DCA21FA085

OPERATIONAL FACTORS, 777 SIM EVALUATION

Attachment 2

777 Simulator and Cockpit Evaluation

October 27, 2022

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A. ACCIDENT

Operator: United Airlines
Location: Bloomfield, CO
Date: February 20, 2021
Time: Approximately 1309 MST[1]
Airplane: B-777-222 N772UA

B. OPERATIONAL FACTORS GROUP

Warren Abrams[2] Chairman
Operational Factors Division (AS-30)
National Transportation Safety Board

Todd Gentry - Member
AVP-100
Federal Aviation Administration (FAA)

Sam Goodwill[3] - Member
Senior Safety Pilot
The Boeing Company

Brad Peterson[4] - Member
778 Fleet Standards Manager
United Airlines

Al Berlinberg - Member
777 LCA
United, ALPA/CASC

C. SUMMARY

On February 20, 2021, about 1309 mountain standard time (MST), United Airlines flight 328, a Boeing 777-222, N772UA, experienced a failure of the right engine, a Pratt & Whitney PW4077, while climbing through an altitude of about 12,500 feet mean sea level (msl) shortly after takeoff from Denver International Airport (DEN), Denver, Colorado. There were no injuries to the 239 passengers and crew onboard, and the airplane sustained minor damage. The regularly scheduled domestic passenger flight was operating under the provisions of Title 14 Code of Federal Regulations (CFR) Part 121 from DEN to Daniel K. Inouye International Airport (HNL), Honolulu, Hawaii

D. FOLLOW-ON DAILY ACTIVITIES

On Monday February 20, 2021, the Ops Group interviewed the captain and first officer of the accident flight, United 328. The the Ops Group consisted of Marvin Frantz – NTSB, Todd Gentry – FAA, Bob Aaron – The Boeing Company, Bob Mackay – United Airlines, Al Berlinberg – Airline Pilot Association, International, and John Hanson – Senior Labor Relations Counsel Airlines Pilots Association on behalf of the captain and first officer. The interviews were recorded

[1] All time are Mountain Standard Time, MST
[2] Warren Abrams replaced Marvin Frantz from the NTSB.
[3] Sam Goodwill replaced Bob Aaron from Boeing for medical reasons.
[4] Brad Peterson replaced Bob Mackay from United as Bob is now on the 787 program.

and transcribed, and the transcripts can be found in the public docket as Attachment 1 when the docket is opened.

On October 25, 2021, at 1400 local, the Ops Group conducted simulator evaluations of various scenarios at the United Airlines Training Center in Denver, CO. Scenarios included Normal Procedures as well as Non-Normal Procedures according to the United 777 Flight Manual. The running of the annunciated Engine Fire Checklist was combined with distractions that a 777-flight crew may encounter in the course of a flight. Timing the crew running the FIRE ENG R checklist was accomplished on two separate occasions.

E. SIMULATOR EVALUATIONS

Location: **United Training Center** Denver, CO
Date: **October 25, 2021,** 1400 MDT[5]
Overall Objectives:

- Document simulator fidelity, systems (Autostart System, Fire Warning System, Fire Detection, and suppression) and alerts
- Document the alerts and warnings with a right engine fire indication.
- Document handling characteristics with the right engine inop, and with vibrations. (Simulate engine vibrations with the turbulence mode in the sim)
- Document approach and landing with right engine and right thrust reverser inoperative.
- Document the crews use of the ECL in performing the Engine Fire checklist. (Two bottle fire) Timed event from the start of the engine fire warning until the discharge of the second bottle.
- Document and time the engine fire event a second time while making a 180 degree turn back to DEN while introducing distractions such as ATC calls and calls from the cabin to the cockpit.
- Of note: there is no amount of simulation that can be introduced that will simulate the actual handling characteristics of the plane with the nacelle and cowling missing.

Aircraft: Boeing B777 simulator[6] 777 SIM #1
Airport: Denver International Airport (DEN)[7]
Invited Participants:

Warren Abrams (NTSB, Operations)
Todd Gentry FAA
Sam Goodwill, Boeing
Al Berlinberg, ALPA
Brad Peterson, UAL
Eric Lich, 777 Sim Operator, (UAL 777 APD)

[5] All times are Mountain Standard Time (MST)
[6] Able to accommodate only 6 occupants at a time
[7] DEN was the departure airport and the landing airport and has an actual simulator model of the DEN airport.

