Air Canada

Submission

to the

National Transportation Safety Board

in the Investigation of the

Overflight of a Taxiway at San Francisco International Airport

on July 7, 2017

NTSB Investigation Number: DCA17IA148

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1. Introduction

Air Canada offers this submission to the National Transportation Safety Board (NTSB) to support the proposed findings, recommendations, and probable cause statement herein.

On July 7, 2017, Air Canada flight 0759 (ACA759), an Airbus A-320, registration C-FKCK, was a regularly scheduled flight from Toronto's Lester B. Pearson International Airport, Ontario, to San-Francisco International Airport, California (CYYZ-KSFO), with 135 passengers and 5 crewmembers onboard. The flight crew were qualified and current for the operation; the Captain was the Pilot Flying (PF) and the First Officer (FO) was the Pilot Monitoring (PM). The landing runway that night at SFO was 28R and Night Visual Meteorological Conditions (VMC) prevailed at the time of the incident.

Arriving in the SFO terminal area, Air Traffic Control (ATC) gave the ACA759 flight crew speed restrictions and numerous vectors due to traffic. They were advised to inform ATC when they had both the runway and "bridges" in sight. Once the crew advised ATC they had the bridges and the runway in sight, they were cleared for the FMS Bridge Visual RWY 28R (Attachments 8.1 & 8.2). The crew flew the FMS Visual Profile until just prior to the final waypoint on the approach, labeled as F101D, at which point the Captain disconnected the autopilot and hand flew the remainder of the approach as was permitted under the Standard Operating Procedures (SOPs).

ACA759 was on an approximate 0.6 mile final when the PM asked the lone, combined local control/controller-in-charge (LC/CIC) in the KSFO tower to verify that they were still cleared to land on Runway 28R as the crew were seeing lights. Several seconds later, the LC/CIC controller responded in the affirmative and re-cleared ACA759 to land on Runway 28R. Based on the LC/CIC controller's delay in responding to the flight crew, it appears he had lost situational awareness of ACA759's position; and he did not offer any additional guidance about the runway 28L closure or construction lighting. In addition, the airport had not conducted any analysis of the adequacy of lighting to be used during the runway 28L construction.

At this point, ACA759 was inadvertently and unknowingly lined-up on parallel Taxiway C, which had four airplanes on it awaiting takeoff clearance (a B787 first in line followed by an A340, B787, and B737). The flight descended below 100 feet Above Ground Level (AGL) before the crew sensed something was wrong and initiated a go-around. As is normal during a go-around, the flight path continued to descend for several seconds while the engines accelerated to go-around thrust. Consequently, ACA759 overflew the first aircraft (B787) after the go-around was initiated but before a positive climb was underway, and the second aircraft (A340) on the taxiway was also overflown. The go-around was properly executed and the remainder of the flight was uneventful. The aircraft landed on July 8, 2017, at 0017 Pacific Daylight Time (PDT) (0317 Eastern Daylight Time (EDT)).

This was not an isolated incident at KSFO as shown by past NTSB investigations. The Federal Aviation Administration (FAA) may wish to conduct a study to determine whether KSFO is disproportionally represented in these areas. Such a study should

include assessment of information available to the FAA as a Commercial Aviation Safety Team (CAST) member from the Aviation Safety Information Analysis and Sharing (ASIAS) system managed by the MITRE Corporation.

2. Background

2.1. Air Canada

Air Canada is Canada's largest airline and the largest provider of scheduled passenger services in the Canadian market, the Canada-U.S. trans-border market, and in the international market to and from Canada. In 2017, Air Canada together with its Air Canada Express regional partners carried over 48 million passengers, offering direct passenger service to more than 200 destinations on six continents. It operates a fleet of more than 390 aircraft manufactured by Boeing, Airbus, Embraer, and Bombardier.

Safety is the paramount value of Air Canada. At all levels and throughout the company, safety is the primary consideration in decision-making, and is an ethical and operational imperative for everyone. Further, Air Canada benefits from a healthy reporting culture, one that aims to differentiate between intentional and unintentional deviations and determine the best course of action for both our organization as a whole and the individuals directly involved. Air Canada policies distinguish willful acts of misconduct from inadvertent errors, and, when appropriate, provide for non-punitive responses, which are essential to assure the effective reporting of systemic safety deficiencies.

The effectiveness of our safety culture is measured and monitored through the use of tangible metrics. The Air Canada internal Organization Safety Culture Assessment, indicates that personnel believe that they will be supported in any decisions made in the interest of safety and also understand that intentional breaches of safety policy will not be tolerated. Air Canada recognizes that the greatest impact for the creation and maintenance of an effective, self-sustaining culture for the management of safety is at the organizational level. Therefore, Air Canada exerts considerable effort to monitor elements that have the potential to affect interactions between senior and junior group members and reactions of personnel under demanding operational conditions.

Air Canada operates as a foreign air carrier in the United States under 14 *Code of Federal Regulations* (CFR) Part 129.

3. Factual Summary

3.1. Flight Details

On July 7, 2017, Air Canada flight ACA759, registration C-FKCK, was a regularly scheduled flight from Toronto's Lester B. Pearson International Airport, Ontario, to San Francisco International Airport, California (CYYZ-KSFO), with 135 passengers and 5 crewmembers onboard. The flight crew were experienced, qualified and current for the operation. The Captain was the Pilot Flying (PF) with over 20,000

hours (7,063 hrs on Type, of which 4,797 hrs are as Pilot In Command) and the First Officer (FO) was the Pilot Monitoring (PM) with over 10,000 hours (2,343 hrs on Type). The landing runway that night at KSFO was 28R; Night Visual Meteorological Conditions prevailed at the time of the incident.

KSFO airport (see Attachment 8.3) is a designated Group II FAA Special PIC Qualification airport and has closely spaced parallels runways (750 feet between centerline) designated as 10L/28R. 10R/28L, 1R/19L, 1L/19R. At the time of the incident, runway 1R/19L and 10R/28L were NOTAM closed for construction at 2300 PDT (0600z), and the runway and approach lights for those runways were not illuminated. There were, however, construction lights on the left of runway 28R. Runway 28R was equipped with centerline lights, touchdown zone lights, and an approach lighting system with centerline sequenced flashers (the sequence flashers were off) (ALSF2, Figure 1). Runway 28R was also equipped with a 4-light precision approach path indicator located on the left side of the runway with a 3.00-degree glide path. Taxiway C does not have blue edge lights but is equipped with green centerline lights per 14 CFR § 139.311.

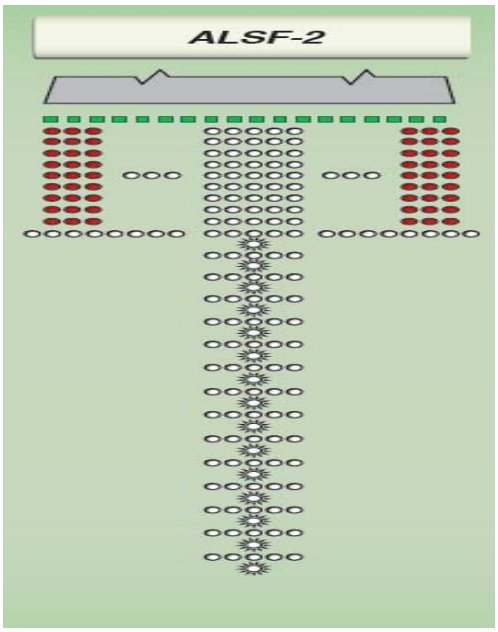


Figure 1: ALSF2

The CA of ACA759 held a Reserve Block for the month of July 2017. The 72-hour history from the event on July 7, back through Wednesday, July 5, was reviewed. The Captain had a day off on Wednesday, and he awoke around 0800 EDT. On Thursday, July 6, he reported on duty between 1600 and 1700 and flew a round-trip to La Guardia (LGA), following which he went off duty about 2313 EDT and reported retiring to bed about 0000 EDT. On Friday, July 7, he fell asleep between 0200 and 0300 and awoke around 0745. About 1120, crew scheduling called to notify him that he had been assigned a flight. He did not take any naps that day and reported to the airport by 1940 for the flight. This flight, the incident flight, departed at 2125 EDT and the CA considered himself rested for the flight.

ACA759 FO was a block holder for the month of July. The 72-hour history from the event on the July 7, back to Wednesday, July 5, was reviewed. On Wednesday, the FO awoke about 0800 and later took a nap in the afternoon for about 90 minutes. He then flew a flight to SFO that night. On Thursday, July 6, he arrived in SFO and went to sleep about 0400 EDT and woke up about 1000 EDT. He later took a one-hour nap and then flew back to CYYZ that night, with the flight arriving in Toronto on Friday, July 7, at 0030 EDT. The FO went to bed about 0300 EDT and awoke about 0900. He later took a 90-minute nap about 1300. He woke up from the nap, spent time with his kids, had dinner and went back to work arriving at 1910 for a 1940 report time; the FO considered himself rested for the flight. The crew advised that both CA and FO were beginning to feel very tired about 0200-0300 EDT on Saturday, July 8, during the last hour or so of the ACA759 incident flight.

The FO retrieved the ACA759 flight plan, Release 1 with his iPad, while at his residence, before leaving for the airport. Once at the airport, Dispatch notified the FO that there was a new version, Release 2, due to an increase in the zero-fuel weight. The FO downloaded the new release via his iPad and printed the first few pages of the flight plan, without NOTAMs, from the briefing room. The crew met at the Gate and noted that the inbound flight was delayed due to weather at CYYZ; this meant the departure of ACA759 would be equally delayed. The Captain briefed the in-charge flight attendant prior to boarding the aircraft. Once onboard, the ACA759 flight crew prepared for departure, briefed the weather expected enroute and reviewed their dispatch paperwork, which included NOTAMs for KSFO. The investigation was unable to verify whether the crew were aware prior to departure from CYYZ of the NOTAM concerning the closure of 28L.

ACA759 had an original scheduled departure time of 2055 EDT and an original arrival time of 2303 PDT (0203 EDT) (0603z); however, the flight departed 30 minutes late. The pushback from the gate, taxi out, and departure were normal. There was some weather around Toronto and through Michigan, and then the flight was uneventful until around the United States Midwest. The weather issue concerned a large line of thunderstorms with some of the thunderstorms embedded in clouds. The crew navigated via a large gap in the line of weather, which they tracked on their weather radar. As they tracked through the area, the crew estimated the gap was about 30 nautical miles wide and had started to close up as they penetrated the line. The cloud tops were estimated at 41,000 feet and higher.

Once they were past the line of thunderstorms, but prior to Top Of Descent (TOD) and the arrival into the KSFO area, the FO (PM) obtained ATIS information “Quebec” via the airplane’s ACARS and printed out the information. This data was incorporated into the flight crew’s arrival briefing as they discussed the weather information and the reported runway in use. The crew anticipated landing to the west and briefed for the FMS Bridge Visual Approach to runway 28R.

