Human Error Modeling
Commercial CFIT Scenario

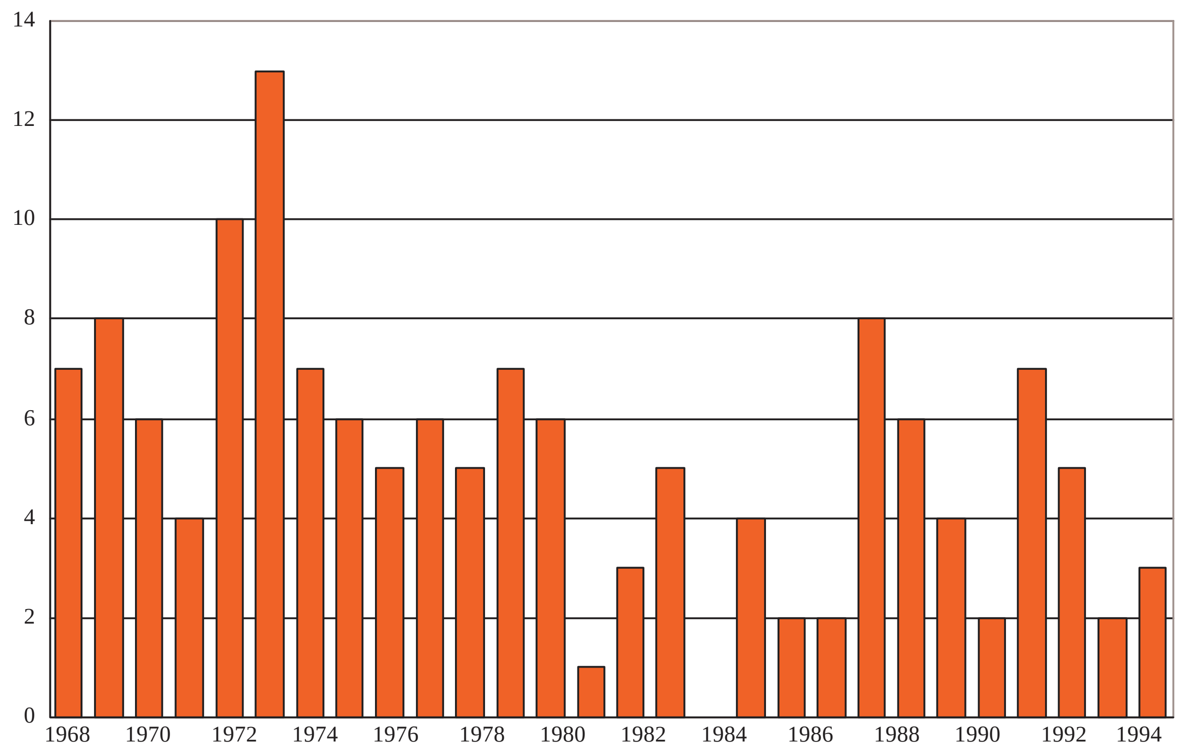
1. The CFIT Accident
    1.1.[1] Description of Event

    Controlled Flight into Terrain (CFIT) accidents can be defined as those accidents in which an aircraft without mechanical defect or malfunction is inadvertently flown into terrain (or water) without previous awareness by the flight crew of the impending disaster.

