



Smoother and safer approaches with geometric altimetry

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Barometric altitude computation

- What is the fundamental difference between these two devices ?



Barometer

=>



Altimeter

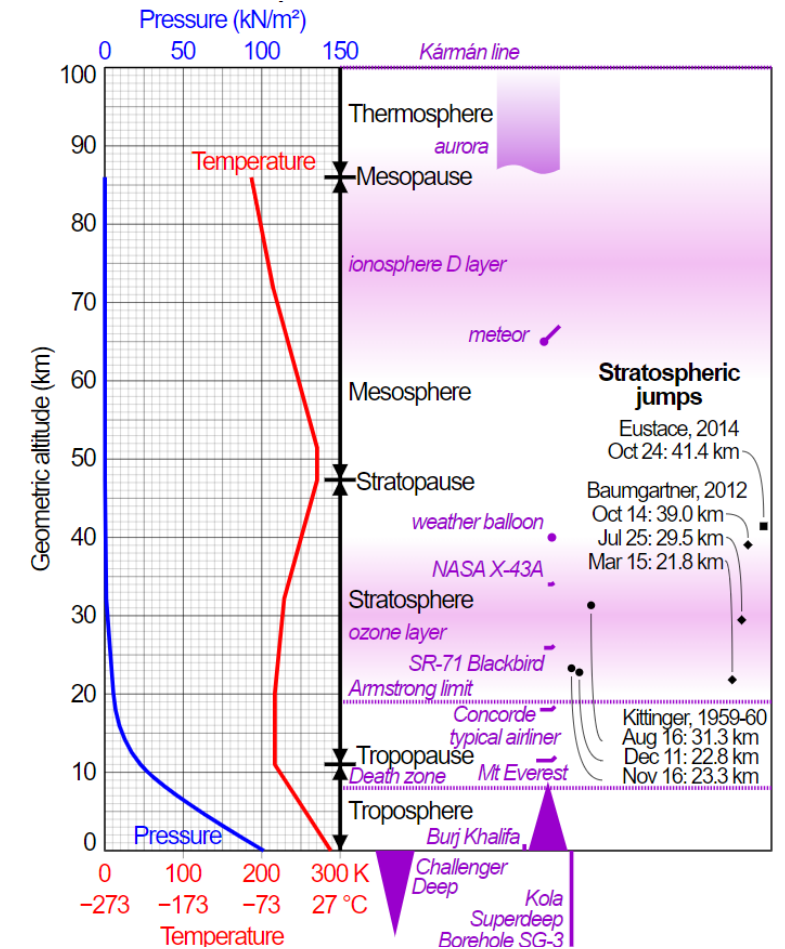
- Answer: Use of ISA model for translation from pressure to altitude

International Standard Atmosphere Model (ISA)

- ISA model is a theoretical model
- Exact relationship between baro altitude and geometric altitude is not constant, depending on meteorological context:
 - Pressure at sea level
 - Temperature at sea level
 - Temperature profile vs. altitude

➔ Definition of standard altitude shared by all aircraft when high enough (far from airport, in Flight Level)

➔ Application of baro-correction when close to the airport



Baro-Altitude vs Geometric altitude

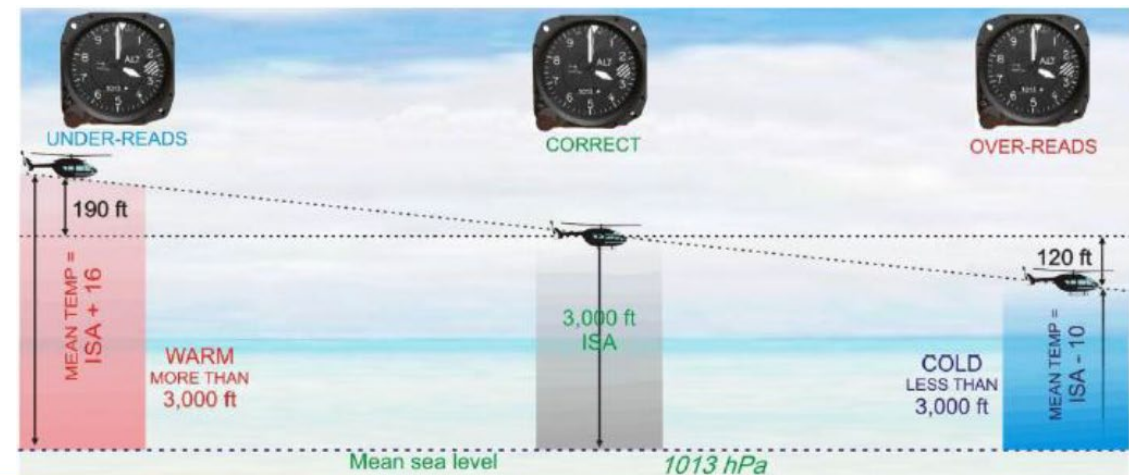
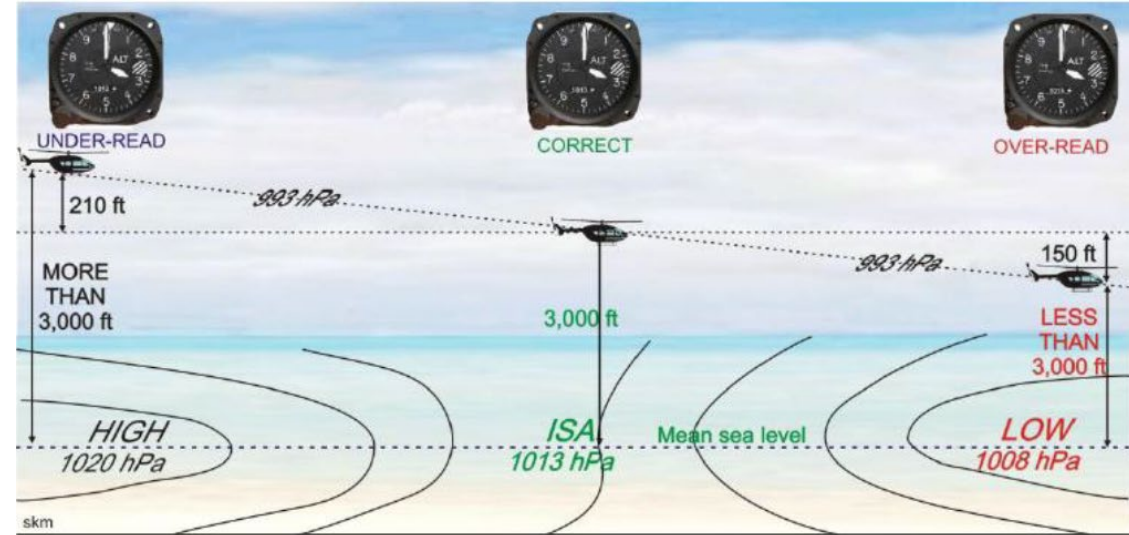
- When the pressure at sea level is higher than 1013.25hPa, the real altitude is higher than the barometric one. This is compensated by the baro-correction

