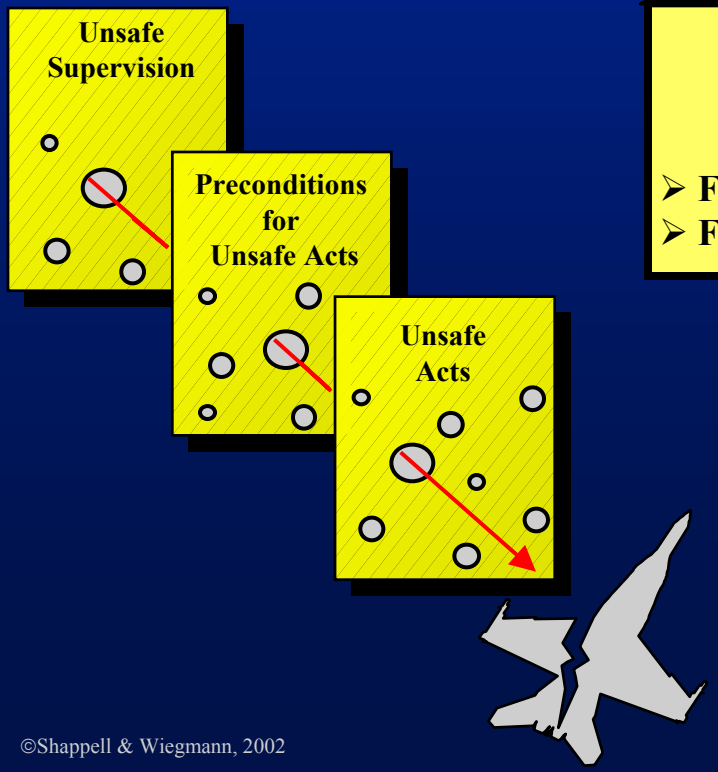


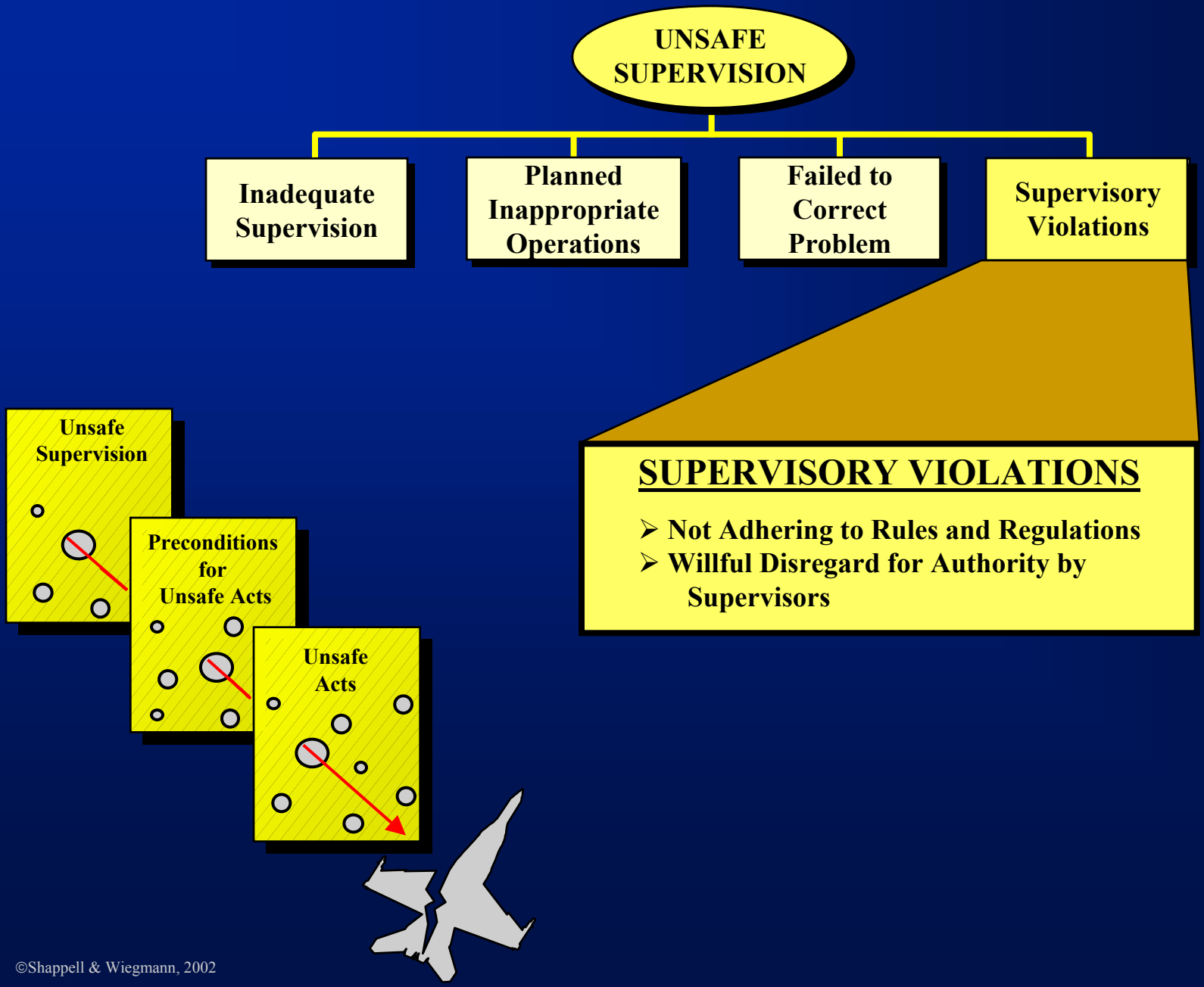
UNSAFE SUPERVISION

- Inadequate Supervision
- Planned Inappropriate Operations
- Failed to Correct Problem
- Supervisory Violations

FAILED TO CORRECT A KNOWN PROBLEM

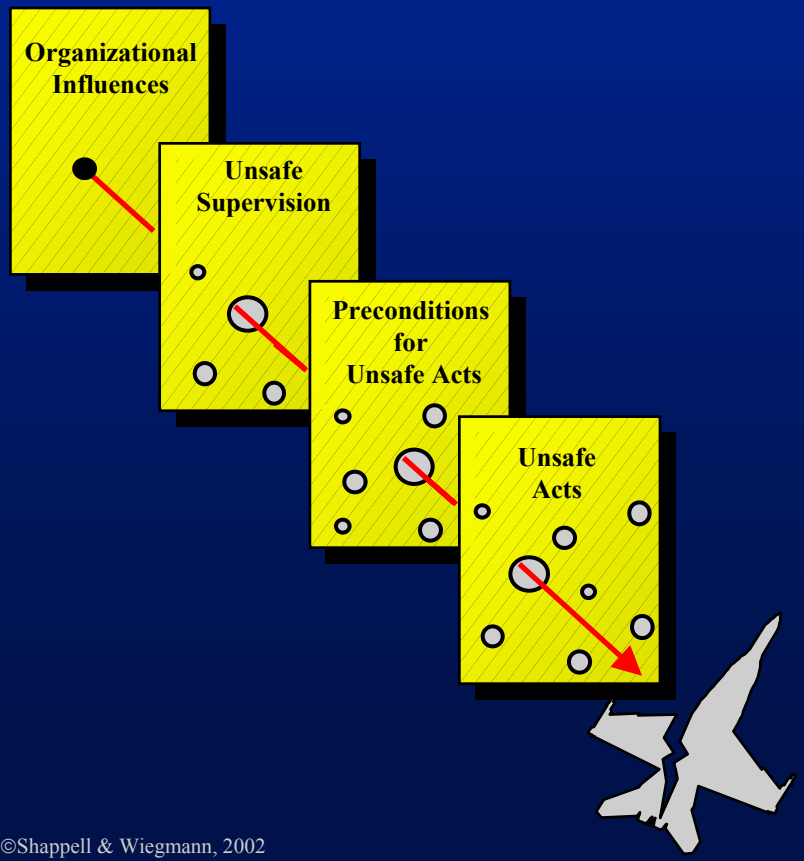
- Failure to Correct Inappropriate Behavior
- Failure to Correct a Safety Hazard

