

AIRBUS A-340



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Teaching Psychology in a \$15 million Virtual Reality Environment

**Dr. Farhad Dastur
Dept. of Psychology, Kwantlen University
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farhad.dastur@kwantlen.ca**

What Kinds of Psychology Can We Teach in a Flight Simulator?

- Human Factors / Engineering Psychology
- Cognitive Psychology
- Perceptual Psychology
- Industrial / Organizational Psychology

Human Factors / Engineering Psychology

To understand how the interaction of psychology and technology in a given environment affects performance, safety, usability, and aesthetics.

Human Factors seeks to inform the design of interfaces and environments with a knowledge of our cognitive capabilities and limits.

Principles of Good and Bad Interface Design

- Digital vs. Analog Displays
- Meters, Dials, Indicators, Switches, Knobs
- Redundancy
- Natural Mappings
- Colour-coding
- Proximity Compatibility Principle

What are the “human factors” that lead to stress, errors, and accidents?

Cognitive Psychology

- Focused vs. Divided Attention
- Cognitive Tunneling
- Working Memory limitations
- Effortful vs. Automatic Processing
- Decision Making
- Learning Theories



Perceptual Psychology

How monocular depth cues create 3-D depth perception:

- linear perspective
- texture gradients
- interposition
- relative size
- relative height
- relative motion
- atmospheric distortion

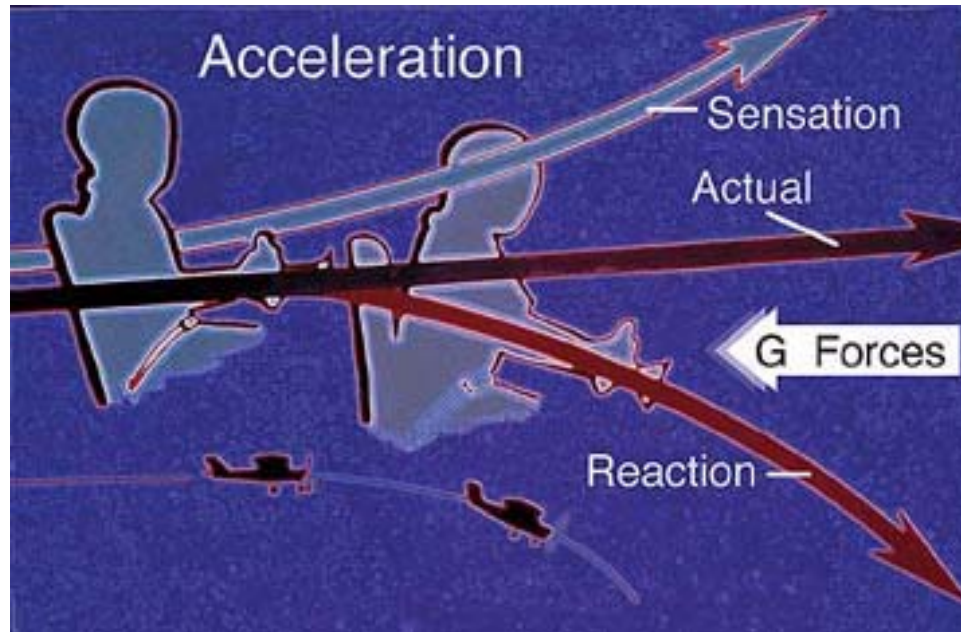


Perceptual Psychology

- Visual illusions
- Inversion illusion
- Head-up and Head-down illusion
- Spatial disorientation
- False climb illusion
- Graveyard Spin and Spiral
- Coriolis Effect



Heads-up illusion



A sudden forward linear acceleration during level flight where the pilot perceives an illusion that the aircraft's nose is pitching up.

The pilot may respond by pushing the yoke forward to pitch the nose down. A night take-off from a well-lit airport into a totally dark sky can also lead to this illusion and possibly a crash.

