

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



DCA22LA133

OPERATIONAL FACTORS

Group Chair's Factual Report

November 16, 2022

TABLE OF CONTENTS

A. INCIDENT	4
B. OPERATIONAL FACTORS GROUP	4
C. SUMMARY	5
1.0 OPERATIONAL FACTORS GROUP ACTIVITIES.....	5
1.1 June 22, 2022	5
1.2 June 29, 2022	5
2.0 HISTORY OF FLIGHT	5
3.0 CREW	7
3.1 Captain	7
3.1.1 Captain's Flight hours	7
3.1.2 Captain's Training.....	8
3.1.3 Captain's 72-Hour History.....	8
3.2 First Officer	9
3.2.1 First Officer's Flight hours.....	9
3.2.2 First Officer's Training Record.....	9
3.2.3 First Officer's 72-Hour History	10
3.3 Trip Pairing	10
4.0 AIRPLANE.....	11
4.1 Flight Plan	11
4.2 Landing Performance	12
4.3 Flight Plan NOTAMs	12
4.4 Discrepancy Information.....	16
5.0 AIR TRAFFIC CONTROL.....	16
5.1 FAA 7110.65Z.....	17
6.0 AIRPORT INFORMATION	17
6.1 JESEY 4 RNAV Arrival	21
6.2 RNAV (GPS) Y Runway 28C.....	22
7.0 METEOROLOGICAL INFORMATION	23
8.0 OPERATOR.....	23
9.0 UNITED AIRLINES PILOT BULLETIN	23

9.1	Flight Operations - B737 MAX Enroute CPDLC	23
10.0	MANUAL EXCERPTS	24
10.1	Runway Awareness Advisory System (RAAS)	24
10.2	Arrival and Approach Briefing	28
10.2.1	RNAV Approaches.....	32
10.3	FMC Fail	38
11.0	NASA ASRS REPORTS	40
D.	LIST OF ATTACHMENTS	40

A. INCIDENT

Location: Pittsburgh, Pennsylvania
Date: June 21, 2022
Time: 0944 Eastern Daylight Time¹
1344 universal coordinated time (UTC)
Airplane: Boeing 737-9 Max; N37513, United Airlines flight 2627

B. OPERATIONAL FACTORS GROUP

Group Chair	Shawn Etcher National Transportation Safety Board Washington, DC 20594
Group Member	Todd Gentry Federal Aviation Administration AVP-100 Washington, DC 20594
Group Member	Michael Gillen United Airlines Chicago, IL 60606
Group Member	Gregory Lipinski Air Line Pilots Association McLean, VA 22102
Group Member	Alessio Ventriglia The Boeing Company Seattle WA 98124
Subject Matter Expert	Betty Koschig ² National Transportation Safety Board Washington, DC 20594

¹ Eastern daylight time. All times within this report will be in EDT unless otherwise noted and at the time of the incident UTC time was EDT + 4 hours. Additionally, the flight departed from ORD which is central daylight time which is EDT - 1 hour.

² Ms. Koschig provided the group with subject matter expertise for air traffic control content within this report.

C. SUMMARY

On June 21, 2022, about 0944 EDT, United flight 2627, a B737-9Max, N37513, landed on runway 28L at the Pittsburgh International Airport (PIT), Pittsburgh, Pennsylvania. The flight was in contact with air traffic control and prior to the landing was cleared for, and acknowledged the clearance to, runway 28C. However, radar data indicated that the flight lined up for and landed on runway 28L. After landing the airplane taxied to the ramp. None of the 174 occupants aboard the flight were injured. The regularly scheduled passenger flight was operating under 14 *Code of Federal Regulations* Part 121 as a scheduled passenger flight from Chicago O'Hare International Airport (ORD), Chicago, Illinois to PIT.

1.0 Operational Factors Group Activities

1.1 June 22, 2022

The Group Chairman was assigned to the incident and began collecting data to begin travel and the investigation. Request for pilot interviews, pilot records, information, and manuals were sent via email to the operator's party coordinator. The operational factors group was formed including the FAA, United Airlines, Air Line Pilots Association, and The Boeing Company.

1.2 June 29, 2022

The group convened in Chicago, Illinois to conduct interviews with the incident flight crew at the Air Line Pilots Association office near O'Hare International Airport. The first officer was interviewed followed by the captain. Their respective interview summaries are included in the docket for this incident.

2.0 History of Flight

ADS-B data indicated that about 0836 the incident airplane began taxiing to runway 28R at ORD. About 0844 the airplane taxied onto runway 28R and approximately 0845 the airplane became airborne. After departure, the airplane made a climbing right turn northeast climbing to about 8,000 ft msl³ and then turning to the east-southeast climbing to FL330⁴. About 0918 the airplane began a descent from FL330.

³ Mean sea level.

⁴ A level of constant atmospheric pressure related to a reference datum of 29.92 inches of mercury, stated in three digits that represent hundreds of feet. Source Aeronautical Information Manual "Pilot/Controller Glossary." FL330 is the height above mean sea level (msl) at standard atmospheric pressure measured in hundreds of feet (i.e., FL330 is about 33,000 feet msl).

According to the flightcrew the flight was arriving on JESEY4⁵ arrival they obtained the current ATIS and then programmed and briefed the RNAV 28C approach. About 25 miles northwest of the airport they were given and subsequently contacted the Pittsburgh approach controller controlling that airspace. Initially the crew was told to expect runway 32 by the controller and they loaded and briefed the ILS 32 into the FMC⁶ for the approach. The controller then offered the flight vectors for the visual approach to runway 28C which they accepted and was provided a heading to fly. The captain selected heading select on the autopilot and flew the assigned heading while the first officer programmed the FMC for the RNAV approach to runway 28C.

According to the flightcrew, the flight was normal and the first indication of anything *"unusual"* was after descending below 10,000, with the autopilot engaged they received an altitude message on the primary flight display which extinguished within *"a few seconds."* Subsequently, the control wheel steering pitch illuminated on the FMA⁷. The crew selected a new pitch mode and everything *"was normal."*

About 0938 the airplane entered the right downwind leg and continued the downwind leg for about 2 minutes before turning to a base and subsequently final approach leg for runway 28L. According to the flight crew, the autoflight system was on level change while on the downwind leg of the approach.

According to the crew, they turned from the downwind leg to the base leg for the runway, when the flight was approximately 4,000 ft msl and would allow them to join the final approach for the runway about two miles east of the SUPPR waypoint⁸. The flight crew reported they had the airport in sight and were subsequently cleared for the visual approach to runway 28C.

The captain requested the first officer to extend the centerline of the approach from the SUPPR waypoint as he turned the heading select knob for the autopilot to intercept the final approach course on an approximate 45° intercept. About the same time the first officer announced that both FMCs blanked and only had the ACARS⁹ prompt available. According to the captain the timeout reselect was not common and he had one screen blank on him on previous flights. However, the other times the single screen blanked it usually came back 5 to 10 seconds later. The captain reported that at that time they had the PAPI lights insight and preceded to the airport visually, since runway 28C was not equipped with an ILS, while the first officer attempted to trouble shoot the FMC and configure the airplane.

⁵ See Section 6.1 in this report for detailed information about the arrival.

⁶ Flight Management Computer.

⁷ Flight Mode Annunciator.

⁸ See Section 6.2 in this report for the RNAV chart for runway 28C. Additionally it was located at 40°29'08.370" N 080°05'19.600" W.

⁹ Aircraft Communication and Reporting System.

The flight crew stated that the FMC came back between 700 and 1,000 ft agl. However, there was no approach guidance displayed on the navigation display.

About two miles from the runway threshold the first officer contacted the tower controller to confirm they were cleared to land on runway 28C, to which the tower controller stated they were and advised there were mowers in the grass area. About 0944, the airplane landed on runway 28L, turned right off the runway, and exited runway 28L at taxiway F5.

3.0 Crew

The incident flight crew consisted of a captain and first officer. The captain was the pilot flying and the first officer was the pilot monitoring for the incident flight.

3.1 Captain

The captain was 52 years old and held an Airline Transport Pilot (ATP) certificate with a rating for airplane multiengine land, commercial privileges airplane single-engine land, and type ratings on the A-320¹⁰, B-737¹¹, B-757¹², B-767 and B-777¹³ which included limitations of B-737, B-757, B-767, A-320, B-777 Circling approach - VMC Only, and English Proficient. He held a Flight Engineer certificate with a Turbojet Powered rating, a flight instructor certificate with airplane single and multiengine, and instrument airplane rating, and a mechanic rating with an airframe and powerplant rating. He held an FAA first-class medical certificate dated April 21, 2022, with limitation of "*must have available glasses for near vision*". At the time of the incident, he was based at ORD.

3.1.1 Captain's Flight hours

The following information was provided by United Airlines, FAA records, and the captain. Times are approximate and **do not** include the incident flight:

Previous 24 hours	0:00
Total Hours B737	8,500
Total Hours B737 as Captain	2,000

¹⁰ Airbus SAS A-318 Series, A-319 Series, A-320 Series, A-321 Series and includes all models on TCDS A28NM. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.

¹¹ The Boeing Company 737-100, 737-200, 737-200C, 737-300, 737-400, 737-500, 737-600, 737-700, 737-700C, 737-800, 737-900, 737-900ER, 737-8, 737-9. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.

¹² The Boeing Company 757-200 Series, 757-200PF Series, 757-200CB Series, 757-300 Series, 767-200 Series, 767-300 Series, 767-300F Series, 767-400ER Series, 767-2C Series. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.

¹³ The Boeing Company 777-200 Series, 777-300 Series, 777-300ER Series, 777-200LR Series, 777F-Series. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.