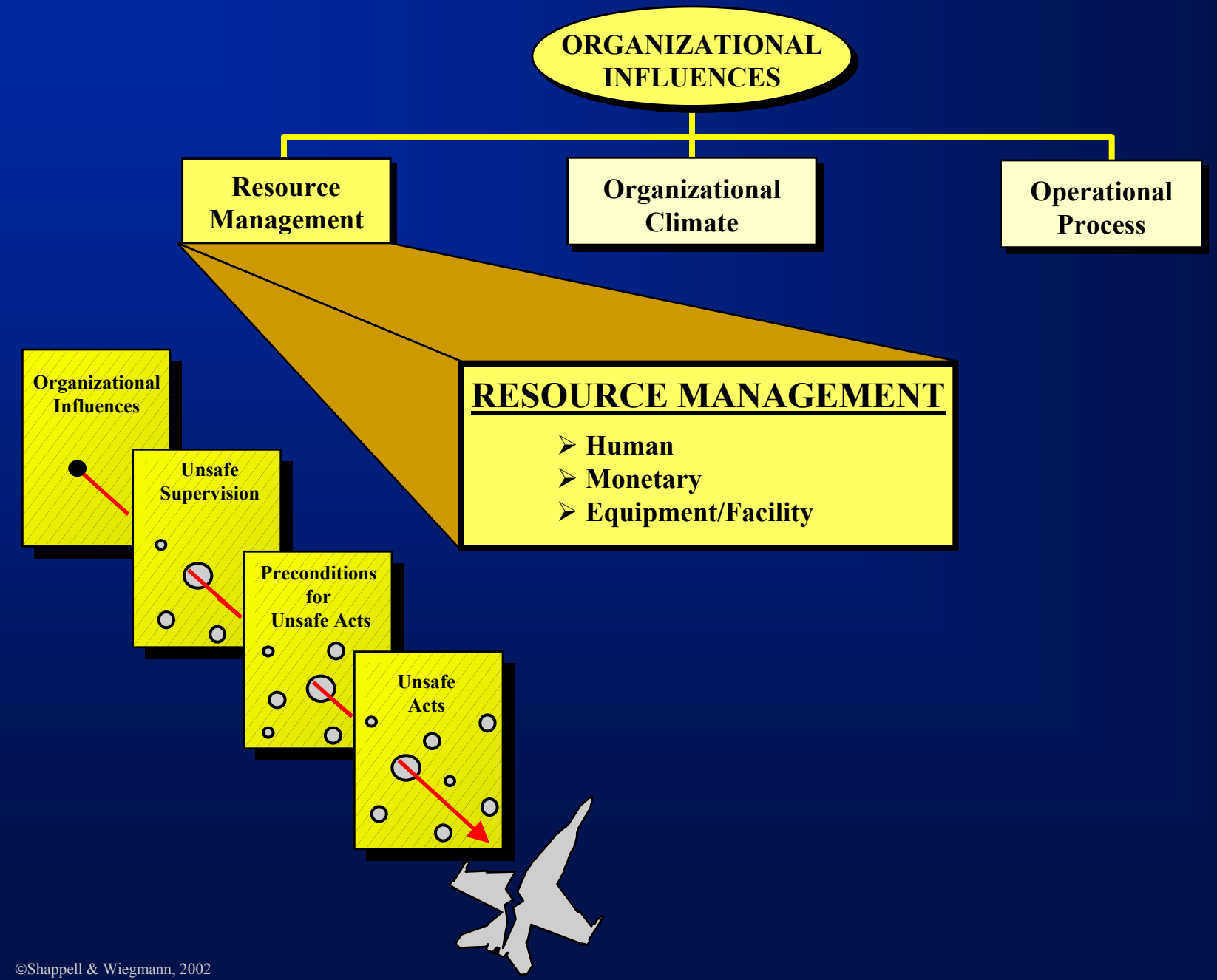


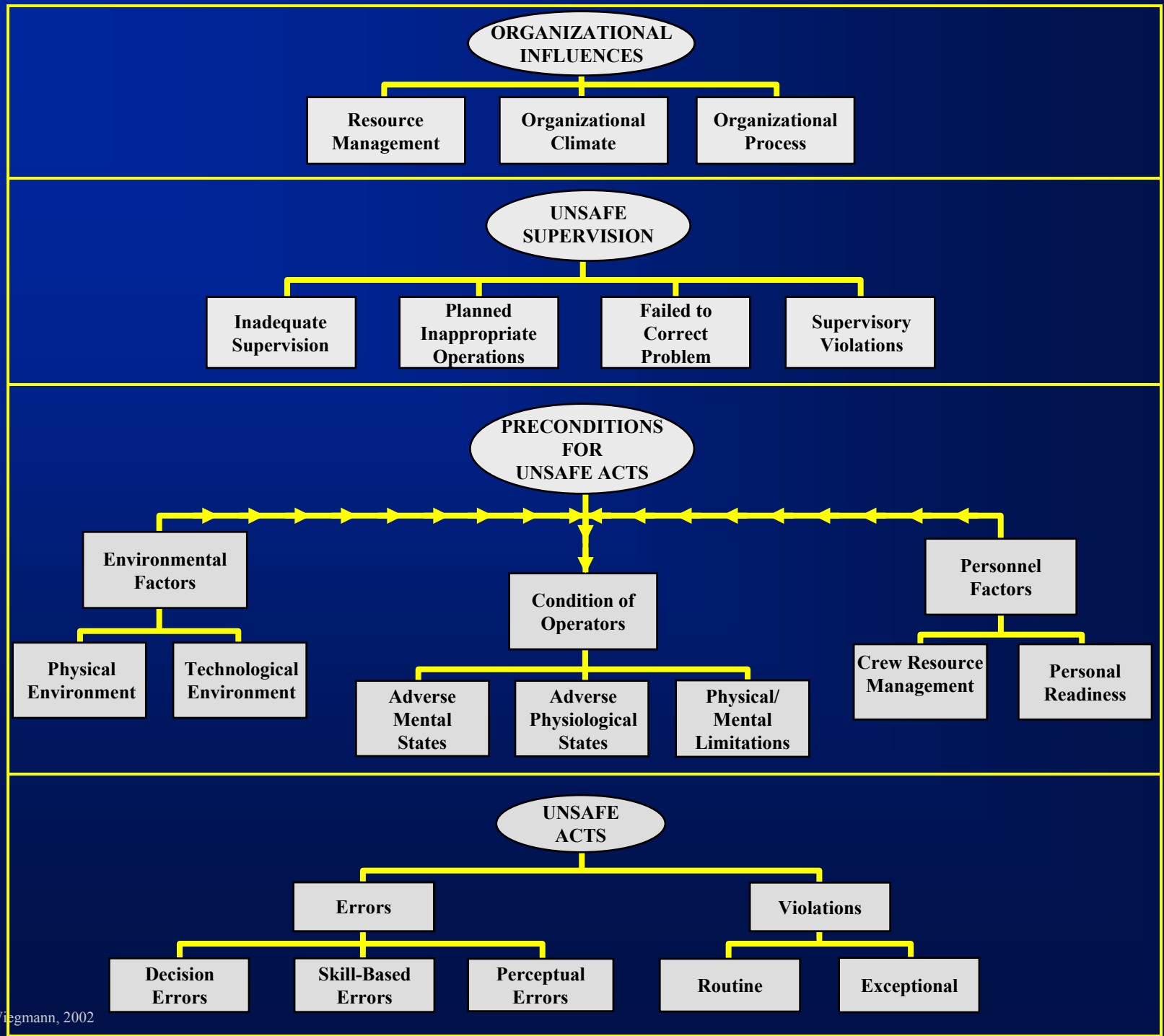


ORGANIZATIONAL INFLUENCES

- Resource Management
- Organizational Climate
- Operational Process

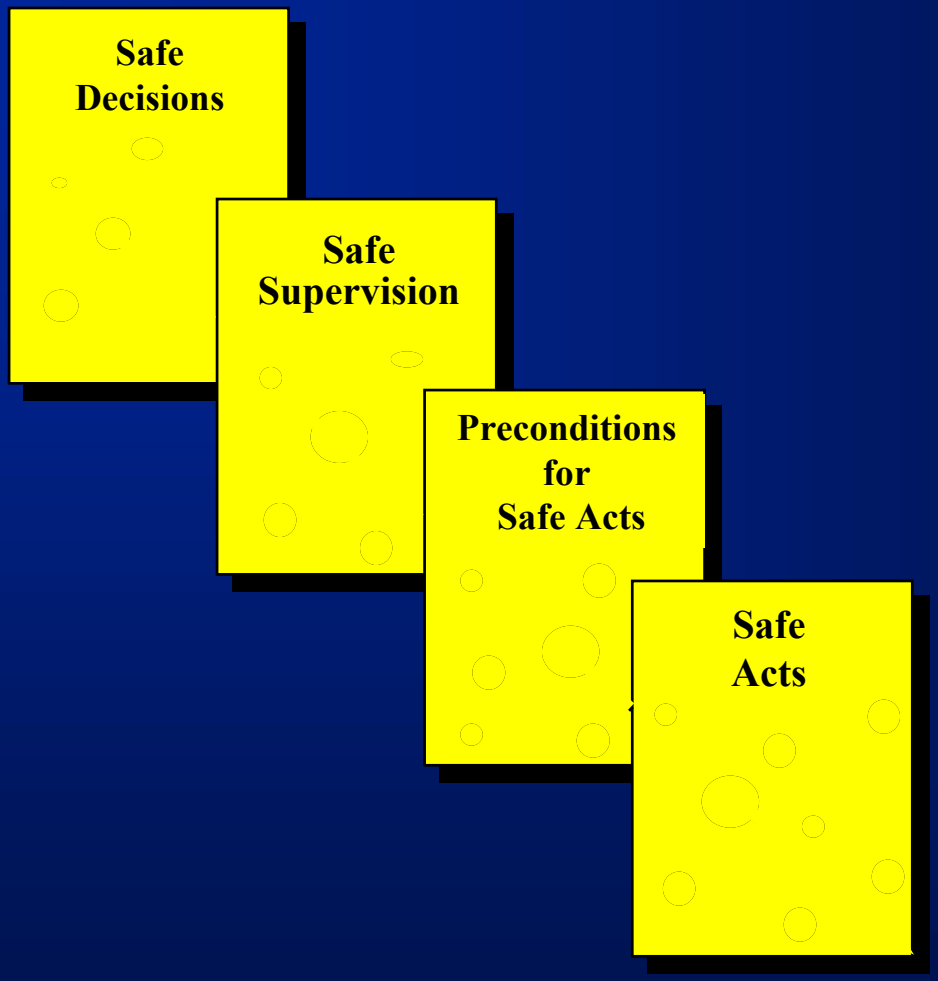


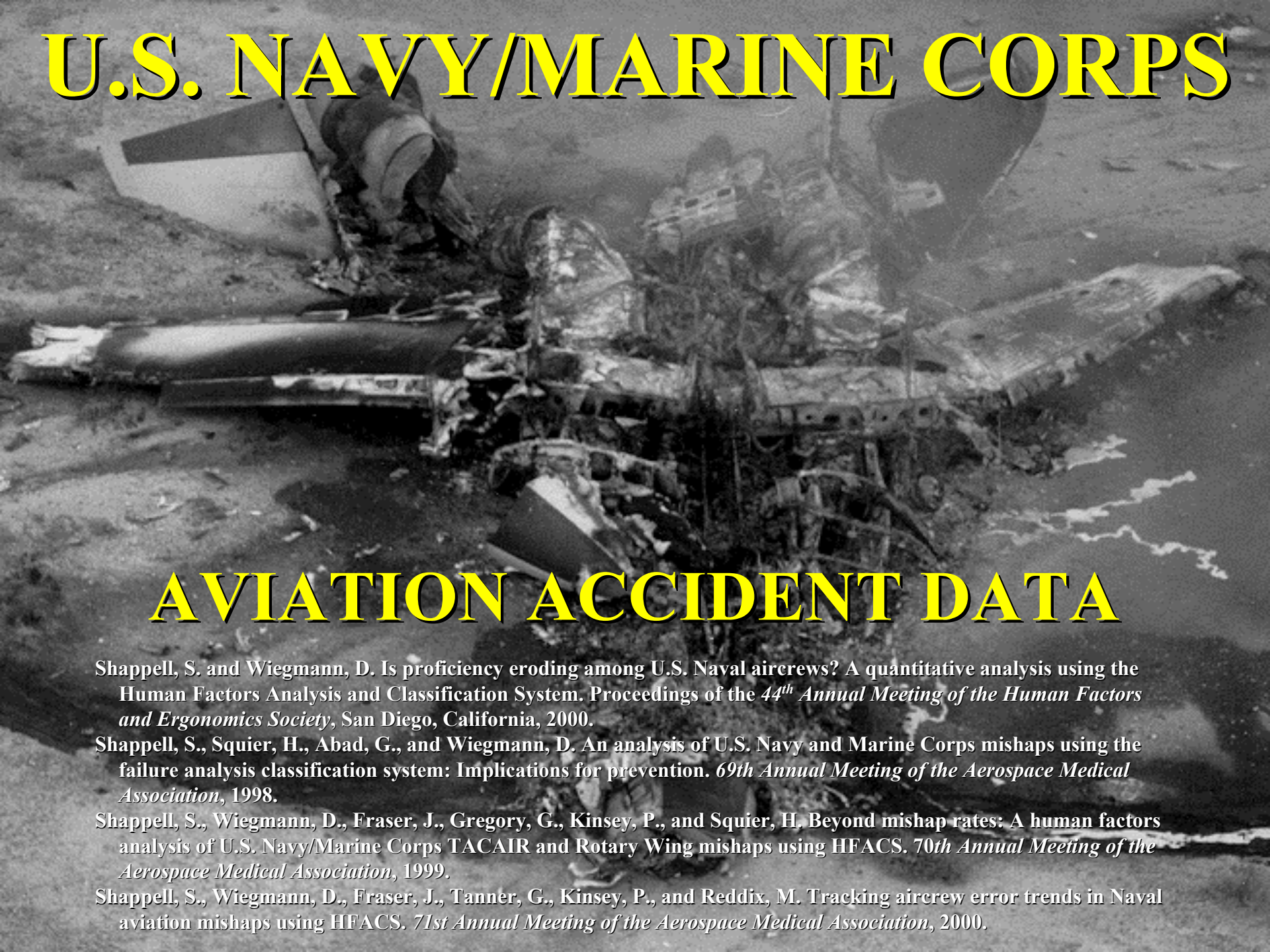





MARINES
10

Intervention: Filling the Holes in the Cheese





U.S. NAVY/MARINE CORPS

AVIATION ACCIDENT DATA

Shappell, S. and Wiegmann, D. Is proficiency eroding among U.S. Naval aircrews? A quantitative analysis using the Human Factors Analysis and Classification System. Proceedings of the *44th Annual Meeting of the Human Factors and Ergonomics Society*, San Diego, California, 2000.

Shappell, S., Squier, H., Abad, G., and Wiegmann, D. An analysis of U.S. Navy and Marine Corps mishaps using the failure analysis classification system: Implications for prevention. *69th Annual Meeting of the Aerospace Medical Association*, 1998.

Shappell, S., Wiegmann, D., Fraser, J., Gregory, G., Kinsey, P., and Squier, H. Beyond mishap rates: A human factors analysis of U.S. Navy/Marine Corps TACAIR and Rotary Wing mishaps using HFACS. 70*th Annual Meeting of the Aerospace Medical Association*, 1999.

Shappell, S., Wiegmann, D., Fraser, J., Tanner, G., Kinsey, P., and Reddix, M. Tracking aircrew error trends in Naval aviation mishaps using HFACS. *71st Annual Meeting of the Aerospace Medical Association*, 2000.