Industrial / Organizational Psychology

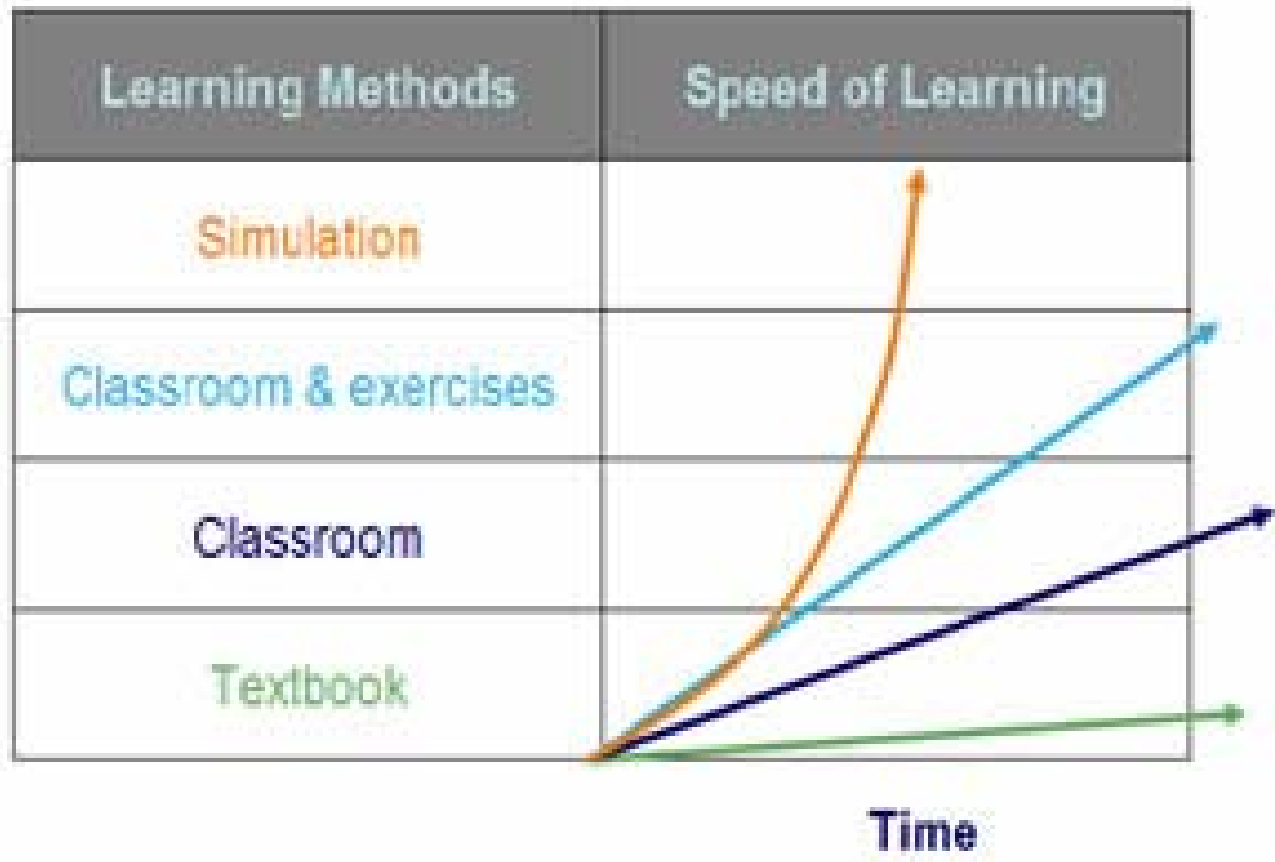
- The pilot, unlike many professionals, is typically judged by their worst performance not their best.
- Some airlines have a policy in which the pilot is fired if they fail two simulator training sessions.