Initial Simulator Setup:

- Configuration[8]:
  - Weight 473,560 lbs.
  - Fuel 112,370 lbs.
  - V speeds selected for the FMS
  - Flaps 15 degrees set for takeoff; 20 degrees set for landing
  - CG 29.2% MAC
- Departure: Runway 25
- Weather:

KDEN METAR 201653Z 21017KT l0SM FEW070 FEW100 FEW200 09/M07 A2982 RMK AO2 SLP091 T00891072.

  - Day
- The evaluation will take place in one session, since we will have the ability to accommodate the entire group at once.
- Left seat is Pilot Flying (PF); Right seat is Pilot Monitoring (PM)
- For the evaluation Brad Peterson (United) and Al Berlinberg (UAL/ALPA), as the pilot flying and pilot monitoring, respectively.
- Fuel freeze will be utilized during the entire simulator evaluation in order to repetitively simulate the accident flight.
- All runs will be conducted with motion ON unless noted otherwise.

Run 1: Engine Autostart with right engine not starting on the first attempt.

Procedure

- Normal engine Autostart procedures (United SOP)
- Both engines started at the same time (normal starting mode)
- Right engine fails to start on first attempt
- Autostart, starts the right engine on subsequent attempt.
- Autostart will abort the start for[9]
  1. Hot start
  2. Hung start
  3. No EGT Rise
  4. Compressor stall
  5. Starter shaft failure
  6. No N1 rotation
  7. Insufficient air pressure for starter operation
  8. Starter time exceeds the starter duty cycle timer

[8] Based on dispatch paperwork computed on 02/20/2021
[9] Boeing 777 Operations Manual D632W001-MAS August 18, 1997

	Notes
	1. Right Engine indications during starting. See photo # 3 2. Checklist usage: No checklist required; it's all automatic for the Autostart. 3. EICAS Messages: None 4. Inhabit: Status messages inhibited from engine start until 30 minutes after takeoff. 5. No requirement to check the Status page after engine start. 6. Does the second engine start attempt look the same to the crew as the first attempt. See photo # 5 7. Additional notes: The second engine attempt uses both igniters.

Photo #1. Normal Autostart. (Start, start, Run, run)

