Flight Path Monitoring:
The Good, The Bad, and The Ugly

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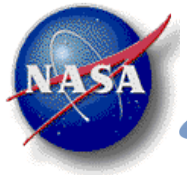
NASA Aviation Safety Program.

Outline

1. Introductions
2. What are Flight Path Management and Monitoring?
3. Barriers and Challenges to Effective Flight Path Monitoring
4. Recommended Practices for Effective Flight Path Monitoring
5. Conclusion, Wrap-Up, Workshop Evaluation



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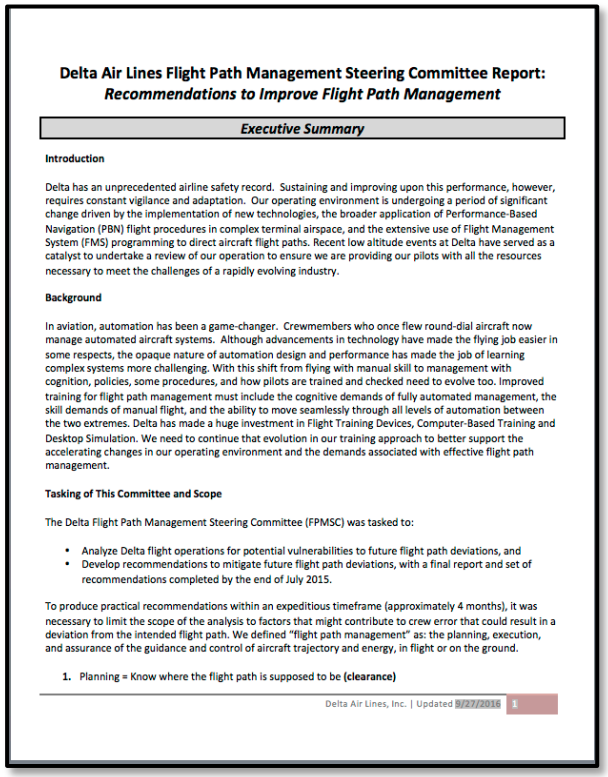
Introductions

1. Who am I?
2. Who are You?
3. Scribes: Airbus, Boeing, Bombardier, Beechcraft/Hawker, Cessna, Dassault, Embraer, Gulfstream; Garmin, Honeywell, Rockwell-Collins; Other/Miscellaneous
    a. Issues:
    b. Techniques:

Some Resources

http://flightsafety.org/files/flightpath/EPMG.pdf



Delta Air Lines Flight Path Management Steering Committee Report:
Recommendations to Improve Flight Path Management

Executive Summary

Introduction

Delta has an unprecedented airline safety record. Sustaining and improving upon this performance, however, requires constant vigilance and adaptation. Our operating environment is undergoing a period of significant change driven by the implementation of new technologies, the broader application of Performance-Based Navigation (PBN) flight procedures in complex terminal airspace, and the extensive use of Flight Management System (FMS) programming to direct aircraft flight paths. Recent low altitude events at Delta have served as a catalyst to undertake a review of our operation to ensure we are providing our pilots with all the resources necessary to meet the challenges of a rapidly evolving industry.

Background

In aviation, automation has been a game-changer. Crewmembers who once flew round-dial aircraft now manage automated aircraft systems. Although advancements in technology have made the flying job easier in some respects, the opaque nature of automation design and performance has made the job of learning complex systems more challenging. With this shift from flying with manual skill to management with cognition, policies, some procedures, and how pilots are trained and checked need to evolve too. Improved training for flight path management must include the cognitive demands of fully automated management, the skill demands of manual flight, and the ability to move seamlessly through all levels of automation between the two extremes. Delta has made a huge investment in Flight Training Devices, Computer-Based Training and Desktop Simulation. We need to continue that evolution in our training approach to better support the accelerating changes in our operating environment and the demands associated with effective flight path management.

Tasking of This Committee and Scope

The Delta Flight Path Management Steering Committee (FPMSC) was tasked to:

- Analyze Delta flight operations for potential vulnerabilities to future flight path deviations, and
- Develop recommendations to mitigate future flight path deviations, with a final report and set of recommendations completed by the end of July 2015.

To produce practical recommendations within an expeditious timeframe (approximately 4 months), it was necessary to limit the scope of the analysis to factors that might contribute to crew error that could result in a deviation from the intended flight path. We defined "flight path management" as: the planning, execution, and assurance of the guidance and control of aircraft trajectory and energy, in flight or on the ground.

1. Planning = Know where the flight path is supposed to be **(clearance)**

Delta Air Lines, Inc. | Updated 9/27/2016 1

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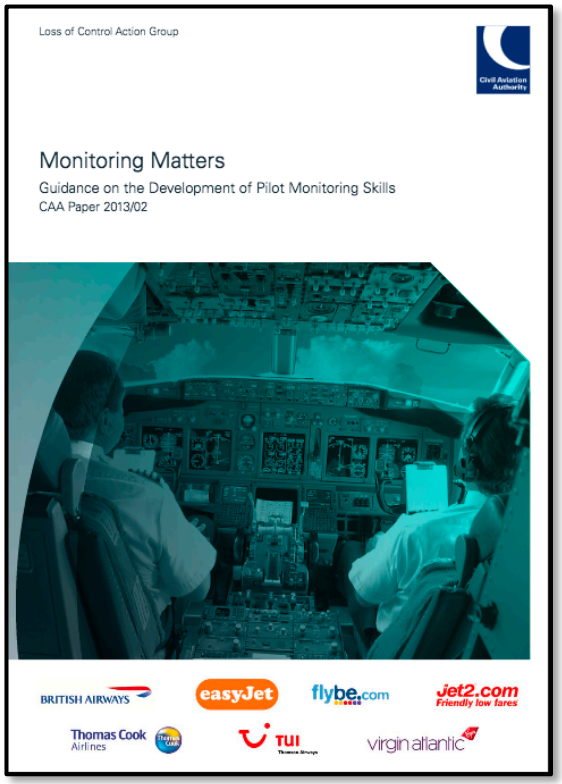

https://publicapps.caa.co.uk/docs/33/9323-CAA-Monitoring%20Matters%202nd%20Edition%20April%202013.pdf

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Some Resources, cont.

http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/afs400/parc/parc_reco/media/2013/130908_parc_fltdawg_final_report_recommendations.pdf

What is Flight Path Management and Monitoring?

Some Definitions

Flight Path:

Pertains to anytime the aircraft is in motion, including during taxi.
It also includes both the trajectory and energy state of the aircraft

Flight Path Management:[1]

The planning, execution, and assurance of the guidance and control of aircraft trajectory and energy, in flight or on the ground

- Planning = Know where the flight path is supposed to be **(clearance)**
- Execution = Put it there **(control)**
- Assurance = Keep it there **(monitor)**

[1] Delta Flight Path Management Steering Committee

Flight Path Management

Confusion arises because many pilots associate ***managing*** the flight path with simply ***controlling*** the flight path, either through manual control inputs or through automated flight guidance inputs.

- This view is dangerously incomplete, as it contains no provision to validate outputs
- Validating that the aircraft is doing "what (you think) it was told it to do" is at least as important as control/guidance inputs
- Ensuring the aircraft is on the intended flight path is accomplished by effective flight path monitoring by ***both*** pilots

Another Definition

Monitoring:

Actively and adequately watching, observing, keeping track of, or cross-checking something or someone

Monitoring is **not** a passive activity!

Monitoring is NOT Passive

Monitoring Requires:

- Attention
- Attention management
- Comprehension
- Prediction
- Action, when all is not what it should be

Monitoring is NOT Passive

Monitoring Requires:

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- Attention management
- Comprehension
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Situation Awareness

Spectrum of Monitoring Activities

The list of things pilots attend to in the course of a flight is large:

- Monitor systems that have internal monitoring and alerting
- Deliberately check critical system configurations such as pressurization system, flaps, and landing gear
- Actively monitor the changing status of their flight path
- Cross-check actions and work of co-pilot
- Monitor external factors such as weather and airport and navaid status
- Monitor what is going on back in the cabin with the passengers
- Time-share all of this with other activities and duties

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“Nowadays, these airplanes pretty much fly themselves.”

Automated aircraft ***do not*** "fly themselves."

At least not yet…..

Flight Path Monitoring

The need to address this issue has been highlighted as a major industry concern by several flight safety organizations and regulatory bodies.

Long-standing Concern – Air Carrier Ops

Effective monitoring has been an identified safety-related topic for more than 20 years.

- NTSB Safety Study (1994)
  - Inadequate monitoring present in 31 of 37 (84%) of reviewed accidents
- Flight Safety Foundation Study (1998)
  - 63% of accidents involved inadequate monitoring and cross-checking
- NASA Study: *Checklists and Monitoring in the Cockpit: Why Crucial Defenses Sometimes Fail*. Key Dismukes and Ben Berman (2010)
  - 1-19 deviations from checklist and monitoring SOPs found per observed flight
- Line Operations Safety Audit (LOSA) at Major US Air Carrier (2013)
  - Observations from more than 14,000 flights showed that flights with poor or marginal monitoring had *2-3 times more mismanaged errors* and *2-3 times more undesired aircraft states* than flights with outstanding monitoring

Barriers and Challenges to Effective Flight Path Monitoring

Barriers/Challenges to Effective Monitoring

- Misunderstanding of monitoring roles and responsibilities
- Human factors issues
- Workload, time pressure, interruptions, & distractions
- Lack of feedback to pilots when monitoring lapses
- Flight deck automation
- Procedures
- External contributors
- Company culture
- Training

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Both pilots are responsible for monitoring the flight path.

PF vs. PM Duties for a Heading Change

PF Duties

- Monitor radio communications
- Acknowledge clearance (with other pilot)
- Rotate heading knob
- Monitor heading bug (verify correct heading set)
- Select heading lateral mode
- Monitor FMA (Verify lateral mode)
- Monitor flight instruments to confirm execution of turn

PM Duties

- Read back clearance
- Acknowledge clearance (with other pilot)
- Monitor heading bug (verify correct heading set)
- Monitor FMA (Verify lateral mode)
- Monitor flight instruments to confirm execution of turn

PF vs. PM Duties for a Heading Change

PF Duties	PM Duties
• Monitor radio communications	• Read back clearance
• **Acknowledge clearance (with other pilot)**	• **Acknowledge clearance (with other pilot)**
• Rotate heading knob	
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• Select heading lateral mode	
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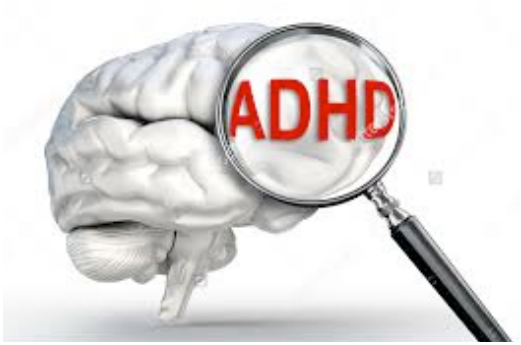
Human Factors Issues