The CA (PF) / FO (PM) advised that they conducted the approach and threat briefing, which included briefing the Air Canada Jeppesen pages 19-3-1 and 19-3-1A, FMS BRIDGE VISUAL RWY 28R (Attachments 8.1 & 8.2), minimum weather requirements, an anticipated taxi route to the gate after landing, and the missed approach

procedures. The crew did not tune the Instrument Landing System (ILS) 28R, which is advised by the Jeppesen 19-3-1A page applicable at that time, though this tuning is done manually and is not a normal procedure for FMS visual approaches. They chose to fly the visual approach. The crew was issued the DYMND 3 arrival (Attachment 8.4) and was cleared to descend via that arrival. Subsequently, the flight was instructed to switch to and contact, Northern California (NORCAL) approach, which it did.

Once ACA759 contacted NORCAL, they were vectored off the arrival by the controller who informed them that it was for spacing (Figure 2). NORCAL also assigned them speed restrictions. Their airspeed was reduced to the point where they had to extend the flaps to the flaps 1 setting. The flight crew anticipated being placed back on the arrival; however, the controller continued to vector them instead. The controller then directed the flight to descend and subsequently cleared ACA759 for the FMS Bridge Visual to runway 28R. As advised by ATC, the crew then visually acquired the preceding aircraft, Delta flight 521, a B737.

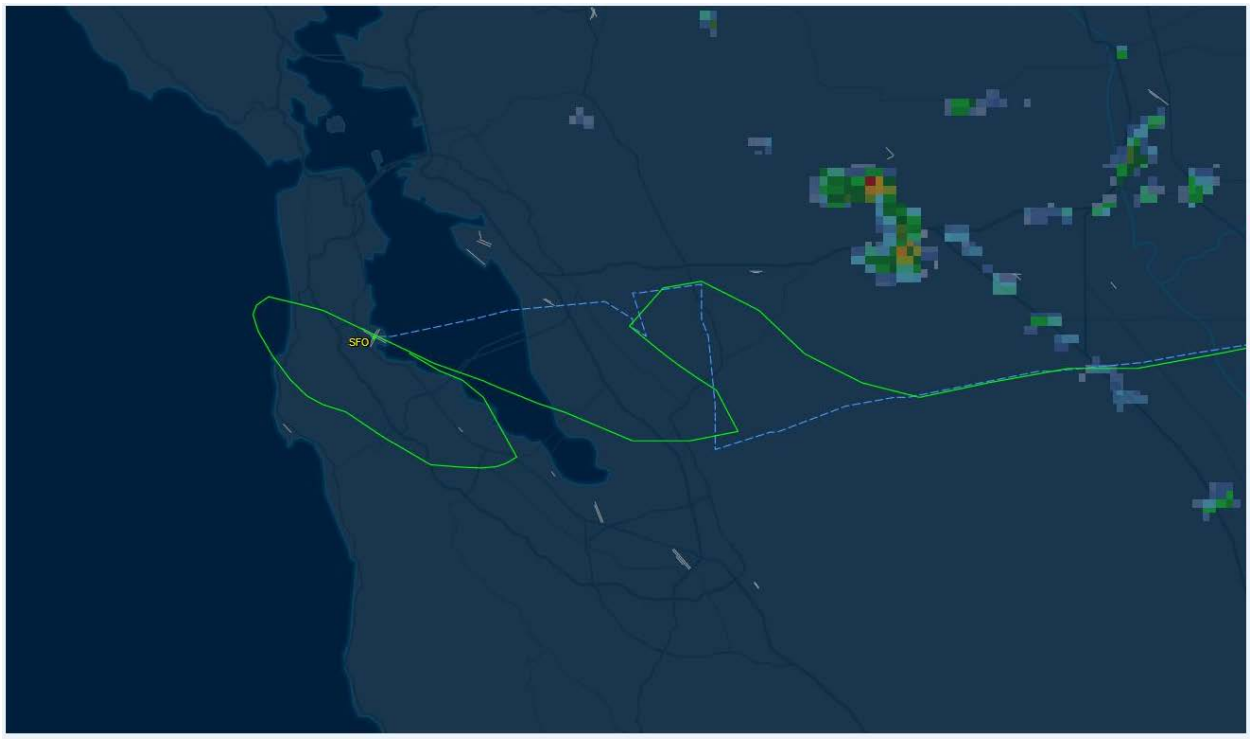


Figure 2: Actual (Green Line) ACA759 Track to KSFO

The beginning of the approach was managed with the autopilot engaged. The controller asked ACA759 to confirm that they had the traffic, Delta flight 521, a B-737, in front of them and if the bridges were in sight. The PM asked the PF if he had these contacts, which he confirmed, and the PM subsequently advised the controller that both the Delta B-737 and bridges were in sight. The flight was then cleared for the BRIDGE VISUAL RWY 28R approach and was instructed to contact the KSFO Air Traffic Control Tower (ATCT).

As the aircraft was on the approach at the "JANYY" waypoint, the Autopilot & Auto Thrust (AP/AT) were engaged in "DES & NAV" mode with flaps 2. The gear was then selected down between "JANNY & SAMUL." At "SAMUL" the aircraft was level at 1500' and the FMS ordered a turn towards 267° per the chart (Figure 3). As the aircraft started to turn towards 267° and around the San Mateo bridge, the autopilot was disengaged and Visual Approach SOP was followed (as directed by Jeppesen 19-3-1A); the aircraft heading reached 273°. The flight director was removed and full flap were selected at 5.2 nautical miles (nm) from SFO VOR. At the final approach fix, F101D, the aircraft heading was 281° with gear down, flaps full and AT engaged. At this point, the crew were visual and following the Visual Approach SOP (AOM 1.04.11.40). In fact, ACA759 was lined-up on the second set of lights to the right, which was Taxiway C. The distance between the centerline of Taxiway C and 28R is approximately 490 ft.

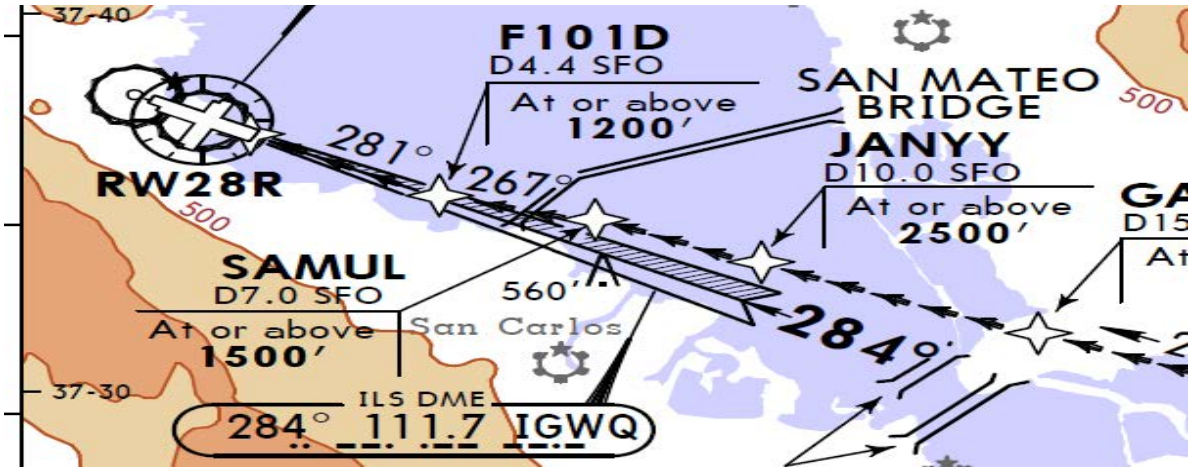


Figure 3: Approach Heading & Altitude

During the final stage of the approach, the PM was busy monitoring the different constraint altitudes, and at the FAF, he selected the missed approach altitude and heading based on the charts. The PM during this phase of flight concentrated more inside the cockpit for cross reference than outside, to ensure the aircraft maintained the stable approach criteria.

After the FAF, the PF noticed lights on the perceived runway and advised the PM to contact ATC to confirm that they were "cleared to land." The frequency was busy with radio communications, forcing the PM to wait a short time until there was a break in radio transmissions before he could inquire about the runway being clear.

The NTSB advised that normal ATC staffing for the KSFO tower midnight shift included two controllers. On the evening of the incident, one controller was in the tower cab. At 2349[1] PDT (7 minutes before the incident), all positions in the KSFO tower (controller-in-charge, local control, local control assist, ground control, flight data, and clearance delivery) were combined at the local control position. Thereafter, the

[1] NTSB timing.

controller operated as a combined LC/CIC controller, and was the sole occupant on duty in the tower.

At 2355:46[2] PDT, when ACA759 was about 0.7 mile from the landing threshold and about 300 feet AGL, the flight crew contacted KSFO tower, mentioned seeing lights on the runway, and requested confirmation that the flight was cleared to land. "ACA759: Just want to confirm this is Air Canada seven five nine we see some lights on the runway there across the runway. Can you confirm we're cleared to land?"

Seven (7) seconds later at 2355:52[3] PDT, when ACA759 was about 0.3 mile from the landing threshold, the combined LC/CIC controller confirmed and re-cleared ACA759 to land on runway 28R. "Tower: Air Canada seven five nine confirmed cleared to land runway two eight right. There's no one on runway two eight right but you." ACA759 acknowledged the clearance; they were approximately 800 feet from the seawall. The LC/CIC controller was unaware of ACA759's position relative to Taxiway C and did not provide the ACA759 flight crew any information about the ongoing construction on runway 28L, the construction lighting, or changes to airport lighting due to the construction.

Once the confirmation was received from ATC that they were cleared to land, the PM was looking outside at the perceived runway environment (Taxiway C) and perceived something was not right visually, but the PM was unsure/unable to identify what was erroneous.

Delta flight 521 landed a few minutes prior to ACA759. When the Delta crew heard the request from ACA759 they believed that ACA759 were suffering from the same illusion they had just experienced. The Delta crew stated that "the construction lights were so bright they could not determine the location of the inboard runway, 28L." Visually acquiring the runway, both Delta 521 crewmembers reported questioning if they were lined up for runway 28R; however, after crosschecking with their LNAV and the HUD, they were able to determine they were lined-up for runway 28R. They received additional confirmation about 300 feet AGL when the Delta captain visually acquired the painted "28R" on the paved surface of the runway. The captain of Delta 521 further reported that the aircraft on Taxiway C were stopped and had their taxi lights off, which "helped to create this misconception that Taxiway C was RWY 28R."[4]

United 1 (a B787, the first aircraft holding on Taxiway C) made two radio transmissions concerning ACA759, first at 2355:59 and then at 2356:02.[5] Neither flight crewmember of ACA759 had any recollection of either of these two radio transmissions. Once the PM realized that something was wrong, he twice ordered a "go-around." As this was happening, the PF applied Take-Off Go-Around (TOGA) thrust simultaneously to initiate the go-around manoeuver at 2356:06.5. The

[2] NTSB timing.
[3] NTSB statement: "This time was an estimate. There was no ATC transcript developed for this event; however, the beginning of the statement occurred approximately 7 seconds after the beginning of the previous statement."
[4] NTSB information.
[5] ATC Factual Report at 6.

initiation of the go-around occurred as the flight was crossing the Taxiway C seawall and at 85 feet AGL (Figure 4). The lowest altitude during the go-around was recorded as 60 feet AGL which occurred approximately two seconds after initiation of the go-around. Given the ground track, ACA759 overflew some of the aircraft on the taxiway during the go-around maneuver. The crew of ACA759 believed that they were between 300-400 feet Mean Sea Level (MSL) when they initiated the go-around.