=> 1hPa = 27 ft



- When the temperature is higher than 15°C at sea level, the real altitude is higher than the barometric one. This is NOT compensated.

=> 10 °C = 4% from total altitude



Operational use of temperature compensation (pilot view)

COLD TEMPERATURE AIRPORTS 12 Aug 2021 – 8 Sep 2022

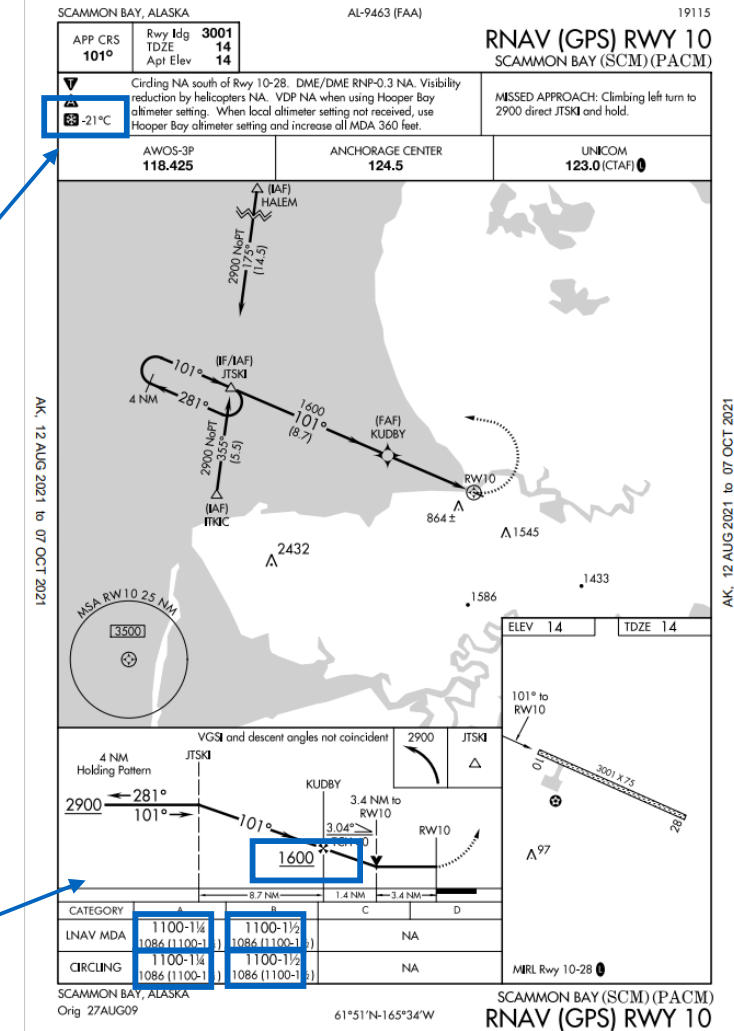
Airports are listed with ICAO code, Airport Name, Temperature in Celsius and Affected Segment/s. The temperature is indicated on Airport IAPs next to a snowflake symbol ❄ in the United States Terminal Procedures Publication (TPP). The segments are listed for operators using Individual Segment(s) Method.

See, Aeronautical Information Manual (AIM), Paragraph 7-3-4, Cold Temperature Airports, for information and procedures.