Total Flight Experience ¹⁴	19,700
---------------------------------------	--------

3.1.2 Captain's Training

The following information, in part, was provided by the captain and United Airlines:

Initial Qualification -B737 ¹⁵	2006
Initial Qualification - B737 PIC ¹⁶	2007
Most Recent Pilot Training ¹⁷	March 29, 2022
Most Recent Line Check ¹⁸	February 2022

3.1.3 Captain's 72-Hour History

The following information was provided by the captain during his interview:

	6/21	6/20	6/19	6/18
Wake up	0400 with a 90-minute drive	0530 which he stated was normal	0530	
Duty hours		Off. He was hanging around the home and cutting the lawn.		Released 1830 home by 2100
Flight hours		Off	Off	7.8 - 8 hours
Eat Breakfast	He ate something			

¹⁴ Most recent FAA Medical application and only includes civilian hours of flight experience. During the interview, the captain stated he had about 19,000 to 20,000 total hours of flight experience.

¹⁵ The captain stated that he was a captain on the 737 in either 2007 or 2008 and flew the 737 for about 2 years prior to changing aircraft. FAA records indicated that he had received an FAA observation on November 20, 2006 to function as pilot-in-command.

¹⁶ Reference footnote 15 above. However, the captain was requalified as PIC on the 737 in January of 2022.

¹⁷ Listed as last flight review or equivalent, including FAR 121/135 checks. Source: NTSB 6120.1 Pilot/Operator Accident/Incident Form completed by a representative of United Airlines. However, the captain stated his most recent training event was in January of 2022, which was his "re-upgrade" training to the B-737. Source: Operational Factors - Attachment 1 - Flight Crew Interview Summaries and Statements, pg. 12.

¹⁸ A line check was done at the completion of IOE for his re-upgrade training. Source: Operational Factors - Attachment 1 - Flight Crew Interview Summaries and Statements, pg. 12.

	before he left the house but, on the flight, could not recall. Did have coffee.			
Eat Lunch		Noon to 1300		
Eat Dinner		1800	1800	
Go to bed		About 2100 fell asleep about 2200	About 2230	Not sure but before 2300
Get up in the middle of the night		Probably once	At least once	

Figure 1. First Officer's Approximate Timeline for Preceding 72-hours.

3.2 First Officer

The first officer was 51 years old and held an ATP certificate with a rating for multiengine land and single-engine airplane, and type ratings in the B-737 and BA-3100¹⁹, with limitations of English Proficient. A flight instructor certificate with ratings for Airplane Single-engine and Instrument Airplane with an expiration date of April 30, 2023. She held an FAA first-class medical certificate dated February 8, 2022, with a restriction of *"must have available glasses for near vision"*. At the time of the incident, she was based at ORD.

3.2.1 First Officer's Flight hours

The following information was provided by United Airlines, FAA Records, and the first officer. Times are approximate and **do not** include the incident flight:

Previous 24 hours	0:00
Total Hours B737 as FO	3,500
Total Flight Experience ²⁰	5,500

3.2.2 First Officer's Training Record

The following information, in part, was provided by United Airlines:

¹⁹ British Aerospace Corporations HP.137, MK.1, Jetstream Series 200, Jetstream 3101, Jetstream 3201. Source: FAA Order 8900.1, Figure 5-88, dated July 15, 2019.

²⁰ Most recent FAA Medical application and only included civilian hours of flight experience.

Initial Qualification - 737 ²¹	March 2000
Most Recent Continuous Line Operating Evaluation ²²	January 2022

3.2.3 First Officer's 72-Hour History

The following information was provided by the first officer during her interview:

	6/21	6/20	6/19	6/18
Wake up	0410	0700	0700-0730	
Duty hours		0	0	
Flight hours		0	0	
Eat Breakfast	No but coffee in the car and on the airplane	NA	NA	On the flight
Eat Lunch	NA	1200		
Eat Dinner	NA	1800		
Go to bed	NA	2130	2130 not a late-night person	Likely 2130
Get up in the middle of the night	NA	no	Normally does not so probably not	

Figure 2. First Officer's Approximate Timeline for Preceding 72-hours.

3.3 Trip Pairing

According to a United representative the crew trip pairing was number O5226A. The trip pairing began with the incident flight. The pairing indicated that once in PIT the crew would begin their layover which was scheduled for 19:10. The following morning the crew was to deadhead back to ORD on another United flight. According to the flight crew this was day one and leg one of a three-day pairing.

²¹ The first officer reported she was initially hired by United in March of 2000 directly into the B737; however, do to furloughs in 2003 and extended leave she did not fly for about 15 years and began flying at United in October 2018 and was put directly into the B737 after requalifying. Source: Operational Factors - Attachment 1 - Flight Crew Interview Summaries and Written Statements, pg. 3.

²² Source: Operational Factors - Attachment 1 - Flight Crew Interview Summaries and Written statements, pg. 3.

05226														Jun 21 22 to Jun 21 22										2	
Flt	Seq	Rest DT	Ferry DH	Eqp	Org	Dst	Dpt Ref	T	Arr Dbrf	OV Po	Au	Fltm	Duty	Tail Lavo	Guar	Total									
2627	010	21		37X	ORD	PIT	0730	S	0958			0128		7513											
DP01	020						0630	A	1013			0128	0243	2025		0128									
2367	030	22		739	PIT	SFO	0715	S	0936			0521		0447											
0697	040	22		739	SFO	PDX	1048	S	1242			0154		0447											
DP02	050						0630	S	1257			0715	0927	1523		0715									
2493	060	23		738	PDX	DEN	0505	S	0841			0236		0257											
0676	070	23		738	DEN	PWM	0955	S	1549			0354		0205											
2348	080	23	DUA	738	PWM	ORD	1703	S	1845			0242		0205											
DP03	090						0420	S	1900			0630	1240			0630									
Pairing Totals				TAIR		DMD		Flight Time				Guar Time			Pay Time										
				06030		0242		1513							1755										

Figure 3. Original Crew Pairing

4.0 Airplane



Figure 4. Incident Airplane (Source: planespotter.com)

The aircraft was a B737-9, Serial No. 64494 and was manufactured in 2019. It was powered by two CFM International Leap-1B2B engines each capable of producing 28,000 pounds of thrust. The aircraft was purchased by and registered to United Airlines on February 27, 2019.

The airplane was equipped with an EFIS²³ and FMS²⁴.

4.1 Flight Plan

The incident flight's flight plan was listed as "RLSE 01." The filed route was direct MOBLE direct ADIME direct OTENS direct ANEWA direct TAMDE direct ACO JESEY4 arrival into PIT.

²³ Electronic flight instrument system.

²⁴ Flight management system.

```

*OFP*
(FPL-UAL2627-IS
-B39M/M-SADE3GHIJ4RWXZ/LB1
-KORD1230
-N0472F330 DCT MOBLE DCT ADIME DCT OTENS DCT ANEWA DCT TAMDE
DCT ACO JESEY4
-KPIT0100
-PBN/A1L1B1C1D1O1S2T1 NAV/RNP2 DAT/1FANS2PDC SUR/260B
DOF/220621 REG/N37513 EET/KZOB0023 SEL/ARFL CODE/A448F5 OPR/UAL
PER/D)

```

Figure 5. Incident Flight's Filed Flightplan.

4.2 Landing Performance

According to the performance data that was calculated at 0925, landing on runway 28C with 30 degrees of flaps, with a dry runway, would require the following length based on a planned landing weight of 149,000 lbs., at a temperature of 21°C, and a wind of 239° at 4 knots:

Autobrake	Required Runway Distance (in feet)
1	8,756
2	6,736
3	5,568
Max	4726

4.3 Flight Plan NOTAMs²⁵

The flight plan consisted of 11 pages of NOTAM information. The NOTAMs applicable to PIT began on page 8 of the document. The following NOTAM information was provided for PIT by the flight's dispatcher:

²⁵ Notice to Air Mission.

KPIT / PIT

21 JUN 2022 10:31-22 JUN 2022 23:59 TWY A BTN APCH END RWY 28R AND TWY AA CLSD	KPITA4584/22 (21 JUN 22)
17 JUN 2022 14:21-31 AUG 2022 23:59 TWY B3 CLSD	KPITA4542/22 (17 JUN 22)
16 JUN 2022 11:30-31 AUG 2022 23:59 TWY B6 CLSD	KPITA4537/22 (16 JUN 22)
16 JUN 2022 11:30-31 AUG 2022 23:59 TWY B5 CLSD	KPITA4536/22 (16 JUN 22)
16 JUN 2022 11:29-31 AUG 2022 23:59 TWY B4 CLSD	KPITA4535/22 (16 JUN 22)
13 JUN 2022 16:37-01 JUN 2037 00:00 ILS OR LOC RWY 10L, AMDT 26... ILS OR LOC RWY 10R, AMDT 10G... ILS OR LOC RWY 28L, AMDT 11... RNAV (GPS) RWY 10L, AMDT 4... RNAV (GPS) RWY 14, AMDT 3C... RNAV (GPS) Y RWY 10C, AMDT 4B... RNAV (GPS) Y RWY 10R, AMDT 3C... RNAV (GPS) Y RWY 28C, AMDT 4C...	KPITA4479/22 (13 JUN 22)