Sample of the Types of Human Error Typically Found

Aircraft Control Not Maintained
Procedures/Directives Not Followed
Abort Delayed
Airspeed (VREF) Not Maintained
APU Selected
Proper Touchdown Point Misjudged
Abort Above V1 Improper
Airspeed (VMC) Not Maintained
Autopilot Improper Use Of
Complacency
Control Interference Inadvertent
Crew/Group Coordination Not Maintained
Proper Touchdown Point Not Attained
Airspeed Not Maintained
Airspeed (VR) Improper
Autopilot Inadvertent Deactivation
Circuit Breaker Selected
Compensation for Wind Conditions Not Possible
Flare Improper
Unsafe/Hazardous Condition Not Identified
VFR Flight Into IMC Attempted
Flight Into Adverse Weather Continued
Hydraulic System Not Selected
Inadequate Surveillance of Operation
Proper Touchdown Point Not Possible
Aborted Takeoff Delayed
Airspeed (VLOF) Not Attained
Airspeed Excessive
Altimeter Setting Not Obtained
Altitude Not Maintained
Became Lost/Disoriented
Checklist Not Complied With
Crew/Group Coordination Not Performed
Flaps Improper Use Of
Flare Excessive
Flight into Known Adverse Weather Initialed
Go-Around Not Performed
Identification of Aircraft Visually Delayed
Inadequate Substantiation Process
Visual Separation Not Maintained
Minimum Descent Altitude Not Maintained
Wheels Up Landing Inadvertent
Aircraft Preflight Not Performed
Aircraft Weight and Balance Misjudged
Altimeter Not Used
Checklist Inaccurate

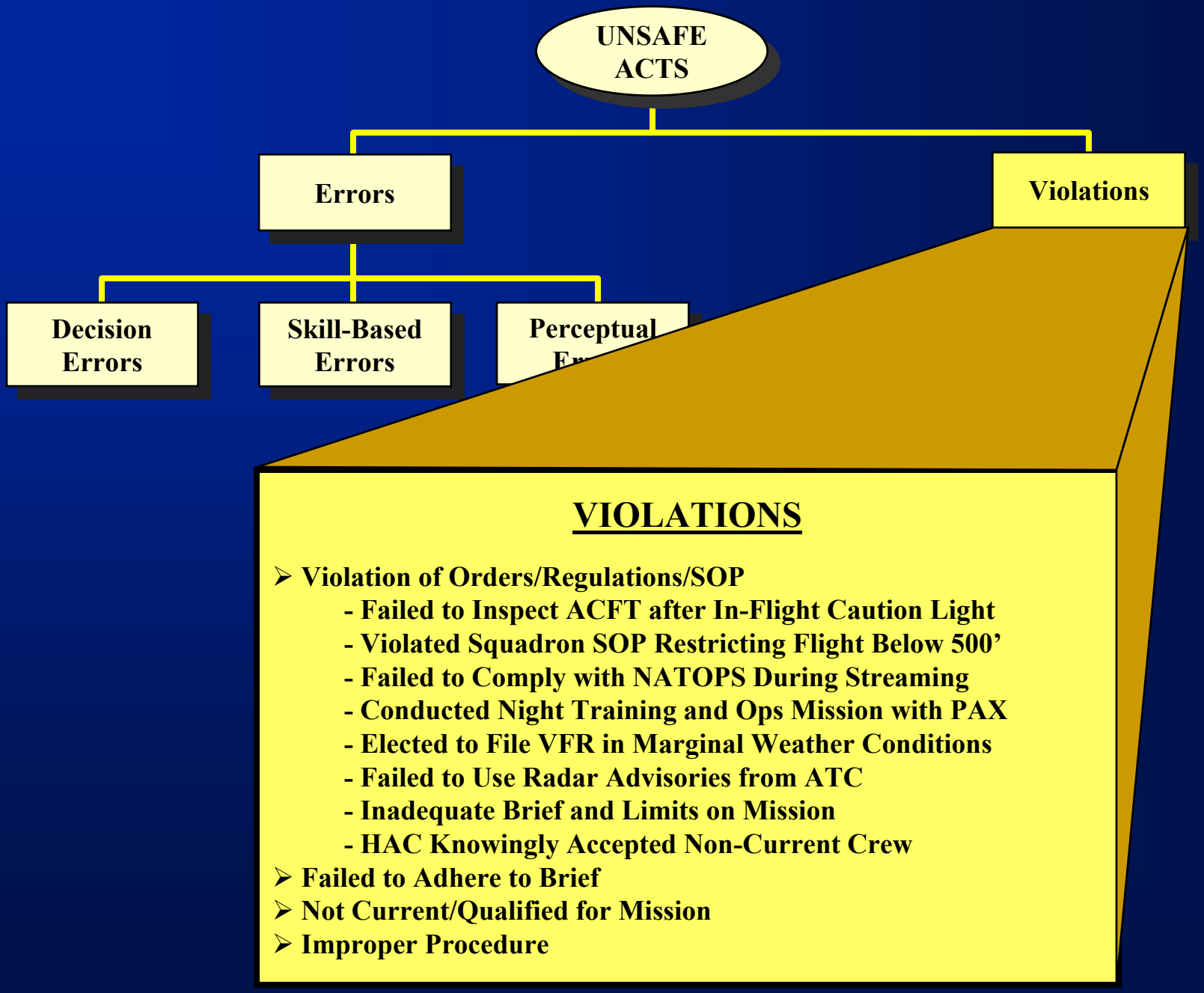
Compensation For Wind Conditions Inadequate
Descent Excessive
Distance Misjudged
Flare Delayed
Ground Loop/Swerve Intentional
Remedial Action Delayed
VFR Flight Into IMP Initiated
Visual Lookout Not Maintained
Abort Above V1 Performed
Compensation for Wind Conditions Improper
Directional Control Not Maintained
Diverted Attention
Ice/Frost Removal From Aircraft Inadequate
IFR Procedure Improper
Aircraft Control Not Possible
Stall Inadvertent
Inadequate Visual Lookout
Lack of Familiarity With Aircraft
Lack of Total Experience in Type of Aircraft
Lowering of Flaps Performed
Pressure
VFR Flight Into IMC Inadvertent
Aborted Takeoff Performed
Communications Not Understood
Emergency Procedure Not Followed
Inadequate Weather Evaluation
Nosewheel Steering Excessive
Procedure Inadequate
Rotation Excessive
VFR Flight into IMC Continued
Emergency Procedure Not Performed
Lack of Familiarity with Geographic Area
Level Off Not Attained
Maintenance, Adjustment Improper
Monitoring Inadequate
Propeller Feathering Not Performed
Remedial Action Not Possible
Visual/Aural Perception
Preflight Planning/Preparation Inadequate
Aircraft Handling Improper
Crew/Group Coordination Inadequate
Spoiler Extension Not Performed
Stall/Spin Inadvertent
Airspeed (VREF) Not Attained
Airspeed (VS) Not Maintained
Go-Around Delayed

Fatigue (Flight and Ground Schedule)
Flight to Alternation Not Performed
Operation with Known Deficiencies in Equipment
Spoiler Extension Inadvertent Activation
Supervision Inadequate
Planning/Decision improper
Raising of Flaps Improper
In-Flight Planning/Decision Improper
Overconfidence in Personal Ability
Parking Brake Not Set
Expectancy
Flight Manuals Improper Use Of
Wrong Taxi Route Selected
Gear Extension Not Performed
Weather Evaluation Inadequate
Stall/Mush Encountered
Parking Brakes Inadvertent Deactivation
In-Flight Planning/Decision Poor
Proper Glidepath Not Maintained
Altitude Inadequate
Conditions/Steps Insufficiently Defined
Evacuation Improper
Passenger Briefing Inadequate
Spatial Disorientation
Throttle/Power Control Improper Use Of
Weather Evaluation Inaccurate
Wrong Runway Selected
Ice/Frost Removal From Aircraft Not Identified
Planned Approach Poor
Recovery from Bounced Landing Improper
Planning/Decision Inadequate
Aircraft Preflight Inadequate
Checklist Inadequate
Descent Inadvertent
Generator Inadvertent Deactivation
Touchdown Inadvertent
Preflight Planning/Preparation Improper
Compensation for Wind Conditions Misjudged
Visual Illusion
Uncontrolled Descent
Proper Descent Rate Not Maintained
Checklist Not Used
Anti-Ice/Deice System Not Used
Inadequate Monitoring
Powerplant Controls Inadvertent Activation
Traffic Advisory Not Identified