Identifier	Airport Name	Temperature	Affected Segment		
			Intermediate	Final	Missed Appr
<u>Alaska</u>					
PABT	Bettles	-45C		X	
PACH	Chukathbatak	-22C		X	
PACM	Scammon Bay	-21C		X	
PACX	Coldfoot	-19C		X	
PADE	Deering	-40C		X	
PADM	Marshall Don Hunter Sr	-27C		X	
PAEG	Eagle	-17C		X	
PAFA	Fairbanks Intl	-32C	X		
PAFM	Ambler	-37C		X	
PAGH	Shungnak	-36C	X		
PAGM	Gambell	-27C		X	
PAGS	Gustavus	-18C	X		
PAGV	Gustavus	-21C		X	

Minimum reported temperature for temperature compensation

Compensation of altitudes constraints, Decision Altitude, Flight Path Angle



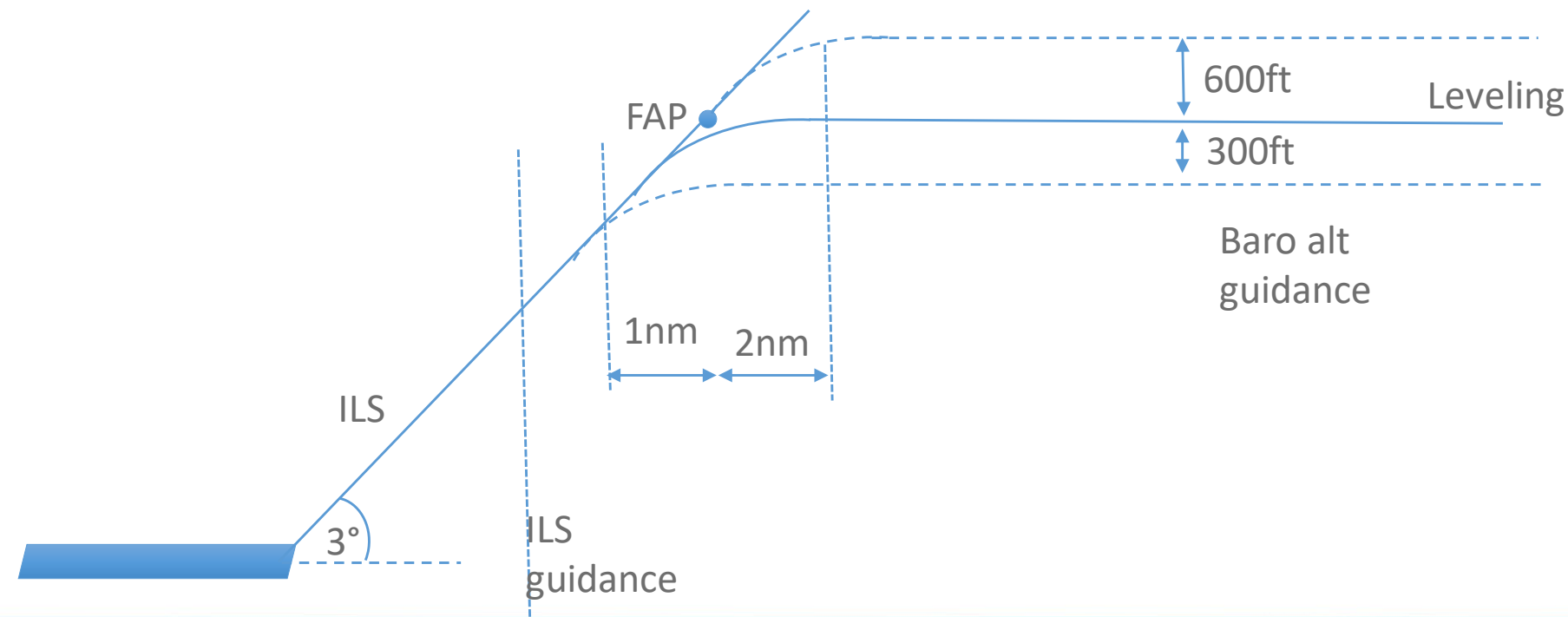
Limitations of temperature compensation

- Incorrect T° information from ATC or erroneous input by the crew
 - obstacle clearance may not be guaranteed
- T° inversion leading to variable Flight Path Angle
 - steeper than expected approach
- Increased workload if performed manually
- If no T° information is available:
 - Do not start the approach
 - Use more conservative value (based on nearest airfield + margins).
 - Steeper slope, possible go-around
- Unstabilized glide intercept