Some Virtues of VR Simulation

- **Risk-free environment – Simulation allows complex and dangerous scenarios to be created that test ability, decision making, and other high level functions with little to no risk to the participants or their organization.**
- **Compression of time – Simulations provide an accelerated learning environment and permit multiple engagements with a scenario.**
- **Sims are cheaper than actual flights**
- **Simulations allow for complex and accurate feedback**

Knowledge Gained



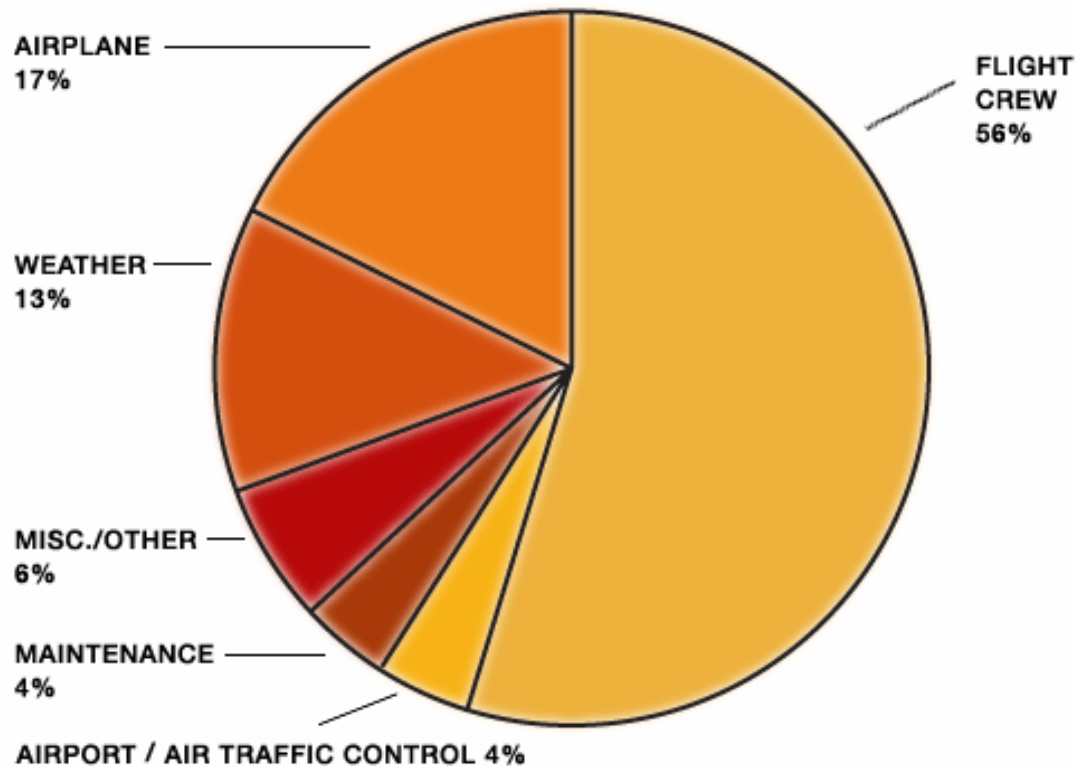
Reference: Abbott Training Systems

Crew Resource Management (1979 NASA workgroup)

- Human error is the primary cause of a majority of aviation accidents
- Human error often results from failures of interpersonal communication, leadership, and decision making in the cockpit
- CRM involves training in communication, situational awareness, problem solving, decision making, workload distribution, and teamwork