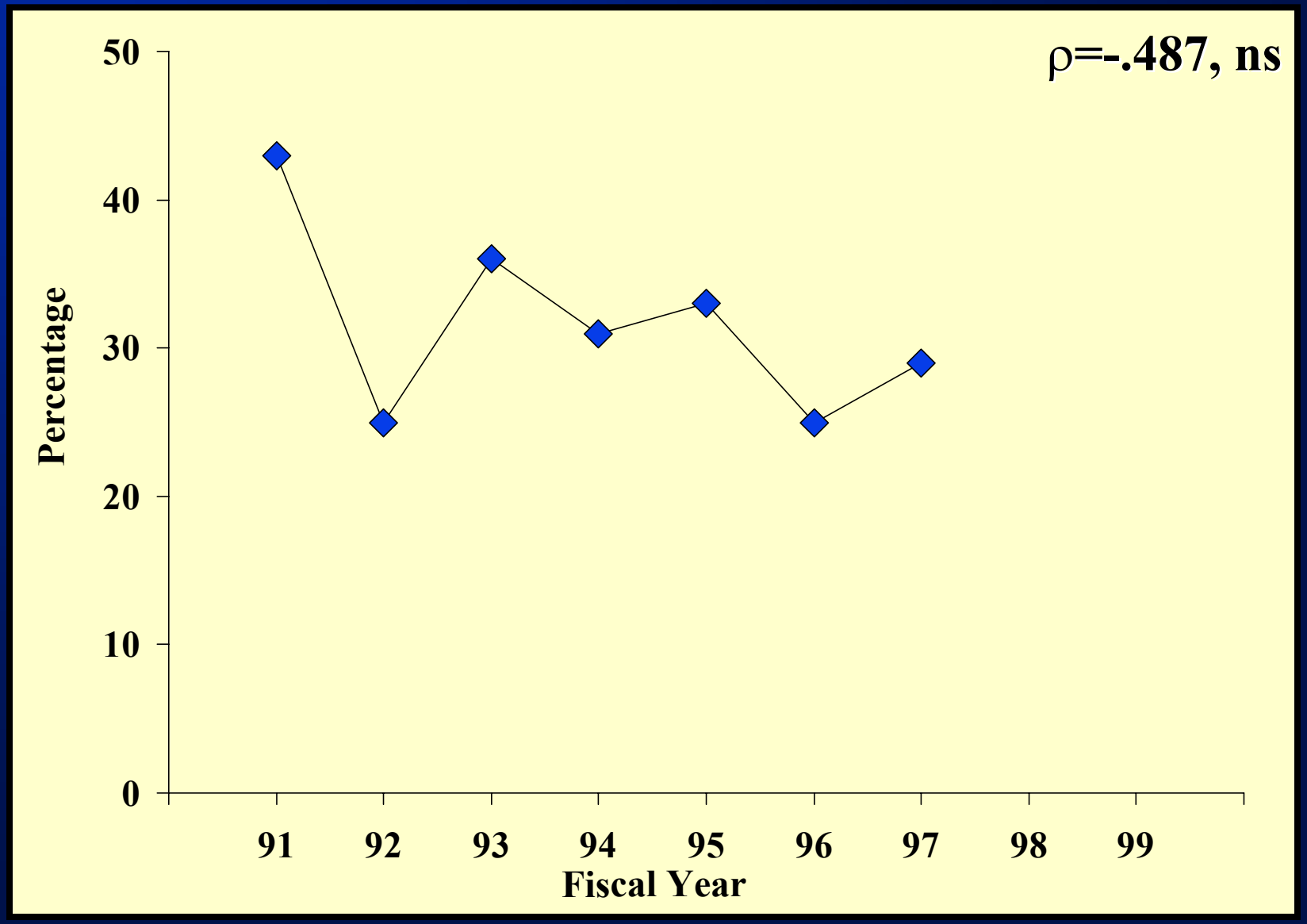
Clearance Misjudged
IFR Procedure Not Followed
Inattentive
Remedial Action Attempted
Someone Goofed
Improper Use of Preflight Briefing Service
Descent Premature
Proper Descent Rate Not Attained
Airspeed Not Maintained (generic)
Inadvertent Stall
Visual Lookout Inadequate
Ice/Frost Removal From Aircraft Nor Performed
Information Insufficient
Self-Induced Pressure
Trim Setting Improper
Flight Controls Improper Use Of
Altitude/Clearance Not Maintained
Maneuver Performed
Preflight Planning/Preparation Poor
Proper Altitude Not Maintained
Flare Initiated
Flight Advisories Not Followed
Altitude/Clearance Inadequate
Distance/Altitude Misjudged
Inadequate Training
Rotation Improper
Unsuitable Terrain or Takeoff/Landing/Taxi Area
VFR Procedures Inadequate
Proper Alignment Not Possible
Remedial Action Improper
Flare Misjudged
Proper Alignment Delayed
Missed Approach Not Performed
Proper Alignment Not Attained
Lack of Total Experience in Type Operation
Minimum Descent Altitude Below
Miscellaneous Equipment Initiated
Proper Alignment Not Maintained
Supervision Improper
Gear Down and Locked Not Verified
Wind Information Misjudged
Aircraft Weight and Balance Exceeded
Aircraft Control-Uncontrolled
Crew/Group Coordination Not Attained
Checklist Not Followed
Clearance Not Maintained

Number and Percentage of Mishaps Associated with Each HFACS Causal Category (FY 91-99)

	USMC n=73		USN n=105	
	Count	(%)	Count	(%)
Organizational Influences				
Resource Management	17	(23)	32	(30)
Organizational Climate	0	(0)	1	(1)
Organizational Process	19	(26)	39	(37)
Unsafe Supervision				
Inadequate Supervision	18	(25)	27	(26)
Planned Inappropriate Operations	9	(12)	11	(10)
Failed to Correct a Known Problem	4	(5)	10	(10)
Supervisory Violations	8	(11)	11	(10)
Preconditions for Unsafe Acts				
Adverse Mental States	57	(78)	79	(75)
Adverse Physiological States	18	(25)	27	(26)
Physical/Mental Limitations	7	(10)	11	(10)
Crew Resource Mismanagement	40	(55)	69	(66)
Personal Readiness	2	(3)	5	(5)
Unsafe Acts				
Decision Errors	36	(49)	64	(61)
Skill-based Errors	38	(52)	57	(54)
Perceptual Errors	23	(32)	28	(27)
Violations	22	(30)	33	(31)



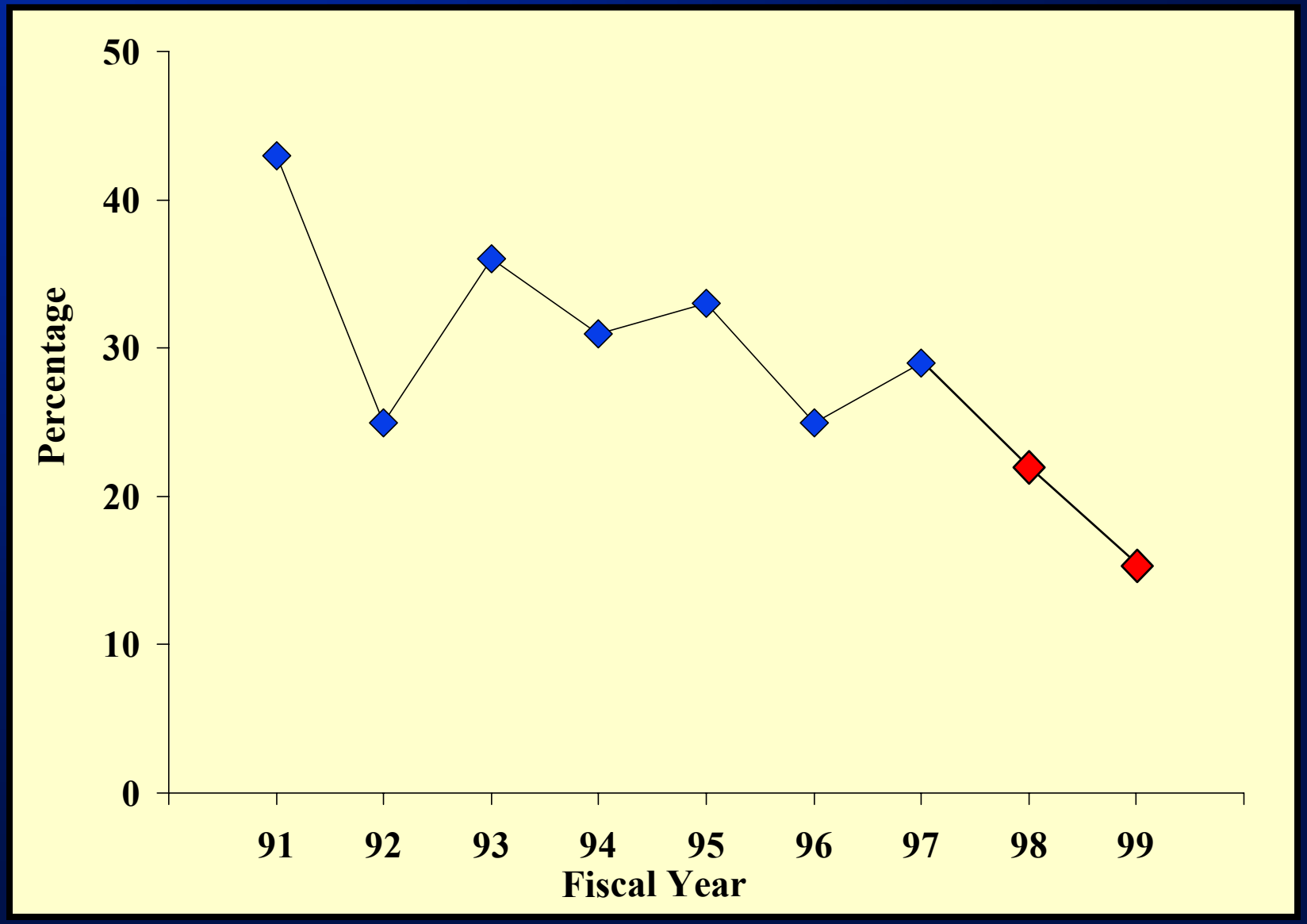
Percentage of Human Error Mishaps Associated with Violations (FY 91-97)