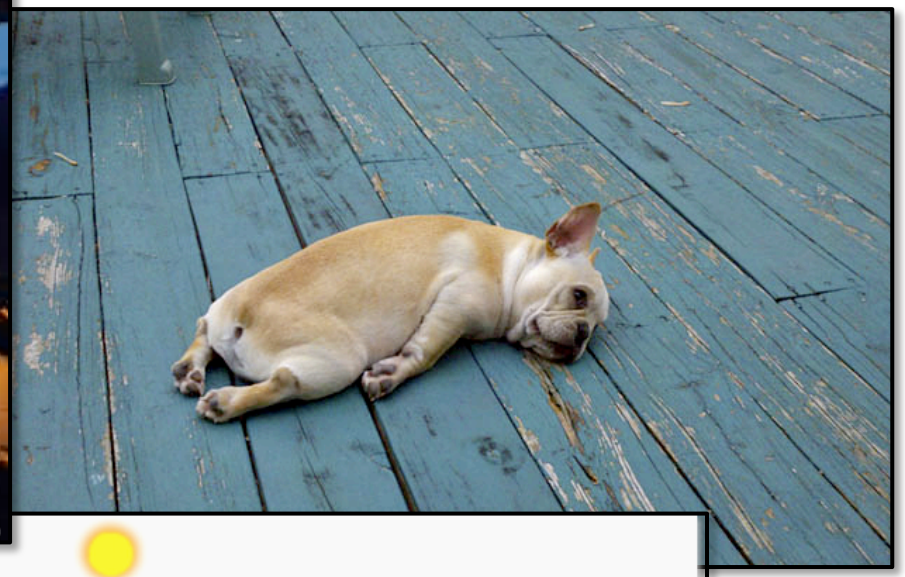
The Human Brain:

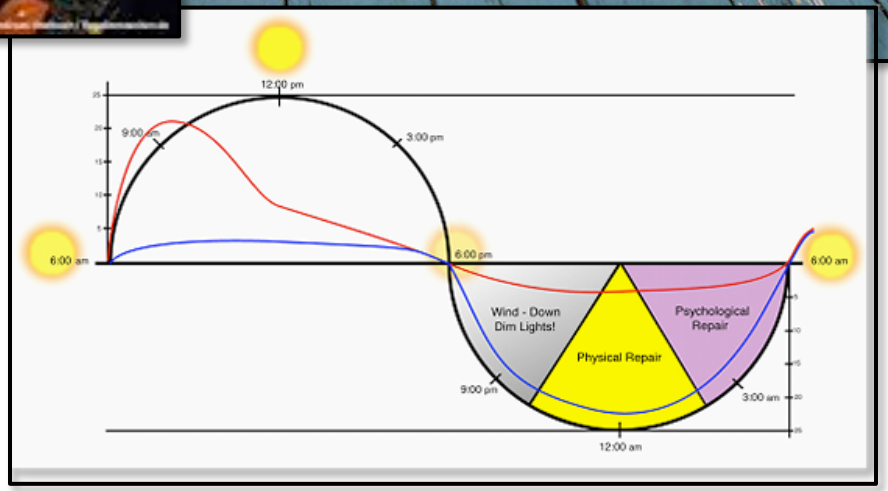


- Is not wired for sustained vigilance
- Has limited ability to multitask
- Is vulnerable to interruptions and distractions
- Is prone to habit capture
- Is vulnerable to inattention blindness – focus on one thing causes us to miss other things

- We are also vulnerable seeing what we expect to see (expectation bias)
- And can have difficulty remembering to do an intended task later (prospective memory failure)

Fatigue and Circadian Rhythm Disruptions





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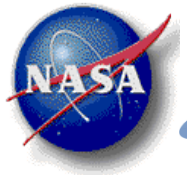

Workload – Interruptions – Distractions

Multi-tasking is a largely a myth

Mostly, we shift attention among multiple tasks

Workload – Interruptions – Distractions

To Avoid Prospective Memory Failures:

- Create salient cues to help you remember
- Take a second to form an intention to pick up where you left off
- Pause just before you resume interrupted task

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Workload – Interruptions – Distractions

Non-Normal Situations

On flight from ATL to SWF, had EFIS failure. FO's pitch, hdg and roll modes all failed approx. 1 hr. 30 mins. into the flight… When the EFIS failure occurs you also lose the autopilot, so I immediately began to hand fly while the FO troubleshot the problem. With me flying and the FO monitoring, we continued to SWF. We were both very 'absorbed' in flying the aircraft by hand as it's something we don't often do.

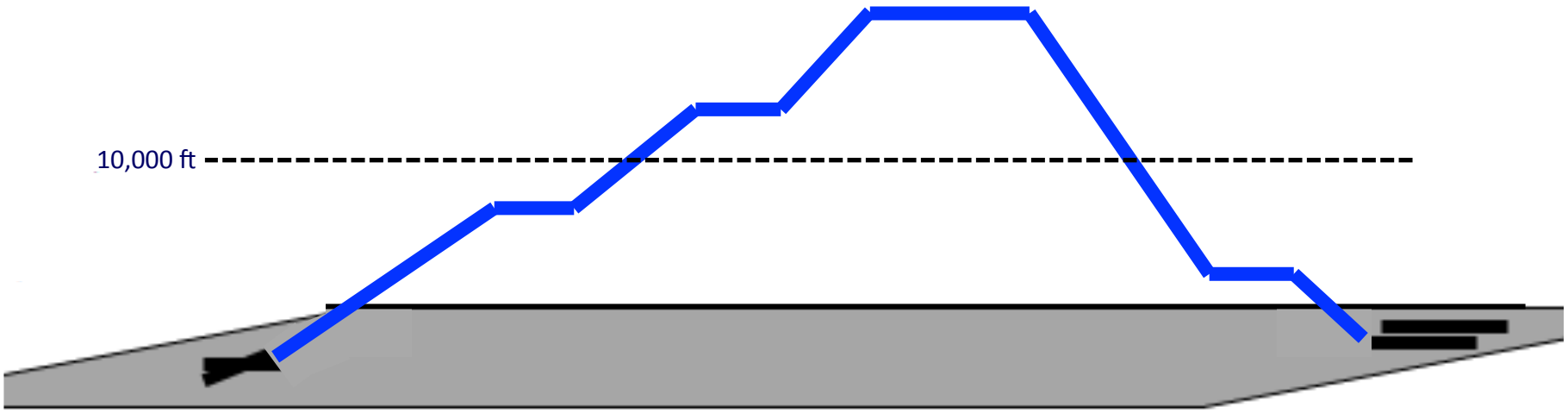
In the process of working through the checklist and trying to get the EFIS back up, we ended up approx. 30 mi from SWF at FL330… I'm not sure whether DCA forgot to hand us off or if we just missed it. Had it not been for the EFIS failure I feel sure we would have caught our error sooner. Further complicating this was the fact that I had a new hire FO who I was watching more closely than I would have been with someone with more experience.

Exercise #1

Areas of Vulnerability – In Flight

High
Medium
Low

Vertical Profile (Side) View

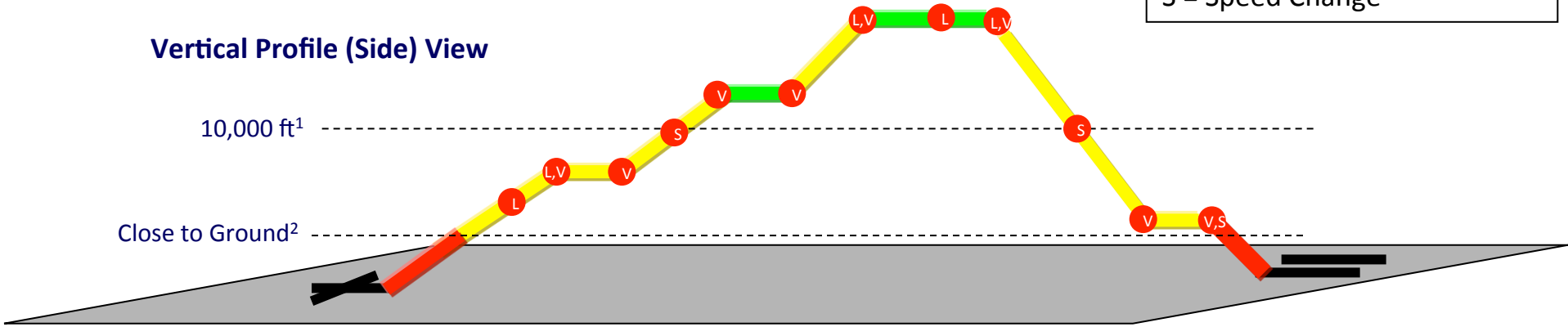


Where in your flight, from take off to landing (with the cruise portion compressed), are you most vulnerable to flight path deviations and why?

Areas of Vulnerability – In Flight

High
Medium
Low

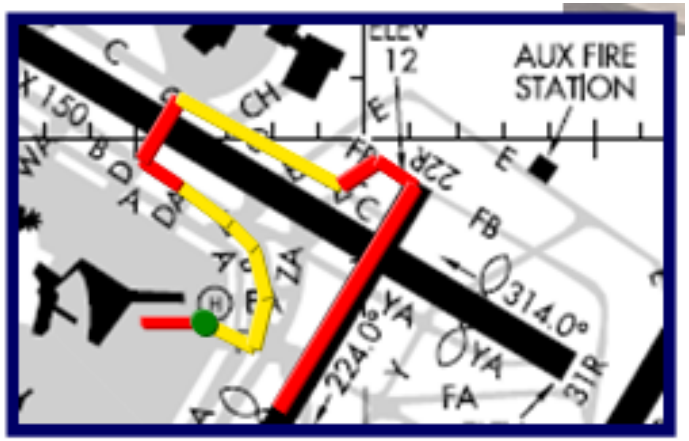
Key to Red Dot Labels:
L = Lateral Trajectory Change
V = Vertical Trajectory Change
S = Speed Change



Note 1: 10,000 ft is used in the U.S. as the boundary altitude for sterile cockpit rules and for the 250 KIAS speed restriction (both required below 10,000 ft). For the purposes of the areas of vulnerability (AOV) model, an altitude other than 10,000 ft may be chosen, but it is suggested that this boundary match the use of sterile cockpit rules for your company (or nation/state) for ease of operational applicability by flight crews.

Note 2: "Close to Ground" may be defined by the company, but it is suggested that this be an altitude no less than (a) 1,500 ft AGL or (b) the altitude of surrounding terrain (if terrain threats exist within 5 nm (9 km) of the flight path), whichever is higher.

Areas of Vulnerability



- On the ground:
  - We are most vulnerable approaching, crossing and entering active runways
  - We are fairly vulnerable whenever we are moving on the ground

Barriers/Challenges to Effective Monitoring

- Misunderstanding of monitoring roles and responsibilities
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- **Lack of feedback to pilots when monitoring lapses**
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Lack of Feedback to Pilots When Monitoring Lapses

Carlos Porges, 2016

Indications of Inadequate Monitoring

- ***Missed (or late) flight path callouts***:
  - "3,000 descending 2,000"
  - "Glide slope intercept altitude 1,500, checked"
  - "1,000 stable, cleared to land"

- If a ***change in pitch, roll or power*** occurs …
  and you were ***not actively looking*** for it
- If a ***mode change*** occurs …
  and you were ***not actively looking*** for it
- If you are ***late to recognize*** terrain, traffic or weather
- If you notice yourself performing ***concurrent (non-flight path–related) tasks during flight path transitions***

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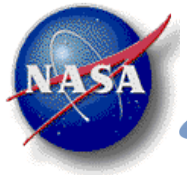

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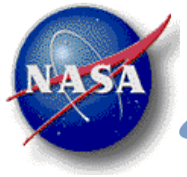
Aircraft Automation - Modes

Mode Confusion:

- Incorrect understanding of what aircraft performance and behavior goes with a particular mode (particularly a problem with vertical/pitch modes)
  - Does this mode control pitch, speed, climb/descent rate…?
  - If ATC wants me to do X, which mode is best suited for this given where I am, where I am going, and what kind of aircraft behavior or performance I want?
- Confusion about mode transitions
  - After you hit this target, this mode will change to….what?
  - Automatic transitions that you didn't program

What modes or mode transitions do you find to be the most confusing on the aircraft you fly?