Photo #2. Left and Right Fuel Control switches in the Run, Run position

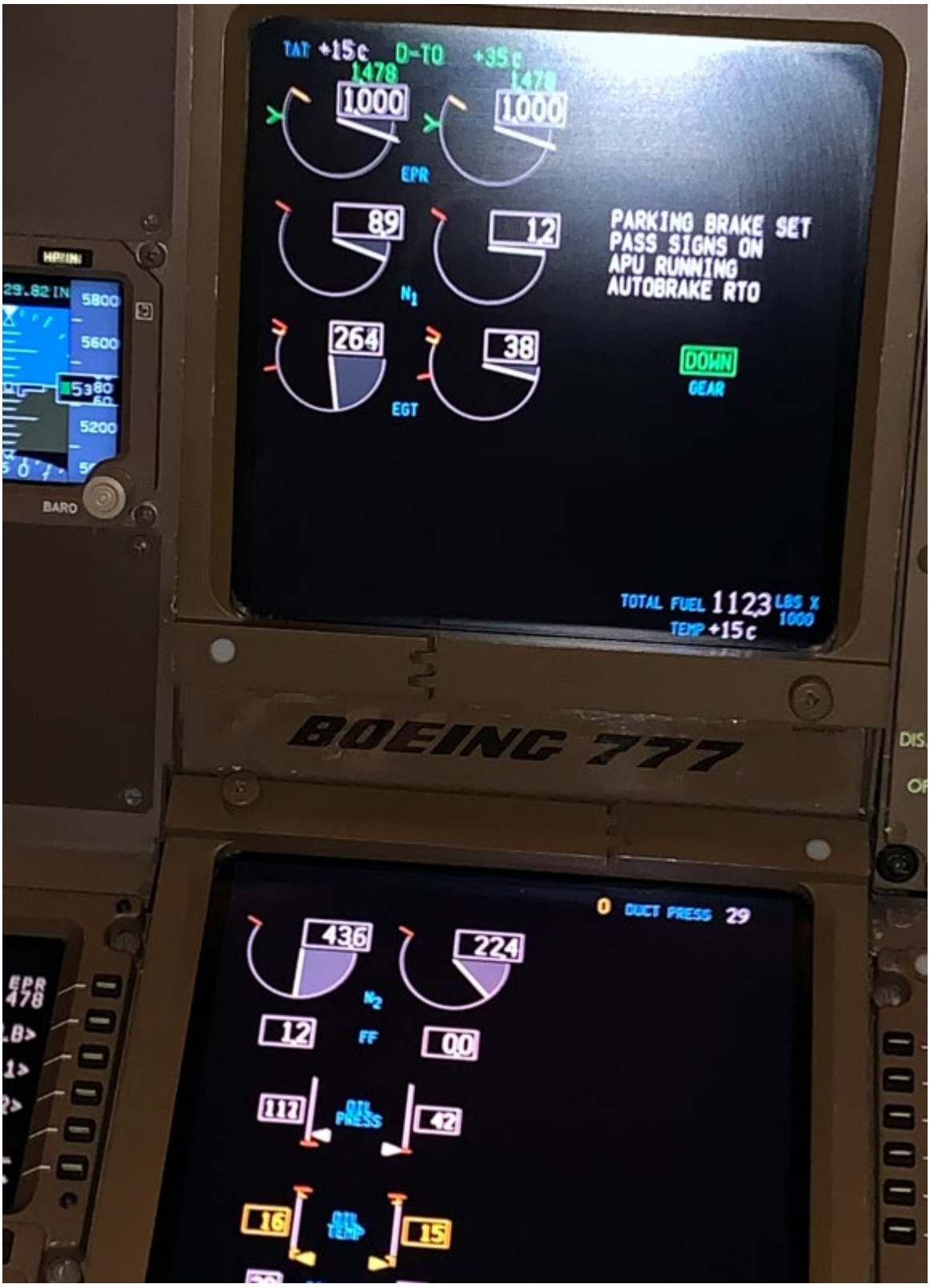

Photo #3 Engine indication of the right engine failing to start with Autostart. No EICAS messages

Photo #4; Status page showing a fault with the Right Engine #1 igniter.

Photo #5: Subsequent start attempt and engine indications

Run 2: Normal Climb out on the Zimmr 3 RNAV Departure with Right engine fire indication above 12,000 msl

Procedure

- Normal climb procedures (United SOP)
- Right engine fire (two bottle fire) non-extinguishable
- Observe and document the running of the [ ] Engine Fire R Checklist.
- Timing the event with no distractions
- Indications of an engine fire are:

    1. The fire bell sounds
    2. The master Warning lights illuminate
    3. The EICAS warning message FIRE ENG (L or R) is displayed
    4. The engine fire switch LEFT or RIGHT fire warning light illuminates.
    5. The engine fire switch unlocks
    6. The engine FUEL CONTROL (L or R) switch fire warning light illuminates.

	Notes
	1. Right Engine Fire indications: See 1-6 above for the indications. 2. Checklist usage [FIRE ENG R] completed. See note 8 below for the time to complete. 3. EICAS Messages: None after known messages accounted for. 4. Limitations: None 5. Document what systems and components were lost/energized when the engine fire handle was pulled. • Arms both engine fire extinguishing bottles • Closes the associated engine and spar fuel valves • Closes the associated engine bleed air valves • Trips the associated engine generator off. • Shuts off hydraulic fluid to the associated engine driven hydraulic pump • Depressurizes the associated engine driven hydraulic pump • Removes power to the respective thrust reverser isolation valve. 6. Additional notes: the time it took to complete the Engine Fire Checklist down to the firing of the second bottle: 2 min 30 sec. (No distractions)

Photo # 6 Right Engine Fire indication

Photo # 7: Right engine fire with the R Fuel Controller shutoff and both fire bottles discharged.

