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A systems perspective on the unstable approach in commercial aviation

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ABSTRACT

Unstable approaches remain a significant contributory factor in commercial aviation accidents that occur during the approach and landing phase. A safe approach requires a carefully ordered sequence of changes to the configuration and speed of the aircraft in order to carry out a safe landing and criteria regarding configuration and speed must be met for an approach to be classified as stable. When an approach does not meet these criteria, often because of unexpected changes, the approach is classified as unstable and the risk of a landing accident or incident is greatly increased. Traditional accident models follow a linear path from cause to effect or describe a linear path through absent or weakened defences. A systems perspective attempts to understand failures by understanding successes under dynamic conditions. Pilots were interviewed about how they choose a particular configuration style during approaches and their reactions to influences that caused them to adapt their profile. Grounded theory method was used to uncover how pilots successfully manage to adapt their working practices in dynamic environments and why these adaptations sometimes fail. The grounded theory based on the data was that pilots must reconcile multiple goals, including those of outside agencies, and it is the success or failure of this reconciliation that determines the success or failure of the approach. The theory of multiple goal reconciliation formed the basis of recommendations to improve the safety of approach procedures, the key one being that a published speed profile would unify the goals of pilots and air traffic controllers, the sole aim then being to get the aircraft to particular positions at particular speeds.

1. Introduction

The Instrument Landing System (ILS) approach is a commonly used instrument approach system that affords flight crew vertical and lateral guidance to manoeuvre an aircraft down to the runway. Once an aircraft is established on an ILS approach, the crew then need to reduce the speed and deploy flaps and the landing gear so that the aircraft is in an appropriate configuration to land. The aerodynamic nature of commercial aircraft is such that it may not be possible to safely reduce the speed below a certain point without having a set amount of flap deployed. Conversely, deploying flap when the aircraft speed is too high may cause aerodynamic damage to the flap and so must be avoided. The same is true for the landing gear. It is necessary for the pilot to manage the speed and the configuration of the aircraft to ensure that the given speed is appropriate to allow a configuration change to be made and that the current configuration of the aircraft is appropriate for the speed reduction being commanded. Sufficient margins are included into standard operating procedures to ensure that the aircraft is not being operated close to the limits of the flight envelope with respect to stalling speeds but these configuration and speed changes still need to be made in a timely manner in order for an approach to be classified as stable.

1.1. Approach and landing accidents

Despite the high level of safety of commercial aviation relative to other forms of transport, approach and landing remain the phases of flight where accidents are most likely to occur [1]. During these phases of flight, pilot workload is high as it is necessary to change both the vertical and horizontal position of the aircraft whilst reducing its speed and altering its configuration by deploying landing gear and flaps in order to make landing possible [2].

The Approach and Landing Accident Reduction (ALAR) Task Force, an international group, found that unstabilised approaches were a causal factor in 66% of 76 accidents and serious incidents that occurred during the approach and landing phase between 1984 and 1997 [3].

An unstable approach is one that does not meet all the following stable approach criteria by a predetermined 'stabilisation height' (either 500 feet or 1000 feet depending on the weather conditions)

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[3] at which point the pilots should discontinue the approach and fly a go-around (also known as a missed approach). It should be noted that although the pilot may raise the stabilisation height if he feels it appropriate, he may not lower the stabilisation height as this is minimum as determined by the weather conditions and/or specific company procedures:

1. The aircraft is on the correct flight path;
2. Only small changes in heading/pitch are required to maintain the correct flight path;
3. The aircraft speed is not more than 20 knots above and 0 knots below the calculated speed required at the point where the aircraft crosses the start of the runway;
4. The aircraft is in the correct landing configuration (gear down and flaps at the required position);
5. Descent rate is no greater than 1000 feet per minute;
6. Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;
7. All briefings and checklists have been conducted.

It was found that whilst approaches that were too low or had insufficient speed tended to result in crashing into terrain, approaches where the aircraft was too high or too fast tended to result in runway overruns [3]. The report also recognised that flight handling difficulties were often triggered by rushed approaches, adverse wind conditions and attempts to comply with inappropriate air traffic control (ATC) clearances.