The PF initiated the go-around with an initial pitch command of 19.5° with a resultant 1.6g vertical acceleration, as the aircraft is climbing at 2100 feet per minute and passing the second aircraft (PAL 115) on the taxiway. At 2356:09,[6] three seconds after ACA759 had initiated the go-around, ATC directed ACA759 to go-around. ACA759 carried out the missed approach procedure cleared by ATC. On the downwind leg of the missed approach, the crew tuned in the ILS for runway 28R and landed without any complication.

Figure 4: Approximate position of ACA759 during Go-Around.

3.2. Event Notification and the Cockpit Voice Recorder (CVR)

After landing and parking at the gate, ACA759 requested the control tower phone number from Ground Control so they could report the event. They then contacted ATC and debriefed the event. They provided limited or basic contact information because the controller was busy. Following this call, the Captain debriefed the Flight Attendants of the go-around event, but did not discuss the reason for the go-around. The crew left the airport and arrived at the hotel at approximately 0130 PDT (0430 EDT), after which the CA called ATC and gave a deeper debrief (license number, name etc.). Following this call, the Captain retired to bed. The next morning, the CA and

[6] *See* Air Traffic Control Group Chairman's Factual Report 6 (March 6, 2018); Operational Factors/Human Performance Group Chairman's Factual Report 9 (January 3, 2018).

FO met and discussed the event and filed a voluntary Air Safety Report (ASR) using the company electronic safety system on the iPad. The ASR was prepared and filed, though due to an iPad synchronization issue, was not submitted, but instead, remained on the iPad.

Later on Saturday, July 8, the FAA contacted the crew and advised that they were at approximately 100 feet AGL when they started the go-around. Following the call from the FAA, the CA called Dispatch and advised Dispatch of the go-around. The Dispatcher asked the nature of the go-around and the captain advised that they lined-up with what looks like Taxiway C. The actual height above ground was not disclosed. The Captain told the Duty Pilot that he lined up with the wrong environment, went around, and that it appears he had been lined up on Taxiway C. The Duty Pilot asked if the localizer was tuned and the Captain told him "the localizer was not tuned in on the first approach, but subsequently, on the second approach it was tuned in." The Duty Pilot said make sure to file an ASR. They then called ACPA, and got ready for their return flight, ACA 0750, back to CYYZ.

At 1600 EDT, July 8, the Duty Pilot advised the Airbus A-320 Chief Pilot of the go-around in SFO that morning. As discussed in Section 4.6, the go-around event, as understood by the crew, which had no information about its severity, was not immediately reportable under NTSB regulations. Meanwhile, the crew completed their preparations and left KSFO shortly thereafter, and flew ACA 0750, KSFO-CYYZ. Upon arrival into CYYZ, the crew were taken out of service for a safety investigation.

The FAA contacted the NTSB late on Saturday, July 8, 2017, or early Sunday, July 9, 2017. Once the NTSB was notified by the FAA, and after completing a review of the severity of the event, the NTSB formally decided to launch an investigation under its domestic authority and Annex 13 to the Convention on International Civil Aviation. The NTSB notified the Transportation Safety Board of Canada (TSBC) around 1800 EDT, Sunday July 9, 2017. The TSBC officially informed the Air Canada Corporate Safety Department of the Annex 13 investigation around 2205 EDT. Both Air Canada Corporate Safety and Flight Operations were unaware of the circumstances of the event. The call from the TSBC was the first such notice to the Air Canada Safety Department regarding the severity and nature of the event. Once so notified, the Cockpit Voice Recorder and Digital Flight Data Recorder (CVR & DFDR) were requested to be removed and quarantined for the safety investigation. Due to the delayed notice to Safety and subsequently to Air Canada Maintenance, the CVR had been overwritten.

3.3. Air Traffic Control (ATC)

The Front Line Manager (FLM)/Controller-in-Charge (CIC) are directed to supervise and direct overall Tower operations and take action to ensure efficient traffic flow. They are to ensure positions are staffed as traffic demands dictate, taking into consideration position assignments, position relief, training assignments and processing leave requests.

The night of the incident, the KSFO ATCT was staffed with two Controllers-in-Charge (CICs). About 2349, all the control positions and frequencies were consolidated and

operated from the LC position by one CIC. At the time of the incident one CIC was working in the tower cab, and the other CIC had left the tower cab and was on a break.

When ACA759 contacted NORCAL, NORCAL vectored them off the arrival and assigned them speed restrictions. (*See* Figure 2). NORCAL informed ACA759 that they were vectored off the arrival for spacing. The flight crew had anticipated being placed back on the arrival; however, the controller continued to vector them instead. The controller then directed the flight to descend and subsequently cleared ACA759 for the FMS Bridge Visual to runway 28R. As advised by ATC, the crew then visually acquired the preceding aircraft, Delta flight 521, a B737.

3.4. Airfield Lighting

Figure 5 depicts the construction lighting, consistent with lighting at KSFO on the night of the go-around event. The only evidence discovered during the investigation regarding any lighting assessment indicated a routine lighting inspection was performed on July 8, 2017, and no discrepancies were noted in the remarks column of the inspection form. There is no evidence that either the airport or FAA performed any analysis of the impact on arriving air crews' ability to discern the runway environment due to the combination of construction lighting, lighting outages, and existing lighting.

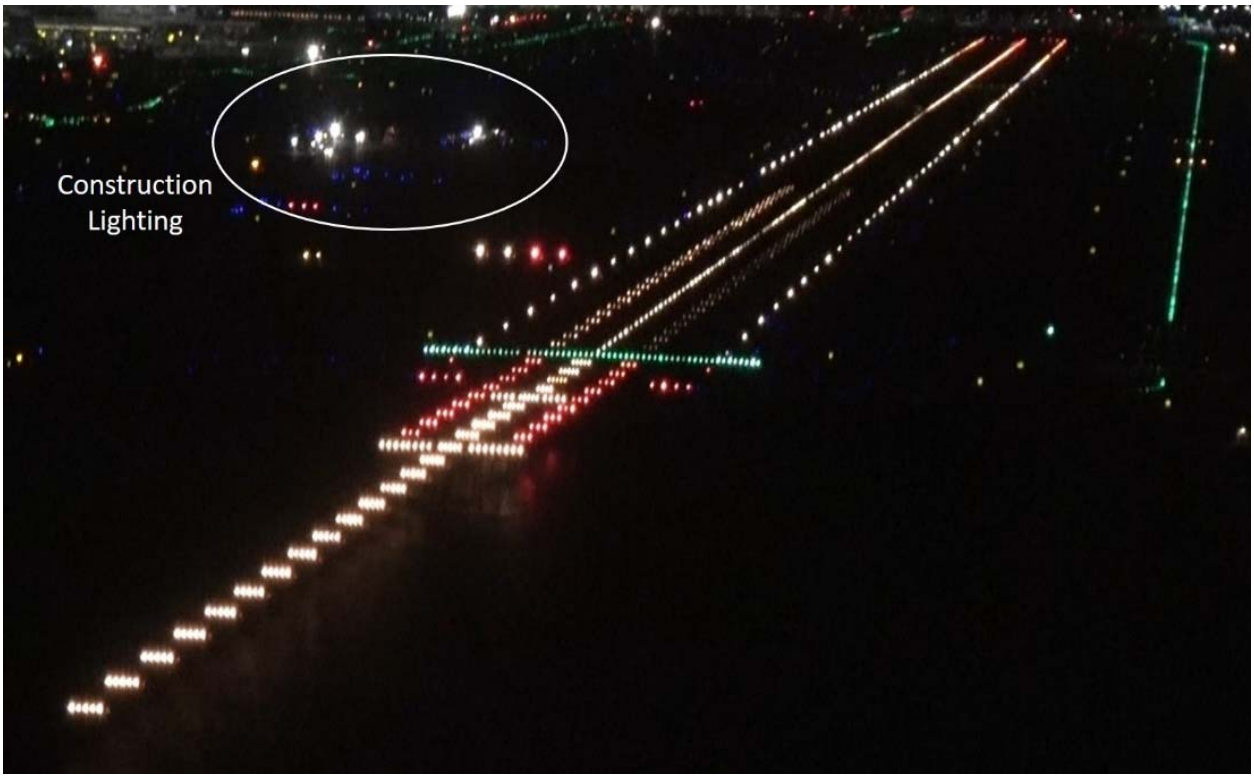


Figure 5: Construction Zone on runway 28L

3.5. ASDE-X / ASSC

SFO was equipped with the airport surface surveillance capability (ASSC) system, which is one of three airport surface detection equipment (ASDE) systems deployed in the national airspace system (NAS). The intended use of ASDE systems is to augment visual observation of aircraft landing or departing, and aircraft or vehicular movements on runways and taxiways, or other parts of the movement area.[7]

The SFO ATCT ASSC display presented aircraft and vehicle positions overlaid on a map of the airport's runways, taxiways and approach corridors. The ASSC display included a two-dimensional display of the extended runway centerlines, which extended out to about 2 1/2 nm.

4. Analysis

4.1. Flight Crew

Both crewmembers were qualified and current for the flight. A review of both crewmember's "ATLAS" files did not reveal any significant issues with either crewmember. The CA had an Operational Evaluation (OE) on March 7, 2017; the flights flown were CYYZ-KSFO-CYVR and met the required standards. The FO had an Operational Evaluation as an FO on the April 25, 2017; the flights flown were CYOW-CYYZ-CYYC-CYVR and met the required standards.

KSFO airport is a designated Group II FAA Special PIC Qualification airport for mountainous region and, as such, the requirement for crewmembers to operate in these airports, per Flight Operation Manual 5.4.5.2, demands, "Either the Pilot-in-Command or FO has operated into, and out of, that airport within the preceding 12 calendar months as an operating flight crewmember or the Pilot-in-Command has completed a thorough self-review of the airport facilities, approaches and procedures as found within the Jeppesen Route Manual including pictorial information provided on the Airport Familiarization pages." There is not a specific (simulator) training requirement for Group II facilities nor are any given at Air Canada. Both crewmembers had flown into KSFO in the preceding 12 months, and, therefore, both satisfied FAA and Company requirements for operating into KSFO. The company requirement that *either* the PIC or FO has operated into the airport was, thus, exceeded.