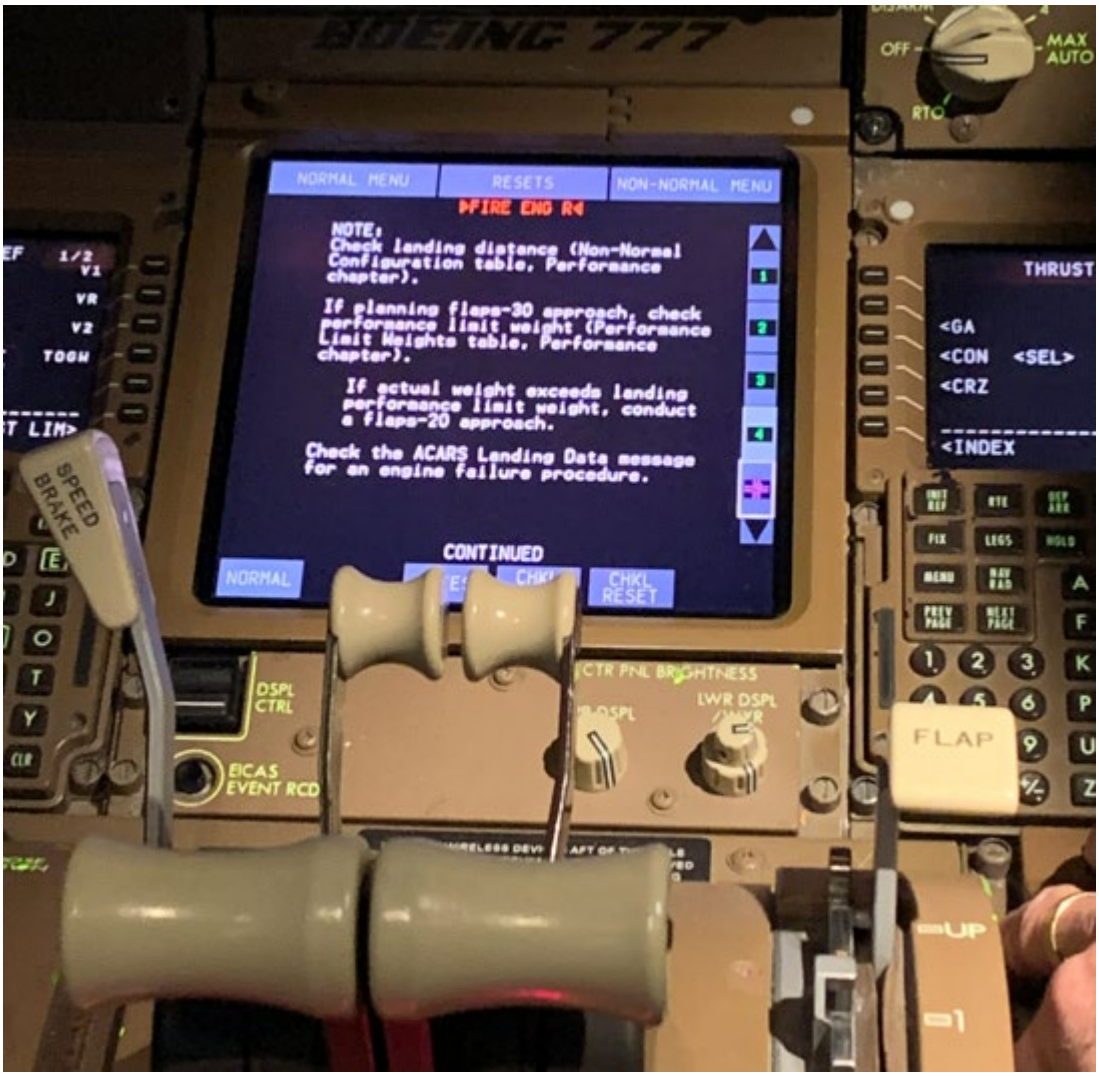

Photo # 8: Page 5 of 6 in the FIRE ENG R checklist.

Run 2A: Normal Climb out on the Zimmr 3 RNAV Departure with Right engine fire indication above 12,000 msl

Procedure

- Normal climb procedures (United SOP)
- Right engine fire (two bottle fire) non-extinguishable
- Observe and document the running of the [ ] Engine Fire L (R) Checklist.
- Timing the event **WITH** distractions
- Introduce turbulence to simulate the engine vibrations
- Several call to the cockpit from the Flight Attendants.
- Indications of an engine fire are:

    1. The fire bell sounds
    2. The master Warning lights illuminate
    3. The EICAS warning message FIRE ENG (L or R) is displayed

4. The engine fire switch LEFT or RIGHT fire warning light illuminates.
5. The engine fire switch unlocks
6. The engine FUEL CONTROL (L or R) switch fire warning light illuminates.