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Automation Mode Changes Can Occur Quickly and Without Warning

Autoflight System

On descent into SFO, we were cleared for the Quiet Bridge Visual approach at 10,000 and told to cross ARCHI at 8,000. We started our descent from 10,000 to 8,000 with 8,000 in the altitude window. As the aircraft failed to capture the selected altitude flying pilot disconnected the autopilot and pitched up to stop the descent and maintain 8,000. The aircraft only went down to 7,800 feet during his prompt correction.

Sometimes the Challenger 300 autopilot with altitude capture is sloppy. We were trusting its ability and when it captured altitude late, we were attentive enough to prevent further altitude loss.

Aircraft Automation – FMS: Pilot Induced

LDA/DME 25 approach to EGE selected but pilot failed to selected RLG transition. Aircraft flew from RLG directly to AIGLE in VPATH and bypassed fixes outside of AIGLE. Thus aircraft was right of airway and descending in VPATH to AIGLE. ATC (I believe it was Tower) announced a low altitude alert and asked pilots to climb to 14,000.

Pilots did not confirm fixes leaving RLG prior to the approach. Pilot not flying [was] off the air speaking with FBO when pilot flying [was] cleared for the approach. Better CRM (approach briefing) and communication may have prevented the deviation.

Also, the two fixes, AIGLE and AQILA both beginning with the letter "A" helped to cause the deviation as it didn't trigger a reaction from us when looking at the FMS fixes and the approach plate fixes. The FMS flew to AIGLE and not to AQILA where it should have.

Automation: FMS Induced

Shortly after liftoff when we engage the LNAV function expecting the LNAV to fly the Anchorage six departure the Anchorage six departure is no longer present in the FMS routing, it simply disappears-it's gone.

I do not know the cause, or why, the programmed departure is no longer available in the FMS following departure.

When should you most often suspect that your FMS may be untrustworthy?

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Database Update

Upon receiving clearance from Dallas Clearance, the crew loaded the SID for the JPOOL6 Departure from DAL in the Collins FMS. The clearance given was "cleared to [destination] via JPOOL6 ACT As Filed, Climb 4000 Expect 6000, Departure Frequency 124.3 [and a squawk]".

Upon takeoff climb, the autopilot was selected above 700ft AGL and began a left turn to intercept a course to TTT VOR. Upon noticing the error, the captain disconnected the autopilot simultaneously while being queried by Departure Control about the clearance… The FMS is not correctly loading the JPOOL6 departure and commanded an erroneous course to the autopilot and flight director upon selection.

Callback:
The reporter advised he had programmed and flown the JPOOL SID on a number of previous occasions without problems. This was his first use since the latest chart and database revision.

Technology and Databases

We had previously planned and briefed a visual approach to runway 20R at SNA. The ILS was set for a backup to the visual approach. We visually identified the airport, reported that to Socal approach and were cleared for a visual approach to runway 20R.

On final approach, the Runway Awareness Advisory System (RAAS) announced "Approaching runway 19R". We confirmed that we were properly established for the correct airport/runway and continued to a normal landing.

Apparently the runways were renumbered sometime during the second half of 2014. Either the RAAS database is not up to date or the latest database is not installed in the aircraft.

Database Updates and Aircraft Differences

I directed the co-pilot to complete the preflight and all aircraft checklists up to engine start. He was also directed to load the new FMS database into the aircraft. Because the database download requires a significant amount of time, he was sent out early to perform the task.

[Unknown to me at the time] due to system design, the "downloaded" database is loaded into the secondary database (an inactive position). The expired database remains active until de-selected by aircrew. The aircrew was unaware of this design feature. However, the NAV data (line one) of the status page shows the newly updated database name, even though it is not active.

Since FMS one was initialized with the out-of-date data, no warning was displayed on the FMS two and three because they too were initialized with the out-of-date data. On the CL601--which is the aircraft I primarily fly--the installed Universal FMS, once loaded, erases all information and then "activates" the loaded database without pilot input.

Our organization's Differences Training [for the CL604] did not address FMS database maintenance issues. In two years, I have had less than 6 hours in the aircraft. Our organization needs to develop currency requirements for dual rated pilots.

Automation and ATC

On arrival into ANC, cleared to 3,000 feet. Descending through 3,500, First Officer (FO) and I both notice TCAS traffic at 2,500 inside 10 miles opposite direction. FO asked ATC about the traffic and the controller casually replied that he was 5 miles and 2,500 feet… As the traffic turned yellow on the TCAS, we grew more alarmed as it seemed to be closing rapidly….We were IMC the entire time and never had the traffic in sight visually.

More disturbing than the actual traffic proximity was the failure of all preventive measures. While the TCAS did alert the traffic and ultimately give an RA, it seemed slow to do so. Both FO and I felt that if we had waited for the RA to take action, it would have been too late.

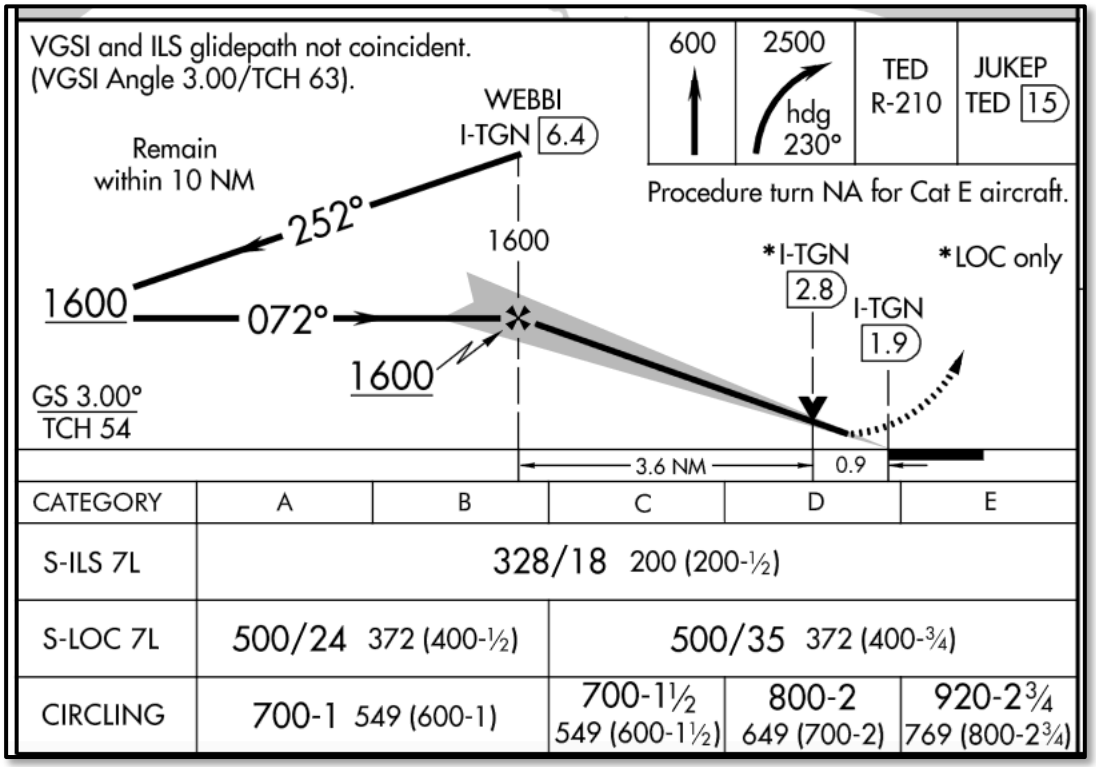
Not only did ATC fail to point out the traffic, when queried, seemed overly casual and unconcerned.

The only thing keeping all the Swiss cheese holes from aligning was crew observation and preemptive action.

Automation and ATC

While intercepting the ILS to 7L at 1600 FT MSL we appeared to momentarily lose the localizer signal. Since we were prior to the FAF and stable we asked for a quick vector to re-intercept the localizer. We were given a vector 5 degrees left to intercept. The localizer appeared to return however we were not in a good position to make the approach.

As we were preparing to go-around, the Tower directed us to discontinue the approach, climb to 2,000, and turn right heading 180. There was confusion about the initial clearance



CATEGORY	A	B	C	D	E
S-ILS 7L	328/18 200 (200-½)				
S-LOC 7L	500/24 372 (400-½)		500/35 372 (400-¾)		
CIRCLING	700-1 549 (600-1)		700-1½ 549 (600-1½)	800-2 649 (700-2)	920-2¾ 769 (800-2¾)

We determined the clearance was to 2,000 and not the published go-around altitude of 2,500. We over shot our altitude by approximately 800 FT.

Manual Flight

- Skill degradation, atrophy
- Impoverished scan
- Reluctance/delay in switching to manual flight when necessary/appropriate

Barriers/Challenges to Effective Monitoring

- Misunderstanding of monitoring roles and responsibilities
- Human factors issues
- Workload, time pressure, interruptions, & distractions
- Lack of feedback to pilots when monitoring lapses
- Flight deck automation
- **Procedures**
- External contributors
- Company culture
- Training

Procedures

- SOPs
- Published Procedures

What are some of your company SOPs that could interfere with effective flight path monitoring?

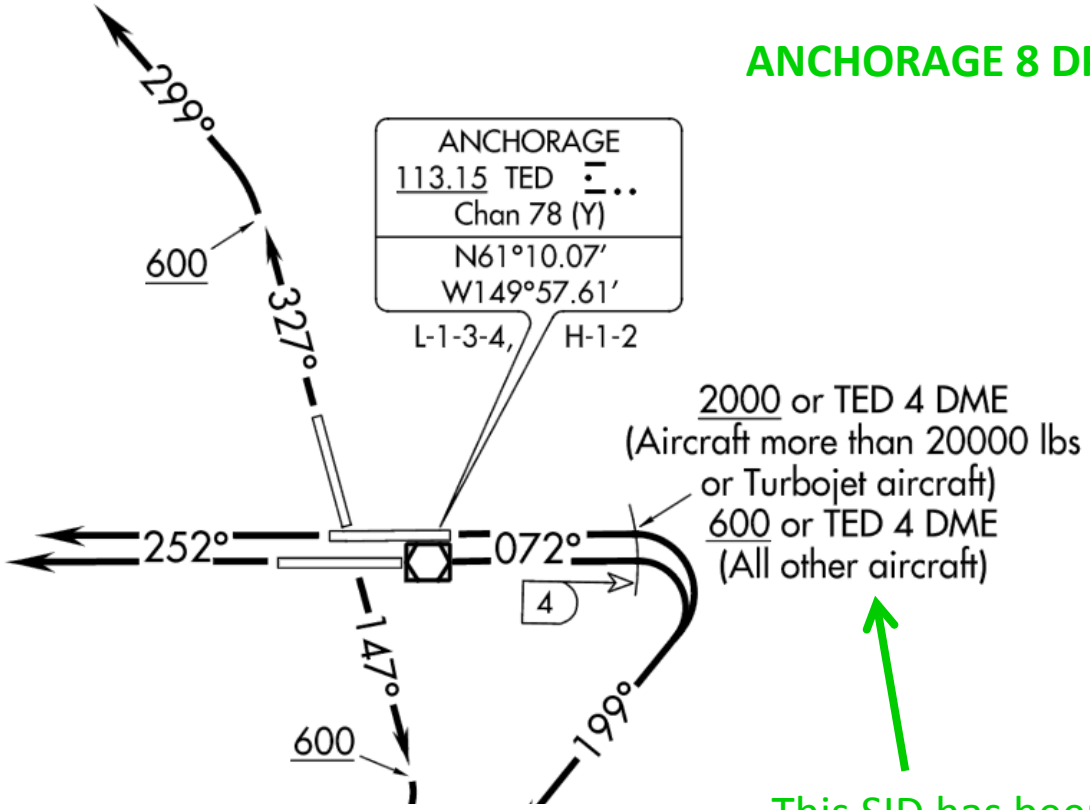
What are some of your company SOPs that actively support effective flight path monitoring?