4.2. FMS Bridge Visual Approach RWY 28R

The Air Canada documentation Jeppesen AC 10-10 pages advise, "Pilots are cautioned that visuals to Rwy 28L may also be in progress along with the Quiet Bridge Approach." Jeppesen 19-3-1 advises, "Closely-spaced parallel visual approaches may be in progress to Rwy 28L utilizing ISFO ILS 28L localizer or RNAV 28L approaches." Jeppesen 19-3-1A advises, "The FMS Bridge Visual Approach is a visual approach procedure. Crews are responsible for traffic watch. ATC may amend the FMS

[7] *See* FAA order 7110.65W, Air Traffic Control, Section 6 Airport Surface Detection Procedures, ¶ 3-6-1, Equipment Usage.

procedure or impose additional restrictions during the approach." The Route Briefing Note (RBN) 4.3, page 111, advises that, "In addition to the above, and just to keep things interesting, San Francisco has a 'Fly Quiet Program' for late night and early morning arrivals and departures. Its purpose is to encourage individual airlines to operate as quietly as possible at SFO. The program promotes a participatory approach in complying with noise abatement procedures and objectives by grading an airline's performance and by making the scores available to the public via newsletters, publications, and public meetings." All of these notes/cautions put emphasis on the requirement for crews to stay to the right of 28L and not infringe on the adjacent approach airspace—the 750 feet between centerlines.

The FMS Bridge Visual approach is an approach designed to come in at an angle/offset to runway 28R, and at the beginning of the approach it is in line with Taxiway C (see Attachment 8.1). This procedure keeps the aircraft away from the approach to 28L and, for noise abatement, away from Foster City (Figure 6). Once runway 28L was closed for construction, there were no requirements to fly the non-precision approach FMS Bridge Visual except for the Fly Quiet Program at SFO, and as such, a precision ILS approach could have been issued. The FAA ATC, after the ACA759 event, commenced vectoring arriving aircraft to SFO ILS 28R approach until the construction was completed.

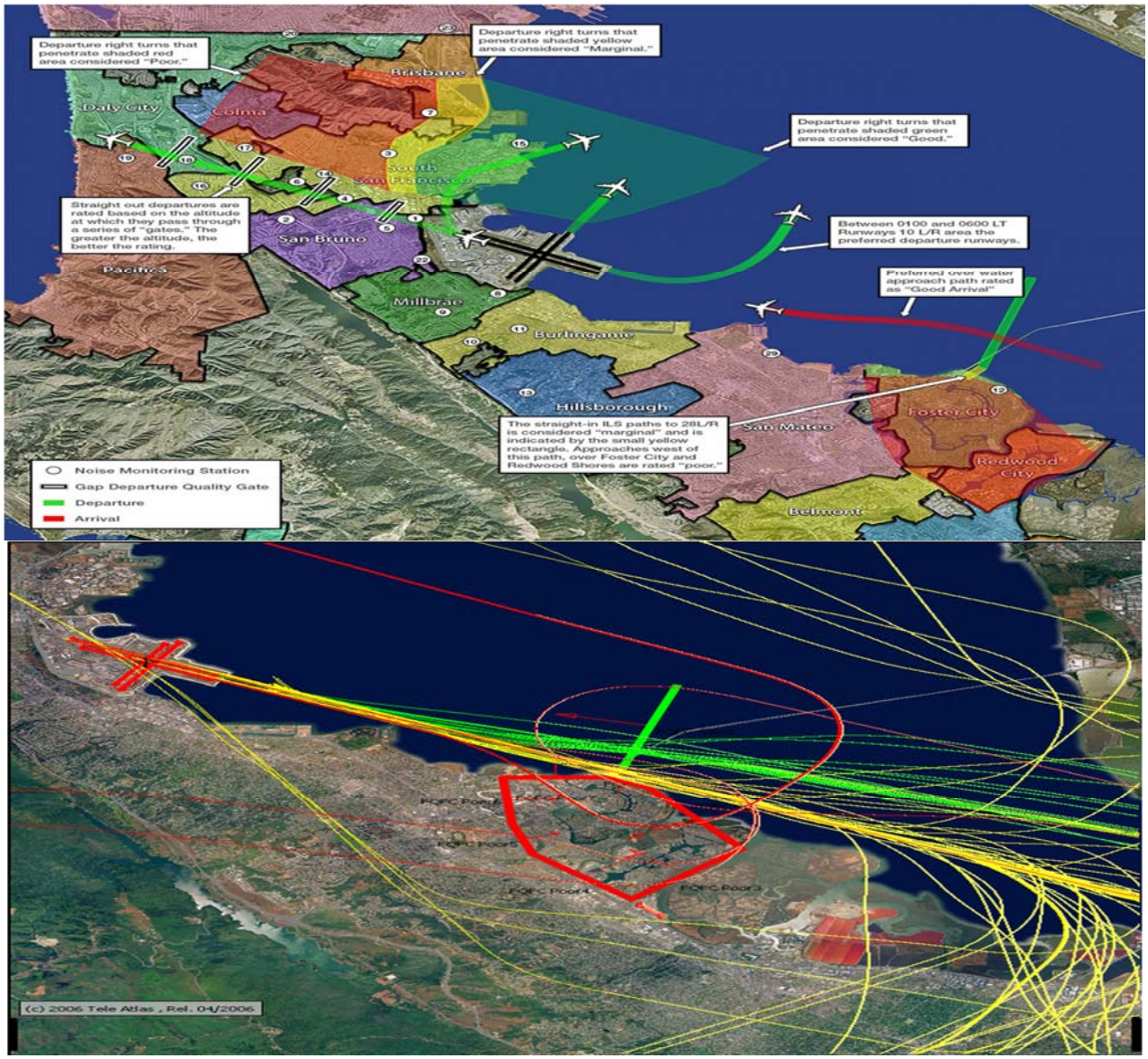
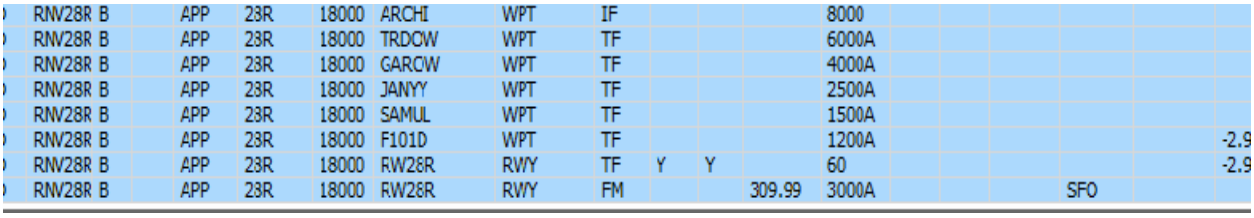


Figure 6: Foster City Arrival Quality Rating

The crew retrieved the 27-page flight plan package through their iPad. The FO, once he arrived at the airport, printed only the first few pages of the flight plan. Although there is an SOP for the crew to carry a flight plan, there was no SOPs regarding the format in which it needed to be carried. Some crews print the full package, some would print only the first few pages, and some would not print anything since the full package is on the iPad. ACA759's Notice To Airman (NOTAM) section of the flight plan was 9 pages, ranging from page 6 to page 15 of the flight plan, and the specific information relating to the runway 10R/28L closure was on page 8 of 27 pages. The crew did their pre-flight review of the flight plan at the gate prior to departure and neither crewmember could recall if they noticed the NOTAM for the Runway 10R/28L closure on page 8.

The ACA759 crew did not tune the ILS 28R per the FMS Bridge Visual Approach Jeppesen 19-3-1A (Attachment 8.2), which states that crews "tune the ILS for 28R." This is done manually and it is not a normal procedure for an FMS Visual Approach. A review of all visual approaches (KEWR, KLAS, KLGA, KPSP, MROC) was conducted and none requires crews to manually tune navigational aids (NAVAIDS). For the FMS Bridge Visual Approach, the ILS must be tuned manually because, unlike a precision approach (ILS), the coding in the FMS database for the FMS Bridge Visual Approach indicates that after the initial fix (IF), the waypoints are defined by Track-to-Fix (TF) legs, including the waypoint associated with the runway threshold (Figure 7). When coded as TF legs, no NAVAID frequencies are coded, which is normal. Only Course-to-Fix (CF) legs have NAVAIDS associated with them, and the NAVAIDs are automatically selected in the FMS when the approach is selected.



)	RNV28R	B	APP	23R	18000	ARCHI	WPT	IF				8000				
)	RNV28R	B	APP	23R	18000	TRDOW	WPT	TF				6000A				
)	RNV28R	B	APP	23R	18000	GARCW	WPT	TF				4000A				
)	RNV28R	B	APP	23R	18000	JANYY	WPT	TF				2500A				
)	RNV28R	B	APP	23R	18000	SAMUL	WPT	TF				1500A				
)	RNV28R	B	APP	23R	18000	F101D	WPT	TF				1200A				-2.9
)	RNV28R	B	APP	23R	18000	RW28R	RWY	TF	Y	Y		60				-2.9
)	RNV28R	B	APP	23R	18000	RW28R	RWY	FM			309.99	3000A			SFO	

Figure 7: FMS Bridge Visual Approach - Database Information

The purpose for manually tuning the ILS is to provide situational awareness during the approach. However, since the FMS Bridge Visual Approach is on a heading of 281° after the final approach fix, F101D, and the ILS 28R localizer is on a heading of 284°, the crew would expect to see the localizer scale indicating left of the centerline, which they were. Therefore, even though the crew did not tune the ILS, the impact would have been minimal since they would have been showing right of the LOC on the Primary Flight Display (PFD).

The Jeppesen 19-3-1A guidance on how to fly the approach advises that crews should, at or prior to the FAF, F101D, disengage the autopilot (A/P) and follow the Visual Approach SOPs. The crew did this around the San Mateo Bridge. As the aircraft was turning toward a 267° heading, the crew disconnected the A/P and, per Visual SOPs, disconnected the Flight Director, after which the aircraft leveled with a heading of 273°. This put the aircraft in-line with taxiway C, and the crew flying the Visual Approach. Although the guidance material was not incorrect, a better procedure would have been to fly the RNAV visual approach per AOM 1.04.11.40 (if GPS equipped) or fly the FMS approach in "LNAV/VNAV" (FINAL APP) mode, which aligns the aircraft perfectly to the runway on short final. The definition of RNAV visual states, "The aircraft navigates using the RNAV system, but the position is monitored by visual reference to the ground, obstacles and other traffic." Either procedure would have brought the aircraft to the threshold of 28R. Flying visual approaches increases the risk of being affected by visual illusion, which in normal circumstances is not an issue.

The crew carried out the approach and threat briefing per FOM 8.9.10.3, however, the crew does not remember if they briefed the approach/runway lighting for 28R. After a review of the flight operation documentations, these briefings did not, at that

time, have a firm requirement to brief the approach lighting, runway lighting and/or visual aids expected during a visual approach. Air Canada has updated Flight Operations Manual (FOM) Article 8.9.10.3, Arrival and Approach Briefing, to ensure that approach lighting and runway lighting as well as the visual aids expected, are and shall be briefed by the crew.