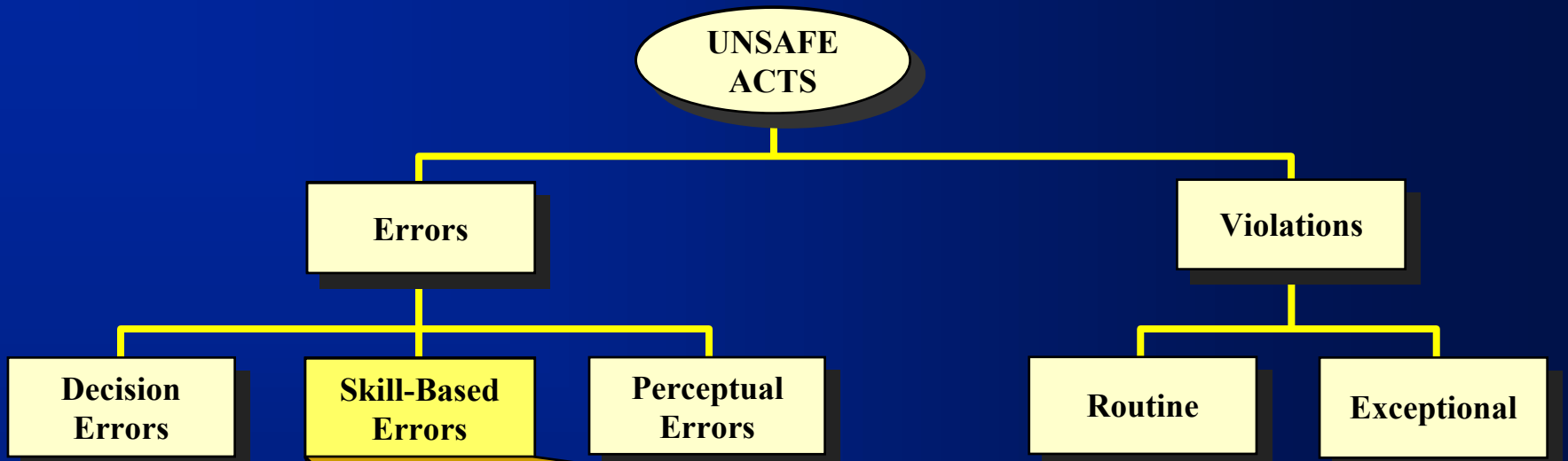


Intervention Strategy

- Professionalism
- Accountability
- Enforcing the Rules

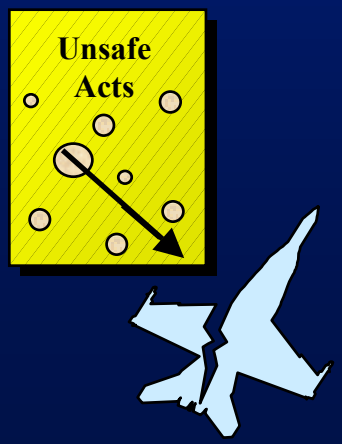
Percentage of Human Error Mishaps Associated with Violations (FY 91-99)