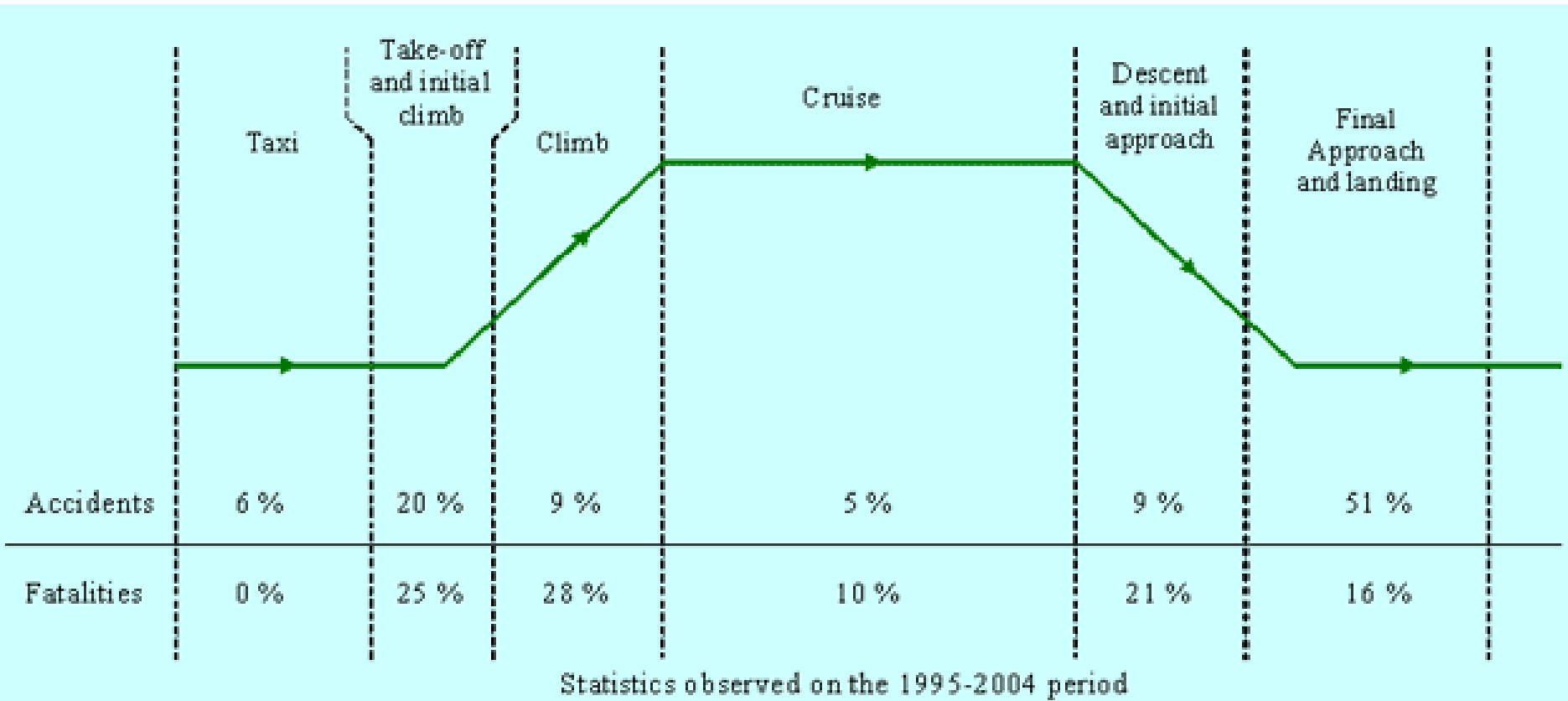
Human factors are the largest contributor to aircraft accidents

Accidents by Primary Cause*
1995 through 2004



*As determined by the investigating authority, percent of accidents with known cause.

Accidents and Fatalities as a Function of Phase of Flight



National Transportation Safety Board Human Error Chart

Unprofessional Attitudes	47%
Visual Perception Misjudgment	19%
Pilot Technique	21%
In-flight Judgment or Decision	5%
Improper Operation of Equip.	6%
Unknown Causes	4%





Early Cockpit Design



Modern Cockpit Design



Electronic Analog Attitude Indicator Boeing

737



Bank Indicator:

Indicates how much the aircraft is banking

Colour coding:

- blue for sky
- brown for ground

Reference Frame:

White center dot represents the aircraft's nose relative to the horizon (pitch) in 2.5 degree increments

Turn and Slip Indicator

Air Speed Tape

Horizontal airspeed (271 knots)

GS = Ground Speed (448 knots)

Current Mach Speed

Class Info

Cognitive Ergonomics (3rd year elective)

Human Factors and Ergonomics (4th year required)