4.3. Airfield Lighting

As noted above, Figure 5 depicts the construction, runway, and taxiway lighting, consistent with lighting at SFO on the night of the go-around event. The only evidence regarding any assessment of lighting is an entry indicating a routine lighting inspection was performed on July 8, 2017, and no discrepancies were noted in the remarks column of the inspection form.[8]

The investigation disclosed no evidence that SFO conducted any study or evaluation of the adequacy of the construction lighting and other existing lighting for assisting pilots to identify the runway environment during the nighttime construction periods. There is no evidence of assessment of the construction lights, no test flights by SFO to verify whether brightness or wash-out would be factors for flight crews, and no consideration of employing devices such as sequenced strobes to assist crews with alignment. The NOTAM for SFO containing three pages of text was the only informational element offered to flight crews.[9]

The crew of Delta flight 521, which landed on runway 28R about 4 minutes prior to the incident, confirmed during an interview conducted by the NTSB that they were also confused by the lighting during the approach. The flight crew of Delta 521 reported that the "construction lights were so bright we could not determine the location of the inboard runway, 28L." Visually acquiring the runway, both crewmembers reported questioning if they were lined up for runway 28R; however, after crosschecking with their LNAV they were able to determine they were lined-up for runway 28R. They received additional confirmation about 300 feet AGL when the Captain visually acquired the painted "28R" on the paved surface of the runway. The Captain of that flight further reported that the aircraft on Taxiway C were stopped and had their taxi lights off, which "helped to create this misconception that Taxiway C was RWY 28R."[10] Air Canada has offered a recommendation related to Airfield Lighting.

4.4. ATC Staffing

The NTSB advised that normal air traffic staffing for the ATC tower midnight shift included two controllers. On the evening of the incident, one Controller was in the tower cab. At 2349 PDT (7 minutes before the incident), all positions in the ATC tower (controller-in-charge, local control, local control assist, ground control, flight data, and clearance delivery) were combined at the local control position. Since the

[8] Airports Specialist Report at 3.
[9] *See* FAA NOTAMS FOR SFO, Attachment 7 to the Operational Factors / Human Factors Factual Report.
[10] NTSB information from the Delta flight 521 crew interview.

combined LC/CIC controller was alone controlling everything on the airport, he was likely overtasked. This resulted in insufficient monitoring of ACA759. The LC/CIC controller took over 7 seconds to reply to the ACA759 request concerning whether runway 28R was clear. During this time, ACA759 travelled approximately 1700 feet longitudinally and continued its descent, after which the LC/CIC controller confirmed that ACA759 was cleared to land and the runway was clear. The LC/CIC controller did not issue a go-around instruction until a critical three seconds had elapsed from the time ACA759 had already begun its go-around maneuver on its own initiative.

The fact that there was only one (1) combined LC/CIC controller on duty impacted his workload. We note ACA759 experienced an excessive delay in response to their question about whether the runway was clear (7 secs) before receiving a response from the controller. Equally, the delay suggests ATC did not know where the aircraft was on the approach. Even after crew in aircraft waiting on Taxiway C voiced concerns, the LC/CIC controller still failed to grasp the evolving situation on approach. A fully staffed and engaged ATC complement would likely have assimilated the clues much earlier and been positioned to assist the flight crew well before the go-around was finally initiated by the crew itself.

A review of industry safety data highlights the fact that KSFO holds a top 5 position in a list of airports in the United States concerning go-arounds, unstable approaches, landings without landing clearance, GPWS events, TCAS RA events, runway incursion events and missed crossing restrictions. All of these events suggest there is a significant FAA ATC threat at KSFO.

4.5. ASDE-X / ASSC

KSFO is equipped with an ASDE-X/ASSC system. The ASSC improves surface surveillance and situational awareness by fusing numerous data stream to produce a highly accurate display for controllers to show aircraft and ground vehicles on the surface movement area as well as display aircraft on the arrival and departure paths within a few miles of the airport.

At 2355:52 PDT,[11] the airplane flew too far right of course to be observed by the local controller's ASDE-X/ASSC and was not visible on the ASDE-X/ASSC display for about 12 seconds. If the LC/CIC controller, following the call from ACA759 concerning whether the runway was clear for landing, had reviewed the ASDE-X/ASSC display, he would have noticed that ACA759 was not on the display and hence was not located where it should have been on the approach. Therefore, instead of a perfunctory reaffirmation that ACA759 was clear to land on runway 28R, the LC/CIC controller could have offered the crew timely and important navigation updates or cautions.

4.6. Event Notification and CVR Retention

There has been some question about the notification process followed after the go-around event and subsequent overwriting of the CVR. It is important to consider that

[11] NTSB information/timing.

this event was not an immediately reportable serious incident under NTSB regulations, and thus regulations did not require measures to preserve the cockpit voice recorder recording. NTSB regulations require immediate notification of aircraft accidents and certain listed serious incidents. A "go-around" is not among the incidents listed. *See* 49 C.F.R. § 830.5. There is a notification requirement if an aircraft "lands or departs on a taxiway, "but no requirement for lining up on a taxiway during approach, noticing the error, and executing a go-around followed by an uneventful landing. *See id.* § 830.5(a)(12)(i). Federal aviation regulations only require preservation of the CVR recording "[i]n the event of an accident or occurrence requiring immediate notification of the National Transportation Safety Board under part 830 of its regulations …." 14 C.F.R. § 121.359(h). Therefore, there was no regulatory requirement to preserve the CVR following the ACA759 go-around.

As soon as ACA759 parked at the Gate, they contacted ATC and debriefed the event with the Controller, but only provided basic contact information because the controller was busy at the time. The crew left the airport and arrived at the hotel at approximately 0130 PDT (0430 EDT) and the CA called ATC Controller and gave a deeper debrief. As the Controller did not express any serious concerns or significance regarding the event, the crew were left with the impression that the event was not severe. Flight Operation Manual (FOM) Section 12-2 advises that "Any aircraft accident, incident, emergency, or other safety related event which may require investigation, monitoring or tracking shall be reported to Dispatch as soon as possible." There was no definition of "as soon as possible" in the FOM. Air Canada has observed events in which crews did not notify Dispatch in a timely manner because the crew did not understand or are unaware of the severity of the events. This impacts the ability of the company to properly react to such an event by, for example, quarantining the cockpit voice recorder and notifying the Government regulatory and/or investigative authorities of the event.

Under the Safety Management System in Canada, should Flight Crews have an issue with ATC, they automatically contact the Air Traffic Control Supervisor once at the gate to discuss the issue. Equally, in those cases where a telephone number for ATC is offered, the crew will automatically contact the tower to resolve or discuss the event with the ATC authority. Perhaps in contrast to American flight crews, Canadian flight crews do not think or concern themselves with the threat of violation by the Regulator because the Air Traffic Agency, the Airline and the Regulator all work under the framework of SMS to address the root cause of the error or mistake without specific concerns about jeopardy or enforcement. For Air Canada, we have been cultivating an atmosphere where people have confidence to report safety concerns without fear of blame and we believe this has assisted in developing a strong safety reporting culture. Given this understanding, it would be expected and normal for the Captain to contact the ATC facility to ensure that ATC was aware and understood the event from the crew's perspective. Following this event, the Captain contacted ATC twice–once when parked at the Gate and then later upon arrival at the hotel. During these calls, neither the details nor seriousness of the event were conveyed to the crew by ATC. In fact, ATC did not express any concerns at all. As a result, the crew was unable to offer such insights to Air Canada's Dispatch Staff, the Duty Pilot or Safety-on-Call.

4.7. Fatigue

Fatigue is characterized by a general lack of alertness and degradation in mental and physical performance. Fatigue manifests in the aviation context not only when pilots fall asleep in the cockpit during flight, but perhaps more importantly, during the task-critical takeoff and landing phases of flight. Reported fatigue-related events have included procedural errors, unstable approaches, lining up with the wrong runway, landing without clearances and poor decision making.[12] There are 3 types of fatigue; transient fatigue is acute fatigue brought on by extreme sleep restriction or extended hours awake within 1 or 2 days. Cumulative fatigue is fatigue brought on by repeated mild sleep restriction or extended hours awake across a series of days. Circadian fatigue refers to the reduced performance during nighttime hours, particularly during an individual's "window of circadian low" (WOCL) (typically between 0200 and 0559).

Common symptoms of fatigue include: measurable reduction in speed and accuracy of performance; lapses of attention and vigilance; delayed reactions; impaired logical reasoning and decision making, including a reduced ability to assess risk or appreciate consequences of actions; reduced situational awareness; and, low motivation.[13]

The crew advised that they considered themselves rested for the flight (see section 3.1 for history). Later during the flight and approach, however, they advised that they were beginning to feel very tired about 0200-0300 EDT, which is during the Window of Circadian Low (WOCL). Both crewmembers at other times before the incident flight had used the booking off process for fatigue, which is a non-jeopardy fatigue program at Air Canada, and as such, both crewmembers were fully aware of the procedures. This understood, if either crewmember felt tired, they knew they could have booked-off the flight, but since they were not tired at the beginning of the pairing, and held no expectation of fatigue, they did not book-off for fatigue.

[12] FAA Advisory Circular 117-3, *Fitness for Duty* (October 11, 2012).
[13] FAA advisory circular 117-3.

A review of the 72- hour Fatigue Factor Assessment for both crewmember was undertaken as part of the Fatigue Risk Management Program.

Sum of fatigue factors		8	5
Assessment of fatigue factors:		* Crew member's responsibility	
0-3 relevant factors:	accept	** Depending on preceding duty	
4-6 relevant factors:	check	***The night before, 2 consecutive nights are relevant	
7-9 relevant factors:	mitigate		
>10 relevant factors:	not acceptable		
Note: Factors are not fully weighted! Most important factors are sleep debt, wakefulness, circadian factors then workload, in this order.			

Figure 8: FO IATA Fatigue Factor Assessment.

Sum of fatigue factors		5	5
Assessment of fatigue factors:		* Crew member's responsibility	
0-3 relevant factors:	accept	** Depending on preceding duty	
4-6 relevant factors:	check	***The night before, 2 consecutive nights are relevant	
7-9 relevant factors:	mitigate		
>10 relevant factors:	not acceptable		
Note: Factors are not fully weighted! Most important factors are sleep debt, wakefulness, circadian factors then workload, in this order.			

Figure 9: CA IATA Fatigue Factor Assessment

The conclusion from the fatigue manager, based on the assessment (Figure 8 &Figure 9), highlighted that the main contributing fatigue factors for the Captain concerned his continued wakefulness. He did not have an afternoon nap in preparation for the night duty, and circadian factor, as his night duty continued into the WOCL. The duty itself, coupled with prior duty, should have had minimal effect on the Captain's alertness. For the FO the main contributing fatigue factors was the circadian factor, a night duty that continued into the WOCL, and sleep debt created as a result of the previous duty. Although not substantiated through modeling, the previous duties may have had an effect on his alertness for ACA759.

