



Evaluation of Aircraft Slide Evacuation Injuries

Vahid Motevalli, Ph.D., PE
Layla Monajemi
Maryline Rassi

Aviation Institute
The George Washington University

**The Fifth Triennial International
Fire & Cabin Safety Research Conference**
Atlantic City, USA
29 Oct. – 1 Nov. 2007

Acknowledgement and Disclaimer

This research has been supported in part by a contract from the Transportation Research Board (TRB) of the National Academies under the Airport Cooperative Research Program (Project 11-02 Task 3) and the George Washington University funds for Area of Excellence in Transportation Safety and Security. The information, data, discussions and conclusions presented here only represents the authors views and have not been reviewed by the TRB as is required.



Introduction

- Emergency evacuation of commercial aircrafts can occur under a number of circumstances such as:
 - Survivable crash scenarios
 - Precautionary emergency landings (e.g. smoke in the cabin)
 - Actual emergencies (e.g. confirmed fire, fuel leak, engine fire, damage to aircraft)
 - Un-commanded evacuations
 - Security related evacuations



Environment of Evacuations



Accident Date:20 AUG 2007 **Time:**10:35
Type: Boeing 737-809
Operator: China Airlines
Location: Okinawa-Naha Airport (OKA) (Japan)



Accident Date:11 AUG 2004
Type: Boeing 777
Operator: British Airways
Location: Houston Int'l Airport (IAH)



Accident Date:2 AUG 2005 **Time:**
Type: Airbus 340
Operator: Air France
Location: Toronto, Canada

Introduction

- This study examines injuries associated with emergency evacuation of commercial aircrafts using inflatable slides and operated under provisions of 14 CFR Part 121
- It is hoped that the findings from this study will improve the evacuations in the following areas:
 - Reduction of injuries
 - Improvement in interaction between first responders and airline crew
- Study Period: January 1st, 1996 to June 30th, 2006
- Large aircraft evacuation, effect of wind & international and other recent events are also considered



Evacuation Slide Requirements

- Each non over-wing; Type A, Type B, or Type C exits, and any other non over-wing emergency exit more than 6 feet from the ground must have an approved means to assist occupants in descending to the ground. (Code of Federal Regulations 14CFR § 25.810)
 - Type A: floor-level exit: > 42 inches x 72 inches
 - Type B: floor-level exit: > 32 inches x 72 inches
 - Type C: floor-level exit: > 30 inches x 48 inches
- Boeing 707-747
- DC 8 – MD 11
- Airbus 300-380
- RJ 70 – 100
- Embraer 170-195



Regulatory Requirement for Slide Evacuation

- Evacuate all the passengers and crew in 90 seconds through half of the available aircraft exits
- Inflatable slides must be:
 - Automatically deploy and erect in 6 seconds (except for assisting means installed at Type C exits)
 - Such length that after full deployment, the lower end is self-supporting on the ground and provides safe evacuation of occupants to the ground after collapse of one or more legs of the landing gear
 - It must have the capability, in 25 knot winds directed from the most critical angle, to deploy and, with the assistance of only one person, to remain usable after full deployment to evacuate occupants safely to the ground.



Literature Search

- Previous studies on different aspects of commercial aircraft evacuation can be summarized as following:
 - Evacuee injuries and demographics in transport airplane precautionary emergency evacuation (Hynes, 2000)
 - Frequency and costs of transport airplane precautionary emergency evacuations (Hynes, 1999)
 - Emergency evacuation of commercial airplanes (NTSB, 2000)



Scope of Study

- The following parameters are used to identify and compile relevant emergency evacuation events:
 - US air transport operations under part 121 (both scheduled and non-scheduled)
 - Deployment of inflatable slides during part 121 operations
 - Inclusion of both accidents and incidents as defined by NTSB and FAA



