National Transportation Safety Board
Aviation Accident Data Summary

Location:	San Diego, CA	**Accident Number:**	WPR15MA243B
Date & Time:	08/16/2015, 1103 PDT	**Registration:**	N442RM
Aircraft:	NORTH AMERICAN ROCKWELL NA265-60SC	**Injuries:**	4 Fatal
Flight Conducted Under:	Part 91: General Aviation - Other Work Use		

Analysis

The Cessna 172 (N1285U) was conducting touch-and-go landings at Brown Field Municipal Airport (SDM), San Diego, California, and the experimental North American Rockwell NA265-60SC Sabreliner (N442RM, call sign Eagle1) was returning to SDM from a mission flight. SDM has two parallel runways, 8R/26L and 8L/26R; it is common in west operations for controllers to use a right traffic pattern for both runways 26R and 26L due to the proximity of Tijuana Airport, Tijuana, Mexico, to the south of SDM. On the morning of the accident, the air traffic control tower (ATCT) at SDM had both control positions (local and ground control) in the tower combined at the local control position, which was staffed by a local controller (LC)/controller-in-charge, who was conducting on-the-job training with a developmental controller (LC trainee). The LC trainee was transmitting control instructions for all operations; however, the LC was monitoring the LC trainee's actions and was responsible for all activity at that position.

About 13 minutes before the accident, the N1285U pilot contacted the ATCT and requested touch-and-go landings in the visual flight rules (VFR) traffic pattern. About that time, another Cessna 172 (N6ZP) and a helicopter (N8360R) were conducting operations in the VFR traffic pattern, and a Cessna 206 Stationair (N5058U) was inbound for landing. Over the next 5 minutes, traffic increased, with two additional aircraft inbound for landing. (Figure 1 in the factual report for this accident shows the aircraft in the SDM traffic pattern about 8 minutes before the accident.)

The LC trainee cleared the N1285U pilot for a touch-and-go on runway 26R; the pilot acknowledged the clearance and then advised the LC trainee that he was going to go around. The LC trainee advised the N1285U pilot to expect runway 26L on the next approach. At that time, three aircraft were using runway 26R (Global Express [N18WZ] was inbound for landing, N6ZP was on a right base for a touch-and-go, and a Cessna Citation [XALVV] was on short final) and three aircraft were using runway 26L (N1285U was turning right downwind for the touch-and-go, a Skybolt [N81962] was on a left downwind for landing, and N8360R was conducting a touch-and-go landing). After N1285U completed the touch-and-go on runway 26L, the pilot entered a right downwind for runway 26R.

Meanwhile, Eagle1 was 9 miles west of the airport and requested a full-stop landing; the LC trainee instructed the Eagle1 flight crew to enter a right downwind for runway 26R at or above an altitude of 2,000 ft mean sea level. At this time, about 3 minutes before the accident, the qualified LC terminated the LC trainee's training and took over control of radio communications. From this time until the collision occurred, the LC was controlling nine aircraft. (Figure 2 and Figure 4 in the factual report for this accident show the total number of aircraft under ATCT control shortly before the accident.)

During the next 2 minutes, the LC made several errors. For example, after N6ZP completed a touch-and-go on runway 26R, the pilot requested a right downwind departure from the area, which the LC

initially failed to acknowledge. The LC also instructed the N5058U pilot, who had been holding short of runway 26L, that he was cleared for takeoff from runway 26R. Both errors were corrected. In addition, the LC instructed the helicopter pilot to "listen up. turn crosswind" before correcting the instruction 4 seconds later to "turn base." (Figure 2 in the factual report for this accident shows the aircraft in the traffic pattern about 2 minutes before the accident.)

About 1 minute before the collision, the Eagle1 flight crew reported on downwind midfield and stated that they had traffic to the left and right in sight. At that time, N1285U was to Eagle1's right, between Eagle1 and the tower, and established on a right downwind about 500 ft below Eagle1's position. N6ZP was about 1 mile forward and to the left of Eagle1, heading northeast and departing the area. Mistakenly identifying the Cessna to the right of Eagle1 as N6ZP, the LC instructed the N6ZP pilot to make a right 360° turn to rejoin the downwind when, in fact, N1285U was the airplane to the right of Eagle1. (The LC stated in a postaccident interview that he thought the turn would resolve the conflict with Eagle1 and would help the Cessna avoid Eagle1's wake turbulence.) The N6ZP pilot acknowledged the LC's instruction and began turning; N1285U continued its approach to runway 26R.