RNAV (GPS) Y RWY 28L, AMDT 5... RNAV (GPS) Y RWY 32, AMDT 6... CIRCLING CATS A/B MDA 1760/HAA 557. TEMPORARY CRANE 1458FT MSL 5098FT NORTHWEST OF PIT AIRPORT (2022-AEA-648-NRA).	
13 JUN 2022 16:37-01 JUN 2037 00:00 ILS OR LOC RWY 32, AMDT 14... ZANTA FIX MINIMUMS (DME REQUIRED) : CIRCLING CATS A/B MDA 1760/HAA 557. TEMPORARY CRANE 1458FT MSL 5098FT NORTHWEST OF PIT AIRPORT (2022-AEA-648-NRA).	KPITA4478/22 (13 JUN 22)
13 JUN 2022 16:37-01 JUN 2037 00:00 RNAV (GPS) Y RWY 28R, AMDT 5... LPV DA 1415/HAT 241 ALL CATS. CIRCLING CATS A/B MDA 1760/HAA 557. TEMPORARY CRANE 1458FT MSL 4776FT SOUTHWEST OF RWY 28R (2022-AEA-648-NRA).	KPITA4477/22 (13 JUN 22)
13 JUN 2022 16:37-01 JUN 2037 00:00 RNAV (RNP) Z RWY 10C, ORIG-D... RNP 0.11 DA NA ALL CATS. RNP 0.20 DA 1604/HAT 463 ALL CATS. TEMPORARY CRANE 1458FT MSL 2708FT NORTHWEST OF RWY 10C (2022-AEA-648-NRA).	KPITA4476/22 (13 JUN 22)
13 JUN 2022 16:37-01 JUN 2037 00:00 ILS RWY 28R (SA CAT I AND II), AMDT 10A ... PROCEDURE NA. TEMPORARY CRANE 1458FT MSL 4776FT SOUTHWEST OF RWY 28R (2022-AEA-648-NRA)	KPITA4475/22 (13 JUN 22)
13 JUN 2022 16:37-01 JUN 2037 00:00 ILS OR LOC RWY 28R, AMDT 10A... S-ILS 28R DA 1415/HAT 241 ALL CATS. S-LOC 28R MDA 1600/HAT 426 ALL CATS. VISIBILITY CATS C/D/E RVR 4000. CIRCLING CATS A/B MDA 1760/HAA 557. CHANGE NOTE TO READ: FOR INOPERATIVE ALS, INCREASE S-ILS 28R CAT E VISIBILITY TO RVR 4000, INCREASE S-LOC 28R CAT E VISIBILITY TO 1 1/4 SM. TEMPORARY CRANE 1458FT MSL 4776FT SOUTHWEST OF RWY 28R (2022-AEA-648-NRA).	KPITA4474/22 (13 JUN 22)
AMOC/5G NOTAM APPLICABILITY	
28 FEB 2022 00:00-07 APR 2024 00:00 NOTAMS citing 5G restrictions are not applicable for aircraft operating in accordance with the following AMOCs: BOEING AIRCRAFT AMOCs APPROVED - ALL RUNWAYS AMOC 720-22-6668 / AMOC 720-22-4522 LRA-900 737NG - ALL aircraft 757 - AC 3124-3141; 3851-3871 767 - AC 6684, 6685, 6686, and ALL 767-400s 777 - ALL aircraft .. AMOCs APPROVED - ALL RUNWAYS AMOC-720-22-6668 ALA-52B 737MAX - ALL aircraft 787 - ALL aircraft .. AMOCs APPROVED - ALL RUNWAYS AMOC-720-22-6668 / AMOC 720-22-4521 ALA-52A 757 - AC 3101-3122 .. AMOCs APPROVED - ALL RUNWAYS AMOC-720-22-6668 / AMOC 720-22-4523 LRA-700 B767-322 - AC 6441 - 6463; 6664 - 6677 AIRBUS AIRCRAFT	UAL 00458/22 (10 JUN 22)

AMOCs APPROVED - ALL RUNWAYS AMOC 720-22-6672 / AMOC 720-22-4527 ERT-530 A319/A320 - AC 40XX, 41XX, 42XX, 46XX, 47XX, 49XX 4871, 4873, 4875-84, 4888-99 (See AMOC 720-22-2319 for specific aircraft converted to the ALA-52B radio altimeters.) .. AMOCs APPROVED - ALL RUNWAYS AMOC 720-22-2319 / ALA-52B 4005/4615/4617/4893 .. AMOCs APPROVED - ALL RUNWAYS AMOC 720-22-6672 / AMOC 720-22-4945 LRA-900 A319 - AC 4872, 4874 (For changes to this NOTAM contact the MDO)	
01 JUN 2022 17:09-31 AUG 2022 23:59 TWY ALL ELEVATED RWY GUARD LGT FOR RWY 10L/28R U/S	KPITA4280/22 (01 JUN 22)
01 JUN 2022 10:56-15 AUG 2022 23:00 ILS RWY 10L CAT II NA	KPITA4271/22 (01 JUN 22)
01 JUN 2022 10:56-15 AUG 2022 23:00 RWY 10L ALS U/S	KPITA4272/22 (01 JUN 22)
01 JUN 2022 11:00-15 AUG 2022 23:00 RWY 28R ALS U/S	KPITA4270/22 (01 JUN 22)
31 MAY 2022 19:42-01 JUN 2037 00:00 TWY N WIP OPEN EXCAVATION ADJ TWY N RUNUP PAD FOR RWY 28R TAXI SPEED RESTRICTED 10 MPH	KPITA4259/22 (31 MAY 22)
31 MAY 2022 19:42-01 JUN 2037 00:00 TWY B1 WIP OPN EXCAVATION ADJ AER 28R TAXI SPEED RESTRICTED 10 MPH	KPITA4258/22 (31 MAY 22)
31 MAY 2022 13:49-18 AUG 2022 20:00 RWY 28R RVR U/S	KPITA4254/22 (31 MAY 22)
31 MAY 2022 13:47-18 AUG 2022 20:00 RWY 10L RVR U/S	KPITA4253/22 (31 MAY 22)
31 MAY 2022 13:46-18 AUG 2022 20:00 ILS RWY 28R U/S	KPITA4252/22 (31 MAY 22)
31 MAY 2022 13:45-18 AUG 2022 17:00 ILS RWY 10L U/S	KPITA4251/22 (31 MAY 22)
31 MAY 2022 12:10-30 NOV 2022 23:59 TWY B1 BTN TWY B AND APCH END RWY 28R CLSD	KPITA4246/22 (31 MAY 22)
31 MAY 2022 12:09-30 NOV 2022 23:59 TWY N BTN TWY B AND APCH END RWY 28R CLSD	KPITA4245/22 (31 MAY 22)
31 MAY 2022 12:08-30 NOV 2022 23:59 TWY B BTN TWY N AND TWY B2 CLSD	KPITA4243/22 (31 MAY 22)
31 MAY 2022 12:07-30 NOV 2022 23:59 RWY 10L/28R CLSD	*KPITA4242/22 (31 MAY 22)
26 MAY 2022 15:20-01 JUN 2037 00:00 VOR/DME AGC/ALLEGHENY 110MHZ CH37X 300-310 UNUSABLE	KPITA4145/22 (26 MAY 22)
25 MAY 2022 14:33-31 JUL 2022 23:59 TWY N WIP OPN EXCAVATION ADJ TXL M TAX SPEED RESTRICTED 10 MILES PER HR	KPITA4130/22 (25 MAY 22)
24 MAY 2022 12:47-31 JUL 2022 23:59 TWY N BTN TXL M AND TWY N4 CLSD	KPITA4110/22 (24 MAY 22)
01 MAY 2022 01:07-01 JUN 2037 00:00 RWY 10L PAPI U/S	KPITA3630/22 (01 MAY 22)
19 JAN 2022 05:01-19 JAN 2024 05:01 AP RDO ALTIMETER UNREL. AUTOLAND, HUD TO TOUCHDOWN, ENHANCED FLT VISION SYSTEMS TO TOUCHDOWN, HEL OPS REQUIRING RDO ALTIMETER DATA TO INCLUDE HOVER AUTOPILOT MODES AND CAT A/B/PERFORMANCE CLASS TKOP AND LDG NOT AUTHORIZED EXC FOR ACFT USING APPROVED ALTERNATIVE METHODS OF COMPLIANCE DUE TO 5G C-BAND	KPITA0366/22 (13 JAN 22)

INTERFERENCE PLUS SEE AIRWORTHINESS DIRECTIVES 2021-23-12, 2021-23-13 FROM SFC TO UNL	
19 JAN 2022 05:00-01 JUN 2037 00:00 ILS RWY 10R (SA CAT I), AMDT 10G ... ILS RWY 28R (SA CAT I - II), AMDT 10A ... ILS RWY 10L (CAT II - III), AMDT 26 ... ILS RWY 10R (CAT II - III), AMDT 10G ... PROCEDURE NA EXC FOR ACFT USING APPROVED ALTERNATIVE METHODS OF COMPLIANCE DUE TO 5G C-BAND INTERFERENCE PLUS SEE AIRWORTHINESS DIRECTIVES 2021-23-12, 2021-23-13	KPITA0360/22 (13 JAN 22)
23 SEP 2021 16:29-01 JUN 2037 00:00 RNAV (GPS) Y RWY 28C, AMDT 4C... LNAV MDA 1600/HAT 466 ALL CATS.	KPITA6537/21 (23 SEP 21)
17 MAY 2021 14:59-01 JUN 2037 00:00 RNAV (GPS) RWY 14, AMDT 3C... LPV DA 1655/HAT 507.	KPITA4087/21 (17 MAY 21)

Figure 6. NOTAMs listed on Incident Flight's Release.

4.4 Discrepancy Information

The United Airlines "Discrepancy Detail²⁶" for the incident aircraft listed that the FMC screens displayed a time out/reselect message. The date of the reported discrepancy was listed as the day after the incident event and included in the comment section *"ref. flight safety/FSAP²⁷ report. While on final approach into PIT the FMC screens displayed time out/reselect message. All lateral and vertical guidance was lost and map displays were blank. Aircraft reverted to control wheel pitch mode. The FMS and MAP displays returned to normal before arriving at the gate."*

Additionally, the discrepancy detail went on to provide the fault codes and that the software was verified correct by comparing the right FMC and configuration file.

5.0 Air Traffic Control

The FAA Airport Traffic Control Tower (ATCT) was in operation at the time of the incident. According to information provided by an NTSB Air Traffic Control Specialist, the flight established communication with the local controller approximately 6 1/2 miles east of the airport. The flight advised the controller they were on a visual approach to runway 28C, and the controller cleared the flight to land on runway 28C. According to radar data, on an approximately 6-mile final the incident flight joined the final for runway 28L. About 2-mile final the incident flight requested verification of their clearance to land runway 28C. The controller advised the incident flight of mowers in the vicinity and cleared the flight to land on runway 28C. The controller subsequently observed the flight had lined up with runway 28L. The controller decided that it was appropriate to allow the aircraft to land given their altitude, and therefore decided not to issue a go-around to the flight as there were no airplanes or vehicles on or near runway 28L. It should be noted that runway 28L was a similar length as runway 28C. The Air Traffic Manager reported that at the time of the incident, the traffic volume was *"light with routine complexity."*

²⁶ Source: Operational Factors - Attachment 2 - Discrepancy Detail.