➡ Safety issues

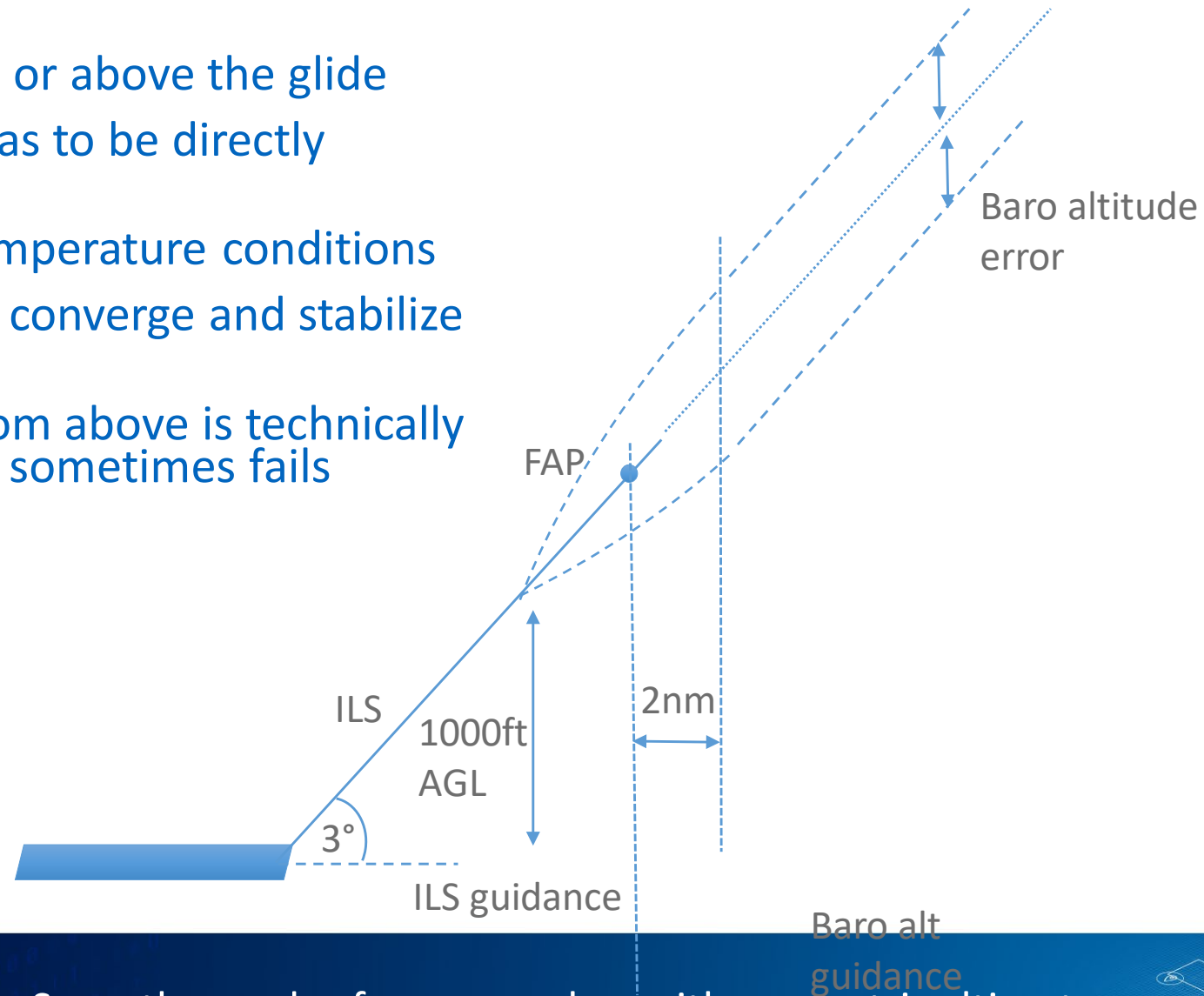
Optimisation of vertical profile : Basic glide intercept

- Baro altitude levelling before Final Approach Point (FAP)
- Acquisition from below the glide
- Error of baro altitude only impacts acquisition point, before or after the FAP, and its distance to the runway.



Optimisation of vertical profile : Continuous Descent

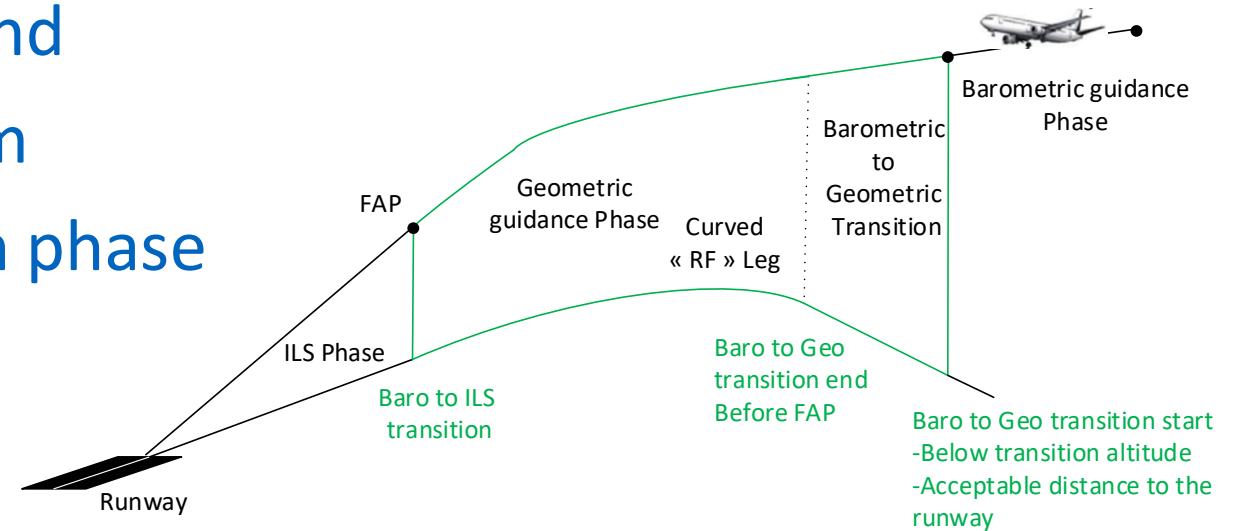
- Acquisition from below or above the glide
 - Error of baro altitude has to be directly absorbed by piloting
 - Steeper slope in hot temperature conditions
- ➔ Additional distance to converge and stabilize to the glide.
- ➔ Acquisition of glide from above is technically difficult for autopilot and sometimes fails