However, the LC never visually confirmed that the Cessna to Eagle1's right (N1285U) was making the 360° turn. Ten seconds later, the LC instructed the Eagle1 flight crew to turn base and land on runway 26R, which put the accident airplanes on a collision course. The LC looked to ensure that Eagle1 was turning as instructed and noticed that the Cessna on the right downwind (which he still mistakenly identified as N6ZP) had not begun the 360° turn that he had issued. The LC called the N6ZP pilot, and the pilot responded that he was turning. In the first communication between the LC and the N1285U pilot (and the first between the controllers in the ATCT and that airplane's pilot in almost 6 minutes), the LC transmitted the call sign of N1285U, which the pilot acknowledged. N1285U and Eagle1 collided as the LC tried to verify N1285U's position.

A postaccident examination of both airplanes did not reveal any mechanical anomalies that would have prevented the airplanes from maneuvering to avoid an impact.

Local Controller Actions

In a postaccident interview, the LC stated that his personal limit for handling aircraft was four aircraft on runway 26R plus three aircraft on runway 26L (for a total of seven). From the time the LC took over local control communications from the LC trainee (3 minutes before the accident) until the time of the collision, the LC was in control of nine aircraft. Thus, the LC had exceeded his own stated workload limit. Research indicates that the cognitive effects of increasing workload may include memory deficits; distraction; narrowing of attention; decreased situational awareness; and increased errors, such as readback errors or giving instructions to the wrong aircraft. (Mica Endsley and Mark Rodgers's 1997 report, Distribution of Attention, Situation Awareness, and Workload in a Passive Air Traffic Control Task: Implications for Operational Errors and Automation [FAA Report No. DOT/FAA/AM-97/13], details the cognitive effects of increasing workload.) To resolve the increasing workload, the LC had two options. He could have directed traffic away from SDM or split the local control/ground control positions, but he did neither. The LC trainee was qualified to work the ground control position, and the SDM ATCT had three controllers in the facility, which was the normal staffing schedule for that day and time.

As a result of the high workload, the LC made several errors after taking over the position from the LC trainee, including not responding promptly to a departure request from the N6ZP pilot and incorrectly instructing a helicopter pilot to turn to crosswind before correcting the instruction to turn

base. The LC also did not provide traffic and/or sequence information with the instructions for the N6ZP pilot to turn 360° right. If the LC had done so, the N6ZP pilot might have reminded the controller that he was departing the airspace or requested clarification per 14 Code of Federal Regulations (CFR) 91.123(a), "Compliance with ATC [Air Traffic Control] Clearances and Instructions." In addition, if the Eagle1 flight crew had heard their aircraft called as traffic to another aircraft, it may have helped their visual search or prompted them to seek more information about the location of the conflicting traffic. The LC's stress amid the high workload was evidenced in his "listen up. turn crosswind" instruction to the helicopter pilot, after which the Eagle1 cockpit voice recorder (CVR) recorded the pilot comment, "wowww. he's like panicking" (with an emphasis on "panicking").

Most importantly, the LC misidentified N1285U as N6ZP and did not ensure that the Cessna to the right of Eagle1 was performing the 360° turn before issuing the turn instruction to Eagle1. Although the N6ZP pilot had already requested a departure from the area and the LC had approved the departure request, the LC still believed that N6ZP was to the right of Eagle1, which indicates that the LC lacked a full and accurate mental model of the situation once he took over communications from the LC trainee. The LC trainee stated in a postaccident interview that when the Cessna on the right did not start the right turn, he suggested to the LC that the intended aircraft may have been N1285U. The high workload due to the increased traffic likely contributed to the LC's incomplete situational awareness.