A SAFE analysis of the crews pairing (Figure 10 & Figure 11) was carried out, and the conclusion from the fatigue manager for the FO operating the same pairing twice in a row did have a minor increase in fatigue on the second flight; however, the analysis indicates the increase in the fatigue score is because ACA759 on July 7 was delayed, thus the flight operated further into the WOCL. For the CA, the Safe analysis shows that the previous pairing the Captain operated should have had no appreciable

negative effect on the fatigue score of ACA759. The increase in fatigue score is most likely related to more exposure to the WOCL than the planned pairing due to the late arrival.

Figure 10: SAFE analysis of CA pairing.

Figure 11: SAFE analysis of FO pairing.

A review of the pairing T3363 (ACA759/0750) (Figure 12) using the SAFE tool received a score of 4.36 on Samn-Perili scale. The rating for the Samn-Perili scale are:

1. Fully Alert, wide awake,
2. Very lively, responsive, but not at peak,
3. OK somewhat fresh,
4. A little tired, less than fresh,
5. Moderately tired, let down,
6. Extremely tired, very difficult to concentrate,
7. Completely exhausted, unable to function.

Based on the above analysis, pairing T3363 has been created to mitigate as much risk to fatigue as possible.

Figure 12: SAFE Analysis of pairing

Under the Air Canada Fatigue Risk Management Program, flights such as ACA759 are monitored for fatigue performance. The Air Canada program includes predictive, pro-active and reactive elements, including bio-mathematical modeling of pairings, evidence-based scheduling practices, reported fatigue risks, fatigue surveys, pilot fatigue reporting and fatigue book-off analysis, to name a few key items considered. When conducting monthly analysis, the Fatigue Safety Action Group (FSAG) benchmarks pairings related to fatigue scores using the scientifically accepted Samn-Perili scoring system. The benchmark high score is a 5 on that scale and pairings that are close to a 5 or over are carefully scrutinized. All data is considered when deciding to mitigate including, but not limited to, the safe analysis, fatigue reporting, flight crew reporting, air safety reporting and fatigue related book-offs. As FSAG assesses fatigue risk for various flights, particular attention is paid to flights that operate in the WOCL. This pairing, T3363, has been created after extensive data collection and feedback directly from pilots through fatigue event reporting. The current Night Duty rules contain mitigations that allow only a single direct leg, an optimal layover and a single direct leg back to home base. The blocking rules do not allow for a previous duty to begin before 1000 Home Base time (HBT) or a following duty to begin before 1000 HBT.

4.8. Other Human Factors

Several human factor issues were present and, likely coupled with a fatigue component, were a factor in this incident (see Section 4.7). These factors included expectation bias, confirmation bias, channelized attention, plan continuation bias, availability heuristic, and visual misperceptions. Human factors issues are not only experienced by flight crews, but impact everyone involved in an operation, including specifically, in this instance, the single, combined local control/controller-in-charge (LC/CIC controller) on duty in the KSFO tower at the time of the incident.

Expectation bias, essentially means "[h]aving a strong belief or mindset toward a particular outcome."[14] Hearing what one expects to hear is frequently listed as a causal factor for ATC and crew deviations that occur both on the ground and in the air. Expectation bias impacted the decisions and actions of the single, combined LC/CIC controller on duty in the KSFO tower during the ACA759 approach, which significantly exacerbated and reinforced the direct impact of these human factor issues on the flight crew. As the crew of ACA759 was soliciting information regarding the status of the runway, the LC/CIC controller took time to scan the runway, check his radar monitor and verify the Airport Surface Surveillance Capability (ASSC) display. The LC/CIC controller noted ACA759 was positioned to the right on the ASSC display but claimed this was normal for the Bridge Visual approach. The Controller told investigators that the ASSC offset could vary by flight and as such, he was not concerned. As the flight progressed, the unexpected radio calls from the flight crews lined-up on Taxiway C were heard and suggested there was a developing concern. A subsequent check of the ASSC by the LC/CIC controller confirmed ACA759 was no longer on the display but instead of taking action, he assumed the target was lost in a blind spot. This action suggests that despite the growing evidence and outside influences, notably the radio calls from the United flight suggesting something was wrong, the Controller was not seeing this situation developing. In fact, the Controller was most probably impacted by expectation bias and was not piecing together the growing body of evidence that a problem had developed. The LC/CIC controller told Investigators that he had no experience with a flight lined-up on a taxiway and had never had an ASSC display disappear. Still, nothing was signaling to him there was a concern; he was seeing what he expected to see for a normal Quiet Bridge visual approach. Finally, in looking for the aircraft, he began to recognize something was not right. After a critical period of an additional three seconds from the time the flight crew of ACA759 had already determined on their own that a go-around was needed and executed this maneuver, the LC/CIC controller advised the crew to go-around.

The actions of the LC/CIC controller after the incident were also important. In his discussion with the Pilot, the Controller stated he was trying not to raise concern with the crew and missed offering pertinent data that could have identified the seriousness of the event. In fact, the LC/CIC controller did not recognize the serious nature himself and did not event file a Mandatory Occurrence Report. Instead, the LC/CIC

[14] Skybrary ATC Expectation Bias.

controller told Investigators he saw the event as a pilot deviation and not an ATC error, and as such, took little action to raise awareness about the actual event.

The LC/CIC controller never considered the airport lighting. The airfield lights were automatically set, and unless the Controller took specific actions to adjust the lights, the standard settings would be offered. This, despite construction and a complete lack of knowledge about the intensity of these lights or their impact on landing crews, suggests a more engaged, proactive LC/CIC controller might have asked crews about the lighting given the construction. Sequenced strobes to Runway 28R were available but not employed–this simple tool would have all but eliminated the possibility of misalignment. To the LC/CIC controller, the normal, automated set-up of lights had always been adequate, and he did not question why anything would be different on this night.

These points highlight that the LC/CIC controller did not perceive an issue with the arriving ACA759 despite growing clues that a problem was developing. Based on what is normal, the LC/CIC controller was convinced this approach was just like all others. The LC/CIC controller appeared to have had no real technical understanding of ASSC limitations or the need to report failures and lost displays. He also did not understand the term, "capture zone," as it relates to the ASSC coverage area. This likely explains why, when the display was lost, he was not concerned. In fact, expectation bias clouded the LC/CIC controller's judgement and delayed his recognition of the evolving situation in time to take actions and give directions to effectively counter the impact of human factors on the flight crew, which would have permitted a timely and more routine go-around direction.

Confirmation bias is another human factor that affected the flight. As a result of limitations in memory and processing capabilities, humans cannot handle the totality of the information displayed in their environment. Instead, they build representations that are meant to support behavior.[15] Saving cognitive resources biases mental models in such a way that partial confirmation is easily accepted. Instead of looking for contradictory pieces of evidence, mental models tend to "wait" for consistent data; this phenomenon is called "confirmation bias."[16] Confirmation bias helps create a hypothetical diagnosis about the situation rapidly but the hypothesis is based only on a subset of available information and may lead to fixation where an incorrect diagnosis is maintained despite an increasing quantity of counter-evidence.

For ACA759, the Captain, given prior flights to KSFO, despite the closure of R28L and its mention in the NOTAM and ATIS "Q", set his mental model on the fact that the second set of lights, those he was seeing now on Taxiway C, was the runway environment for 28R. This was based on prior flights to KSFO, without ongoing runway construction activities, coupled with all the guidance material provided that further emphasized the need to stay to the right of 28L. The importance of the runway 28L closure may not have registered because they were landing on 28R, even

[15] Rabardel, P. (1995). Les hommes et les technologies.
[16] Klayman, J. & Ha, Y.-W. (1989). Hypothesis testing in rule discovery: Strategy, structure and content. *Journal of Experimental Psychology*: *Learning, Memory and Cognition.*

though the closure was on the latest ATIS "Q" retrieved by the FO just prior to the top of descent to KSFO.

Channelized attention is the focusing of one's attention on a particularly limited area to the exclusion of other areas or cues. The phenomenon can be exacerbated by fatigue, lack of knowledge, excessive motivation, or the novelty of the situation. The CA focused so much his attention on the second set of lights that he missed the cues of no approach runway lighting to the Taxiway C. The workload for the FO during the approach was more demanding ensuring that ACA759 made all the altitude constraints during the approach due to the crew electing to employ "Open Descent" and then later, once the autopilot disconnected, he concentrated his attention inside the cockpit to ensure the proper crossing altitude at the FAF and ensuring the "missed approach and Runway heading bug" were set on the flight guidance panel. During the final stage of the approach he channelized his attention mainly inside the cockpit to ensure that they met all the stable approach criteria for the approach until the CA requested the FO to contact ATC and confirm that they were "cleared to land." It was at this point that the FO looked outside, and internalized that things "didn't look right." Although he was not certain what was incorrect, he was unable to process what he was seeing.

Plan continuation bias may impede a crew's ability to recognize that they need to change their course of action. People tend to seek information that confirms their chosen course of action and avoid information or tests whose outcome could be in conflict with their choice.[17] This is a powerful but unconscious cognitive bias to continue the original or habitual course of action. This bias may be especially strong during the approach phase, when only a few more steps are required to complete the original plan, and it may operate by preventing pilots from noticing subtle cues indicating that the original conditions have changed.[18] Once the CA saw aircraft lights on what he believed was the runway, he was looking unconsciously for confirmation that his mental model matched what he was seeing. Once the ATC confirmed that he was "clear to land", this action reaffirmed the original mental model thus creating a delay in processing the clues that they were lined up with Taxiway C and delaying the go-around decision.

Delta flight 521 was the preceding aircraft, which landed on runway 28R about 4 minutes prior to the incident; and as confirmed by the NTSB Interview of the Delta 521 flight crew, they too suffered from an illusion, perhaps to a lesser extent than ACA759, during the approach. The flight crew of Delta 521 reported that the "construction lights were so bright we could not determine the location of the inboard runway, 28L." Visually acquiring the runway, both crewmembers reported questioning if they were lined up for runway 28R; however, after crosschecking with the LNAV they were able to determine they were lined-up for runway 28R. They received additional confirmation about 300 feet AGL when the Captain visually acquired the painted "28R" on the paved surface of the runway. The Captain of that

[17] Shappell & Wiegmann.
[18] NASA Ames Research Center.

flight further reported that the aircraft on Taxiway C were stopped and had their taxi lights off, which "helped to create this misconception that Taxiway C was RWY 28R."[19]

Availability heuristic helps to collect information rapidly, but puts more emphasis on the most easily available information sources rather than the most reliable and relevant sources. Availability heuristic can be counteracted through good design of instruments and procedures, and training that teaches the flight crew to focus on the contextually most relevant information sources, and underlines the limitations of the sources. The availability heuristic in human thought is based upon how people use repetition as means to remember information. The availability heuristic inverts the repetition technique and uses the strength of association to judge frequency of occurrence. While the availability heuristic is a source of cognitive bias, it is also recognized as an "ecologically valid clue for the judgment of frequency because, in general, frequent events are easier to recall or imagine then infrequent ones."[20] The Runway 28R Quiet Bridge Visual is frequently assigned to Air Canada crews, but the nature of this approach, specifically the closely spaced runways, simultaneous operations, and the fact the approach is flown as a VFR approach, makes it unique and challenging. Couple this with the fact that tuning the ILS manually for an FMS approach is not a common task—KSFO, a designated Group II FAA Special PIC Qualification airport, is the only approach in the Air Canada network that requires crews to manually tune a NAVAID for a FMS visual approach—and the clues become less evident.