Solution: use of geometric altitude for transition from barometric to ILS

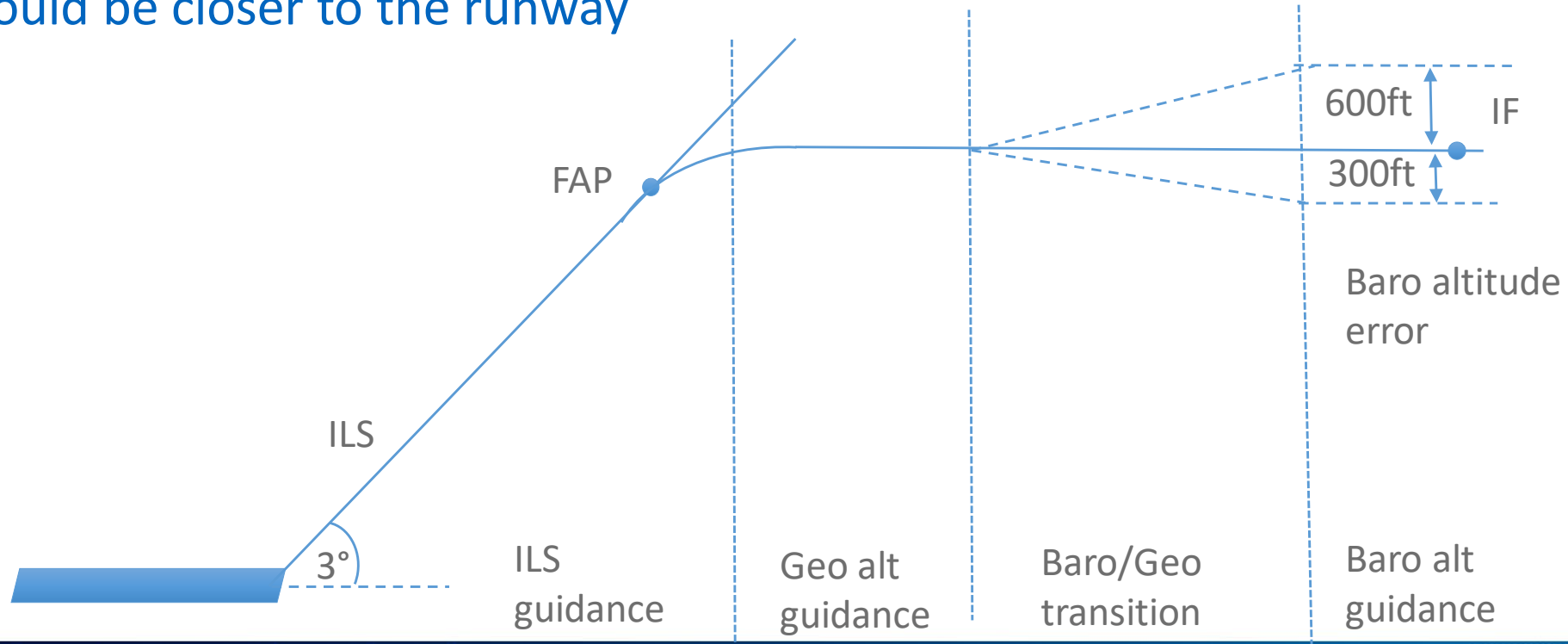
Goal: getting rid of T° compensation in approach

- Improve safety close to the ground
- Accurately intercept the ILS beam
- Reduce the required stabilization phase
- Optimize the approach profile



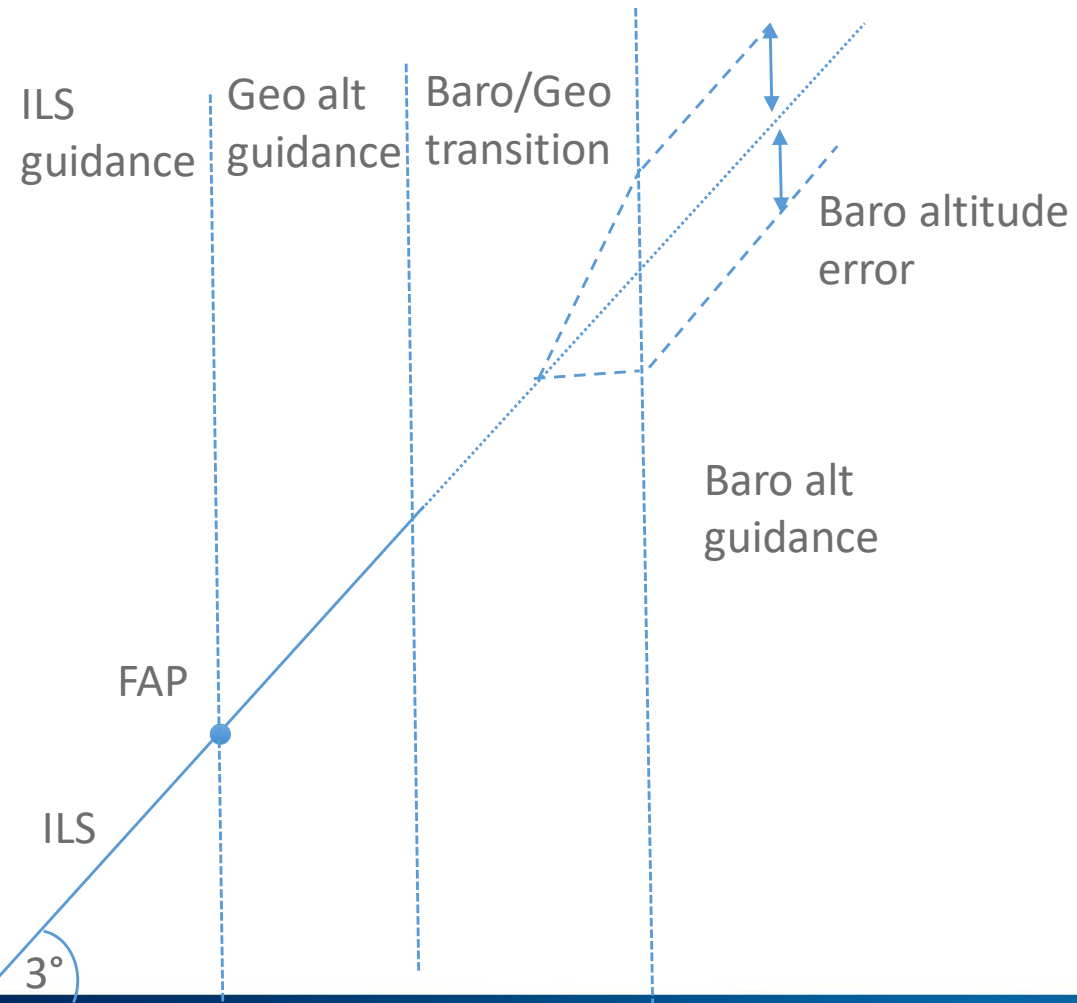
Glide intercept with transition from barometric to geometric altitude