²⁷ Flight Safety Awareness Program.

5.1 FAA 7110.65Z

FAA Job Order (JO) 7110.65Z, Change 2, "Air Traffic Organization Policy," dated May 19, 2022, prescribed air traffic control procedures and phraseology for use by air traffic control personnel. It further required controllers to be familiar with the provisions within the order that pertain to their operational responsibilities and *"to exercise their best judgment if they encounter situations not covered by it."*

Additionally, JO 7110 defined the role of ATC services, in part, as *"The primary purpose of the ATC system is to prevent a collision involving aircraft operating in the system. In addition to its primary purpose, the ATC system also: Provides a safe, orderly, and expeditious flow of air traffic"*²⁸

The JO 7110 further provided, in part, the following guidance regarding "Duty Priority" and "Landing Clearance"²⁹:

Give first priority to separating aircraft and issuing safety alerts as required in this order. Good judgment must be used in prioritizing all other provisions of this order based on the requirements of the situation at hand.

NOTE– *Because there are many variables involved, it is virtually impossible to develop a standard list of duty priorities that would apply uniformly to every conceivable situation. Each set of circumstances must be evaluated on its own merit, and when more than one action is required, controllers must exercise their best judgment based on the facts and circumstances known to them. That action which is most critical from a safety standpoint is performed first...*

b. When you become aware that an aircraft is aligned with the wrong surface, inform the pilot and:

- 1. Issue control instructions/clearances, or*
- 2. If time permits, verify the pilot is aligned with the correct runway. Issue control instructions/clearances as necessary.*

6.0 Airport Information

Pittsburgh International Airport was located about 12 miles northwest of Pittsburgh, Pennsylvania, had a field elevation of 1,202.9 ft msl, and was located at latitude/longitude of N40°29.49'/W080°13.96'. The airport was owned by Allegheny County Airport Authority and was serviced by an FAA Air Traffic Control Tower that was in operation 24-hours a day. Approach radar services were provided by Pittsburgh

²⁸ Source: FAA JO 7110.65Z changes 1 and 2, Section 2-1-1. "ATC Service." [7110.65Z Basic w Chg 1 and 2 dtd 5-19-22 \(faa.gov\)](#)

²⁹ Source: FAA JO 7110.65Z changes 1 and 2, Section "2-1-2a. Duty Priority" and Section "3-10-5b. Landing Clearance." [7110.65Z Basic w Chg 1 and 2 dtd 5-19-22 \(faa.gov\)](#)

Approach control. The ATCT was approximately 1 1/2-miles from the approach ends of runway 28L and 28C.

At the time of the incident, PIT, had four paved landing surfaces for airplanes designated as 10R/28L, 10C/28C, 10L/28R, and 14/32. Runway 10R/28L was 11,500 ft long and 200 ft wide and runway 28L was serviced by a 4-light PAPI on the left side of the runway and MALSR approach lights. Runway 10C/28C was 10,775 ft long and 150 ft wide. Runway 28C was serviced by a 4-light PAPI located on the left side of the runway and runway centerline lights.

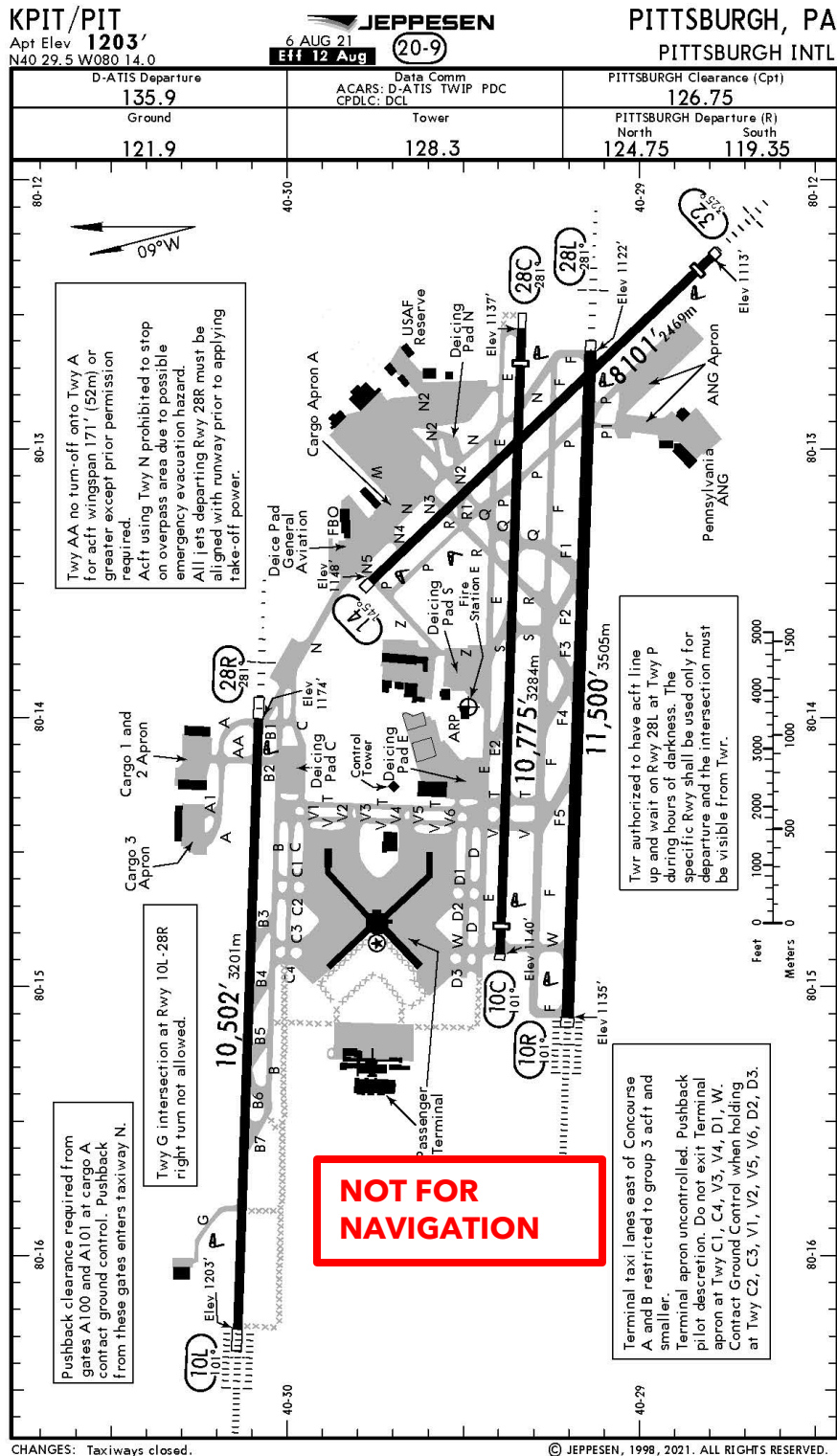


Figure 7. PIT 20-9 Airport Diagram (Source: Jeppesen)

KPIT/PIT

JEPPesen
6 AUG 21 **20-9A** Eff 12 Aug

PITTSBURGH, PA
PITTSBURGH INTL

GENERAL										
Deer and birds on and in vicinity of airport. Low-level wind shear alert system. Terminal Doppler Weather Radar. ASSC in use. Operate transponders with altitude reporting mode and ADS-B (if equipped) enabled on all airport surfaces.										
ADDITIONAL RUNWAY INFORMATION						USABLE LENGTHS		TAKE- -OFF	WIDTH	
RWY					Threshold	Landing Beyond Glide Slope				
10R	HIRL CL ALSF-II TDZ ① PAPI-L	grooved RVR		②		10,493' 3198m			200'	
28L	HIRL CL MALSR TDZ ① PAPI-L	grooved RVR				10,500' 3200m			61m	
① Angle 3.00°. ② LDA 11,492' 3503m.										
10C	HIRL CL REIL PAPI-L (angle 3.0°)	grooved RVR		③ 10,310' 3142m					150'	
28C	HIRL CL TDZ PAPI-L (angle 3.0°)	grooved RVR		③ 10,173' 3101m					46m	
③ LDA 9708' 2959m.										
10L	HIRL CL ALSF-II TDZ ④ PAPI-L	grooved RVR				9251' 2820m			150'	
28R	HIRL CL MALSR TDZ ④ PAPI-L	grooved RVR		⑤		8992' 2741m			46m	
④ Angle 3.00°. ⑤ LDA 10,102' 3079m.										
14	HIRL CL PAPI-L (angle 3.0°)	grooved RVR		⑦					150'	
32	HIRL CL MALSR TDZ ⑥ PAPI-L	grooved RVR		③ 7766' 2367m		6802' 2073m			46m	
⑥ Angle 3.00° ⑦ LDA 7366' 2245m. ⑧ LDA 7466' 2276m.										
TAKE-OFF										
Rwy 10L										
① With Min climb of 215'/NM to 1400'						STD		Other		
2 operating RVRs are required All operating RVRs are controlling										
CL & HIRL		CL		3 & 4 Eng		1 & 2 Eng				
TDZ RVR 5		Mid RVR 5		Rollout RVR 5		Mid RVR 10		RVR 16 or 1/4		
								RVR 24 or 1/2		
								RVR 50 or 1		
								300-1 1/4		
① Alternatively, with standard take-off minimums and a normal 200'/NM climb gradient, take-off must occur no later than 1400' prior to departure end of runway.										
Rwys 10C, 10R, 14, 28L, 28C, 28R										
2 operating RVRs are required All operating RVRs are controlling				Adequate Vis Ref		STD				
CL & HIRL		CL, or RCLM & HIRL				3 & 4 Eng		1 & 2 Eng		
TDZ RVR 5		TDZ RVR 10		RVR 16 or 1/4		RVR 24 or 1/2		RVR 50 or 1		
Mid RVR 5		Mid RVR 10								
Rollout RVR 5		Rollout RVR 10								
Rwy 32										
With Min climb of 255'/NM to 1500'						STD		Other		
2 operating RVRs are required All operating RVRs are controlling				Adequate Vis Ref						
CL & HIRL		CL, or RCLM & HIRL				3 & 4 Eng		1 & 2 Eng		
TDZ RVR 5		TDZ RVR 10		RVR 16 or 1/4		RVR 24 or 1/2		RVR 50 or 1		
Mid RVR 5		Mid RVR 10								
Rollout RVR 5		Rollout RVR 10								
								300-1 1/2		
FOR FILING AS ALTERNATE										
ILS Rwy 10L ILS Rwy 28L/R ILS Rwy 32		ILS Rwy 10R		RNAV (RNP) Z Rwy 10C/R RNAV (RNP) Z Rwy 28L/C/R RNAV (RNP) Z Rwy 32		LOC Rwy 10L/R LOC Rwy 28L/R LOC Rwy 32		RNAV (GPS) Rwy 10L RNAV (GPS) Rwy 14 RNAV (GPS) Y Rwy 10C/R RNAV (GPS) Y Rwy 28L/C/R RNAV (GPS) Y Rwy 32		
A	600-2		600-2		800-2		800-2			
B										
C										
D			700-2 1/4						800-2 1/4	
CHANGES: None.										
© JEPPESEN, 1998, 2021. ALL RIGHTS RESERVED.										