Study Resources & Databases

- FAA incident data base, Aviation safety information analysis and sharing (ASIAS) formerly known as NASDAC
- NTSB's accident database
- CASE database produced by Airclaims, Limited
- RGW Cherry & Associates limited
- Survey conducted from ARFF units at the major airports throughout the country
- Service difficulty report
- Aviation Safety Reporting System (ASRS)
- Individual airlines

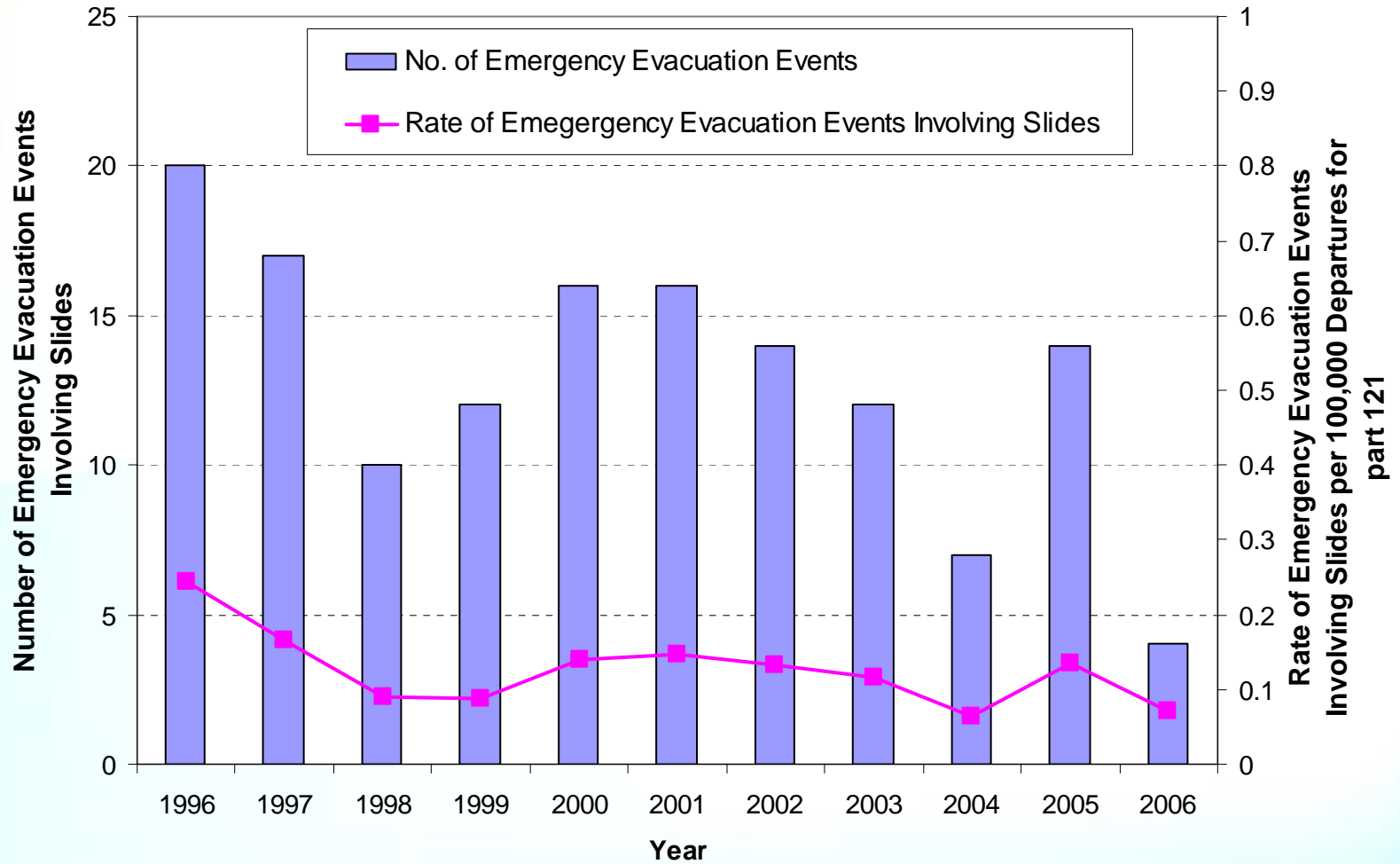


Issues Surrounding Collection of Data

- Many evacuation incidents are not formally reported and certainly not investigated
- Lack of detailed reports
- Lack of information on type of injuries
- Legal barriers to obtaining information from airlines
- Lack of process and procedure by Airport Rescue and Fire Fighting (ARFF) to collect information