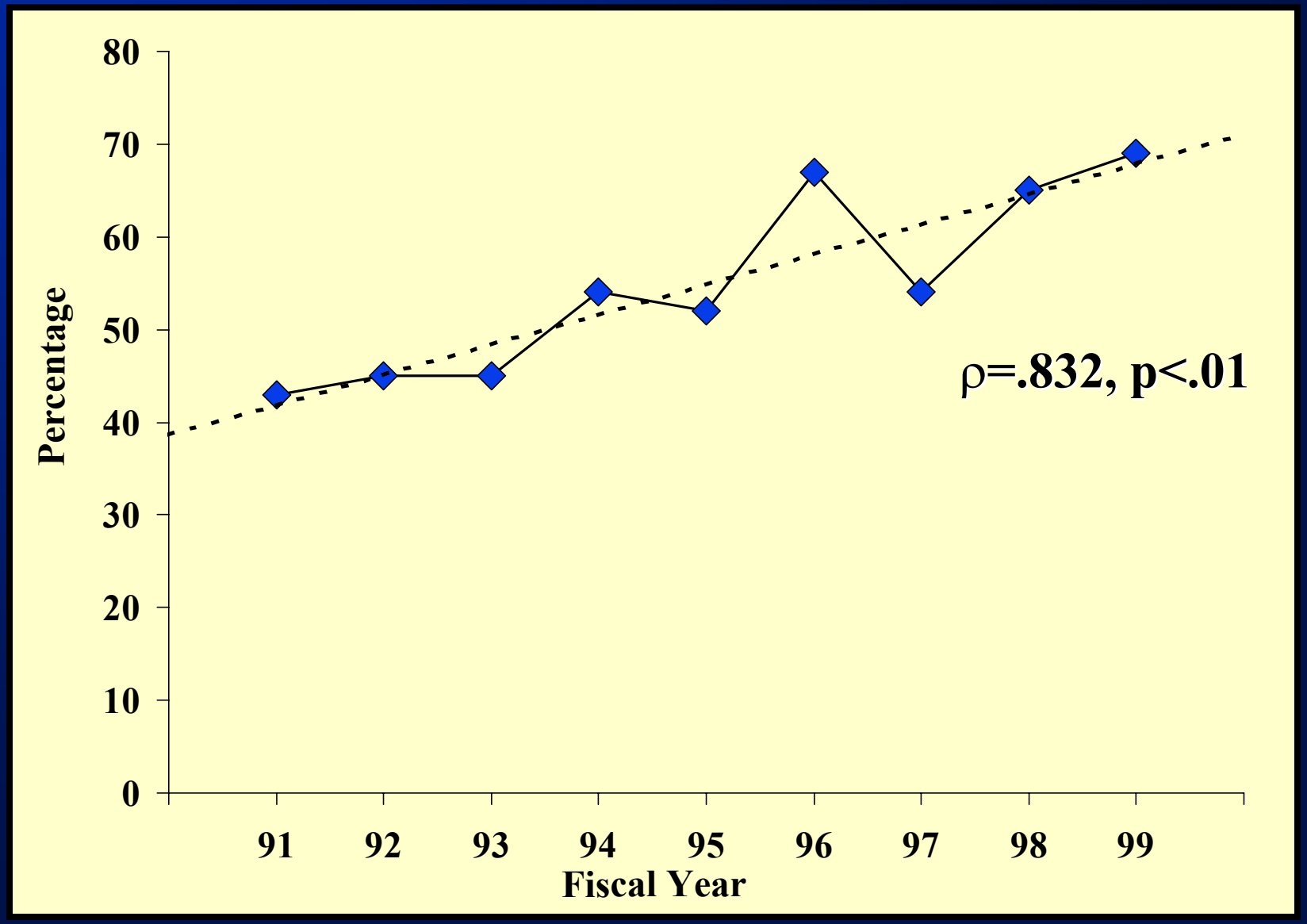


SKILL-BASED ERRORS

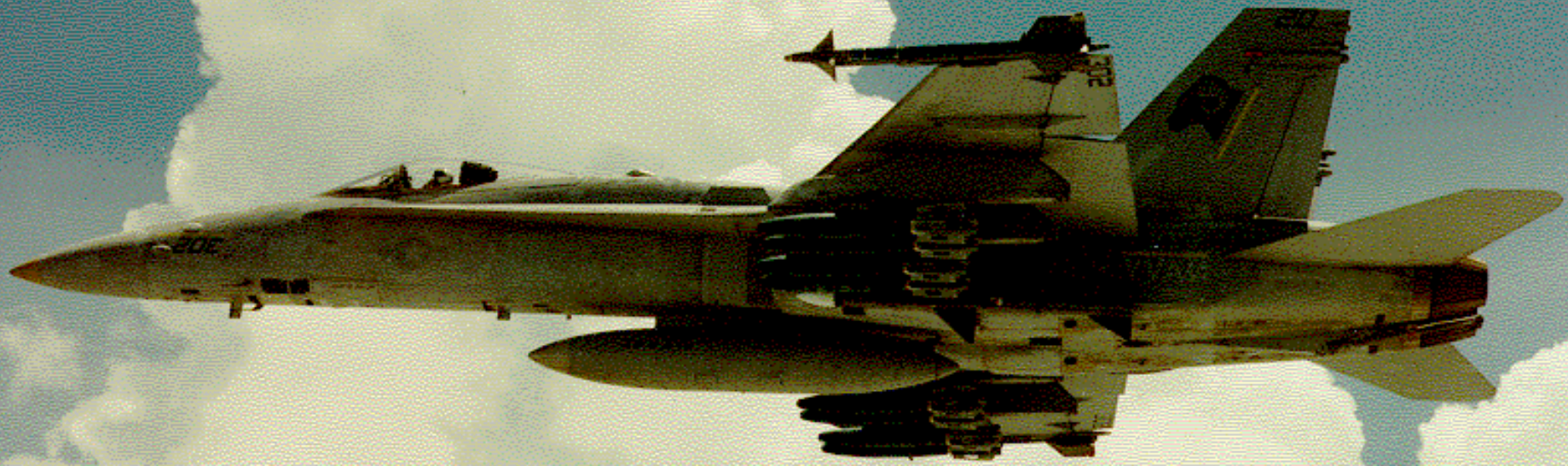
- Breakdown in Visual Scan
- Failed to See and Avoid
- Poor Technique
- Omitted Checklist Item
- Inadvertent Operation of Control
- Improper Use of Flight Controls



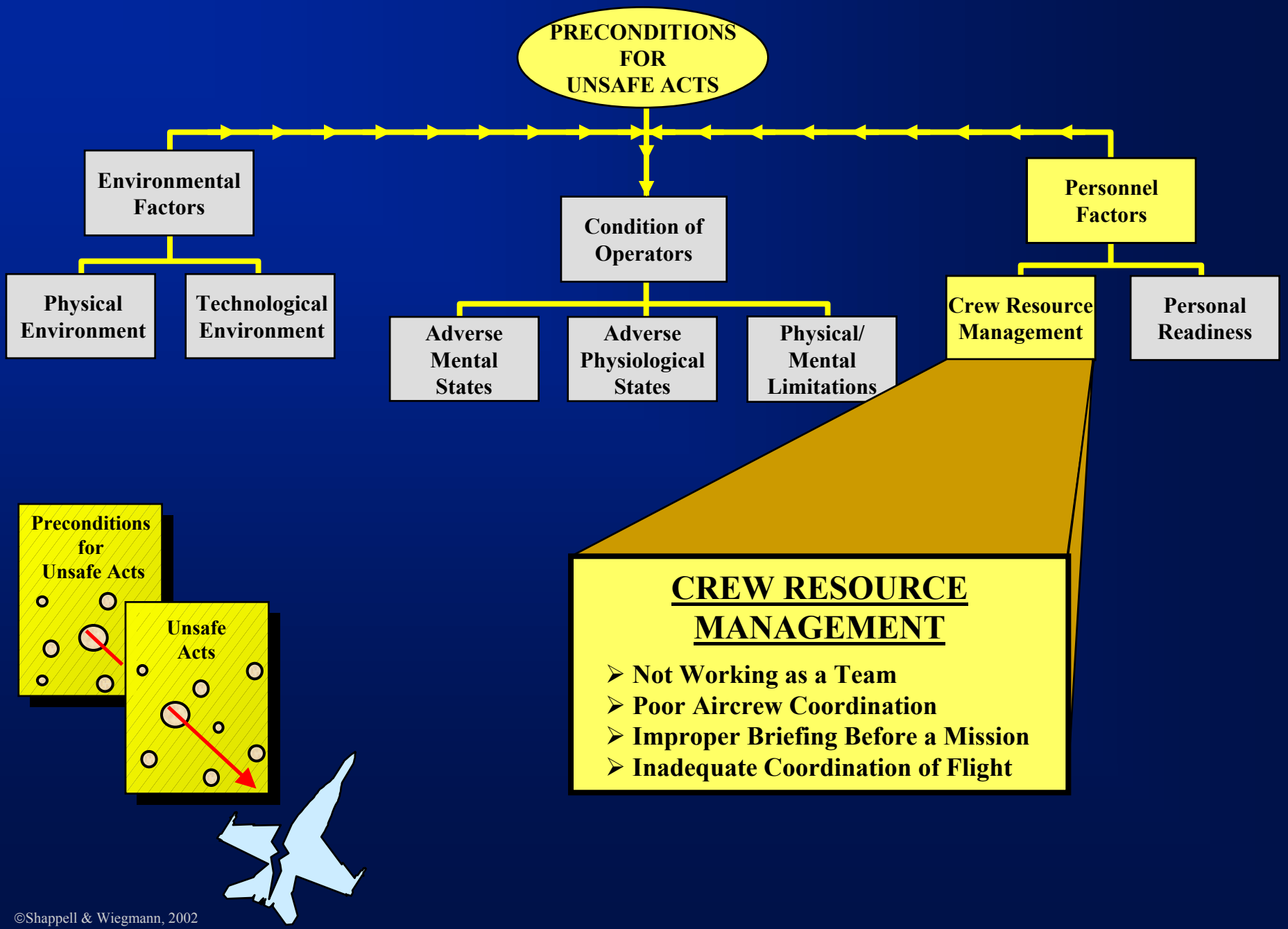
Percentage of Human Error Mishaps Associated with Skill-based Errors (FY 91-99)