In a postaccident interview, the LC reported that, at the time that he took over for the LC trainee, he had four issues to resolve, one of which was the potential conflict between Eagle1 and the Cessna on the right. Thus, he was aware of the potential conflict between two aircraft, even though he did not have the accurate mental picture of which Cessna was which. The LC explained that the acknowledgement from the N6ZP pilot of the right 360° turn to rejoin the downwind indicated to him that the intended Cessna pilot to Eagle1's right had received and acknowledged his instructions. Had he looked up to ensure that the control instructions that he provided to the Cessna on the right were being performed, he would have noticed that the Cessna to the right of Eagle1 was not turning and likely would not have issued the conflicting turn instruction to Eagle1.

Further, Federal Aviation Administration (FAA) Order 7110.65, paragraph 2-1-6, "Safety Alerts," states, in part, that a controller should "issue a safety alert to an aircraft if you are aware the aircraft is in a position/altitude that, in your judgment, places it in unsafe proximity to terrain, obstructions, or other aircraft..." About 14 seconds elapsed between the LC's base turn instruction and landing clearance for Eagle1 and his call to the N6ZP pilot to ask about the right 360° turn instruction. When the LC saw that the airplanes were in unsafe proximity to each other, his priority should have been to separate the aircraft by issuing a safety alert to the Eagle1 flight crew (such as "TRAFFIC ALERT, Eagle1, to your right and below at pattern altitude, advise you climb immediately"). However, instead of issuing a safety alert to the Eagle1 flight crew, he separately called each Cessna pilot to verify their call signs and positions, which demonstrated narrowing of attention, another indication of the LC's stress due to high workload. If the LC had issued a safety alert to the Eagle1 flight crew as soon as he looked up after clearing Eagle1 to land and noticed that the Cessna to the right of Eagle1 was not turning, the Eagle1 pilots may have been able to take action to avoid N1285U. After the accident, on August 26, 2015, the SDM ATCT issued a Corrective Action Plan regarding inconsistencies in how controllers were issuing traffic advisories and safety alerts. The plan required controllers to review FAA Order 7110.65V, Air Traffic Control, paragraphs 2-1-6 and 2-1-21, as refresher training before working an operational position.

See-and-Avoid Concept

According to 14 CFR 91.113, "Right-of-Way Rules," "when weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft." In addition, FAA Advisory Circular (AC) 90-48C, "Pilots' Role in Collision Avoidance," which was in effect at the time of the accident, stated that the see-and-avoid concept requires vigilance at all times by each pilot, regardless of whether the flight is conducted under instrument flight rules or VFR. (AC 90-48D replaced AC 90-48C in 2016 and contains the same statement.)

The see-and-avoid concept relies on a pilot to look through the cockpit windows, identify other aircraft, decide if any aircraft are collision threats, and, if necessary, take the appropriate action to avert a collision. There are inherent limitations of this concept, including limitations of the human visual and information processing systems, pilot tasks that compete with the requirement to scan for traffic, the limited field of view from the cockpit, and environmental factors that could diminish the visibility of other aircraft.

A review of the ATCT and Eagle1 CVR transcripts revealed that during the entire time that the Eagle1 flight crew was on the ATCT local control frequency, there were no communications to or from N1285U. According to the CVR transcript, the Eagle1 pilots were aware of other traffic in the area and were actively looking for it; they had multiple airplanes in sight while on the downwind leg, and the pilot stated "I see the shadow but I don't see him" shortly before the accident. (Review of available data indicated that it was most likely the shadow of N1285U.)

Aircraft Performance and Cockpit Visibility Study

Our aircraft performance and cockpit visibility study determined that once Eagle1 began the turn to base leg, Eagle1 would have been largely obscured from the N1285U pilot's field of view but that N1285U should have remained in the Eagle1 pilots' field of view until about 4 seconds before the collision. (Figures 8a and 8b in the factual report for this accident show the simulated cockpit visibility from the Eagle1 copilot's seat and the N1285U pilot's seat at 1102:34, respectively.) Although the Eagle1 copilot would have had a better viewing position (in the right seat) to detect N1285U than the pilot, he was the pilot flying; thus, his attention would have been divided among multiple tasks, including configuring, operating, and maneuvering the airplane for approach and landing, as well as scanning for traffic. (Throughout Eagle1's CVR recording, the pilot, seated in the left seat, was communicating on the radio and responding to checklists, consistent with that pilot acting as the pilot monitoring and the copilot, seated in the right seat, acting as the pilot flying.) N1285U's lack of relative motion in the Eagle1 pilots' field of view, combined with the fact that N1285U was below their horizon and, therefore, against the visual clutter of the background terrain, significantly decreased N1285U's visual conspicuity to the Eagle1 pilots.

