



## **CMPE349 Lecture 02 Precision Landing Systems**

**Dr. LaBerge (CMPE)**



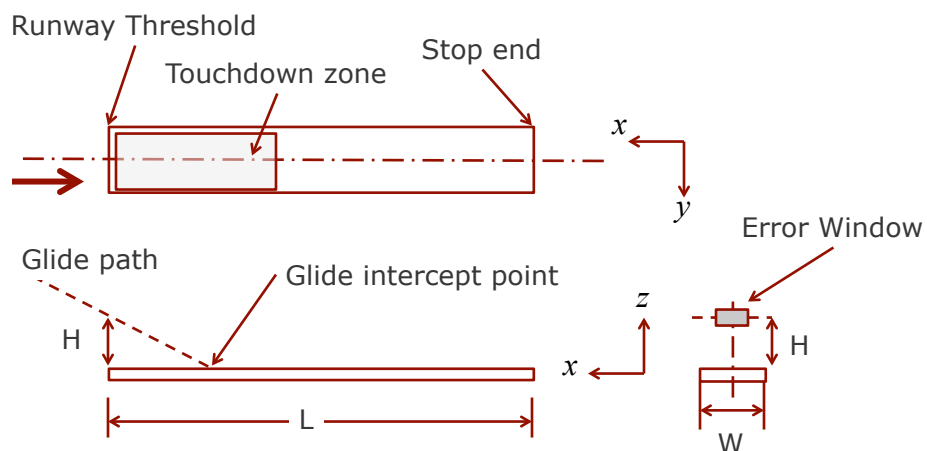
### **This is our task**

- **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)



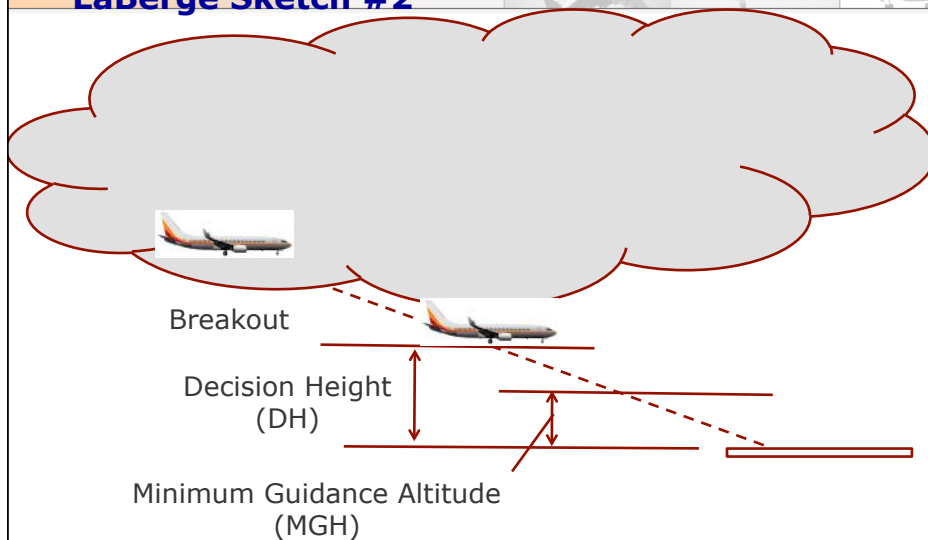
## Items on the sketch

- 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

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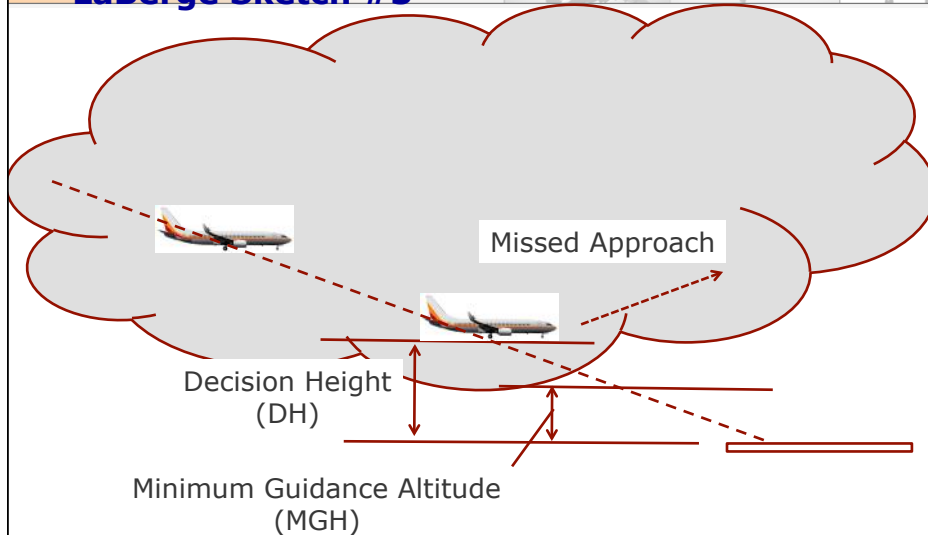
## LaBerge Sketch #2



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### LaBerge Sketch #3



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### Items on sketch #2

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

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## ICAO Landing Categories

Table 1 ICAO Precision Landing Categories

Precision Landing Category	Decision Height & Minimum Visibility	Minimum Guidance Altitude
Category I	200 feet & $\frac{3}{4}$ nautical mile	100 feet
Category II	100 feet & $\frac{1}{2}$ nautical mile	50 feet
Category III A	50 feet & $\frac{1}{4}$ nautical mile	8 feet
Category III B	50 feet & $\frac{1}{8}$ 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)

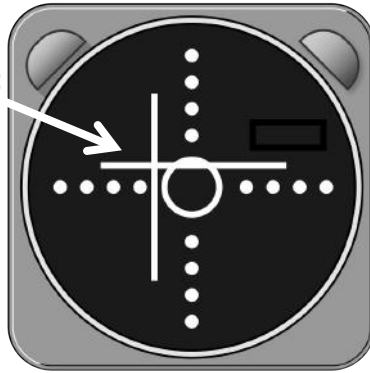
## Three dimensional guidance

- 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!