	Notes
	1. Right Engine Fire indications: Same as outlined above in number 1-6. 2. Checklist usage: EIRE ENG R ECL 3. EICAS Messages: FIRE ENG R 4. Limitations: All engine out limitations and restrictions apply, which were none. 5. Document what systems and components were lost when the engine fire handle was pulled. Normal Brakes, Right HYD system, Right generator and right back up generator, and right system flight controls, 6. Additional notes: The time it took to complete the Engine Fire Checklist down to the firing of the second fire bottle. 3 minutes 03 seconds. (With distractions)

Initial Landing Setup

- Configuration
  - Weight 450,000
  - Fuel 89,000
  - CG 27%
  - Flaps 20
  - Vref selected from the FMC
- Weather
  - VFR
  - Wind 210/15
  - Altimeter 29.82

Run 3: Approach and Landing with Right Engine Fire and Failure

Procedure

Normal approach and landing Procedures (United SOP)
Document the Non-Normal event.

	Notes
	1. Right Engine inop and on Fire for landing _____ 2. Checklist usage: All checklist completed 3. EICAS Messages if any: No EICAS messages displayed in accordance with United SOP. 4. Limitations: No limitations based on the condition of the aircraft 5. Comments: Normal Brakes were lost based on the Right HYD system being inop. ALT and Reserve braking worked just the same as Normal Brakes with no crew action necessary. Right Thrust Reverser was inop with the right engine being shut down. Directional control was not an issue landing on runway 26 based on the wind of 210/15. This created a 11.49 kt. crosswind component.

The FIRE ENG R EICAS message and associated Engine Fire indications all disappeared shortly before landing according to the crew interviews.[10] However, the fire was still burning within the engine according to the Fire Chief who was attending to the emergency with the airplane on the ground.

[10] According to the FO interview, "the flight was southeast of the airport on an extended downwind, just turning base when it went out."

Photo 9: Engine still on fire with no indication to the crew that the detection loops burned through.

[ ] ENG AUTOSTART L (R)

Condition: During a ground start, one of these occurs:

- Autostart did not start the engine.
- FUEL CONTROL switch is in RUN at low engine RPM with the AUTOSTART switch OFF.

1 FUEL CONTROL switch (affected side). . . . . CUTOFF

2 START/IGNITION selector (affected side) . . . . . START

3 Motor engine for 30 seconds.

4 START/IGNITION selector (affected side) . . . . . NORM

■■■■

[ ] FIRE ENG L (R)

Condition: Fire is detected in the engine.

1 A/T ARM switch (affected side) . . . . . Confirm . . . . . OFF

2 Thrust lever (affected side) . . . . . Confirm . . . . . Idle

3 FUEL CONTROL switch (affected side) . . . . . Confirm . . . . . CUTOFF

4 Engine fire switch (affected side) . . . . . Confirm . . . . . Pull

5 **If the FIRE ENG message stays displayed:**

Engine fire switch . . . . . Rotate to the stop and hold for 1 second

If after 30 seconds, the FIRE ENG message stays displayed:

Engine fire switch (affected side) . . . . . Rotate to the other stop and hold for 1 second

6 Choose one:

- **On the ground:**

■■■■

- **In flight:**

▶▶Go to step 7

7 Driftdown checklist . . . . . Consider

8 APU selector (if APU available) . . . . . START, then ON

9 Transponder mode selector . . . . . TA ONLY

10 ***Plan to land at the nearest suitable airport.***

▼ Continued on next page ▼

▼ FIRE ENG L (R) continued ▼

Note: A flaps-20 approach is preferred anytime an engine is shut down or operating at reduced thrust. A flaps-30 approach is available when stopping distance is critical or other considerations make a flaps-30 approach necessary.

Check landing distance (Non-Normal Configuration table, Performance chapter).

If planning flaps-30 approach, check performance limit weight (Performance Limit Weights table, Performance chapter). If actual weight exceeds landing performance limit weight, conduct a flaps-20 approach.

Check the ACARS Landing Data message for an engine failure procedure.