It is likely that, as N1285U neared the end of the downwind leg (after Eagle1 overtook N1285U from behind and to the left), the pilot was anticipating his turn to the base leg and that his primary external visual scan was to the right, toward the airport, instead of to the left where Eagle1 was. Although the pilot may have had some cues of Eagle1's relative positioning in the pattern based on his monitoring of the ATCT communications, the challenge remained of detecting the airplane visually while maneuvering in the pattern.

Cockpit Display of Traffic Information

Although the N1285U and Eagle1 pilots were responsible for seeing and avoiding the other aircraft in the traffic pattern, our aircraft performance and cockpit visibility study revealed that their fields of

view were limited and partially obscured at times. Research indicates that any mechanism to augment and focus a pilot's visual search can enhance their ability to visually acquire traffic. (AC 90-48D highlights aircraft systems and technologies available to improve safety and aid in collision avoidance, and our report regarding a midair collision over the Hudson River [AAR-10/05] states that "traffic advisory systems can provide pilots with additional information to facilitate pilot efforts to maintain awareness of and visual contact with nearby aircraft to reduce the likelihood of a collision. ...") One such method to focus a pilot's attention and visual scan is through the use of cockpit displays and aural alerts of potential traffic conflicts. Several technologies can provide this type of alerting by passively observing and/or actively querying traffic. The accident airplanes were not equipped with these types of systems, but their presence in one or both cockpits might have changed the outcome of the event. (The images from our in-cockpit traffic display simulation are representative of the minimum operations specifications contained in RTCA document DO-317B, Minimum Operational Performance Standards for Aircraft Surveillance Applications System [dated June 17, 2014], but do not duplicate the implementation or presentation of any particular operational display exactly; the actual images presented to a pilot depend on the range scale and background graphics selected by the pilot.)

While Eagle1 remained obscured from the N1285U pilot's field of view during Eagle1's downwind-to-base turn, N1285U remained in the Eagle1 (right seat) copilot's field of view for the majority of the 3 minutes preceding the accident. Even though both Eagle1 pilots were aware of and actively looking for traffic in the pattern, they still failed to see and avoid colliding with N1285U, which underscores the shortcomings in the see-and-avoid concept. An in-cockpit traffic display would have shown the Eagle1 pilots all of the traffic at the airport about the time of their initial call to the ATCT, and, about 2 minutes later, the Eagle1 pilots would have received an aural alert; the display would have shown N1285U's target change from a cyan color to a yellow color positioned between Eagle1 and the airport. About 1 1/2 minutes later, the Eagle1 pilots would have received another aural alert. The N1285U pilot would also have received an aural alert several seconds before impact, which may not have given him enough time to take evasive action. While most systems are limited to aiding pilots in their visual acquisition of a target and cannot provide resolution advisories (specific maneuvering instructions intended to avoid the collision), a cockpit indication of traffic would likely have heightened the pilots' situational awareness and possibly alerted them of the need to change their flightpaths to resolve the conflict.

Postaccident Actions

In November 2016, we issued safety recommendations to the FAA and Midwest Air Traffic Control, Robinson Aviation, and Serco (companies that operate federal contract towers) to (1) brief all air traffic controllers and their supervisors on the ATC errors in this midair collision and one that occurred on July 7, 2015, near Moncks Corner, South Carolina; and (2) include these midair collisions as examples in instructor-led initial and recurrent training for air traffic controllers on controller judgment, vigilance, and/or safety awareness.

In November 2016, we also issued a safety alert titled "Prevent Midair Collisions: Don't Depend on Vision Alone" to inform pilots of the benefits of using technologies that provide traffic displays or alerts in the cockpit to help separate safely. (In May 2015 [revised in December 2015], we issued a safety alert titled "See and Be Seen: Your Life Depends on It" regarding the importance of maintaining adequate visual lookout.)