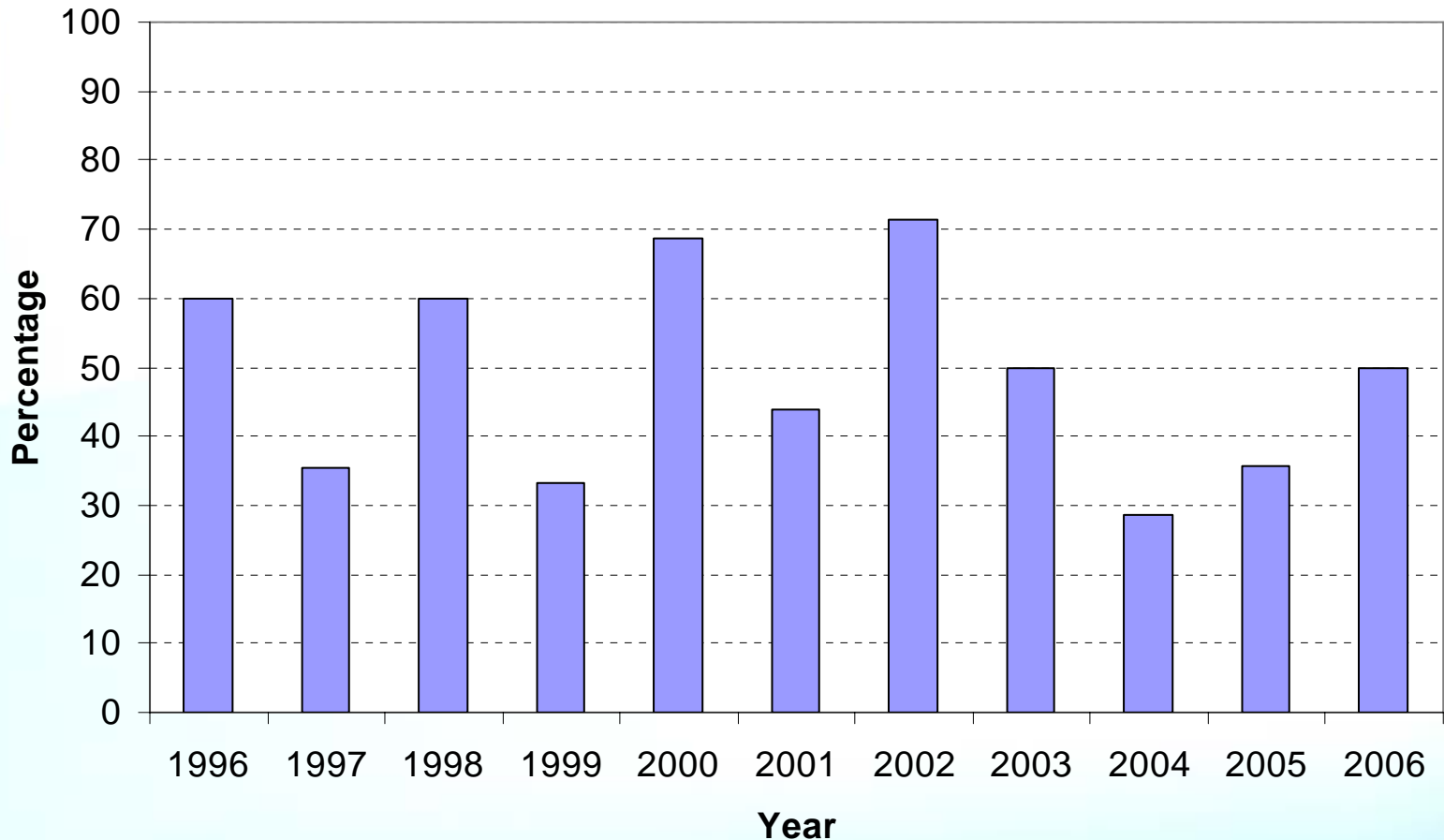


Data Analysis



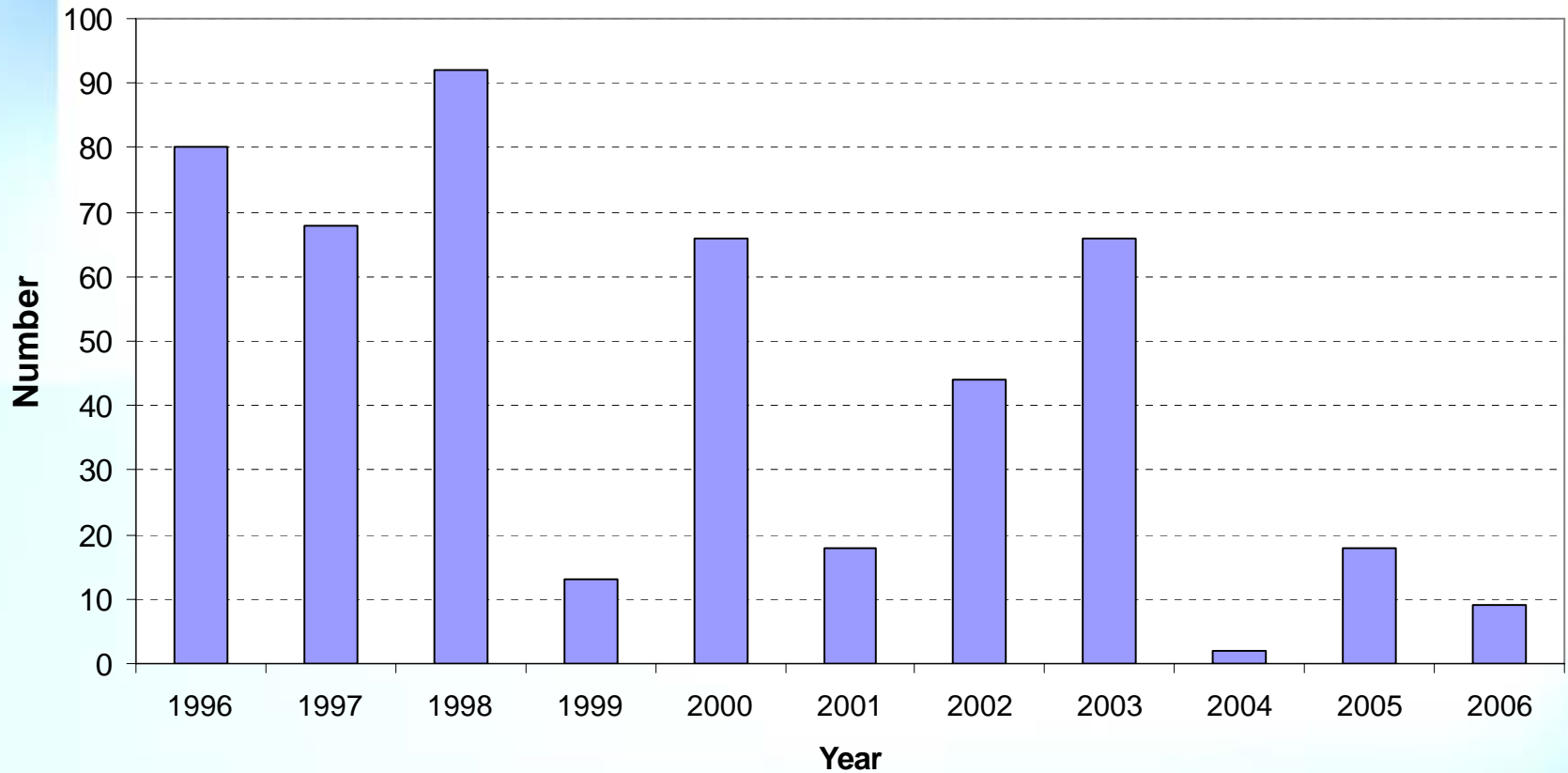
Data Analysis

Percentage of emergency evacuation events resulting in injury due to use of slide