    1.2. Impact on Aviation Safety

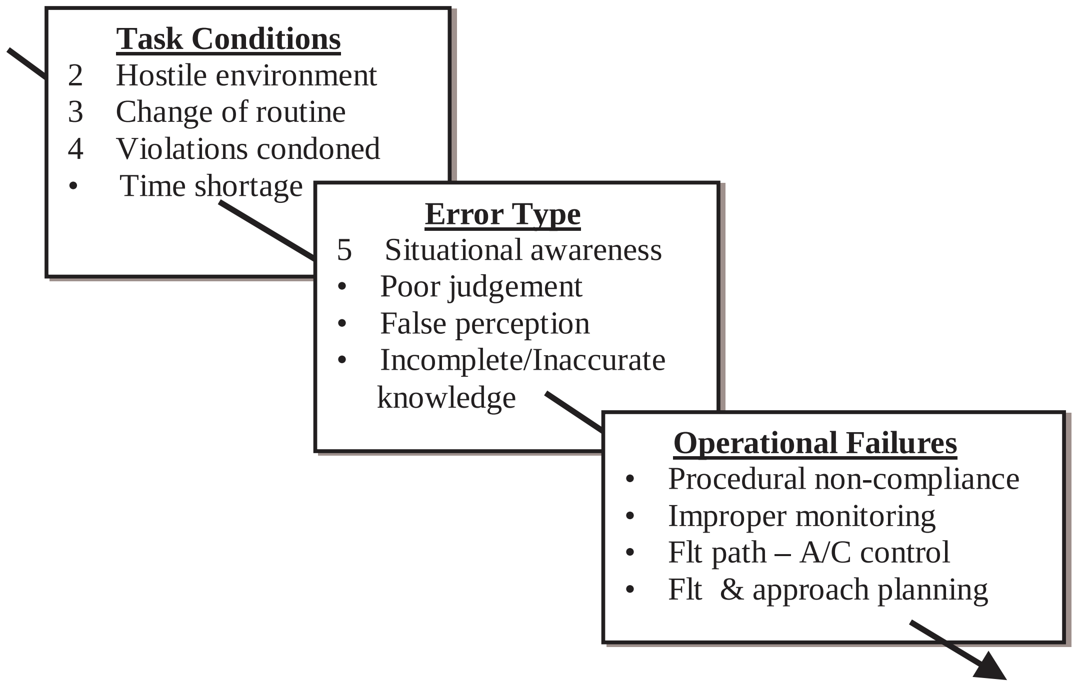
    Since the beginning of commercial jet operations, more than 9000 people have lost their lives in aircraft accidents attributable to controlled flight into terrain. Although recent years have shown a decline in the number of CFIT accidents, the risk needs to be reviewed against the rate at which commercial aviation continues to grow. If the current rate of CFIT incidents is applied to forcasted growth in global commercial aviation, there would be more than one major hull loss to CFIT per month by the year 2010. For this reason, there is widespread consensus among the international aviation community that additional remedial measures and enhancements to system safety are needed to further reduce CFIT risk.

Annual CFIT Hull-Loss Accidents Worldwide:
Commercial Jets



1.3 Common Factors in CFIT Events

A 1995 ICAO (International Civil Aviation Organization) analysis of 24 commercial CFIT accident reports from 1984 to 1994 delineated a range of latent and active factors which characterized these types of mishaps. According to the analysis, the most common pattern of factors seen in the causal chain of events or “active failure paths” leading to CFIT accidents were as follows:



Similarly, a 1999 Flight Safety Foundation report evaluated 156 CFIT accidents between 1988 and 1994 and ranked, in order of occurrence, the primary causal factor in such accidents as:

- Omission of action/ inappropriate action
- Lack of positional awareness
- Slow and/or low approach
- Flight handling
- Poor professional judgement

For each of the evaluated CFIT accidents, on average, no less than 10 causal factors (contributory, secondary, and primary) were identified -- highlighting the cascading and compounding nature of events which lead to catastrophic failure. The report also noted the following statistics regarding situational factors associated with CFIT mishaps:

2. 75% occurred during non-precision approach
3. 71% involved poor visibility conditions
4. 67% occurred in mountainous or hilly environment

2. Baseline CFIT Accident Scenario

2.1. Research and Modeling Questions

- Demonstrate a reconstruction of this accident scenario which provides explicit timing parameters for events, actions, and state changes while preserving the sequence of these elements and scenario outcome.
- What are the error types that are committed by the flight crew in this scenario and can they be linked to workload, interruptions, faulty communications and/or other precipitating conditions?

2.2. Scenario Narrative

Descending through 7000' in the night sky some 22 miles north east of Sandybeach Airport on the popular Caribbean resort of the same name, a Global Airways 747-400 charter flight is offered an alternative "straight-in" landing to Runway 23R. ATC cautions that the glidescope for this runway is inoperative. Though the crew has already briefed a precision landing for Runway 6L per the flight plan, they accept the revised landing in order to expedite their already late arrival. Little time is left to review the ILS to Runway 23R which is an unusual approach for several reasons. The YYY VOR/DME located 3.3 miles from the end of the runway, is used as a "step-down fix" on the localizer approach. As the nonprecision approach is flown, the DME distance should count down to station passage, and then count back up again to the missed approach point, 2.8 DME. This type of approach is typical of a VOR approach, but rare among localizer approaches.

2.3. Equipment Configuration

Boeing 747-400 as detailed in Boeing document D6U10030 "747-400 Systems" , 1989.