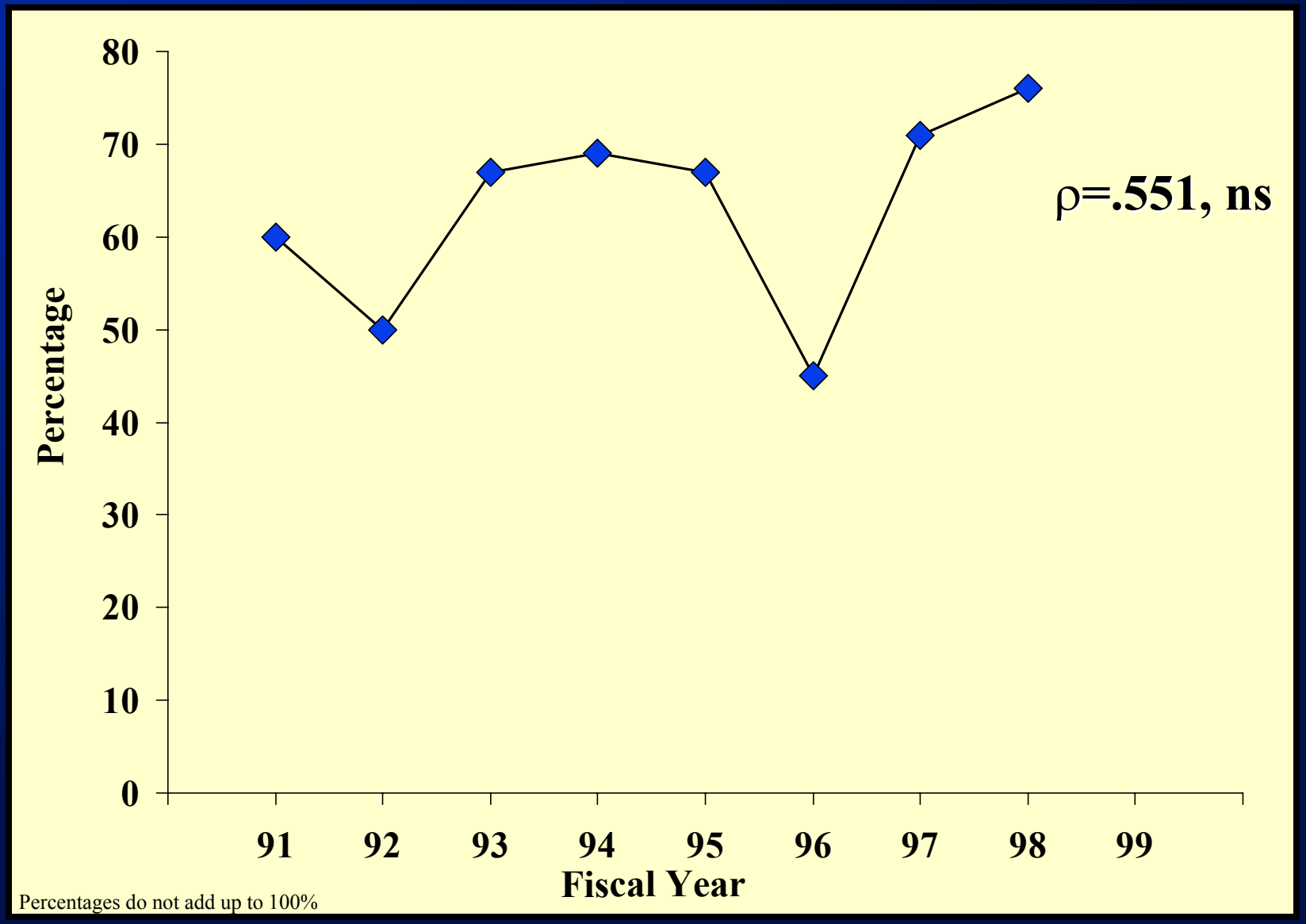
Preliminary Intervention Strategy



- Improve instrument scan
- Prioritizing attention
- Recognizing extremis situations
- Refine basic flight skills (Stick-and-Rudder)
- Practice procedures
- Review the mishap database!



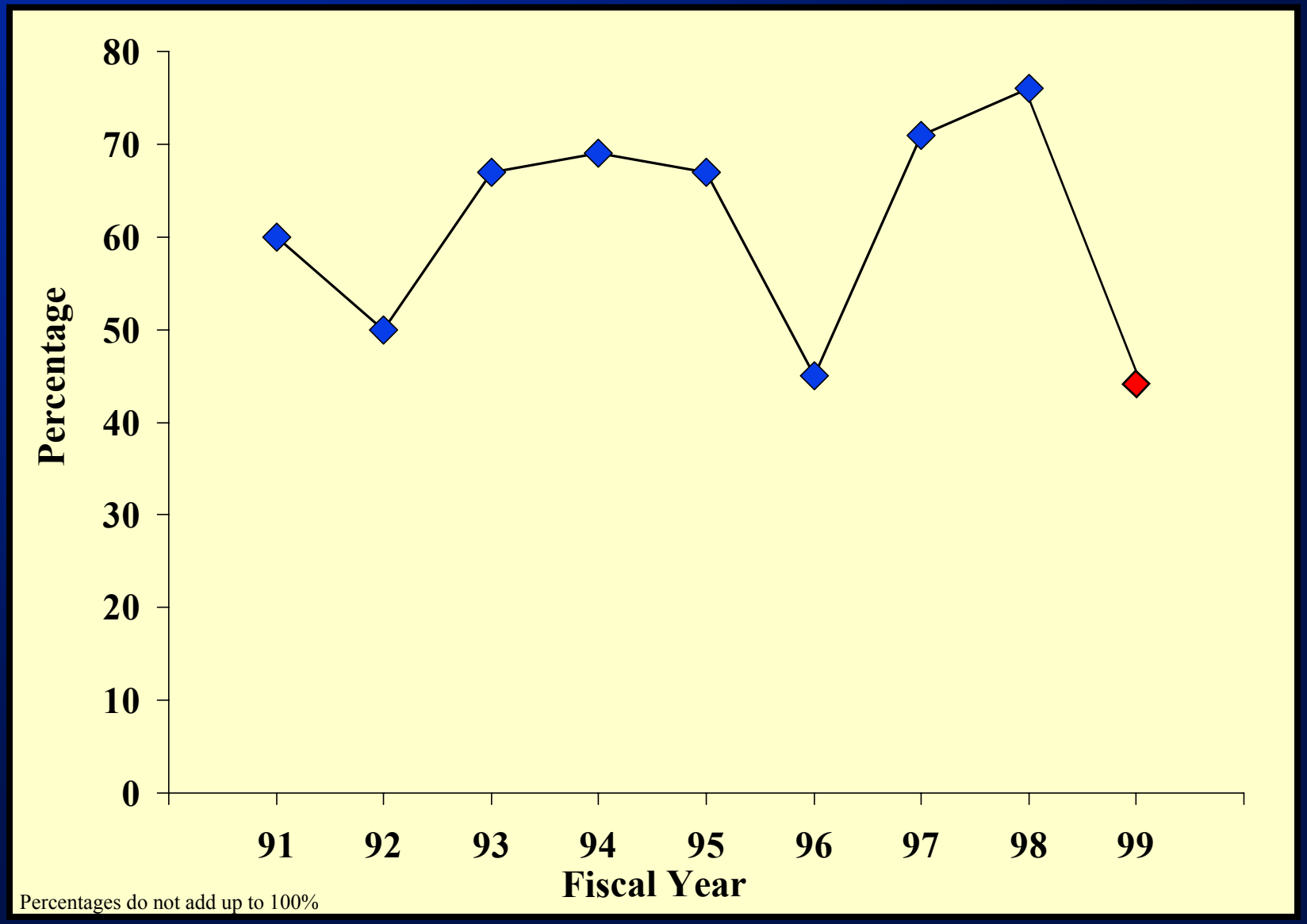
Percentage of Human Error Mishaps Associated with Crew Resource Management Failures (FY 91-98)



Preliminary Intervention Strategy

- Platform specific training
- Use of video feedback
- Restructure tasks (i.e., EP's)
- Change group composition
- Attempt to change attitudes
- Additional research...

Percentage of Human Error Mishaps Associated with Crew Resource Management Failures (FY 91-99)



Research Sponsors

- FAA, DoD, NASA, & Airlines provide funding for safety research programs.
- Research programs are needs-based and data-driven. Interventions are therefore very effective.

Data-Driven **Research**

Effective **Intervention and Prevention Programs**

Prevention

Mitigation

Human Error

- Errors occur less frequently.
- Safety programs are effective at preventing the occurrence or consequences of these errors.

ACCIDENT

Accident Investigation

- Sophisticated techniques and procedures
- Information is qualitative and quantitative
- Focus on both "what" happened and "why"

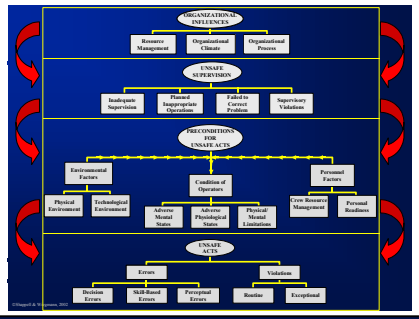
Accident Database

- Designed around a well-known human error framework
- Well-defined variables
- Organization and structure easy to understand

Database Analysis

- Traditional human factors analyses are much less onerous due to well-defined variables and error database
- Analyses can now be performed to identify human factors safety issues

HFACS



Feedback

HFACS can be applied anywhere!