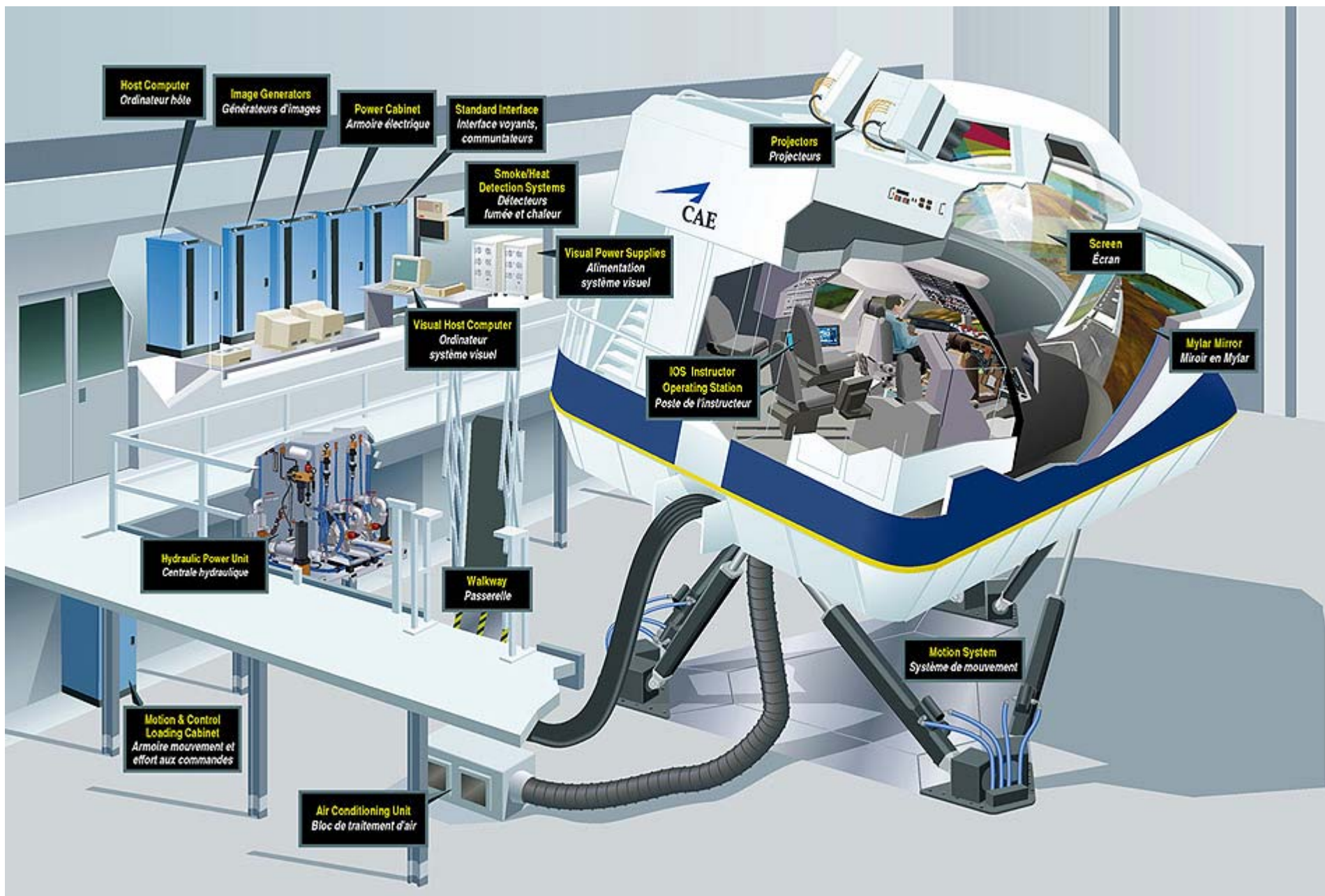
Class Size: 25 students

Prerequisites: Cognitive Psychology & Research Methods



- Four Full motion simulators: Airbus A319 and A340, Boeing 767 and 737
- 2 hour rental at \$300 / hour
- The Air Canada Flight Training Center at Vancouver International Airport
- Two dates to accommodate student schedules
- 2 hour commitment
- Voluntary participation (100% attendance)