- Baro altitude Levelling before FAP. Acquisition from below the Glide
- ➔ Major reduction of distance needed to converge
- ➔ FAP could be closer to the runway



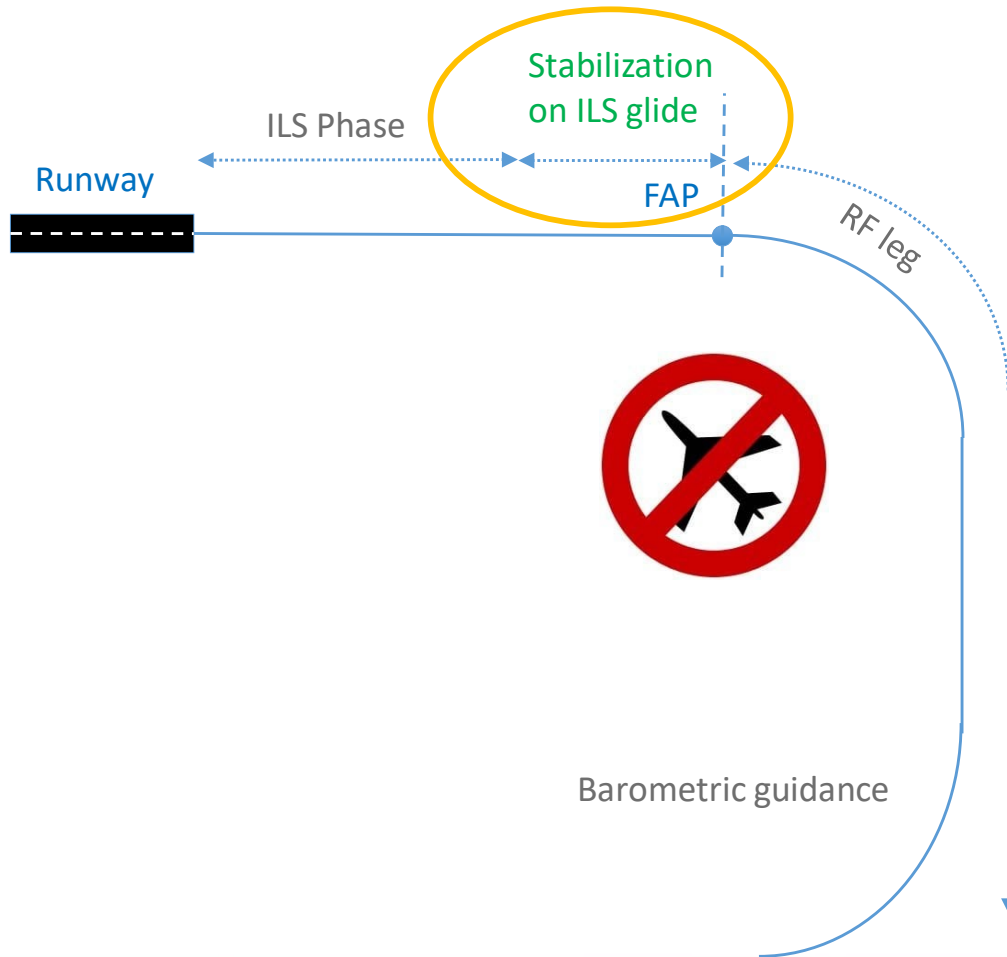
Continuous descent with transition from barometric to geometric altitude

- Acquisition from below or above the Glide
 - ➔ Major reduction of distance needed to converge
 - ➔ FAP could be closer to the runway
 - ➔ Reduction of acquisition failure