Data Analysis

Number of Reported Injuries per Year during Emergency Slide Evacuation

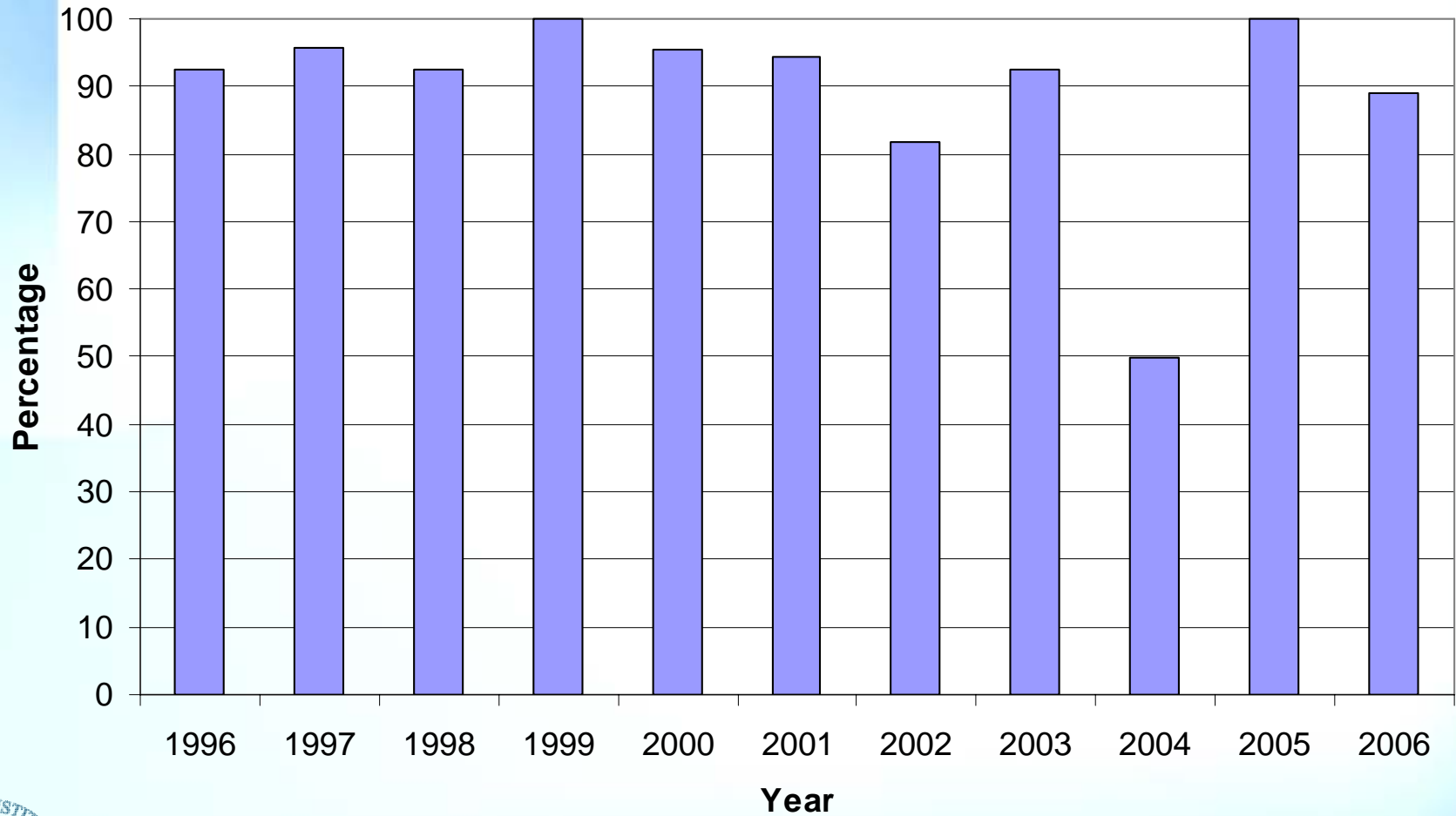


Data Analysis

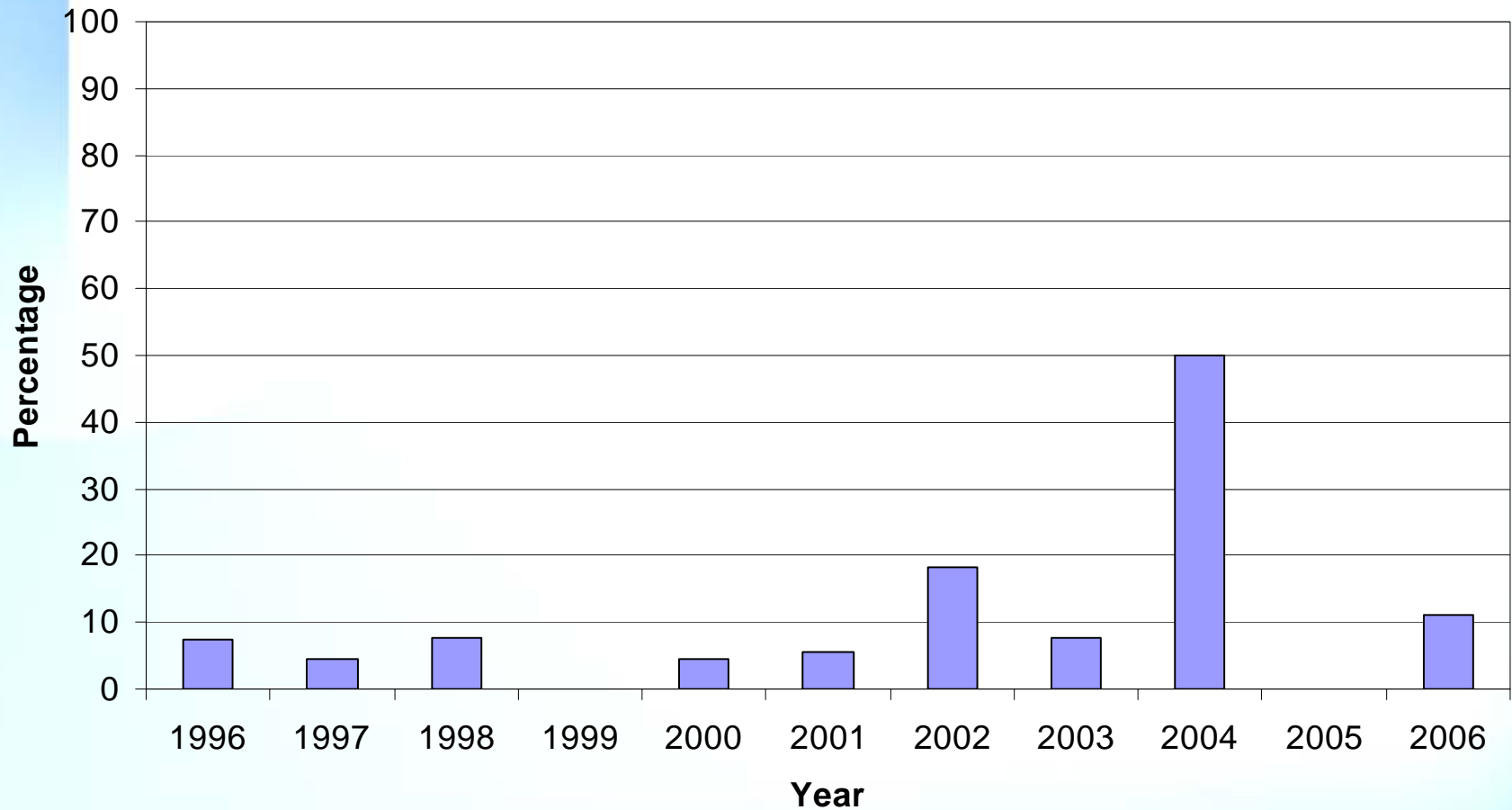
- 142 collected cases involved:
 - 441 minor injuries (detailed information on 113 cases is available)
 - 35 serious injuries (detailed information on 12 cases are available)