Visual misperceptions will occur due to perceptual limitations.[21] This is partly due to transferring the 3-dimensional objective world into a 2-dimensional retina image, and back into a 3-dimensional mental formation; and partly due to the imposition of cognitive influences such as assumptions, inferences and pre-conceived ideas. This latter "interference" can be summed-up by the phrase we see what we expect to see. Such optical illusions are numerous and include the misperception of aircraft height above touchdown caused by our inability to differentiate between the length of a runway and its slope. The crew of ACA759 believed that they were 300-400 feet MSL when they initiated the go-around; they reported this to the Duty Pilot the next day. Once they passed the FAF, their concentration was mainly to the outside environment and less on the cockpit displays, as the crew relied on visual cues for the perception of height. A normal sight picture for a runway is 200 feet and your mental models are based on that sight picture because they were lined-up on a taxiway with a width of 100 feet, or less, the perception would be that they were higher than they actually were (Figure 13).

[19] NTSB information from the Delta flight 521 crew interview.
[20] Tversky & Kahneman, 1974.
[21] Skybrary Pilot Perception.

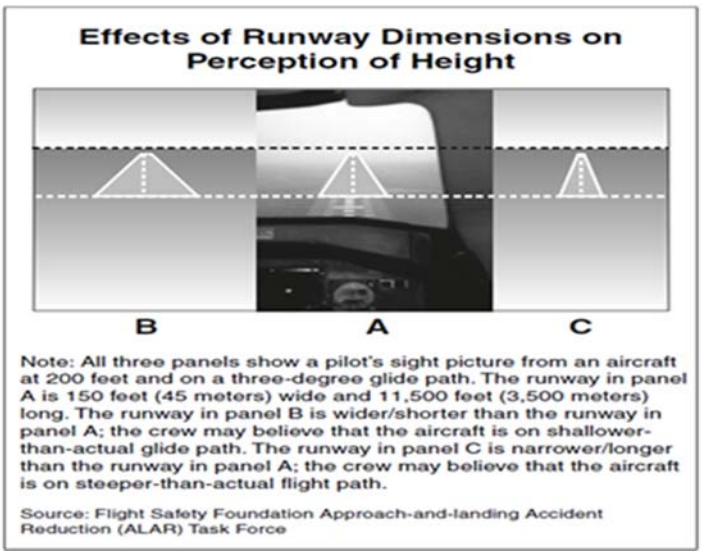


Figure 13: Effect of Runway dimension[22]

5. Proposed Conclusions

5.1. Findings

5.1.1. The ACA759 flight crew believed that Taxiway C was runway 28R. The crew were confused by the lighting presented on final approach and attempted to resolve their confusion by contacting ATC, but ultimately the crew believed they were aligned with runway 28R when they were aligned with Taxiway C.

5.1.2. The SFO Approach/Runway lighting caused confusion about the runway environment for both the ACA759 flight crew as well as the Delta flight 521 crew immediately ahead of ACA759.

5.1.3. The ACA759 flight crew did not manually tune ILS 28R.

5.1.4. The ACA759 initiated the go-around at approximately 85 feet AGL.

5.1.5. The ACA759 overflew some of the aircraft on Taxiway C.

5.1.6. Though a minimum of two (2) ATC controllers normally staff the KSFO tower, there was only one (1) ATC controller for all positions during an extended period, including the ACA759 event.

5.1.7. The ACA759 crew detected the possibility that something may not have been right and proactively questioned ATC about what they were seeing on what they believed to be runway 28R.

[22] FSF info.

5.1.8. The single, combined LC/CIC controller in the KSFO tower responded to ACA759 question regarding the runway seven (7) seconds after it was posed, during which critical time period ACA759 continued its descent.

5.1.9. The LC/CIC controller conveyed no indication of any irregularity prior to the crew recognizing it themselves, but instead confirmed that ACA759 was clear to land on Runway 28R, exacerbating the continuation and confirmation bias experienced by the flight crew.

5.1.10. The LC/CIC controller lost situational awareness of the location of ACA759 on the approach.

5.1.11. The LC/CIC controller was not sufficiently knowledgeable about the ASDE-X/ASSC systems to use them to maintain situational awareness.

5.1.12. The LC/CIC controller did not effectively utilize lighting resources available to him to make the runway environment more clear.

5.1.13. Despite the confirmation from the LC/CIC controller and the impact of confirmation and continuation bias, the ACA759 flight crew recognized the irregularity and initiated the go-around 3 seconds before the LC/CIC controller requested it.

5.1.14. The ACA759 flight crew were likely affected by some degree of WOCL/Fatigue.

5.1.15. Bright construction lighting created a visual distortion.

5.1.16. The ACA759 Approach Briefing was inadequate and ineffective.

5.1.17. A go-around is not an immediately reportable event under NTSB regulations.

5.1.18. The FAA and NTSB did not advise Canadian authorities of the event or their intent to conduct a full investigation in a timely manner and as such, pertinent data including the CVR was lost.

5.1.19. Approach/Runway lighting was not a mandatory part of the approach brief.

5.1.20. There was no definition of “as soon as possible” in the FOM when it comes to an incident that requires notification to Dispatch.

5.1.21. NOTAM depiction on the flight plan and the amount of NOTAM with the Flight Plan can lead crews to miss important information.

5.1.22. The lack of onboard GPS, HUD or software tools to assist with alignment placed the crew in a position where they would be susceptible to illusions and biases.

5.1.23. Following the landing of a Boeing 767 on Taxiway M at Hartsfield-Jackson Atlanta International Airport (ATL), Atlanta, Georgia, the FAA declined to perform a technical review of Airport Surface Detection Equipment–Model X to determine if the capability exists systemwide to detect improper operations such as landings on taxiways, as described in NTSB Safety Recommendation A-11-012.

5.1.24. KSFO elected not to deploy ATCT tools and resources to monitor aircraft on approach and to advise on runway misalignment.

5.1.25. KSFO did not conduct a hazard assessment of the closure of 28L and the impact of construction lighting and other changes to airport lighting.

5.1.26. After the ACA759 event, KSFO ATC commenced vectoring arriving aircraft to the KSFO ILS 28R approach until the construction was completed.

5.2. Proposed Probable Cause

The Probable Cause of the ACA759 overflight incident was the flight crew's misperception of SFO Taxiway C as Runway 28R during the approach. Contributing to the incident were: (1) San Francisco International Airport's inadequate lighting of the runway environment, including lighting of the ongoing construction, to distinguish the normally-configured parallel runways from runway 28R and Taxiway C given the closure of runway 28L; (2) failure of the sole, combined local controller/controller-in-charge (LC/CIC controller) in the KSFO tower to provide any direction or information to the flight crew, following the flight crew's request, until after the flight crew had already initiated the go-around; and (3) insufficient training and knowledge by the combined LC/CIC controller on use of available lighting resources and ADSE-X/ASSC capabilities.

5.3. Proposed Recommendations

5.3.1. To the FAA, conduct a study analyzing runway closure lighting, taking night visual approach procedures into consideration, and evaluate alternatives to enhance runway environment identification at night.

5.3.2. To the FAA, based on the study above, implement appropriate measures to enhance runway environment identification at night.

5.3.3. To the FAA, reiterate prior NTSB Safety Recommendations A-11-012 and A-11-013 regarding the studying and implementing of ASDE-X/ASSC which would provide alerts to air traffic controllers.

5.3.4. To the FAA, conduct a study of KSFO operations in light of all factors affecting the airport, including without limitation, surrounding terrain, air traffic flow, traffic flow and loss of situational awareness by the LC/CIC controller during this incident, and the number and severity of past events that may have been identified in the ASIAS system, to evaluate whether KSFO should establish a requirement that a minimum of two controllers be on duty at all times.

6. Safety Actions Taken as of the Air Canada Submission Date

Air Canada has assisted the NTSB investigation in its role as a technical advisor to the TSBC. Air Canada has also worked diligently with Transport Canada and the FAA regarding the SFO event. While the work of the NTSB and the Technical Representatives continued, Air Canada identified several areas in which immediate actions was required and immediately took the following actions:

a. Charting for San Francisco – specifically KSFO 10-10 and 19-3-1A (known as our Quiet / FMS visual approaches) have been reviewed and revised for clarity and simplicity;

b. Flight Operations Manual (FOM) Article 8.9.10.3 - Arrival and Approach Briefing, has been amended to ensure that approach lighting and runway lighting as well as the visual aids expected, are and shall be briefed by the crew;

c. Air Canada has removed guidance to set the ILS frequency as the ILS scale is not visible when flying the FMS approach. Guidance is provided that requires the crew to fly the FMS approach in “LNAV/VNAV” (FINAL APP) mode in order to ensure the aircraft is perfectly aligned to the runway on short final;

d. Air Canada has examined its training requirements and has implemented changes to ensure that SFO-specific training is now conducted in the simulator as part of the new 4-month additional training session;

e. Air Canada has implemented on the Airbus recurring simulator program the “FMS Bridge Visual Approach” and this approach is a mandatory sequence to be flown in the simulator”;

f. Air Canada Flight Operations has defined the term “as soon as possible” in Flight Operations Manual (FOM) Revision 33 in order to minimize delays in reporting to the Company;

g. (FOM 33 1.7.7.2 Word Meanings definition), The following word meaning apply to the FOM. “As soon as possible” means to accomplish promptly or as soon as time permits;

h. Air Canada increased vigilance on training and documentation, as well as enhanced oversight rides into selected airports. Further, the frequency of

visits and exchanges between the regulator and Company has been voluntarily increased and serves to highlight concerns and issues whether in the operation or with regulatory policy;

i. In recognition of various illusions and human factors issues that affect all crews and aviation operations, Air Canada has developed a specific Human Factors training module to discuss continuation bias and expectation Bias and offer crews strategies to recognize and mitigate such events in their operation. The new module will allow all crews to understand why competent professional pilots make errors, understand the most common biases and how to recognize them and examine larger mitigation strategies to remove these risks and challenges, to the greatest degree possible, for our operation. The training was implemented as part of the 2018/2019 Annual Recurrent training (ART) program that started 01 April 2018;

j. In response to safety proposals and industry research, Air Canada elected to retrofit its new B-737 Max aircraft, as well as provision its new C-Series aircraft with dual Heads-Up Displays (HUDs). This action is taken to enhance situational awareness for crews and help address issues of cognitive bias during high risk/low visibly approaches;

k. Air Canada Flight Operations has implemented a unique Learning Management System (LMS) module to address Group II/III and unique airports; and

l. Industry options to improve crew situational awareness and runway alignment, such as Honeywell's SmartLanding / SmartRunway System, are being actively assessed by Air Canada for our aircraft and operations.

