CMPE349 Lecture 02
Precision Landing Systems

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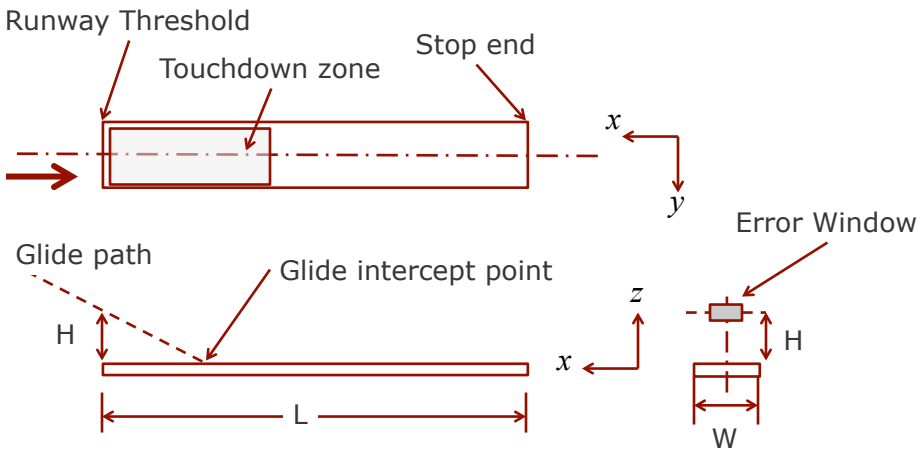
This is our task

- We're going to be designing elements of a precision landing system for fixed wing (airplanes) and rotary wing (helicopters) aircraft
- To do the design exercise, we need some common vocabulary
- I'll post a document that goes through much of this in a slightly different way
- My goal today is just to introduce the vocabulary

A *precision* landing system

- A *landing system* is a collection of devices that permit a pilot to land an aircraft on a selected runway in low-visibility conditions
- At it's simplest, a landing system provides guidance to the pilot indicating if the aircraft is left or right of runway (or at least landing zone)
- A *precision* landing system also provides guidance to the pilot about whether the aircraft is above or below the desired flight path to the landing zone.
- The vertical element of the approach path is called the glide path, or elevation angle even though the aircraft isn't gliding during the approach.

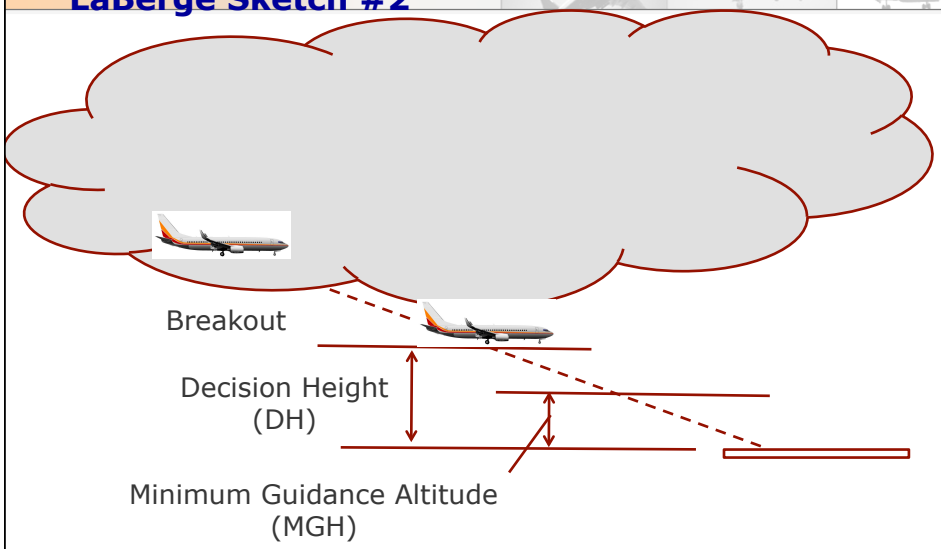
LaBerge Sketch #1 (On board in lecture)