Procedures

Aircraft X departed Runway 7L on the ANCHORAGE SIX SID. The SID states to fly runway heading until 2,000 or TED VOR 4 DME, whichever comes first, then turn right to heading 200.

Aircraft X was observed to pass an estimated 2.8 miles from a mountain at 4,000 where the mountain peak is depicted on our charts as 4,700. This event is not a singular occurrence.

ANCHORAGE 8 DP



TAKEOFF RUNWAYS 7L/R:
AIRCRAFT MORE THAN 20000 LBS OR TURBOJET AIRCRAFT: Climb heading 072° until leaving 2000 or TED 4 DME, whichever comes first, turn right heading 199°. Advise ATC prior to departure if unable to be established on heading 199° by 4 DME east of TED VOR/DME.
ALL OTHER AIRCRAFT: Climb heading 072°, upon passing 600 or reaching TED 4 DME, climbing right turn to heading 199°. Advise ATC prior to departure if unable to be established on heading 199° by 4 DME east of TED VOR/DME. Thence. . . .

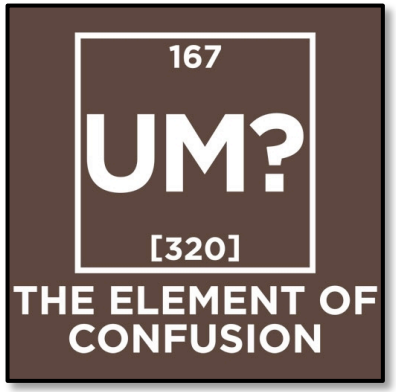
This SID has been changed since the ASRS report was filed – does this help?

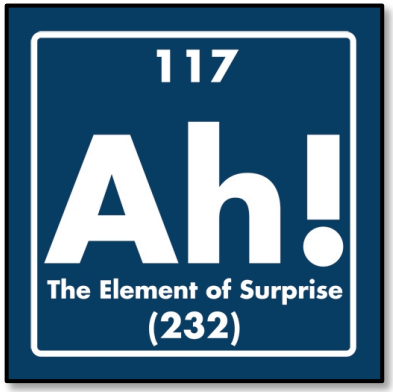
ATC and Procedures

Shortly after departure on the Teterboro Nine departure out of TEB, tower switched us to New York departure. Upon check in, ATC queried our aircraft speed. We responded back with current speed which was around 135 knots. ATC then returned with "135 knots... that slow? Don't ever do that again."

We were slower than normal speed because we were complying with TEB's noise abatement procedure which requires aircraft to maintain V2+10-20 knots. Teterboro is a noise sensitive airport with a three strike rule. If aircraft violate this rule they are banned for a year - which can be very detrimental to a charter operation.

Procedure Confusion





What are some of the

"Gotcha's"

on procedures you fly?

NASA

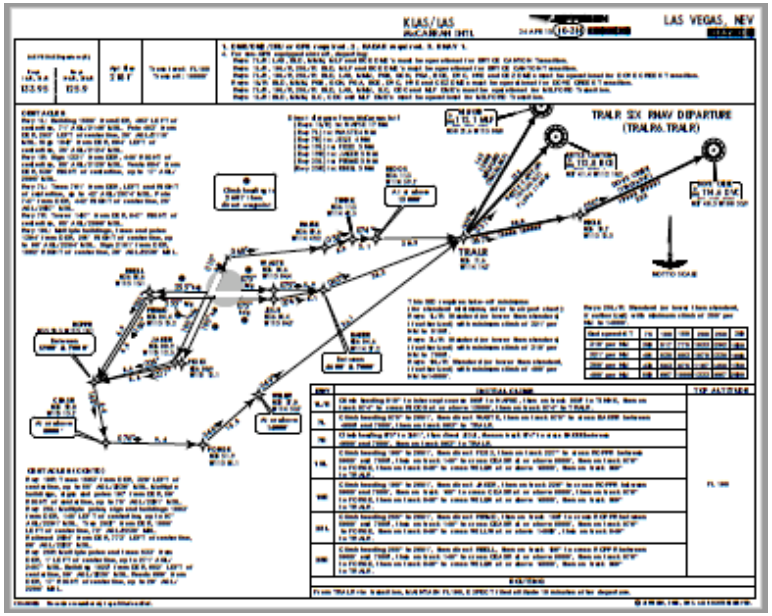
Human Systems
Integration Division

Professional Pilot, May 2016

How Well Do you Know "Climb Via"?

1. If ATC issues the instructions "cleared via the TRALR Six RNAV Departure," the flight is permitted to climb to meet any published altitude restrictions
   a. True b. False

2. Select the true statement(s) regarding a "climb via" clearance for this SID:
   a. The clearance limit altitude is FL190
   b. ATC will assign a top altitude of FL190
   c. The flight must comply with all published altitude restrictions
   d. Upon initial contact with Las Vegas Departure, the pilot must state the flight number or aircraft identification, current, altitude, and "climbing via TRALR Six RNAV Departure to 190."



3. "Climbing on the TRALR Six Departure" is an appropriate way to verify to ATC that a "climb via" clearance was issued by a previous controller.
   a. True b. False

4. A Flight departs from Rwy 25L after receiving a "climb via" clearance. If, after passing RBELL, ATC issues a clearance to "climb and maintain 16,000," the flight should comply with the published altitude restriction at ROPPR.
   a. True b. False

5. A flight is cleared to "climb via the TRALR Six RNAV Departure, BRYCE CANYON Transition." Unless issued further instructions, at TRALR, the flight should:
   a. Maintain FL190
   b. Maintain FL200
   c. Maintain 11,000 ft MSL
   d. Climb to the filed altitude

6. If ATC issues the clearance "Climb via TRALR Six Departure, except maintain FL180," the flight must:
   a. Request an amended clearance from ATC because the chart depicts a top altitude of FL190
   b. Comply with the lateral path requirements of the SID but climb at the minimum climb gradient to FL180 after departure
   c. Comply with the charted altitude restrictions and maintain FL180 until the procedure indicates a climb to the top altitude of FL190
   d. Comply with the charted altitude restrictions while climbing to FL180 and stop the climb at FL180 until issued further clearance from ATC

7. While climbing via TRALR Six RNAV Departure you request a lateral deviation around weather just before reaching CEASR. If ATC approves the deviation, do you still need to comply with the published altitude restrictions?
   a. Yes, but only the one at CEASR, all remaining restrictions are cancelled
   b. Yes, but only the top altitude of FL190, all interim restrictions are cancelled
   c. Yes, but only if your deviation will take you to another waypoint on the RNAV Departure that has an altitude restriction; all subsequent restrictions must also be met
   d. No, if a lateral deviation is granted, the climb via clearance is cancelled and ATC must assign an altitude to maintain

How Well Do you Know "Climb Via"? - Answers

1. If ATC issues the instructions "cleared via the TRALR Six RNAV Departure," the flight is permitted to climb to meet any published altitude restrictions

   b. False

   Only a "climb via SID" clearance gives the flight the vertical authorization to climb and comply with the published altitude restrictions. "Cleared via the TRALR Six RNAV Departure" is an example of a lateral clearance only. Refer to section 5-2-8 of the AIM for more info.

2. Select the true statement(s) regarding a "climb via" clearance for this SID:

   a. The clearance limit altitude is FL190

   c. The flight must comply with all published altitude restrictions

   A "climb via" SID clearance means that a flight must comply with the lateral path of the SID and with all published speed and altitude restrictions. ATC does not assign the top altitude (FL190) when one is published on the chart in the clearance. If a flight has received a "climb via" clearance, upon initial contact, the pilot should report the flight number or aircraft identification, followed by the current altitude and then state "climbing via the (SID name" departure." The pilot should not state the altitude that the aircraft is climbing to if it is climbing via the published top altitude of the procedure.

3. "Climbing on the TRALR Six Departure" is an appropriate way to verify to ATC that a "climb via" clearance was issued by a previous controller.

   b. False

   When changing frequency, pilots must advise ATC on initial contact of current altitude, "climbing via/descending via" with the procedure name, and runway transitions, if assigned. Non-standard phraseology has caused a number of pilot deviation reports to be filed. Phrases such as "on the" or "Climbing on" a procedure are not appropriate and can create confusion and additional ATC workload to verify the clearance that was issued to the pilot by the previous controller. See FAA Information for Operators 14003 for more information.

How Well Do you Know "Climb Via"? - Answers

4. A Flight departs from Rwy 25L after receiving a "climb via" clearance. If, after passing RBELL, ATC issues a clearance to "climb and maintain 16,000," the flight should comply with the published altitude restriction at ROPPR.

b. False

Unlike a "climb via" clearance, when cleared to "climb and maintain," the aircraft is expected to vacate its current altitude and begin an unrestricted climb to comply with the clearance. For aircraft already climbing via a SID, published altitude restrictions are deleted unless re-issued by ATC.

5. A flight is cleared to "climb via the TRALR Six RNAV Departure, BRYCE CANYON Transition." Unless issued further instructions, at TRALR, the flight should:

a. Maintain FL190

The "top altitude" of the SID is the published or ATC assigned altitude limit until cleared to climb higher by ATC. The flied/expected altitude is not relevant, and has no bearing on the SID unless communications are lost between the pilot and ATC. Even if there is a published altitude restriction at a fix that is higher than the charted top altitude, the flight is only cleared to the charted "top altitude" contained in the narrative of the procedure, unless ATC assigns a different altitude.

According to the FAA's Climb Via Implementation Work Group, the Top Altitude is NOT considered a published altitude constraint, just the ATC assigned altitude limit

6. If ATC issues the clearance "Climb via TRALR Six Departure, except maintain FL180," the flight must:

d. Comply with the charted altitude restrictions while climbing to FL180 and stop the climb at FL180 until issued further clearance from ATC

Section 5-2-8 of the AIM states that in this situation, the aircraft must comply with the departure lateral path and any published speed and altitude restrictions while climbing to FL180. The aircraft must stop the climb at FL180 until issued further clearance by ATC.