2.4. Procedures

The modeler may select the procedures from any major air carrier to determine the exact prescriptive procedures for use. The scenario is not intended to be dependent on a particular set of procedures.

2.5. Contextual Configuration

2.5.1. Mission

Global Airways charter flight from Montreal to Sandybeach

2.5.2. Weather

Visibility has been generally good (six miles as reported at start of descent) but deteriorating with sporadic rain showers moving in which might degrade visibility at certain points along the flight path

2.5.3. Equipment Malfunction

Glidescope Rwy 23R is inoperative

2.5.4. Organizational Pressures

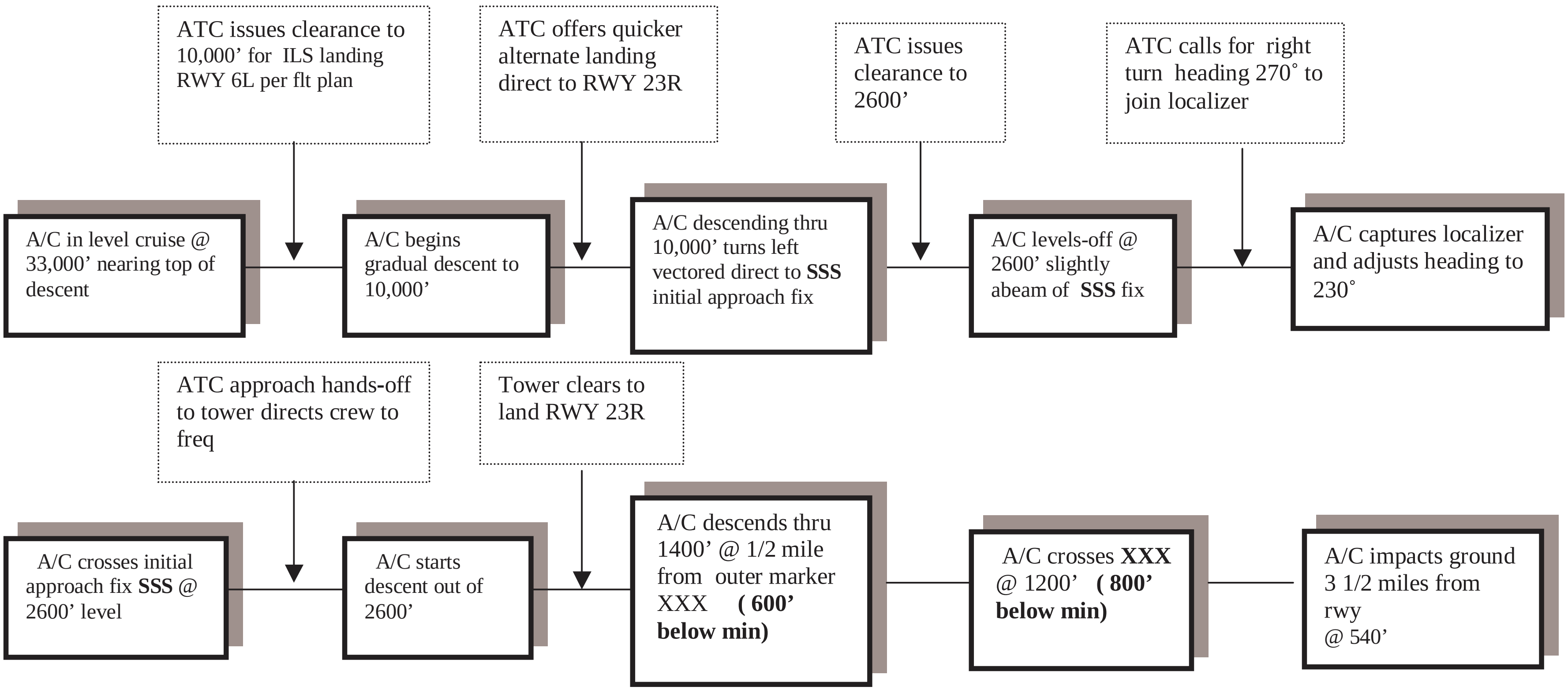
A very late departure from Montreal has put the crew's required layover rest time in jeopardy if they are to keep the next day's return schedule

2.5.5. Crew State

The crew is relatively unfamiliar with this airport and has never made this particular approach