Minor Injuries	Serious Injuries
Sprain	Fractured ankle
Friction abrasions	Broken leg
Scrapes from slides	Major Bruises
Strain	Laceration
Abrasions	
Contusion	

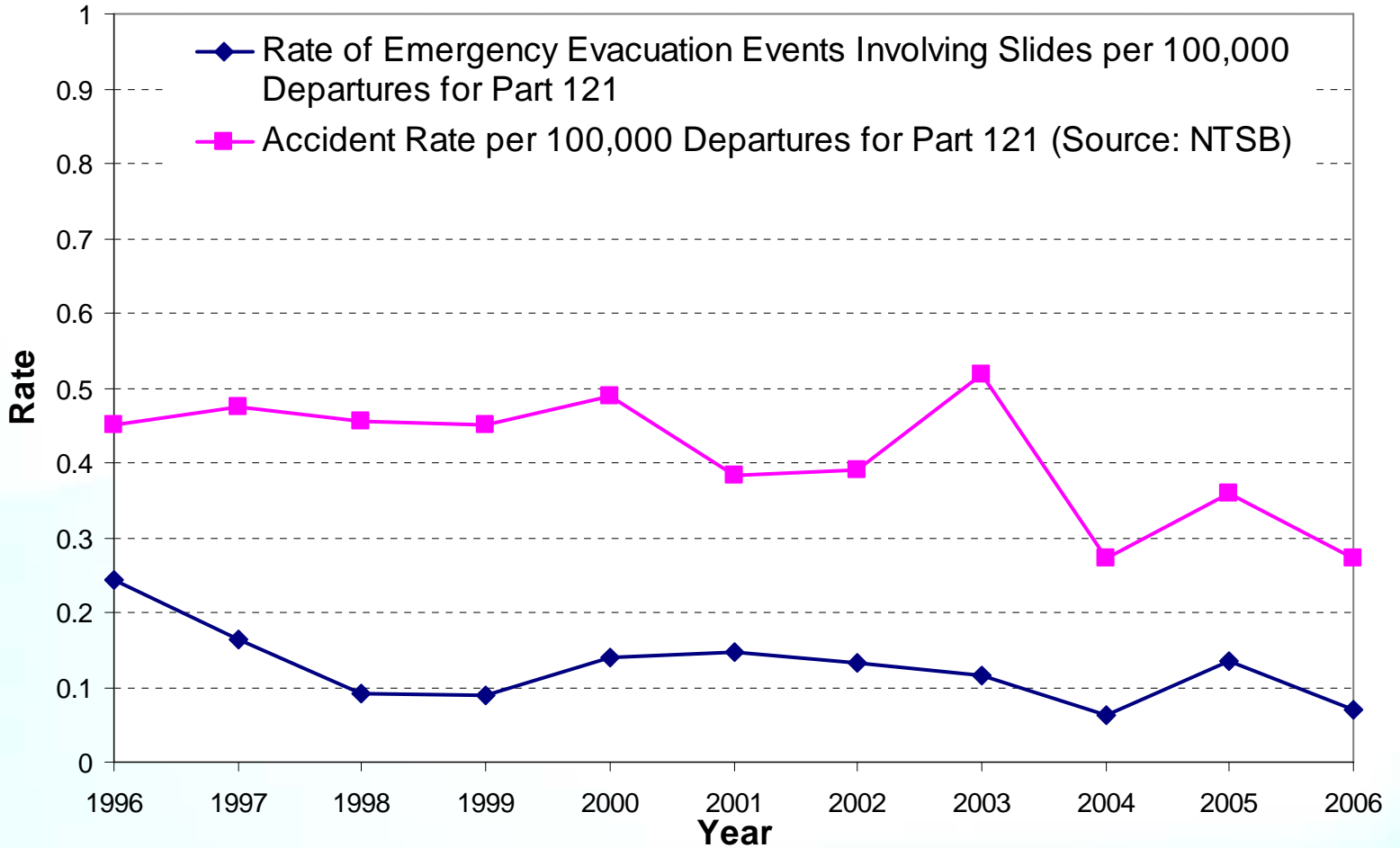
Minor Injuries during Slide Evacuation



Serious Injuries during Emergency Slide Evacuation



Accident Rate



Injury Mechanisms

- Predominant causes of injuries are:
 - Friction from slide surface
 - Impact with the ground at the bottom of the slide
 - Falling forward onto the pavement after reaching bottom of the slide
 - Assisting other passengers with exiting the slide at the bottom
 - Anxiety from evacuation



Emergency Evacuation of Large Transport Aircrafts

- From 142 emergency evacuation events only 2 of them involved B747 aircrafts
 - August 19th, 2005 in Agana, Guam
 - 2 minor injuries during slide evacuation
 - Detailed injury mechanisms are not available
 - May 1998 in Tokyo
 - 385 persons onboard, 4 serious injuries and 20 minor
 - Serious injuries were female passengers aged between 38 & 73 and consisted of different types of fractures
 - Minor injuries suffered mostly from bruises, sprains, contusions, exonerations, and abrasions



A380 Emergency Evacuation

- On March 26th, 2006 A380 emergency evacuation certification was performed
 - No serious injuries
 - Very few minor injuries which were significantly less than the “official” 5% acceptable FAA percent injury rate
 - Evacuation was performed in 78 seconds
 - “No difference was found in the behavior of passengers evacuating from main deck and those evacuating from upper deck” (from Airbus Report)



Using inflatable slides under adverse wind conditions