How Well Do you Know "Climb Via"? - Answers

7. While climbing via TRALR Six RNAV Departure you request a lateral deviation around weather just before reaching CEASR. If ATC approves the deviation, do you still need to comply with the published altitude restrictions?

   d. No, if a lateral deviation is granted, the climb via clearance is cancelled and ATC must assign an altitude to maintain

Departure Clearances: Summary

Climb Via SID

- Comply with "everything" on the SID up to the Top Altitude which is published on the chart

Climb Via SID, Except Maintain (Altitude)

- Comply with "everything" on the SID up to the "ATC assigned" altitude

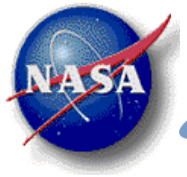
Climb and Maintain (Altitude)

- Used on SIDs that do not contain published altitude constraints, other than the Top Altitude

- Cancels all published altitude constraints

Barriers/Challenges to Effective Monitoring

- Misunderstanding of monitoring roles and responsibilities
- Human factors issues
- Workload, time pressure, interruptions, & distractions
- Lack of feedback to pilots when monitoring lapses
- Flight deck automation
- Procedures
- **External contributors**
- Company culture
- Training



External Contributors

- Environmental
- Terrain
- Airports
- Aircraft
- People
- Things

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Terrain

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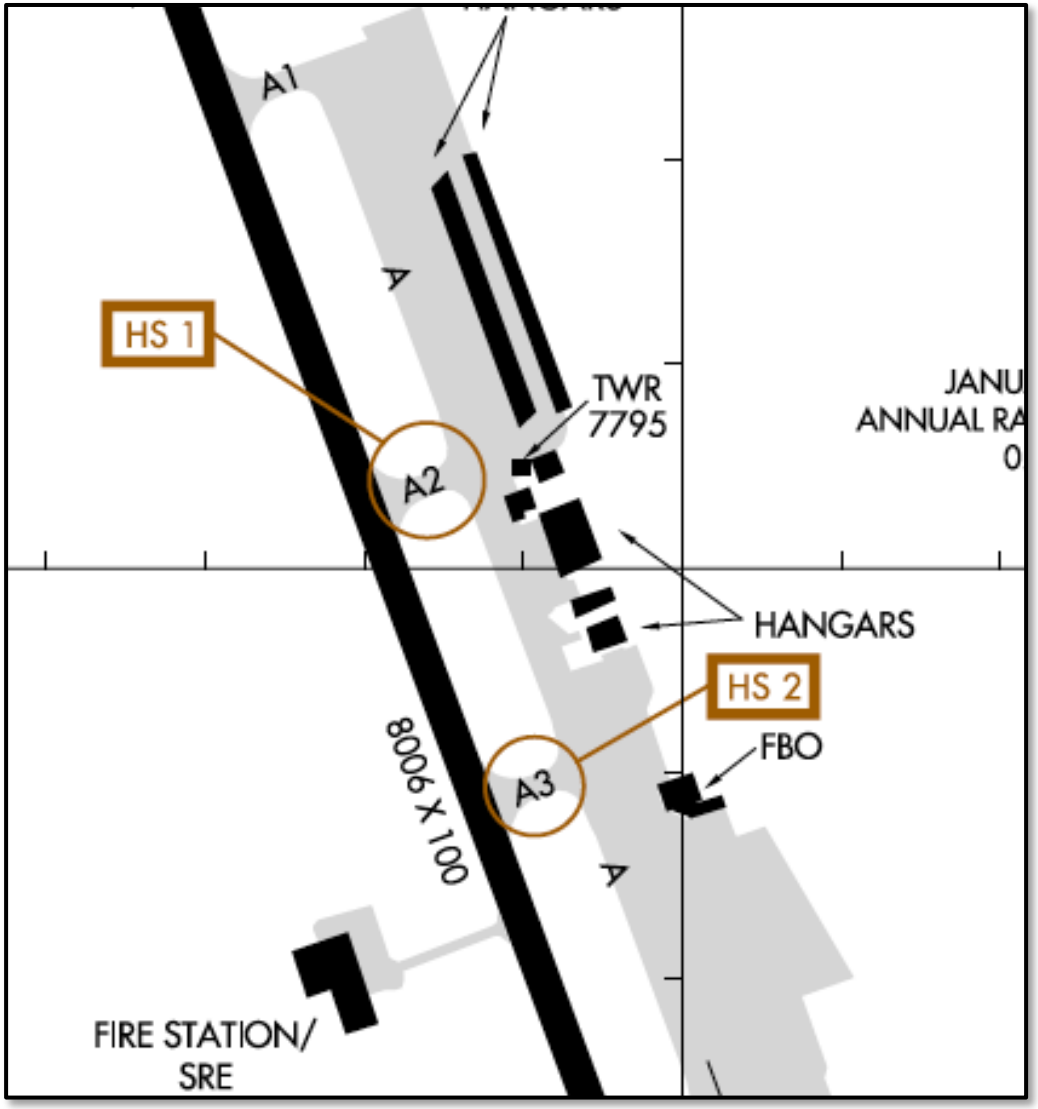
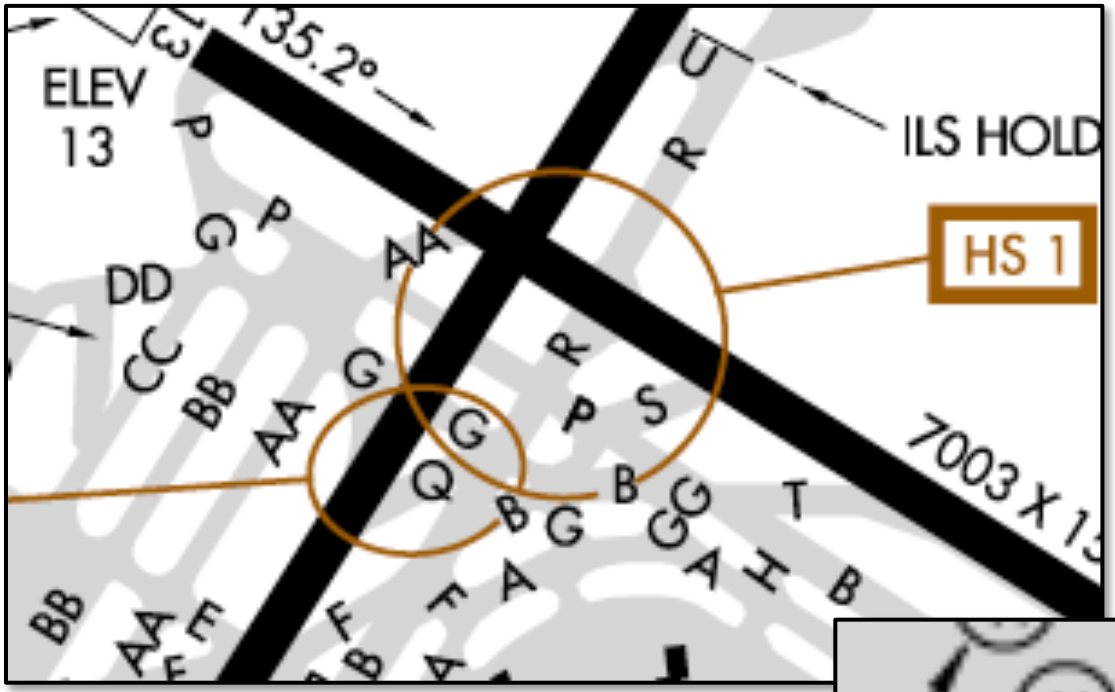
Time and Space Compression



Aspen – Pitkin County (ASE)

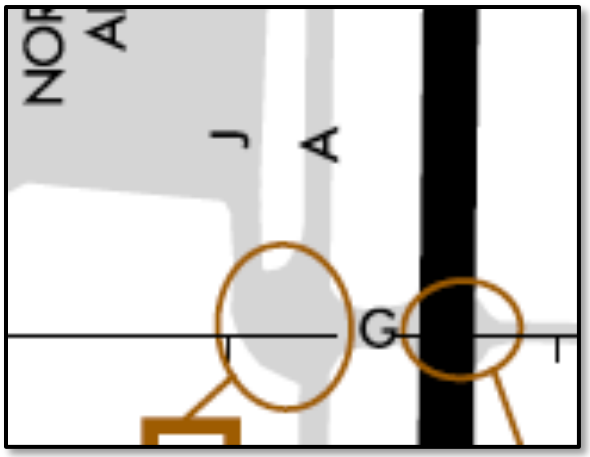
Very short taxi (HS 1 and HS 2)