For a flaps-20 approach and landing, REF speed is 20 REF. Select the GND PROX FLAP OVRD switch to OVRD. Use flaps 5 for go-around.

For a flaps-30 approach and landing, REF speed is 30 REF. Use flaps 20 for go-around.

11 Do *not* accomplish the AUTOTHROTTLE checklist.

12 Checklist complete except Deferred Items

▼ ▼ ▼ ▼ ***DEFERRED ITEMS*** ▼ ▼ ▼ ▼

Descent Checklist

- Recall and notes . . . . . Checked
- Landing distance and autobrakes . . . . . Checked, ___set
- Reference speed . . . . . Flaps___, (REF)___, set [PM], set [PF]
- FMC, radios . . . . . Set
- Arrival briefing . . . . . Complete
- Ground proximity flap override switch . . . . . As required

Landing Checklist

- Speed brake . . . . . Armed
- Gear . . . . . Down
- Flaps . . . . . ___

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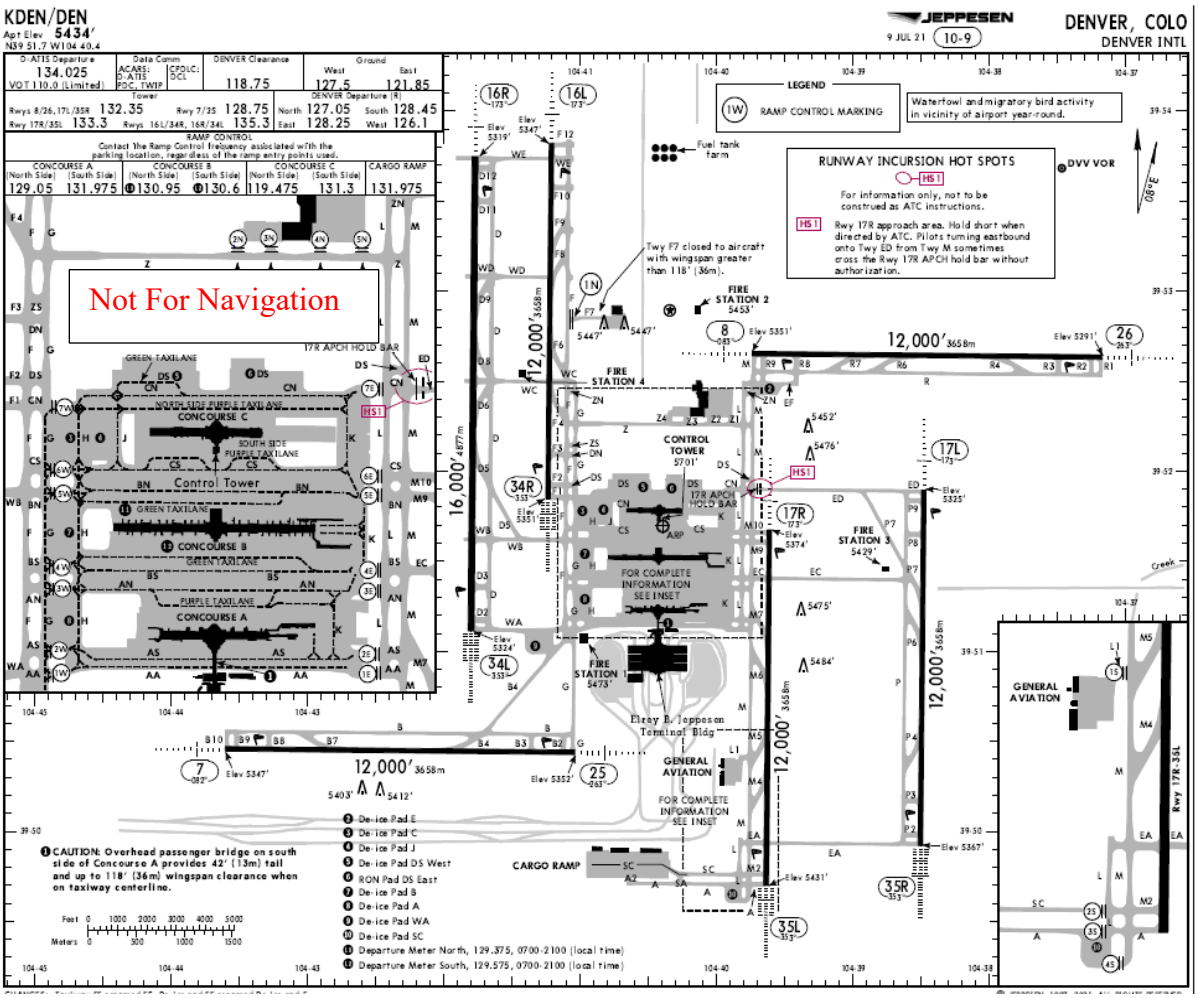
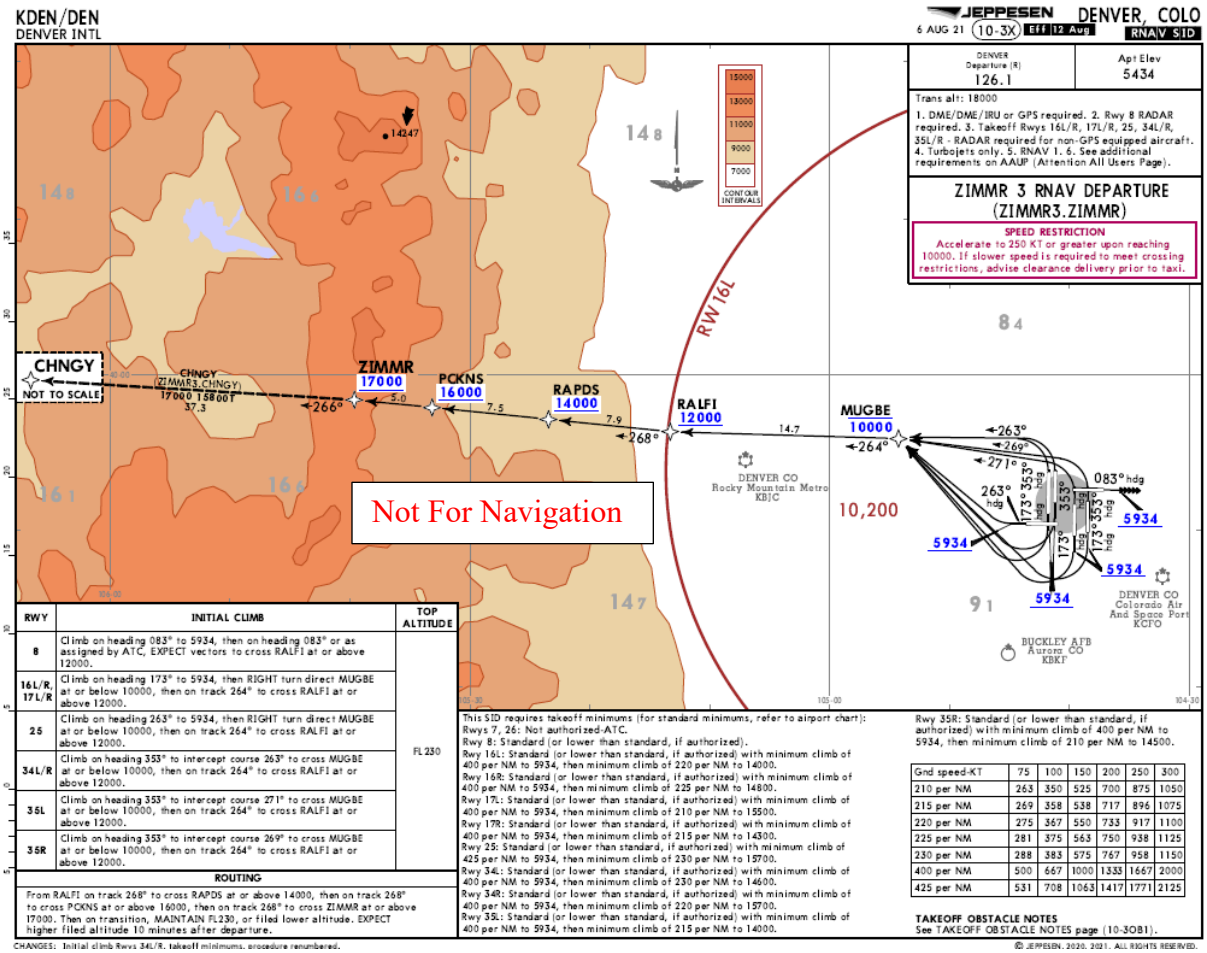
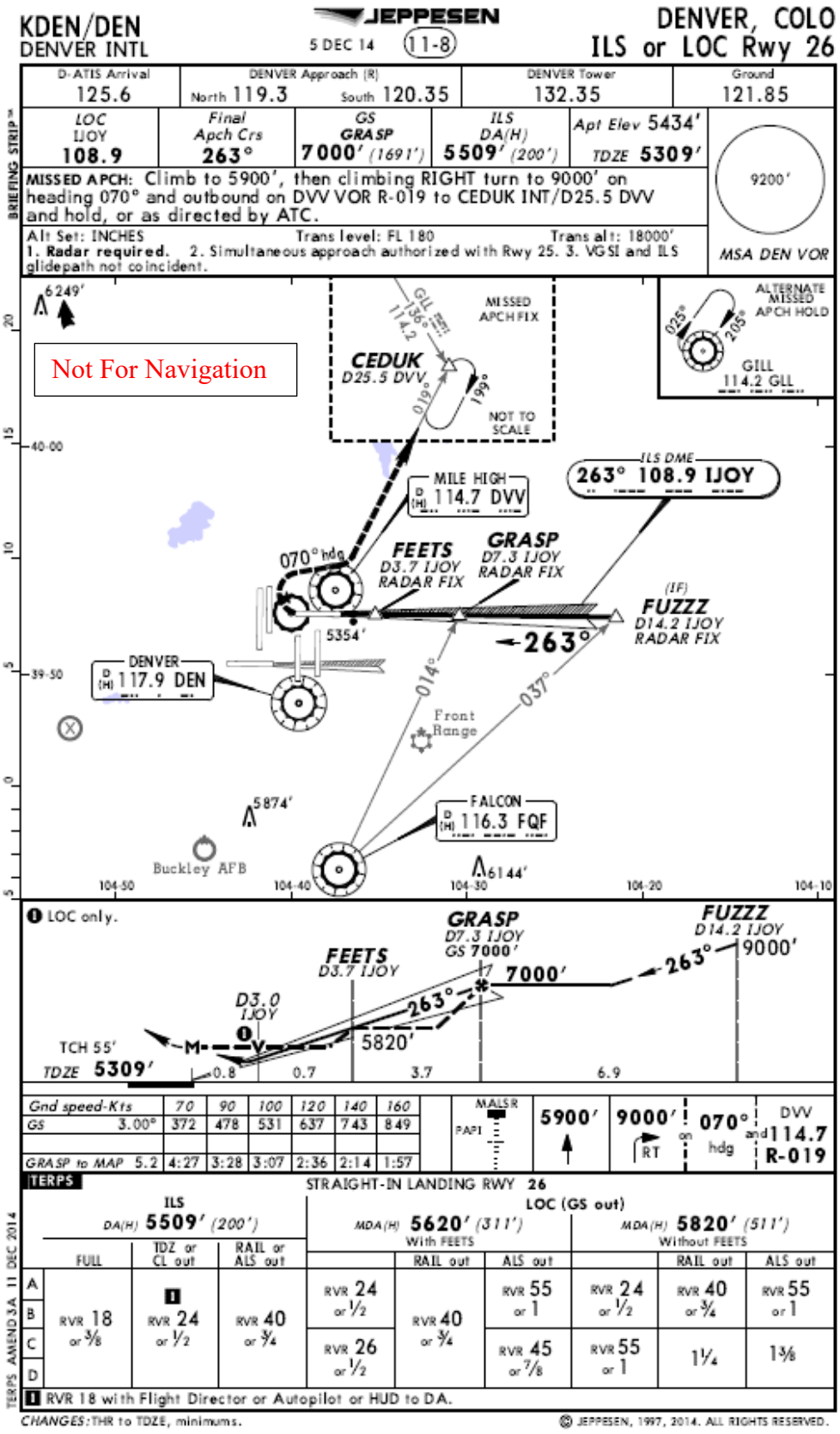


DEN Airport Diagram: Courtesy of Jeppesen



DEN ZIMMR 3 RNAV Departure: Courtesy of Jeppesen



DEN, COLO ILS RWY 26 Approach Chart: Courtesy of Jeppesen

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