CHANGES: None.

© JEPPesen, 1998, 2021. ALL RIGHTS RESERVED.

Figure 8. Pittsburgh 20-9A Airport Runway Information Page (Source: Jeppesen)

6.1 JESEY 4 RNAV Arrival

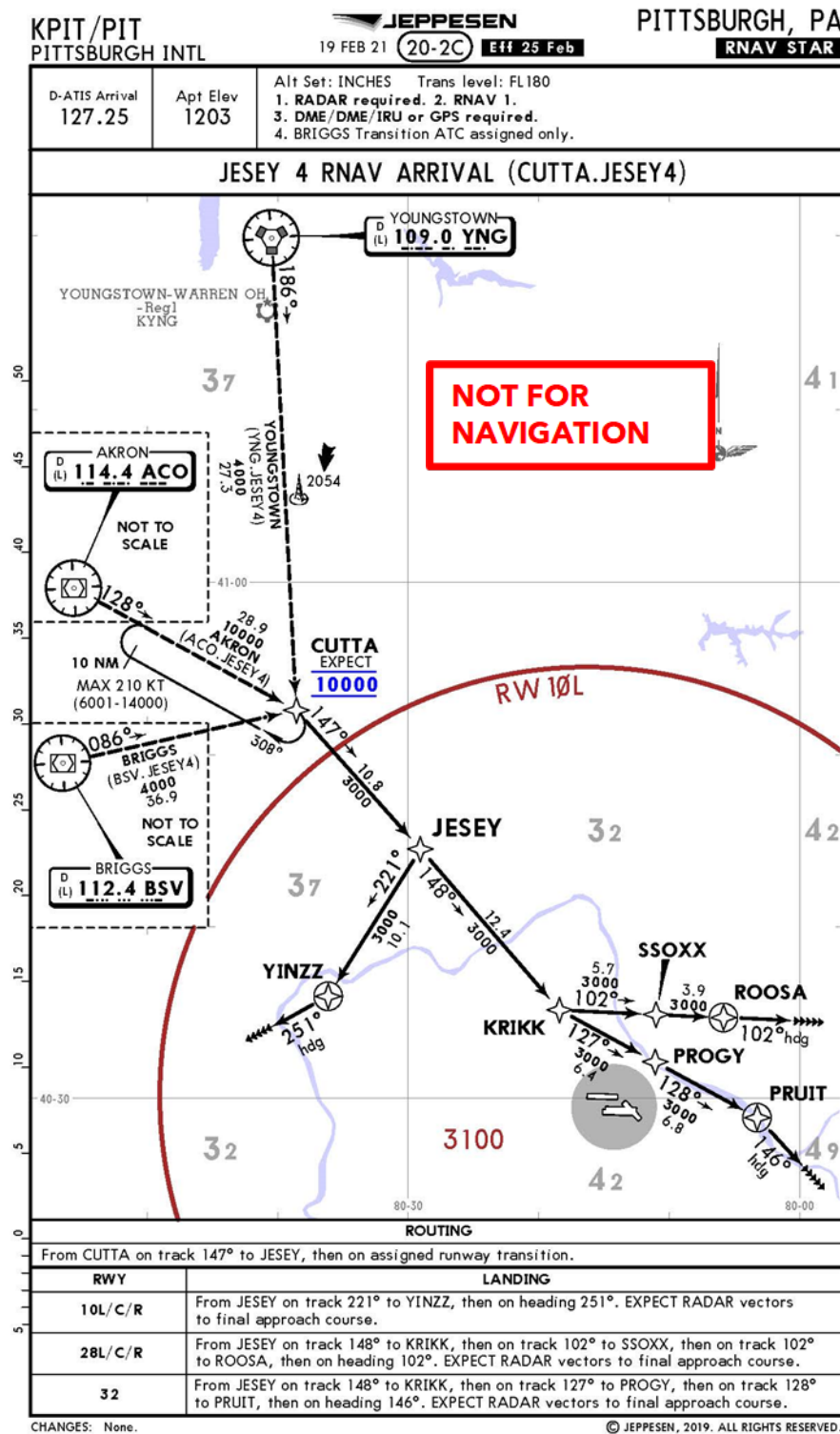


Figure 9. JESEY 4 RNAV Arrival [Source: Jeppesen]

6.2 RNAV (GPS) Y Runway 28C

Runway 28C was served by two instrument approach RNAV (GPS) Y and RNAV (RNP) Z. The flight was cleared for, and accepted, the visual approach to runway 28C. The crew utilized the RNAV (GPS) Y for electronic backup guidance.

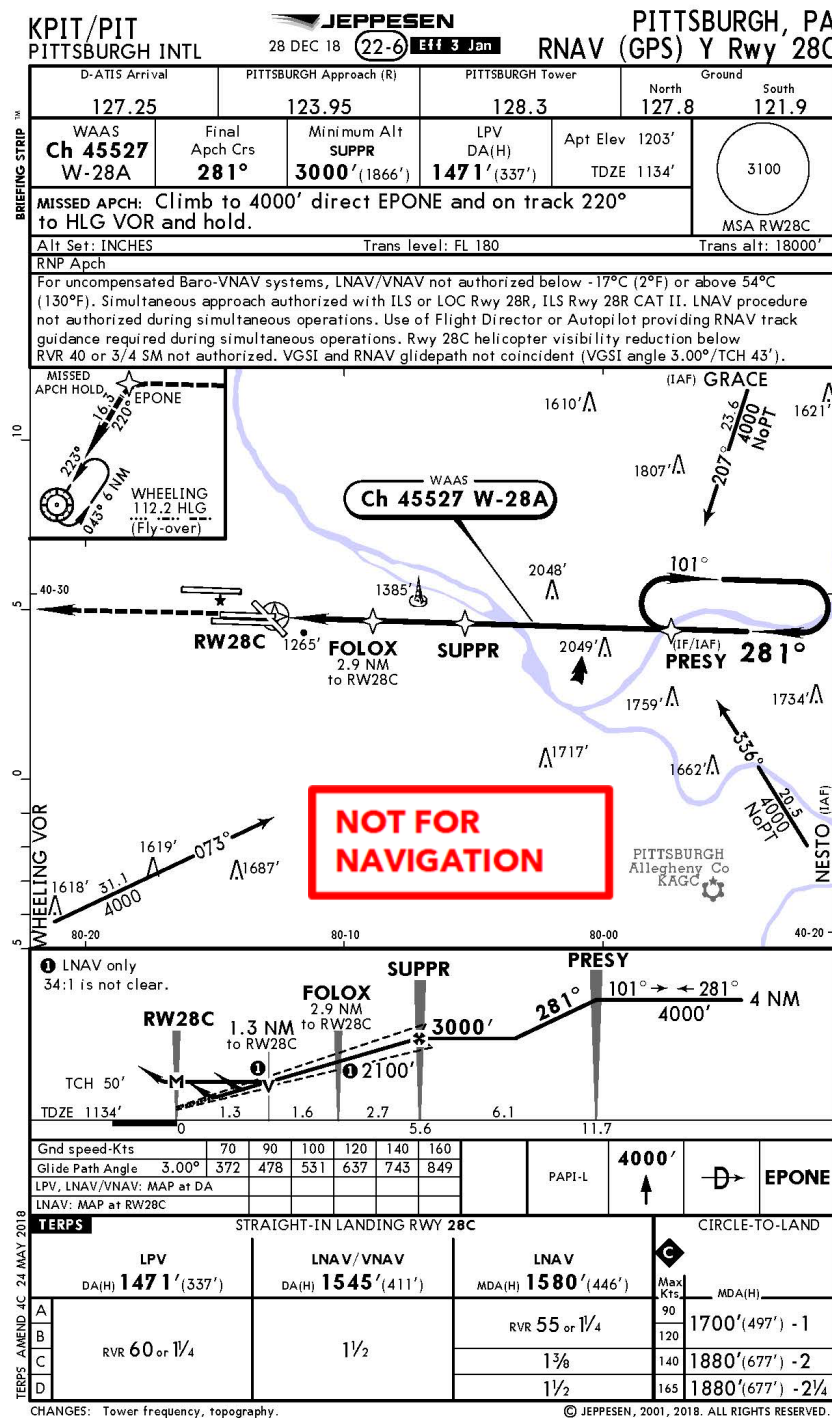


Figure 10. Pittsburgh 22-6 RNAV Y Runway 28C (Source: Jeppesen)

7.0 Meteorological Information

The most recent recorded weather, prior to the incident, was the PIT METAR, which recorded the following:

*METAR KPIT 211451Z 26006KT 10SM FEW140 26/15 A3017 RMK AO2 SLP216
T024600150 58003=*

*METAR KPIT 211351Z 22005KT 10SM FEW130 FEW250 23/14 A3018 RMK AO2
SLP221 T02330144=*

Incident Landing

*METAR KPIT 211251Z 23005KT 10SM FEW050 FEW130 SCT250 21/13 A3017
RMK AO2 SLP 220 T02060133=*

*METAR KPIT 211151Z 24004KT 10SM FEW050 SCT140 BKN250 18/13 A3018
RMK AO2 SLP222 T01830133 10183 20156 51008=*

At the time of the incident ATIS information "Alpha" was current and broadcasting, which was issued at 0851 (1251Z listed above).