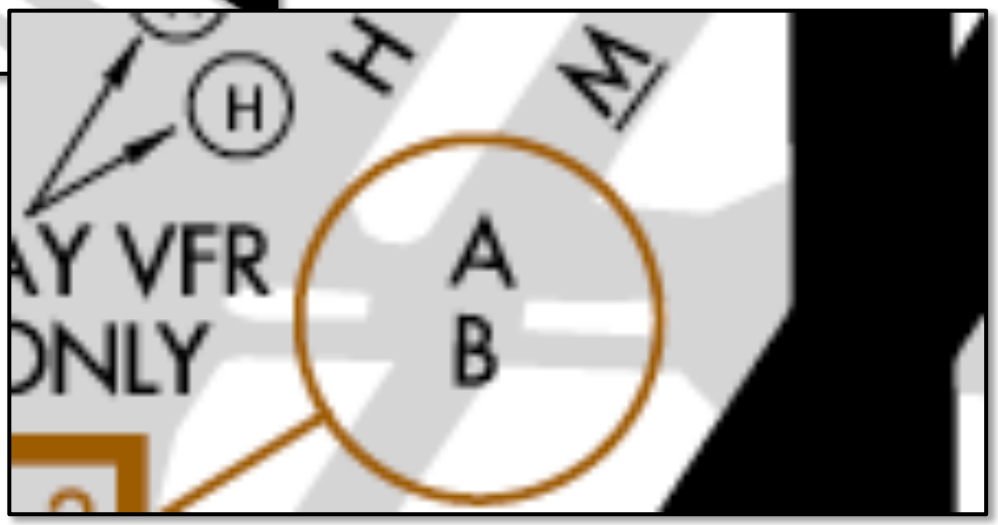
Spider Webs - Intersection Congestion



LGA

LVK



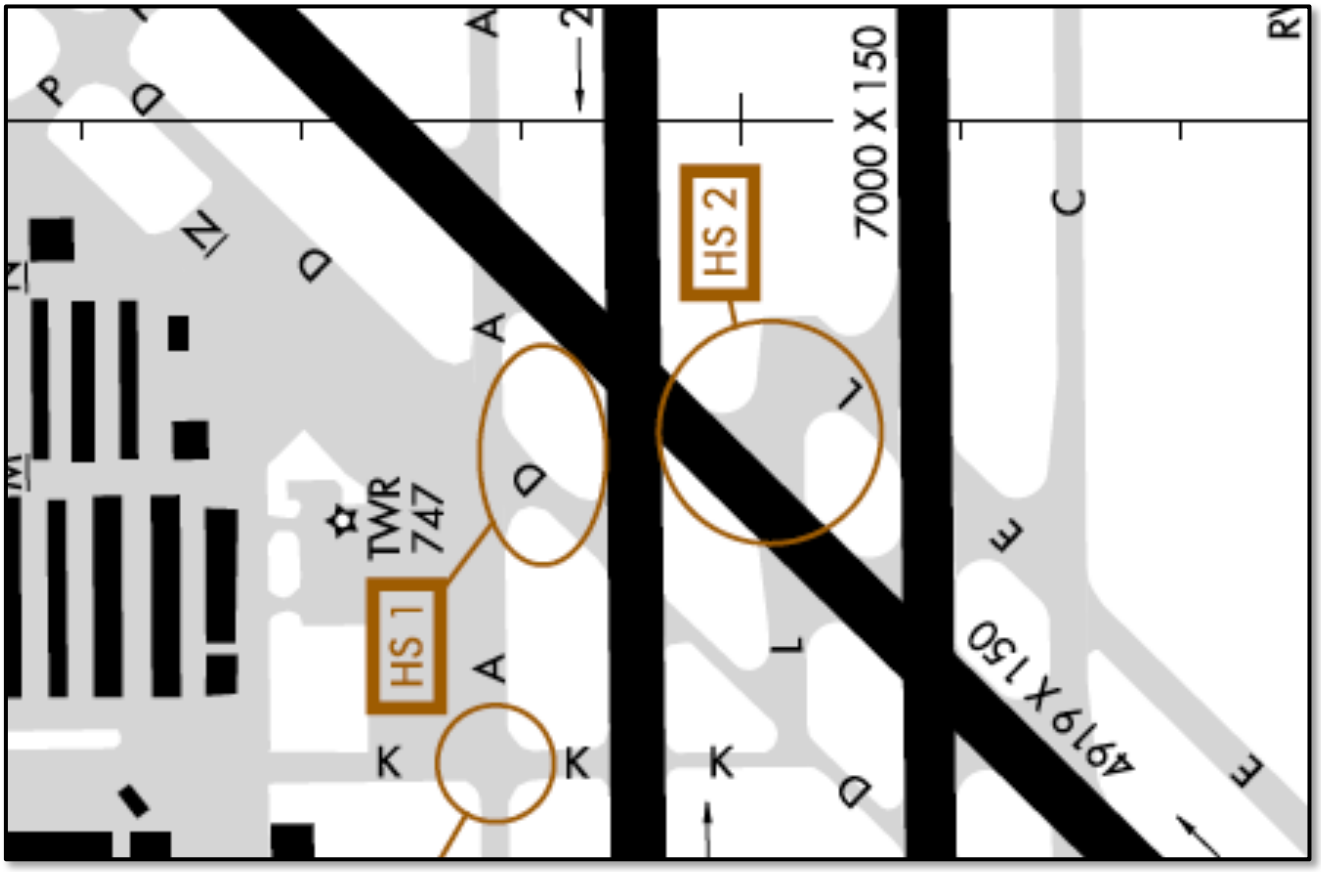


SAC

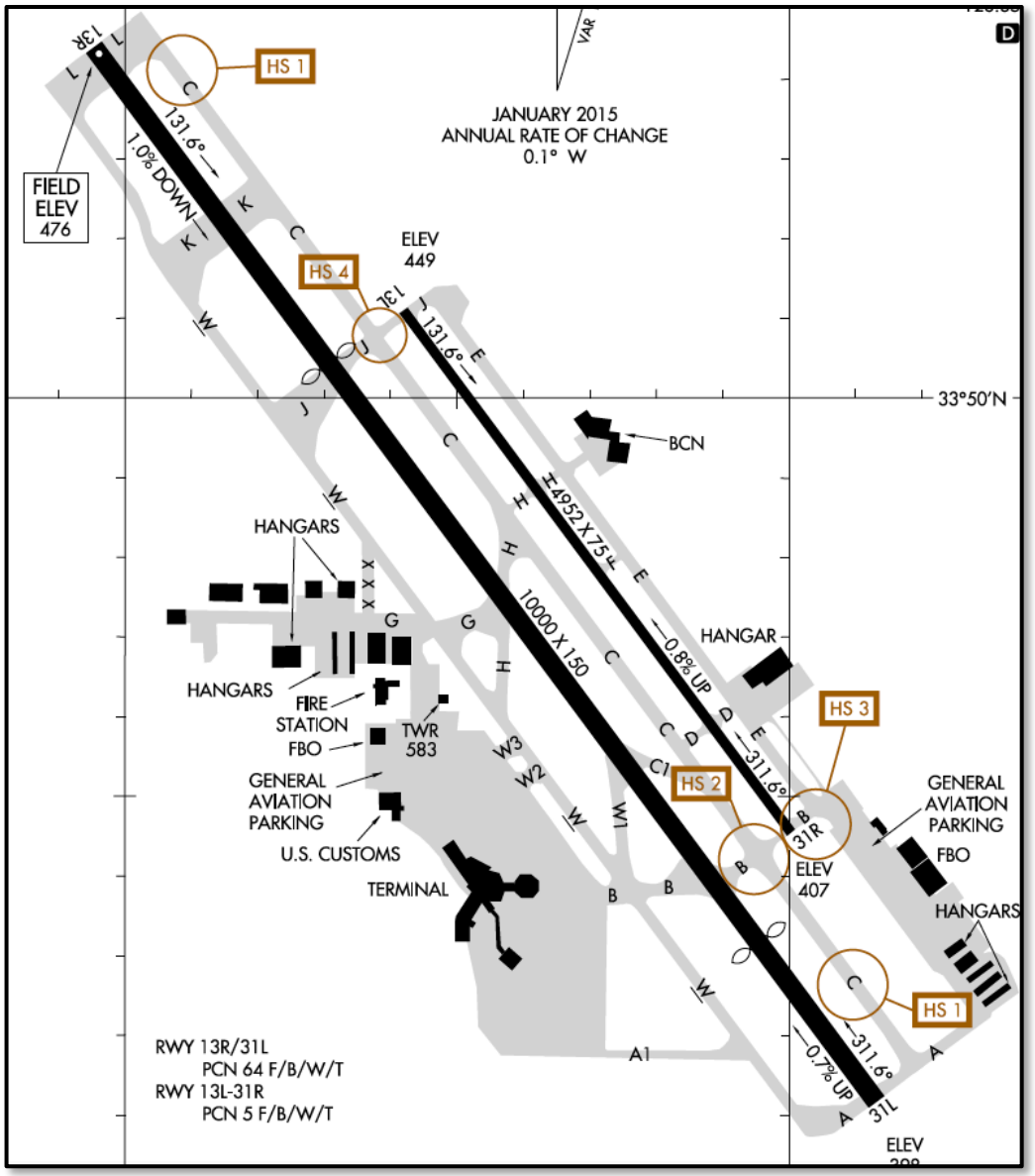
Blob ‘o Concrete and “Where am I going?”

Chino (CNO)

Taxiway Close Proximity to Runway (HS 2)



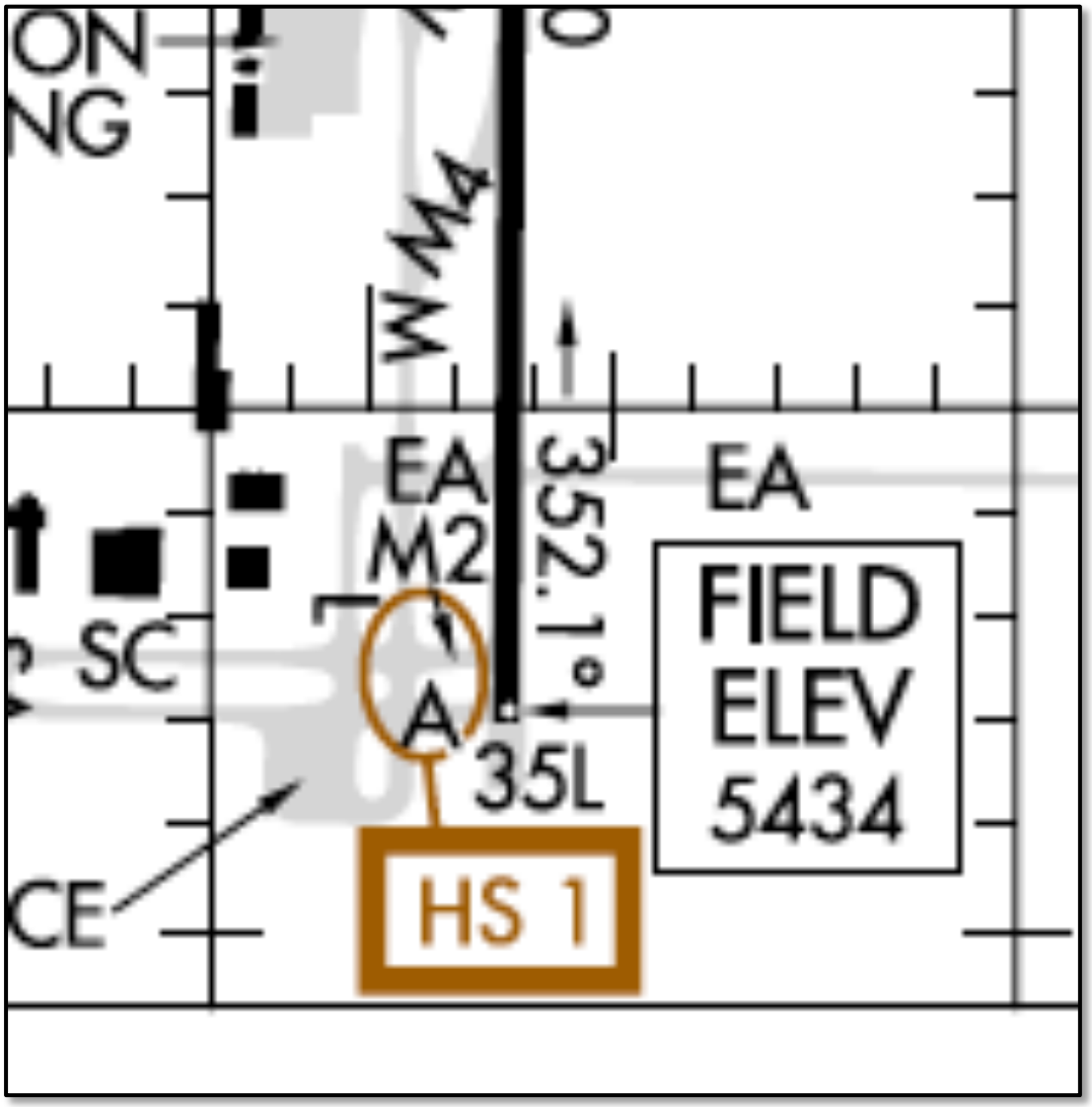
Visual Illusion/Misperception



Palm Springs International (PSP)

Mistaking Twy C for one of the two runways (HS 1)