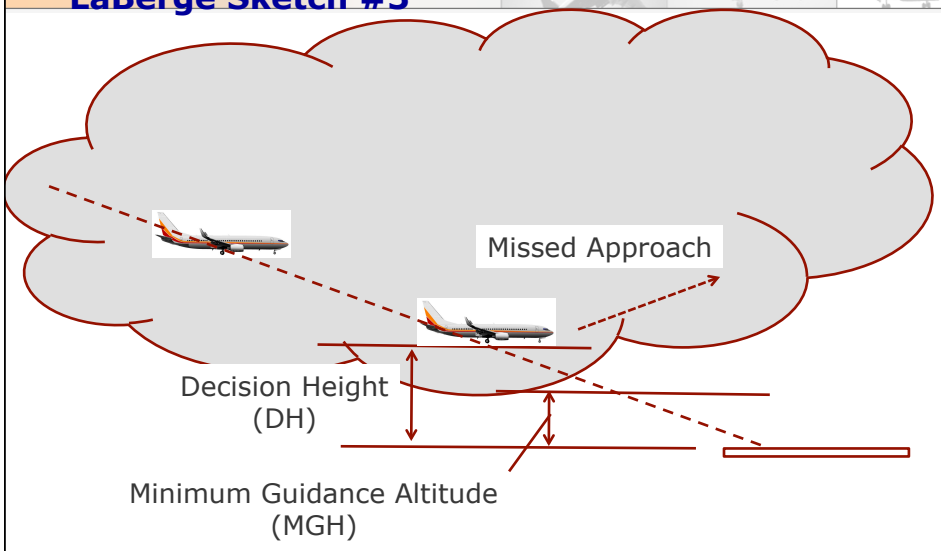
Items on the sketch

- Runway surface
- Runway centerline
- Runway stop end
- Runway dimensions
- Threshold
- Glide path
- Lateral position error
- Vertical position error
- Glide Path Intercept Point
- Touchdown zone
- Threshold crossing height
- Error window

LaBerge Sketch #2



LaBerge Sketch #3



Items on sketch #2

- **Decision Height**
- **Minimum Guidance Altitude**
- **"Break Out"**
- **Missed Approach**

ICAO Landing Categories

Table 1 ICAO Precision Landing Categories

Precision Landing Category	Decision Height & Minimum Visibility	Minimum Guidance Altitude
Category I	200 feet & ¾ nautical mile	100 feet
Category II	100 feet & ½ nautical mile	50 feet
Category III A	50 feet & ¼ nautical mile	8 feet
Category III B	50 feet & 1/8 nautical mile	8 feet
Category III C	0/0	8 feet, taxi guidance required

Standard for Safe Landing

- **ICAO wants the aircraft to have the same probability of landing safely at the specified Category as and aircraft operating in "Visual Flight Rules" or VFR,…**
- **…where the pilot can clearly see the runway at all times during the final phases of the approach.**

Guidance vs. Position

- Landing systems generally provide *guidance* not direct *position*
- *Position* is the aircraft location in space, referenced to some accepted coordinate system (more later)
- *Guidance* consists of instructions to the pilot on how the position of the aircraft to match a selected and defined path
- Think of using Google Maps on your phone.
  - Position (via Google Maps)
  - Desired Path (you choose destination)
  - Guidance relative to that path ("turn left on Wilkens Ave)

Three dimensional guidance

- Precision Landing guidance is always three dimensional
  - Lateral (fly to the left or fly to the right)
  - Vertical (fly up or fly down)
  - Distance to touchdown…
  - …followed by distance to stop end.

How does the guidance get to the pilot?

- **Analog form via the CDI, "fly to the bars"**

Fly up and to the left

By Fred the Oyster, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=35320370

How does guidance get to the pilot?

- **In a Cat I+ landing, the pilot rarely flies the aircraft directly…**
- **… at least until reaching the decision height…**
- **…and often not even then**
- **The actual control of the aircraft is done by the automatic flight control system (AFCS)…**
- **…using inputs from the precision landing system.**
- **Most modern AFCS are fancy computers, which "like" digital inputs…**
- **…so modern landing systems also provide digital words containing both position and guidance.**
- **How often this data is provided, and the precision (number of bits) are subject to the system design.**

Broad Categories of Precision Landing Systems

- **Autonomous: The aircraft determines its position with a very limited (ideally no) external inputs, and computes guidance relative to a pilot-selected path.**
- **Air derived: The aircraft determines its position using well-defined external inputs, and computes guidance relative to a pilot-selected path.**
- **Ground derived: The ground system at the airport determines the aircraft position using well-defined external inputs, and computes guidance relative to a ground selected path. This guidance information is then transmitted to the aircraft via some radio link.**
- **Voice Command: The ground system at the airport determines the aircraft position, and displays that position relative to a ground selected path. A controller (human) then instructs the pilot how to fly to follow the selected path**

What might be some issues with each?

- **Autonomous:**
- **Air derived:**
- **Ground Derived**
- **Voice Controlled**

What might be issues associated with

- Precision landing in flat terrain (Kansas?)
- Precision landing with local obstacles (BWI?)
- Precision landing in mountainous terrain (Alaska?)
- Precision landing at busy airport (JFK/Dulles?)

Near term schedule

- We will meet HERE this Friday
- We will receive a request for information about a landing system.
- We'll discuss it and see what might be our way forward,…
- …or other things we might need to know.
- CATME Surveys should be available by Wed evening, please respond before Friday!