Flight Events

Approach-VFR pattern base - Midair collision

Probable Cause

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

The local controller's (LC) failure to properly identify the aircraft in the pattern and to ensure control instructions provided to the intended Cessna on downwind were being performed before turning Eagle1 into its path for landing. Contributing to the LC's actions was his incomplete situational awareness when he took over communications from the LC trainee due to the high workload at the time of the accident. Contributing to the accident were the inherent limitations of the see-and-avoid concept, resulting in the inability of the pilots involved to take evasive action in time to avert the collision.

Findings

Personnel issues-Psychological-Attention/monitoring-Attention-ATC personnel - C
Personnel issues-Task performance-Communication (personnel)-Accuracy of communication-ATC personnel - C
Personnel issues-Psychological-Perception/orientation/illusion-Situational awareness-ATC personnel - F
Personnel issues-Task performance-Workload management-Task scheduling-ATC personnel - F
Personnel issues-Psychological-Attention/monitoring-Monitoring other aircraft-Pilot of other aircraft - F

Pilot Information

Certificate:	Airline Transport; Flight Instructor	**Age:**	41
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Instrument Rating(s):**	Airplane
Other Aircraft Rating(s):	Glider	**Instructor Rating(s):**	Airplane Multi-engine; Airplane Single-engine; Glider; Instrument Airplane
Flight Time:	4485 hours (Total, all aircraft), 347 hours (Total, this make and model), 3861 hours (Pilot In Command, all aircraft), 18 hours (Last 90 days, all aircraft), 18.2 hours (Last 30 days, all aircraft), 3 hours (Last 24 hours, all aircraft)		

Co-Pilot Information

Certificate:	Airline Transport; Commercial	**Age:**	66
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Instrument Rating(s):**	Airplane
Other Aircraft Rating(s):	None	**Instructor Rating(s):**	None
Flight Time:	6400 hours (Total, all aircraft), 3307 hours (Pilot In Command, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	NORTH AMERICAN ROCKWELL	**Registration:**	N442RM
Model/Series:	NA265-60SC 60	**Engines:**	2 Turbo Jet
Operator:	BAE SYSTEMS TECHNOLOGY SOLUTIONS & SERVI	**Engine Manufacturer:**	P & W
Operating Certificate(s) Held:	None	**Engine Model/Series:**	JT12A-8
Flight Conducted Under:	Part 91: General Aviation - Other Work Use		

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	**Condition of Light:**	Day
Observation Facility, Elevation:	KSDM, 515 ft msl	**Weather Information Source:**	Unknown
Lowest Ceiling:	None	**Wind Speed/Gusts, Direction:**	6 knots / , 310°
Temperature:	33°C	**Visibility**	10 Miles
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	San Diego, CA (KSDM)	**Destination:**	San Diego, CA (KSDM)

Airport Information

Airport:	BROWN FIELD MUNI (SDM)	**Runway Surface Type:**	Asphalt; Concrete
Runway Used:	26R	**Runway Surface Condition:**	Dry
Runway Length/Width:	7972 ft / 150 ft		

Wreckage and Impact Information

Crew Injuries:	4 Fatal	**Aircraft Damage:**	Substantial
Passenger Injuries:	N/A	**Aircraft Fire:**	In-Flight and On-Ground
Ground Injuries:	N/A	**Aircraft Explosion:**	In-Flight and On-Ground
Latitude, Longitude:	32.577500, -116.948889 (est)		

Administrative Information

Investigator In Charge (IIC):	Andrew L Swick	**Adopted Date:**	11/15/2016
Note:	The NTSB traveled to the scene of this accident.		
Investigation Docket:	http://dms.ntsb.gov/pubdms/search/dockList.cfm?mKey=91793		

accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

The Independent Safety Board Act, as codified at 49 U.S.C. Section 1154(b), precludes the admission into evidence or use of any part of an NTSB report related to an incident or accident in a civil action for damages resulting from a matter mentioned in the report.