Most companies issue their pilots with a recommended configuration profile for their aircraft, but it is just a recommendation and may be adjusted depending on the operational conditions. Fig. 1 shows an example of a recommended approach profile used by an airline operator.

1.2. Incidence of unstabilised approaches

Whilst not every approach will become unstabilised and not every unstabilised approach will lead to an accident or a serious incident, continuing with an unstable approach decreases the operational safety margin. The French Direction Générale de l'Aviation Civile (DGAC) conducted a survey that suggests that 3% of approaches are unstable [4]. They note, however, that this rate varied considerably according to aircraft type. A national programme of flight data monitoring for corporate jets in the United States of America gives the incidence of unstabilised approaches as 4.5% in 2009 [5]. During line operations safety audits, jumpseat observers on the flight decks of 4532 commercial flights between 2002 and 2006 found that 5% of approaches were unstable [6]. Interestingly, the observers also noted that only 5% of unstable approaches resulted in a go-around.

1.3. Understanding unstable approaches by understanding stable ones

There is now considerable evidence that unstabilised approaches significantly erode safety margins. The Flight Safety Foundation conclude that a stable approach is 60 times safer than an unstable one [4], and have published the following factors that can contribute to potentially stable approaches becoming unstable [7]:

- Attempting to comply with inappropriate ATC instructions;
- A desire to execute a fuel-efficient approach by maintaining a higher speed and delaying configuration changes that would increase aerodynamic drag;
- Unanticipated tailwinds on approach.

Although these sound reasonable, no evidence was found of a systematic investigation and so these contributory factors may be based on anecdotal cases or the personal opinions of the authors.

The transition from stable to unstable can be said to represent a failure of the systems in place to prevent such an occurrence. The central feature of a systems approach is that in order to understand system failures, it is necessary to understand system successes; examples of how the system has successfully buffered the influence of external, unanticipated factors to still give a successful outcome [8]. For example, many approaches are subject to unanticipated factors that necessitate a change in the standard configuration profile and yet these approaches end up being stable. The aim of this study is to empirically uncover the factors that affect the pilot's plan of how to configure the aircraft during the approach, what factors he perceives as having an effect on the plan before the approach commences, what factors affect his plan during the approach and, in cases where an approach is unstable, what factors lead to this unsafe approach being continued to a landing rather than the mandatory go-around required when stabilisation criteria are not met.

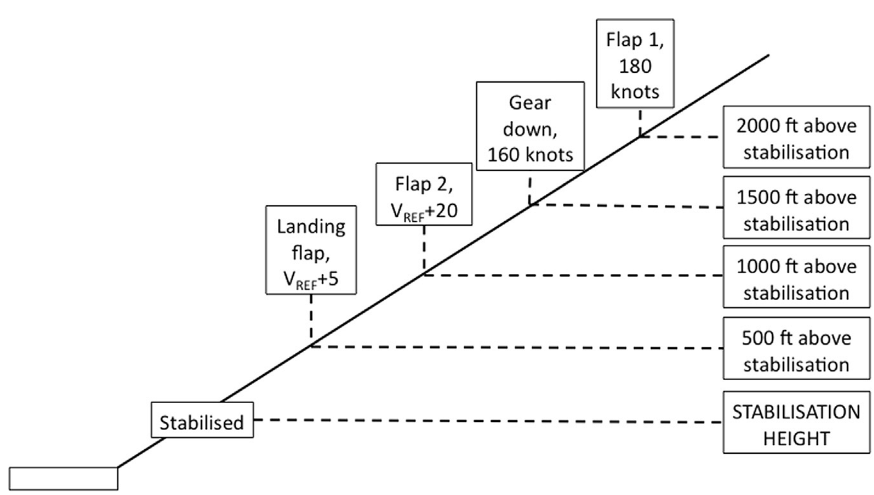

Fig. 1. Recommended approach profile (V_{REF} is the speed that the pilot calculates that the aircraft should be flying at when it crosses the start of the runway just before landing).