2.6. Accident Scenario Events

2.6.1. Eventline (Flowchart)



2.6.2. Timeline (Table Format)

Time	External Events	Specific Crew Actions	A/C State or Position
Initial			in descent nearing 10,000' clearance
T+1	ATC issues revised clearance to 2600'		in descent nearing 10,000' clearance
T+2		Reset target alt	in descent nearing 10,000'
T+3	ATC offers alternative landing to rwy 23R	Flap adjusted	passing thru 7000'
T+4		Accept revised landing	3° descent to 2600'
T+5		Revised approach 23R reviewed	3° descent to 2600'
T+6	ATC vectors to **SSS** fix	Approach check list started	3° descent to 2600'
T+7		Adjust heading	3° descent to 2600'
T+8		Flaps increased	Level-off 2600 ' abeam **SSS** fix
T+9	ATC calls right turn heading 270 intercept **SSS**		Level flight 2600 '
T+10		Adjust heading for intercept	Level flight 2600 '
T+11	ATC clears approach rwy 23R		Level flight 2600 '
T+12		Localizer captured - heading adjusted 230	Level flight 2600 '
T+13		Flaps increased further	Level flight 2600 '
T+14		ILS freq tuned on nav radio	Level flight 2600 '
T+15		Gear down	Level flight 2600 '
T+16		Increase Flaps	Crosses **SSS** @ 2600'
T+17	Storm cell crosses approach corridor 4 mi ahead		3.5° descent begins @ 8 mi out
T+18	Spurious signals cause movement vert pointer	Glidescope monitored -- confusion over operability	3.5° descent
T+19	ATC directs hand-off to Tower		3.5° descent
T+20		Tower informed of intercept with 23R localizer	3.5° descent passing 2100'
T+21	Tower clears to land rwy 23R	Clearance acknw -- landing check list begun	3.5° descent
T+22		Alt alerter set for 560' per MDA	Descending thru 1400' @ 5 mi out
T+23		Intense scan begun for visual sighting of rwy	Descending
T+24	Rain increases -- forward vis obscured	Windshield wipers activated	Descending thru 1200' @ **XXX**

T+25		checklist continued	Descending
T+26		Concern mounts about lack of visual sighting	Descending
T+27	GPWS intones "500"	Discussion commenced re stabilizing approach	Descending
T+28	GPWS blares "minimums, mininums"	Discussion commenced re go-around	Descending thru 840'
T+29		Auto-pilot disconnected -throttles advanced	
T+30		Column pulled hard - full power to engines	pitch reaches 8˚
T+31	GPWS squawks 100…50…40…30….		Impact 3 1/2 mi from rwy

2.1.7. Potential Error Types

- Poor situational awareness (a/c position and terrain)
- Incomplete knowledge (possible confusion regarding particulars of revised approach)
- Procedural non-compliance (failing to initiate go-around when rwy not sighted)
- False perception (possible reliance/confusion regarding usability of glidescope indicator)
- Poor judgement (accepting revised landing without adequate preparation time and familiarity)
- Improper monitoring and challenging (failure to monitor/cross-check PF's execution of the approach)
- Poor flt and approach planning (relying on an essentially visual approach in deteriorating wx conditions)
- Procedural non-compliance (failure to respond immediately to GPWS warnings)

3. Variations to Baseline Scenario

3.1. Research and Modeling Questions

- Implicit in the baseline scenario are a number of human related operational failures including poor judgement, loss of positional awareness, monitoring and challenging errors, and procedural non-compliance. After pin-pointing some these occurrences, run a series of simulations in which individual failures, and then clusters of failures are reversed in order to determine their criticality to the casual chain of errors leading to system failure.
- Model this scenario with 3 descending levels of automation usage for flight path management and navigation: FMS/CDU, Autoflight/MCP, and manual control. Utilizing model output, compare the relative advantages and disadvantages of each of these levels for the circumstances of this scenario.
- Specify a notional vertical situational display in terms of information parameters available to the user and normal operational usage. Model the scenario with the addition of such a display and note possible outcomes.

3.2. Possible Dependent Parameters Short of Accident Occurrence

- Deviation from glidepath or localizer
- A/C falls below MDA
- Exceedance of nominal attitudes
- Failure to meet all comm requirements
- Failure to complete check lists
- High workload or other indications crew rushed to land

4. Additional Inofrmation

4.1. Plan View/ Profile View ILS Approach Runway 23R at Sandybeach