- As dictated by Code of Federal Regulations (14CFR § 25.810) inflatable slides must have the capability, in 25 knot winds directed from the most critical angle, to deploy and, with the assistance of only one person, to remain usable after full deployment to evacuate occupants safely to the ground.



Using inflatable slides under adverse wind conditions

- From 142 emergency evacuation events only one event occurred under adverse wind condition
 - March 6th, 2001 in Boston which resulted in no injuries
 - Wind was blowing at 35k, gusts to 55k
 - Slide was deployed to the ground but wind gusts lifted the slide off the ground. ARFF had to hold the slide down to facilitate evacuation
- However, survey of ARFF groups show their concern with stability and performance of slides under windy conditions



Categorizing Injuries

- Abbreviated Injury Scale (AIS) are used to rank injuries on a scale of 1 to 6

AIS Code	Description
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Maximum
7	Injured (unknown severity)

Categorizing Injuries

- Based on our study, majority of minor injuries due to use of inflatable slides were abrasions, bruises, and contusions which fall under AIS 1 and AIS 2. Serious injuries which are mostly fractured bones, broken leg, and laceration fall under AIS 3



Conclusion

- 142 emergency evacuation events involving slides were identified over the period of January 1st, 1996 to June 30th, 2006
- There is significant annual variation in number of emergency evacuation events
- Nearly 30% of such events result in injuries on an annual basis
- More than 80% of reported injuries due to use of slides during emergency evacuation have been minor injuries
- Slide deployment events are not documented well and most are not investigated