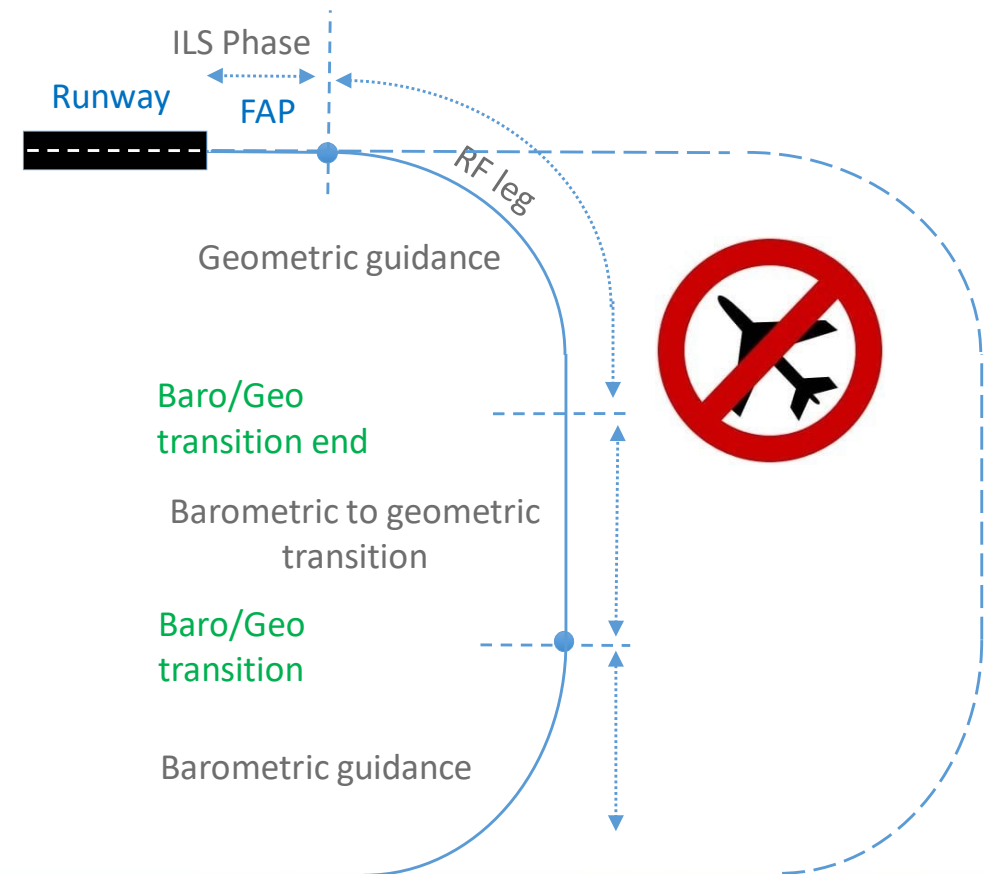


Optimized lateral profile

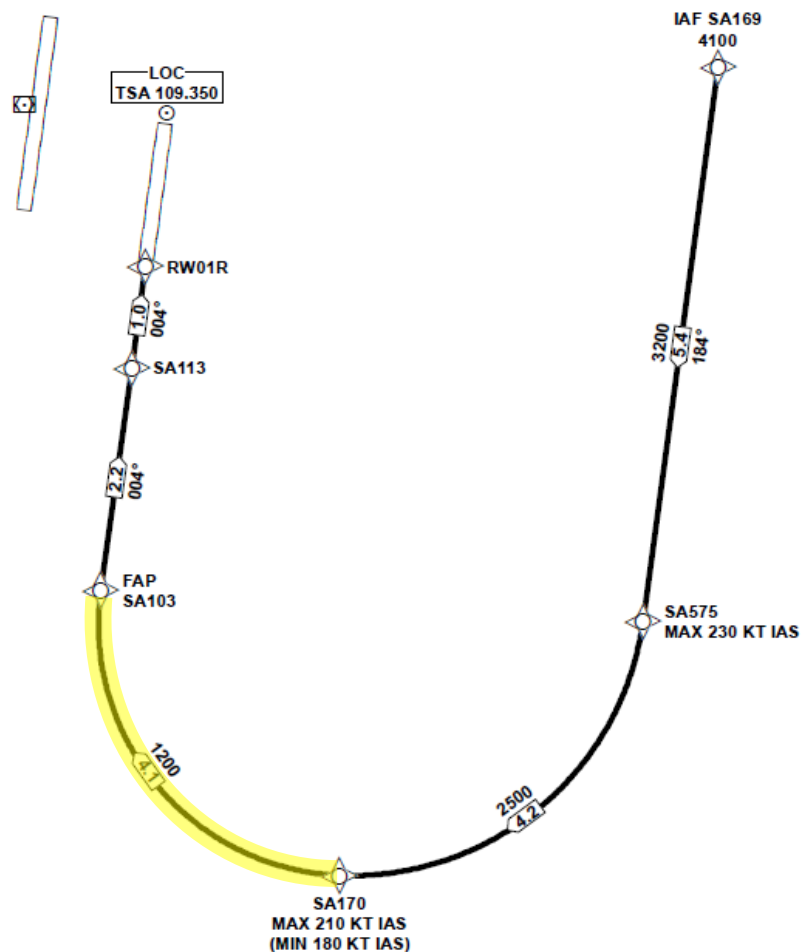
Current procedure



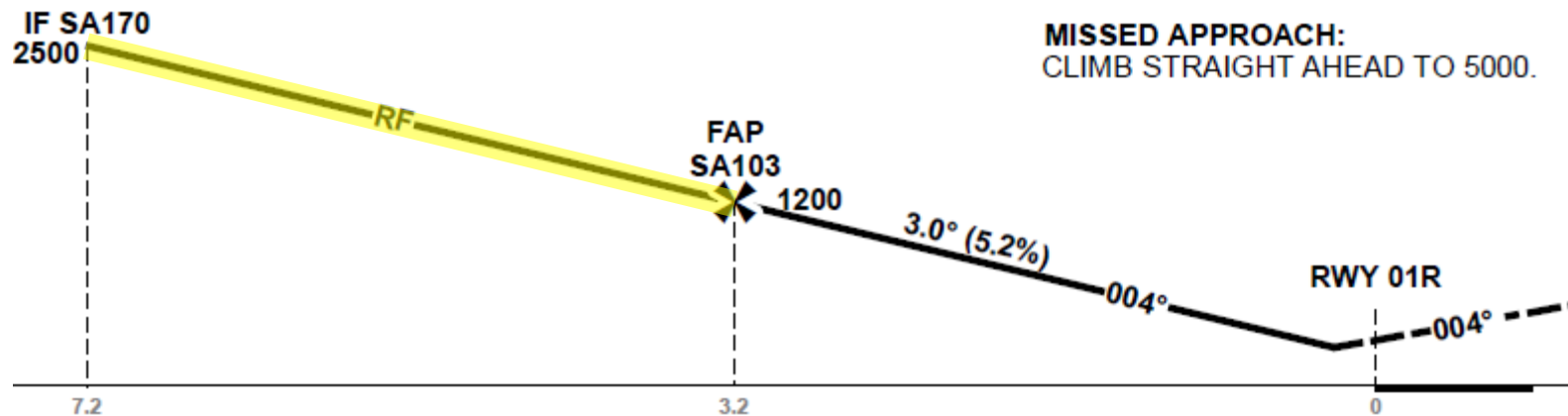
New procedure



Procedure design



Thanks to the “smooth” and stable capture of the glideslope at the FAP, the 3 degree “glide-path” could be extended through the curved segment



But a couple of challenges at ATC level...

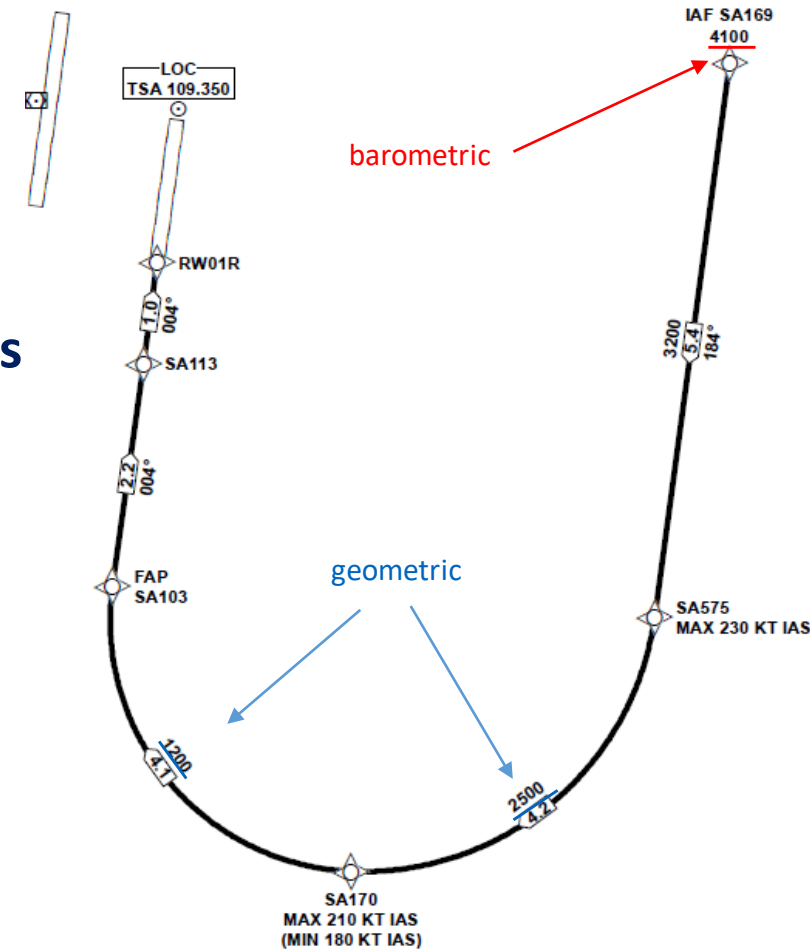
- ATC has to cope with a mix of barometric and geometric referenced traffic
- It is important that all instructions by ATC remain understood as baro altitude (level off, missed approach phase).
- Aircraft actual vertical path needs to adhere to altitude constraints

=> The impact on ATC is still an open research question, in particular:

- The baro to geometric transition phase
- The need for geometric and barometric altitude information at ground level