8.0 Operator

United Airlines conducted scheduled passenger operations and had a CFR Part 121 certificate that was issued on July 11, 1938. According to the FAA website³⁰, United conducted both domestic and flag (passenger/cargo) operations, had 856 airplanes, and of those aircraft 388 were B-737. There were four FAA certificate management offices (CMOs) that oversaw United Airlines, and they were in Chicago, Denver, Houston, and San Francisco. The Chicago and Denver CMO were responsible for the oversight of flight operations, including aircrew training. The FAA principal operations inspector was in the Chicago office.

United had an FSAP³¹ and FOQA program. The crew stated they filed an FSAP report for this event.

9.0 United Airlines Pilot Bulletin

9.1 Flight Operations - B737 MAX Enroute CPDLC

At the time of the incident United Airlines had a "Pilot Bulletin" issued, bulletin number 22-154. The bulletin had an effective date of May 27 thru December 31, 2022 and was issued to "extend the expiration date and replaces 22-043" and was set to expire "once Boeing issues an update to the U14 FMC software." The bulletin was issued after Boeing had "identified an anomaly with the U14 FMC software on B737 MAX aircraft." The anomaly resulted in the FMC dropping an air traffic control issued

³⁰ Source: [Federal Aviation Administration - Airline Certificate Information - Detail View \(faa.gov\)](https://www.faa.gov/airline-certificate-information-detail-view)

³¹ Flight Safety Action Program.

message or clearance which would not be displayed to the crew. The bulletin further stated that *"this issue occurs primarily with hand-offs to approach controls (TRACONS) and hand-offs to external non-US ATSU's (Oceanic, Canada, etc.)."*

The bulletin further provided the following policy/procedure:

Effective immediately, ENROUTE CPDLC is not authorized on the B737 MAX aircraft. DCL clearances on the ground may still be used. Do not accept any enroute clearances/request issued by ATC and revert to normal voice clearance procedures. Dispatch is in the process of changing the flight plan filing codes for the B737 MAX aircraft.

The incident airplane, at the time of the event, had the U14 software installed.

Data provided by United Airlines on the B737 fleet beginning in January 2018 through July 10, 2022 recorded 212 events involving the FMC. Of those events, 39 were listed as dual FMC failures and 64 were listed as single FMC failures. Additionally, at least three of the dual FMC failures included a time that the screen was blank prior to the system rebooting. The time ranged from 30 to 60 seconds (See Systems Group Factual Report).

Post incident testing of the FMC units that were installed on the incident flight indicated that *"a second or two after VECTOR³² became the GO TO, the dual reset occurred, After approximately 30 seconds, both boxes recovered."*³³

10.0 Manual Excerpts

The following are manual excerpts taken from the operator's manuals:

10.1 Runway Awareness Advisory System (RAAS)

The United B737 "Flight Manual", Section 6.150.10.9 "Warning Systems - Warning Systems Description" provided the following information on RAAS:

RUNWAY AWARENESS AND ADVISORY SYSTEM (RAAS) (MAX)

System Overview

The Runway Awareness and Advisory System (RAAS) is an enhancement to the GPWS system. RAAS provides aural callouts along with visual alerts on the

³² VECTOR was a programmed term to indicate that at some point after that waypoint the flightcrew should anticipate a radar vector from air traffic control.

³³ Source: GE "FMC Download Report UAL2627" located in the docket for this incident.

navigation display (ND) to assist the pilots with situational awareness during ground operations, approach to landing, and go-around.

RAAS requires the following databases or systems for proper operation:

- Terrain and airport runway database is in the GPWS computer,
- Aircraft is on or approaching an airport in the RAAS airport runway database,
- Global positioning system (GPS) and other required signals are available and accuracy meets minimum requirements.

When enabled, RAAS callouts operate without any action required from the pilots. If desired, RAAS availability can be verified on the ground. There is no automatic display of RAAS functionality. Visual display of RAAS callouts and alerts on the ND requires the selection of the terrain feature. RAAS callouts and alerts may be inhibited by the runway inhibit switch.

Assumptions, Limitations, and Constraints

Defined nominal runway length for landing and advisory hold times are options specified by an operator.

In flight callouts and alerts are based on an algorithm that numerically subtracts the landing runway TDZE in the GPWS database from the pressure altitude of the aircraft. The term "above field elevation" is used in the system description for these altitudes.

Note: • RAAS callouts and alerts are based on RAAS airport runway database details and GPS position.

- RAAS does not include knowledge of ATC clearances or pilots intent.
- RAAS does not take into account aircraft performance factors such as aircraft weight, wind, runway conditions, slope, air temperature, or airport altitude.
- Absence of a RAAS annunciation does not ensure that the that a runway is appropriate for takeoff or landing.
- RAAS annunciations do not ensure that a runway can, or cannot, be safely used for takeoff or landing.
- Pilot is responsible by other means to ensure correct runway selection. RAAS does not include knowledge of Notice to Airmen (NOTAM) or Automatic Terminal Information Service (ATIS).
- RAAS callouts and alerts are not intended for navigation purposes.
- RAAS is not designed to enhance traffic awareness.

RAAS callouts and alerts have a lower priority than any GPWS alert, including radio altitude callouts. Some may reoccur, depending on aircraft position, when the higher priority advisory clears.

CALLOUTS, ALERTS, AND ND MESSAGES DURING APPROACH, LANDING, AND REJECTED TAKEOFF (MAX)

Voice Callouts, Alerts, and ND Messages	Description
(3000 FEET) REMAINING - RTO ND display message not available.	Sounds during RTO when the aircraft is on the ground: - Is on a defined minimum length from the runway end - With ground speed greater than 40 knots, <i>and</i>
	After ground speed decreases by seven knots from the maximum ground speed achieved.
(2000 FEET) REMAINING ND display message not available.	Distance Remaining Sounds once each time the aircraft is: 2000 feet from the runway end; <i>and</i> - During rollout with airspeed greater than 40 knots.
ONE HUNDRED REMAINING ND display message not available.	Sounds once each time the aircraft: - Is within 20° of the runway heading, <i>and</i> - Is within 100 feet of the end of a runway, <i>and</i> - Ground speed is less than 40 knots.
Callout: CAUTION TAXIWAY CAUTION TAXIWAY ND amber message: TAXIWAY	Sounds once each time the aircraft: - Aircraft is airborne between 150 and 250 feet AGL; <i>and</i> - Aircraft climb rate is less than 450 FPM; <i>and</i> - Aircraft is within 5 NM of a runway and is not lined up with a runway.
Callout: FLAPS FLAPS (with pause between) ND amber message: FLAPS	Sounds once when the aircraft: - Flaps are not in landing configuration, at 600 feet AFE; <i>and</i> - Aircraft is not required to be aligned with runway.
Callout: FLAPS - FLAPS (no pause) ND amber message: FLAPS	Sounds once when the aircraft: - Flaps are not in landing configuration, at 600 feet AFE; <i>and</i> - Aircraft is aligned with runway.
Callout: TOO HIGH - TOO HIGH ND amber message: TOO HIGH	Sounds once when the aircraft: - At 950 feet AFE if gear is down, landing flaps set; <i>or</i> At 600 feet AFE aligned with runway. - Regardless of flaps/gear.
Callout: TOO FAST - TOO FAST ND amber message: TOO FAST	Sounds once when the aircraft: - At 950 feet AFE if gear is down, landing flaps set; <i>or</i> At 600 feet AFE aligned with runway. - Regardless of flaps/gear.

Callout: UNSTABLE ND amber message: UNSTABLE	Active at 450 feet AFE. Provided one of the approach monitors is active at the time.
Callout: LONG LANDING ND amber message: LONG LANDING	Aircraft is airborne above 5 feet AGL, but below 100 feet AGL. And aircraft has passed 3000 feet from approach end of runway.
Callout: ALTIMETER SETTING ND amber message: ALTM SETTING	The aircraft has been above the transition altitude (from database) for more than 30 seconds, but not more than 5 minutes. Aircraft has descended below the transition altitude (from database) for more than 30 seconds or height above field is less than 1500 feet.
Callout: ALTIMETER SETTING ND amber message: ALTM SETTING	Aircraft has descended below the transition altitude (from database) for more than 30 seconds or height above field is less than 1500 feet.

Figure 11. RAAS Callouts and Alerts. Source: UAL B737 Flight Manual.³⁴

10.2 Arrival and Approach Briefing

United Airlines, Flight Manual, Chapter 3 "Normals," Section 180 "Visual Approaches" provided the following guidance:

GENERAL

A visual approach is conducted under an IFR flight plan and allows the pilot to proceed visually to the airport. See FOM>Navigation>Visual Approach Procedures.

VISUAL APPROACHES PROCEDURE

- [PF, PM] FMC, radios Verify/set
Line select an appropriate approach.

WARNING: When cleared for the visual approach, do not set a lower MCP altitude or begin descent until approaching a normal visual or electronic glidepath and terrain and obstacle clearance can be assured throughout the approach. An early descent may compromise terrain/obstacle and/or Class B vertical limits.