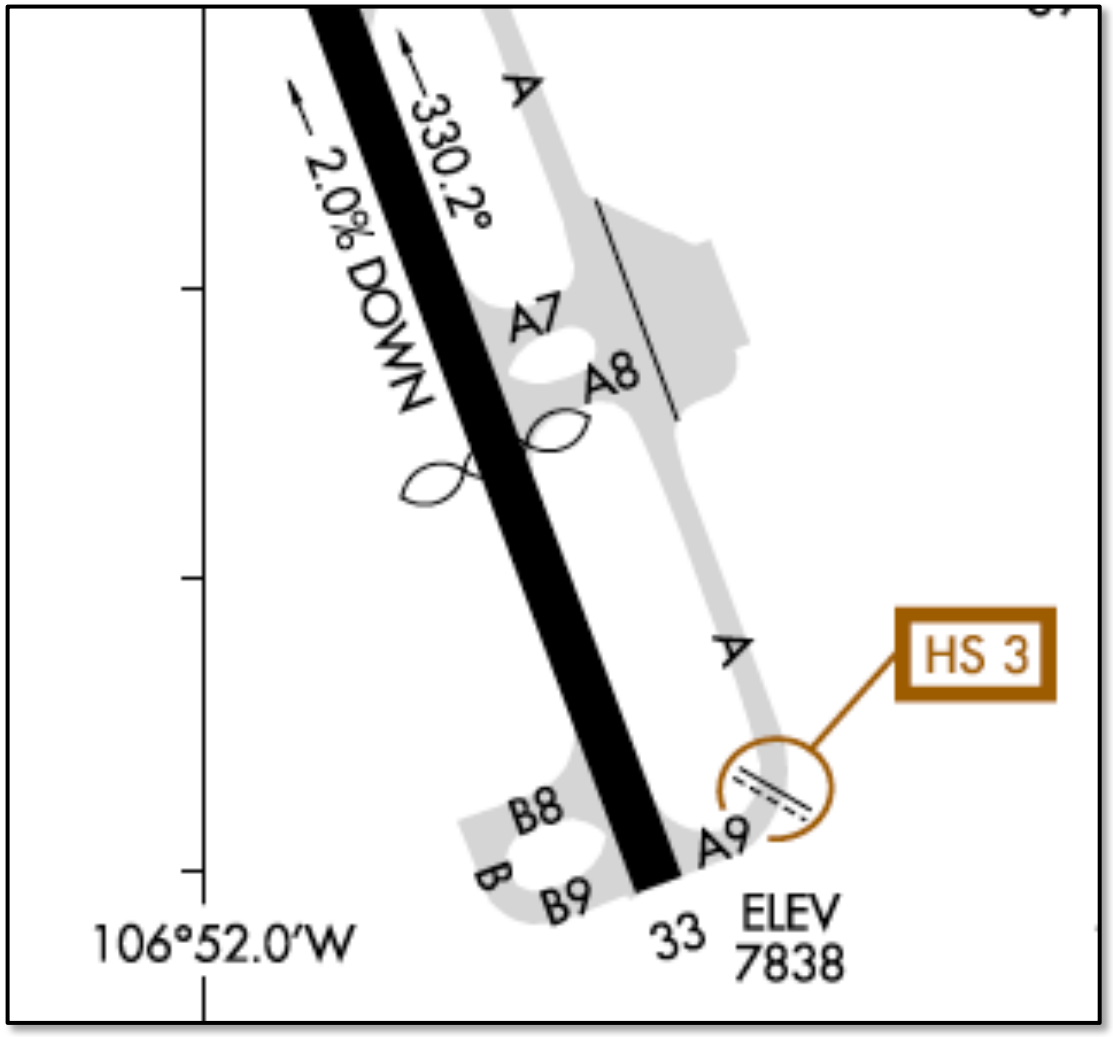
Sign? What Sign?



Denver International (DEN) HS 1

Rwy 35L hold signs may not be visible from Twy SC or Twy A until entering Twy M – Pilots sometimes enter Rwy 35L without authorization

Well, That's Unusual!



Aspen – Pitkin County (ASE) HS 3

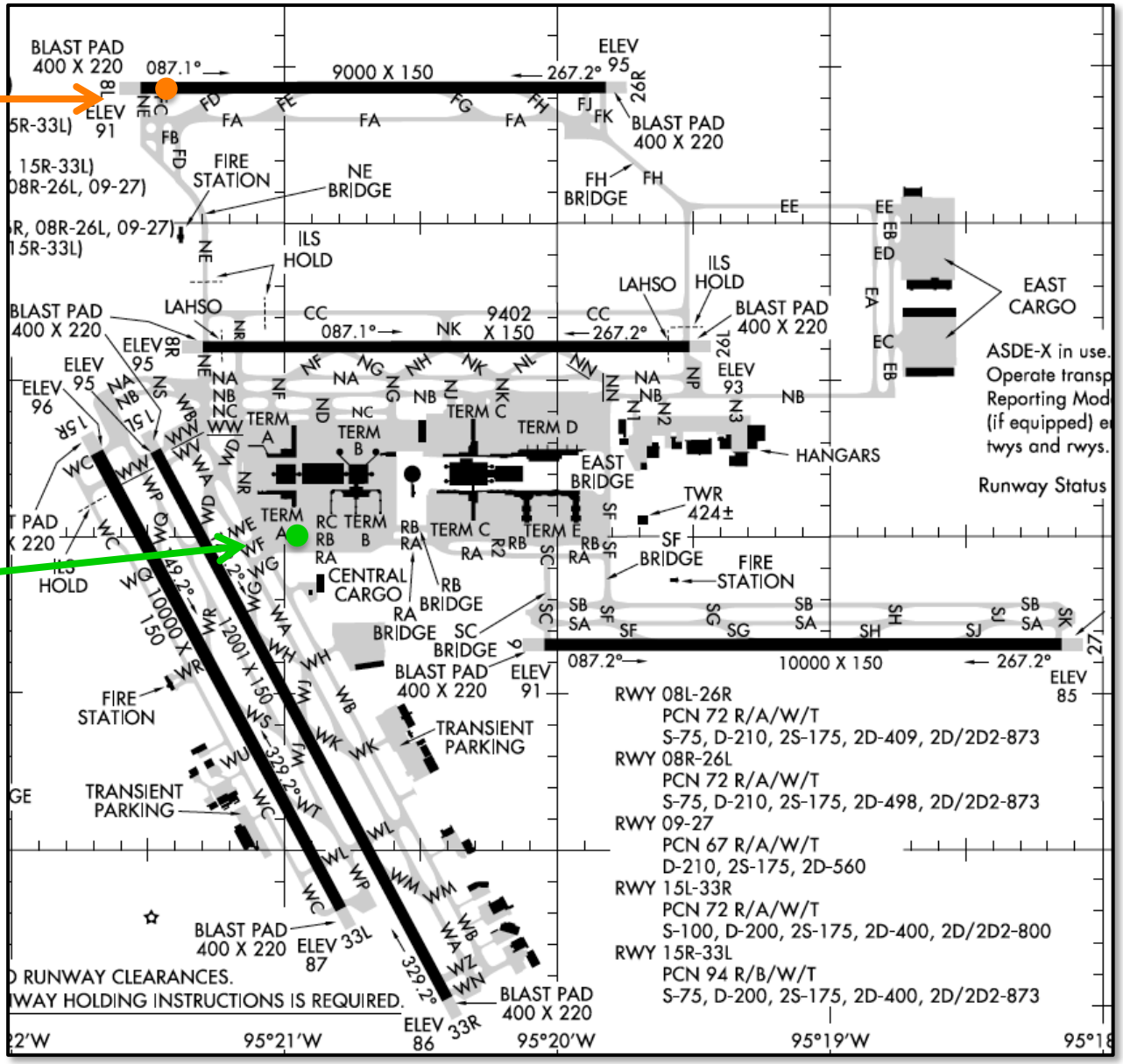
Non-typical location for Rwy holding position marking

"Cleared to Taxi Foxtrot Gulf-Foxtrot Alpha-Foxtrot Hotel-Cross 26L-November Papa-November Alpha-November Golf-November Charlie-November Romeo-Whisky Bravo"

Landing

Parking

Taxiway Labels – Houston International (IAH)



Airports - Construction

ATC, Airport Signage, Runway Change

We were cleared to taxi to Runway 30L at SJC. After arrival at the hold short line Tower cleared us to cross 30L. He said, "cleared to cross 30L and sort of angle to the right across to hold short of Runway 30R at taxiway Alpha." I taxied across and turned 45 degrees right, and looked for the "A" sign.

I only saw one taxiway Alpha sign, straight ahead, and briefly continued towards it. I then realized that the sign I was looking at was on the far side of runway 30R and that the hold short line I had crossed was not the exit one for 30 left, but the approaching one for 30 right.

We had gone over the hold short line by a bit over one plane length… I would have had to turn a hard 90 degree right turn to have seen the taxiway sign we were intended to see, and that it was not easily visible once past the hold line for 30 left.

The Controller's instructions to angle across the hold area were a bit confusing, the distance between the two hold lines is not much wider than the airplane is long, which would not allow you to turn at an angle less than 90 degrees. As soon as I had turned 45 degrees right to follow the "angle" instructions the front of the airplane was past the hold short line.

I was focused on the location of the sign rather than the hold short lines. We had been told to expect a 30L departure, so the monitoring pilot had looked down at his iPad to check the runway length and departure procedure, and only for a few seconds.

Any time a controller says something that is not standard it should cause the crew to be extra careful before trying to follow it. Runway changes require the crew to check performance, change the box, maneuver the airplane, and splits the attention of the crew. Slow down and don't feel pressured to be ready for an immediate takeoff.

External Contributors

- Environmental
- Terrain
- Airports
- **Aircraft**
- People
- Things

Taxiing on the Ramp

We were taxiing out towards Z1 when we were advised to exit Z2 because a plane was being towed in on Z1… We taxied between 2 planes that were parked. I was looking out the right side to assure clearance and informed the captain, who was taxiing, that we had plenty of room. I assumed we cleared the left side as we continued to taxi. I felt a small bump as we taxied out, and assumed we had passed over one of the drainage grates on the ramp.

Upon landing, as I opened the door, the lineman said something to the effect of "you're missing part of the wing". I looked up to see that the top of the winglet was indeed missing…. Wing walker would have prevented this. We didn't call for them because I incorrectly believed we had more than ample space to pass between parked aircraft.

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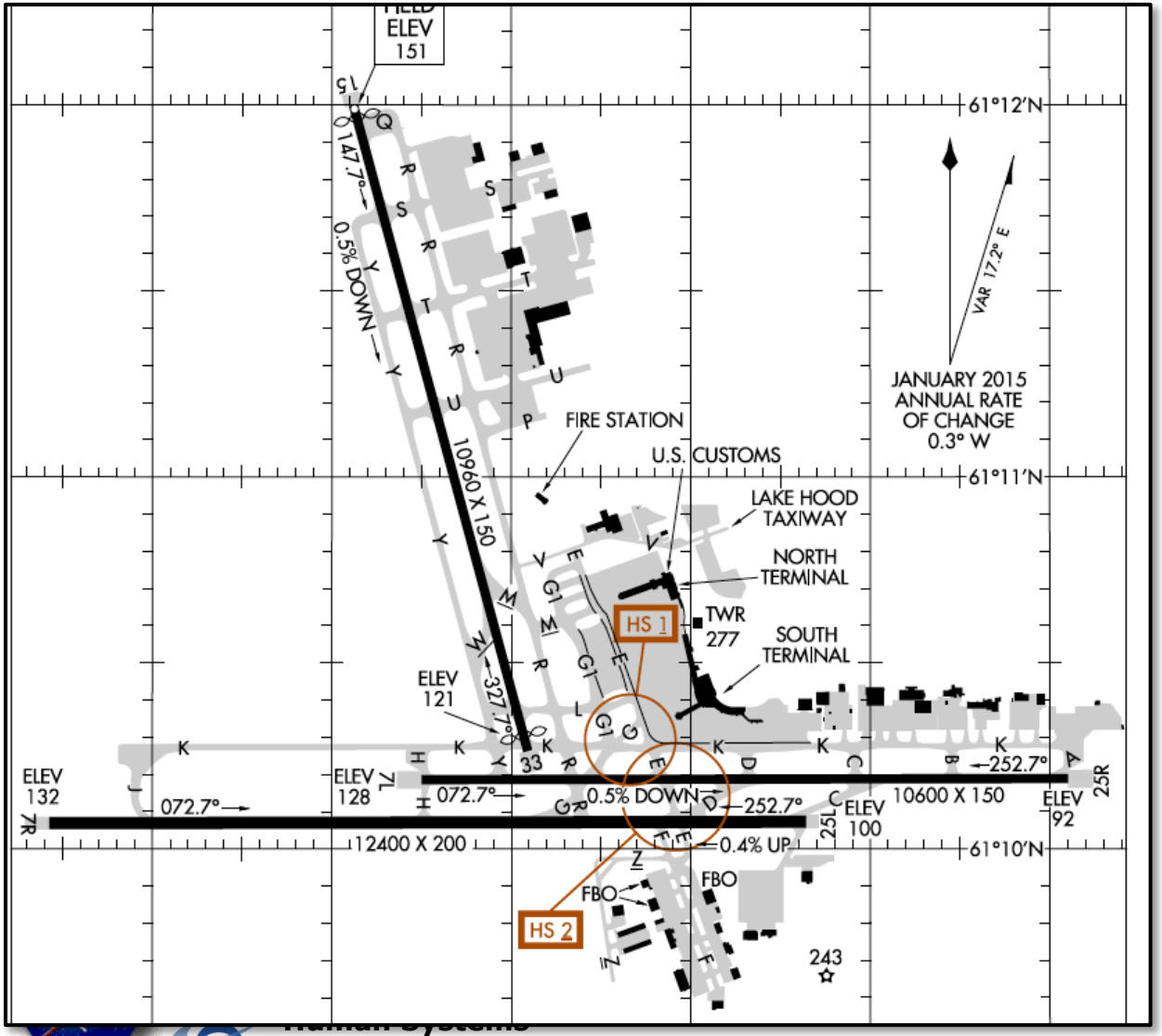
Runway Layout and Wake Turbulence



Runway 7R is 12,400 feet long. The threshold for runway 7L, just estimating from the airport diagram, is roughly 6,000 feet beyond the threshold for 7R. If the heavy aircraft lands 1000 feet beyond the threshold for 7L, and we plan to land 1,000 feet beyond that, it leaves something slightly more than 4,000 feet of runway on which to stop.