- The mixing of geometric and barometric traffic

And also...

- At procedure design:
 - New procedures mixing GPS and barometric reference levels
 - Extension to standard procedure to improve capture rate
- At avionics level:
 - Provide a smooth, accurate and safe baro-to-geo transition
- At pilot level:
 - Change of mindset from baro to geo

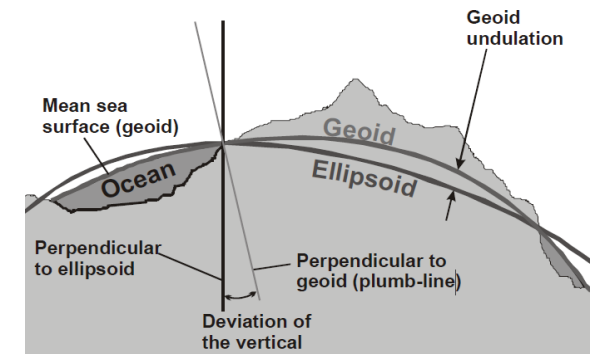


GPS as an enabler : yes but....

- Availability, accuracy and integrity of GPS altitude are key performances for these new approaches
- Approach procedures are referenced to Mean Sea Level altitude for:
 - Obstacle clearance
 - Altitude constraints
 - Runway threshold elevation

⇒ **geoid elevation**

- GPS provides “WGS-84” altitude **referenced to ellipsoid**, a simplified model of Earth
- Conversion needed with the expected accuracy





THANK YOU !