- [Auto] "2500" Announce
 - [PF, PM] "___ in/hPa" Announce
- After cleared for the approach:***
- [PM] MCP altitude Set (as required)

³⁴ According to the Senior Manager Fleet Standards - B737 United Airlines did not all an airborne audible alert to announce which runway a flight was approaching to minimize any distractions while on final approach to maintain a "quiet cockpit" environment.

- [PF] Approach guidance. Select
Select appropriate lateral and vertical guidance to aid in flying the approach.

When in a position to begin final descent to the runway:

- [PF] Set TDZE Announce
- [PM] MCP altitude Set TDZE
Set MCP altitude to TDZE (rounded up to nearest 100 feet).

By 1500 feet or the FAF/FAP/GP Intcpt equivalent, whichever occurs later:

- [PF] Gear down Announce
- [PM] Landing gear lever Down

By 1000 feet RA:

- [PF/PM] Speed brake. Arm
The Captain normally arms the speed brake.
- [PF] Flaps ____ Announce
- [PM] Flaps Set
- [PM] Landing Checklist Accomplish
- [PF] Target speed. Set, when appropriate

At 1000 feet RA:

- [Auto] "1000" Announce
- [PF] "Set missed approach altitude. Cleared to land." or
"Set missed approach altitude. No landing clearance." Announce
- [PM] Missed approach altitude. Set
Set missed approach altitude for the backup approach briefed or as
assigned by ATC.

At 500 feet RA:

- [Auto] "500" Announce
- [PF] "Stable" or "Unstable, going around" Announce
If required, the PM directs a go-around and the PF must execute the
go-around. See FOM>Navigation>Common Approach Procedures.

If continuing the approach to land:

- [PF] Autopilot Off
Disconnect the autopilot no later than required by aircraft limitations.
***If the runway environment is not in sight or the approach cannot be
continued:***
- [PF] Go-around Execute

Initiate a go-around if an approach cannot be continued to a landing.
Remain in VMC. Published instrument missed approach procedures do not apply
to visual approaches. Follow ATC instructions or fly the published visual missed
approach procedures. If an FMC course is available, TOGA to LNAV will

automatically command steering to follow that course. Select an appropriate roll mode to remain in VMC.

VISUAL APPROACHES CONSIDERATIONS/PLANNING

Plan the approach to arrive at or before the FAF (or an equivalent point) within stabilized approach parameters. Planning may begin with a published arrival fix that is 30-40 NM from the airport, at an appropriate altitude. If no such fix exists, consider building a fix that represents a similar altitude/distance and energy relationship.

Certain airports or conditions may dictate slight variances. These may include high density altitude airports where approach speeds result in higher true airspeeds, approaches with a tailwind component near the maximum permissible level, or non-normal configurations. These conditions may result in high energy approaches.

VISUAL APPROACH CONSTRUCTION

A visual approach should be flown using an approximate 3° descent path while aligned with the extended centerline of the runway. Back up the visual approach with a line-selectable instrument approach or charted visual approach if it is available. If an approach with glideslope guidance is not available (e.g., a LOC approach), load the approach and extend a fix on the approach or the runway itself. If no charted approach is available, consider loading and extending the runway to provide lateral and vertical guidance.

In the absence of a suitable line-selectable approach, other options include selecting the arrival runway and inserting appropriate waypoints and altitudes (as required) along the inbound course to the runway. This provides lateral guidance and a vertical profile to the runway threshold. Manually tune and display backup raw data, as required. The visual approach may be flown using LNAV/VNAV when programmed.

If a published approach is not available for the desired runway, the runway and a runway extension may be loaded. The FMS creates a path, inline with the runway centerline, beginning at a point 50 feet above the runway threshold and extending upward at a default flight path angle (FPA) of 3°. A different FPA may be entered as desired.

LATERAL NAVIGATION

The runway is the primary lateral reference on a visual approach. Displaying the MAP mode with terrain selected enhances situational awareness. The localizer provides accurate course information.

VERTICAL NAVIGATION

Plan to fly the visual approach with a constant, stable descent from traffic pattern altitude through the landing. To ensure adequate main gear clearance over the threshold, the visual descent profile should be approximately 3°. Plan to cross the runway threshold at 50 feet RA.

Two general techniques exist to determine a point to start the descent:

- *Load an approach and extend a fix on the approach. When cleared for the visual approach, descend to the FAF/FAP/GP Intcpt altitude with reference to intermediate fixes, surrounding terrain, obstacles, and Class B airspace vertical limits. Once established at FAF/FAP/GP Intcpt altitude, start the final descent at the published FAF/FAP/GP Intcpt.*
- *Select and extend the runway. This technique provides the pilot with lateral course guidance and runway distance to go information. Divide the height above touchdown by 300 feet per nautical mile. This provides a distance in nautical miles from the end of the runway to begin the descent on a 3° glidepath.*

If vertical information is programmed in the FMC, the VNAV path pointer and deviation scale provides vertical path information. Once stabilized on the descent, if TDZE is set, the green arc should be close to the runway threshold on the ND.

CHARTED VISUAL FLIGHT PROCEDURES

Charted visual flight procedures (CVFPs) are established for environmental, noise abatement, and traffic efficiency purposes. Unless indicated as a Class B airspace floor, all depicted altitudes are for noise abatement only. The approach charts depict prominent landmarks, courses, and recommended altitudes to specific runways.

See FOM>Navigation>Charted Visual Flight Procedures for more information.

RNAV VISUAL APPROACH PROCEDURES

RNAV visual approaches should be utilized when line selectable from the FMS.

When conducting an RNAV visual, utilize RNAV approach procedures. See Normals>RNAV (GPS/GNSS) and RNAV (RNP) Approaches. The autopilot may be disconnected at any point on the approach if desired.

10.2.1 RNAV Approaches

United Airlines, Flight Manual, Chapter 3 "Normals", Section 172 "RNAV (GPS/GNSS) and RNAV (RNP) Approaches" provided the following guidance:

GENERAL

This section contains the requirements and procedures for flying FMS-based non-ILS/GLS approaches.

Note: *If conducting a VOR or NDB final approach segment substitution, comply with the RNAV (GPS) procedures. For specific requirements, see FOM>Navigation>General Approach Procedures>Nonprecision Approach>RNAV Substitution (AC 90-108)>VOR and NDB Final Approach Segment Substitution (OpSpec C085).*

Note: *For RNAV (PRM) approaches, see Normals>PRM Approaches.*

REQUIRED NAVIGATION PERFORMANCE

Note: *ICAO recently introduced approaches titled RNP and RNP (AR). An RNP approach is equivalent to an RNAV (GPS) or RNAV (GNSS) approach.*

An RNP (AR) approach is equivalent to an RNAV (RNP) approach. These terms may be used interchangeably in the Flight Manual.

RNAV (GPS) Approaches *RNP is 0.30.*

RNAV (RNP) Approaches *Use charted RNP minimums.*

AUTOPILOT USE

Autopilot use is required if the weather is less than 1000/3.

RNAV (RNP) Approaches *Use of the autopilot is mandatory from IAF to DA regardless of reported weather conditions, except:*

- *The autopilot may be disconnected once the runway is in sight and can be kept in sight throughout the approach and landing. Autopilot should be used while on an RF leg. Fly the published lateral and vertical path.*

- When conducting an RNAV (RNP) approach to parallel runways, the autopilot may be disconnected once the runway is in sight and the aircraft is aligned with the runway centerline.

LATERAL MODE

LNAV must be used.

VERTICAL MODE

RNAV (GPS) VNAV is the preferred vertical mode. If VNAV is unavailable, plan to use V/S.

RNAV (RNP) VNAV must be the vertical mode.

When conducting an RNAV (RNP) approach, VNAV PTH must be annunciated on the FMA by the FAP.

RNAV (GPS/GNSS) AND RNAV (RNP) APPROACH PROCEDURES

- [PF, PM] FMC. Verify/set
Verify the FMC is correctly programmed. Line select the approach and verify all waypoint and altitude constraints on the LEGS page match the approach chart. Altitude constraints must be in large font.
- Ensure GPS is updating prior to IAF (FMC NAV STATUS page 1). There is no requirement to monitor the FMC update source, only to monitor appropriate FMC messages listed below.
- ANP must be less than or equal to RNP.
- RNAV (GPS): Manually set RNP 0.30.
- RNAV (RNP): Manually set RNP per approach plate.
- One pilot displays PROG page 4/4 to verify ANP/RNP/XTK ERROR.

Other pages may be momentarily displayed for situational awareness.

- [PF, PM] Radios Verify/set
Raw data not required. It is recommended that 108.00 be tuned in order to avoid false navigational guidance.

Inhibit all VOR and DME updating from NAV OPTIONS page 2 prior to initial approach fix.

- [PF, PM] EFIS control panel Set

Both pilots display MAP mode. At least one pilot in 10 NM scale or less, no later than the FAF/FAP/GP Intcpt.

- [PF, PM] Altimeter setting and tolerance Verify Local altimeter required for RNAV (RNP) approach. Prior to reaching the FAF/FAP, crosscheck the Captain's and First Officer's altimeters to ensure a difference of 100 feet or less. If there is greater than a 100-foot difference between the primary altimeters, RNAV (RNP) approaches are not authorized.

WARNING: *The lowest altitude that may be set in the MCP is the FAF/FAP/GP Intcpt altitude until the requirements listed in Approach>Approach Procedure are complied with.*

WARNING: *Do not change vertical mode from VNAV without resetting MCP altitude to the next altitude constraint.*

Note: Do not request or accept a vector:

- Direct to any waypoint beginning or within an RF leg.
- To intercept a leg preceding an RF leg.
- Direct to the FAF/FAP/GP Intcpt.
- [PF] Autopilot As required
- [Auto] "2500" Announce
- [PF, PM] "___ in/hPa" Announce

After cleared for the approach:

- [PF/PM] LNAV Engage/arm
Monitor PROG page 4/4 for XTK ERROR inside the IAF.
- [PF] "Set ___" (altitude) Announce
- [PM] MCP altitude Set
- [PF/PM] Vertical mode Engage/arm
Track progress along the final approach vertical path and ensure compliance with any charted step down altitude restrictions.