While that is well within the capability of the Lear 31, landing on the last third of a runway is not something we would ever plan to do in any normal circumstance…

What Are You Doing Up There?

Taking Off (clearance: fly runway heading, climb and maintain 4000')

Starting with rotating and ending at reaching 4000', what do you do in what order?

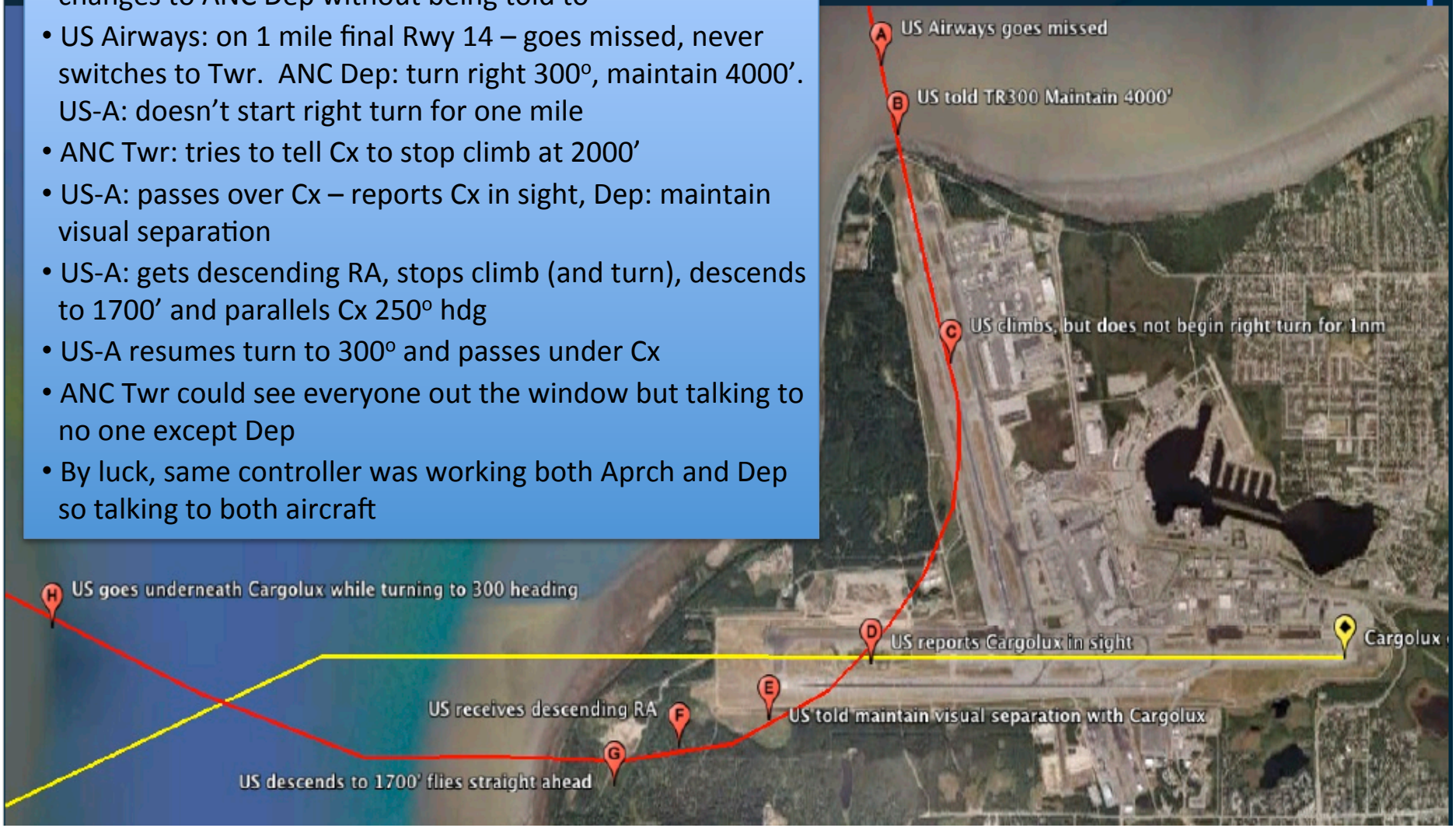
On Approach (one mile final, decide to go missed: clearance turn right heading 300°, climb and maintain 4000')

Starting with acknowledging the clearance and ending at reaching 4000', what do you do and in what order?

ANC Near Miss

May 21, 2010, midnight
A319 approach Rwy 14,
B747 TO Rwy 25R

- Cargolux TO clearance: fly Rwy hdg (250°) maintain 4000', changes to ANC Dep without being told to
- US Airways: on 1 mile final Rwy 14 – goes missed, never switches to Twr. ANC Dep: turn right 300°, maintain 4000'. US-A: doesn't start right turn for one mile
- ANC Twr: tries to tell Cx to stop climb at 2000'
- US-A: passes over Cx – reports Cx in sight, Dep: maintain visual separation
- US-A: gets descending RA, stops climb (and turn), descends to 1700' and parallels Cx 250° hdg
- US-A resumes turn to 300° and passes under Cx
- ANC Twr could see everyone out the window but talking to no one except Dep
- By luck, same controller was working both Aprch and Dep so talking to both aircraft



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The Person in the Seat Next to You

The Person in the Seat Behind You

External Contributors

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Drones

On approach in to PBI we were vectored to join the ILS 10L. Controller gave us 150 heading to join and 2000 feet cleared for the ILS. As we crossed ZISUR Tower issued a Drone sighting on final (anywhere from 1000 feet-2000 feet), at which I had just caught glimpse of it directly on the centerline and 100-200 feet above our altitude. It passed directly above us and did not cause us to maneuver the aircraft to miss it. We notified tower of its location and altitude. Landing was uneventful.

There was very little we could do as a crew besides maintain outside traffic scanning. After catching sight, we alerted tower to the exact location (ZISUR) and it appeared to be right at 2000 feet. Had the glideslope not captured we most likely would have had to maneuver the aircraft or would have hit the drone.

Different Radio Frequencies

- Crew members monitoring different frequencies
  - Communication breakdown
  - Impairs cross-checking
- Single ATC Broadcasting on multiple frequencies
  - Possible confusion as to who is talking to whom
- Multiple frequencies in use in same airspace/airport
  - Party-line lost – affects situation awareness

Barriers/Challenges to Effective Monitoring

- Misunderstanding of monitoring roles and responsibilities
- Human factors issues
- Workload, time pressure, interruptions, & distractions
- Lack of feedback to pilots when monitoring lapses
- Flight deck automation
- Procedures
- External contributors
- **Company culture**
- Training

Company Culture

- What does your company value when it comes to monitoring and flight path management, and
- How is this demonstrated?
- Is the passenger's happiness paramount?
- Does your company take pride in a culture or "persona" that runs counter to monitoring and safe, effective flight path management?

- Does your company have well defined policies with regard to automation use and manual flight?
- Recall our earlier discussion of your company SOPs that help or hinder monitoring and/or effective flight path management

Barriers/Challenges to Effective Monitoring

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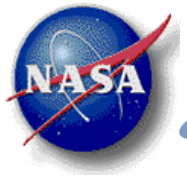
Training

Does your training provider:

- Train pilots about why they are vulnerable to errors and monitoring lapses?
- Emphasize the importance that monitoring has for both the PF and PM?
- Reinforce the responsibility of monitoring pilots to challenge deviations?
- Develop and publish clearly defined monitoring tasks, training objectives and proficiency standards?
- Have and implement a comprehensive approach to training and evaluating the use of autoflight systems and flight path monitoring?
- Incorporate monitoring training into simulator sessions or other device training?
- Give adequate emphasis to monitoring during training?
- Ensure that their instructors and evaluators are proficient at training and evaluating monitoring proficiency standards?



Human Systems
Integration Division

Shouldn't they?

Recommended Practices for Effective Flight Path Monitoring

Recommended Practices

1. Follow SOPs consistently
   - Sterile cockpit, MDAs, missed approach procedures, and stable approach criteria exist for a reason
2. Assertively manage distractions and interruptions
3. Plan your workload to protect "Areas of Vulnerability"
   - Anticipate foreseeable task loading and get work done early
4. Mentally fly the airplane
   - Scan the flight instruments and anticipate control inputs exactly as you would when hand-flying – even when the autopilot or co-pilot is flying

Recommended Practices

5. Predict and anticipate automation mode changes
   - Stay ahead of the aircraft
6. Intervene if modes or aircraft actions don't agree with expected behavior
7. Hand-fly regularly, as per your company policy
   - Helps to maintain proficiency
   - Requires a sound instrument cross-check that helps to hone monitoring skills

Recommended Practices

8. Monitor as if you suspect the PFD or ND may be lying to you
   - Always be on the lookout for evidence that confirms or disconfirms what the displays are saying
   - Continuously compare known pitch/power settings to current flight path performance
9. Set and check targets
   - Intermediate altitudes, crossing restrictions, altitude and DME targets on departure and approach
10. Clearly communicate intentional deviations to other crew member

Recommended Practices

11. Alert other crew member when monitoring is inhibited (e.g., head down)

12. Audibly re-state constraints and restrictions periodically, especially when:
    - When there is a long time between the clearance and the constraint
    - When the environment is very busy or distracting
    - When you are tired
    - At the beginning and end of a large pop-up task
    - After completing a checklist while taxiing
    - After unusual or distracting events

Recommended Practices

13. State clearances in a loud, clear voice
    - Helps to encode it in your memory and helps the other pilot remember it, too

14. Verbally acknowledge when distracting events occur – triggers both pilots to deliberately review last steps
    - "Hey, we just got sidetracked there, we were about to start down to make Providence at 11…"

15. Methodically regain flight path situational awareness after completing non-flight-related tasks

Recommended Practices

16. Make and encourage specific deviation callouts
    - Call out your own deviations (“I’m 10 knots slow, correcting”)
    - Thank your co-pilot for deviation callouts

17. Refuse problematic clearances
    - “Unable” is a powerful tool to use when a clearance will jeopardize your ability to manage your flight path – providing options to ATC about what you *can* do may be appreciated.

Thank You!!

Barbara.K.Burian@nasa.gov
http://human-factors.arc.nasa.gov/flightcognition/

- Break-Out Groups (Exercise #4)
- Comments/Questions?
- Wrap-up and Evaluations