Airbus Instrument Display

Real Aircraft (left) vs. Flight Simulator (right)



The Flight Simulator Provides an Immersive, Multisensory, Virtual Reality Experience

Visual Sensations

- 3-D CGI of the visual world with near real-time scenery updates

Auditory Sensations

- Acoustic simulation of engine noise, wind, and voice warnings

Tactile Sensations

- Simulated shaking and vibrations such as the “tires” rolling across bumps and cracks in the runway

Kinesthetic (Vestibular) Sensations

- Illusory sense of acceleration, deceleration, pitching, yawing, and rolling

Proprioceptive Sensations

- Sense of the location of body parts in space as simulator pitches, yaws, and rolls

Sequence of Activities

Preflight

- Teach HF principles
- Watch video
- Analyze cockpit voice transcript

Flight

- Briefing at Flight Training Center
- Observation flight
- Student at controls
- Debriefing

Post Flight

- Assignment
- Questions on Final Exam

Preflight Preparation

- Teach Human Factors principles in class. Arrange simulator experience half-way through the semester
- Watch a video of a simulator
- Analyze the moment-by-moment cockpit transcript of an actual aviation accident: the Tenerife Accident

Flight

- 30 min. briefing at the Flight Training Center by the Chief Flight Sim. Instructor
- Each student flies as an observer in the simulator for 15-20 min.
- Each student pilots the simulator for 5 – 10 minutes and performs one or more of the following: turns, ascent, descent, take-off, landing, a simulated emergency
- 15 minute debriefing by Ft. Sim. Instructor



Post Flight

1. Assignment:

Download an image of a cockpit, identify 5 displays and 5 controls, describe the function of each, and identify a design principle being used in that display or control

2. Questions on the Final Exam

3. Relate classroom concepts back to the field trip

Case Study: The Tenerife Disaster

On March 27, 1977, a KLM 747 preparing for take-off collided with a taxiing Pan Am 747 on a fog-covered runway of Los Rodeos airport in the Canary Islands

583 people died—the highest death toll in aviation history





The Pilots

KLM 4805

- Captain van Zanten
- KLM's chief training Captain for Boeing 747s.
- 12,000 hours experience