In the event VNAV is not available, plan to use vertical speed.

For RNAV (RNP) approaches, VNAV is required and the use of V/S is not authorized. Monitor PROG page 4/4 for the VERT DEV error inside the FAF.

If the deviation approaches the limit, an immediate correction back to path is needed. Monitor the vertical NPS (as installed) inside the FAF/FAP/GP Intcpt. If the deviation approaches the limit, an immediate correction back to path is needed. VERT DEV error is not to exceed 75 feet inside the FAF/FAP/GP Intcpt. If

the deviation exceeds the limit, an NPS amber vertical deviation alert occurs. VTK is not to exceed 75 feet from the VNAV path deviation indication on the map display inside the FAF/FAP/GP Intcpt.

CAUTION: *There may be some RNAV (RNP) procedures with RF legs that have speed restrictions depicted on the approach plate. These speed restrictions must not be exceeded. Failure to adhere to these restrictions places the aircraft outside of the obstacle evaluation area for that approach. Plan deceleration to comply with charted speed restrictions.*

- [PF/PM] MCP speed Set, as installed
RNAV (RNP): Do not exceed speed restrictions on RF legs, whether charted or as found in FOM>Navigation>General Approach Procedures>Nonprecision Approach>RNAV Approach>Radius-to-Fix (RF) Legs.

Speed intervention (as installed) may be used at the crew's discretion outside the FAF to comply with operational constraints. Inside the FAF fix, the speed window should be closed unless operationally necessary to use MCP speed instead of FMC speed.

- [PM] FMA Confirm
- [PF] Set TDZE Announce
- [PM] MCP altitude Set TDZE
Set MCP altitude to TDZE (rounded up to nearest 100 feet) when established on a published segment with VNAV as the active pitch mode.

By 1500 feet or the FAF/FAP/GP Intcpt, whichever occurs later:

- [PF] Gear down Announce
- [PM] Landing gear lever Down

By 1000 feet RA:

- [PF/PM] Speed brake. Arm
The Captain normally arms the speed brake.

- [PF] Flaps ____, Landing Checklist Announce
- [PM] Flaps Set
- [PM] Landing Checklist Accomplish
- [PF] Target speed. Set, when appropriate

At 1000 feet RA:

- [Auto] "1000" Announce
- [PF] "Set missed approach altitude. Cleared to land." Or
"Set missed approach altitude. No landing clearance." Announce

- [PM] Missed approach altitude. Set
At 500 feet RA:

- [Auto] "500" Announce
 - [PF] "Stable" or "Unstable, going around" Announce
- If required, the PM directs a go-around and the PF must execute the go-around.
See FOM>Navigation>Common Approach Procedures.

At 100 feet above minimums:

- [Auto] "Approaching minimums" Announce
- At minimums:**
- [Auto] "Minimums" Announce.
- If the runway environment is in sight and continuing the approach:**

- [PF] "Landing" Announce
- At minimums, the "Landing" callout implies that the PF has sufficient visual references to proceed to landing.
- [PF] Autopilot Off
- Disconnect the autopilot no later than required by aircraft limitations.

WARNING: If a missed approach is initiated prior to the missed approach point, follow the published approach track until reaching the missed approach point, then comply with the missed approach procedure. Level off at or initiate climb to missed approach altitude.

WARNING: If a missed approach is executed when flying an RF leg, fly the depicted curved track, even if disengagement of the autopilot and manual control is required. This may also include disregarding the flight director if LNAV is not the engaged lateral mode.
If the runway environment is not in sight or the approach cannot be continued:

- [PF] Missed approach/go-around. Execute
- Fly the missed approach procedure for the instrument approach just flown unless otherwise specified by ATC.

RNAV (GPS/GNSS) AND RNAV (RNP) APPROACHES CONSIDERATIONS

For additional requirements regarding RNAV (GPS/GNSS) and RNAV (RNP), see FOM>Navigation>General Approach Procedures>RNAV Approach.

APPROACH CONSTRUCTION

For RNAV (GPS/GNSS) and RNAV (RNP) procedures, the approach must be line-selectable in the FMC database. No lateral or vertical modifications or waypoint additions/deletions from the FAF to the missed approach point are allowed except as follows:

- *Altitude modifications other than cold temperature corrections are not authorized. At or above altitudes up to and including the FAF may be set as hard altitudes if desired. For cold temperature altitude corrections, see FOM>Navigation>Altimetry.*
- *Speed modifications outside the FAF/FAP/GP Intcpt are allowed as long as the maximum published speed is not exceeded.*
- *If any inadvertent modifications occur, the entire approach must be reselected.*
- *If an additional waypoint reference is desired, consider using the FIX page.*

TRANSITION TO VISUAL CONDITIONS

*Descent path created by the FMC may not coincide with VASI/PAPI.
The flight director continues to provide guidance with reference to VNAV PTH.
The guidance provided by the VASI/PAPI and other visual cues takes precedence over flight director guidance below minimums.*

MANDATORY MISSED APPROACH

Unless able to continue visually and land, execute a missed approach for the following:

- *Inside the IAF, the nose of the aircraft symbol no longer touches the active course line using the 10-mile scale or XTK ERROR exceeds RNP (PROG 4/4).*
- *An NPS amber deviation alert, a NAV UNABLE RNP message, or a VERIFY POSITION FMC scratchpad message. VTK ERROR outside of the FAF does not apply. In the event of a missed approach, continue to make corrections back to and maintain the required course.*
- *VERT DEV exceeds 75 feet above or below the path inside the FAF/FAP/GP Intcpt (PROG 4/4).*
- *UNABLE REQD NAV PERF - RNP, FMC DISAGREE, or any VERIFY POSITION alert message inside the IAF.*
- *Inside the FAF/FAP/GP Intcpt and the FMA does not display VNAV PTH.*
- *RNAV (RNP): PROG (4) XTK ERROR exceeds RNP.*

10.3 FMC Fail

The United 737 MAX Quick Reference Handbook, dated 20 May 2022, section 110 “Flight Management, Navigation” provided the following guidance for an FMC failure:

FMC FAIL**FMC
P/RST**

Condition: Display of VTK followed by MAP failure flags on one or both navigation displays.

Objective: To restore dual FMC operation, configure for single FMC operation or resume conventional navigation.

Note: *LNAV/VNAV may disengage.*

- 1 Check both navigation display MAP modes and FMC CDUs.
- 2 Choose one:
 - ◆ No FMC data on the Captain's *and* First Officer's navigation display MAP modes and no FMC data on both CDUs:
Both FMCs are failed.
▶▶ Go to step 7
 - ◆ No FMC data on the Captain's navigation display MAP mode and no FMC data on both CDUs:
Left FMC is failed.
▶▶ Go to step 3
 - ◆ No FMC data on the First Officer's navigation display MAP mode, MSG light is illuminated and SINGLE FMC OPERATION scratchpad message is shown:
Right FMC is failed.
▶▶ Go to step 3
- 3 FMC source select switch BOTH ON L or BOTH ON R
Select the operating FMC.
- 4 Wait 1 minute.
- 5 Check for FMC-L and FMC-R bearing/distance information on POS SHIFT page 3/3.
- 6 Choose one:
 - ◆ Bearing/distance information for *both* FMCs is displayed:
FMC source select switch NORMAL

■ ■ ■ ■
 - ◆ Bearing/distance information for only a single FMC is displayed:
Continue with single FMC operation.

■ ■ ■ ■

▼ Continued on next page ▼

▼ FMC FAIL continued ▼

- 7 Resume conventional navigation. Without an operating FMC, LNAV and VNAV are not available.
- 8 Verify position relative to terrain using conventional navigation.
Note: GPWS may use inaccurate GPS position data or an inappropriate value of RNP. This could result in a VSD terrain display (if installed) that is incorrectly positioned relative to the aircraft track.
- 9 When preparing for the approach:
 - (MAX) Use the N1/SPD REF SET page to set the current gross weight.
 - (MAX) Use the N1/SPD REF SET page to set the reference airspeed bugs.
 - (MAX) Use the N1/SPD REF SET page to set the N1 bugs.



Figure 12. FMC Fail Checklist (Source: UAL B737 MAX QRH)

11.0 NASA ASRS Reports

In a review of NASA ASRS data reports beginning July 2012 until the date of the incidents, revealed that there were 21 reports of FMC blanking and of those reports 8 were in a B737 aircraft. One of the reports mentioned an FMC failure (ACN: 1697152) that “*was unable to reset inflight;*” however, after landing the FMC “returned to normal values.”

A review of NASA ASRS data report beginning July 2012 until the date of the incident, revealed that there were at least 19 reports of flight crews lining up with the wrong runway. Of those reports 15 of those were operated under CFR Part 121 and 5 reports indicated ATC either issued a go-around or cleared the flight to land on the misaligned runway. Of the 19 reports the lowest altitude the crew noted before conducting a go-around was 300 feet (ACN: 1324379). However, several reports indicated that the crew became aware of the incorrect runway after landing.

D. LIST OF ATTACHMENTS

- Attachment 1 - Flight Crew Interview Summaries and Statements
- Attachment 2 - Incident Flight Discrepancy Details
- Attachment 3 - Incident Flight Release
- Attachment 4 - Incident Flight NOTAMs and Weather Packet
- Attachment 5 - Incident Flight Performance Landing Data
- Attachment 6 - United 737 Flight Manual [Excerpts]
- Attachment 7 - United 737 MAX Quick Reference Handbook [Excerpt]
- Attachment 8 - NASA ASRS Database Query Results
- Attachment 9 - ATC Mandatory Occurrence Report

Attachment 10 - Pittsburgh NOTAMs Archived
Attachment 11 - United Pilot Bulletin 22-154
Attachment 12 - Operational Factors Group Party Forms

Submitted by:

Shawn Etcher
Operational Factors Investigator