Air Canada understands that KSFO and the FAA have taken measures since the incident and are assessing additional measures to address incidents during approaches to the airport.

7. Acronyms

A/C	Aircraft
ACA	ICAO Air Canada code
ACARS	Aircraft Communications Addressing and Reporting System
AGL	Above Ground Level
ALSF-2	Approach Lighting System with Sequenced Flashing Lights configuration 2
APP	Approach
ASDE-X	Airport Surface Detection Equipment, Model X
ASIAS	Aviation Safety Information Analysis and Sharing system
ASSC	Airport Surface Surveillance Capability
ATC	Air Traffic Controller
ATIS	Automatic terminal information service
ATLAS	Database for Pilot qualification and training results
CFR	Code of Federal Regulations
CVR	Cockpit Voice Recorder
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FMS	Flight Management System
ILS	Instrument Landing System
LC/CIC	Local Control/Controller-in-Charge
LNAV	Lateral Navigation
MSL	Mean Sea Level
NOTAM	Notice To Airman
NTSB	National Transportation Safety Board
RNAV	aRea NAVigation
RWY	Runway

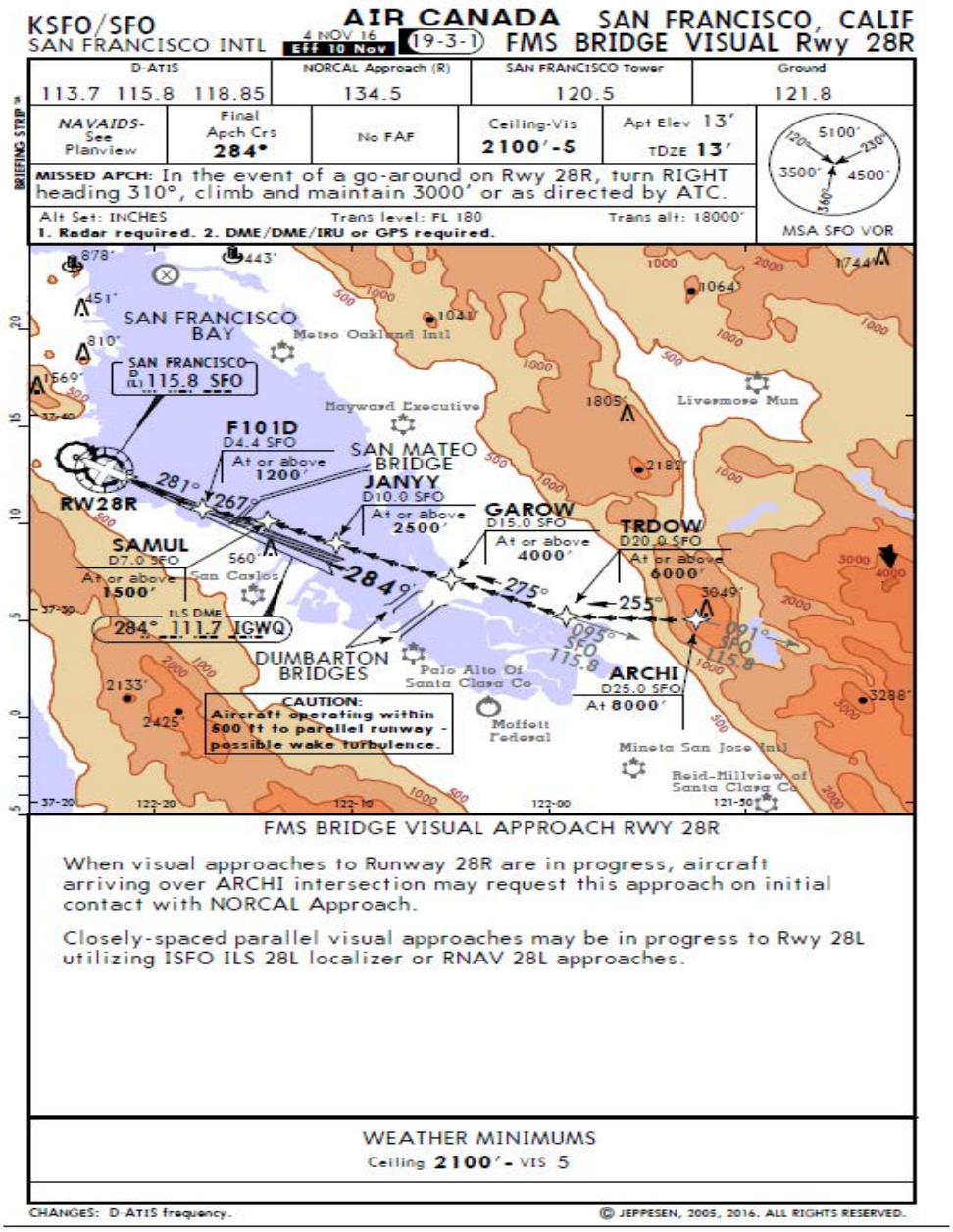
TOD Top of Descent

TSBC Transportation Safety Board of Canada

VNAV Vertical Navigation

8. Attachments to Air Canada Submission

8.1. KSFO 19-3-1 FMS BRIDGE VISUAL RWY 28R.



8.2. KSFO 19-3-1A FMS BRIDGE VISUAL RWY 28R.

KSFO/SFO **AIR CANADA** SAN FRANCISCO, CALIF
3 NOV 17 (19-3-1A) SAN FRANCISCO INTL

FMS BRIDGE VISUAL APPROACH RWY 28R (RNAV 28R)

The FMS Bridge Visual Approach is coded as the RNAV 28R Approach. Selecting this procedure will display the entire approach procedure, including missed approach guidance.

The FMS Bridge Visual Approach is a visual approach procedure. Crews are responsible for traffic watch. ATC may amend the FMS procedure or impose additional restrictions during the approach. Clearance may also be issued to follow the FMS path or intercept the final approach course prior to receiving clearance for the approach. When doing this, the controller should use the following phraseology: 'PROCEED DIRECT ARCHI, MAINTAIN EIGHT THOUSAND, INTERCEPT FINAL APPROACH COURSE or INTERCEPT FMS APPROACH COURSE'

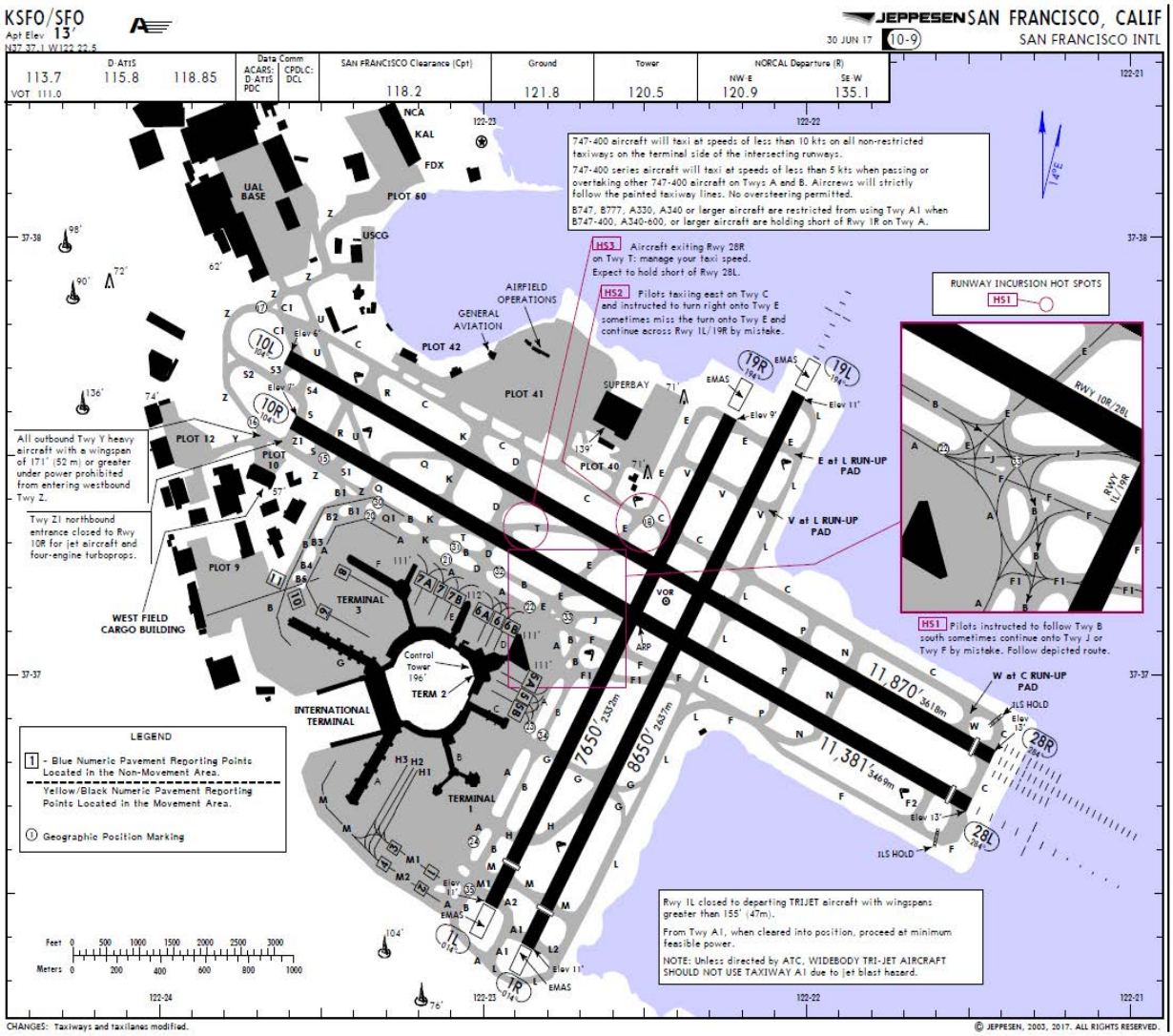
Embraer
The FMS Bridge Visual Approach 28R is coded as RNV 28R in the FMS database. The approach is flown using LNAV/VNAV modes.

A319/320/321
Select the RNV28R approach from the database. Anticipate crossing ARCHI at 8,000'. Intercept the FMS BRIDGE VISUAL track in NAV mode. Once cleared for the approach push the APPR PB and descend via the published vertical profile. At FINAL APP engagement set the Missed Aprroach Altitude.

Boeing
The FMS Bridge Visual Approach 28R is coded as RNV 28R in the FMS database. The approach is flown using LNAV/VNAV modes.

CHANGES: None.

8.3. KSFO Airport Diagram



8.4. DYAMD 3 RNAV Arrival Chart.