Pan AM 1736

- Captain Grubbs
- 57 year old veteran pilot
- 21,000 hours of experience



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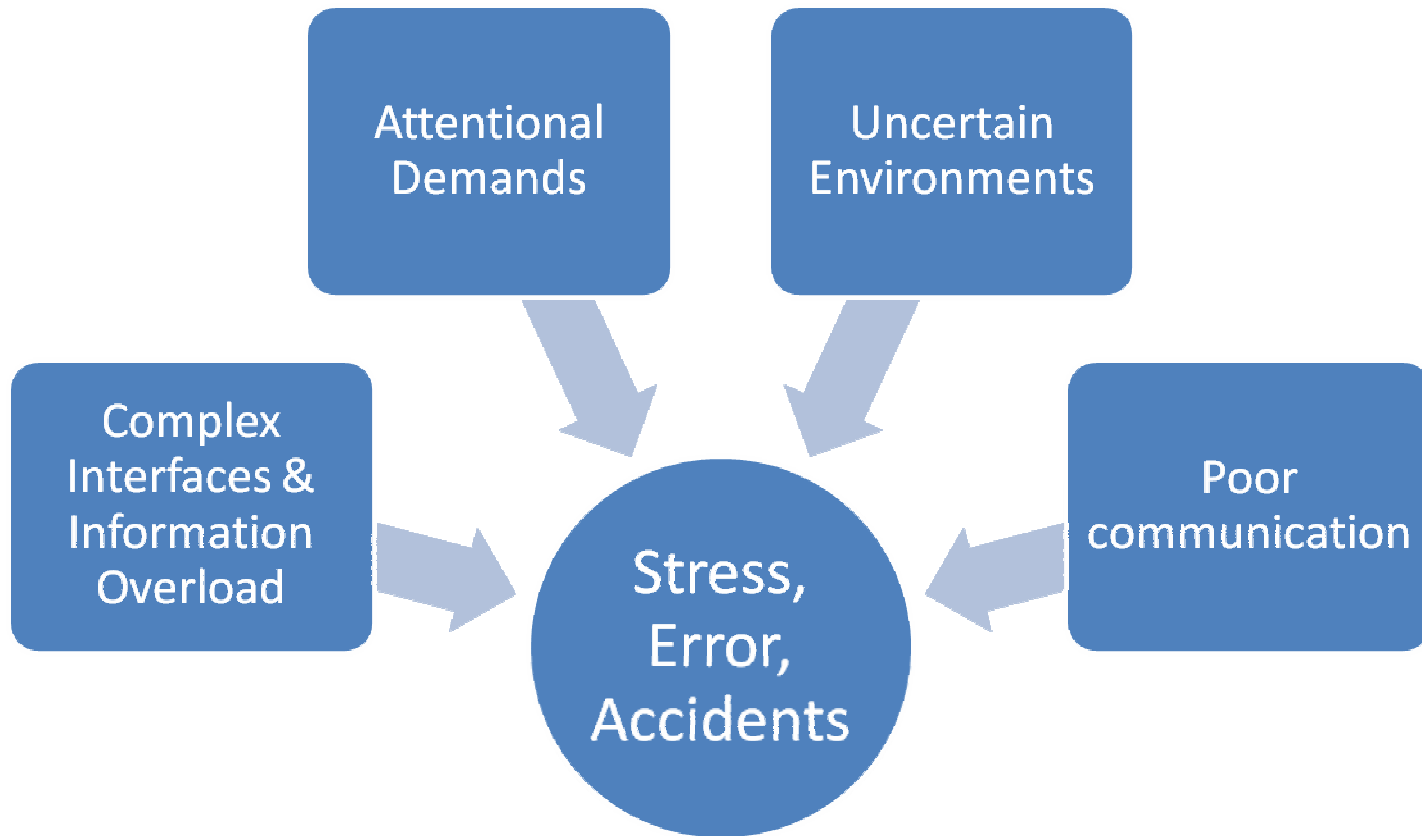
aviation-safety.net

A Chain of Events

- ATC gave the KLM crew its ATC clearance, which is not a clearance to begin take-off, but a clearance to fly a certain route immediately after take-off.
- The KLM captain mistook this to be permission for the take-off itself. He released the brakes and the co-pilot responded with a heavy Dutch accent with words that could either be "We are at take off" or "We are taking off."
- The control tower was confused by the message and asked for the KLM plane to stand by. Simultaneous communication from Pan Am, reporting that they had not finished taxiing, caused a heterodyne, making the tower response inaudible to the pilots.
- Fog limited the visual range to 1000 feet (305 meters).

Probable Causes: A Multifactorial Model

- In reply to the flight engineer's query as to whether the Pan Am airplane had already left the runway, the KLM captain replied emphatically in the affirmative.
- The use of non-standard phrases used by the KLM co-pilot ("We're at take off") and the Tenerife control tower ("O.K.").
- The Pan Am crew continued back taxiing along the runway instead of turning at exit C3, as directed.
- On hearing this, the KLM flight engineer expressed his concern about the Pan Am not being clear of the runway, repeating this concern a few seconds later, but he was overruled by the captain.



Conclusions of the Accident Investigation

The combination of interruption of important routines, false assumptions, misinterpretations, a loss of cognitive efficiency, and a loss of communication accuracy created an environment for the rapid diffusion of multiple small errors.

The Future

The future of our teaching of psychology will involve simulations of virtual worlds that will engage learners in compelling and challenging scenarios and will permit deep encounters with active learning, collaborative learning, and problem-based learning.

Student Comments

“Dear Dr. D,

I just wanted to pass on a short note of thanks for arranging the field trip to the Air Canada Flight Training Centre. Not only did the experience in the simulator bring all of the principles and theories into focus in a very real, visceral way, it was also a once in a life time opportunity to fly a jet. --T.A.”

